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Constantine Stephanidis (Ed.)

Universal Access in Human-Computer Interaction

Context Diversity

6th International Conference, UAHCI 2011
Held as Part of HCI International 2011
Orlando, FL, USA, July 2011, Proceedings, Part III

3 Part III

HCI 2011 INTERNATIONAL

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Volume Editor

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Foreword

The 14th International Conference on Human–Computer Interaction, HCI International 2011, was held in Orlando, Florida, USA, July 9–14, 2011, jointly with the Symposium on Human Interface (Japan) 2011, the 9th International Conference on Engineering Psychology and Cognitive Ergonomics, the 6th International Conference on Universal Access in Human–Computer Interaction, the 4th International Conference on Virtual and Mixed Reality, the 4th International Conference on Internationalization, Design and Global Development, the 4th International Conference on Online Communities and Social Computing, the 6th International Conference on Augmented Cognition, the Third International Conference on Digital Human Modeling, the Second International Conference on Human-Centered Design, and the First International Conference on Design, User Experience, and Usability.

A total of 4,039 individuals from academia, research institutes, industry and governmental agencies from 67 countries submitted contributions, and 1,318 papers that were judged to be of high scientific quality were included in the program. These papers address the latest research and development efforts and highlight the human aspects of design and use of computing systems. The papers accepted for presentation thoroughly cover the entire field of human–computer interaction, addressing major advances in knowledge and effective use of computers in a variety of application areas.

This volume, edited by Constantine Stephanidis, contains papers in the thematic area of universal access in human-computer interaction (UAHCI), addressing the following major topics:

- Universal access in the mobile context
- Ambient assisted living and smart environments
- Driving and interaction
- Interactive technologies in the physical and built environment

The remaining volumes of the HCI International 2011 Proceedings are:

- Volume 1, LNCS 6761, Human–Computer Interaction—Design and Development Approaches (Part I), edited by Julie A. Jacko
- Volume 2, LNCS 6762, Human–Computer Interaction—Interaction Techniques and Environments (Part II), edited by Julie A. Jacko
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- Volume 5, LNCS 6765, Universal Access in Human–Computer Interaction—Design for All and eInclusion (Part I), edited by Constantine Stephanidis
- Volume 6, LNCS 6766, Universal Access in Human–Computer Interaction—Users Diversity (Part II), edited by Constantine Stephanidis

- Volume 8, LNCS 6768, Universal Access in Human–Computer Interaction—Applications and Services (Part IV), edited by Constantine Stephanidis
- Volume 9, LNCS 6769, Design, User Experience, and Usability—Theory, Methods, Tools and Practice (Part I), edited by Aaron Marcus
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- Volume 21, LNAI 6781, Engineering Psychology and Cognitive Ergonomics, edited by Don Harris
- Volume 22, CCIS 173, HCI International 2011 Posters Proceedings (Part I), edited by Constantine Stephanidis
- Volume 23, CCIS 174, HCI International 2011 Posters Proceedings (Part II), edited by Constantine Stephanidis

I would like to thank the Program Chairs and the members of the Program Boards of all Thematic Areas, listed herein, for their contribution to the highest scientific quality and the overall success of the HCI International 2011 Conference.

In addition to the members of the Program Boards, I also wish to thank the following volunteer external reviewers: Roman Vilimek from Germany, Ramalingam Ponnusamy from India, Si Jung "Jun" Kim from the USA, and Ilia Adami, Iosif Klironomos, Vassilis Kouroumalis, George Margetis, and Stavroula Ntoa from Greece.

This conference would not have been possible without the continuous support and advice of the Conference Scientific Advisor, Gavriel Salvendy, as well as the dedicated work and outstanding efforts of the Communications and Exhibition Chair and Editor of HCI International News, Abbas Moallem.

I would also like to thank for their contribution toward the organization of the HCI International 2011 Conference the members of the Human–Computer Interaction Laboratory of ICS-FORTH, and in particular Margherita Antona, George Paparoulis, Maria Pitsoulaki, Stavroula Ntoa, Maria Bouhli and George Kapnas.

July 2011 Constantine Stephanidis

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HCI International 2013

The 15th International Conference on Human–Computer Interaction, HCI International 2013, will be held jointly with the affiliated conferences in the summer of 2013. It will cover a broad spectrum of themes related to human–computer interaction (HCI), including theoretical issues, methods, tools, processes and case studies in HCI design, as well as novel interaction techniques, interfaces and applications. The proceedings will be published by Springer. More information about the topics, as well as the venue and dates of the conference, will be announced through the HCI International Conference series website: http://www.hci-international.org/

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Table of Contents – Part III

Part I: Universal Access in the Mobile Context

Part II: Ambient Assisted Living and Smart Environments

Part III: Driving and Interaction

Part IV: Interactive Technologies in the Physical and Built Environment

Part I
Universal Access in the Mobile Context

Results of the Technical Validation of an Accessible Contact Manager for Mobile Devices

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Abstract. The apparition of new mobile phones operating systems often leads to a flood of mobile applications rushing into the market without taking into account needs of the most vulnerable users groups: the people with disabilities. The need of accessible applications for mobile is very important especially when it comes to access basic mobile functions such as making calls through a contact manager. This paper presents the technical validation process and results of an Accessible Contact Manager for mobile phones as a part of the evaluation of accessible applications for mobile phones for people with disabilities.

Keywords: Accessible Contact Manager, Technical Validation, Evaluation, Mobile Phone Contact Manager.

1 Introduction

Nowadays, the emergence of new mobile operating systems like Android, iOS or W7, and the opening of new markets for mobile application (e.g. Android and Iphone markets) have led to the development of many applications sometimes not as accessible as they should be to be used by people with disabilities.

The accessibility of the applications is especially important when trying to perform basic activities with the mobile phone, such as selecting a contact or initiating a voice call. These actions may be difficult or even impossible to be made by persons with disabilities if the contact manager application is not accessible, and/or it is not properly configured and customized.

The European research project AEGIS [1] seeks to determine whether third generation access techniques will provide a more accessible, more exploitable and deeply

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embeddable approach in mainstream ICT (desktop, rich Internet and mobile applications). One of the specific deliverables of the AEGIS project is the development of an affordable Accessible Contact Manager application able to fill the accessibility gap of existing contact management applications for mobile phones. Designed for easy use by people with disabilities, in particular users with cognitive disabilities that currently have less presence when designing and developing accessible applications, the accessible contact manager user interface is configurable by: font size, colours with high contrast, position of contacts pictures and size configurable layout, explanatory text, customizable sounds alternative to images, and configurable button size. As shown in figure 1, it is also operable with a touch screen, or with the joystick of the mobile phone keypad.

Fig. 1. Accessible Contact Manager Home page: left image with default configuration and right image with layout and colour theme modification

The development of the accessible contact manager has followed the process of "Design thinking" taking into account the current state of the contact management applications and the needs of disabled users in an iterative process of evaluation and technical validation.

2 Evaluation Plan

To provide a complete validation of the application, an evaluation plan was developed covering three iterative phases, according to the maturity of the application [2]. This plan contains a technical validation and human factors evaluation plan [3] [4] that follows a common approach. The scope of this paper covers the technical validation of the first phase iteration phase, when the application was still a prototype under development.

The technical validation plan for the first phase was based upon a technical validation research hypothesis according to the maturity of the Accessible Contact Manager and the development of different objectives and technical key indicators. Different scenarios covering several tasks/actions were developed to validate the technical key indicators with different automatic and manual measurement techniques, such as log files or manual verification metrics, to check the fulfilment of the success threshold.

2.1 Technical Validation Research Hypothesis

The Accessible Contact Manager will be considered successful, given that it provides a navigation of a list of contacts and their contact details in an appropriate time, without creating further problems. It should perform as a regular contact manager that is installed in any mobile device with adequate response times. In addition, the application should be able to adapt its layout and contents according to the user preferences taking into account the limitations of the mobile device.

2.2 Main Technical Evaluation Objectives and Key Indicators

The following table shows the technical key indicators, with metrics and success thresholds in order to check research hypothesis made.

2.3 Technical Validation Procedure

The technical validation was carried out in the usability and accessibility lab of Vodafone Spain Foundation. The log files were gathered automatically using a computer connected to the mobile device. The technical test was performed with two different mobile devices: HTC Diamond and Sony Ericsson Xpheria X2. Both devices run a Windows Mobile OS and had a JavaFX runtime installed to be able to run the application. The colour contrast was analysed manually using the Contrast Analyser Version 2.2 and the emulator version of the application that runs on the computer. To evaluate the intelligibility of the sounds, the mobile devices were configured with the system sound at maximum levels.

The technical validation consisted on a series of tasks that evaluated the technical characteristics of the application. Each task was focused on each of the technical key indicators that have been defined in table 1. These are some examples of the tasks carried out:

Task 2 (focused on the second Key indicator of Table 1):

- Open NetBeans 6.8 IDE
- Connect the mobile device to the desktop computer using a USB cable

- Synchronize the mobile device with the computer
- Run the contact manager project on the connected mobile device using NetBeans
- Use touch screen gestures to move up or down of the contact list
- Note down the time logs of the response time in a navigation movement using gestures with touch-screen
- Calculate the average response time

Task 7(focused on the seventh key indicator of Table 1): Go to the settings page and check the correct behavior of the application under these configurations:

- Small image size
- Medium image size
- Large image size
- Small font size
- Medium font size
- Large font size
- Dark background colour
- Light background colour
- Select English language
- Select Spanish language
- Select Dutch language
- Select Swedish language

Table 1. Main technical evaluation objectivs, key indicators, measuring tools and success thresholds for the Accessible Contact Manager

Technical Key Indicators	**Metrics (for each indicator) and ways/tools to measure them**	**Success Threshold (for each metric)**
Timeliness – Response time in a navigation movement using the joystick	Log files	2 seconds (0,2 seconds) [1]
Timeliness – Response time in a navigation movement using gestures with touch-screen	Log files	2 seconds (0,2 seconds)
Timeliness – Response time in a modification of the layout	Log files	15 seconds (not available in common contact managers)
Reliability – Number of errors	Log files and manual evaluation	Less than one error message per 50 user interactions with the device

[1] The response time given in the parentheses is the average response time of common contact managers that are built-in with mobile devices (as estimated for this scope). However, the success threshold for the accessible contact manager are higher, as may noticed, since the application is much more demanding graphically and it takes much more time to navigate.

Table 1. *(continued)*

Accessibility – Text alternatives (WCAG 2.0 Guideline 1.1 [5]) - Provide text alternatives for any non-text content so that it can be changed into other forms people need, such as large print, Braille, speech, symbols or simpler language	Manual Evaluation	Every symbol presented to the user are provided is a text alternative
Accessibility – Time based Media (WCAG 2.0 Guideline 1.2). Provide alternatives for time-based media	Manual Evaluation	An alternative for time-based media (the audio voices of the contacts) is provided that presents equivalent information with other alternatives (textual – names of the contacts and/or graphical – pictures)
Accessibility – Adaptable. WCAG 2.0 Guideline 1.3 - Create content that can be presented in different ways (for example simpler layout) without losing information or structure	Manual Evaluation	The application should be adaptable in at least two of the following: adapting layout, menus, font size, colour themes, language
Accessibility – Distinguishable. WCAG 2.0 Guideline 1.4 - Make it easier for users to see and hear content including separating foreground from background	Manual evaluation for adequate sound level of voices and colour contrast analyser application to measure the minimum contrast	- At least one of the colour themes should provide visual presentation of text and images (except images of contacts) of at least 4,5:1 - Colour is not used as the only visual means of conveying information - Text can be resized without loss of content or functionality - Sounds and voices should provide an adequate level of volume to be intelligible

3 Results

The following table shows the results of the technical validation according the Key indicators shown in Table 1.

Table 2. Aggregated evalua tion results of the Accessible Contact Manager

Technical Key Indicators	**Iterations (number if available)**	**Mobile Device**	**Success Threshold (for each metric)**	**Aggregated result (per task scenario if more than one)**
Timeliness – Response time in a navigation movement using the joystick	5	Sony Ericsson Xperia X2	2 seconds (0,2 seconds)[2]	1,620 seconds
Timeliness – Response time in a navigation movement using gestures with touch-screen	5	Sony Ericsson Xperia X20	2 seconds (0,2 seconds)	1,430
	5	HTC HD 2	2 seconds (0,2 seconds)	1,123
Timeliness – Response time in a modification of the layout of the application	5	Sony Ericsson Xperia X2	15 seconds (feature not available in common contact managers)	13,463
	5	HTC HD 2	15 seconds (feature not available in common contact managers)	4,644
Reliability – Number of errors	100	Sony Ericsson Xperia X2	Less than one error message per 50 user interactions with the device	No error messages
	100	HTC HD 2	Less than one error message per 50 user interactions with the device	No error messages

[2] The same as in footnote [1]

Table 2. *(continued)*

Accessibility – Text alternatives (WCAG 2.0 Guideline 1.1) - Provide text alternatives for any non-text content so that it can be changed into other forms people need, such as large print, braille, speech, symbols or simpler language	All icons were reviewed	This metric does not depend on a particular mobile device	Every symbol presented to the user are provided is a text alternative	The success criteria was met and all symbols were provided with text alternatives
Accessibility – Time based Media (WCAG 2.0 Guideline 1.2). Provide alternatives for time-based media.	All sounds were reviewed	This metric does not depend on a particular mobile device	An alternative for time-based media (the audio voices of the contacts) is provided that presents equivalent information with other alternatives (textual – names of the contacts and/or graphical – pictures)	The success criteria was met and all audio sounds were provided with text alternatives
Accessibility – Adaptable. WCAG 2.0 Guideline 1.3 - Create content that can be presented in different ways (for example simpler layout) without losing information or structure	12 configurations were tested	This metric does not depend on a particular mobile device	The application should be adaptable in at least two of the following: adapting layout, menus, font size, colour themes, language	The success criteria was met and the application provided 4 methods that allow users to adapt the application to their preferences: layout, font size, colour themes and language
Accessibility – Distinguishable. WCAG 2.0 Guideline 1.4 - Make it easier for users to see and hear content including separating foreground from background	2 colour themes were tested	This metric was tested using the mobile emulator running on a desktop computer	At least one of the colour themes should provide visual presentation of text and images (except images of contacts) of at least 4,5:1.	The success criteria was met and the minimum contrast ratio was 11,6 for the dark colour theme. The other colour theme has a minimum contrast ratio of 4,6 which is also above the threshold

Table 2. *(continued)*

	N/A	This metric does not depend on a particular mobile device	Colour is not used as the only visual means of conveying information	The success criteria was met and all UI elements do not rely only in colour to provide information
	3 font sizes were tested	This metric does not depend on a particular mobile device	Text can be resized without loss of content or functionality	The success criteria was met and the behaviour of the application was the same when the font size was changed by the user
	3 voices of contacts	Sony Ericsson Xperia X2	Sounds and voices should provide an adequate level of volume to be intelligible	The success criteria was met and the sound level was adequate to listen and understand the voices of the con-tacts
	3 voices of contacts	HTC HD 2	Sounds and voices should provide an adequate level of volume to be intelligible	The success criteria was met and the sound level was adequate to listen and understand the voices of the contacts

The accessible contact manager application has an important number of functionalities that are not included in conventional contact manager applications. Therefore, the response times have not been comparable to these built-in applications but have successfully improved the threshold values. It should be noticed the improvements of HTC HD2 in comparison with the Sony Ericsson X2, not only in response time but also in user navigation which is much more friendly as it uses a capacitive touch screen that does not require the use of a stylus.

The accessible contact manager has proven to be a very flexible and adaptable application for the users. The research hypothesis and the success criteria have been largely met. The prototype has worked without any error messages or further problems. In addition, the application has been able to adapt its layout and contents according to the user preferences taking into account the mobile device limitations.

4 Future Work

The main problems that occurred during the technical validation were due to the use of the resistive touch-screen without using a stylus. The navigation was much better with the capacitive touch-screen of the HTC HD2 in comparison with the resistive touch-screen of the Sony Ericsson Xperia X2. This should be taken into account for future decisions on which devices are going to be used during the trials, because it affects the user experience and especially those who are motor impaired. In the near future the final application of the Accessible Contact Manager will be again evaluated taking into account the results of the human factors evaluation and the technical validation presented in this paper, checking if the improvements made into the applications will fulfil the technical recommendations and users needs.

Acknowledgment. This work has been carried out as part of the AEGIS (Open Accessibility Everywhere: Ground-work, Infrastructure, Standards) project co-funded by the European Commission under the Seventh Framework Programme funding for Research on e-Inclusion, grant agreement No. 224348.

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Developing Accessible Mobile Phone Applications: The Case of a Contact Manager and Real Time Text Applications

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Abstract. Mobile phones are becoming increasingly popular and are already the first access technology to information and communication. However, people with disabilities have to face a lot of barriers when using this kind of technology. This paper presents an Accessible Contact Manager and a Real Time Text application, designed to be used by all users with disabilities. Both applications are focused to improve accessibility of mobile phones.

Keywords: Mobile Application, Accessibility, Real Time Text, Contact Manager, Phone Dialer.

1 Introduction

In a mobile world where technology development reaches the market every time faster and mobile subscriptions expects to be at the end of 2010, 5.3 billion [1], people with disabilities face different barriers to access and use mobile devices. Although some of the mobile Operating System (OS) developers are making the effort to build more accessible OS by providing accessibility Application Programming Interfaces (APIs), like the Android and IPhone OS, if the application developed does not make use of these Accessibility APIs or follow accessibility guidelines, most of the effort made is useless.

The accessibility barriers faced by people with disabilities in mobile phones are more critical when it comes to essential applications needed for basic communications, such as dialer, contact manager or instant messengering, this last especially for users with hearing or speech disabilities. To fulfill the accessibility requirements of these applications, an Accessible Contact Manager with phone dialer and a Real Time Text application have been developed within the context of the European funded

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Project AEGIS [2] that seeks to determine whether 3rd generation access techniques will provide a more accessible, more exploitable and deeply embeddable approach in mainstream ICT.

2 Accessible Real Time Text Application

This application consists of an instant messaging application in real time. This means that each time the user writes a character, it is automatically received by the recipient. Thus, it is not necessary to press an additional button to send what the user is writing. This application is very useful for users with hearing or speech disabilities as it allows a faster communication process.

This kind of communication works as a simple voice call. To establish the connection the Voice over IP (VoIP) protocol is used. The application connects to the internet network using the mobile phone available network e.g. 3G or WiFi.

The protocol that has been implemented to allow sending and receiving data in real time is the Real Time Protocol, IETF RFC4103(1), using the control of the connection through the open source SIP server Kamailio [3]. A voice connection is needed to register the mobile device in the server and to send invitations to start a conversation. Once the invitation is accepted, the application provides the user with two text boxes, one to write the messages and the other to show what the received messages, like in a standard chat application.

The connection security and reliability is one of the most important features of the RTT application. This has been guaranteed using the redundancy method of Real Time Protocol (RTP). The other protocol that helps to manage the communication is the Real Time Control Protocol [4] which provides the information about the status of the connection. At the same time, before the real time connection is established, a process for authentication and negotiation of capabilities between each device is required. These steps are carried out through the Session Initiation Protocol and Session Description Protocol [5].

The Graphical User Interface (GUI) has been implemented following accessibility guidelines to ensure a high usability of the application. Furthermore, a configuration screen has been implemented, to allow the user to personalize some parameters like the font size, color theme, icon type or icon size. This is shown in figure 1.

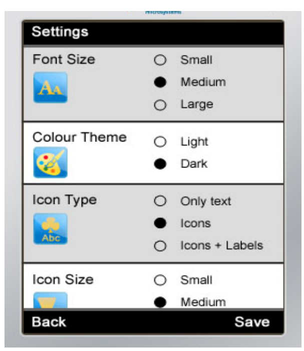

Fig. 1. RTT application: configuration screen

When all steps to launch the application have been followed (configuration, connection with the server, call and call accepted), the user interface shows the screen divided in two parts, one to write and the other to see what the other user is writing (see figure 2).

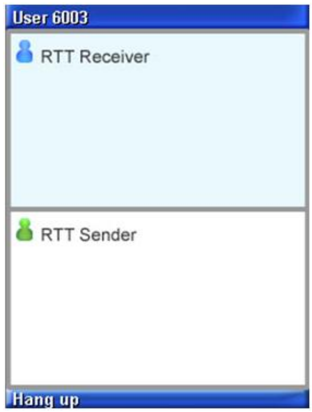

Fig. 2. RTT application: main screen

As it was mentioned before, the message could arrive with some errors, so when the application detects them, it shows a special character to indicate the user that this specific information could be wrong and, if it is possible to solve the error using de redundancy method, the affected characters are replaced by the correct ones. The main innovation of this solution relies on the use of real time text communications in mobile phones.

3 Accessible Contact Manager Application

The Accessible Contact Manager with phone dialer has been developed under Android 2.2 OS. The design has followed the process of "Design Thinking" following a path that has as starting point the definition of the problem and the analysis of the state of the art of phone dialer existing in the market. Only the best features of the available applications have been selected, thus discarding those that did not meet accessibility requirements. For example, the attribute that avoids redundancy of buttons functionality has high priority, as well as the location of buttons across the screens. All these characteristics contribute to facilitate the cognitive accessibility of the application.

Furthermore, the icons used are very intuitive always accompanied by explanatory texts which are configurable. This is an accessibility advantage, especially for people with visual and cognitive disabilities. The font size, layout and colors are as well configurable: various types of contacts placements are available on the screen, the location of contacts can be combined with a specific font size, white over black is used or optionally black over white according to the personal preferences and especially based on the user needs (see figure 3).

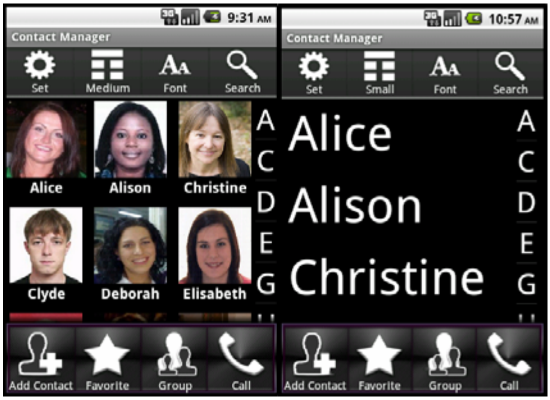

Fig. 3. Contact Manager main screen

All these features implemented are supported by Android guidelines [6], especially buttons on both header and footer, which have the normalized size.

The main functionalities of this application are directly accessed from the main screen, by pressing the buttons of the header and footer. The table below presents the available actions.

Table 1. Main screen available functionalities

Element	Information	Action
Contacts showed on the screen	Name and/or photo (depending on the layout)	OnClick: open the contact details for this contact OnScroll: move the list to show more contacts
Settings	…	OnClick: open settings configuration window
Layout	Next layout	OnClick: change to the next layout (1x1,2x2,3x3 and name list without photo)
Font	…	OnClick: change to the next font size
Search	…	OnClick: look for a contact
Add Contact	…	OnClick: open the add contact window.
Favourite	…	OnClick: open the favorites group contacts window
Group	…	OnClick: open the group contact selection window

Table 1. *(continued)*

Call	…	OnClick: call the selected contact
Alphabetic list	Actual position of the contact list	OnClick: Move the list of contacts showing the first contact which name starts with the letter selected. If the action is a long click, the font size of the alphabetic list is changed OnScroll: move the alphabetic list and the contact list in a synchronized way

In order to provide an accessible contact manager, it is extremely important to know which contact is being selected. Therefore, when a new contact is added, the application provides a way to link different features to the same contact. This is achieved associating an audio file to every contact that can be recorded from the contact himself to help people with cognitive or visual disabilities to identify them, or even Text to Speech, audible through the cursor movement or a simple touch over the contacts.

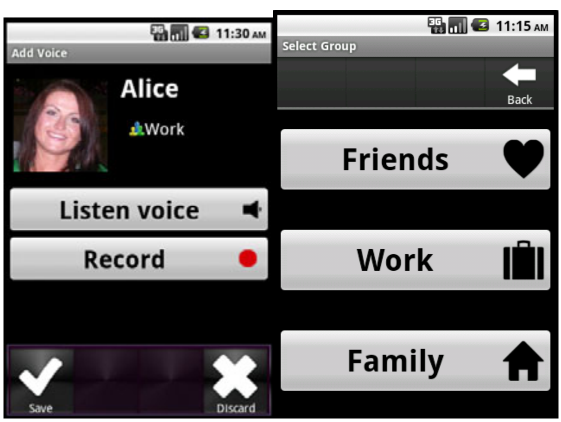

Fig. 4. Listen/Record audio file and Group screens

This feature is very useful especially for blind people or people with cognitive disabilities as it provides an easy way to recognize the contact that is being call. In addition to that, the application allows affiliating each contact to a group (friends, work, family ...), so the user can associate and recognize a contact also through the group in which it is associated (see figure 4).

4 Evaluation Results

Following the release of the first prototypes, different tests have been conducted with a limited number of end users of five category groups: visual, hearing, motor, cognitive and speech/communication disabilities.

According to the preliminary evaluation results, it was agreed that the contact manager has an important number of functionalities that are not included in conventional contact manager applications. Therefore, the response times have not been comparable to these built-in applications but have successfully improved the threshold values. The users found the application easy to navigate and to understand, however it can be hard to use for the users with some hand motor dysfunction.

The deaf and hard of hearing persons showed acceptance of the real time messaging and enjoyed the quickness offered by the application, however some did not like the other person seeing their spelling mistakes.

In general, the Accessible Contact Manager and the Real Time Text applications have proven to be very flexible and adaptable applications for the users.

Within the framework of the AEGIS project, two more evaluation phases will be carried out as well as a final demonstrator that will ensure that the applications are developed according to the preferences of the users.

5 Conclusions

This paper has presented two different prototypes of accessible mobile applications. Although the barriers that users have to face when accessing mainstream ICT systems and applications are common in most of the ICTs environments, mobile platforms add some restrictions that should be taken into account when designing accessible applications.

During the evaluation of the first prototypes by the end users, several features that improve the accessibility of the applications have been identified. Even though a great effort has been put to identify accessibility solutions that could improve the user experience, the end-users have identified several modifications to adapt the application to their real needs. The use of a user centred design methodology and the iterative evaluation will guarantee the optimization of the application in future versions

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BrailleTouch: Mobile Texting for the Visually Impaired

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Abstract. BrailleTouch is an eyes-free text entry application for mobile devices. Currently, there exist a number of hardware and software solutions for eyes-free text entry. Unfortunately, the hardware solutions are expensive and the software solutions do not offer adequate performance. BrailleTouch bridges this gap. We present our design rationale and our explorative evaluation of BrailleTouch with HCI experts and visually impaired users.

Keywords: mobile computing, HCI, eyes-free, accessibility, Braille, soft keyboard, multi-touch, touch screen, text entry.

1 Introduction

Eyes-free text entry has long been a goal of academic researchers in the arena of mobile computing, especially in the field of wearable computing [1]. In this paper, we focus on visually impaired users, whose real needs for eyes-free text input go beyond academics. For the visually impaired, eyes-free text entry is a pervasive need, especially when using mobile computing devices. Current solutions are compelling but have significant drawbacks. On the one hand, there are several special-purpose and expensive ($400 - $6000) hardware solutions available for eyes-free mobile texting (see table 1). While these hardware solutions interface relatively seamlessly with other mobile devices via Bluetooth, they still present the user with an additional item to carry, with its own expense, batteries, and setup time. This option is expensive and cumbersome enough to dissuade some members of the visually impaired community from participating in the use of mobile computing devices. One visually impaired subject we interviewed reported that she tends to not engage in mobile technology, even though much of her time "is spent waiting on others" in various places.

On the other hand, many software solutions for mobile eyes-free text entry are cheaper than the hardware alternatives. One example is Apple's VoiceOver, which comes standard with their latest generation of mobile products including the iPhone 4 ($200 with plan). Unfortunately, at 0.66 words per minute (wpm), its typing speed is impractical [2].

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Table 1. The table lists various hardware solutions for Braille text entry sorted by price in USD. The optional Braille display is typically a matrix of pneumatic pins that pop up to encode a Braille character for tactile output.

Device Name	Braille Display	Price $(USD)
Braille Sense Plus	Yes	6000
Voice Sense	No	2000
VoiceNote BT	No	1900
Refreshabraille 18	Yes	1700
PAC Mate BX 400	No	1500
Braille+ Mobile Manager	No	1400
Maestro	No	1300
Nano	No	1000
EasyLink & Pocketwrite	No	1000
GalaTee	No	400

2 Related Work

Bonner, Brudvik et al. recently developed a system called No-Look Notes [2]. No-Look-Notes is a soft keyboard for eyes-free texting on a touch screen. The interface divides the screen into eight wedge shapes, as opposed to 26 or more on a QWERTY keyboard. The eight wedges equally utilize the full screen of the phone, dividing it into eight radial segments. Users enter text through two-finger interaction, where one finger finds the appropriate wedge and the second finger manipulates a scroll window to find a letter in the group. The device provides speech feedback. No-Look Notes showed a marked improvement in input speed, error rate, and positive feedback from the participants as compared with the current accessibility application from Apple, VoiceOver. Visually impaired users were able to input an average of 1.32 wpm with No-Look Notes, as compared to 0.66 wpm with VoiceOver.

Castellucci and MacKenzie of York University evaluated and compared Graffiti against Unistrokes, which are two different stylus-based (or potentially finger-based) text entry technologies for touch screens [3]. Graffiti, so named because it closely resembles the handwritten Latin alphabet, was far easier for novices to become familiar with. Unlike Graffiti, Unistrokes does not closely resemble the Latin alphabet. Its design maps simple gestures into characters. Unistrokes, once mastered, showed consistently better results in both wpm and error rate. Both input technologies started at about 4 wpm, with Graffiti reaching just over 12 wpm and Unistrokes reaching just below 16 wpm over the course of 20 sessions. Castellucci and MacKenzie also report that the correction rates remained steady for Graffiti, while they dropped from 43.4% to 16.3% for Unistrokes.

Slide Rule was created by Kane, Bigham, and Wobbrock at the University of Washington's DUB group [4]. It was accepted and presented at ASSETS 2008. Slide Rule is a system for general operation of a touch screen mobile device by the visually impaired, with applications that include playing music and navigating through menus. While greatly increasing accessibility in some areas, Slide Rule continues to use a QWERTY soft keyboard, a standard keyboard visually rendered on the screen, for text entry. Kane's paper recognizes the shortcomings of this type of interaction for the visually impaired and mentions that a chorded, multi-touch input technology, like No-Look-Notes or a Braille chorded input system, are areas for future research.

2.2 The Braille Code

Braille is a 3 by 2 binary matrix that encodes up to 63 characters, not counting the all-null state, which is when no dots are present ($63 = 2^6-1$). In English Braille, a single matrix combination encodes one character. For example, position 1 (upper left) encodes the letter “A”, while positions 1 and 4 together (upper left and upper right) represent the letter “C” (see Figure 1) [5]. This code progresses in a logical and expanding pattern of neighborhoods that include landmarks that serve as mnemonic devices. For instance, the letters “A” through “J” only reside in the top four positions. The letters “K” through “T” add a dot on the third row (lower left) and repeat the same pattern of the first 10 letters. At “U” the pattern repeats itself with the addition of position six (lower right). Note that the patterns of the first two rows of a Braille cell repeat every 10 letters. For example, “A”, “K”, and “U” have identical first two rows, as do “B”, “L”, and “V”. The letter “W” does not follow this pattern because it doesn’t exist in Braille’s native French and was added after the system was created. Thus, “X”, “Y”, and “Z” share the patterns of the first two rows of “C”, “D”, and “E”. These and other landmarks help users learn Braille. There are special sequences to type capital letters, numbers, and punctuation marks.

Louis Braille, who was blinded at age three, developed and then published this writing system in 1829. Braille was inspired by a system of communication called Night Writing that was developed for French artillery personnel during the Napoleonic Wars [6]. This tactile communication code was a 2x6 matrix of dots which represented sounds instead of letters. Braille’s version improved upon Night Writing by not only conveying letters instead of sounds, but also by using the binary code more efficiently [7]. The Braille code now exists for many languages, including English, Japanese, Hebrew, and French. There are also Braille codes for musical and mathematical notations.

Braille is an efficient encoding system that allows users to type with reasonable speed and accuracy. Unfortunately, it is extremely difficult to find rigorous statistics of its typing performance. Consequently, we resorted to interviewing people in the industry. According to Jude Jonas, head engineer at Perkins Products, users of traditional Braillewriters achieve 3 to 7 keystrokes per second, which roughly converts to 36 to 84 words per minute [8, 9]. This is well within the range of traditional full-sized QWERTY keyboards, where expert users can reach speeds of 70 –100 wpm [10].

For over one hundred years, new technologies have brought Braille literacy to the visually impaired community. In 1892, Frank Hall invented a Braillewriter that functioned in a similar manner to a typewriter. In current times, Braille reading may be in decline because of the great success of text-to-speech software solutions. On the other hand, given that there are few alternatives for the visually impaired to input text on a mobile device, Braille typing may be on the rise.

Although only 16% of the visually impaired in the US today are fluent readers of Braille, there are three reasons we believe our BrailleTouch text entry system will be successful in the visually impaired population [11]. First, based on observations and communications with members of the visually impaired community, especially Braille instructors, writing Braille is considerably easier and more pervasive than Braille reading within the population. Second, members of the population who are already fluent in touch-typing on a Braille keyboard can easily translate this skill for use on the BrailleTouch device, as the mapping of fingers to the primary six keys is the same on both devices. Third, the population that is not fluent in typing on a Braille keyboard may easily use the audio feedback feature of BrailleTouch to become fluent.

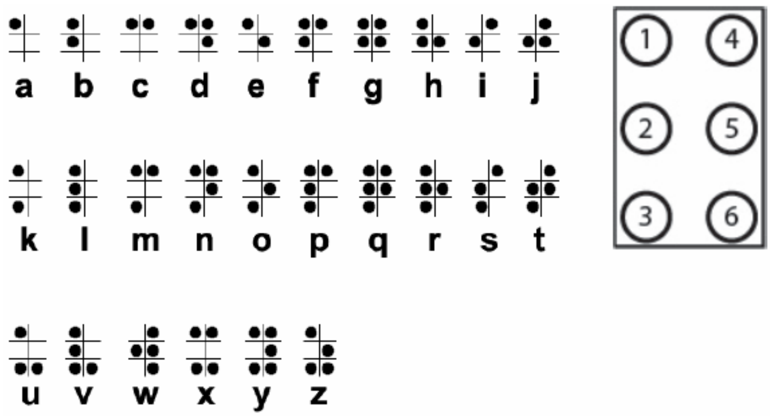

Fig. 1. English Braille and the number labelling of each cell

3 Design of BrailleTouch

BrailleTouch is an eyes-free text entry technology for touch screens. It is a Braille soft keyboard prototyped as an application on an iPod Touch. The key aspect of the technology is that it has fewer buttons than fingers. Thus, the user does not have to move the fingers around to find the correct sequences and combinations to type. Once placed, the fingers remain in the same position. This is crucial for eyes-free text input on a smooth surface, like a touch screen or a touch pad. Simply stated, BrailleTouch allows touch typing on a touch screen.

The iPod prototype includes an ergonomic case to help the user hold the device and position the fingers on the keys. Users hold BrailleTouch with two hands, and use their fingers in a layout and functionality with a one-to-one correspondence to a Braille writer. Concretely stated, the left index goes over key 1, the left middle finger, over key 2, and so on. Users hold the device with the screen facing away from them. Some hold it with their pinkies, their thumbs, and cradle the device in their fingers (see Figure 2); others grasp it with the balls of their hands or even their palms.

The six buttons on BrailleTouch spatially correspond to the mental map of the six cells in a Braille character as well as to the placement of the six fingers (see Figure 3). As the user types, BrailleTouch provides audio feedback for each selected character.

Fig. 2. BrailleTouch's back faces the user

Fig. 3. BrailleTouch's input surface faces away from the user

It is important to point out a caveat to the design of BrailleTouch. A traditional Braille typewriter has extra keys including a space bar and a backspace key. We implemented a large central button for the space bar, and we coded the backspace button to be a combination of button 6 and the space bar (see Figure 3).

4 Evaluation

Several experts in the field of usability have examined BrailleTouch. The most consistent feedback was to change the case in a way to better guide users to the proper position for operation, with the screen facing away from them. This is important because for most individuals, even the visually impaired, the natural inclination is to hold the device with the screen facing toward them. Two visually impaired users also provided feedback on BrailleTouch. One person was fluent in Braille, while the other claimed only a slight ability. Within a few minutes, both people were able to successfully operate BrailleTouch. The person fluent in Braille confirmed that, with practice, BrailleTouch would be as quick and easy to use as the Braille input device he uses every day, a model similar to a Refreshabraille 18, which retails for approximately $1700. During the interview, the authors were able to observe how the visually impaired use Braille input devices, which resulted in several additional improvements to the case design.

These user interviews, along with the comments from one of the usability experts, encouraged us to further explore the potential of BrailleTouch as a teaching tool. We interviewed two visually impaired Braille instructors. Both felt that this device has strong potential in this area. One likened it to a device called Braille and Speak, which was from the era of the child's toy Speak and Spell [12]. This instructor also expressed excitement about BrailleTouch and encouraged us to fully implement the device as quickly as possible. Both instructors participated in non-logged bench tests. They were able to input text at rates quick enough to cause the verbal feedback to vocalize letters consecutively. Since most sound files we used for the letters of the alphabet are a quarter of a second in length, this roughly translates to 30 to 50 words per minute.

We also received information that dispelled some of our assumptions on how the members of the visually impaired community interact with their world. One vital new piece of information concerned the case design. In the original version (see figure 2) there are raised lines and tactile Braille characters on the back of the case, which faces the user. Our purpose for this design was to provide the user with a mental map of what is occurring on the front. After several awkward attempts to read the back of the case, our initial interviewees explained to us that they don't use their thumbs to read Braille. The skin on the thumb is too thick to be sensitive enough to read. In a future version, we will change the case in favor of a comfortable and high grip surface. We may place some markers on the front of the case or on a screen protector to allow the indices to read clearly without interfering with the interaction with the touch screen.

5 Conclusion

We have demonstrated BrailleTouch, an eyes-free text entry application for mobile devices. BrailleTouch, as an assistive technology for the visually impaired, offers advantages over comparable technology that is currently available. Compared with existing solutions available today, BrailleTouch has the potential to be considerably less expensive than the hardware options, while offering superior performance to the software options. In addition, BrailleTouch technology can be incorporated into existing mobile touch screen devices, such as the iPhone and Android smart phones, so that the user does not need to carry an additional piece of hardware while on the go.

6 Future Work

We are currently designing a study to formally evaluate BrailleTouch through both quantitative and qualitative methods. In this study, we will measure the typing speed and accuracy of visually impaired users operating this device. We will also capture the feedback from study participants in areas such as comfort, ease of use, and perceived value. Our previous feedback from Braille instructors has inspired us to also evaluate the utility of BrailleTouch as a teaching tool, through interactive games as well as traditional Braille instruction methods. Furthermore, we will explore the use of BrailleTouch by sighted users, as a universal eyes-free mobile text input technology to be used in place of soft QWERTY keyboards, Graffiti, and other current mobile text input methods.

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Supporting Universal Usability of Mobile Software: Touchscreen Usability Meta-test

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Abstract. Present day mobile applications are becoming increasingly pervasive and complex, involving sophisticated user interfaces and touchscreen-based interaction designs. Their overall acceptance is highly dependent on usability, hence there exists a strong need to make related usability issues an integral part of the mobile software development. In this paper we propose a touchscreen meta-testing model, a set of individual test cases which represents what we believe to be the basic aspects of usability, common to all touchscreen applications. The main goal of the meta-test is to provide relevant feedback on elementary mobile touchscreen interaction, and to use obtained results as important parameters and usability guidelines within the mobile software development process. Along with universal usability support for touchscreen mobile applications in general, this experimental framework can provide some additional benefits, related to different possible ways of both applying meta-test model and using its final outcomes.

Keywords: universal usability, mobile software, touchscreen interaction, usability testing.

1 Introduction

The advance in technical development experienced in the past few years has transformed artifacts like mobile phones from basically simple communication devices to powerful application platforms. This has been made possible by a massive research effort itself being motivated by a vast market demand. In such a framework, both designers and developers have been under continuous pressure by the imperative of rapid application development for such a hungry market, and have worked out many different operating systems and development platforms for mobile applications. On the other hand, it has been also noticed that during the development of mobile software the process of creating an adequate functionality leaves less space to interaction design and usability issues often resulting in their neglect. As problems related to

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usability are becoming all the more prominent, otherwise forcing users and engineers to take over the design process [1], it became apparent that this situation should be changed by both raising the awareness of the importance of usability and properly addressing usability issues within the early development stages. The specificity of mobile domain confronts developers with particular problems derived from both technology variety and user diversity [2]. These differences represent a barrier to the concept of universal access [3], which can be lowered by sustaining universal usability throughout the process of mobile software development. Our previous research already addressed the importance of usable interaction design in the mobile environment (e.g. [4, 5, 6, 7]), leading to our present focusing on improving both the quality of touchscreen mobile applications and related development process, by providing a usability testing framework as a support for getting both instant answers and appropriate guidelines regarding relevant usability factors.

The paper is structured as follows. In Section 2 we try to determine the most widespread HCI issues and the associated usability problems in nowadays mobile applications based on touchscreen interaction. Following the main idea of reducing these issues, thus making the ground for supporting universal usability of mobile software, in Section 3 we propose the touchscreen usability meta-test model, along with the respective test scenarios which are explained in detail. Also, some layout snapshots of the initial implementation are displayed, illustrating the current state of our efforts. The last section offers a brief recapitulation, including the list of additional expected benefits of the proposed meta-test model, which represents the outline of our future research plan.

2 Common Usability Issues of Touchscreen Mobile Applications: Causes and Consequences

In general, no matter all the benefits it imposes, comprehensive design at programming level of both interface and interaction may not be sufficient for the elimination of all usability problems. Eventual residues can be the result of inherent characteristics of the application itself, what can be closely related with standard approaches to mobile software development, the first of them shown in Figure 1a, where testing and evaluation of touchscreen interaction is performed by using the (physical) mobile device. In this way the developer can obtain very precise and detailed target device feedback, but the main disadvantage of this method is obvious: using a single gadget there is a high probability of making the application device-specific, with user interface (UI), interaction design, and related usability being linked to a distinct group of device models. On the other hand, mobile software development can be based on the utilization of a touch sensitive monitor and emulator platforms (Fig. 1b). Obviously, the development cycle results more efficient, but in such a working setup it is quite hard to evaluate the actual user experience (UX) supported by emulation, especially for different contexts of use. Consequently, possible interaction design limitations can remain undetectable, and eventually overseen (cf. the problem of touchscreen boundary objects).

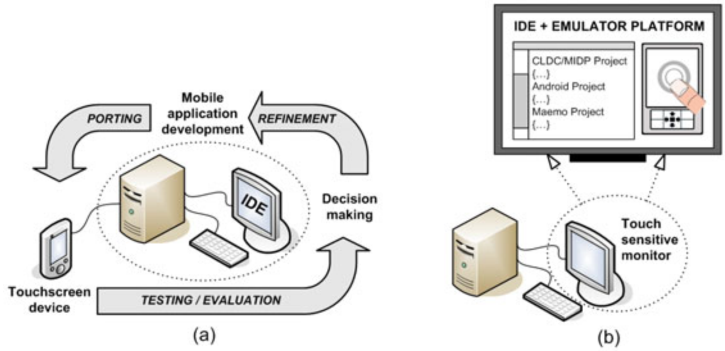

Fig. 1. Standard approaches to the mobile software development process

As a result, although each of the abovementioned approaches to development have their own pros and cons, both can impose severe usability problems. Regardless of development method, complexity, application domain, and target device, several interface elements and related use cases can be extracted as general characteristics of touchscreen mobile interaction. These identified use cases represent what we believe to be the typical usability issues, common to all touchscreen applications. Specifically, they are: optimal size of touchscreen objects, visual search-and-selection, edge-positioning, occlusion, dragging gestures, and efficiency of virtual on-screen keyboards. Descriptions of these issues, along with references to related work, are shown in Table 1.

Table 1. Typical usability issues in mobile touchscreen interaction.

Issue	Standpoint	Related work
Interactive object size	There are no formal recommendations and precise guidelines about quantitative measures for target object size. The problem translates further to portability of object sizes among different mobile devices (with different screen characteristics).	[8], [9]
Visual search and selection	There is a need to efficiently present a number of UI controls/elements (e.g. icons) on a small screen so that the user can easily find a target object among visual distractors.	[10]
Edge-positioning and occlusion	Regardless of the interaction method used (one-thumb, two-thumbs), the problem arises with the occlusion of objects underneath the finger(s) touching the screen. Moreover, interface objects that are located along the edge of the screen of the mobile device can be difficult to reach.	[11], [12], [13]
Dragging gestures	Interaction techniques similar to drag-and-drop can be applied to a touchscreen to improve tasks such as target selection, zooming, panning, and scrolling. However, efficiency and accuracy of performing the corresponding gesture should be thoroughly analyzed.	[14], [15]
Virtual keyboard usage	Text and/or numeric entry via virtual on-screen keyboards imposes the problem of activating a sequence of closely placed UI controls. The core of this usability issue (erroneous input) lies in the controls' size and their mutual distance (i.e. keyboard layout).	[16], [17]

Problems related to HCI aspects of mobile applications highlighted in this section may sometimes be regarded as only minor annoyances of no particular importance. However, we deeply believe that this is not true, as the cumulative effect of irritating the user while she/he is trying to get through the interface can surely have a negative effect on usability. Therefore, we are trying to acquire as much as possible information about usability of fundamental GUI actions that correspond to abovementioned issues. We believe that this is possible by making use of a specially designed touchscreen usability meta-test, a model of which we propose and describe in detail in the next section.

3 Touchscreen Usability Meta-test

The main goal of the touchscreen usability meta-test is to provide relevant (both quantitative and qualitative) feedback on elementary touchscreen actions, and to use the obtained results to make usability issues an integral part of the development process, thus combining the advantages of both the developer-centered and the user-centered design (UCD).

Following UCD guidelines, granting enough attention to abilities and skills of the end user (throughout a "user understanding" phase) should precede activities like defining interaction (by writing use cases) and designing the user interface proper (by prototyping and evaluation) [18]. Generally, appropriate usability testing involves measuring typical users' performance on carefully prepared tasks that are typical of those for which the system is being designed, as well as carrying out user satisfaction surveys (through questionnaires and interviews) for obtaining users' subjective opinions [19]. Usability tests are generally application-specific, where user performance is usually measured in terms of the number of errors and time to complete application oriented tasks. While performing these tasks, user interaction with the application software is somehow logged (automatically by the software itself, or observationally by the evaluators), and the collected data is afterward used to calculate performance times, identify errors, and help explain the nature of users' interaction behavior.

However, the main problem with traditional usability testing (when it is not purposely put aside and finally ignored) is its dependency on target system/application, as well as on the usual practice of conducting usability testing after the deployment phase (when it is usually too late for "usability debugging"). In order to achieve the goal of providing support for universal usability of mobile software in general, relevant feedback on touchscreen interaction elements usage is needed in the preliminary stage of development already. However, this feedback should not be associated with some particular mobile application, but should instead represent applicable data based on common usability issues as noted in the previous section. Consequently, our touchscreen usability meta-test model (Fig. 2) consists of five test scenarios which include the following: (i) object sizes (in)convenient for the direct touch technique, (ii) search for a given interface object, (iii) selection of boundary located interface objects, (iv) drag-and-drop gesture feasibility, and (v) keystroking using a soft (emulated, touch) keypad.

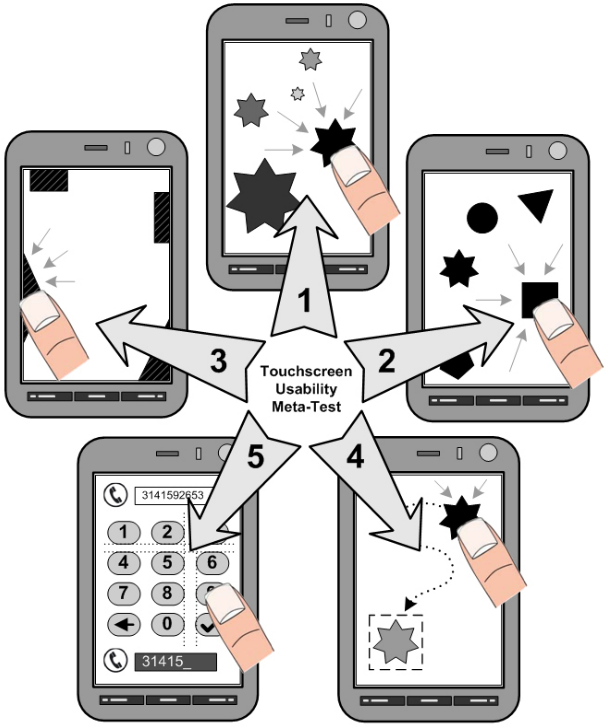

Fig. 2. The meta-test, consisting of five test scenarios, deals with fundamental aspects of mobile touchscreen interaction: appropriate size of interactive object (1 – *Target Size*), search for a distinct object among distractor items (2 – *Object Search*), selection of edge-positioned objects (3 – *Boundary Objects*), dragging gestures (4 – *Drag&Drop*), and sequential input via a virtual on-screen keyboard (5 – *Soft Keystroking*).

3.1 Meta-test Scenarios

The first test case, *Target Size* (Fig. 2: arrow 1), addresses the size of an object visible on the target device display. Herein, the object can represent a range of UI elements that are responsive to the direct touch technique (e.g. button, icon, textbox, scrollbar slider). The purpose of this test scenario is to determine the most suitable object size that is applicable to devices having different display resolutions and running different application types. Proper object size should minimize wrong selections, void touch-screen actions and the overall direct touch inaccuracy. This test is based on direct touch repetitive use in targeting (tapping) a displayed object. The application software displays one object at a time, at a randomly chosen position, while the user's goal is to be as much as possible efficient and accurate when hitting objects with her/his thumb or forefinger. With appropriate logging procedures, all of the users' interaction data can be available for the subsequent statistical analysis, and particularly task completion time and user targeting precision.

The second test scenario, denoted *Object Search* (Fig. 2: arrow 2), is very similar to the *Target Size* test, but includes on-display *distractor* objects. Once again, the user is confronted with a task sequence of targeting a given graphical target object, but in the same time additional items are also drawn on the application canvas. Accordingly, the user goal within the given task consists in searching the application visual space for a particular object and in its actual selection using direct touch. This test addresses the search problem found in real mobile applications with touchscreen interaction; e.g. activating the preferred option from a menu toolbar, selecting the particular picture from a thumbnail list, clicking the proper hyperlink in a mobile Web browser, or typing the right letter on a touch keypad. With the test outcomes thus obtained, we expect to get a better insight into the correlation between the type and number of distraction objects and users' performance while working with rich mobile interfaces. Additionally, elements of the *Target Size* test can be included in this scenario, hence both target and distraction objects can be randomly resized throughout the respective task sequences. Furthermore, the number of distractors can be altered during the test, making the final results dataset even more valuable.

Finding out how, and to what extent, the edge-positioning of GUI elements can implicate touchscreen interaction constraints is the main goal of the *Boundary Objects* test (Fig. 2: arrow 3). In this test setting the user is supposed to repetitively hit targets that are randomly positioned near the application canvas border, with the interaction speed and accuracy being constantly measured and logged. Two different test outcome datasets can be obtained in this scenario, since the user can achieve the given task goals using either the thumb (when the hand holding the device is the same one used to target boundary objects), or her/his forefinger (when one hand is holding the device and the other one is performing the interface actions). Boundary objects can additionally be rendered with different sizes and shapes, hence particular interaction tasks could be quite demanding, e.g. hitting relatively small objects in the far corner of the device display. Although interface design procedures should generally avoid the introduction of interactive boundary objects in mobile applications, it would be very useful to find out their optimal size and the best possible distance from the display border.

The next test case, *Drag&Drop* (Fig. 2: arrow 4), covers selecting and moving the target object by dragging it to a different canvas location. The objective of this test is to get a better insight into the usability of the touchscreen based drag-and-drop interaction, by calculating both error ratio and average time for a typical task completion. Such user task consists of (i) selecting a moveable object (the token) by direct touch, (ii) dragging it to a new given location (target area) following the given route, and (iii) eventually releasing the token by lifting the finger from the device display. By performing these steps, various dragging gestures can be tested and analyzed. Throughout the user task sequence, the size of both token and target area could be (randomly) changed, while the dragging task will be much more challenging with these sizes coming to a similar value. Since the exact positions of token and target areas are also randomly generated, thus creating the possibility for their placing near the application border, we can assert that the *Drag&Drop* test has certain properties inherited from both *Target Size* and *Boundary Objects* test scenarios. The results obtained in this part of the meta-test should provide information on the cost-benefit ratio and on the feasibility of introducing dragging gestures into a mobile application interaction design.

Finally, the last test scenario within the meta-test model, *Soft Keystroking* (Fig. 2: arrow 5), studies the specific touchscreen problem of activating a sequence of closely placed UI control commands. Two most common instances of this problem are: (i) using a soft (on-screen emulated) keypad for text input (e.g. composing an e-mail, or SMS text inputting), and (ii) using a soft numeric keypad for entering a particular series of numbers (e.g. dialing a phone number). Herein, the core of the usability issue lies in the interactive controls' size and their mutual distance. Therefore, the related test case is based on the emulation of the numeric keypad and consists of tasks requiring the input of a given phone number. When performing this test, the user's objective is to try to be as much as possible quick and precise while interacting with the soft keypad. Interaction speed can be measured through task duration; on the other hand the precision attribute encompasses several values stored in the interaction log: the number of incorrect digits in the entered sequence, the number of "backspace" keystrokes, and the number of void touchscreen actions. The purpose of the test scenario is to find out optimal dimension and spacing values for a particular set of interactive controls, which are to be used in a frequent activation mode.

3.2 Implementation

The described model of touchscreen usability meta-test is intended to be run in an environment with real test users on real mobile devices, while each test user participates in every test scenario.

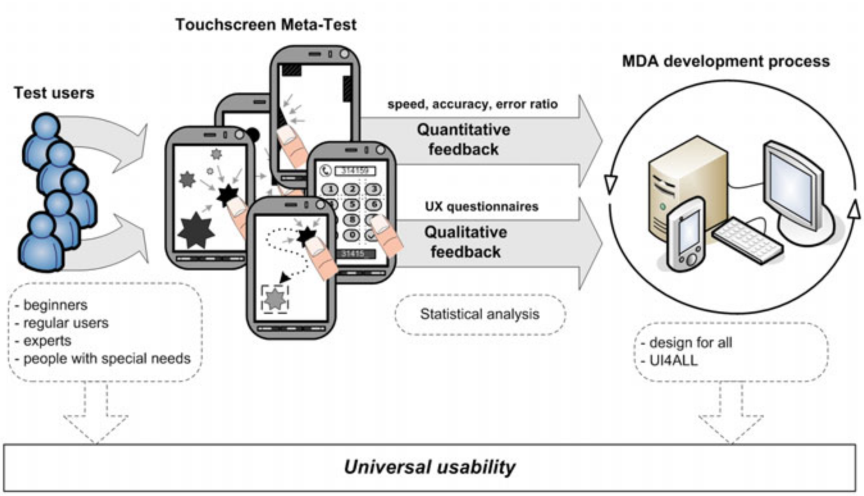

Fig. 3. Applying the proposed meta-test model. Involving different user categories in the testing process promises a possibility for optimal UI design – a step forward in pursuing universal usability.

While performing the corresponding tasks, users' interaction speed and accuracy has to be constantly measured and logged (by the application software itself), thus providing extensive datasets for statistical analysis (calculating performance times, identifying errors, explaining the nature of users' interaction behavior). We believe that the outcomes obtained from this experimental framework can represent a valuable input and a strong starting point for mobile software development, in the same time increasing the level of universal usability (Fig. 3).

In the current stage of development, we are refining our data logging system along with the module for statistical data analysis (ANOVA included). While the first version of proposed meta-test model was implemented using *Java2ME* technology for CLDC/MIDP architectures [20] (so as to be run as *Java MIDlet* on every suitable Java-enabled touchscreen mobile device), a new version is developed using *Android SDK* for increasing group of device models based on this popular mobile operating system [21]. Some screenshots of the current *Android* implementation are shown in Figure 4.

Fig. 4. From left to right: *Object Search*, *Drag&Drop*, and *Soft Keystroking* test instances, running in an *Android SDK* emulator with HTC skin.

4 Conclusion and Future Work

Through the five test scenarios pertaining to the presented meta-test model, fundamental issues of touchscreen interaction can be tested and subsequently analyzed. These typical challenges in mobile HCI can be found in almost every contemporary mobile application, hence benefits in applying the meta-test are expected regardless of the domain of the software being developed. The meta-test final outcomes could provide a synergetic effect as: (i) developers should early enough gain valuable knowledge about devices, users, and touchscreen usability, (ii) mobile software development enriched with support for universal usability should result in better applications with a "highly practical" interaction and (iii) target users should be more efficient and more satisfied when interacting with a particular application, while the overall user experience would be increased to a higher level.

Our future research directions follow from the expected additional contributions of the meta-test model, and will specifically include: (i) better insight into the correlation between real devices and emulator-based interaction effects, (ii) analysis of usability discrepancy between different display technologies, (iii) support for mobile software UI rapid prototyping, (iv) utilization of game-based usability testing concept, and (v) involvement of a wide population base in the testing process. These points of interest can be studied according to different ways of both applying the meta-test model and using its final outcomes (see Table 2).

Table 2. Additional expected benefits of the proposed touchscreen usability meta-test.

Benefit	Approach to applying the meta-test / Using test outcomes
Better insight into the correlation between real devices and emulator-based interaction effects and usability issues	Performing the usability meta-test experiment in controlled environment with two setups: (i) using real touchscreen mobile devices, and (ii) interacting with device emulators on a touch sensitive monitor.
Detailed overview of discrepancy in usability aspects arising from different display technologies	Involving a broad spectrum of different touchscreen mobile device models within meta-test, with capacitive and resistive displays equally numbered.
Support for rapid prototyping and predictive evaluation of mobile software UI	Using meta-test outcomes as formal parameters for predictive evaluation of UI prototypes (implemented with mobile software for on-device UI layout design).
Proof of concept for game-based usability testing	Adopting and presenting usability meta-test cases in the form of mobile game with scoring system. In such an experiment, we can presume better users' involvement in the testing process, as well as more trustworthy results.
Widest possible test-users base	Involving a wide population base in the testing process by making use of popular web services. This includes (i) publishing the meta-test model online as a free mobile game application, and (ii) using social networks for "game" promotion.

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Mobile Technologies for Promoting Health and Wellness among African American Youth

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Abstract. This paper describes an effort to address life-threatening diseases and health conditions through engaging use of mobile devices. The design targeted children ages 7-11, with a goal of becoming aware of the nutritional value of foods that they eat on a regular basis. The implementation efforts resulted in Health Attack, a matching and memory game that seeks to raise the knowledge-level of participants about the foods that they eat. The evaluation of Health Attack, conducted through a demo and questionnaire administered to K-12 teachers, suggests that this type of game would be engaging for younger audiences as a first step in raising health awareness.

Keywords: mobile computing, games, games, evaluation.

1 Introduction

In the African-American community, there are a growing number of life-threatening diseases that can be prevented or lessened with a healthy diet and exercise, including heart disease, cancer, and diabetes (e.g., [1,2]). We assembled a team of designers to create an engaging interface to address health and wellness concerns among African Americans. The design and implementation was led by four developers, under the guidance of two program supervisors, an academic advisor, one technical supervisor, and one health and wellness domain expert. The demographic constitution of the design team sought to ensure that people aware of issues first-hand would have a prominent role in the creation of the interfaces. It was also expected that the team

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would have appropriate access to ensure active end-user involvement by the target populations. To ensure appropriate leveraging of readily available technologies, the team selected the iPhone mobile phone as the development platform within the first week, since ownership of mobile devices is higher among African Americans and Latinos, and those groups are more likely to use their mobile device as their primary internet access device [3].

The design team sought to target a younger family demographic with their application, expecting that behavior would be easier to influence and that the lessons would be reinforced in schools and other community groups. Specifically, there was a focus on children, ages 7-11 to become nutritionally aware of the foods that they consume on a daily basis—particularly important given recent increases in childhood obesity. The paper introduces *Health Attack*, a matching and memory game which takes common foods found in the African American community and puts them in their respective places on the USDA food pyramid. The expectation for this application is that it will help increase the nutritional awareness of African-American children and give the children information on the food that they eat on a daily basis. The game reinforces what is learned in school about the USDA food pyramid. As it is our belief that responsiveness to cultural norms is of import in the usefulness of a health and wellness application, Health Attack leverages cultural norms and values central to the African-American community such as "role-modeling of behaviors" in convening and reinforcing nutritional messages. The Health Attack interface is described in Section 3.

Evaluation of Health Attack took place through a demo and questionnaire. The feedback questionnaire was given out to different participants, of different ethnic backgrounds, who viewed information and used this application at a highly interactive poster session. Each user was allowed to test the application; in total, sixteen users filled out the questionnaire. The evaluation is described in Section 4.

2 Related Work

There are a great many life-threatening diseases—many of which disproportionally affect African Americans—that can be prevented or lessened with a healthy diet and exercise, including heart disease, cancer, and diabetes (e.g., [1,2]). In particular, there have been recent increases in childhood obesity in recent years, (e.g, [4,5,6]) leading to a focus in the childhood obesity area by First Lady Michelle Obama.

Prior work suggests that mobile devices are a good match for our work. Ownership of mobile devices is higher among African Americans, and that group is more likely to use their mobile device as their primary internet access device [3]. Mobile device interfaces are showing strong potential as enablers of behavioral change, particularly in the health and wellness areas (e.g., UbiFit Garden fosters physical activity through the use of mobile displays [7], and mobile games can help African Americans make better eating and exercise decisions [8,9]).

In particular, games provide an experience for users that is both engaging and informative. Games have been leveraged previously to reach out to both adults and children, e.g., [10]. Moreover, findings suggest that computer games could be effective in promting healthier food and beverage consumption [11]; hence our research focus on developing and evaluating a mobile game for young people.

3 Health Attack

A team of designers was assembled and charged with creating an engaging interface to address health and wellness concerns among African Americans. The design and implementation was led by four developers, under the guidance of two program supervisors and one technical supervisor. Five of the seven people on this team were African American, providing connections and empathy with the target population with potential for improved interfaces [12]. The team was given eight weeks to create and test their interface.

The demographic constitution of the design team sought to ensure that people aware of issues first-hand would have a prominent role in the creation of the interfaces. It was also expected that the team would have appropriate experiences and access to ensure active end-user representation by the target populations. To ensure appropriate leveraging of readily available technologies, the team selected the iPhone mobile phone as the development platform, since ownership of mobile devices is higher among African Americans and Latinos, and those groups are more likely to use their mobile device as their primary internet access device [3]. The iPhone also was the fastest growing smartphone of 2008 [13], with the largest market share of any single phone, ensuring a presence in many homes.

Many of the early group meetings focused on brainstorming ideas to meet the needs of the target population, but within two weeks the focus turned to rapid prototype development. After an initial prototype was created (by week four), the remaining time was dedicated to iteration and testing. Prototypes were presented both formally and informally to domain experts and user interface development experts to influence positively future iterations. This paper describes a summative evaluation with a group of K-12 educators (see Section 4).

The first important design decision was the application target domain. Based on the team's knowledge of the African-American community, there are a growing number of life-threatening diseases that can easily be prevented with a healthy diet and exercise—diseases such as heart disease, cancer, and diabetes that three of the main causes of deaths to African-Americans in the United States (see www.cdc.gov/omhd). These diseases have been linked to the preparation of certain foods in the African-American community known as “Soul Food”—typically, food that is prepared with heavy amounts of sodium, sugar, and fat to bring more flavoring to the food that leads to an increased risk for heart disease, high blood pressure, and high cholesterol.

The design team sought to target a younger family demographic with their application, expecting that behavior would be easier to influence and that the lessons would be reinforced in schools and other community groups. Specifically, there was a focus on children ages 7-11 to become nutritionally aware of the foods that they consume on a daily basis—particularly important given recent increases in childhood obesity. The resulting application, called “Health Attack”, is a matching and memory game which takes common foods found in the African American community and puts them in their respective places on the USDA food pyramid. The expectation is to help increase the nutritional awareness of African-American children and give the children information on the food that they eat on a daily basis. Employing these lessons in a game created an environment targeted for children, but highly accessible by older youth and adults of all ages.

Games provide an experience for users that is both engaging and informative. Games have been leveraged previously to reach out to both adults and children, e.g., [10]. This game reinforces what is learned in school about the USDA food pyramid. As it was the developers’ collective belief that responsiveness to cultural norms is of importance in the usefulness of a health and wellness application, the game leverages cultural norms and values central to the African-American community such as “role-modeling of behaviors” in convening and reinforcing nutritional messages.

With the African American culture in mind, the developers designed the interactive game for African-American children to provide awareness of nutritional information of commonly-eaten food. Important to culturally situated design, the design team conducted a review of the literature and supported field studies while using relevant cultural elements central to the African-American community—drawing heavily from their own experiences as youth and as older siblings. An important step was to find symbols of black culture in our surrounding communities by going around the local community and to take pictures and notes about African American culture—quickly centering on issues of food selection and preparation. After finding important symbols in the community, the design team discussed how to convert that same tradition and important characteristics into the application targeted for African-American children (though accessible to children and adults of all ages and demographics).

While preparing and reviewing candidate interface development specifications, the development team wanted to develop and choose a detailed description that could correlate well with the ideas of our findings within the African American community, listing realistic scenarios and factors that should be considered while developing the Health Attack application. The team decided to create a matching card game where players collect different food items and have them placed in their respective places on the USDA food pyramid.

While users are playing the matching game, they are also being given health facts about the food they are matching. This back and forth feedback is used to balance fun and learning, to attract users and to give them a reason to continue learning more about health and nutrition. The selection of foods that are popular in the African American community provides a sense of ownership for the target users. Also included were quotes from African Americans to serve as role models to help make the game feel more authentic and accessible to the African American community.

Health Attack was implemented using Xcode, an objective-C language intended to provide a smooth and easy workflow, with the Interface Builder toolkit to support smooth aligned images. This made development for the iPhone easy to implement in a short time frame—supporting the goals of rapid prototyping and constant user feedback.

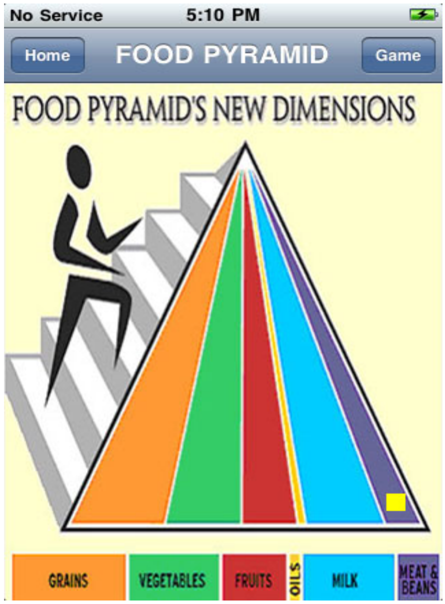

Fig. 1. Pyramid view of Health Attack, adapted from the USDA food pyramid. Each color on the pyramid corresponds to a class of foods, labeled at the bottom. Users can select any of the food types to play Health Attack with that type of food (see figure 2).

There are three major components that we implemented into this application: the USDA pyramid (figure 1), the matching game (figure 2), and the information cards (figure 3). The game alternates between these views, as described in the figures, with primary game play taking place in the matching game view. A user selects a food category in the pyramid view, taking them to the matching game (with hidden pairs of foods from the selected category).

When the user finds two matching cards, the information card view appears, with nutritional information about the food shown on the cards. The user repeats the process until all matches in the section are found, at which time the user is returned to the pyramid view. At any time during the game the user can go to the food pyramid. The user can also interact with the pyramid by clicking on the box below the sections and see the food icons of the food they have matched.

Students initial component is the USDA pyramid (figure 1). The USDA pyramid features six sections representing the different food groups: Grains, Vegetables, Fruits, Oils, Milk, and Meat & Beans. Although there are six sections on the USDA pyramid, this application only interacts with five of them—excluding the oils section because there is little positive nutritional value about this section. Each time the user starts a new game, the USDA pyramid is empty. However when a match is made in the matching game component the USDA pyramid is updated with that matched food in its proper section; for example, the user touching or tapping a card with green beans then finding a match results in the Vegetables section in the pyramid component being automatically with green beans. The user can then click a section on the pyramid to see food icons that they previously matched.

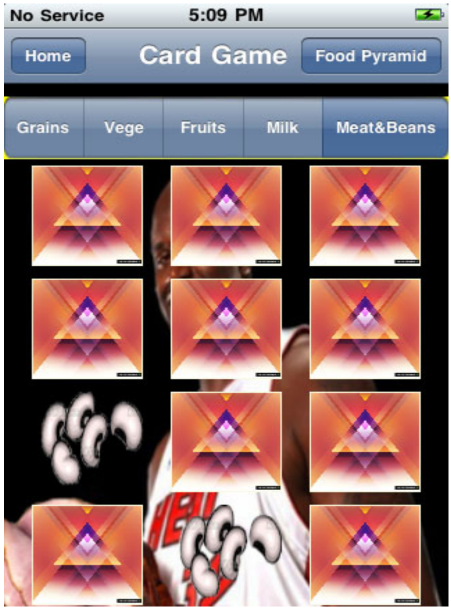

Fig. 2. Game view of Health Attack, showing a “match” of black-eyed peas selected by a user. All cards are initially face down, with a food represented on the reverse side. A user can select any two cards, and if the images match then information about the food is displayed (see figure 3).

The matching game is the main component of the application, where users spend most of their time. It consists of a 3x4 grid of cards that, when tapped, reveal cartoon images of food. It is a standard card-based matching game: the user taps or touches a card to select it, the image is revealed, then the user must select another card. If a match is made, a pop-up card with nutritional information (the information card, see figure 3) about the particular food that the user has matched comes to the front of the screen. If there is no match, both cards are hidden and the user must try again to find a match.

There are two types of information cards in this application. The first type of information cards are revealed when a match is made. These cards contain brief nutritional facts about the matched food. They also contain a picture of the food with the background color of its section in the USDA pyramid.

The second type of information cards are seen when the user enters the pyramid section and clicks on a type of food. This type of card contains two pictures of the food, as well as the background color from food’s category in the USDA pyramid. This type of card also has three sections: the first is a fact section which is just a short informative fact about the food; the second section is a nutritional fact; and the third section tells the user how this type of food can be prepared (e.g., boiled, steamed, or fried). The first section gives the user something fun and informative to read. The second section gives additional detail. The final section gives the user different ways that the food can be prepared, so they can understand familiar (and healthy) options.

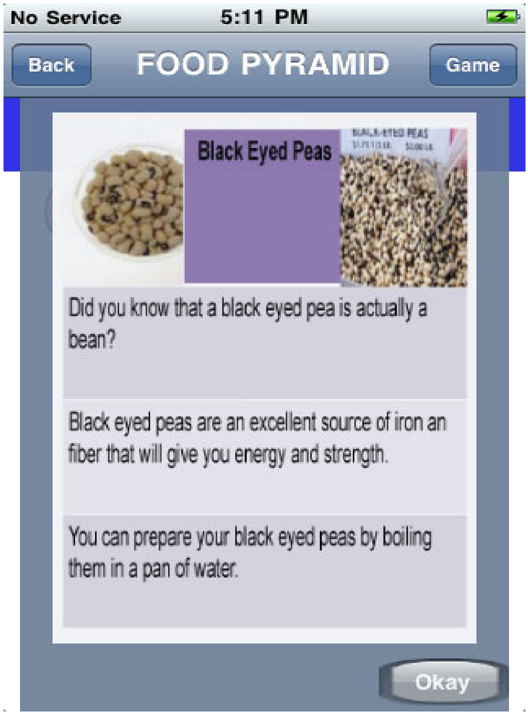

Fig. 3. Information view of Health Attack, showing data about black-eyed peas. Each card includes pictures of a food and information about it—including interesting facts, nutrition information, healthy preparation suggestions, and/or testimonials from African American role models.

Another of the cultural aspects implemented in the application are role models and foods that are authentic to the culture. The role models in the application are in the background of each of the five 3x4 grids. The role models in the backgrounds are: Barack Obama, Shaquille O'Neal, Michelle Obama, Jennifer Hudson, and an African American model. When the user has matched all of the cards in a section the background becomes visible. All of the role models have food in the picture that is related to the section they are in. Role models are a big part of any culture especially in the African American community because kids are often influenced by people they look up to and children are more likely to relate to media heroes that are of the same ethnicity [14]. The types of foods that are incorporated in "Health Attack" are foods that African Americans generally eat. Remaining authentic while not being stereotypical the application gives nutritional information about certain foods that have been considered part of the culture.

4 Evaluation

Evaluation of Health Attack was conducted through a demo and questionnaire. The feedback questionnaire was given out to sixteen participants—primarily K-12 teachers, but also some college teachers and senior students. The participants viewed information on a poster, talked with developers and project leads, and experienced hands-on use of the application at a highly interactive poster session.

First, the developers discussed the background of the application. Then each participant was allowed to test the application. On the questionnaire, each participant was asked six questions. Three questions allowed the participant to rank the performance of the application on a one (worst) to ten (best) scale. The other three questions asked for each participant's free-form opinions about the application.

For the first ranking question—the overall enjoyment of the application for the participant—the average ranking for this question was 8.6, with a high of 10 and a low of 7. Based on this average and range, the participants seemed to feel as though the application provided a positive experience. The second question asked if the participant felt as though the application would be helpful to raise nutritional awareness for children, specifically African-American children; the average ranking for this question was 8.4, with a high of 10 and a low of 5. From this average, a majority of the participants felt as though this application will have a positive effect on children, specifically African American children. For the third ranking question, the participant was asked how they felt about the different role models used in the backgrounds throughout the game; the average ranking for this question was 8.5, with a high of 10 and a low of 5. Two of the participants did not answer this question, perhaps because they did not notice the role models in the background.

On the questionnaire, the participants were also asked for their personal opinions for improvements for the game, the effectiveness of the role models used in the backgrounds throughout the game, and the relatedness of the foods to the African American culture. Many of the comments were suggestions for key components to improve the application. A couple of the participants suggested coordination with other applications—such as a food diary or log to enter in the foods they eat and get points for the foods that they eat. Other comments asked for a "search" feature for different foods. Other participants recommended that the application include more animation, sounds, and music to enhance the user experience with the application. Another recommendation from one of the participants was to add multiplayer interaction—even something as simple as a high-score log and a comments area may excite users—so that the user could be able to play and interact with other people.

When asked about the effectiveness of the role models, many of the participants responded positively to the question. One participant said that "positive association is always valuable"; another participant said "yes it raises awareness but that's the first step". However, it seems that some participants did not even notice the presence of the role models. From these positive responses, a much stronger emphasis should be placed on the role models in the backgrounds of the game.

Since many of the participants were not African American or did not understand the African American culture, they may not have felt comfortable answering the last question on the questionnaire. However, most of the participants who did respond provided positive feedback about how the food was related to African American culture. For the future, we wish to target audiences that are familiar with the African American culture in order to get accurate results.

5 Conclusions and Future Work

This paper introduced an application, Health Attack, that targets 7-11 year olds with a game-like environment for learning about healthy foods and the USDA food pyramid. We described the creation of Health Attack, including the roles of developers, interface experts, and a domain expert. An experiment with 16 participants revealed promising directions for Health Attack and similar applications.

Based on the data taken from the feedback and from the expert review of project supervisors and a domain expert, the overall perspective and effectiveness of this application is very positive. A key strength of this application is the incorporation of role models in the backgrounds throughout the game. Another strength of the game is the presence of the food pyramid in the game; many of the participants felt as though this helped with having the children learn where each food is placed.

There are several possible future directions for the game (and similar games). One is the use of sound effects and animations—an engaging way to draw users to the game. There was also concern that the language used on the pop-up messages and food pyramid information cards was too high of a level for the children to understand, requiring a match between target population and language level. Furthermore, many of the participants felt as though the information on the pyramid cards needed to be more relative to the children and also less wordy; it seems better to convey a small amount of information to all users rather than have most users ignore the information. Finally, we feel that the card game approach to conveying information is worthy of further exploration—the concise, clearly-delineated information that fits on a card provides user-digestible quantities of information that can be matched, sequenced, or otherwise associated toward furthering learning and exploration.

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Privacy, Security and Interoperability of Mobile Health Applications

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Abstract. This paper will discuss the security, privacy and interoperability of mobile health applications (MHAs) and how these issues must be reconciled in order for MHA devices to be implemented in the most robust fashion. Balance is needed between privacy and accessibility, between security and interoperability and between flexibility and standardization. The interoperability of diverse MHA devices must be a goal for the future in order to realize portability, true continuity and quality of care across a wide spectrum of health services. A pilot project to determine potential threats to the privacy of personal health information on an iPad will be described

Keywords: Security, interoperability, privacy, mobile health devices, usability.

1 Introduction

This paper will discuss the security, privacy and interoperability of mobile health applications (MHAs) and how these issues must be reconciled in order for MHA devices to be implemented in the most robust fashion. Balance is needed between privacy and accessibility, between security and interoperability and between flexibility and standardization. The interoperability of diverse MHA devices must be a goal for the future in order to realize portability, true continuity and quality of care across a wide spectrum of health services. Without some assurance that there will be interoperability, consumers, particularly parents with children or people in other vulnerable populations, will be reticent to invest the time necessary to obtain and fully utilize MHA devices and there will be wide variation in the quality and granularity of information that is collected, displayed and transmitted from these devices. Without privacy and security across state lines and international borders, it is doubtful that children, their parents or their health care providers will trust MHA devices. To better frame the issues, the paper will focus on opportunities and challenges for using MHA devices to address childhood obesity from a legal and health care perspective.

Health care providers and industry experts believe that empowering patients by providing access to their medical information and appropriate resources and tools to manage their health can significantly improve outcomes and reduce costs. The

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combination of standard health record-keeping function of traditional EHRs and PHRs and action-oriented feedback through MHA devices can enable users to maintain their health and prevent diseases such as childhood obesity. Programs directed towards overweight children and teenagers may contain a number of elements, including a complete medical evaluation, nutritional counseling, home visits, behavioral therapy and fitness skills. In order to be most effective, a social component or "buddy" may also be helpful for providing peer encouragement and peer pressure. Issues remain with respect to the interoperability of MHA devices and the privacy and security of these devices.

2 Literature Review

Recent literature reveals proposed or current uses of mobile and handheld devices for a number of different health care applications, particularly for the physician and other health care professionals. For example, Bellamy et al. report that the Osteoarthritis Index can be delivered by mobile phone in a way that is valid, reliable and responsive[1]. Other authors propose changing the paradigm of mobile phones to something they refer to as a personal wellness dashboard [2, 3]. However, the need for regulations, standards, industry alliances, security, reliability and minimal discomfort in data collection is needed. Among the user centric applications proposed for Smartphones are personal health records (PHRs), medication adherence and selection programs, physician selection and second opinions, monitoring physical well-being, including fitness and diet, health and disease monitoring and management, including home monitoring, and healthy lifestyle suggestions. Patrick et al. discuss some policy issues for mobile phones, including usability and access, data security and interface with personal and medical health records [4].

Health and Hospital Networks (H&HN) (September 2010) reported that at Vanderbilt University Medical Center anesthesiologists are allowed to check vital signs, communicate with colleagues and observe operating rooms from their cell phones. Remote health monitoring using mobile phones [5] and the next generation of telehealth tools for patients [6] also present some potentially powerful opportunities for mobile health applications devices. Likewise, Blake reports on the use of mobile phone technology in chronic disease management, including monitoring health status, electronic tracking, patient self-management and improving health communication [7].

What is perhaps the more interesting aspect of mobile health devices is when they are operated and controlled by patients. Krishna and Boren provided a systematic review of self-management care via cell phone for diabetes patients [8]. Bernabe-Ortiz et al. reported on a comparative study in Peru involving the use of handheld computers for collecting sensitive data from citizens in surveys as compared with paper-based surveys [9]. The study indicated that it was feasible to develop a low-cost application for handheld computers that could collect data on sexual behavior and that this was a viable alternative to paper forms. However, the concerns with the privacy and security of personal health information, especially when collected, stored and transmitted using a mobile device has not been fully explored. Moreover, there may be additional concerns when the patients who are using these devices are children, most of whom do not have the authority to provide consent for or make decisions about their own medical care.

Shieh et al. note a number of challenges with mobile healthcare, including the need for interoperability among electronic health records, developing better display technologies and security controls and developing smart algorithms to detect clinically significant events before notifying caregivers [10]. Likewise, Pharow and Blobel asserted that aspects of security, safety, privacy, ethics and quality reach importance when discussion health information and health systems, including mobile solutions and that there are both legal and technological challenges [11].

3 Challenges of the Use of MHA

3.1 Interoperability

Interoperability in the context of health information technology is traditionally viewed in terms of connectivity: Information can be exchanged over a common medium in a secure, accurate and efficient way without special effort on the part of the user. To address the epidemic of childhood obesity and related issues, interoperability has to surmount not only the connectivity for health information exchange- local to global- the medical efforts must be coupled with observational data from the daily environment outside the clinic walls. Interventions to address childhood obesity combine data from disparate sources (i.e., combining provider data from multiple EMRs, payers, labs, dental services, nutritional services, school nurses, childhood obesity registries, parents or guardians), record matching services are needed [12]. Any MHA therefore will need interfaces to external applications to retrieve child data located across disparate ancillary systems; requesting attention to syntactic interoperability – structure to the information – and semantic interoperability – Information is understood by everyone involved in the care of the individual [13]. The National Broadband Plan (2010) and the push to adopt health IT support these priorities by dramatically improving the collection, presentation and exchange of health care information, and by providing clinicians and consumers the tools such as MHA to transform care. Technology alone cannot heal, but when appropriately incorporated into care, technology can help health care professionals and consumers make better decisions, become more efficient, engage in innovation, and understand both individual and public health more effectively.

3.2 Privacy

Most U.S. citizens may be under the impression that privacy is a right accorded them through the U.S. Constitution. In one sense, this is true, in that a number of the Amendments do have an underlying theme of privacy, including the right to free speech and association, freedom of religion and freedom from unreasonable search and seizure. On the other hand, privacy has also evolved through a number of famous cases, including *Roe v. Wade*, *Griswold v. Connecticut* and *Loving v. Virginia*.

A patchwork quilt of statutes at the federal level have attempted to address privacy issues related to various specific facets of modern life, including the Gramm-Leach-Bliley Act for financial information and the Health Insurance Portability and Accountability Act (HIPAA) for personal health information. The tension between national security and privacy is a more recent concern, given the enactment of the U.S.A Patriot Act and the seemingly more generous allowance for law enforcement to use technology for surveillance without a warrant. Indeed, privacy may be the "civil rights" issue of the next decade. Likewise, states also grapple with privacy from a number of vantage points, including statutes for health records, for public records and for information related to children.

At the same time, there seems to be a lack of concern for privacy on the part of some people, particularly children and adolescents. The desire to participate in social networking sites such as Facebook, YouTube and MySpace may mean that young people are revealing personal information that not only puts them at risk from child predators, but may also cause harm later. It is now not uncommon for information posted on these social networking sites to be used by schools for disciplinary purposes, by future employers, by law enforcement and by attorneys. It is also unclear how companies who are providing "hosting" services might use the information now or later. Abril and Cava note that "[m]any privacy breaches on social media occur at the mouse-clicks of fellow cyber-patients or are facilitated by the patients themselves…As evidenced by numerous surveys, the majority of website users do not understand, access or know the significance of privacy policies and terms of use" [14].

In articulating a research agenda for PHRs, Kaelber et. al note that "[p]atient's greatest concern about nearly every type of electronic healthcare applications, including PHRs, is security and privacy. Ninety-one percent of people report they are 'very concerned' about the privacy and security of their personal health information" [15]. This article also notes several important issues regarding PHR privacy – who controls sharing and acing of the information in the PHR, how to optimally design PHR systems in order to allow patients to maximize the security of their PHRs and who to develop authentication methods that ensure both privacy and security yet do not present a major barrier to access [15]. As the article states, "[c]lear tradeoffs exist between privacy, security and access, even for patients [15]. Clearly, the issues are even more complex with any device or system that gathers personal health information from children, especially when trying to design a MHA device tailored for children with obesity.

In terms of protecting patient privacy in the information age, Kendall notes that "[t]he loss of privacy seems to be a foregone conclusion in the information age. Polls show that most Americans believe they have lost all control over the use of personal information by companies. Americans are also concerned about the threats posed by identity theft and fraudulent internet deceptions like phishing. People are learning the hard way to withhold information unless it is absolutely necessary to disclose it" [16]. A reluctance to provide personal health and financial information is not difficult to understand, given the many high-profile reports of data security breaches from some top companies and organizations. These breaches are not just caused by a lapse in computer security practices, but have often occurred because of stolen laptops and misplaced back-up tapes. With identity theft that fastest growing crime in American, followed closely by Medicare fraud, the heightened awareness about data security on the part of the public is not surprising. For example, many people are now taking advantage of laws in various states that allow them to "freeze' access to their credit reports. Therefore, any MHA device must be able to ensure the privacy of its information, especially the personal health information of children, while still being appealing, accessible and easy to use.

3.3 Security

It is fair to say that the public is keenly aware of the security risks to computer systems and networks, particularly when breaches in security may mean that their personal health and financial information is vulnerable. Indeed, identity theft is the fastest growing crime in the U.S., followed closely by Medicare fraud; both of these crimes are greatly facilitated by technology, particularly where the individual consumer or patient has little control and can only take remedial action once a breach has occurred. For example, in a report dated February 10, 2010, more than 500,000 current and former members of BlueCross BlueShield of Tennessee will be receiving letters altering them that their personal information was included on computer hard drives stolen from the insurance company last year [17]. Another aspect of security that many people fail to consider is disaster planning. Natural disasters, such as earthquakes and floods, as well as manmade disasters like broad attacks on an individual company or network or on the nation's Internet infrastructure, may also impact the security of mobile health devices and the systems that run them. Individual MHA devices may be particularly at risk, being small and easy to steal or lose. Also, since these are wireless devices, there is increased risk that personal health information could be compromised. On the other hand, the trend is for increased virtualization of computer systems to third-party vendors, known as cloud computing. Not only does this pose additional security risks, but this adds another layer of questions on the extent to which personal health information is protected.

Mobile health application devices, which have the advantages of portability and accessibility, can also present security threats, as reported by Wright and Sittig [18]. Fortunately, these devices also can also be equipped with encryption and security features, such as passwords, and are designed to be attached to a keychain or lanyard and carried with the patient [19]. At the time of their study, many manufacturers of USB-based personal health records were still in the development phase for their products. Of course, in terms of pediatric mobile health devices, a significant issue will be keeping track of the device itself rather than just protecting the information on the device, given the propensity of young people losing things. On the other hand, the transition from desktop and laptop computers to smaller mobile devices means that both physical and information security for these devices must be considered if they are to be useful on a regular basis for children with obesity. For example, a mobile health device for children with obesity might be designed to allow for regular input of food consumption, either via text, pre-programmed pull-down menus or camera phones and the logging of physical activity, such as participation in fitness programs, 5K runs/walks and weight lifting.

Another issue with an MHA device for children with obesity is the extent to which the information can be altered. In the context of health information provided in through a PHR, Simborg argues that while there is no question that patients own their PHRs, at least those that are "untethered" from a provider, employer or payor, "advocating the right of a consumer to alter professionally sourced information may put the entire future of PHRs at risk" [20]. This issue is even more complex with a mobile health device for children with obesity, because there would be an additional question of the extent to which a parent or guardian would be allowed to alter information, particularly information that might present the child or the parent in a bad light. On the other hand, health care providers must certainly be concerned with future liability if confronted with health care information contained in a PHR had been altered in a way that suggested unaddressed medical needs.

4 Exploratory Study: Use of the iPad in Health Care

After the iPad was introduced, user comments suggest improved usability and use compared to the previous small screen mobile devices. Increased screen size and better readability of the screens make the iPad more suitable for clinical use. The question though arises if the increased screen size is a threat to privacy and confidentiality of protected health information (PHI).

Upon exploration of the technical specifications, testing some of different types of PDA, and reviewing the literature [21, 22] the following usability, privacy and confidentiality issues have been identified:

- small screen size allows only for display of limited information
- small font size and limited back light
- most WWW sites are poorly formatted for PDA viewing
- patient confidentiality during use of PDA is an area of significant concern and potential problem and is more apparent when larger screen size
- potential for lost or misplacement
- disclosure of PHI
- potential for medical identity theft

Despite these issues, the PDA has been integrated in clinical practice. Usability studies [23] of the recently introduced iPad has proven to be more appealing because of a bigger screen, better visual acuity, easier web browsing, etc. While small screen size and visual acuity may have protected information displayed, the benefits of the iPad may be a drawback regarding privacy and security.

4.1 Methodology

A pilot study was conducted in order to test the privacy of an iPad application. The purpose of this study is to explore (1) the circumstances under which information posted on the iPad can be seen by bystanders and (2) how well the information can be recognized.

Eighteen visitors at the campus student center were randomly asked if they wished to participate in an iPad confidentiality survey and the purpose of the study and expectations were explained. Participants were assured that no personal information would be asked and that the survey would take only about 5 minutes of their time. Three different scenarios were used for the survey. Each scenario was either in landscape or portrait display of the iPad for the entire survey. Each participant participated in only one scenario and only one display type. The survey scenarios included:

- A mock-electronic health record (EHR) of a patient who is HIV-positive (scenario A)
- A picture of a multi-trauma patient (scenario B)
- A combination of a picture and EHR of a patient (scenario C)

One research assistant asked the participants if they could see the iPad screen from different distances and angles. The distances varied from10 feet, 5 feet and 3 feet away from the iPad, the angles ranged from 180 degrees to 45 degrees. The participant will be sitting or standing behind, in front or next to the research assistant holding iPad. If they can, they will be asked to describe what they can see. These distances were chosen because it is a reasonable distance a patient or companion may be from a physician while they are using the IPad. The description of the display by the participant describes is recorded by research assistant 2. Research assistant 1 will record accuracy of the participant's description.

4.2 Study Results

The results of the study are reported in table 1

As can be deduced from the study results and illustrated in Figure 1, the bystander was able to read and describe the content of the display (codes 1 and 2) in 78.5% of the time. In about 59% of the time, the content was reported correctly; in 21.5% of the time the bystander was unable to see the content of the display.

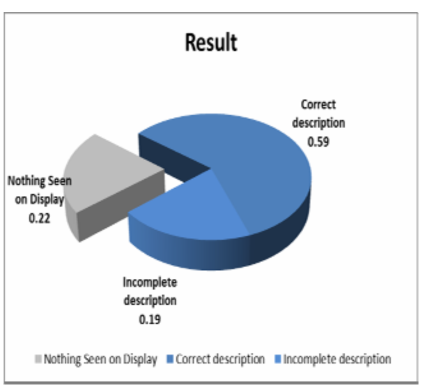
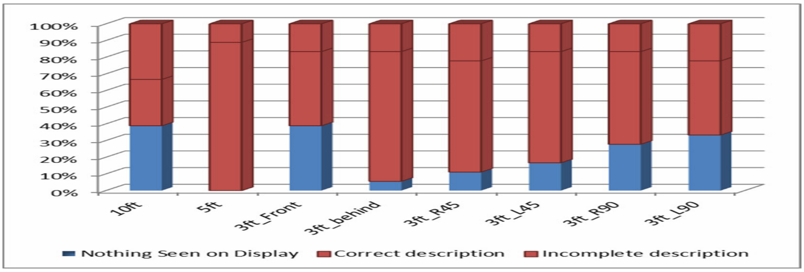


Table 1. Participants report of IPad display

Participant	Scenario	Position 1=standing 2=sitting	Orientation L=Landscape P=Portrait	10 feet	5 feet	3 feet front	3 feet behind	3 feet 45 degrees right	3 feet 45 degrees left	3 feet 90 degrees right	3 feet 90 degrees left
1	B	1	L	0	1	0	1	0	1	0	0
2	B	1	L	0	1	0	1	1	1	1	0
3	C	1	L	0	1	1	1	2	1	0	2
4	C	1	L	2	1	1	1	2	1	1	1
5	A	1	P	0	1	0	1	1	0	0	0
6	A	1	P	1	1	1	1	1	1	0	0
7	B	1	P	0	1	1	1	1	1	1	0
8	B	1	P	1	1	1	1	1	1	1	1
9	C	1	P	2	2	0	1	1	0	2	2
10	C	1	P	2	1	0	1	1	2	0	0
11	B	2	L	0	1	1	1	1	1	1	1
12	C	2	L	1	1	2	2	2	2	2	2
13	A	2	P	0	1	1	0	1	1	1	1
14	A	2	P	2	1	0	1	1	1	1	1
15	B	2	P	1	1	0	1	1	1	1	1
16	B	2	P	1	1	1	1	0	0	1	1
17	C	2	P	2	2	2	2	2	2	2	2
18	C	2	P	2	1	2	2	1	1	1	1

Results coding: 0 = nothing seen on display; 1=correct description of content on display; 2= incomplete description of content on display.

Noteworthy is that from a distance of 5 feet independent of the position, all bystanders were able to describe the content, all or some, of the display. Content on the display is also easily viewed from a distance of 3 feet, the bystander behind the user (see Figure 2).



Health care providers and consumers are likely to use the iPad in the future for medically related tasks, including receiving and reviewing information updates, as a tool during their standard practice and to complete paperwork. Yet the results of this limited study recommend some caution to secure the privacy and confidentiality of PHI.

5 Conclusions

Interoperability, security and safety are on top of the priority list and supersede usability when it comes to protecting PHI. The paper addresses the identification of some specific aspects like mobile technology and safety when moving both IT and people towards mobile health aiming at increasing providers and patients' awareness, confidence, and acceptance in MHA to manage their health.

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GeoDrinking: How to Extract Value from an Extended Social Wine Drinking Experience

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Abstract. Within the Telecom Italia Research Projects a service prototype has been developed in order to satisfy both the needs arising from the consumption and wine production. Thanks to the new technological opportunities opened by the Internet of Things and Distributed Intelligence, the GeoDrinking service is designed to allow worldwide users to publish on the main social networks their wine consumption behaviour patterns. At the same time GeoDrinking allows the wine producers to watch on a dedicated platform those spatial and time consumption patterns, exploiting those data for marketing purposes.

Keywords: Location Services, LBS, HCI, Service Design, Crowdsourcing, Food & Wine.

1 Introduction

For many years, wine drinking custom was characteristic of few countries, whose meaning was mainly related with a feeding dimension. For French and Italians wine used to come with every meal, but in the rest of the world was not a normal eating habit: beer and spirits were preferred.

After the Second World War, United States soldiers returned from the war experience in France and Italy bringing with them the pleasure and the memory of different wines. However, the product was almost impossible to find outside of Europe, given its limited production to only few countries in the world. During the early fifties some tenants in the United States were the first to think to overcome this weakness by pushing forward the idea that the consumption of wine could become a habit at first among the American mass, and then in the rest of the world. Today, more than 50 years after, the United States are amongst the biggest consumers of wine in the world, and Europe, while maintaining the primacy of exports, has lost its exclusivity.

However, the wine has never been solely a drink. Aggregation factor in taverns, pubs, bars, restaurants, parties and private houses, wine has always brought with itself a strong social component, related to communication and identity expression. And, if in the past, the wine as a socially distinctive and differentiating symbol, was a privilege reserved only to the wealthy classes, now this aspect of wine has become available

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to everyone: as for food, cars, fashion, and all those luxury goods present in our social world, the wine is now one of the elements through which ordinary people can express their personality, their taste and, ultimately, their lives. To share what we "are" through what we consume, both in terms of material goods and cultural, seems to have become a crucial need in recent years. The huge success of social networks like *Facebook*® and *Twitter*® is largely due to the satisfaction of this need, which allow individuals to express their identity along a continuous "time" dimension: the public identities construction over the internet proceed progressively through the stratification over time of single user post *("I'm doing that", "I'm watching this", "I'm buying this", etc.).*

On the opposite side, the producers of goods and services are becoming increasingly aware of these mechanisms. Corporate communication is not anymore solely focused on increasing loyalty of consumers to the brand through customer services, but really struggle to create a unique product and company image that can be internalized by people to express themselves, so working on the components that differentiate and distinguish the lifestyles and personalities of individuals *(for instance Apple® consumers are often see as cult followers).*

In this context, Telecom Italia amongst the Research & Trends Projects has developed a solution aimed to extract value from wine consumption matching the changing needs of both consumers and producers, taking full advantage of recent technological opportunities opened by the Internet of Things and Distributed Intelligence. The GeoDrinking service, using the latest technology components, on the field of image recognition, context awareness and personalization, aims to give visibility to the consumption of wine brands on a worldwide scale, enabling direct and indirect communication between different users and between consumers and producers trough their products.

2 Related Works

Nowadays, research works that aim to bring together the food area with the technology area seem to have concentrated on two different sides [4]: on one hand we have those studies aimed at solving problems that people think they have with food, trying to improve and correct behaviours and habits such as cooking, shopping and eating. On the other hand there are other technologies that are designed to encourage current practices, trying to open up new ways of expression and increase the satisfaction performing behaviours and habits already settled in individual lifestyles.

On the first side we find applications aiming to reduce user indecision like *Kalas* [9, 10] that tries to reduce the user uncertainties seeking out and finding recipes through a social navigation database, which allows them to access choices, feedback and ratings of other people. Or those who seek to promote sustainable consumption patterns [2]: *SourceMap* (www.sourcemap.org) [1], for example, promotes geospatial context awareness in the world of food in a sustainable direction, through a platform for research and optimization of supply chains, with the aim of making visible the origin of products and their components. *Zeer* (www.zeer.com) proposition allows meeting the lack of nutritional information on food finding out the nutritional content of any packaged food (calories, nutrients, vitamins), also enabling product review, voting and rating (like *Amazon*® does for different products). The *Counteractive* [19] falls in that last set of applications that seek to support learning, in this case of new recipes, through an augmented reality system that provides support to the users through text-based interactions, videos and pictures.

The second front, instead, has not yet received massive attention from the HCI research work. *Living Cookbook* [11] is a tablet PC-based device that allows individuals to be videotaped while they are in the kitchen and make the sharing of their videos with friends and family, with the aim of enlarging the intimacy sphere characteristic of cooking activities. Several suggestions are emerging to stimulate users' creativity, increasing their pleasure encountering food (e.g. [4]), but most of the proposals that seek to improve communication and social experiences related to food through technology today come from exclusively commercial purpose applications. In particular, in web-based services and application related with food and wine sphere, it is possible to find the spread of many thematic social networks: like *Vinix.it* (www.vinix.it) an Italian social network focused on wine that allows to find contacts, addresses, products, and to exchange news and information; or *Foodproof* (www.foodproof.com) that allows to post videos, photos, and comments about food. Also In the mobile area are nowadays numerous the examples of smartphone applications, especially for iPhone and Android platform, oriented to improve the wine purchasing experience: *Hello Wine*, for example, provides support in purchasing decision suggesting the best combinations of food and wine, allowing the sharing of recommendations among the friends circle through the direct connection with *Twitter*® and *Facebook*®; *Wine Prices* is a tool that allows advanced wines search and price comparison with the possibility to find places where they are sold.

In any case it seems to lack in this specific area, research works that, keeping at centre the innovation, try to combine into a single service the needs of consumers, today more and more interconnected trough the social networks, and the wine producers, nowadays facing the global market challenges, also taking into account new business models emerged in recent years.

3 The GeoDrinking Service Concept

The idea behind the GeoDrinking service is to be a prototypical solution aiming to satisfy both the needs arising from the consumption side and the production side of wine world (Fig.1). The application is designed to allow the user/customer to publish worldwide, on a dedicated platform and, simultaneously, on the main social networks, his wine consumption behaviour in order to immediately express his taste and preference, and also addressing the construction of his digital identity on the internet. Wine consumption becomes so a means, among others, to distinguish themselves, to express feelings, share experiences, provide information. The service concept is designed to eliminate all obstacles that may interfere in its use and diffusion, developing a mechanism for fast and intuitive posting, which uses the latest research findings in the area of image recognition. At the same time the GeoDrinking service allows single wine producers both to monitor real-time the consumption of their labels, understanding the geographical dissemination of their products right from the post of individual customers, both to have a reverberation of their brand in all the main social networks, and last but not least to have access to some weird pattern of consumption indicative of possible brand counterfeiting. In this way the user becomes a probe of wine consumption on a worldwide perspective.

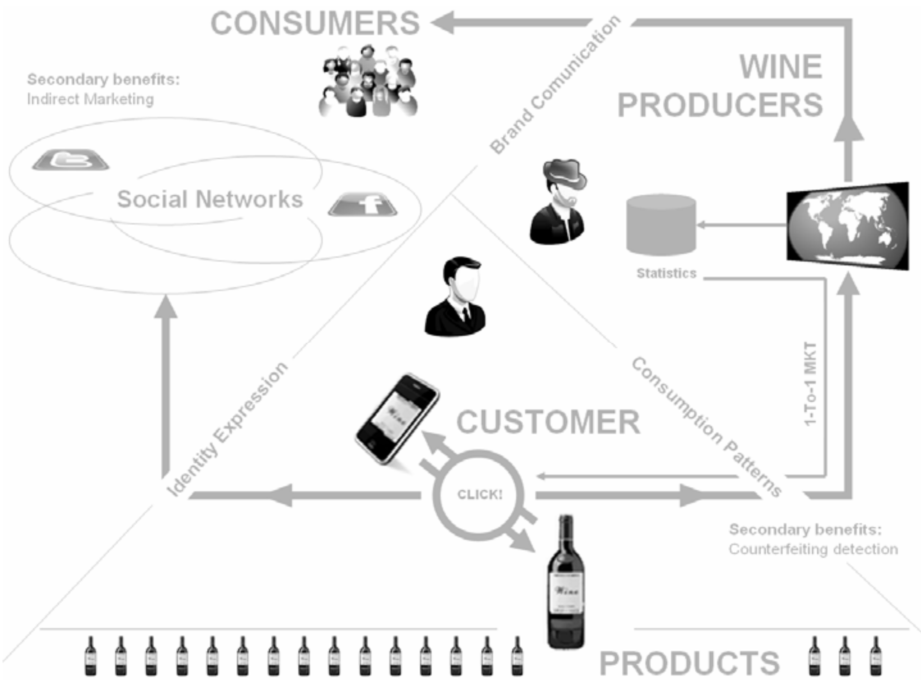

Fig. 1. General overview of the Geordrinking System. The customer chose amongst different products the one that better match his taste, preference and also better expresses his identity. Framing the label with the mobile phone generates three flows of communications. 1/ From the product and wine producer toward the customer. He receives information about the label (and possibly a 1-to-1 communication from the producer, like a promotion of a new label of the cellar). 2/ From the customer toward the main social networks and in general toward possible consumers. His click generates a post on his social network (*I'm drinking …*) reverberating then around his buddies and generating indirect advertising. 3/ From the customer toward the wine producer. His click generates a post toward the producer map and feeds the producer statistics also informing him about weird pattern of consumption maybe due to counterfeit labels. The producer can then reuse this data for his brand communication.

The proposition aims to give visibility to the wine consumption of small (no need to have barcodes) like big brands on a worldwide level (without any changes into the existing processes, using the actual labels that are already on the bottles).

So, "GeoDrinking", starting with a specific application context (the wine), through seamless mode of interaction (appropriate to the context of use), and publishing on its own platform as well as known social networks, brings the so appreciated by wine producer mechanism *of "word of mouth"* on a enormously larger dimension than that of a dinner with few friends.

On a very basic architectural point of view the system operates on a client-server model (Fig.2). The behaviour of the system for each query made by the user is as follows: the parameters received by the *RequestHandler* are translated into actual parameters for the *Web Services Communication Module*; the *Communication Module* sends the request of picture comparison to the *Image Matching Server* and receives as answer a set of thumbnails with associated a value of similarity; additional data are retrieved from the *Detailed Info DB* for each thumbnail received and aggregated by the *Data Aggregator module*; then an HTML page with a list of the results (ordered from the most to the less similar thumbnails) is generated in the *Web Server* and the *Map Viewer*, which could be accessed by the producers, is updated; finally the answer is sent to the client as an url to the page in the *Web Server*. Authentication and publication on Social Networks (*Facebook®, Twitter®, etc.*) are instead entirely performed on the client side. In conclusion, the service developed at present relies on commercial Social Networks and allows a return channel of direct communication with the wine producer exploiting also all the possibilities of the location services of the client.

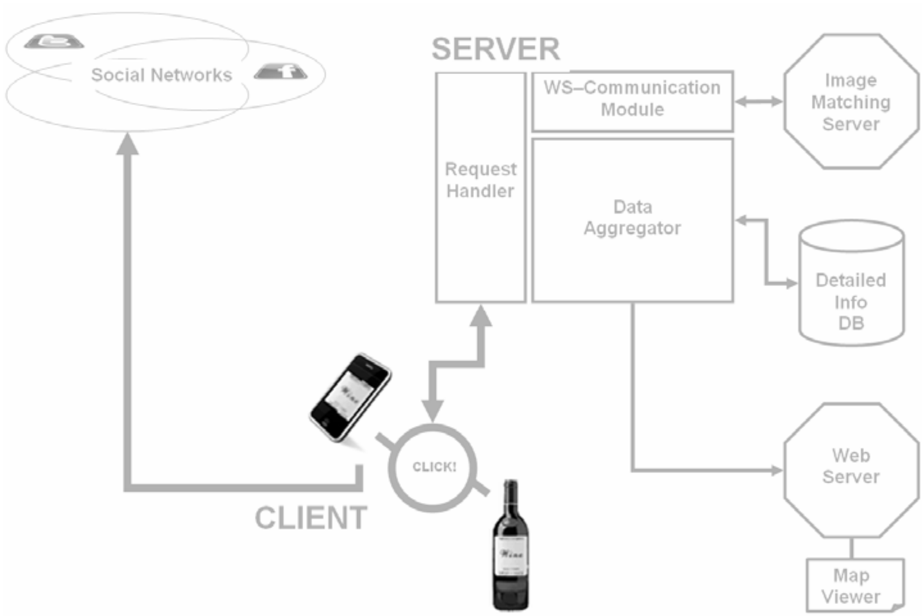

Fig. 2. Basic architecture of Client-Server GeoDrinking system

The service concept and the design process of the application will be illustrated in two separate paragraphs to reflect the experience enjoyed both by the user/customer both by the wine producers.

3.1 The CUSTOMER Side of GeoDrinking Experience

The advent and spread of a participatory culture in contemporary society have become increasingly obvious: people have an increasing need to participate, be interconnected, be part of the cultural production process and communicate their identity, their own life styles, their own experiences. Recent technological innovations that have led to the advent of Web 2.0 have done nothing but exploiting and feeding these needs through the proliferation of so called "social" applications, such as *Facebook®, Twitter®*, and so on. In this framework also the cultural and material consumption patterns are becoming increasingly important, as they are identified by people as a major component, if not the most important, of individual identity construction. In this perspective it becomes essential not only to share our feeling or thinking, but even more the books we read, the movies we watch, the places we frequent, the food we eat. Hence the spread of many thematic social networks and services that allows to satisfy these needs: *aNobii* (http://www.anobii.com), *miso* (http://gomiso.com), *Foursquare* (http:/ /foursquare.com) make this work, functioning as repositories of crowd-sourced recommendations for books, movies, places to eat and general places of interest, and at the same time contributing to the construction of people digital identities through the display and communication of their consumption styles.

In this context, with the GeoDrinking service individual users can publish what they are drinking, in real time. The posting mechanism is facilitated by the automatic recognition of the label of the wine without the user having to search through a text interface, or recognize a bar code [3]. The faster automatic recognition instead of the manual manner adds more natural interaction (*point-and-click like*), since the user is no longer required to input some text through the keyboard and must simply frame the wine label in order to perform the object search.

Let's make a script example about the system as seen by the user/customer. Jackie chose a glass of her favourite red wine in a New York wine bar. She frames the label on the bottle with her mobile phone and, thanks to the recognition made by the server, that database contains all the labels, she is immediately returned to the page with name, year and information about the wine she is drinking. Now she decides to publish her choice so that other friends are able to know what she's doing and what she's drinking. The mobile client publishes real-time information about the wine that Jackie is drinking, both in her *Facebook*® and *Twitter*® profiles and on the "GeoDrinking" web map of "*where people are drinking what*". Now producers can see what Jackie or her friends are consuming, or who is drinking what, choosing whether to deepen the knowledge of Jackie or what is drunk in the world.

3.2 The WINE PRODUCER Side of GeoDrinking Experience

The wine producers nowadays are more and more into the challenge of the new global market. Even the small local producers struggle in the need of exportation of their products in rest of the world, relying on international distributors or new ways of direct sales. To better understand the needs and desires of these producers, and how the new ICT/IT technologies could give them an effective help and improvement in their daily activities, we carried on a qualitative research on the Piedmont region wine producers thanks to the collaboration with the *WantEat* project (www.wanteat.it). In particular we focused our attention on the Langhe and Astigiano area: the first one is renowned in the whole world for his red wine production, that can count on some rare wines, like Barolo and Barbaresco; the latter, instead, has just undertake the way of the high quality wine production and has to face now the challenge of new market shares acquisition both in Italy and overseas.

We decided to perform some deep qualitative semi-structured interviews, customized on the specific features of the interviewees (in terms of duration, with a minimum of 60 minutes, and topics of the interview, focused on the general production process or on specific business activities). The producers were selected on the basis of the features considered relevant for the research purposes [3, 6]. The final sample was composed by six wine producers (2 small/2 mid-size/2 large) of *Langhe* and *Astigiano*. The schema of the interview was traced towards three pilot interviews with Turin area wine producers and was split into three parts: a general section in order to gather producer personal data and information about his business; a communication section to investigate the promotion and advertising process carried out by the specific producer; a TLC/ICT section to gather information about the actual use of new communication technologies, and to present some possible use cases in order to stimulate the imagination of the interviewee, projecting himself in using some hypothetical future services into the every day processes of the winery.

The data gathered bring us to some general findings valid for all the producers interviewed, and some specific results characteristic of the different areas involved. For all the producers, it is important to know where their product are sold after the distribution (restaurants, clubs, etc.). Both areas under investigation showed their main market abroad: this is the reason why the producers, who, for the most part, trust on the international distributors for the foreign market, rarely know the exact final destination of their bottles. The "*word of mouth*" is the best way of advertising and the customers are severely selected and spoiled specially for small high quality brands. The e-commerce is a solution neither pursued nor desired. Finally the single producers showed a strong individualism in the production, distribution and even promotion patterns proving to be averse to getting together, refusing syndicates and professional associations, that are seen as binding and without an effective surplus value.

In addition a specific feature of the *Langhe* area is the valorization of the territorial heritage and the traditional productive processes: the most part of their customers is loyal and sees in the product a high prestige niche beverage such that the possibility to buy some bottles could worth the visit of the area. The *Astigiano* producers instead are constantly in the research of new markets and new ways to convey their wines. They put all their efforts into growing up the status of their own products, in order to compete at par with the more renowned *Langhe* producers. In order to do that kind of promotion they are always in search of a communication channel for potential customers. These results take us to consider with particular attention the various requirements of the producers, tailoring the GeoDrinking service on their real needs. Adopting the GeoDrinking service indeed the wine producers can track the consumption of their products, finding where they are sold in the world, thanks to the visualization on a map of all the single bottles drunk by their customers. Besides they can consult the consumption statistics and receive a direct feedback from their customers about the quality of their wines through comments, votes and reviews and even activate some 1-to-1 marketing actions. And last but non least they can benefit from the reverberation of indirect advertising in the social networks and from the discovery of unusual patterns of consumption sometimes related with counterfeiting activities, an arising problem in high quality food and beverages.

Let's make a script example about the system as seen by the wine producer. Massimo has a winery that exports in four continents. Many customers have contacted him seeing on *Facebook*® that his wine is consumed in a popular wine bar in London. He then decides to pay a fee to the platform to add labels and information about his products. When someone drinks one of his *Barolo* bottles in the world he can see it in real time or show it to his customers through the real-time map published in his winery website, or even on the big screen in his cellar. He can also check the weekly or monthly consumption trend for his labels.

4 Possible Business Models for GeoDrinking

The development of the ICT field in the last years pivots mainly on the Web 2.0. The technology that has made possible this evolution is very various, including server-side software, content syndication, messenger protocols, and, most of all, client-side browser-based software. Particularly, we are talking about Rich Internet Applications (RIAs), that is, web applications with features typical of the desktop applications (like drag and drop, cut and paste, and so on), developed by technologies as Asynchronous JavaScript and XML (Ajax), Adobe Flash and JavaScript/JavaFX, now available in the new versions of the most common browsers. The content syndication technologies, that permit the data exchange between different websites towards machine-readable formats, like RSS, RFD and Atom, allow the final users to use the data of a specific website in another context (i.e. another website, a browser plugin, a desktop application). These ones together with the spread of the Web API (e.g. REST or SOAP) and the P2P technologies have concurred to the birth of the paradigm of the “Participation Architecture” in witch the contents and the services could be recombined in a very simple way. Another technology feature of the Web 2.0 is the concept of Software as a Service (SaaS), that is, online services instead desktop applications, continuous improvements instead periodical releases, temporal subscriptions instead licences of use. The appearance of Apple® in the mobile market, with his mobile phone (iPhone), has introduced the concepts of the web 2.0 in the mobile world. The challenge was taken up by both the smartphone producers (Nokia, Samsung, HTC, RIM, etc.) and Os mobile producers (Symbian, Blackberry, Windows Mobile, Android).

This technology landscape has required the definition of new business models that could find new means of support to the development of the so called Web 2.0 services. Various authors have tried to define and classify these emergent e-business models [5]. The main models born in the last years and suitable for the GeoDrinking Applications are the follows.

- *Advertising model*. The advertising model is a consequence of the traditional business model of the media broadcasters (Tv, Radio, Newspaper) and for this reason is one of the first models that has became apparent. Since the interactivity of the Web 2.0 technologies, however, the static advertisements have been overtaken by more evolved solutions, like interactive or contextual advertisements. It is possible, besides, towards user personalization systems, to provide personalized contents and advertisement to the users that have accepted to register their preferences.

- *Application Store Model*. This is the most common business model in the mobile world: Apple® (with his App Store for iPhone), Google (Android market), RIM (Blackberry App World), Nokia (Ovi store), Microsoft (Windows Marketplace) have all adopted this model. The application developer exploits the Store as a market place, gaining a percentage of the sells of his own application, while the owner of the store takes a charge on each download.

- *Freemium model*. The freemium term is a neologism created merging the terms "free" with the term "premium", and it means a business model that involve the offer of a free core-base service and an advanced layer of services with fee.

A combination of these models, based on a crowdsourcing platform (as GeoDrinking in fact is), make economically sustainable the GeoDrinking proposition. For instance the wine producers could have a free base service (*freemium*), that will consist in inserting up to three labels in the system, but which could be increased in order to accept more labels and information on an annual basis payment fee. This premium modality could allow the producers to consult different statistics about their products, using advanced analysis on the consumption patterns data or simply increase their indirect advertising trough the social network reverberation of their labels generated by more recognition operated by customers around the world.

5 Future Works and Conclusions

In conclusion the service developed up to now represent an information channel for the consumer, managed directly by the producer, which relies on well established social networks and allows a return channel of direct communication with the producer exploiting all the advanced features provided by the mobile client. Many are the evolutions and the possibility of extension of this kind of service as well as the related business models depending on the various sectors of consumption that can be addressed.

Future developments include for instance the possibility: to have a 1-to-1 producer-consumer communication channel (for rebates, bonuses, etc..), to create competitor statistics of consumption for the producer, to create a WikiWine or a global catalog of wines created on a *crowdsourcing* logic, as well as the fundamental component to improve the education side about production techniques, consuming awareness and culture of good food and good drinking.

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Enhancing Mobile Interaction Using WLAN Proximity

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Abstract. Over the last decade a manifold of WLAN-based localization methods have evolved, whereupon most approaches focus on accurate location estimation and tracking using absolute coordinates. In this paper we propose a system prototype utilizing WLAN infrastructure for relative spatial determinations using discrete, unambiguously distinguishable zones. The prototype allows imitating near field communication (NFC) and beyond using conventional mobile devices not equipped with NFC hardware but a WLAN interface. We prove the functional correctness of our system in the course of a payment scenario at cash-desks, where customers are required to "show" their electronic store card at spatial proximity to their cashier without interferences from neighbors.

Keywords: Proximity Interaction, WLAN Proximity Engine, Sensor Network.

1 Introduction

Contact-free computer interaction at spatial proximity is considered an indispensable paradigm in mobile computing environments [1]. Typical setups comprise access control systems, sports applications (e.g., time measurement in mass sports events) or payment systems. The preferred technology for those setups is commonly based on radio frequency signals, embedded into NFC or Bluetooth standards [2]. However, employing NFC or Bluetooth bears certain disadvantages with respect to non-restrictive mobile interaction. In terms of NFC usage people are required to carry a separate tag (smart card) for each distinct application or a (non-commercial) NFC-enabled mobile phone, which consequently reduces its public applicability. The Bluetooth standard on the other hand is broadly integrated into commercially available mobile phones. Nevertheless, it has barely found its way into public mobile applications primarily due to security and privacy concerns of its users. Moreover, the bandwidth for service applications is low and the number of clients to be served is limited.

In this work, we propose an approach for contact-free computer interaction at spatial proximity (within a certain interaction range) [3] based on WLAN, which is widely spread, commercially available and considered as a mature, trustworthy technology. Based on recent research on WLAN localization [4] we have identified the potential of the Wi-Fi medium as an alternative to NFC. It offers a broader service bandwidth, elaborated security mechanisms and has reached a high degree of penetration in public environments. Hence, more sophisticated service applications can be built upon WLAN technology in the context of contact-free proximity interaction [5] [6].

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2 Related Work

The technique of proximity sensing for determining the position of a mobile user relative to the sensor's position has been widely studied with respect to various radio technologies. In [7], Hightower and Borriello presented a survey on location sensing describing three different approaches for inferring the proximity of an object or a person to a sensor by *"using a physical phenomenon with limited range"*. According to them such phenomenon can either be physical contact, the contact of an ID tag (e.g., credit card, RFID tag, etc.) with a reader device whose location is known, or the being in range of one or more access points in a wireless cellular network. Seen from another perspective, they distinguished between three zones of proximity (direct, near, and distant contact). The system proposed in this paper emphasizes a different classification using a near zone and several graded distant zones for interaction (cf. Section 5). In [8], the term proximity sensor is refined describing a sensor that locates an entity or device as being within a region. To determine the exact position however a setup of several proximity sensors with overlapping ranges applying triangulation algorithms is needed. The WLAN Proximity Engines (WPE) accentuated in this work can basically be interpreted as proximity sensors. In order to reliably distinguish a greater amount of interaction zones our system allows for a cooperative peer-to-peer communication among the WPEs (cf. Section 3).

In terms of the underlying sensor technology, RFID has been a prominent basis for proximity-based localization and interaction in the last decade of research. The LANDMARC system [9] uses stationary RFID readers as sensors to localize active RFID tags that appear within range. The localization process then refines the position of the tag by comparing the received signal strength to the measurements of reference tags deployed at known positions. In [10], a RFID-based monitoring system for a queuing environment is proposed, comprising sequentially deployed RFID readers that provide queue length estimation by sensing the proximity of tags passing by. The setup suggested in this paper makes use of proximity information in a different way. Derived from the proximity to one or more stationary sensors we associate mobile users with certain interaction zones. These zones determine the user's interaction interface with the back-end server systems.

Ultrasound technology is considered the most precise sensor technology for determining the location of an emitter at the time of this writing, allowing accuracy results of 5 to 10 centimeters [11]. The Active Bat system [12] has been one of the first systems to utilize ultrasound sensor infrastructure for indoor localization. It employs a time difference of arrival (TDOA) algorithm to track a user carrying an emitter tag. In order to narrow down the potential location of a Bat emitter the system generates a bounding region for each Bat dependent on the radio zone covered by the nearest sensors. Similar to the WPE approach this system combines sensor readings to a fingerprint for each zone that separates the covered environment. In [13], the Relate system makes use of the spatial relations of mobile peers equipped with an ultrasound sensor. They study the incorporation of proximity aspects into the user interface and present a toolkit API for mobile applications.

In the context of Bluetooth proximity sensing most contributions concentrate on signal strength measurements using stationary beacons [14] or PCs as sensor stations [15]. In either way, the proximity of the mobile device to another station allows to infer on the location of the user profiting from the limited radio communication range of the Bluetooth technology. In [16], a localization approach is presented that allows the tracking of mobile phones without software modification. This important aspect has been one of our main objectives for building the WPEs because the acceptability of our system strongly depends on such usability considerations in a real-life setup.

In the field of WLAN-based localization proximity sensing has been relegated to a niche existence. This is mainly due to its radio propagation characteristics. In opposition to Bluetooth, WLAN provides a higher range of signal dispersion, i.e., two stations might communicate at a distance of up to 100 meters in indoor environments. Consequently, a simple Cell-of-Origin (COO) approach does not narrow down the client's location. The NearMe Wireless Proximity Server [6] addresses this issue by applying a more sophisticated approach. By skipping the intermediate step of computing absolute location information of mobile clients, the NearMe system determines the proximity of two mobile users by mutually exchanging lists of Wi-Fi signatures (i.e., lists of access points and clients signal strengths). Based on similarities in the signatures the distance can be estimated. Like the system presented in this paper, the NearMe system does not need to be calibrated beforehand since it uses relative location instead of absolute location (e.g., WGS-84 coordinates). In [17], a neighborhood detection algorithm based on ZigBee sensors supports wireless LAN-based localization to compensate signal interferences provoked by people and alike. Even though such interferences do not affect close proximity readings obtained by the WPEs, we apply a similar algorithm to improve the distinction of distant interaction zones.

3 A WLAN Sensor Network

The system presented in this work aims at reliably separating zones of mobile interaction on the basis of networked WLAN sensors that solely utilize proximity localization and consequently do not rely on a preceding training phase. In our prototype setup (cf. Section 4) we use these interaction zones to provide different views and functionality to mobile clients embedded in a web service. Our main design objective was to implement a system operating without any client pre-requisites but a WLAN communication interface and a mobile internet browser for service access. The resulting advantages of this approach are twofold. On the one hand, the usability of the system benefits from the commercial availability of WLAN in public places and its integration into modern mobile phones. Sophisticated encryption and security measures are already realized on common WLAN infrastructure. The deployment of our system is merely a matter of configuration. On the other hand, the bandwidth of the 802.11 standard allows for elaborate applications (e.g., multimedia web applications) as opposed to Bluetooth. As a further benefit the client's communication traffic originated from service consumption is reused for localization purposes and, consequently, acts as signal emitter process.

Figure 1 depicts the basic system architecture. The core of our system is built upon off-the-shelf access points (further referred to as WPE – WLAN Proximity Engine) altered with a Linux operating system and enhanced with customized software. As sketched in the figure, our prototype setup uses *Linksys WRT610N* access points that feature a 533 MHz processor and two separate WLAN interfaces covering the 2.4GHz and the 5GHz frequency band. In our setup the 2.4GHz band (802.11bgn) is used for proximity localization and service provisioning. The 5GHz band (802.11an) acts as backbone network for the WPEs. Due to its processing power the hardware platform is capable of concurrently running the proximity engine, a web server and a database in the background. Hence, service provider functionality is incorporated in the WPE device. Optionally, our setup supports interfacing with a back-end server to ease the integration into existing service infrastructure at potential deployment sites.

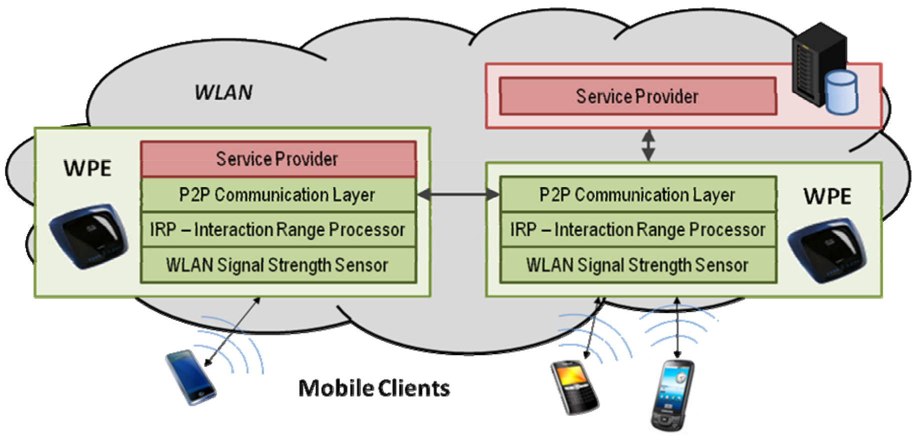

Fig. 1. System architecture

As sketched in Fig.1 the WPE software comprises four components: (*i*) a WLAN signal strength sensor, (*ii*) an interaction range processor (IRP), (*iii*) a peer-to-peer communication layer and (*iv*) a service provider. The WLAN signal strength sensor is realized as a low-level daemon process that queries the interface driver in raw packet monitoring mode for RSSI (Received Signal Strength Indicator) measurements of the mobile clients. Its sole purpose is to supply the IRP with measurement data in real time. The IRP uses these data to separate spatial regions into distinct interaction zones. As our proposed setup demands for reliable zone separation, the IRP uses unambiguous peak values to determine the respective interaction zone of a mobile client. The system distinguishes the near interaction zone (i.e., signal strength measurements of -25dBi and higher) and several distant interaction zones graded by signal strength thresholds. Depending on the amount of cooperating WPEs and the characteristics of the setup environment the granularity of distant zones can be refined. A more detailed discussion on refining these interaction zones is given in Section 5.

In order to allow WPE cooperation the system entails a communication layer that utilizes a peer-to-peer principle. During an initial discovery phase each WPE executes a simplified voting algorithm using broadcasts on the backbone network. The first appearing WPE is assumed the master peer, which waits for other WPEs to appear on the network until the configuration application is triggered. The master peer acts as central service provider hosting the configuration application that is responsible for defining the sensor network topology and additional parameters that represent the setup environment. After configuration, each cooperating WPE continuously reports live proximity measurements to the master WPE. The service provider instance at the master peer acts as front-end and determines the relative location of inquiring clients on the basis of the sensor input delivered by the WPE network. Finally, the front-end application differentiates the clients' locations into interaction zones by applying a set of topology depending separation patterns.

For compensating signal strength fluctuation provoked by people in the line of sight between sensor and the inquiring client, our system emphasizes the usage of a stationary control signal emitter placed behind the region of interest [18]. The control signal is steadily broadcasted by a WLAN capable device (e.g., a normal access point or a mobile phone) and measured at each WPE. As part of the configuration process the initial signal strength value of the control signal is stored as a reference at each WPE. During live operation the fluctuation in the control signal strength serves as adjustment factor for client signal measurements.

4 Use Cases

The applicability of our system is being demonstrated in the course of a supermarket cash desk scenario under laboratory conditions: four cash desks have been arranged in parallel with a distance of about 1.5m to each other. Our application prototype implements an electronic store card utilizable on the clients' mobile phones which can be "shown" to the cashier on a single button click and automatically associated to the correct cash desk and purchase. The challenge in this setup is to confidently detect the correct desk by WLAN depending on the client's proximity when the client presses the button on his mobile phone. Moreover, it must be assured that several clients in a queue at the same cash desk are handled correctly even when they simultaneously press their buttons. The setup provides for a WPE at every cash desk mounted at spatial proximity to the cashier. The clients are requested to hold their mobile phones close to the appropriate WPE and press a button in order to initiate network traffic which can be used to explicitly determine physical closeness. This further triggers an authentication process to ensure correct association of client and service.

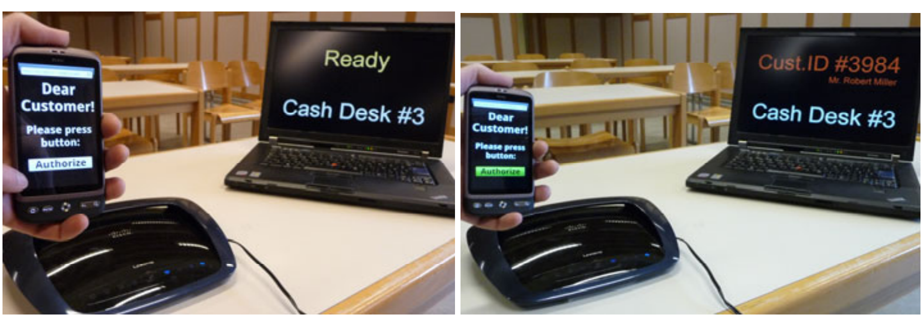

Fig. 2. Cash desk scenario (user interaction)

Fig. 2 shows a snapshot of the prototypical arrangement: a Linksys access point is used as the WPE and detects physical closeness of an off-the-shelf mobile phone (here: HTC Desire operating on Android 2.2). The browser component of the phone enables the user to consume the provided service of the WPE (recognizable by an authorization screen for “showing” the user’s store card). For confirming the button click near the access point every cash desk is equipped with a screen showing the customers’ identification data through the WPE service.

We have arranged this setup in four parallel lines in order to simulate a supermarket cash desk scenario with customers being simultaneously served at the four desks and interfering in the queues. Fig 3 exemplarily illustrates that two customers in different lines and at different proximity to the cash desk are handled correctly, i.e., they are only then identified when their mobile device is closer than 30cm to the access point when pressing the authentication button. This near zone is intended to manage security related interaction (e.g., exchanging customer identification data).

Fig. 3. Cash desk scenario (parallel interaction)

Beyond operations at very close distances (i.e., in the near interaction zone), the WPE sensor network is capable of distinguishing further discrete interaction zones (cf. Section 5) enhancing the variety of applications that can be set up upon, e.g., for non critical operations characterizing a semi-close area around the WPEs. At the far distance zone the system could advert to latest offerings and common vendor services.

In the vicinity of the checkout lines customers may be reminded of cross-checking their shopping list, by means of a web-service provided by the supermarket, which customers may fill out at home. Enqueued in a checkout line the customers' waiting time could be shortened e.g., by participating in a (yet anonymous) quality survey rewarded with credits. These credits can finally be encashed right away in the near interaction zone, where the customer is identified for the first time.

In general, the WPE approach contributes to an innovative interaction paradigm in mobile computing environments, where people are able to trigger electronically controlled actions just at spatial proximity without the needs of glimpsing at displays, typing, clicking or pressing buttons (cf. [19]). Usually, human attentiveness is required by conventional interaction metaphors via display and/or keystroke at the place of event in order to open a gate, buy a ticket, start or stop an engine, etc. However, attentiveness for pressing a button or glimpsing at a display may occasionally be unavailable when the involved person must not be distracted from performing a task (e.g. while driving in a car) or is handicapped through wearable limitations (e.g. gloves, protective clothing) or disability. As the WPE on the one hand is capable of discretely detecting physical proximity and on the other hand includes a customizable service provider component it is possible to automatically trigger those actions just at physical closeness of a person, i.e., dismissing displays and keypads in order to ease human computer interaction.

5 Results

In indoor localization research, most contributions concentrate on accurate location estimation and user tracking in indoor environments to supply location-based services with absolute coordinates of the users' current whereabouts. This work emphasizes the usage of discrete interaction zones for application scenarios that benefit from clearly separated zones that can be associated with different functionality (e.g., consumer interaction in the supermarket, public display interaction, access control systems or elderly care scenarios).

First experiments with the WPEs showed that signals emitted at distances < 30cm (LOS and NLOS) can reliably be differentiated from those sent out beyond. Weak signals transmitted at distances > 15m also show significant measurement characteristics. Consequently, one single WPE can robustly determine three zones: (*i*) the near zone identified by signal strength measurements greater than -25dBi, (*ii*) the far zone identified by signals less than -70dBi referring to distances of > 15m (indoors and NLOS), and (*iii*) the distant zone for measurements in between these two extremes.

Table 1. Measurement results of the WPE sensor network using a HTC Desire smart phone

	0m (*near zone*)	3m (*distant zone 1*)	9m (*distant zone 2*)
Line0:	[**-04**, -34, -39, -40]	[**-29**, -35, -37, -36]	[**-45**, -41, -41, -38]
Line1:	[-32, **-05**, -29, -32]	[-35, **-31**, -46, -35]	[-38, **-40**, -46, -40]
Line2:	[-36, -26, **-11**, -27]	[-39, -35, **-34**, -29]	[-46, -43, **-41**, -41]
Line3:	[-44, -36, -26, **-08**]	[-38, -36, -37, **-33**]	[-42, -47, -44, **-41**]

Table 1 lists the measured signal strengths obtained by WPE sensor arrangement in the setup described in Section 4 (four cash desk lines). The quadruples in the table columns refer to the measurements taken by the four WPEs [WPE_0, WPE_1, WPE_2, WPE_3]. The highlighted entries mark the respective WPE assigned to the cash desk line. The bold-faced values in the near zone column illustrate distinct measurement peaks allowing a unique classification. Even though the measurements related to distant zone 1 and 2 seem decisive regarding their associated WPE, the signal strength values within this range tend to fluctuate in the order of ±10dBi mainly due to multi-path propagation, attenuation provoked by people in the LOS and emitter characteristics of different WLAN chipsets. In order to robustly separate the two distant zones these fluctuations must be compensated. Hence, we use the collaboratively obtained average value of the measurements to mitigate signal variability. Since the strength of the WLAN signal decreases logarithmically, the system is able to reliably separate four interaction zones in the course of our sketched setup arrangement (cf. Fig. 4).

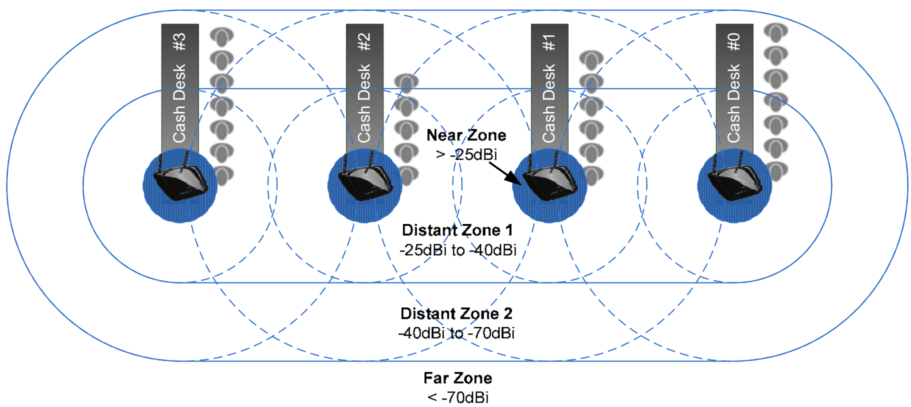

Fig. 4. Identified zones of interaction

6 Conclusion and Future Work

The idea of using WLAN-based localization has been a matter of research mainly investigating accuracy aspects concerning absolute positioning as an indoor alternative to GPS. In this work we envision a human computer interaction scenario utilizing a proximity-based mechanism to determine relative spatial associations of mobile users. To this end, we have developed a network of Wireless Proximity Engines, i.e., either detached or collectively applicable entities associating mobile devices with discrete interaction zones. In the course of a prototypical cash desk setup we have robustly distinguished four interaction zones providing specific customized services (e.g., store card authorization, advertisement delivery, electronic shopping list, etc.). Our system is instantly operable without any training effort and users can interact without any prerequisites on the client-side but a WLAN interface.

According to the results presented in related work [18], the accuracy of indoor localization benefits from spatial variability, i.e., the reflection, diffraction or absorption of the WLAN signal by stationary obstacles (such as furniture, walls, doors and alike) leading to unique characteristics of each potential location spot. Given such characteristics typically found in real-life environments the number of distinguishable interaction zones is likely to increase. In this context, further investigation has to be conducted on filter patterns for separating the zones combined with the arrangement of the WPE sensors (e.g., parallel, circle, square, radial, etc.).

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Tracking Observations of Everyday Living with Smart Phones

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Abstract. Reports of health information systems failures identified the guilty parties laying with issues around social, technical, and organizational factors. The reason so many systems fail may lie in the socio-cultural fit of e-Health systems. We do not understand how to deliver information to providers when they need it, in a usable format, and in a way that fits transparently into their workflow and into the daily lives of patients. In addition to understanding how clinicians use HIT in order to promote health behavior change, it is necessary to consider patient goals, preferences and capacities. Patients with multiple diagnoses are often complex to manage because so much of their experiences happen in between clinical visits. Information and communication technologies (ICT) can play an important role in assisting patients managing personal health information. The key question is how do we take advantage of the power of low-cost ICTs to extend care?

Keywords: Information and communication technologies, Socio-technical systems, consumer health, usability, human-computer interaction.

1 Introduction

The shortcomings of healthcare information and communication technology implementations have been well documented [1-4] and identified the guilty parties laying with issues around social, technical, and organizational factors [5-9]. The reason that so many systems fail may lie in the socio-cultural fit of these systems. Often health information technology (HIT) are poorly automated [1,9,10]; slow [11, 12]; insensitive to human factors engineering principles [13], introduce unanticipated workflow concerns [14-15] and often deliver non-computable data. We do not understand how to deliver information to health care providers when they need it, in a format they can use, and in a way that fits transparently into their workflow and into the daily lives of patients. This is crucial to understand given the significant health improvements there have been demonstrated using HIT that utilize concepts of patient involvement in the documentation of health outcomes, increased patient-provider communication and patient engagement [16].

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In addition to understanding how clinicians use HIT in order to promote health behavior change [17], it is necessary to consider patient needs, goals, preferences and capacities [18-20]. Patients with multiple diagnoses are the most difficult and complex patients to manage because so much of their experiences happen in between clinical visits. Research shows that the collection of data in between clinical visits is a key way to manage patient health information and empower patients to be an active part of their care [21,16]. Some would have you believe that the organization of the paper medical record is driven by billing concerns and only tracks discrete clinical data. Upon further consideration, the health record also contains information that is not all quantitative; it often captures qualitative information obtained at the clinical encounter. Personal health records (PHRs) in particular, are demonstrating new ways of collecting, organizing, displaying and using that information. The ultimate goal being to use data from everyday life to understand how personal choices affect one's health. Information and communication technologies (ICT) can play an important role in assisting patients managing personal health information [16] which has been shown to be a tool to improve care for complex patients [5,6,22].

Broad acceptance of "Medicine 2.0" technologies will continue to provide an avenue for the education and communication of patients and clinicians. Hornik [23], Napoli [24], and others think that the use of innovative ICT applications can take advantage of mobile applications needed to effect change. Research on the use of low-cost ICT's with medically underserved populations is sparse despite the expressed need for tools that are affordable and effective [16]. Harnessing the power of "smart" technology can be a bridge that crosses the "digital divide" to support general patient well-being given the prevalence of mobile technology use in underserved populations [25]. In the past, use of ICTs has been hindered because of costs, access and cultural relevance. Medically underserved being defined by a population that faces economic barriers (low-income or Medicaid-eligible populations), or cultural and/or linguistic access barriers to primary medical care services as defined by the Index of Medical Underservice [26]. Reports have shown that mobile technology is ubiquitous in these communities and patients are willing to use them for managing their health [16]. However, healthcare has not capitalized on the capabilities of low cost (ICT)'s and their potential to bring ICT's to different populations. The key question is how do we take advantage of the power of low-cost (ICT) to extend e-health/medicine 2.0 to underserved communities?

2 Observations of Everyday Living

The Robert Wood Johnson foundation has led the way in funding efforts to understand how personal health records can be enhanced by collecting data generated between clinical visits. Five grantee teams are currently working to demonstrate how to improve the health and well-being of people with two or more chronic diseases by helping them capture, understand, interpret and act on information gathered from their observations of daily living [27-28]. The research teams are currently working with clinical partners and patients to identify, capture and store several types of observations. The long-term goal is to enable patients to share this information with members of their clinical care team in a way that can easily integrate into their clinical work flow, ultimately impacting policymakers and clinical leaders.

Tracking observations of everyday living allow for behavioral observations to be captured on a commonly used device to capitalize on patients' ability to easily document activities. They build an ability to record thoughts and feelings and associate them with patients' activities. Table 1 contains a short list of less obvious observations of everyday life that could be tracked.

Table 1. Observations of Daily Living

Observations of daily living	**Meaningfulness for Individuals**	**Meaningfulness for care providers**
Self rewards	Understanding how self-rewards move patients toward or away from their goals can provide insight into self-care and coping.	Individuals use self rewards often. Differentiating between positive and negative rewards can shed light on activities that impact health
Stress	Identifying causes and effects of stress can be the first step toward recovery	Identifying the causes and incidents of stress can assist can direct care plans
Pain	Identifying the sources and incidents of pain can assist in isolating the source and possible solutions	Identifying the sources and incidents of pain can assist in isolating the source and possible solutions
Impact of spirituality	Spirituality is a source of support and comfort in this population.	Awareness of how and when that support is present assist in identification of possible care strategies

The novelty of the range of observations of everyday life is exemplified by the expectation that the data analysis will reveal patterns of daily living across a variety of behaviors in chronic disease management. Not only can observations of everyday life change patients and their relationship to their own health care, but they may allow providers the chance to see a fuller picture of their patients. This comprehensive view of care by definition lends itself to more complete and accurate care.

3 Health Information Management and ICT's

Health behavior change requires a highly sophisticated understanding of the dynamic social practices that occur [29]. ICTs must be designed to work in many settings with a broad range of different consumers and providers [30-32]. While health communication generally has been "person-directed," the process of initiating and maintaining a life change is made in the context of family, community, and other cultural factors [30-32].

3.1 Previous Uses of ICT's in Healthcare

Three landmark studies have examined how web-based information and support systems affect patient care. First, the Comprehensive Health Enhancement Support System (CHESS) serves several diverse patient populations (Breast cancer, prostate cancer, HIV/AIDS, heart disease, asthma, caregiving and dementia, and menopause), providing information, decision support and connection with medical experts and other patients [33-35]. Secondly, Brennan and colleagues [36,37] developed and evaluated Heartcare, an Internet-based information and support system for patient home recovery after coronary artery bypass graft surgery. HeartCare matched recovery resources with patient needs by providing individually tailored recovery information, peer support and nurse-patient communication. The HeartCare system used WebTV (now MSN TV) and was designed to be an enhancement and extension of traditional nursing services. This randomized trial significantly improved symptom management, reduced depression and physical dysfunction in the HeartCare group as compared to the "lower tech" comparison intervention. Finally, Columbia University's Informatics for Diabetes Education and Telemedicine (IDEATel) project [38,39] is a demonstration project of the Centers for Medicare and Medicaid Services to evaluate the feasibility, acceptability, effectiveness and cost effectiveness of advanced computer and telecommunication technology to manage the care of persons with diabetes. These studies were pioneers in the field in demonstrating that low income users will utilize technology to improve their healthcare. However, the studies were completed before the emergence of Web 2.0 interactive tools that allow for multiple avenues for data collection, social support and information sharing. In addition, each gave participants specialized tools to complete the intervention, which has been shown to not be a preference of underserved users [16].

3.2 Usability of ICT's in Healthcare

Initial studies using ICTs for supporting patient information management have used devices that were often designed specifically for this function [40]. Recent studies have shown that underserved patients would prefer if such systems were available on devices they already use [16,21]. Until recently, most software products being tested were desktop based. Moving the user interfaces of HIT systems on to mobile devices creates new challenges for system design and usability evaluation [41]. From a usability perspective, the main difference between desktop-based and mobile computing is related to the environment of use. For desktop-based applications, use typically involved a stationary user using a keyboard and a mouse. Mobile technology, on the other hand, is embedded into the user's physical and social life, referred to as embodied interaction by Dourish [42]. Embodied interaction is characterized by presence and participation in the world [42]. As such, interaction with mobile technology is fundamentally different from the interaction with desktop-based systems, because of the switching between being at the focus of the user's attention and residing in the background of their work/life [43]. Prior studies conducted by the author indicate that usability testing and evaluation can offer only incremental improvements in health information technology (HIT) use and success is contingent upon integration with clinician's workflow and the patient's lifestyle.

4 Future Research and Development

As observations of everyday life enhance patients' understanding of themselves and their relationship to their health care, it is anticipated that clinical practice will change as providers are given a more complete view of patient status. Clinical use of observations of everyday life can allow for timely feedback to patients as data is received and analyzed. In addition, the provider will be able to engage patients in their own care by reflecting the data about daily activities back to patients and incorporate new connections between activities, feelings and well-being into their treatment plan. For example, parents who track their children's eating habits gain insight into their own food choices, particularly since it is unlikely that they prepare separate meals. Once patient data is analyzed, the clinician will be able to incorporate this data into treatment plans that are based on evidence-based practices. The outcomes will bring awareness to the individual patient and to providers that can lead to changes in how individuals manage their chronic conditions and how care is delivered, enabling clinicians, public health professionals and medical caregivers to better understand patterns of health behaviors within this population. Most studies of patient behavior look to what causes people to not follow their recommended regimen. Observations of everyday life offer a window into what helps people make good choices and how they reward themselves.

5 Summary

If we can understand how collecting data from patient's everyday life can be successfully used by clinicians, we can provide designers with the basis for impact on workflow. Current implementation studies often only focus on one-time IT use with no consideration for integration into the clinical workflow and use for improving health outcomes. As we think about new research questions, studies should investigate how to capture and process observations of everyday living made by patients and clinic staff. This understanding will enable healthcare providers to engage patients in their own care by establishing connections between activities, feelings and well-being into their treatment plan (e.g. high blood pressure readings after eating salty foods). A new theory of HIT design is essential for this to succeed. This work has the potential to impact not only information technology design approaches and methods but to discover design requirements for technologies to support patients from diverse and underserved populations.

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Effect of Protective Coating on the Performance of Wearable Antennas

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Abstract. Current smart clothing faces challenges due to discomfort provided by some technological components. A wireless body area network using inductively coupled fabric antennas is suggested as one of the solutions to overcome this. Different types of fabric substrates (denim, broadcloth, and jersey) and protective coating (acrylic resin, polyurethane, and silicone) were selected and engineered to optimize the antenna performance – in terms of mechanical and electrical properties. Experimental results show that protective coating affects almost every mechanical property very significantly. Resistance of the antenna was recorded lowest on the polyurethane-coated antennas and inductance was minimized on the broadcloth substrates. Recognizing a trade-off between electrical performance and comfort, this research looks at ways to optimize the overall usability.

Keywords: Smart clothing, Conductive printing, Protective coating, Fabric antenna, Inductive coupling, FAST.

1 Introduction

E-textiles refer to fabrics which can function as electronics or computers and physically behave as textiles. Both electrical properties (such as conductivity) and mechanical properties (such as flexibility) are very important in the creation of e-textiles [1]. The methods most commonly used to integrate conductivity into textiles are weaving, stitching, couching, knitting, and printing [2]. With a reduction in production cost over the other techniques, conductive printing contributes to the feasibility of mass production. Printability, which describes efficiency of conductive printing, is determined largely by whether conductive ink penetrates the substrate or remains on the surface, and is highly related to micro pores distributed on the fabric surface. Electrical conductivity of printed media is maximized when the printing remains on the surface of the fabric and does not penetrate into the fabric structure [3].

Protective coatings are necessary to ensure a long and effective working life of the printed media. Applied onto conventional printed circuit boards (PCBs), conformal coating refers to a protective non-conductive dielectric layer, whose thickness is up to 0.005 inches [4]. This coating protects PCBs from electrical arcing, environmental contamination, and physical damage. Typical conformal coatings are made by silicone, polyurethane, epoxy, or acrylic resin [4, 5]. According to the varying chemical

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and physical properties, they offer different degrees of protection, performance, and application. Protective coating is highly suggested for conductive prints on the fabric substrates as they may crack and peel off due to mechanical agitations during wearing or laundering. In order to improve the printing durability without sacrificing the flexibility of fabric substrates, flexible coating materials such as silicone or polyurethane are favorable. Polyurethane protective coating dramatically saves conductive prints from losing electrical conductivity after several laundering cycles [6]. It is observed that the protective layer holds the conductive ink together even if cracks and breaks occur in the ink layer [7].

This research aims to investigate the effect of different types of protective coating on the mechanical and electrical performance of wearable antenna printed on a variety of fabric substrates. Single jersey, broadcloth, and denim are selected to simulate common fabrics for everyday clothing. Three different protective coatings made of acrylic resin, polyurethane, and silicone are applied to the fabric surfaces before and after the conductive printing, which are intended to improve the printability of the silver ink and to prolong the life of conductive path, respectively. Results will be useful in determining which type of protective coating is effective to support conductive printing on specific fabric substrates, and will be of interest to professionals working with e-textiles for a variety of applications, such as healthcare, recreation, entertainment, and the military.

2 Wireless Body Area Network (BAN)

Wireless transmission is the transfer of electrical energy over a distance through electromagnetic waves. It is necessary to satisfy smart clothing users as they do not like wires all over their body which might get caught, broken, and tangled. Depending on the area the network can cover, wireless transmission network is categorized into Wide Area Network (WAN), Local Area Network (LAN), and Personal Area Network (PAN). Recently, prompted by the rapid growth in wearable technology and smart clothing field, the concept of wireless Body Area Network (BAN) has attracted much interest. Wireless communication in a few centimeter ranges can be realized between a set of compact intercommunicating devices either worn or implanted in the human body.

Inductive coupling is one of the methods used to obtain the connectivity between the devices. Two inductors are referred to as 'inductively coupled' when one wirelessly transfers electrical energy to the other by means of a shared magnetic field [8]. Typically, an inductively coupled system uses a coil antenna which can cover less than one meter distance to transfer data and power [9]. The coupling efficiency dramatically improves if resonance is involved. A LC circuit resonates at a specific frequency when the circuit impedance maximizes. Resonant frequency (F_0) of a parallel LC circuit (Figure 1) is known as follows.

$$F_0 = \frac{1}{2\pi\sqrt{LC}} \tag{1}$$

where, F_0 = resonant frequency, L = inductance, and C = capacitance

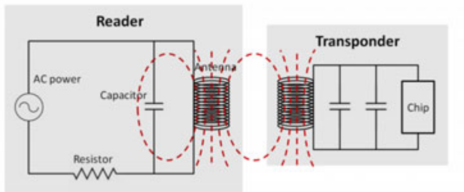

Fig. 1. A LC circuit inductively coupled

Inductive coupling is good to transfer electrical power and data signals wireless within a short distance. It is useful to transfer small packets of data without an integrated power supply. As a transponder is powered by the coupled magnetic field, it requires no battery and therefore, no interconnection to the power source [9]. Operating with low power consumption, inductive coupling is favored for continuous long-term communication. Also, inductive coupling is less sensitive to other radio frequency interferences [10] as it favors relatively lower frequency – typically, 13.56 MHz.

3 Fabric Antenna Production

Fabric antenna is produced by printing a spiral inductor on the various fabric substrates using silver conductive ink. Different types of protective coating are applied to secure the antenna area.

3.1 Material

Screen-printable silver ink is used as a conductive material. It contains 60% silver particle and its resistivity is reported as low as 2.5×10^{-7} Ω·cm. For the protective coating, silicone, polyurethane, and acrylic resin are selected as they are most common for conventional PCBs. Characteristics of the materials are specified in Table 1.

Table 1. Material Specifications

	Silver ink	Silicone	Polyurethane	Acrylic resin
Product	E-8205	422	4223	419B
Manufacturer	Sun Chemical®	MG Chemicals®	MG Chemicals®	MG Chemicals®
Solid content (%)	60	25	N/A	25
Viscosity (g/cm·sec)	25-30	0.11	1.8-2.4	2.2-2.4
Resistivity (Ω·cm)	2.5×10^{-7}	1.0×10^{14}	N/A	8.7×10^{15}

3.2 Fabric Substrate

Various fabric substrates are selected to print antennas such as denim, broadcloth, and jersey. Each is a fabric typically chosen for outer, inner, and underwear. Detailed information of the fabrics is given in Table 2. The print area is treated with the coating material identical to protective coating before the printing in order to improve the printability of the silver ink. The printed structure is shown in Figure 2.

Table 2. Fabric Substrate

Fabric Type	Structure	Fiber Contents (%)	Density (mg/cm^2)	Typical Applications
Denim	Twill weave	Cotton = 100	~42.8	Jackets, Pants
Broadcloth	Plain weave	Cotton = 100	~12.8	Dress shirts
Jersey	Sheer knit	Cotton = 100	~15.6	T-shirts

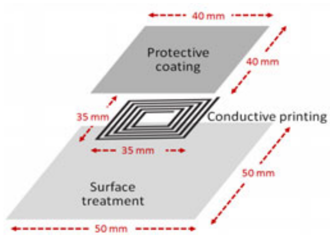

Fig. 2. Printed structure and dimensions

3.3 Antenna

Based on the literature [9, 11, 12], design for the antenna pattern (Figure 3) is created from a planar spiral inductor, which is 35mm × 35mm (Figure 2). It is manually printed on fabric substrates by screen printing using conductive silver ink. According to the ink manufacturer's recommendations, a screen frame is created with a polyester mesh of 230 tpi and the silver ink is cured at 90°C for 5-10 minutes after printing. This spiral inductor would serve as an antenna for wireless transmission within a few centimeter ranges at the frequency of 13.56 MHz.

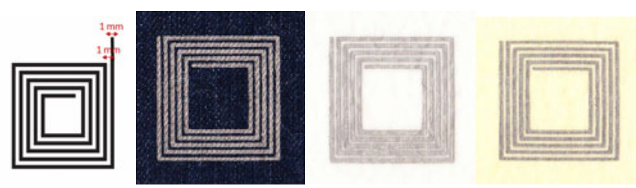

Fig. 3. Antenna pattern (*first*) printed on denim (*second*), broadcloth (*third*), and jersey (*last*)

4 Measurement

The fabric antennas are observed in terms of their mechanical properties before and after printing and coating to estimate the restrictions newly added by the antenna and protective layer. Electrical properties are tested by measuring resistance (R) and inductance (L) to evaluate the possibilities for a wireless transmission system. Mechanical performance is observed by measuring tensile, compression, bending, and air permeability characteristics. Fabric Assurance by Simple Testing (FAST) system is used to estimate extension and compression properties. Bending force and air permeability are accessed based on ASTM D4032 and ASTM D737, respectively. These measurements are listed in Table 3.

Table 3. Measurements for mechanical property

Property	Standard Method	Measures	Unit
Extension	FAST-3	Extension at three different loads	%
Compression	FAST-1	Compressible thickness	mm
Bending force	ASTM D4032	Force required to bend	N
Weight	N/A	Weight	mg/cm^2
Air permeability	ASTM D737	Amount of air passing through	$cm^3/sec \cdot cm^2$

Fabric specimens are prepared as the standard testing methods instruct. All fabrics are washed prior to any treatment or measurement based on ASTM D4265. This is done to eliminate residues of mill finishing agents which might influence the experimental results. Then, they are conditioned in the standard atmosphere (21°C and 65% R.H.) at least 16 hours. As instructed, fabric specimens are prepared in dimension of 50mm × 200mm for extensibility test and 100mm × 100mm for the rest of the tests. Antenna area is 50mm × 50mm (Figure 2) for every specimen and located on the center of the specimens.

Electrical performance of the printed antenna is analyzed with resistance and inductance. Resistance (*R*) is a property to oppose current flow and resistors dissipate electrical energy. Inductance (*L*) is typified by the behavior of a coil of wire to resist the change of electric current through the coil and inductors have ability to temporarily store electrical energy in the form of magnetic field surrounding them. Resistance and inductance are estimated using a network analyzer, Agilent Technologies, E5071B ENA series. Two-way ANOVA (Analysis of Variance) judges the significant difference in mechanical and electrical performance between the antenna systems printed on the various fabric substrates with different protective coating layers. Tukey's post hoc test is chosen for further analysis. SPSS 19 was used for analysis.

5 Result and Discussion

5.1 Mechanical Performance

Mechanical properties of the untreated fabrics are described in Table 4. Extensibility is measured at three different load levels (5, 20, 100 gf/cm) in both warp and weft directions. Compression is observed by subtracting the thickness at the pressure of 100 gf/cm^2 from the thickness at 2 gf/cm^2, which may represent for the amount of compressible thickness on the fabric surface [13]. Bending force is obtained from the maximum pressure applied to bend the fabric. Air permeability measures the amount of air volume passing through the fabric specimen per unit area and unit time.

Table 4. Mechanical Properties of Untreated Fabrics

Coating Type		Unit	Denim	Broadcloth	Jersey
E5	(warp)	%	0.0 (± 0.0)	0.0 (± 0.0)	2.7 (±0.7)
	(weft)	%	0.0 (± 0.0)	0.1 (± 0.1)	5.0 (±0.3)
E20	(warp)	%	0.3 (± 0.1)	0.5 (± 0.3)	11.4 (±0.8)
	(weft)	%	0.1 (± 0.1)	1.5 (± 0.4)	19.5 (±0.4)
E100	(warp)	%	3.2 (± 0.4)	1.9 (± 0.4)	17.6 (±4.3)
	(weft)	%	1.2 (± 0.1)	6.6 (± 0.3)	21.5 (±0.0)*
T2		mm	1.311 (± 0.042)	0.557 (± 0.014)	0.903 (±0.016)
T100		mm	1.020 (± 0.016)	0.361 (±0.006)	0.656 (±0.006)
T2-T100		mm	0.291 (± 0.291)	0.195 (±0.013)	0.247 (±0.013)
Bending force		N	12.0 (± 1.2)	0.7 (±0.1)	0.4 (±0.0)
Weight		mg/cm^2	42.8 (± 0.8)	12.8 (± 0.2)	15.6 (±0.2)
Air permeability		$cm^3/sec{\cdot}cm^2$	3.12 (± 0.07)	3.74 (±3.59)	57.57 (±1.19)

* 21.5% extension is the maximum measurement FAST system allows.

Tensile Property. All ANOVA models for the extension tests are very significant at 0.001 α-level. Significant difference by the fabric type is only observed with jersey fabrics (Table 5) which can be characterized by excellent extensibility as a knit fabric. The significance is primarily due to the significant difference between coated and non-coated fabrics (Table 6). Extensibility dramatically decreases after conductive printing and protective coating. As shown in Table 5, lower level extension (E5) does not have any significant difference among coating materials, while the difference between silicone and acrylic becomes apparent with higher level extension (E20, E100).

Table 5. Effect of Fabric Substrate on Antenna Extensibility (%)

Fabric Type	E5		E20		E100	
	(warp)	(weft)	(warp)	(weft)	(warp)	(weft)
Untreated Denim*	0.000^a	0.000^a	0.317^a	0.067^a	3.217^a	1.150^a
Untreated Broadcloth*	0.000^a	0.117^a	0.450^a	1.533^b	1.850^a	6.550^b
Untreated Jersey*	2.717^b	5.000^b	11.400^b	19.517^c	17.617^b	21.500^c
Denim	0.000^a	0.000^a	0.204^a	0.067^a	1.708^a	0.754^a
Broadcloth	0.008^a	0.050^a	0.208^a	0.663^b	$1.\ 025^a$	3.679^b
Jersey	0.992^b	1.668^b	5.367^b	9.263^c	10.713^b	18.563^c

(Superscript a, b, and c refer to the homogeneous subsets of the group)
* Untreated refers to bare fabrics where no antenna is printed and no coating is applied.

Table 6. Effect of Coating Material on Antenna Extensibility (%)

Coating Type	E5		E20		E100	
	(warp)	(weft)	(warp)	(weft)	(warp)	(weft)
Silicone	0.139^a	0.267^a	0.917^a	1.539^a	2.900^a	5.178^a
Polyurethane	0.122^a	0.283^a	1.200^{ab}	2.289^b	3.217^{ab}	7.444^b
Acrylic	0.167^a	0.061^a	1.533^b	2.246^b	4.250^b	8.306^c
Untreated*	0.906^b	1.706^b	4.056^c	7.039^c	7.5561^c	9.733^d

(Superscript a, b, c, and d refer to the homogeneous subsets of the group)
* Untreated refers to bare fabrics where no antenna is printed and no coating is applied.

The antenna area takes 50% of entire fabric specimen as the actual length fed in to the measurement is 100mm out of the 200mm. Most of extensibility must come from the bare fabric area, not from the antenna area. The antenna area is proven to contribute to the entire extensibility to some extent as extensibility is different depending on coating materials, but the level of extent could hardly be specified in this research. What can be verified from this research is that extensibility is reduced by approximately half to one third after the antenna system is applied (Table 5). Silicone provides the least extensibility and acrylic shows the most (Table 6).

Compression Property. ANOVA models are very significant at 0.001 α-level. As shown in Table 7, fabric thickness increased by ~0.3mm at 2 gf/cm^2 and ~0.2mm at 100 gf/cm^2 after the antenna system applied. Compression (T2-T100) of the fabric substrates becomes undistinguished as the antenna system is applied. Compression is known to be more related to the appearance or fabric hand than mechanical performance [13]. Silicone coating does not change fabric thickness significantly, while polyurethane and acrylic do. Compression (T2-T100) changes significantly after acrylic coating. It is only silicone that does not affect the thickness and compression of the fabric substrates (Table 8).

Table 7. Effect of Fabric Substrate on Compression of Fabric Antenna (mm)

Fabric Type	T2	T100	T2-T100
Untreated Broadcloth*	0.55650^a	0.36117^a	0.19533^a
Untreated Jersey*	0.90317^b	0.65600^b	0.24717^b
Untreated Denim*	1.31133^c	1.02033^c	0.29100^c
Broadcloth	0.88775^a	0.56917^a	0.31858^a
Jersey	1.22100^b	0.82271^b	0.39829^a
Denim	1.59321^c	1.17842^c	0.41479^a

(Superscript a, b, and c refer to the homogeneous subsets of the group)
* Untreated refers to bare fabrics where no antenna is printed and no coating is applied.

Table 8. Effect of Coating Material on Compression of Fabric Antenna (mm)

Coating Type	T2	T100	T2-T100
Untreated*	0.92367^a	0.67917^a	0.24450^a
Silicone	0.82744^a	0.72022^a	0.10722^a
Polyurethane	1.21311^b	0.95778^b	0.25533^a
Acrylic	1.97172^c	1.06989^c	0.90183^b

(Superscript a, b, and c refer to the homogeneous subsets of the group)
* Untreated refers to bare fabrics where no antenna is printed and no coating is applied.

Bending Property and Weight. Bending seems to be the property impaired most by the antenna system. The bending force is measured from the two-ply fabric specimens cut in 100mm × 100mm, respectively. The antenna area (50mm × 50mm) takes 25% of surface area. If 100% antenna area is tested, unrealistic numbers of bending force must have been reported.

The second column in Table 9 describes how dramatically the antenna system increases the bending force on every fabric substrate. Broadcloths and jerseys do not differ from each other, while denim fabrics have significantly huge bending force. Silicone has the least increase and polyurethane has the most (Table 10). This difference is very significant as much as the bending force becomes almost doubled for different coatings.

The third columns in Table 9 and Table 10 show the weight changes. Antenna system adds about 6-7 mg/cm^2 to fabric substrates. The change of weight depending on different coating materials is very significant. Silicone is the lightest (~7.1 mg/cm^2) and polyurethane is the heaviest (~10.8 mg/cm^2).

Air Permeability. Air permeability directly indicates thermal and moisture comfort of the fabric. Table 9 and Table 10 include the air permeability in its last columns. The antenna system diminishes air permeability by the one third of its original air permeability. This time, the antenna area covers about 65% of the fabric specimen area tested. Silicone coated antenna is the most permeable and polyurethane antenna is the least permeable.

Table 9. Effect of Fabric Substrate on Bending, Weight, and Air Permeability

Fabric Type	Bending force (N)	Weight (mg/cm^2)	Air permeability (cm^3/sec·cm^2)
Untreated Broadcloth*	0.717^a	12.800^a	33.7400^b
Untreated Jersey*	0.400^a	15.633^b	57.5733^a
Untreated Denim*	12.033^b	42.783^c	3.1250^c
Broadcloth	21.950^a	18.146^a	22.4917^b
Jersey	25.592^a	22.337^b	33.7979^a
Denim	113.163^b	50.104^c	2.3188^c

(Superscript a, b, and c refer to the homogeneous subsets of the group)

* Untreated refers to bare fabrics where no antenna is printed and no coating is applied.

Table 10. Effect of Coating Material on Bending, Weight, and Air Permeability

Coating Type	Bending force (N)	Weight (mg/cm^2)	Air permeability (cm^3/sec·cm^2)
Untreated*	4.383^a	23.739^a	31.4794^a
Silicone	33.672^b	30.850^b	17.9783^b
Acrylic	60.289^c	31.678^c	16.0544^c
Polyurethane	115.928^d	34.517^d	12.6322^d

(Superscript a, b, c, and d refer to the homogeneous subsets of the group)

* Untreated refers to bare fabrics where no antenna is printed and no coating is applied.

5.2 Electrical Performance

Electrical performance of printed antenna is evaluated by measuring resistance and inductance. Low resistance and high inductance are observed when the conductive ink is printed on the fabric surface consistently and reliably. Fabric substrates have significant effects on antenna resistance, while coating materials influence antenna inductance.

Resistance. Polyurethane-coated antennas exhibit significantly low resistance (Table 11). The solvent used in silicone and acrylic, which is xylene or acetone, is considered to penetrate the silver ink layer impairing its conductivity. Polyurethane which does not contain solvent component could secure the silver ink layer successfully compared to silicone and acrylic.

Table 11. Effect of Coating Material on Resistance and Inductance

Coating Type	Resistance (Ω)	Inductance (nH)
Polyurethane	52.06[a]	940.07[a]
Acrylic	137.85[b]	785.84[a]
Silicone	158.78[b]	764.63[a]

(Superscript a and b refer to the homogeneous subsets of the group)

Inductance. Significantly superior inductance appears on denim and jersey antennas (Table 12). Due to its light weight and low fabric density, broadcloth does not have enough capacity to hold the large volume of coating materials applied by surface treatment before printing, and this might result in low antenna quality.

Table 12. Effect of Fabric Substrate on Resistance and Inductance

Fabric Type	Resistance (Ω)	Inductance (nH)
Denim	100.23[a]	905.31[a]
Jersey	114.94[a]	922.46[a]
Broadcloth	122.42[a]	624.37[b]

(Superscript a and b refer to the homogeneous subsets of the group)

6 Conclusion

The experimental results show that the selection of fabric substrates and coating materials needs to be considered after evaluating every mechanical and electrical performance. For example, silicone-coated antennas are extended the least which might be a weak point from comfort side, but regarded also as a strong point from antenna protection point of view. This research does not extend its scope to durability of the antenna against the mechanical deformation. It has been reported from previous research [6, 7] that protective coating could prolong the lifetime of conductive prints successfully.

Silicone-coated antennas are reported to be the most flexible, while polyurethane-coated ones are most rigid. However, polyurethane-coated antennas exhibit significantly low resistance, which is beneficial to establish powerful wireless transmission. Acrylic is measured better than polyurethane in bending and air permeability, but in fact, acrylic does not show any recovery from the deformation, while polyurethane or silicone does. Acrylic antenna results in permanent deformation such as cracks on its surface after the mechanical deformations, which must disqualify it as proper protective materials.

As another variable affecting the mechanical property of the fabric antenna, the percentages of antenna area over the entire fabric specimen will be of interest for future research. Further steps of this research will include the measurement of actual wireless transmission between two fabric antennas when resonance is involved.

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The Effects of Font Size and Page Presentation Method of E-Book Reading on Small Screens for Older Adults

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Abstract. It is predictable that the E-book market would attract more and more older customers, and has the potential benefits for older adults to interact with technology and enjoy the reading pleasure. The main purpose of this research is to investigate the effects with font sizes and page presentation methods for the E-Book reading performance. 24 older adults, ages 62 to 70, participated in the study. Reading speed and accuracy were measured and subjective satisfaction assessment of older adults recorded. The results indicate that reading with flip page method of E-book caused significantly higher reading speed than reading with scrollbar page method. Subjective results showed that older adults preferred 14 font size and more positive comments showed a preference with flip page presentation method.

Keywords: Older adults, E-book, Font size, Page presentation method.

1 Introduction

Recently, the ‘‘E-book” was introduced into the market as one kind of personal digital information service. Total sales in 2003 amounted to $10 million representing an increase of more than 32% over 2002 [1]. The E-book is a new information technology product that facilitates reading and acquisition of information. It is a written work readable on the screen of PC or handheld device: mobile phone, PDA (personal digital assistant), and reader specifically designed for the purpose (I-Pad, Amazon Kindle, Nook). Different company also developed various applications for the E-book reading platform (iBook, B&N eReader, Kindle, Stanza, Kobo, etc). Under this trend, more and more people would like to start changing their reading habit to read the E-book via different kinds of device. Also, usability research studies about E-book issue focused on investigating the effect of reading performance from paper and screen and the relationship between reading speed, accuracy, comprehension, fatigue, preference and reading performance. Mayes et al. [2] showed that subjects take longer to read text on a screen than on paper. As for accuracy, Egan et al. [3] reported that students using digital hypertext on a screen to find out specific information in the text had higher accuracy than students using the paper text. For reading comprehension, Dillon and Gabbard [4] concluded that comprehension when reading from a screen is better than reading from paper when performing substantial searching or manipulation and

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comparison of visual details among objects. Some studies have investigated on how to display textual information on small screens. For example, presenting text dynamically on screens (e.g. vertical scrolling) [5] and analyzing web design guidelines for applicability to small screen interfaces [6]. Recommendations for text sizes from previous studies have indicated font size 14 for children [7], font size 14 for older adults [8], and font size 12 for young to middle-aged adults [9]. The Kang compared the differences between reading an E-book and a conventional book (C-book) with objective measures. The results indicate that reading an E-book causes significantly higher eye fatigue than reading a C-book [10]. Furthermore, Siegenthaler et al. [11] investigated the requirements of e-reader design and tested five electronic reading devices and one classic paper book. The results showed that the current e-reader generation has large deficits with respect to usability. Users were unable to use e-readers intuitively and without problems.

Therefore, developers followed these research results and better designed a series of E-book reading application to fit for personal reading requirements and improve the insufficient parts for the E-book interface. The main goal is to provide a reading experience as close as possible to the clarity and the lack of glare found with print books. Current E-book interface offered some tailored functions: Font, sizes, text background, page flip type, and page layout for users to adjust. Ideally, such an E-book reading would allow the user to pick the most comfortable presentation and be able to reflow the content for that setting. Furthermore, a lightweight E-book reading with friendly interface would be easy for users to hold and manipulate.

However, apart from the current usability studies and implications about E-book, seldom researches and developers had focused on the older adults readers. As the oldest Baby Boomers become senior citizens in 2011, the population 65 and older is projected to grow faster in Taiwan. According to the investigation of older adult' leisure activities in Taiwan, reading newspaper and book is one of the major recreation in their daily life [12]. It is predictable that the E-book market would attract more and more older customers, and has the potential benefits for older adults to interact with technology and enjoy the reading pleasure. Furthermore, these portable and handheld e-book approaches are also convenient for older adults to catch the information at their preferred time and place. However, in Taiwan, most of the current E-book readers are with small screen, like mobile phone and PDA. A lot of aging decline changes on motor, perceptual and cognitive abilities could affect the text reading and performance on the small screen reader device. Older adults may struggle with E-books, magazines and newspapers because of the declined aging effects.

As mentioned before, the previous studies were targeted on younger adults with computer or other small screen device usage, but few data are available on how different variables vary with E-book reading performance and comprehension for older adults. Under this circumstance, we need to have an insight on the E-book interface that is easy to use and quick to learn for older adults. Apparently, the E-books might be the solution in many cases with appropriate design and resolutions available for older adults as well. Many older adults will not consider an E-book interface if they have to invest several hours or days to learn how to use it.

In this paper, we chose the mobile phone as an E-book reader device. The reason is the current released E-book approaches are popular in this device, and it corresponds for the small screen device features. Reading E-book from an electronic interface of small screen is completely different than reading a conventional book. The reading behavior and visual demand when using an E-book require further study. In this study, we selected two most common elements (font size and page presentation method) as the variables on the base of previous E-book research studies. We aim to elicit an indication of a suitable font size to use under different page presentation methods on small screen devices and determine whether concrete font sizes and page presentation methods are required when designing E-book for older people. Therefore, it may be expected that there will be differences of font size, page presentation methods and reading performance on small screen display, especially for older adults. We also investigate the user satisfaction to get better understanding for the subjective evaluation on E-book reading under different situations. The next section outlines the experiment used in this study. The results from the experiment are then presented and discussed. Some areas for further investigation are suggested. Finally the conclusions drawn from our experiences are given.

2 Methods

The experiment was a 3 x 2 factor between-subjects design. The first factor was font size (three levels: 10, 12, and14 point) and the second factor was page presentation method (two levels: Scrollbar page and Flip page, Figure.1). Based on the factorial design, there are totally six articles composed of designated levels for the experiment. One article assigned four participants to read. Their response measures included reading performance (speed and accuracy) and subjective satisfaction assessment.

(a) (b)

Fig. 1. The illustration of page presentation method: (a) scrollbar page and (b) flip page used in this study

2.1 Participants

In this study, we invited 24 older adults took part in the E-book reading performance test and satisfaction investigation. All participants were fluent in Chinese as their first language and educated to at least secondary/high school level. The 12 females and 12 males were between the ages of 60 and 75 years (mean = 64.8, SD = 5.72). They were required to have at least 20/25 visual acuity with corrective lenses and to be without physical or mental problems. They were also requested not to stay up late, take medicine, alcoholic drinks and any other substance that might possibly affect the test results. All subjects had no previous experience using the E-book. A small gift was given to participants as payment for taking part.

2.2 Equipment

An HTC HD2 (www.htc.com.tw) which has a 65,000 color TFT capacitive touch screen with a resolution of 480x800 pixels was used to present the E-book text (see Figure 1). This has the optimal quality screen available. The screen was backlit and participants sat in a usability lab which was illuminated by overhead fluorescent lights. The HTC HD2 used the Microsoft Windows Mobile 6.5 professional operating system and had Clear Type enabled to anti-alias the edges of fonts to improve quality. The touch screen could allow the participants use the finger to control the paper turning function. Adobe Flash software was used to present the experimental texts and page presentation method. An example of the software running on the HTC HD2 is shown in Figure 1.

2.3 Materials

The standard Microsoft Ming type Chinese characters was chosen for displaying text since it has been found that is the most frequently used font for Chinese textual information and is also known as the standard writing type. Text was presented to participants at font sizes 10pt、12pt and 14pt. Examples of each size are shown in Figure 1.

Two different page presentation methods of E-book were used. The “scrollbar page” is a page function used frequently in a graphical user interface (GUI) with which continuous text, pictures or anything else can be scrolled. Scrollbars are present in a wide range of electronic devices including computers, graphing calculators, mobile phones, and portable media players. They usually appear on one or two sides of the viewing area as long rectangular areas containing a bar (or thumb) that can be dragged along a trough (or track) to move the body of the document as well as two arrows on either end for precise adjustments. In the E-book reading, participant can use their finger to drag the bar for turning pages back and forth.

Flip page refers to the effect of flipping through the pages of a digital document as if it were a physical document. A flip page application is often made in Adobe Flash and requires the Adobe Flash Player to run in a browser interface. The benefit of having a flip page document is that it affords the user experience of reading an actual copy of a physical document or magazine. The technology is commonly used by traditional publishers that want to create (and spread) a digital version of their physical document/paper/magazine.

2.4 Reading Performance and Subjective Satisfaction

In the experiment, all subjects read one articles as the E-book demonstration test. Each subject spent about 5 to 10 minutes to read passages page by page with an average of

Chinese characters in each article. There were three reading test questions after article reading. The test was recall-type questions. For example, ‘‘What are the critical ingredients could promote assimilated calcium for human beings?” or ‘‘What are the best prepared time for preventing suffered from Osteoporosis?” Subjects were required to answer correct selections for specific information in the text. Both reading speed and reading accuracy (proportion of correct recall) were taken as performance measures.

2.5 Experiment Procedure

A standard laboratory desk and chair were provided for experimentation. The experiment environment was standardized. Prior to the experiment each participant was instructed about the purpose and procedure of the study. Participants were asked hold the HD2 and to read the passages from a comfortable position and were told that they could bring the HD2 closer to the face if necessary. The article was randomized for each participant. At the beginning of each reading session, the participant was then asked to read one health-care issues article and then take a reading recall test. Instructions were given to only say the erroneous word(s) and nothing else while reading a passage and keep questions/comments for the breaks between passages. Both reading speed and reading accuracy (proportion of correct recall) were measured. After being presented with an initial set of 6 articles to read, participants were requested to answer the subjective satisfaction on what they thought of the different text sizes and page presentation method of the E-book by 5 point Likert scale. For the analysis of the data, this study applied Two-way Analyses of Variance (ANOVA) to examine significant differences of the reading performance and accuracy. In addition, the significant differences were analyzed by utilizing the Scheffe Method as the post hoc test for multiple comparisons. Significance was accepted at the level of $p<.05$, while the degrees of freedom and corresponding probability, or the F-value, were also shown in the statistical test. In all, the statistical analysis was conducted by utilizing the Windows SPSS Statistics 18 Program.

3 Results

3.1 Reading Performance

Reading performance was measured by reading speed and reading accuracy (proportion of correct recall). Table 1 shows the average performance of reading on E-books. These findings indicated that there is no significant interaction effect among the reading speed [$F(2, 18) = 0.93$, $p > .05$] and reading accuracy [$F(2, 18) = 0.60$, $p > .05$, in all cases] for older adults in the experiment. The effects of two independent variables, Font size and page presentation method, were explored (Table 2). The analysis of variance indicated that only the page presentation method [$F(1, 18) = 5.60$, $p < .05$] affected reading speed of the older adults. Though there was a slight decrease in reading time at font size 14 it was not statistically significant. Therefore, we continue perform the post hoc multiple comparisons in order to understand the difference between these two page presentation method level. The post hoc multiple comparisons were integrated and are shown in tables 3 in this study.

Table 1. The ANOVA results

Factor	Reading Performance	
	Reading Speed	Reading accuracy
Font Size (A)	-	-
Page Presentation Method (B)	*	-

*: $p < 0.05$.

Table 2. Significant analysis of two independent variables on reading speed

Source of Variances	Sum of square	Df	MS	F	P value
Text Size (A)	4823.5	2	2411.7	0.74	0.487
Page Presentation Method (B)	16287.5	1	16287.5	5.60	0.037*
A * B	5994.05	2	2997.02	0.93	0.412
Error (A * B)	57932.07	18	3218.4		

*: $p < 0.05$.

Table 3. Results of reading speed on page presentation method and text size

Source of Variances	Presentation Method*		Font Sizes		
	Scrollbar	Flip Page	10 point	12 point	14 point
Time(unit: seconds)	134.86	82.75	115.77	121.61	89.04

According to the results of the ANOVA, there was a significant difference with the page presentation method on the reading speed of total times. For both page presentation methods, the performance of total time was larger on the scrollbar page than on flip page method (Table 3).

3.2 Subjective Satisfaction Results

It is important to consider whether there are no any significant differences between font size and old participant's subjective satisfaction or whether preferences change between scrollbar page and flip page. However, older adults' comments on specific font size and flip page presentation method were examined and recorded on protocol content. Older adults expressed that they preferred 14 point font size with flip page presentation method, received more desirable comments, both fairly neutral.

Furthermore, the majority of 70% of participants also agreed that flip page presentation method was desirable for the E-book usage. On the other hand, scrollbar page had a negative rated from older adults, especially while font size 10 was considered.

4 Discussions

The results show that objective measures (time and accuracy) of reading performance are not affected significantly by changes in font size, but only affected by the page presentation method for older adults. Even the time needed to read the text and the reading accuracy did not differ between the different font sizes. It could also be mentioned the fact that participants had the possibility to get accustomed to the current font size probably on a small screen display. However, older adults still complained about reading the small text on the E-book is tired and exhausted. It could because of reading distance was inconstant and font size in the E-book was very small, some participants (especially older participants) reported problems with reading. The possible reason for the time increased could due to the eye fatigue with small font size. Therefore, larger font size can efficiently lower eye-movement fatigue and lead to better usability and also to better legibility in the E-book reading. Otherwise, as font size increases the number of pages will add. Increasing font size inevitably results in a higher number of pages and, as a consequence, more page-turns. Interestingly, older adults do not afraid turning too many pages, but did feel frustrated with the small font sixe. Even though there was no significant effect on reading performance, the big font size of the E-book was somewhat preferred than that of the small font size.

Actually, in our research, the reading performance was only affected by the page presentation method. Flip page presentation method take a shorter time than the scrollbar page method. Obviously, the digital displays of E-books have become more sophisticated and are increasingly realistic present. The visual appearance with flip page is intuitive for the older adults. Therefore, older adults can turn page easily between pages. In particular, older adults responded the page-turns with scrollbar still take more delayed seconds. The scrollbar page were required the older adults to achieve higher manual dexterity demand. Because of the aging effects on hand ability, it is hard to scroll a "page" slightly while finish the reading page. A possible explanation is that even the scrollbar function is a common function in electronic interface, it could be a different situation used on a small touch screen E-books, which requires more detailed scrolling action within the passages changes.

The E-book technology for small screen devices is changing rapidly for the better. The e-link technique used in the future version of the readers make the text and characters much easier to see at small sizes. This indicates that our findings may not be applicable to future displays with improved resolutions. However, our findings that a bigger font sizes is preferred by older adults are likely to be the same for future screens, with the bounds of the range changing with resolution changes.

5 Conclusions

This study evaluated the performance and subjective satisfaction of reading an E-book with two kinds of variables (font size and page presentation method). Although there were no significant differences on font size in reading performance or accuracy due to aging deficiency, there was variation in older adults' subjective preferences on the font size used. The results indicate that page presentation method caused significantly difference on higher performance with than scrollbar page in E-reading. This is mainly due to the intuitive concept of the display for an E-book. Since the reading habit for E-books was different with conventional books, especially for older adults. There are more issues needed to take into consideration. Moreover, E-book reading will become a promising trend for future development. Therefore, the establishment of current research results for optimized E-book design is of great significance.

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Product Form Feature Selection for Mobile Phone Design Using LS-SVR and ARD

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Abstract. In the product design field, it is important to pin point critical product form features (PFFs) that influence consumers' affective responses (CARs) of a product design. In this paper, an approach based on least squares support vector regression (LS-SVR) and automatic relevance determination (ARD) is proposed to streamline the task of product form feature selection (PFFS) according to the CAR data. The representation of PFFs is determined by morphological analysis and pairwise adjectives are used to express CARs. In order to gather the CAR data, an experiment of semantic differential (SD) evaluation on collected product samples was conducted. The LS-SVR prediction model can be constructed using the PFFs as input data and the evaluated SD scores as output value. The optimal parameters of the LS-SVR model are tuned by using Bayesian inference. Finally, an ARD selection process is used to analyze the relative relevance of PFFs to obtain feature ranking.

Keywords: Feature selection, Least squares support vector regression, Automatic relevance determination, Bayesian inference.

1 Introduction

The way a product looks is one of the most important factors affecting a consumer's purchasing decision. Traditionally, the success of a product's design depended on the designers' artistic sensibilities, which quite often did not meet with great acceptance in the marketplace. Many systematic product design studies have been carried out to get a better insight into consumers' subjective perceptions. The most notable research is Kansei engineering (KE) [1]. The basic assumption of KE studies is that there exists a cause-and-effect relationship between product form features (PFFs) and consumers' affective responses (CARs) [2]. Therefore, a prediction model can be constructed from collected product samples and the CAR data. Using the prediction model, the relationship between PFFs and CAR can be analyzed and a specially designed product form for specific target consumer groups can be produced more objectively and efficiently. The construction of the prediction model can be regarded as a function estimation problem (regression) taking PFFs of collected product samples as

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input data and the CAR data as output values. Various methods can be used to construct the prediction model including multiple linear regressions (MLR) [3] quantification theory type I (QT1) [4], partial least squares regression (PLSR), neural networks (NN) [5] and support vector regression (SVR). Of these methods, SVR's remarkable performance makes it the first choice in a number of real-world applications [6] but it has not been adapted to the product design field according to our knowledge.

It is an important issue in KE [2], that the problem of product form feature selection (PFFS) according to consumers' perceptions has not been intensively investigated. The subjective perceptions of consumers are often influenced by a wide variety of form features. The number of form features could be many and might be highly correlated to each other. Therefore, manual inspection of the relative importance of PFFs and finding out the most critical features that please consumers is a difficult task. In the product design field, critical design features are often arrived at based on the opinions of experts or focus groups. However, the selection of features based on expert opinion often lacks objectivity. Only a few attempts have been made to overcome these shortcomings in the PFFS process. For example, [2] used several traditional statistical methods for screening critical design features including principal component regression (PCR), cluster analysis, and partial least squares (PLS). In the study of [7], a genetic algorithm-based PLS method is applied to screen design variables.

In our previous study [8], a PFFS method for SVM-RFE based on a multiclass classification model of product form design was proposed. Unlike the classification-based feature selection method, such as SVM-RFE, which is based on the consumer's judgment to discriminate the product form design from each other, the regression-based feature selection method, such as ARD used in this study, treats the PFFS problem in a different manner. This study proposes an approach based on least squares support vector regression (LS-SVR), as a variant of the SVR algorithm and ARD to deal with the PFFS problem. A similar backward elimination process of SVM-RFE is used to gradually screen out less important PFF based on the soft feature selection mechanism of ARD. PFFs used as input data and the CAR scores gathered from the questionnaire as output values are used to construct the LS-SVR prediction model. The optimal values of the parameters of the LS-SVR model are determined by Bayesian inference. ARD as a soft-embedded feature selection method is used to determine the relevance of PFFs based on the constructed LS-SVR model. The remainder of the paper is organized as follows: Section 2 presents the outline of the proposed PFFS method. Section 3 introduces the theoretical backgrounds of the LS-SVR algorithm and the ARD method for feature selection. A detailed implementation procedure of the proposed method is given in Section 4. Section 5 demonstrates the results of the proposed method using mobile phone designs as an example. Finally, Section 6 presents some conclusions and discussions.

2 Outline of the Proposed Method for Product form Feature Selection

The procedure of the proposed method for PFFS comprises the following steps:

1. Determine the product form representation using morphological analysis.

2. Conduct the questionnaire investigation for semantic differential (SD) evaluation to gather the CAR data on product samples.
3. Construct the LS-SVR prediction model based on PFFs and the pairwise adjectives.
4. Analyze the relative relevance of PFFs and obtain feature ranking using the ARD selection process.

3 Theoretical Backgrounds

3.1 Least Squares Support Vector Regression

This section briefly introduces the algorithm of LS-SVR. A training data set D of l data points are given, $(x_1, y_1)\ldots(x_l, y_l)$ (Eq. 1), where $x_i \in R^n$ is the input data, $y_i \in R$ is the desired output value. LS-SVR begins with approximating an unknown function in the primal weight space using the following equation $f(x) = w \cdot \phi(x) + b$ (Eq. 2), where $w \in R^k$ is the weight vector and $\phi(\cdot): R^n \to R^k$ is a nonlinear function that maps the input space into a higher dimension feature space. By introducing the quadratic loss function into LS-SVR, one can formulate the following optimization problem in the weight space

$$\text{minimize } \frac{1}{2}\|w\|^2 + C\frac{1}{2}\sum_{i=1}^{l}\xi_i^2 \tag{3}$$

subject to the equality constraints

$$y_i = w \cdot \phi(x_i) + b + \xi_i,\ i = 1,\ldots,l \tag{4}$$

where $C > 0$ is the regularization parameter, b is a bias term, and ξ_i is the difference between the desired output and the actual output. When the dimension of w becomes infinite, one cannot solve the primal problem in Eq. (3). The dual problem can be derived using the Lagrange multipliers method. The mapping ϕ is usually nonlinear and unknown. Instead of calculating ϕ, the kernel function K is used to compute the inner product of the two vectors in the feature space and thus implicitly defines the mapping function $K(x_i, x_j) = \phi(x_i) \cdot \phi(x_j)$ (Eq. 5). The following are three commonly used kernel functions [1]: linear: $x_i \cdot x_j$ (Eq. 6), polynomial: $(1 + x_i \cdot x_j)^p$ (Eq. 7), radial basis function (RBF): $\exp(-\frac{\|x_i - x_j\|^2}{\sigma^2})$ (Eq. 8), where the indices i and j correspond to different input vectors. p in Eq. (7) and σ in Eq. (8) are adjustable kernel parameters. In an LS-SVR algorithm, the kernel parameter and the regularization parameter C are the only two parameters that need to be tuned, which is less than that for the standard SVR algorithm. In the case of the linear kernel, C is the only parameter that needs to be tuned. The resulting LS-SVR prediction function is $f(x)=\sum_{i=1}^{l}\alpha_i K(x,x_i)+b$ (Eq. 9). For detailed deviations of the LS-SVR algorithm the authors refer to the textbook of [2].

3.2 Feature Selection Based on Automatic Relevance Determination

In this study, ARD is used to perform the soft feature selection, which is equivalent to determining the relevant dimensions of the n-dimensional input space using Bayesian inference. The simplest form of ARD can be carried out by introducing the standard Mahalanobis kernel [3] as $K(x_i,x_j)=\exp(-\sum_{d=1}^{n}\frac{\left\|x_i^d-x_j^d\right\|^2}{\sigma_d^2})$ (Eq. 10), where x_i^d denotes the dth element of input vector x_i, $d=1,\ldots,n$. The Mahalanobis kernel can be regarded as a generalized RBF kernel in Eq. (8), which has a separate length scale parameter σ_d for each input space. The influence of the dth feature in the input space can be adjusted by setting larger or smaller values of σ_d. The Bayesian inference of ARD is then implemented by minimizing an objective function and the relevance of each input can be determined automatically according to the optimized σ_d values. However, the objective function often converges very slowly and results in very large values of optimized σ_d when using the standard Mahalanobis kernel. As a consequence, an augmented Mahalanobis kernel with an additional two parameters is adapted as $K(x_i,x_j)=\kappa_a\exp(-\sum_{d=1}^{n}\frac{\left\|x_i^d-x_j^d\right\|^2}{\sigma_d^2})+\kappa_b$ (Eq. 11) [4], where $\kappa_a>0$ denotes the amplitude parameter and $\kappa_b>0$ denotes the offset parameter. The parameters $\{\kappa_a,\sigma_1,\ldots,\sigma_n,\kappa_b\}$ can be determined simultaneously during the optimization process. The ARD process for PFFS combined with Bayesian inference for parameter tuning is described in Section 4.5. For detailed derivations of Bayesian inference for ARD, the authors recommend the textbook of [2].

4 Implementation Procedures

This study implements a method for PFFS by considering the case study of mobile phone design. The detailed procedures are described in the following paragraphs.

4.1 Determination of Product Form Representation

In this aspect of form representation for product design, this study adopted morphological analysis [5]. In fact, morphological analysis in KE studies is the most widely used technique in KE due to its simple and intuitive way to define PFFs. The mixture of continuous and discrete attributes is also allowed. Practically, the product is decomposed into several main components and every possible attribute for each component is examined. For this study, a mobile phone was decomposed into body, function button, number button and panel. Continuous attributes such as length and volume are recorded directly. Discrete attributes such as type of body, style of button etc. were represented as categorical choices. Twelve form features of the mobile phone designs, including four continuous attributes and eight discrete attributes, were used. The list of all PFFs is (X1) length of body, (X2) width of body, (X3) thickness of body, (X4) volume of body, (X5) type of body, (X6) type of function button, (X7) style of function button, (X8) shape of number button, (X9) arrangement of number button, (X10) detail treatment of number button, (X11) position of panel, (X12) shape of panel. Notice that the color and texture information of the product samples were ignored and emphasis was placed on the form features only. The images of product samples used in the experiments described in Section 4.2 are converted to gray image using image-processing software.

4.2 Experiment and Questionnaire Design

A total of 69 mobile phones of different design were collected from the Taiwan marketplace. Three pairwise adjectives including traditional-modern, rational-emotional and heavy-handy were adopted for SD evaluations [6]. In order to collect the CAR data for mobile phone design, 30 subjects (15 of each sex) were asked to evaluate each product sample using a score from -1 to +1 in an interval of 0.1. In this manner, consumers can express their affective response toward every product sample by choosing one of the pairwise adjectives.

4.3 Construction of the LS-SVR Prediction Model

LS-SVR was used to construct the prediction model based on the collected product samples. The form features of these product samples were treated as input data while the average utility scores obtained from all the consumers were used as output values. Since LS-SVR can only deal with one output value at a time, three prediction models were constructed according to the selected adjectives. Since the relationship between the input PFFs and the output CAR score is often nonlinear, the frequently used methods such as MLR [7] and QT1 [8], which dependent on the assumption of linearity, can not deal with the nonlinear relationship effectively. SVR has proved to be very powerful when dealing with nonlinear problems. Compared to the standard SVR algorithm, LS-SVR has higher computing efficiency and fewer parameters that need to be determined.

The performance of the LS-SVR model is heavily dependent on the regularization parameter C and the kernel parameters. In order to balance the trade off between improving training accuracy and prevent the problem of overfitting, conducting a grid search with cross validation (CV) is the most frequently adopted strategy in the literature. In this study, tuning the parameters of the LS-SVR model using Bayesian inference can avoid the time-consuming grid search with CV.

4.4 The ARD Process for PFFS

By using the ARD technique, the relevance of PFFs can be determined in a ‘soft’ way by introducing the augmented Mahalanobis kernel in Eq. (11). The selection mechanism of features is embedded in the Bayesian inference. Small values of σ_d will indicate the high relevance of the dth input; while a large value will indicate that this input is less relevant with the other inputs. As a consequence, a reverse elimination process similar to that of SVM-RFE can be used to prune off the least relevant features with the largest value of σ_d. This process is repeated until all features are removed. The complete feature selection procedure based on LS-SVR and ARD is described as follows:

1. Preprocessing the form features;
2. Optimize the regulating parameter C and the parameter σ of the RBF kernel using Bayesian inference;
3. Use the optimized value of σ obtained in Step (3) as the initial values $\sigma_1 = \sigma_2 = \ldots = \sigma_n$ of the augmented Mahalanobis kernel with initial values of $\kappa_a = 1$ and $\kappa_b = 0$;
4. Start with an empty ranked feature list $R = []$ and the selected feature list $F = [1,...,d]$ with all features;
5. Repeat until all features are ranked:
   (a) Find the feature e with largest value of σ_d using feature list F;
   (b) Store the optimized parameter σ_d for the remaining features;
   (c) Remove the feature e from the feature list F;
   (d) Inset the feature e into feature list R: $R = [e, R]$;
   (e) Re-calculate the parameter C for the training data using the feature list F;
   (f) Re-calculate the initial value of the parameter σ for the training data using the feature list F.
6. Output: Ranked feature list R.

The overall ranking of PFFs can be determined by the resulting feature list R. The relative relevance of each feature in each elimination step can be analyzed by examining the optimized values of σ_d. Note that in each step of the selection procedure, the regulating parameter C and the initial value of parameter σ need to be re-calculated after eliminating the least important feature in order to obtain optimal prediction performance.

5 Experimental Results and Analyses

5.1 Effects of Optimization Algorithms for ARD

Since the Bayesian inference of ARD involves minimizing an objective function, the choice of the optimization algorithm has a great influence on the obtained results. In this study, two algorithms: the steepest descent method and the BFGS method were investigated. In order to examine the effects of the algorithms, the parameters $\kappa_a = 1$ and $\kappa_b = 0$ were fixed to the standard Mahalanobis kernel in Eq. (10). The pairwise adjectives "traditional-modern" were taken as an example and the results of the first

ARD step with the original twelve input features are shown in Figure 1. Notice that the value of the objective function declines quickly in the first few iterations in both algorithms. However, the BFGS method takes fewer (about 1/10) iterations than that of the steepest descent to reach minimization. In addition, the optimized σ_d values obtained by the BFGS method were much larger (about 100 times) than that of the steepest descent. These observations indicate that the BFGS method converges more dramatically than that of the steepest descent. More specifically, the values of σ_d in steepest descent change very steadily after the 100th iterations. The values of σ_d in the BFGS method increase rapidly after only 10 iterations (35th~45th) and the maximum σ_d (least important feature, X11) was about 250 times larger than the minimum σ_d (most important feature, X3). As for steepest descent, the maximum σ_d (X11) was only 25 times larger than the minimum σ_d (X3).

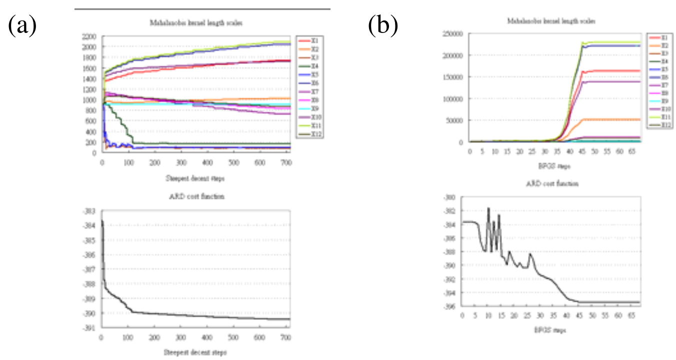

Fig. 1. Step 1 of Bayesian inference on length scales (traditional-modern) using (a) steepest descent method and (b) BFGS method with fixed $\kappa_a = 1$ and $\kappa_b = 0$

After examining the previous analysis using standard a Mahalanobis kernel, the steepest descent method was favored to obtain the feature ranking due to its steady convergence properties. However, it may suffer from not really reaching the minimum of the objective function compared to the BFGS method due to its slow convergence. This problem can be easily overcome by introducing the augmented Mahalanobis kernel with additional parameters in Eq. (11) to accelerate the convergence while still maintaining a steady variation of σ_d. Another issue is when to stop the iteration process in each elimination step. Since most applications of ARD emphasize improving the generalization performance of the prediction model, the iteration of ARD is often set to stop when the training error, e.g. root mean squared error (RMSE), becomes smaller than a pre-defined threshold. However, in the proposed method, the initial values of σ_d were first optimized using the RBF kernel and the initial state of the LS-SVR model had already achieved a relatively low training error. As a consequence, the training error of the LS-SVR did not improve significantly during the ARD iteration process. In this study, another stopping criterion was used.

Concerned that the difference between the form features perceived by the consumers should be kept to a reasonable proportion, the stopping criterion of each elimination is triggered when the proportion of the maximum σ_d to the minimum σ_d exceeds to a pre-defined threshold. The purpose of this study is to analyze the relative relevance of the form features as well as to obtain the feature ranking; how to provide a meaningful comparison between the features is our main concern. In this manner, when the relevance of one feature is small enough, that is, the σ_d of this feature is larger than the other features and thus can be eliminated. In each elimination step, the feature with the largest value of σ_d will be pruned off and the feature ranking obtained.

5.2 Predictive Performance of the LS-SVR Model with ARD

In order to examine the effectiveness of Bayesian inference applied on the LS-SVR model with ARD, the predictive performance is compared with a typical LS-SVR model (RBF kernel) using a grid search with LOOCV and an MLR model. The predictive performance was measured by using RMSE. A grid search with LOOCV is taken using the following sets of values: $C = \{10^{-3}, 10^{-2.9}, ..., 10^{2.9}, 10^{3}\}$ and $\sigma^2 = \{10^{-3}, 10^{-2.9}, ..., 10^{2.9}, 10^{3}\}$. An optimal pair of parameters is obtained from with the lowest RMSE value from the grid search.

Figure 2 shows the predictive performance of the prediction models for the "traditional-modern" pairwise adjective. The blue solid and red dash lines are the original and predictive adjective scores of all the training product samples respectively. For the result shown in Figure 2(a), the parameter C and the parameter σ of the RBF kernel, obtained by Bayesian inference before applying ARD, was $(C, \sigma^2) = (2.4156, 911.09)$. The performance of the model produced the result of RMSE = 0.147. The training result after applying ARD is shown in Figure 2(b). The optimal parameter sets $(C, \sigma^2) = (2.4156, 911.09)$ was used as the initial values of ARD. The performance of the ARD model using the augmented Mahalanobis kernel was more accurate and improved to where the RMSE = 0.036. The improved performance of the ARD model benefits from the soft feature selection mechanism by gradually adjusting the influence of each feature in the Bayesian inference process. As for the result of LS-SVR with LOOCV shown in Figure 2(c), the optimal parameter sets (C, σ^2) were $(25.119, 251.19)$ and produced the result of RMSE = 0.174. The result of MLR shown in Figure 2(d) produced the result of RMSE = 0.197. Among these four constructed models, LS-SVR with ARD gives the best predictive performance. In this study, the posterior distribution of the model parameters can be approximated by the most probable value using Laplace's method. The inverse covariance matrix can be regarded as confidence intervals (error bars) on the most probable parameters. As shown in Figs. 3(a) and 3(b), the black dotted lines denote the upper and lower bound of the error bars. It can be observed that the width of the error bar after applying ARD became more compact than before applying ARD.

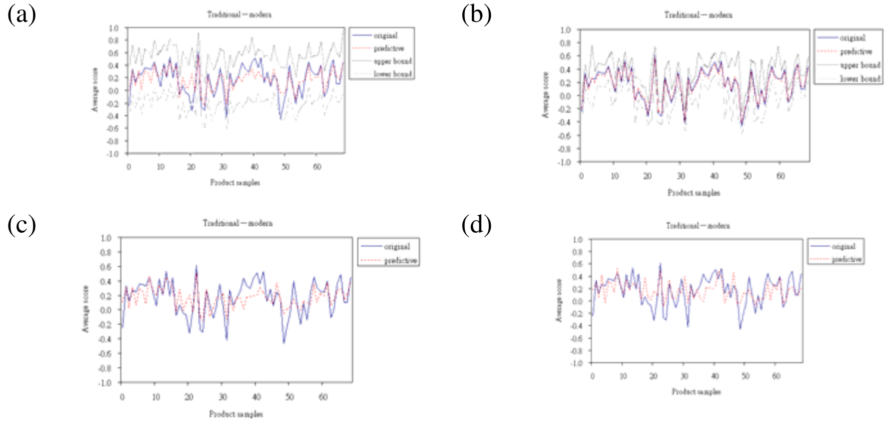

Fig. 2. Performance of the traditional-modern pairwise adjective of (a) LS-SVR with Bayesian inference before ARD, (b) LS-SVR with Bayesian inference after ARD, (c) LS-SVR with LOOCV and (d) MLR

6 Conclusions

In this study, an approach based on LS-SVR and ARD is proposed to deal with the PFFS problem. PFFs are examined by morphological analysis. Pairwise adjectives are used to express CARs. The LS-SVR prediction model is formulated as a function estimation problem taking the form features as the input data and the averaging CAR data as the output value. A backward elimination process based on ARD, a soft-embedded feature selection method, is used to analyze the relative relevance of the form features and obtain the feature ranking. In each elimination step of ARD, the influence of each form feature is adjusted gradually by tuning the length scales of an augmented Mahalanobis kernel with Bayesian inference. Depending on the designated adjective to be analyzed, this proposed method for PFFS provides product designers with a potential tool for systematically determining the relevance of PFFs.

Although the resulting feature ranking obtained by the proposed method based on LS-SVR and ARD, is similar to that of the MLR with BMS, the proposed method gives a higher predictive performance benefits from the soft feature selection mechanism. However, our case study was based on the design of mobile phones and used a relatively small amount of PFFs. The form features of other products such as consumer electronics, furniture, automobiles, etc., may have to consider different characteristics. A more comprehensive study of different products is needed to verify the effectiveness of the proposed method. Also, inducing more complex product attributes other than form features, such as color, texture and material information on the product samples, is the main research direction being taken by the authors.

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Mobile Wikipedia: A Case Study of Information Service Design for Chinese Teenagers

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Abstract. This study applied User Centered Design in mobile service design. First, an interview was conducted to analyze needs of teenagers. Chinese teenagers desire more information about daily life and more interaction between users. Second, based on the results of the interview, a low fidelity prototype was develped. To evaluate the design, teenagers participated in the second interview and told its pros and cons. Finally, refinement was made and a high fidelity prototype was ready. This prototype combined both Wikipedia and the query-based interaction. Results of this study have reference value for practitioners to involve target users into development process of information service.

Keywords: Chinese teenagers, Wikipedia, mobile phone, information service, User Centered Design.

1 Introduction

China is the biggest mobile phone market in the world. The number of mobile phones users is more than 850 million [1]. Among them, 277 million use mobile net citizens. Mobile net citizens become the main driving force for the rising of general net citizen scale in China [2].

Teenagers contribute to a considerable part of mobile communication market. A large proportion of teenagers in Korea (80.6%) and Japan (77.3%) own mobile phones. In China, 48.9% of Chinese teenagers aged between 12 and 18 are mobile phone users [3]. There is a big market potential to attract the other half of teenagers.

Chinese teenagers are a user group with unique characteristics. Different from western teenagers, they obey parents and have heavy study burden. As a result, they have limited time and money to use mobile phones. This calls for modification of current design for better matching of their needs. To achieve this goal, this study applied User Centered Design to develop information service. Prototypes of Wikipedia named Wikiteen for mobile phone were developed and tested. It is an explorative study to apply methodologies of human factors to service industry, which is a relatively less studied area.

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The design process of this study is of reference value to practitioners, and is one way to attract more teenagers. This is important because young people are generally early adopter of new technology, and their adoption, in turn, will contribute to the mass adoption. Service providers compete severely to attract young people especially during the spread of 3G technology.

2 Literature Review

Young people's usage of Wikipedia was studied in education context. Clark et al. (2009) studied young learners' usage of web 2.0 tools and activities in and out of school. They found young learns would like to use some Web 2.0-type technologies including Wikipedia to support learning in more formal contexts [4]. The impact of Wikipedia on classroom was also studied by Harouni (2009). He used Wikipedia to help high school students develop research skills [5].

Searching is frequently used in Wikipedia and therefore many researchers studied presentation and organization of searching results. Traditional list-based search results can be improved by using the form of tables, infoboxes, lists, and hierarchies [6], by clustering searcher results [7], or by supporting image search [8].

Another important activity is submitting articles. Sharing knowledge on Wikipedia is a behavior driven by many reasons. The most important one is the internal self-concept motivation. People judge whether knowledge sharing gives them a sense of personal achievement and whether it is consistent with personal standards [9]. Since many young people are reluctant to contribute to Wikipedia [10], a good incentive system may be needed.

A more related study is the interview of 15 young people aged from 13 to 24. The results indicated that young people use Wikipedia as a tool for a narrow range of tasks. Wikipedia was not deeply integrated into their everyday lives. To change this situation, much work such as information reliability needs to be done. And the most important work is to analyze the deeper needs of users to make Wikipedia fit into young people's lives [10].

3 Methodology

Teenagers were involved in the entire process of User Centered Design, from needs analysis to design to evaluation. Based on user needs identified in an interview, a low fidelity prototype was designed and tested. Then, it was refined to be a high fidelity prototype.

3.1 First Interview

The aim of the first interview was to gather teenagers' needs. Three teenagers aged between 16 and 18 participated in the interview. Two of them were high school students and the other one was freshman. Two of them were male. Participants were asked to talk about three topics: 1) Wikipedia, to know their knowledge, usage behavior, and interested information; 2) mobile phone, to know their usage frequency, Internet use, and monthly cost; 3) mobile Wikipedia, to know their desired information, incentive, and article length.

Participants perceived that Wikipedia was similar to Baidu Knows, which is the largest query-based community to share knowledge and experience in China. But Wikipedia was more about academia while Baidu Knows was more about daily life. They thought there was a professional team to check information created by users. However, they did not use Wikipedia often because they usually need information related to daily life rather than academia. They were interested in gossip, daily life in collage, current affairs, sports, and some professional knowledge.

Participants used mobile phones frequently. They often surfed on mobile Internet to know current affairs, weather, and updates of social network websites such as RenRen. They could ask for 50 to 100 RMB per month from parents to pay mobile phone bill.

Participants' desired information of mobile Wikipedia included both professional knowledge and entertainment information. They would like to look up definition of mathematical concepts and explanation of English words. Also, they would like to see news of famous person, current affairs, and some jokes. Incentive (e.g. a discount on their phone bill) was helpful for inspiring them to submit article, but they did not want to submit long articles due to the difficulty of text entry on mobile phone. Besides, they felt safer if all users are teenagers.

3.2 Low Fidelity Prototype

Based on results of the first interview, a low fidelity prototype was developed. Sketches were drawn to show overall structure and relationship between screens. They were refined as ideas become clearer. Then, post-it note stickers were stuck to sketches, representing a particular status of the application as the user navigates it. Finally, they were added to the mobile phone display. Multiple note stickers were labeled with numbers, shown in Figure 1.

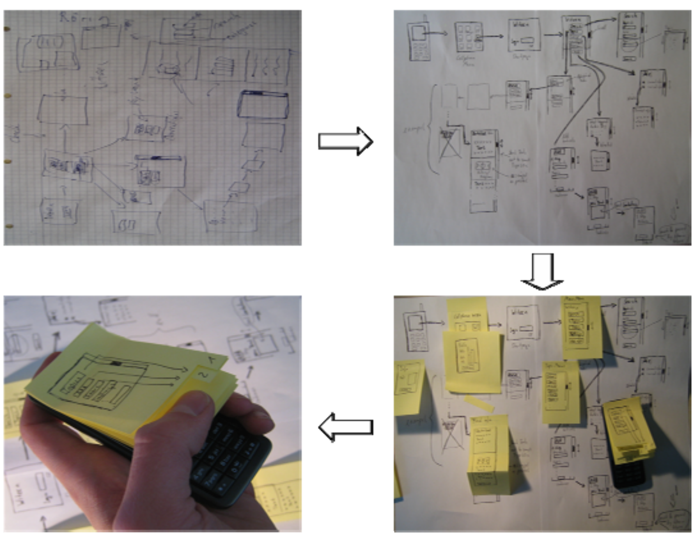

Fig. 1. Low fidelity prototype development process

The structure of this system is shown in Figure 2. It consisted of four major functions: Search, Topics, Today, and Add. Teenagers can choose their interested information in Topics and know current affairs in Today. There was a special session named Add. Teenagers can submit articles and questions here. This could satisfy their needs to ask questions and get answers related to daily life.

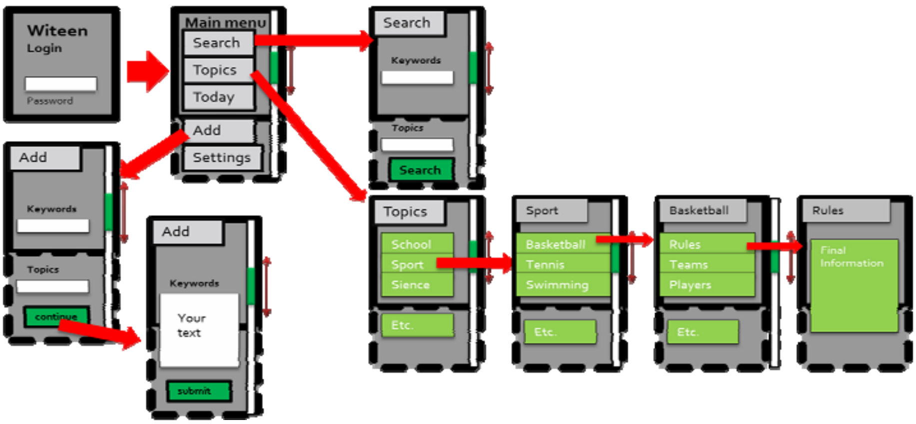

Fig. 2. Structure of low fidelity prototype

Fig. 3. Main page

3.3 Second Interview

To get feedback towards the low fidelity prototype, three teenagers from high school were interviewed. They aged between 15 and 16. Two of them were male. Their attitude towards the prototype and intention to submit articles were interviewed. Besides, they were asked to find out ways to ask questions in Wikiteen.

The results showed that they can easily understand the prototype. And they can quickly find the page which was used to add questions. However, they thought the interface should be more attractive and support different profile templates, so that they could change styles anytime. Besides, they were more willing to submit articles if there was an incentive mechanism.

3.4 High Fidelity Prototype

The high fidelity prototype used the same structure as the low fidelity prototype, but added attractive appearance and dynamic change between screens. The high fidelity prototype was implemented with the software Photoshop CS 3.0 and Balsamiq Mockups.

Fig. 4. Search, Topic, Today, and Add pages

As shown in Figure 3, the main page supported users to search keywords, to browse interested topics, to kill time by seeing what happened today, and to ask and answer questions. They can log in to access more personalized information. Different from low fidelity prototype, users were not required to log in at the start page.

Although this prototype was not equipped with full functional database, the information search can carry out on a few examples. As shown in Figure 4, in the Search page, users can search keywords and search under a list of topics and history record. In the Topic page, each topic had its own portal including both news and questions. In the Today page, users can edit news and communicate with other users. Add page was another channel to ask and answer questions. They can also search among lists of questions and answers.

4 Discussion

Comparing with the Wikipedia website and existing mobile Wikipedia applications, the prototype in this study took needs of Chinese teenagers into account. The development process and deign outcomes reflect consideration of user needs. In the development process, teenagers were involved. Their needs and attitudes were important input for improvement. As to design outcome, the prototype featured combing Wikipedia with personalized information and query-based interaction.

One interesting finding from need analysis was that Chinese teenagers perceived that Wikipedia was similar to Baidu Knows, but the former one had more academic information and the latter one had more daily life information and more user interaction. Teenagers would like to look up daily life information besides academic information. They wanted strengths of both Wikipedia and Baidu Knows. Therefore, questions and answers were included in Topic, Today, and Add, so that interaction between users would be convenient.

The biggest limitation of this study is the small sample size. Results cannot apply to general population. Besides, there is a lack of quantitative measures to test people's satisfaction. Future study may measure satisfaction with the Likert's scale, and compare the difference in satisfaction between two versions of prototypes. Despite of these limitations, results of this study have reference value to show how to involve target users into design process, and help practitioners design more popular service through the iterative design-test-redesign-retest cycle.

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Part II

Ambient Assisted Living and Smart Environments

A Method with Triaxial Acceleration Sensor for Fall Detection of the Elderly in Daily Activities

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Abstract. Falls are one of the major risks which the elderly people face. Recently, due to the demands for guardianship of physical functions, the device to detect falls automatically is urgently needed. This study was focused on the method of fall detection and the wireless device based on a triaxial acceleration sensor. To evaluate the performance, experiments were conducted on fall, squat, stand up and walk. The device was also set in three body positions (head, shoulder and belly) to get fall signals compared. It is considered that the difference between valley and peak of the acceleration on z axis can be used to detect falls as an obvious feature. If it's higher than 0.5V, it can be concluded that the person has a fall occurrence. The device is expected to be useful to detect falls of the elderly as healthcare equipment.

Keywords: Fall Detection, 3D Acceleration Sensor, Wireless Detection Device, Different Body Positions, the Elderly.

1 Introduction

In most countries, the elderly people are becoming an important segment of the population, and there is a trend that more and more elderly people are living alone. This fragile group needs much more health care both physically and mentally. One of the major risks they face is fall. It is estimated that over a third of adults aged 65 years and older fall each year [1], making it the leading cause of nonfatal injury for that age group. Among older persons, 55 percent of fall injuries occur inside the home. An additional 23 percent occur outside, but near the home [2]. There are many factors, which can result in falls [3]. Meanwhile, there are also many methods to prevent falls in advance. From inside, the elderly can have more exercises to improve the physical balance and increase the bone density. From outside, we can use many facilities to help the elderly people concerned to detect falls and take measures to get help once a fall occurs.

Since the variety of daily activities that the elderly perform, a device with a high precision is needed to detect the fall. The kinds of fall detection methods have been

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classified into three categories: wearable device, camera-based and ambience device [4]. Among many researches, the use of 3D acceleration sensor has the most influential impact on solving this issue [5-6]. However, the research concerning the 3D acceleration sensor is often lacking of detail explanation about where to put the sensors and how the whole detection process works.

In this paper, a research about how to detect falls using 3D acceleration sensors will be discussed in detail. First, the wireless device will be shown, and then the signal got will be processed by eliminating noise. The results of falls and other daily activities will be followed. Detail discussion about the fall progress and different body position placement will be explained in the last section explicitly.

2 Materials and Methods

2.1 Wireless Device

The hardware setup developed for the fall detection prototype includes a 3D acceleration sensor, a wireless communication unit and a data processing unit.

MMA7260 is a kind of specialized 3D acceleration chip, which is adopted to sample the instant human body's posture in our posture experiments [7-9]. MMA7260 can notice the change of acceleration in three perpendicular axes at the same time and output the acceleration change with the form of voltage at the three output pins. The microcontroller gets the sampled data through an A/D conversion ship, then does simple analyses or transports the data directly to the PC.

Fig. 1 shows the real module used in our experiment which is designed and made by our team. We fixed a helix antenna in each senor node instead of a patch antenna to enhance the strength of wireless signal.

In general, the module of fall detection is portable and wearable [10], so wireless communication is adopted to transmit the data sampled from the fall detection sensor node. At first, a wireless communication program without any specialized protocol was written. In an obstacle-free room, the quality of wireless transmission was stable. But when the sensor node carried by human body was placed in a cluttered room, the quality of wireless transmission declined evidently. After a series of comparisons and experiments, a kit of ZigBee2006 protocol was given to guarantee a lower error rate of wireless transmission [11]. CC2430 is designed by Texas Instruments specialized for organizing ZigBee networks, it contains a multiple A/D conversion module which can meet the characteristics of MMA7260 to exchange acceleration change in three axes at the same time.

GSM Modem is accepted in this project and a mobile card (SIM) is utilized to work with GSM Modem to connect into the mobile phone's network. When the fall detect module notices a specified event which maybe in a dangerous situation, it sends a warning message to the PC. We developed a VC++ application program to drive the GSM Modem to ring up the elderly person. If the elderly person is safe and sound, then he rings back to the GSM Modem, the application program will know that there is no accident happened and cancels the warning. Otherwise the application program will ring up to notify the person who is responsible for the elderly person and then call for the ambulance.

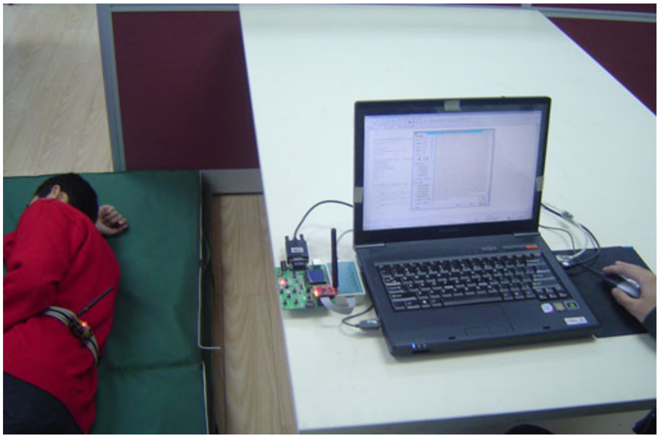


Fig. 1. Fall detection module

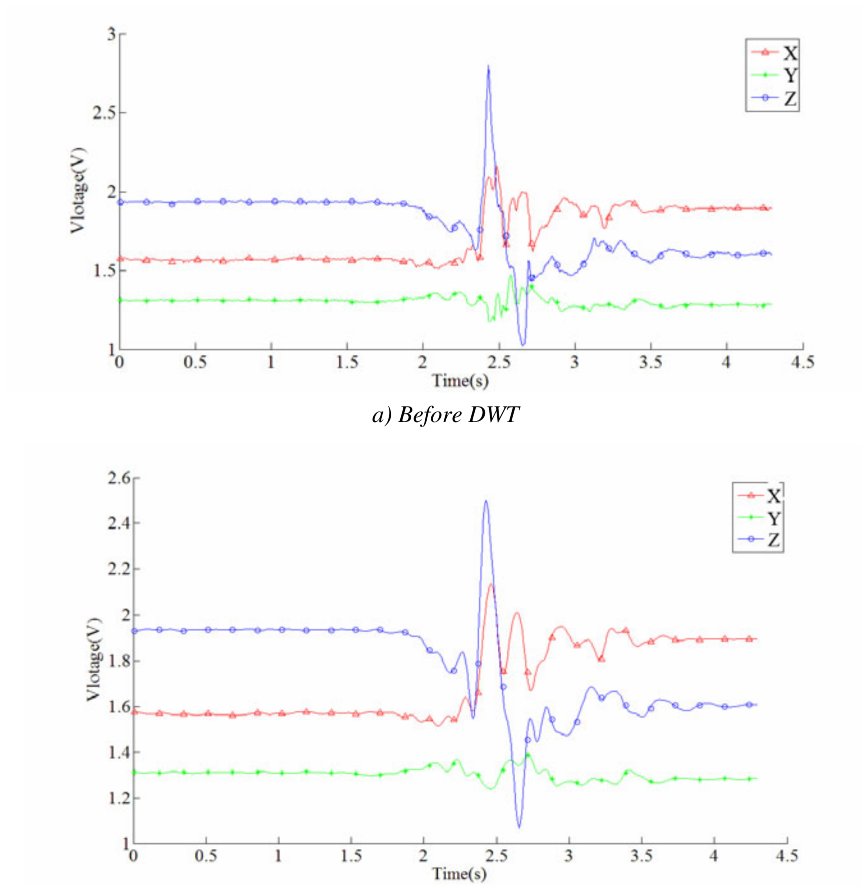
2.2 Denoising

In order to eliminate the noise in the sampled data, Discrete Wavelet Transform (DWT) is used in this step. DWT is a very useful tool for signal multi-resolution analysis. It has two complementary filters, the low-pass filter g and the high-pass filter h, which saves the approximation part and the detail part of the signal respectively. The signal $s(n)$ is split into two parts through the first level transform-approximation coefficients V_1 and detail coefficients W_1. These two coefficients can be split into the second level approximation coefficients V_2 and detail coefficients W_2. The coefficient g, the low-pass filter, associates with the scaling function φ and the coefficients h, the high-pass filter, associates with the wavelet function ψ. The functions are defined as

$$\phi_{j,m}(n) = 2^{-\frac{j}{2}}\phi(2^{-j}n - m) \tag{1}$$

$$\psi_{j,m}(n) = 2^{-\frac{j}{2}}\psi(2^{-j}n - m) \tag{2}$$

These coefficients can also be used to reconstruct the signal again. Also compared to Fourier Transform, DWT has temporal resolution: it captures both frequency and time information. There are many mother wavelets we can choose to use. In this paper, a Symlets mother wavelet (sym2) was used in decomposition and reconstruction and 2 levels of transforms was applied (results are shown in Fig. 2) due to its better performance than others by testing. It is clear that the signal after using DWT has the least error estimation and is suitable to be further processed.



a) Before DWT

b) After DWT

Fig. 2. The waveform before and after DWT

3 Results

An experiment was conducted on falls and another 3 kinds of actions (squat, stand up and walk). Besides, the device was also placed in three different positions (head, shoulder and belly) to get falling signals compared. The results are as follows after using DWT:

3.1 Device Set on Head

Head is a perfect place to set the sensor, but due to the neck's effect, it's very flexible and may not in the same plane as the body when fall happens. This could lead to wrong judgment.

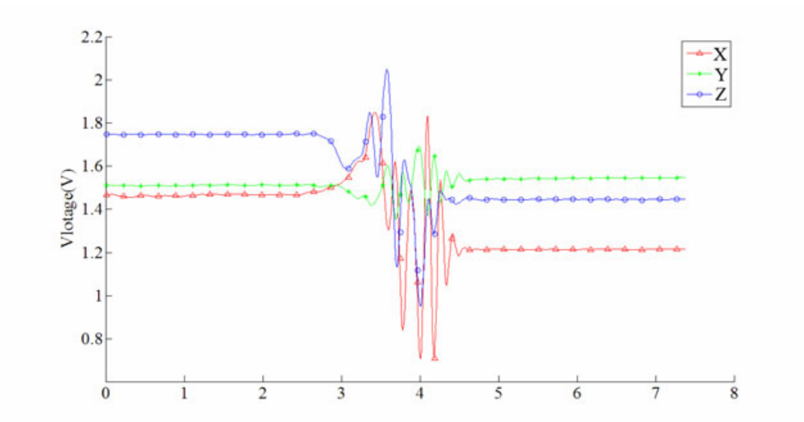


Fig. 3. Fall when the sensor is placed on head

3.2 Device Set on Shoulder

Shoulder is another place suitable for wearable sensors. But as we know, the joints around arms are also very flexible and people have the instinct to resist falling, which leads to the disaccord with the body when falling down.

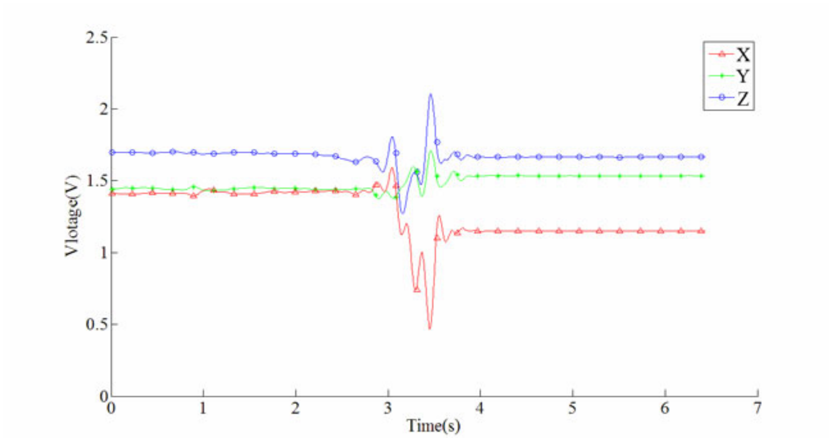


Fig. 4. Fall when the sensor is placed on shoulder

3.3 Device Set on Belly

Placing the sensor on belly can ensure its accordance with bodily direction when falling down. And it is very easy to fix because we can integrate it with a belt. Its disadvantage may be that it will be affected by respiration to some extent.

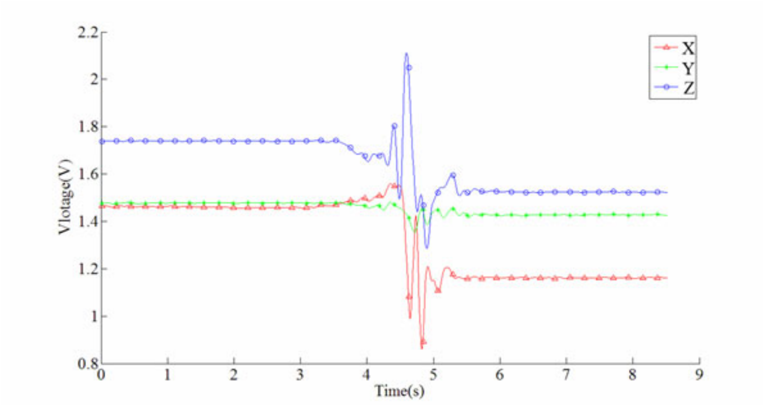
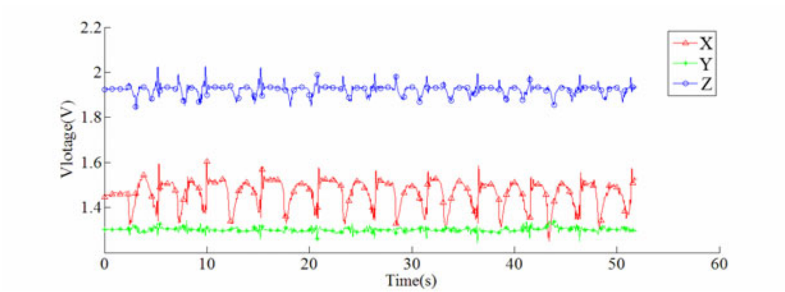


Fig. 5. Fall when the sensor is placed on belly

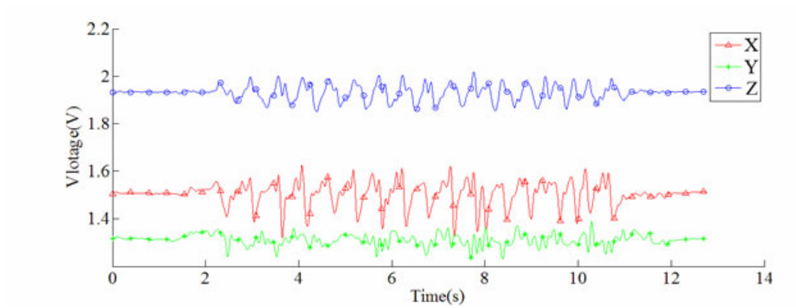
3.4 Device Set on Belly When Standing Up, Walking and Squatting

Standing up and walking are the most common activities in daily life. Squatting suddenly may be like falling down more or less, only without fierce changes in *z* axis. Here we use this action to be distinguished with falling.



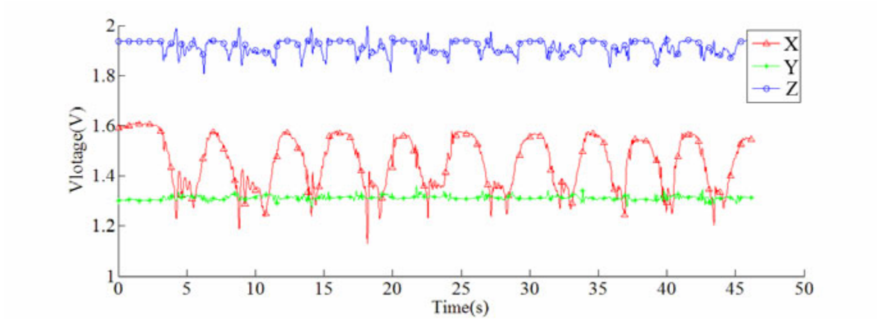
a) Standing up

Fig. 6a. Sensor placed on belly when standing up



b) Walking

Fig. 6b. Sensor placed on belly when walking



c) Squatting

Fig. 6c. Sensor placed on belly when squatting

4 Discussion

4.1 Fall Waveform Analysis

From the large amount of data we got, it shows that when people started to fall, it only took about 2 seconds for people to fall on the ground. In this period the acceleration changes to a great scale. The whole process can be divided into 5 phases. Fig. 7 shows the 5 phases:

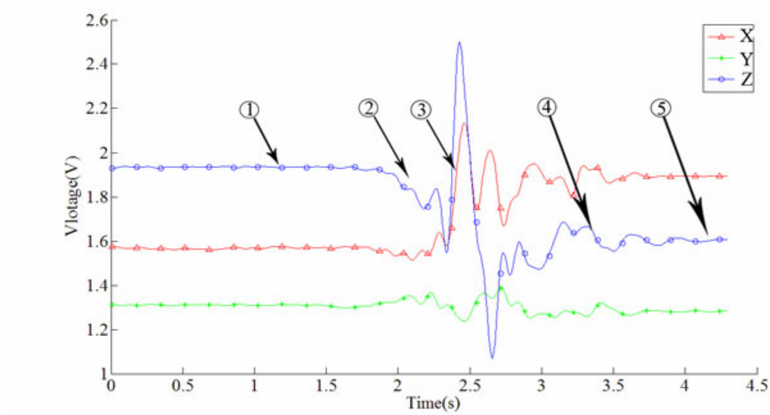


Fig. 7. The 5 phases of a fall

Phase I: At the beginning, the static status which includes the values of three axes is shown. Before a fall occurs, the values of the three axes will fluctuate slightly in the specific region but don't vary much, which indicates that the status is static.

Phase II: Once there is an inclination of falling, a weightlessness process occurs. The time interval of this phase is determined by the height between the sensor and ground. Also the value of z axis can't be more than $1g$. During the progress of weightlessness, the output voltage decreases because the distance in capacitance decreases relatively.

Phase III: After the weightlessness process, fierce impaction happens. The obvious phenomenon is that we will get a very high value of z axis which may be greater than $3g$ sometimes, and the values in the other two axes will also vary a lot. The reason is obvious. The plate in capacitance is in the decelerated state while the distance's becoming larger. As soon as the speed comes to zero, the accelerator and the distance get the highest value but in opposite direction, which leads to output the highest voltage. After that, the plate still vibrates until velocity comes to zero, which contributes to the lowest voltage.

Phase IV: The plate in capacitance will fluctuate in both directions until it is static. Generally, some slight vibrations come after the severe impaction. The amplitudes of the 3 axes waves will come to be constant after a short period.

Phase V: The last status, which comes back to static, can be a comparison to the first situation. We can get these statues to judge the last posture and the direction of falling.

4.2 Data Analysis

Compared with the acceleration of other actions (squat, stand up and walk), the acceleration of falls changes more severely in the 3rd phase mentioned above. Our method is based on this point to judge whether people fall by testing the difference between valley and peak of the acceleration on z axis.

We first tried three positions to place the sensor, head, shoulder and belly. The results calculated by our method are shown in Table 1.

Table 1. The difference between valley and peak of fall on z axis in different positions

	Device Set on Head	Device Set on Shoulder	Device Set on Belly
1	0.8917	1.1232	0.9379
2	1.0971	0.9887	0.8257
3	0.7877	0.6314	0.6489
4	1.3573	0.9737	0.9089

From Table 1, it can be seen that the three different positions have the similar extent when falling. Considering the advantage belly placement has discussed above, in actual experiment, we mainly focus on the data got from belly. Table 2 shows the calculated results of fall and other activities with the sensor set on belly.

Table 2. The difference between valley and peak of fall on *z* axis in different actions

	Fall	Squat	Stand Up	Walk
1	1.4179	0.1559	0.1772	0.1546
2	1.3333	0.2172	0.1713	0.1472
3	1.4318	0.1467	0.1555	0.1216
4	1.3648	0.1508	0.1527	0.1304
5	1.1753	0.1465	0.1649	0.1421
6	1.1661	0.1259	0.1623	0.1479
7	1.2577	0.1124	0.1290	0.1421
8	1.3532	0.1594	0.1078	0.1441
9	1.1158	0.1292	0.1235	0.1396
10	1.2959	0.1324	0.1054	0.1306
11	1.2565	0.2477	0.1828	0.1610
12	1.4287	0.2384	0.1805	0.1582
13	1.4729	0.2386	0.1801	0.1617
14	1.3754	0.2397	0.2703	0.1885
15	1.2427	0.1817	0.1986	0.1771
16	1.3513	0.2008	0.201	0.2042
17	1.3311	0.2212	0.1976	0.2230
18	1.4853	0.2235	0.2700	0.1746
19	1.0824	0.2141	0.2131	0.1989
20	1.3354	0.1923	0.1998	0.1818

5 Conclusions and Future Work

From Table 1 and Table 2, we can conclude that the three different positions (head, shoulder and belly) have the similar extent when falling and all differences from falls with the sensor placed in different positions are more than 0.5V, comparatively, all other actions' values are less than that value. So we can use this value as a threshold to distinguish fall and other daily activities. Once the difference value exceeds 0.5V, a primary assumption that a person has fallen can be concluded.

However, it's not enough to judge the fall occurrence alone. Many other related works, like the following steps after fall, also need careful and intensive research. What's more, the device can be designed to set many sensors in different positions in order to strengthen the detection effect and confirm the preciseness of fall direction. Meanwhile, the direction of the fall can be confirmed according to the relative position change of the three axes before and after the fall.

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The REMOTE AAL Project: Remote Health and Social Care for Independent Living of Isolated Elderly with Chronic Conditions

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Abstract. REMOTE is an AAL project that aims at advancing the state-of-the-art in fields of tele-healthcare and ambient intelligence by enhancing the elderly's home with audio-visual, sensor, motoric monitoring and automation abilities to trace vital signs, activity, behaviour and health condition, and detect risks and critical situations, as well as provide, proactively and reactively, effective and efficient support at home. This paper presents the project objectives, the approach and principles endorsed, and the expected results. Overall, REMOTE is characterised by: a user-centered philosophy and consistent involvement of users; processes for reaching consensus among all stakeholders; strong commitment to ethical and legal issues; sound scientific and evidence-based methods (incl. real context pilots in 6 countries) to measure usability, impact and acceptance of the developments by elderly populations.

Keywords: Chronic conditions, Tele-healthcare, Ambient Assisted Living.

1 Introduction

Chronic diseases are the leading cause of mortality in the world, representing 60% of all deaths [1]. Today, about 133 million people live with a chronic condition, which requires ongoing adjustments by the affected person and long lasting interactions with the health care system. With this number being projected to increase by 2030 by more than one percent per year, resulting in an estimated chronically ill population of 171 million, several challenges arise for modern healthcare systems.

With ICT pervasively affecting all areas of social and economic life, particularly in industrialised countries, several opportunities are there to be pursued through a digital

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revolution for healthcare. Meeting these opportunities will require nothing less than a transformation of healthcare, from a system that is essentially reactive - responding mainly when a person is sick - to one that is proactive and focused on keeping a person as healthy as possible. Applications, such as health telematics [2], can be used in homes to upgrade the way health-related services are conceived and delivered.

Significant research is underway to enable elders and people with disability to use smart assistive technology and smart homes to more easily perform activities of daily living, continue social participation, engage in entertainment and leisure activities, and to enjoy living independently[3]. Today, networks, microprocessors, chips, smart sensors and actuators are faster, cheaper, more intelligent, and smaller than ever.

Current advances in such enabling technologies, coupled with the need to transform the health care delivery system in rural areas, are giving rise to novel applications and services for improving the quality of life for all. In the context of an ageing population, increased burden of chronic diseases, active participation of more demanding patients and ever increasing health expenditure, the realisation and amplification of telemedicine services is important and urgent.

To speed the transition, an AAL[1] project, *REMOTE*[2] ("Remote health and social care for independent living of isolated elderly with chronic conditions", Grant Agreement no. AAL-2008-1-147), was proposed and accepted for funding. REMOTE implements a novel approach, which aims at addressing emerging deficiencies in current tele-healthcare R&D and summarizes the basic elements for improving care in health systems at the community, organization, practice and patient levels.

2 The Project Concept

REMOTE aims at defining and establishing a multidisciplinary and integrated approach to R&D of ICT for addressing, in real life contexts, identified needs of frail elderly, especially of citizens at risk due to geographic and social isolation in combination with chronic conditions , such as hypertension, arthritis, asthma, stroke, Alzheimer's disease, and Parkinson's disease, and the coexistence of lifestyle risk factors, such as obesity, blood pressure, smoking, alcohol abuse, poor eating / drinking habits, stress, and low levels of physical activity.

To this end, the project will advance the state-of-the-art in fields of tele-healthcare and ambient intelligence (AmI) and enhance the elderly's personal environment with audio-visual, sensor / motoric monitoring, and automation abilities for tracing vital signs, activity, behaviour and health condition, and detecting risks and critical situations as well as providing, proactively and reactively, effective and efficient support at home. In particular, scale-up of existing research prototypes and development of new systems for collecting, recording and analysing health- and context-related data will be deployed in the course of the project. These include, on the one hand, wearables and sensors [4] for detecting intra-oral miniature wetness and jaw movements, body temperature, blood pressure, heart rate, human posture and motion / acceleration recognition, etc., and, on the other hand, sensors and actuators to be installed in

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[1] Website of the Ambient Assisted living (AAL) Joint Programme: http://www.aal-europe.eu/
[2] Project website: http://www.remote-project.eu/

premises (and vehicles), for providing context information, e.g., air temperature, luminance, humidity, human location and motion, etc.

Then, in order to focus on the specific risks and problems experienced by elder individuals with chronic conditions because of living on their own (about 1 in 3) or due to the growing gap between urban and rural areas, the project is aimed to enable professional carers to access remotely such real-time and past activity and medical data of their patients at anytime and from anywhere, and to promptly diagnose and react to health and life risks. The project introduces an innovative, ontology-driven, open reference architecture and platform to enable interoperability, seamless connectivity and content sharing among different applications and services.

3 Target Users

REMOTE focuses on the particular needs of elderly with specific chronic conditions, especially those living in rural and isolated areas (**primary users**), by designing automated and multi-user controlled home environments that offer the comfort, security and safety required. Aiming at autonomy, self-confidence, mobility and well-being, elderly-oriented applications and services will be designed to enhance their self-care, social interaction, and skills maintenance ability. Overall, the elderly will be supported in learning to understand their condition and live successfully with it. Thereby, elderly people will be supported in: managing their risk factors; performing self-healthcare, such as dietary management, medicine management, etc.; maintaining communication and interaction with families, friends and other caregivers; and going out for everyday activities or even on long trips and vacation.

Building on its integrating approach, the project will provide professional health carers (**secondary users**) with tools for continuous monitoring run-time and history patient data and, thereupon, implementing patient-centric tele-healthcare, while reducing paper work and travel required from both ends. Through the professionals front-end of the system, doctors will be able to get access to electronic medical records, real time data (transmitted through wireless and wired links) and records of the patient's condition (body temperature, blood pressure), activity (physical activity, medication, food and water consumption), and life environment (i.e., house) changes. Professionals will be further supported by decision support tools aiming to facilitate patient-data reviewing tasks and the generation of personalised, disease care plans and every-day feedback to the patients. All of these modules will be Web-based to enable professionals to access them at anytime and from anywhere.

Ultimately, accumulated knowledge and lessons learned throughout the project will be turned into appropriate forms for serving as guidelines to developers and feeding into standardisation processes, thus satisfying the cost reduction, interoperability, and standardisation requirements of **tertiary end-users**.

4 Progress Beyond the State of the Art

The state-of-the-art of REMOTE encompasses an enormous domain of related applications and services for the elderly, architectures, ontologies and standards for their inter-connection, integration, etc. We will focus here on discussing REMOTE's breakthrough against major limitations of other approaches.

First of all, most efforts so far have a focus restricted on health-related issues [2], failing to see the person as a whole entity of a dynamic and complex nature with, often, multiple conditions and social and psychological aspects playing a major role in individual well-being and quality of life. For elderly, these aspects are even more important because of natural decrease of abilities and skills and the progressive limitation of social life. This implies the need for integrated, scalable and adaptive care solutions for all stages of life, acute care, chronic care, preventive services, rehabilitation services and end of life care.

REMOTE, recognising isolation -both geographical and social- as a common multiplying risk factor, aims at overcoming these limitations by both changing the focus of the research, and by adopting an approach whereby ICT and AmI-based applications and services are part of holistic strategy to health care and management as well as to subjective well-being of the elderly.

Regarding REMOTE's progress beyond the state-of-the-art in integration of technologies and products, the following areas are notable.

Open reference architectures and ontologies: REMOTE moves substantially beyond the state-of-the-art by relating ontology development to a mature and well-defined set of best practices available in software engineering. Principles basic to software engineering will be applied here and the resulting high quality, well-structured ontology will result to a new interoperability standard that will be deployed and evaluated across a broad range of applications for the elderly.

Intelligent agents and AmI framework: Innovation in relation to previous efforts, exploited in REMOTE (i.e. ASK-IT, IM@GINE-IT, etc.) is identified in the following issues: (a) REMOTE adopts a rather light multi-agent architecture of flexible and efficient agents, to ensure a high performance AMI framework; (b) REMOTE agents undertake the process of low-level information filtering using real-time data - information filtering operations are not undertaken by the previous projects' agents; (c) agents of the REMOTE framework act in a more deliberative function compared to the SoA agents - from a technical perspective this is realised by the development of specific techniques for learning and decision-making, such as Bayesian belief networks, and rational decision making abstract models.

Wearables, sensors and health/activity monitoring: The most significant innovation in REMOTE is the multi sensor approach, performing a data fusion of various sensor inputs (body sensors, wearable and mobile/portable sensors), combined with expert knowledge and individual user information in the REMOTE framework.

Independent living applications: Taking into account all previous research, REMOTE proposes an innovative approach of integration of many AAL-enabled Independent living applications through the use of a common set of interconnected ontologies.

Social support applications: Development of advanced social networking visualisation engines; Increase the scope of devices and networks supporting social applications; Address needs of wide range of user groups (55, 65 and 75+).

In-home and domotic sensors and localisation systems: To address sensors diversity and facilitate their integration, quality-aware sensor abstraction and sensor fusion will be established in a common framework between the high-level application and the low-level communication infrastructure installed at home.

User interfaces and adaptive systems: In a parallel line of work to user-oriented adaptivity, UI research has recently addressed the identification of, and adaptation to, the situational and technical context of interaction although, most of the time, user- and context- oriented adaptivity are combined. This includes systems that adapt: to the user's device's form factor, the actual interaction devices available to the user, the user's geographical location, etc. In the context outlined above, REMOTE aims to provide high-quality, ambient user interfaces, by effectively addressing diversity in the following dimensions: target user population and changing abilities due to aging; categories of delivered services and applications; and deployment computing-platforms (i.e., e.g., PDA, smart phone, desktops, laptops) and input devices. To this end and towards increasing accessibility, usability and subjective satisfaction, an innovative design approach that guarantees device and modality independence will be employed and enhanced by device-, user- and context- adaptation facilities.

Tele-healthcare products and services: Another problem that this project aims to cope with is that of elderly people not wanting to, and/or not being able to buy new apparatus or equipment. One of the most important points is that the REMOTE technology (sensors, devices, software, etc.) will be scalable, flexible and adaptable in a manner that it can be easily integrated into existing set-ups and contexts.

5 Methodological Approach

The REMOTE uses cases (UC) and scenarios of use will be defined in detail early in the project (see Fig.1), based on a thorough literature review, user surveys, interviews and field work, technological benchmarking and iterative consensus building among key stakeholders, including user representatives; all of which are already present in the REMOTE consortium and will be significantly increased through the complementary involvement of external ones (e.g., the User Forum for primary users, while a Health professionals Forum will be considered for enhancing the project's access to independent secondary users).

The UCs constitute a fundament tool towards the success of the project as it offers, among others, the opportunity to present concepts and development plans to all interested parties in comprehensive way and at early stages the project, and ultimately receive thereby extremely valuable feedback regarding the usefulness, ease of use, ethical issues and overall acceptance levels of the envisioned developments.

The approach of REMOTE is simple in conception: direct re-usability of information is to be provided across heterogeneous services and devices. Much of the individual components of such advanced re-usability are already in place. Various service providers currently provide or are interested in providing health-related assistive services for the elderly. Much of the complexity that arises for providing monitoring-based, intelligent assistance then revolves around issues of effective and efficient communication between the user and their assisting devices, as well as communication between different elements of the assistive service. In all cases, to achieve efficient services, it is necessary to ensure a 'common understanding' of contextual information about different services and objects [5]. Such common understanding and sharing of contextual information can only be achieved by enabling the interconnection of heterogeneous data models used by each service (i.e. by each service provider) or even module of service. This will in turn enable the integration of the plethora of diversiform services into a common platform in order to provide not only improved but also new services for the elderly. In order to achieve interoperability of services and sharing of contextual information between different services and objects, it is necessary to model them first, by extracting each service's individual structure up to its most primitive level. In current approaches, this can lead to more or less ad hoc solutions.

Fig. 1. Overall Methodology of extraction of the REMOTE Use Cases

The REMOTE solution is to provide foundational ontology components, specifically tailored to the requirements of the applications to be covered and the services provided. Overall, the implementation of the REMOTE platform will be based on an AmI framework which integrates healthcare applications, content and services, as well as health-monitoring hardware sensors. From a technical perspective information gathering capabilities where applicable will rely on an ontology-driven service-oriented environment whose purpose is to interact with the users and provide real-time invocation of the appropriate services either on user demand or in an autonomous fashion when necessary (e.g. in case of emergency).

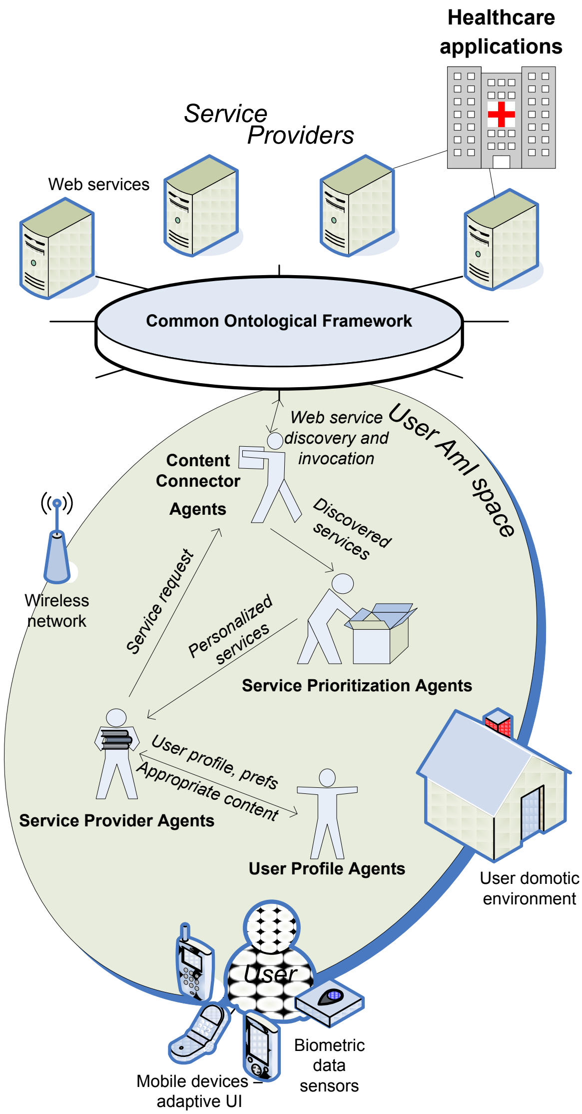

Fig. 2. REMOTE AmI abstract and functional architecture

The main parts of the REMOTE architecture are the following (see Figure 2):

- AmI framework managed by software agents. The AmI framework consists of the software infrastructure and the physical communication network that implements the body-area network that surrounds the user at home. Four types of software agents reside on the AmI. These are the following:
  - o User Agents. These agents which belong to the user personal AmI space are in direct interaction with the user and his/her surrounding environment. User

Agents play the role of user representative in the AmI. They are responsible for carrying and handling information about user profile and preferences. This information may include, apart from user-specific attributes, their needs and wants, the type of the end-user device, as well as the attributes of user's physical environment which they conceive through the wireless sensors network. By collecting all user-related info, these agents become capable of synthesising suitable user-profile data, which they store in a local repository. In addition, these agents may perceive events occurring in the user AmI space and take specific actions, such as to invoke a specific service in order to provide real-time context sensitive information to the user or to notify a medical centre in case of emergency.

- o Service Prioritisation Agents. The Common ontological framework which is described later operates as a semantic search engine of Web services, in order to fulfill specific user requests for services. The returned results are received by the Service Prioritisation Agents, whose role is to provide a ranking of the returned services according to user-specific needs, preferences and habits. They actually implement a low-level information filtering process, thus providing the most valuable services to the end user.
- o Service Provider Agents. The real invocation of a requested service is performed by the service provider agents that also take into account user profile-specific information in order to make sure that users receive the appropriate content on the appropriate device.
- o Content Connector Agents. These agents are responsible to interact with the Common Ontological Framework and launch the Web discovery process. These agents take into account user-related information in order to discover those services that best match the user profile. They do this by receiving combined information by the User and Service prioritisation agents.

- Common Ontological Framework. This part of the REMOTE architecture provides a semantics-aware infrastructure that facilitates discovery and invocation of Web services and integrated applications on behalf of software agents. It serves as an ontology-driven middleware infrastructure which receives requests for services and returns the required content.
- Monitoring and tracking infrastructure: The AmI environment is supported by a network of wireless sensor devices. These include biometric data readers and health-monitoring devices. The devices communicate in the body area network with the end-user devices via Bluetooth that the user is equipped with. Additional devices include user location and motion tracking sensors. Monitoring data (at various levels) sets the grounds for implementing intelligent mechanisms (personalised, evidence-based) for automated (at home) and semi-automated (remotely, e.g., controlled by professionals) support provision to health and social care to frail and isolated elderly.
- Service-oriented content management architecture. The required information and content is delivered to the user device in the AmI space via a service-oriented infrastructure. This is comprised by a set of registered service providers as well as customised services whose role is to integrate user-asistive applications, such as healthcare, self-care and medical applications.

- Adaptive user interfaces and mobile devices. Users are equipped with multiple front-ends on which a set of personalised, customisable and adaptive user interfaces are installed. These interfaces exploit user and context information to adapt to diverse usage conditions. Adaptations are oriented towards accessibility and increased usability and satisfaction levels.
- Healthcare applications (at the primary user's end). A set of healthcare applications to be developed in the project will be interfaced to the AmI through appropriate Web services provided by the REMOTE SoA.

6 Conclusions

Telemedicine works: For instance, disease management through telemonitoring of heart conditions reduces mortality rates by an estimated 20%. It has also demonstrated the influence on attitudes and behaviour of patients resulting in better clinical outcomes[3]. Elderly people at large, especially individuals with chronic conditions and/or in risk of exclusion, will benefit from REMOTE in terms of an increased level of self-management capacity. The feeling of security and command that aged people 'on the edge' in the European countryside will receive, will strengthen their confidence in leading an independent life at home and delaying, if not fully avoiding, institutionalization [6]. Without being highly intrusive, REMOTE enables continuous health monitoring services, thus allowing health care personnel at hospitals and care institutions to seamlessly supervise, follow-up, treat, and monitor elderly people in their own homes or within elderly homes. Older people will be able to live longer on their own, while in an emergency help can be called for immediately. The REMOTE open Reference Architecture will enable sharing of data and interoperability between various services, thus enabling "*integrated care processes for the ageing population*".

Overall, REMOTE has the potential to contribute to the following areas:

Information extraction and use: The REMOTE project, through its planned activities for investigating user needs (both for the elderly and the health professionals), will identify types and sources of information that, once collected and properly combined, can lead to advanced (combined) information, such as health/disease progress, user activity, habits, behavioural patterns, preferences, etc. The project, in addition to making this information available to personal care giving teams, will investigate and suggest new ways for further exploiting such information within its intelligent mechanisms (decision making support, adaptation mechanisms).

Understanding of (chronic) and age-related conditions: Given the fact that REMOTE will give the chance to health professionals to monitor real-time health data of their patients and thereupon provide personalised tele-health care, the collected data records will give the chance to academics and researchers from the medicine field to further study chronic conditions (signs, symptoms, etiology, and factors / interrelations) in real settings and without interfering biases due to the presence of the doctor. Long term use of the suggested REMOTE system, has the potential of empowering

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[3] Systematic Review of Home Telemonitoring for Chronic Diseases: The Evidence Base: J Am Med Inform Assoc. l 14, 269—277 (2007).

academia with data for statistical studies towards achieving deeper understanding and better management of chronic and other age-related conditions.

Patient modelling (the medical perspective): Understanding a chronic condition alone cannot guarantee efficient management unless the deployed care strategy takes into consideration the behavioural and lifestyle aspects of each patient. Through the projects user needs analysis, as well as throughout the pilot studies, significant knowledge in terms of patient patterns, needs and requirements will be accumulated, organised and properly disseminated. Of particular interest will be the information to emerge with regards to individuals in (risk of) isolation, both geographical (e.g., living in rural areas, remote islands, mountains, etc.), as well as social (e.g., lack of partner, family and friends, even when living in urban areas with everything nearby).

Elderly-friendly user interface design & development: REMOTE will enrich the available design knowledge with an innovative design paradigm that focuses on organising the user options in layouts that allow optimised user performances with all potential input modalities through common and assistive devices such as mouse, keyboard-only, joystick, special switches, speech input, etc.).

Guidelines, standards and policy: REMOTE will further elaborate on its findings and outcomes (see SoA advances in previous section) to translate them into useful guidance to developers, into appropriate input to standardisation working groups, and into a R&D roadmap for aging-well that will be disclosed to policy developers, academia and industry.

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Observe the User Interactive Behavior with a Large Multi-touch Display in Public Space

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Abstract. Multi touch is a new-type technology of human computer interaction, it can provide multi user to operate on the same display. Hence, different type of interface design will cause manipulation problem. This study is going to create a 100 inch multi-touch display to observe the user's interactive behavior through the 6 cameras in public space area. In addition to the manipulation interface, a "Photo.DIG" interface is development to control photos in the depth.

Keywords: Multi-Touch display, Public space.

1 Introduction

Multi touch is a new-type technology of human computer interaction, it can provide multi user to operate on the same display. Therefore, different type of interface design will cause manipulation problem. Most of large Multi-touch display research topic is in large public space display, it focus on promote share information and spread broadcast ability of people communication and social network. However, how to encourage the people to interactive with the public display is the core problem to solve.

Brignull's [1,2] research point out the most limited of people to interactive with the large public display is their user experience of the psychological aspects, like the "Social embarrassment" will barriers on people interaction with the display. He proposed a public interaction flow model to explain the "Social embarrassment," including three activities: peripheral awareness activities, focal awareness activities, and direct interaction activities. Prante et al. [3] also notice a "Hello.Wall" interact model which is dependent on distinguish distance from inside to outside space: ambient zone, notification zone, and cell interaction zone.

Vogel & Balakrishnan [4] developed an interaction framework. By dividing Prante et al's "cell interaction zone" into the subtle and personal interaction phases and by generalizing the notion of a "notification zone" into an implicit interaction phase, this framework suggests a wider range of implicit and explicit interaction techniques.It covers the range from distant implicit public interaction to up-close explicit personal interaction, with four continuous phases with fluid inter-phase transitions: ambient display, implicit interaction, subtle interaction, and personal interaction. This interaction framework differs from the three zone model used in Prante et al's

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“Hello.Wall”model. It did not rely solely on physical proximity to delineate different phases. It emphasized fluid transitions between phases and supported sharing by several users each within their own interaction phase.

In this study, we are going to build a 100 inch multi-touch display to observe the user’s interactive behavior through the 6 cameras in the public space area. In addition to the manipulation interface, a "Photo.DIG " interface is development to control photos in the depth.

2 Build Multi-touch Display

As computers become pervasive in our daily life, researchers bring up the idea that technologies and computers should offer friendly interfaces for their users, such as to bridge the gap between people and digital information. Natural user interface, such as Multi-touch, is the most popular and important topic in Human-Computer Interface research area recently. Multi-touch can not only give us the ability to use more fingers simultaneously to interact with the information/objects on the screen without traditional input devices, such as physical mouse or keyboard, but also provide the possibility of multi-user interaction. These characteristics of Multi-touch blur the line between physical and virtual worlds, and lead the concepts of Human-Computer Interaction to a great revolution. The rise of Multi-Touch technology enables new ways of interacting with information. The developments of Intuitive gestures and innovative interfaces are still ongoing. Therefore, build up a Multi-Touch platform to support the new kind of interface research is the beginning of this study. First, the frame structure is designed and simulated with CAD software to arrange the camera position (Fig. 1).

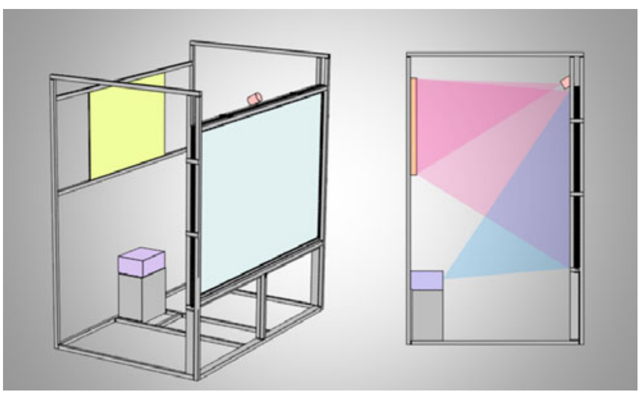

Fig. 1. Design the frame structure of Multi-Touch display

After that, we setup the whole 100 inch multi-touch platform at the art gallery of Chi-Mei building in national cheng-kung university. Figure 2 shows the interior design construction.

Fig. 2. Interior design construction of 100-inch multi-touch display

2.1 Photo.Dig Interface

For interface design process, we observe the people how to find a bunch of photos scattered on the desk. Usually people will using their both hand poke the upper photo to search the one they real want to see, the gesture is very nature and directly. We contrast this metaphor just like the tradition way to find the photos, we call it "Dig.Gesture"(Fig. 3), it let the user can direct use their both hand to expose their photo like the real tradition way.

Fig. 3. Dig.Gesture to implement Photo.Dig interface

Like the search photo way of "Dig.Gesture", we utilize the photo within historical timeline scale to be the design contents, and collect the old photos at NCKU (National Cheng Kung University), to arrange the photo in period from 1920 to 2000, by use the Dig.Gesture to control the timeline to change the batch photo show on the screen, this way use the timeline concept correspond the depth axis to represent the different period.

3 Results and Conclusion

After finish the platform construction and interface design, we setup 6 cameras around the multi-touch platform to observe users' behavior during manipulation the Photo.Dig interface. In 9 days' observation period, we found people moving from outside of exhibition space into the inside exhibition space, then to be close to the display wall, and finally touch the multi-touch interface. We conclude the user behavior into the five-stage: pedestrians, visitors, viewers, users, and operators. We observe the visitor into the space usually have two main types: active and passive. The people in passive type sometimes mostly because of the peer's traction, and often appear in parents and children, at this time the children always played a pioneer role, the parents are following. But there have other visitors in the observe space, it will enhance the existing pedestrian initiative noted that the proportion of space, especially when people in use around multi-touch screen, it is particularly attractive other pedestrians into this area to visit it, and join other people use the screen wall.

The group interaction usually appear in the visitors groups themselves, different groups of visitors will not appear too much further more interaction, but will choose a different part of contents to visit. However, different groups of visitors will be attracted and gathered in front of the large size of the multi-touch display.

In this study, we usually observe the users' social interaction behaviors: people are trying to touch the display without body contact to each other, and only familiar users or children have personal interaction during operate the same part of interface without body contact. The body contact interaction will happen in intimate users.

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Detection of Wheelchair User Activities Using Wearable Sensors

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Abstract. Wearable sensors are increasingly used to monitor and quantify physical activity types and levels in a real-life environment. In this project we studied the activity classification in manual wheelchair users using wearable sensors. Twenty-seven subjects performed a series of representative activities of daily living in a semi-structured setting with a wheelchair propulsion monitoring device (WPMD) attached to their upper limb and their wheelchair. The WPMD included a wheel rotation datalogger that collected wheelchair movements and an eWatch that collected tri-axial acceleration on the wrist. Features were extracted from the sensors and fed into four machine learning algorithms to classify the activities into three and four categories. The results indicated that these algorithms were able to classify these activities into three categories including self propulsion, external pushing, and sedentary activity with an accuracy of 89.4-91.9%.

Keywords: Activity monitors, wearable sensors, activity classification, wheelchair users, rehabilitation.

1 Introduction

Manual wheelchair users rely extensively on their upper limbs for mobility and activities of daily living. The long-term reliance on the upper limbs for performing daily activities has been associated with the prevalence of overuse-related musculoskeletal injuries and reports of pain [1-4]. The Consortium for Spinal Cord Medicine published a Clinical Practice Guideline on Preservation of Upper Extremity Function Following Spinal Cord Injury [5]. The Guideline recommends reducing the frequency of repetitive upper limb tasks, minimizing forces required to complete tasks, and minimizing extremes of wrist and shoulder motions [5]. However, such information is usually collected in laboratory or clinical settings. The functional amount of use and the repetitiveness of upper limb activities that occur on a daily basis in manual wheelchair users are unclear.

Recent advances in miniature sensor technology have led to the development of wearable devices that use acceleration, audio, video, and other sensors to recognize user activity in a free-living environment. While much has been published on

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developing instrumentation and recognition software to monitor activities in the ambulatory population [6-8], only a few studies have evaluated wearable devices in detecting activities among manual wheelchair users [9-15]. Washburn and Copay evaluated an accelerometry-based wearable device and found significant correlations ($r=0.52$-0.66, $p<0.01$) between the activity counts from the device worn on the wrist and the energy expenditure during wheelchair propulsion [9]. Warms et al. found low to moderate correlations ($r=0.30$-0.77, $p<0.01$) between the activity counts from an Actiwatch wrist-worn device and self-reported activity [10]. Tolerico et al. used a wheel rotation datalogger to collect gross mobility characteristics of manual wheelchair users in two real-life settings including the National Veterans Wheelchair Games (NVWGs) and the subjects' residential setting [11]. They found that manual wheelchair users travelled a distance of 6745.3 ± 1937.9 meters per day at a speed of 1.0 ± 0.2 meters/second in the NVWGs, and a distance of 2457.0 ± 1195.7 meters per day at a speed of 0.8 ± 0.2 meters/second when returning to their homes. However, it was not clear if the wheelchair movements were due to self-propulsion or being pushed by others. French et al. used a wrist worn tri-axial accelerometer called eWatch to classify wheelchair propulsion patterns and were able to achieve an accuracy of 60-90% in three subjects without any disability [12]. They were also able to classify self-propulsion and external pushing using one eWatch on the wrist and another eWatch on the frame of the wheelchair with an accuracy of 80-85%. Postma et al. used a wearable monitoring system containing six accelerometers to detect wheelchair propulsion from a mixed set of activities of daily living among 10 subjects with SCI [14]. The accelerometers were attached by medical tapes to each wrist, each thigh, and over the sternum and a data recorder connecting the six accelerometers was carried in a belt around the waist. The results indicated that wheelchair propulsion could be detected with an overall accuracy of 92%. A subsequent study by the same group of researchers showed that using this wearable monitoring system did not influence the amount of daily wheelchair propulsion [15]. Furthermore, subjects in the study reported burdens with wearing this wearable system.

This study combined the eWatch and the wheel rotation datalogger to form a wheelchair propulsion monitoring device (WPMD) to capture and categorize wheelchair related activities. A primary objective of this study was to evaluate the performance of the WPMD in detecting and classifying different types of activities performed by manual wheelchair users. Knowing the upper limb usage for wheelchair propulsion and other activities of daily living in real-life environments will contributes to our understanding of the etiology of upper limb injuries and pain among this population.

2 Method

2.1 Subjects

The Institutional Review Board at the University of Pittsburgh and the Department of Veteran Affairs (VA) Pittsburgh Healthcare System approved the study protocol before initiation. The study was conducted at the 29th National Veterans Wheelchair Games (NVWGs) held in Spokane, WA, USA in 2009. Subjects were recruited recruitment through a booth located at the NVWGs and flyers that were posted around the facilities during the event. Participants in the NVWGs who were interested in the study were informed of the study aim, protocol, and the eligibility criteria. Subjects were recruited based on the inclusion criteria that they were between 18 and 70 years of age, used a manual wheelchair as their primary means of mobility, and were able to provide written informed consent. Subjects were excluded if they were unable to tolerate performing activities for 2 hours, which was the estimated length of the study.

2.2 Experimental Protocol

Signed informed consent was obtained from all subjects before the start of data collection. Subjects were asked to complete a brief demographic survey. In addition, the WPMD consisting of a wheel rotation datalogger and an eWatch was attached to the subject's wheelchair and wrist. The wheel rotation datalogger was self-contained, lightweight, and can be easily attached to the spokes of a manual wheelchair with zip-ties. It was developed at the Human Engineering Research Laboratories (HERL), University of Pittsburgh to monitor mobility characteristics of manual wheelchair users in real-world environments. It measures the rotation of the wheelchair wheel through the use of three reed switches mounted 120 degrees apart on the back of the printed circuit board and a magnet mounted at the bottom of a pendulum [11]. The eWatch was developed at the Human Computer Interaction Institute, Carnegie Mellon University. The eWatch consists of a tri-axial accelerometer that can sense three-axes of acceleration at user controllable sampling rate. In this study, the eWatch was worn on the subject's dominant wrist and sampled at a frequency of 20Hz. The wheel rotation datalogger and the eWatch were synchronized by setting their clocks to the same reference.

Subjects followed an activity protocol to perform a variety of activities of daily living (ADLs). The ADLs included resting, propelling their wheelchair over different surfaces and terrains, being pushed by an investigator, typing on a computer, reading, doing laundry, folding clothes, preparing meals, and transferring between their wheelchair and a chair. The wheelchair propulsion trials included propelling on a low-profile carpet for a distance of 20 meters, and propelling eighteen trials up and down a ramp of 3.7 meters in length. The ramp was a wooden platform with fixtures to adjust the surface type, the slope angles, and cross slope angles to simulate various types of real-world terrains. Each subject were asked to perform eighteen trials along the ramp when it was configured to three types of surfaces (i.e., wood, blind guide, and Teflon drizzled with soapy water) at three different cross slope angles (i.e., 0°, 1°, and 2°) and two different slope angles (i.e., 0° and 5°). The three surfaces simulated the smooth, rough, and slippery road conditions. The wheelchair population trials and other ADLs were mixed in terms of the sequence. Subjects were asked to perform these activities in their own manner at their own pace. Subjects performed only those activities that they were able to perform. Two investigators followed the subjects throughout the protocol and used a stopwatch to annotate the start and finish times of each activity.

2.3 Data Collection and Analysis

The data from the wheel rotation datalogger and the eWatch were downloaded using their specific software, respectively. A custom MATLAB® (The Mathworks, Inc., USA) program was written to extract features based on the wheelchair velocity, and the tri-axial and resultant accelerations at the wrist. The extracted features include the mean, standard deviation, root mean square (RMS), mean absolute deviation (MAD), zero crossings (ZCR), mean crossings (MCR), fluctuations in amplitude, energy, and entropy. Features were calculated using the 50% overlapping sliding windows of 10 seconds. MATLABArsenal, which includes SVMLight and Weka softwares, was used to classify the activities based on the extracted features [16]. The annotated data were used as the reference. The activities were classified into three and four categories. The four categories included self-propulsion, external pushing, sedentary upper limb activity, and non-activity. The three categories included self-propulsion, external pushing, and sedentary activity which combined the sedentary upper limb activity and non-activity. The classifiers used were Support Vector Machines (SVM), k-Nearest Neighbors (KNN), Naïve Bayes (NB), and Decision Tress (C4.5). The performance of each classifier was analyzed by a leave-one-subject-out (LOSO) cross-validation approach.

3 Results

A total of 27 subjects participated in the study. Due to device malfunction, two subjects had missing data and were not included in the data analysis. Data of 25 subjects including 19 males and 6 females with an average age of 49.4±10.5 years were analyzed in this study. Nineteen subjects had spinal cord injury with injury levels ranging from C4 to L5, three subjects had multiple sclerosis, and the remaining three subjects had lower extremity amputation. The average duration since the onset of disability in the subjects was 14.3±9.8 years.

All the subjects were able to complete the protocol. Table 1 shows the classification performance of four classifiers. In addition to using a full set of features based on the wheelchair velocity, and the tri-axial and resultant accelerations at the wrist, we also selected a reduced feature set using the Best First search method and Correlation-based Feature Selection (CFS) algorithm [17]. The CFS algorithm uses an evaluation heuristic that examines the usefulness of individual features along with the level of inter-correlation among the feature. The reduced feature set included the RMS and zero crossing in the x-axis acceleration, mean crossing in the y-axis acceleration, mean and mean crossing in the resultant acceleration, and mean velocity from the wheel rotation datalogger. All the classifiers were able to classify three categories of activities with higher accuracies than when classifying four categories. The performances of these classifiers were not significantly influenced by the reduced number of features.

Table 1. Performance of four classifiers based on the LOSO cross-validation (%)

Activity Category	All Features (45)				Reduced Features (6)			
	SVM	KNN	NB	C4.5	SVM	KNN	NB	C4.5
3	89.4	91.5	89.7	90.5	91.9	91.4	91.2	91.7
4	80.6	75.3	76.8	73.1	75.6	73.0	74.1	76.0

Table 2 shows the classification accuracy for each activity category (out of three activity categories) based on the LOSO cross validation on the reduced feature set. Table 3 shows the confusion matrix for the decision tree C4.5 classifier using the LOSO cross validation for the three activity categories on the reduced feature set. Table 4 shows the classification accuracy for each activity category (out of four activity categories) based on the LOSO cross validation on the reduced feature set. Table 5 shows the confusion matrix for the decision tree C4.5 classifier using the LOSO cross validation for the four activity categories on the reduced feature set.

Table 2. Classification accuracy for three activity categories (%)

Activity Category	SVM	KNN	NB	C4.5
Self-Propulsion	85.5	84.1	88.1	86.0
External Pushing	64.2	71.0	64.8	74.6
Sedentary activity	96.0	95.3	93.9	94.9

Table 3. Confusion matrix when using C4.5 classifier for three activity categories (%)

	Detected SP	Detected EP	Detected SA
Annotated Self-Propulsion (SP)	86.0	1.6	12.4
Annotated External Pushing (EP)	7.5	74.6	17.9
Annotated Sedentary Activity (SA)	4.7	0.5	94.9

Table 4. Classification accuracy for four activity categories (%)

Activity Category	SVM	KNN	NB	C4.5
Self-Propulsion	88.5	86.2	89.5	87.6
External Pushing	66.8	71.3	68.7	76.2
Sedentary activity	46.7	48.8	33.0	56.8
Non Activity	86.1	79.1	89.4	79.9

Table 5. Confusion matrix when using C4.5 classifier for four activity categories (%)

	Detected SP	Detected EP	Detected SA	Detected NA
Annotated Self-Propulsion (SP)	87.6	1.7	7.6	3.2
Annotated External Pushing (EP)	9.8	76.2	6.2	7.8
Annotated Sedentary activity (SA)	11.3	0.8	56.8	31.1
Annotated Non Activity (NA)	2.4	0.4	17.3	79.9

4 Discussions

All the classifiers were able to classify three activities i.e., self-propulsion, being pushed, and sedentary activity with an accuracy of about 90% or higher (Table 1).

The performance is similar to the results by Postma et al., who used six accelerometer based sensors to detect wheelchair propulsion versus non-propulsion [14] and achieved the accuracy of 87-92%. Compared to attaching six accelerometer based sensors to the thighs, wrists and the sternum, the WPMD has only two sensors with one being attached to the wheelchair wheel and one acting as a wrist watch. Our solution is more practical for capturing activities performed in real-life environments. However, the WPMD was unable to detect any motion in the lower extremities and the trunk. It may also miss detecting the upper limb motion if subjects used their non-dominant arm rather the dominant arm where the eWatch was attached. In terms of data preprocessing, the previous study disregarded the data if a task lasted less than five seconds while the current study used all the data from the testing without trimming off data.

The results of the decision tree C4.5 classifier (Table 2 and Table 4) for self propulsion and external pushing (74-86%) are similar to the study by French et al where three non-wheelchair users were tested with an eWatch on the wrist and another eWatch on the wheelchair frame, and the classification accuracy of self-propulsion and external pushing ranged from 80-85% [12]. From the confusion matrices (Table 3 and Table 4), self-propulsion and non-activity category were usually detected with good accuracy. This could be due to the very distinguishable features such as high resultant acceleration with wheelchair movement for self-propulsion and very low resultant acceleration without wheelchair movement for non-activity, respectively. Self-propulsion was occasionally confused with sedentary activities, which can be attributed to the transitions between activities and inaccuracies in hand annotation where the annotator incorrectly assigned the activity type. For example, doing laundry was assigned as a sedentary upper limb activity, but may require subjects to move their wheelchairs. In some cases the classifiers predicted external pushing as self-propulsion, which could be due to the upper limb movements by the subjects while being pushed in their wheelchair. The low classification accuracy of sedentary upper limb activity and non-activity (Table 4) could also be also due to inaccuracies in hand annotation. For example, dialing a phone was assigned to sedentary upper limb activity, but there were moments where subjects may not move their upper limbs and wheelchairs, and stayed in non-activity state. Nonetheless, the high LOSO cross-validation accuracy for the three activity categories by all the classifiers on the reduced feature set suggested that these classifiers can be used in real-world applications where activities in manual wheelchair users need to be classified.

One limitation of the study was to use hand annotation rather than video recording as the reference method. With self-propulsion episodes being accurately detected out of a series of activities of daily living, the next step is to investigate the relationship between upper limb acceleration and important biomechanical variables in wheelchair propulsion such as propulsion frequency and forces. Such wearable devices may help researchers and clinicians to quantify propulsion performance and upper limb usage, and monitor the effectiveness of interventions targeting to improve propulsion skills among manual wheelchair users.

5 Conclusions

In this paper, we discussed using a portable WPMD comprised of a wheel rotation datalogger and an eWatch to monitor wheelchair related activities in a semi-structured setting among 27 manual wheelchair users. We showed that common machine learning algorithms can be used to classify wheelchair related activities into self-propulsion, external pushing, and sedentary activity with an accuracy of around 90% or higher. The results suggest that it is feasible to use the WPMD to quantify self-propulsion and other ADLs in real life environments. The information on upper limb usage in manual wheelchair users will help understand the etiology of upper limb injuries and pain among this population.

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Universal Access in Ambient Intelligent Environments: A Research Agenda

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Abstract. In this position paper the information society is supposed to emerge as some form of Ambient Intelligence (AmI) environment. On the basis of the results of the DfA@eInclusion project, it is maintained that this development asks for a different approach to the solution of inclusion problems, i.e. the Design for All (or Universal Design) approach. The main lines of research and development activity to be carried out in order to contribute to the development of an inclusive AmI environment are then pointed out.

Keywords: Universal Access, Design for All, eInclusion.

1 Introduction

Universal Access is receiving increasing attention, due to the recently emerged interest at the political level and to the technological developments. From the political perspective, the Riga Ministerial Declaration (2006) defines eInclusion as a form of Universal Access, i.e. as the right of people to be granted availability of all information and communication facilities in the Information Society and to be supported by ICT for achieving their goals in all environments.

From the technological perspective, the information society is materialising as some sort of ambient intelligent environment, which, if suitably designed, could develop according to the two components foreseen in the definition of eInclusion in the Riga Ministerial Declaration. First, it could make available an accessible ICT environment where intelligent objects offer (support) functionalities useful for access to information, interpersonal communications and environmental control. Moreover, the environment is assumed to be connected with the external world and it could contribute with more complex functionalities (services), also offering explicit support to people. From the perspective of interaction, a migration is foreseen to a model where people use (disembodied) natural interfaces with functionalities made available by single intelligent objects, by their cooperation under the supervision of a control centre, and by the cooperation through external networks.

According to the definition in the Riga Declaration, e-Inclusion will be favoured by this emerging environment, if the functionalities made available will be inclusive (i.e., accessible) and if they will take care of supporting users with activity limitation, by redefining activities so that they can be carried out with the available abilities, and/or by proactively supporting users in tasks where they have limitations.

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2 Universal Access and Design for All

In this position paper, it is maintained that Universal Access needs a conscious and systematic effort based on Design for All, in order to develop an Information Society available to all citizens. The requirement for Design for All stems from the different dimensions of diversity, which are intrinsic to the Information Society. These dimensions become evident if the analysis is not limited to few and narrow user profiles, but considers the broad range of user characteristics, the changing nature of human activities, the variety of contexts of use, the increasing availability and diversification of information and knowledge sources and services, the proliferation of technological platforms, etc.

This needs a redefined research agenda for solving the eInclusion problems. In the Design for All for eInclusion project (DfA@eInclusion – www.dfaei.org), a Coordination Action funded by the European Commission to support the European Design for All e-Accessibility Network (EDeAN - www.edean.org), the main conceptual aspects of Design for All in ICT, i.e. of mainstreaming eInclusion, have been discussed. Methodologies for its implementation have been defined and examples of technical approaches for its implementation have been presented. Then, methodologies have been defined to elicit gaps in research and developments from the perspective of eInclusion. The methodologies, which take into account the two aspects of e-Inclusion as defined in the Riga declaration are structured in order to consider: (i) the evolution of the present situation, where the focus is upon the interaction with specific devices and services; (ii) the emergence of the AmI Information Society, where interaction with the environment becomes relevant.

3 Methodologies for the Structured Identification of R&D Agendas

Due to the inherent characteristics of Design for All of being a user centred methodology, the analysis of the possible impact of technological developments and, consequently, the identification of research and development activities to carry out in order to maximise advantages and minimise risks of exclusion for all citizens must start from an analysis of user needs, requirements and preferences.

First, the inclusion problems created by present technology and possible solutions were considered. Then, the AmI environment was analysed. Unfortunately, the technology to be used in AmI environments is only partially available and the way of integrating it in functional environments (apart from some preliminary examples in the home environment) is under study. Therefore, the elicitation of user needs, requirements and preferences is not straightforward. There are not products to be tested in real usage contexts. It is necessary to use methodologies based on usage scenarios. However, the DfA@eInclusion project did not create scenarios, because there are plenty of scenarios about possible future instantiations of the "Information Society", created by the European Commission (e.g. by ISTAG (ISTAG, 2003) and by the SWAMI project (Friedewald, 2006), or by industry (e.g. Siemens) and outside Europe (e.g. by the Australian Government). The project used available scenarios to construct a simple narrative, which describes possible situations of people's life connected to the use of ICT. People with different abilities are virtually observed and opportunities and problems are pointed out. When problems are identified and these can be considered as caused by knowledge or technological gaps, research activities are looked for that can possibly reduce these gaps improving eInclusion.

Firstly, an optimistic analysis was carried out, meaning that the AmI environment was considered as a perfect implementation of the specifications, and possible inclusion problems were pointed out. Then, a SWAMI perspective was assumed, considering that something could go wrong from a technological and/or organizational perspective (Safeguard aspects). The project adopted a subset of the list of issues identified in the SWAMI project: i.e, privacy, security, identity, trust, loss of control, dependency, surveillance, identity theft; malicious attacks.

4 A Research Agenda

In the short term, when eInclusion problems are connected to available technology characterised by ICT systems, services and applications based on multimedia and multimodal interactions, a lot of knowledge resulted available. The matching of the user abilities with different media and alternative functionalities to be offered to people with activity limitations are widely described in available literature.

The situation is different if Design for All as a design methodology in ICT in the AmI environment is considered. For example, it resulted that there are Design for All aspects for which research is needed. The first is the impact of DfA on the user, considering, e.g., the efficiency of DfA solutions, their cost, and acceptability. The second is the impact of the methodology on industry, as, e.g., the penetration of DfA in mainstream industry, its impact on planning the design of new products, the economic aspects, business cases, etc.

In the medium-long term, the main effort is not supposed to be devoted to the identification of gaps in the accessibility to specific technologies, systems and services, most of which will be probably taken care by the foreseen developments of technology itself, but of gaps in the generation and application of the knowledge that can lead to a "Design for All" solution to the problems of eInclusion in general.

4.1 Users in the Research and Development Cycle

Recommendations for research activities in HCI are connected with the need of integrating users in the design process and are based on the concept of extending user-centred design to support new virtual activities. At the scientific level, this is also connected with the need to establish a cross-discipline research agenda, fostering potential synergies amongst relevant disciplines. The main research lines are summarised in the following.

Foundations for designing computer-mediated human activities in the Information Age. User-centred design (Norman and Draper, 1986) has surfaced as the primary design approach to facilitate usable interactive systems. User-centred design, as a philosophy, should be extended to provide a more prescriptive design framework. Actions in this area should strive to assess potential HCI design contributions rooted in disciplines that focus on human communication in social contexts (e.g., developmental psychology, the social sciences, the humanities, etc) and extend existing analytical design approaches (e.g., design space analysis techniques) with social constructs to provide new methods for studying virtual spaces.

Metrics for important interaction quality attributes. Metrics provide a powerful instrument for measuring different aspects of an interactive system. In the past, the field of HCI has attempted to provide metric-based techniques in the form of usability scales for measuring qualities of interactive systems. Actions are needed to extend metrics to interaction in the emerging environment.

Computational tools for usability engineering. Usability engineering has been traditionally conducted without the assistance of computational environments or tools. Actions in this area should aim to provide for computer-supported usability engineering platforms comprising inter-operable software components.

Requirements engineering methods to facilitate the elicitation of requirements in novel contexts of use and different user groups. Actions in this area should strive to provide improved means for eliciting, capturing and consolidating requirements for a broad range of activities in the Information Society, including the development of tools to facilitate the mapping of requirements to design concepts.

Protocols for effective user participation in design activities. Actions in this area should aim to: (i) establish new methods and tools for managing user participation in design; and (ii) promote practice and experience of participatory design and develop suitable models.

4.2 Interaction in Ambient Intelligence

It is clear that the problem of interacting with AmI environments is more complex than interacting with a computer. It is not any more a problem of giving access to a keyboard, a pointer, and a screen where object are manipulated to produce and access (multimedia) information. People must interact with a multitude of objects that is supposed to concur to give them the possibility of communicating, accessing information and controlling the environment. The nature of interaction in AmI environments will change, evolving from human-computer interaction to human-environment interaction (Streitz, 2007). Interaction shifts from an explicit paradigm, in which the attention is on computing, towards an implicit paradigm, in which interfaces themselves drive human attention when required.

It is likely that some of the built-in features of AmI environments, such as multimodality, will satisfy the requirements of a wider base of user groups, thus facilitating the provision of solutions that will be accessible by design (Emiliani and Stephanidis, 2005). However, due to the intrinsic characteristics of the new technological environment, it may be that interaction will pose different perceptual and cognitive demands on humans compared to currently available technology. The main challenge in this respect is to identify and avoid forms of interaction which may lead to negative consequences such as confusion, cognitive overload, frustration, etc.

Individualisation and user interface adaptation. A critical property of AmI environments will be their capability for adaptation and individualisation. This is necessary to ensure accessibility by all users to community-wide information and communication resources, as well as to satisfy experiences in the use of systems that carry out a broad range of social activities.

Design recommendations for suitable/plausible interaction modalities and combinations. In the recent history of HCI, the visual modality has been predominant in the systems and tools which have been developed for humans to work with. However, it is presently becoming pertinent to consider multimedia and multimodal interaction. Thus, it is important to investigate how to design for alternative modalities and how to combine modalities into integrated environments.

Architectures for multiple metaphor environments. The notion of a multiple metaphor environment implies a particular embodiment of an integrated system, capable of performing context-sensitive mapping between concepts from a source domain to symbols in a (target) presentation domain (or metaphor), and vice-versa. Actions are needed to determine how multiple metaphor environments can be constructed and how they can provide the technology for building systems exhibiting desired usage properties.

4.3 Group Activities

In the AmI environments group activity become particularly important. It is therefore useful to devote efforts toward the development of integrated systems sharable by communities of users (environments of use). In contrast to tools, which enhance the productivity of individuals, environments of use would promote the concept of systems suitable for a broad range of communication and collaboration intensive activities amongst groups of people. Finally, they should provide unobtrusive means for supporting social activities.

Properties of environments of use. Such environments (e.g., the virtual university, the virtual theatre, the virtual market place) are likely to be substantially different from conventional interactive software. To facilitate the construction of such environments, studies are needed to identify their properties and characteristics, as well as the norms that characterise their operation.

Novel architectures for interactive systems for managing collective experiences of users and non-users. Traditional interactive software architectures do not account for several of the desirable or envisioned properties of environments of use, such as interoperability, adaptation, co-operation, intelligence, etc. (Stephanidis et al., 1998). Actions in this area should strive to introduce and validate new architectural models for interactive software; define desirable architectural properties (e.g., adaptation, co-operation, collaboration, portability, interoperability, scalability, modifiability) and produce guidelines on how they can be met.

Multi-agent systems and components to support co-operation and collaboration. Two of the important dimensions of environments of use are expected to be (a) a shift in the computing paradigm, departing from the desktop embodiment of the computer to distributed "intelligence" in the living environment; and (b) co-operation and collaboration, which will need to be facilitated and actively supported. In this context, and in order to address the two dimensions together, it is necessary to cater for environments that will be jointly inhabited by human and software agents.

Social interaction amongst members of on-line communities. A primary characteristic of the emerging broad range of human activities in the Information Society is their inherently group-centric and social nature. In order to facilitate the development of "sociable" interactive environments, it is important to enrich the current practices with concepts which have a social focus. New models are needed to facilitate social awareness, social immersion and social navigation in virtual spaces.

Methodologies for collecting/analysing requirements and understanding virtual communities. Traditional models and tools of information processing psychology, focusing on individual users, need to be enhanced to provide a broader view of interaction, accounting for small groups and communities of users.

Individual/collective intelligence and community knowledge management. Recent advances in telecommunications and, in particular, networking, have broadened the scope and type of computer-mediated human activities. Increasingly, users find themselves associated with various virtual/on-line communities to attain professional and social goals. Knowledge, therefore, no longer constitutes an individual's asset, but a community-wide resource which can be shared and articulated by members of that community. Actions are needed to support the life-cycle of communities and community-based knowledge management.

Accessing community-wide information resources. Information generated and captured by virtual communities of users should be stored and accessed in a manner that is effective, efficient and satisfactory for the individual members of the community. Actions are needed to facilitate human interactions with large information spaces (and concurrently with other humans) and to provide technological solutions which will make community-wide information resources accessible, scalable to new generations of technology, persistent and secure.

4.4 Support Services

Some interesting conclusions can be drawn from available scenaria, with reference to services available as an integral part of the AmI environment and service whose deployment can be of interest of people with activity limitations.

First of all, environmental control systems, introduced for the independent living of persons with motor disabilities, become an integral part of all living environments. Another type of service (relay services) of interest for people who cannot hear/and or speak is available by default in the AmI environment, where voice recognition and synthesis, automatic translation, gesture recognition (sign language and lip reading) and animation (synthetic sign language and lips movements) are available. The entire AmI is a pervasive and sophisticated alarm and support/control system. AmI can continuously control people's behaviour in the various environments according to their known habits and intervene if necessary. For example, if a person cannot see, AmI is able, if necessary, to describe its layout and functionalities, as well as the functionalities of its devices. The same is true with navigation systems. They are present everywhere. In the AmI environment people are able to converse on an audio/video system and cooperatively access information. This can introduce a remote socialisation component, which can be crucial to reduce stress and to support people.

However, the real winning factor is the "intelligence" in the environment and in services, and this should be an important focus of future research activities. A first example is the availability of intelligent agents for shopping. According to ISTAG, support by intelligent agents is supposed to be available for all citizens. Therefore, their implementation is supposed to be considered in the mainstream research and development activities. In addition to being intelligent, the agents in the environment must know people. According to the Design for All approach, this is one fundamental task left to eInclusion in this particular environment, i.e. the collection of information about (i) user characteristics and (ii) user behaviour in the different contexts to be used in user modelling systems.

5 Intelligence in the Environment

Intelligent agents seem interesting to offer focused services to people. They normally address a single "intelligent" task and try to mimic the behaviour of the owner. The problem is much more difficult when the entire environment or complex parts of it must be controlled in a way to show behaviour that people can consider "intelligent". The problem is too far reaching to be tractable in this paper. Only, some examples will be made in order to give an idea of the complexity of the involved problems.

At the technological level, artificial intelligence is crucial in supporting the development of basic technologies considered important in the implementation of AmI. For example, the ISTAG experts write that pattern recognition (including images, speech and gesture) is a key area of artificial intelligence which is already evolving rapidly and should improve significantly the situation.

At the level of interaction, a smart environment may provide an extremely large number of complex choices. An interface that directly offers all the possibilities to the user may result cumbersome and complex. On the contrary, the user interface should act as an intelligent intermediary between the system and the user. This is the reason why Artificial Intelligence methods and techniques are starting to be used for the development of adaptive intelligent interfaces. Intelligent interfaces are first supposed to be able to adapt to the user's physical, sensorial and cognitive capabilities, some of which may be restricted due to aging or impairments and/or may change along the day, due to e.g. fatigue, and changes in motivation. To this end, the interface must have a model of the users and be able to make "assumptions" about their actual situation from the current value of a number of parameters as measured by sensors and/or made available by the evolving interaction behaviour. Moreover, an intelligent interface must be able to recover from errors in adaptations.

Another important characteristic of the human interfaces for smart environments is their spatial dependency. Many features and possible effects of interaction depend on the position of the user. For instance, a simple command as "switch on the lights" must be differently interpreted according to the place where it has been given. Provided that the user is located with enough precision, the interface needs a spatial model to be able to decide what the lights to be switched on are. In addition, the interface, in order to avoid potential dangers, must be able to decide the services that can be offered to the user in the current location.

In contrast to graphical user interfaces, ambient user interfaces should take advantage of the available AmI Infrastructure, in order to support interaction that is tailored to the current needs and characteristics of a particular user and context of use. Thus, they could be multimodal and distributed in space (e.g., employ the TV screen and stereo speakers to provide output, and get input through both speech and gestures), allowing interaction with the ambient technological environment in an efficient, effective and intuitive way which also guarantees their well-being, privacy and safety and supporting seamless, high-quality, unobtrusive, and fault-tolerant user interaction.

At level of context of use, the AmI environment must take care of the contexts of use. In AmI, the situation is very complex, because in the ubiquitous interaction with information and telecommunication systems the context of use may change continuously or abruptly and the same systems or services may need to behave differently in different contexts. Recently, research tendencies have evolved to consider context not statically, but as a process, defined by specific sets of situations, roles, relations, and entities. It is not sufficient for a system to behave correctly at a given instant, but it must continue to behave correctly for the entire process. This requirement is coherent with the idea that in AmI intelligence must be essentially in the environment and not in the individual objects. Functionalities will be surely more easily available if they can migrate through the network, instead of being entrapped in objects.

Another important issue is avoiding the risk of a possible mismatch between the model of interaction of the system and the user's mental model of it. As a matter of fact it must be considered that in today systems, designers have pre-programmed solutions for the design space of the systems, while in AmI the interaction space is ill-defined and unpredictable. In a context, defined as above, three level of abstractions exist: the sensing level (numeric observables), the perception level (symbolic observables), and the level of the identification of situation and context. This is the level where the conditions for moving between situations are identified and anticipate needs of the user and of the system. This requires replacing explicitly coded responses to situations and contexts, with a higher-level, more knowledge-intensive use of machine-readable strategies coupled with reasoning and learning.

At the level of intelligent support, additional complexity can be inferred if the main specifications of an AmI environment are considered. According to ISTAG, the ambient intelligence environment must be unobtrusive (i.e. many distributed devices are embedded in the environment, and do not intrude into our consciousness unless we need them), personalized (i.e. it can recognize the user, and its behaviour can be tailored to the user's needs), adaptive (i.e. its behaviour can change in response to a person's actions and environment), and anticipatory (i.e. it anticipates a person's desires and environment as much as possible without the need for mediation). Therefore, in AmI the emphasis is on (abstract) goals of the users that the environment must infer and structure in a set of tasks adapted to the users themselves and the context of use (for example without interfering with the goals of other persons in the same environment).

The acceptability and uptake of the new paradigm will be essentially dependent on how smart the system is in inferring the goals (desires) of the users in the varying contexts of use and in organising the available resources (intelligent objects, services and applications in the environment) in order to help users to fulfil them. This means that an "intelligent" control must be available. So far most of the available control systems are deterministic. This is not compatible with the emerging situation for two main reasons. The first is that AmI is not only concerned with measurements from sensors, but with goals of people to be fulfilled and interaction in a social context. Moreover, it must take into account that the emerging model may be a social group interacting in order to cooperate for carrying out activities connected with independent living and interactions within a social environment.

Finally, ambient intelligence is also supposed to inspire trust and confidence and to be controllable by ordinary people. The requirement about trust and confidence is very challenging, because they can be obtained only if the user has a complete knowledge at the conceptual level of the running principles of the systems, services and applications and is given the possibility of controlling all the steps necessary to obtain the required results. For what concerns control by ordinary people, in some discussions, a simple and naïve concept is assumed, i.e. that the user is given the possibility of switching off the system, service or application. But the problem is not so simple. For example, switching off the telephone can be a problem if a user is connected through it to an alarm system or a health care monitoring system. Therefore, it is necessary that the AmI environment is able to cooperate with the users, according to their profile (e.g. culture, technical knowledge, and possible impairments), the context of use, and the emotional situation in order to find a compromise between privacy or fatigue etc. and possible security aspects.

6 Conclusions

The technological developments that lead to an Information Society as an Ambient Intelligence environment as such seem to increase the possibilities of inclusion, because the technology which was so far mainly used in niche environments (for example voice synthesis and recognition) is supposed to be made available for use by the public at large.

The AmI environment also promises to be structured in such a way that many services used to support people with activity limitations (e.g. alarm and control services) are integral part of it, particularly if a Design for All approach is used. Interdisciplinary problems, mainly related to the introduction of users in the design cycle and to group activities, appear of particular importance. Both in the interaction with the environment and its organization and control Artificial Intelligence appears as one of the most important sectors of future activity.

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Mobile Interfaces for Better Living: Supporting Awareness in a Smart Home Environment

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Abstract. This paper describes efforts toward creating an integrated living space to support heightened awareness of a user's environment. The work seeks to balance the needs and desires of an individual with those of other people within the locality, community, and world, to include basic comforts like temperature and humidity of a living environment as well as use of resources like power and water. The use of mobile technologies—already prominent among many populations—can be used to raise awareness of the needs and responsibilities of the individual and can highlight opportunities to live in ways that are friendlier to others. Mobile technologies have great promise in connecting users to their environment, and a smart environment enhanced with technology that supports better living can improve the lives of individuals, groups, and the broader community. The goals of this work are toward encouraging: 1) increased awareness of information in the user's surroundings; 2) integrated control over factors in one's surrounding and home environments; and 3) increased ability to support sustainable living for both individuals and groups. This work builds on the many smart, green, and sustainable living environment initiatives that have emerged in recent years.

Keywords: smart house, awareness, mobile computing.

1 Introduction

The notion of a smart home, aware home, or green home has been explored toward incorporating environmentally friendly initiatives and techniques into the built environment. Often computing technology plays a key role in monitoring the information generated by these homes and in controlling certain aspects of the home. Awareness can be raised through the use of mobile notification systems, which attempt to deliver current, important information to the user in an efficient and effective manner. This work first seeks to present key HCI-related questions regarding the presentation of

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information via mobile device—enabling individuals to understand how their decisions may impact the environment, and enabling groups to reach consensus on decisions.

To demonstrate this type and access to information, this work extends our prior experiences with LumenHaus [1], Virginia Tech's award winning solar house at the 2010 European Solar Decathlon competition. This paper outlines an interface construction effort that aggregates weather data. The interface seeks to provide the information such that users can maintain constant knowledge of changing weather patterns, toward making informed decisions about the state of LumenHaus; e.g., whether to vent with outside air, how to position the solar panels, and how to maximize comfort for a diverse group of people in LumenHaus.

The interface is used to investigate emerging interface construction directions through a stakeholder investigation study, conducted with individuals or small groups of architects, technologists, and target users. The study took place via in-house presentations or post-demo symposium discussions, when the participants could understand both the interface and the environment. This study highlighted the needs of the stakeholders, and the results from the study influenced not only the construction of the prototype, but, more importantly, the brainstorming of future directions for mobile device development presented in the next section.

2 Related Work

The notion of a smart home, aware home, or green home has been explored at places like Virginia Tech, Georgia Tech [2], Stanford, Florida, and Duke, toward incorporating environmentally friendly initiatives and techniques into the built environment. Often computing technology plays a key role in monitoring the information generated by these homes and in controlling certain aspects of the home. For example, the Georgia Tech Aware Home includes motion sensors that monitor the activities of elderly home dwellers and conveys an overview of the activity level to a remote caretaker [3], and under-development interfaces envision in-home sensors like smart scales and glucometers sharing health related data [4].

Awareness is raised through the use of mobile notification systems. Notification systems attempt to deliver current, important information to the user in an efficient and effective manner. Examples of notification systems include messaging systems, email alerts, and news and stock tickers. Significant development work has taken place in the construction of location-aware notification systems; e.g. [5], [6], [7]. An example of notification interfaces being leveraged in an integrated living space is Intel Research Seattle's UbiFit Garden system, with the central premise to foster more regular physical activity through the use of mobile displays, on-body sensing, and journaling. Results from preliminary field studies have shown UbiFit Garden's effectiveness in helping people maintain a more physically active lifestyle and provide evidence validating the usefulness of interactive technologies such as notification interfaces in supporting health-related behavioral change [8].

The effectiveness of such notification systems also depends how well they are integrated with the living environment. Weiser states that "the most profound technologies are those that disappear" [9]. The disappearance effect is a consequence of human psychology. When an artifact becomes well understood and can be used "without thinking," the information presented by the artifact is used without really noticing the artifact itself. Information technology components, such as mobile devices, displays, and sensors, are becoming (or already are) a part of our everyday life and living environments. They are being adapted into the existing patterns of use and are beginning to "disappear" [10].

The "smart" house augments the traditional home with a rich computational and communicational infrastructure. The infrastructure provides a variety of services that improve the living experience and allow for customization based on the user preferences. For example, the temperature and light levels may depend on the current occupancy, i.e. who are the users occupying the space. Domisilica [11] allows the user to access and associate the information as a part of a home.

There are obvious advantages of the "smart" home outlined above. However, this focus on the domestic also introduces new challenges "…that move design beyond the current focus on information and knowledge work … and exposes us to the demands of new user groups, including the elderly, the disabled, and the mentally impaired …" [10].

The home provides an intersection between the public and private [12] that reflects on the use of information technology. The problem of privacy in public can be described using a concept of "contextual integrity" to capture the nature of challenges in using information technology [13]. This concept requires that information gathering and dissemination of information must be appropriate to that context, in accordance to the governing norms.

In collaborative and communicative environments we often use the notions of "space" and spatial organization to facilitate and structure interaction. However, there is the critical distinction between "space" and "place" because it is actually a notion of "place" which frames interactive behavior [14]. Place is not derived from three-dimensional structure. Instead, it derives from a tension between connectedness and distinction. We need to understand and related how buildings change with research activities to determine the challenges in designing ubiquitous technologies for domestic environments [15].

Aipperspach et al. [16] discuss the homogeneity of the domestic environment along three dimensions: space, technology, and time. They introduce the concept of the "heterogeneous home," a diverse and dynamic domestic environment. The interaction between technology and architecture in the home can be used so that the two can be jointly designed to create a rich environment that suits the complexities and variety of life in the home. The concept of temporal home concretizes various temporal patterns, either by enhancing the existing natural patterns or by bringing the new patterns. The devices can be used to turn temporal rhythms and to decide how in our out of sync the activities of the home are with the natural world outside.

However, this is not limited just to homes. Workplace, public buildings, shops are all architectural spaces where people can interact and perform various tasks. Information technology within the architectural space has to address the social context and our needs for privacy and security in order to offer an experience that is sustainable. While progress is being made addressing these issues, the use of information technology is still far away from being as "refreshing as taking a walk in the woods" [17].

Arguably, the home (especially smart home) is a primary example of human-architecture interaction and primary target of current research. We can leverage those results and generalize them to be applicable to a wide variety of architectural spaces. By learning what makes and architectural space a home we can learn about our interaction with architecture in general.

Crabtree and Rodden [10] describe ethnographic studies conducted to explore the notion of 'routine' and how it affects design, especially in terms of communication. They also discuss key properties of the ecological organization of communication in the home. The design process is affected by the ecology of the domestic space and distributed arrangements of collaboration to communication. A particular attention is given to ecological habitats, activity centers, and coordinate displays.

This work first seeks to present key CHI-related questions regarding the presentation of information via mobile device—enabling individuals to understand how their decisions may impact the environment, and enabling groups to reach consensus on decisions. We introduce LumenHaus [1], a self-sustaining home, and describe an initial interface construction effort used to speculate on emerging interface construction directions.

3 Approach

Undertaking this effort led to the following questions:

1. What are appropriate methods for collaborative application and social interaction using mobile devices? The growing use of mobile devices, and increased connections to in-home technologies, provides an important opportunity to raise awareness and support interactions for both individuals and groups.
2. What are the constraints and opportunities for mobile new-generation applications? Emerging technologies like the iOS platform (iPhone, iPad, and iPod touch) provide novel interaction techniques—shaking, tilting, multi-touch, tight information integration—that do not yet have accepted uses in the realms of awareness and interaction with data repositories, a focus of this work.
3. How can co-located groups of people effectively balance their needs—and the impact on the environment—toward raising awareness and identifying mutually acceptable decisions? Many decisions regarding an environment are made with immediate impact on a small group of people but environmental impacts on larger groups, as explored in this work.

These questions were explored within the context of a technology-enhanced home that generates data accessible to the iOS platform. Student designers assembled an initial prototype used in participatory design sessions to brainstorm application possibilities.

3.1 Designing for LumenHaus

To explore our questions, we constructed and presented an iPhone interface designed by a group of undergraduate students for LumenHaus (Figure 1). Students visited and worked during the construction of LumenHaus, meeting on multiple occasions with the stakeholder groups, including 1) potential users of the completed structure; 2) architects with experience in constructing LumenHaus and similar facilities; and 3) computer scientists with a good understanding of the feasibility of current and future mobile integrated location-aware devices. These meetings enlightened the students as to the needs of the stakeholders, and the results from the meetings influenced not only the construction of the prototype presented in this section but, more importantly, the brainstorming of future directions for mobile device development.

Fig. 1. The LumenHaus [1] energy-efficient living environment. The external view at left shows the movable solar panels and venting system, which can be used to leverage external light and air in a manner optimal for energy usage and human comfort. Similarly, users can view and control water usage, heating, and other in-home aspects. The internal view at right highlights the living environment, which encourages social interaction and benefits from tools for heightened awareness.

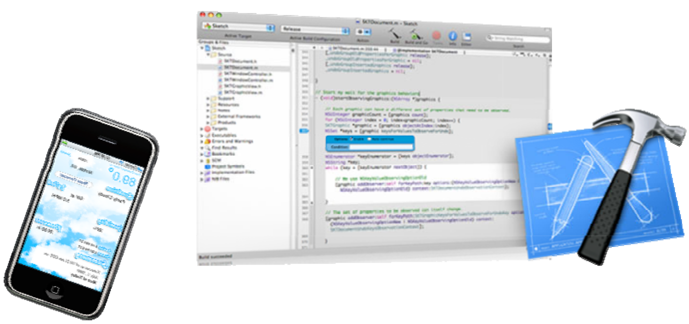

Fig. 2. The development environment

Students made use of the iOS platform for the development of interfaces. Initial weeks of the project were dedicated to student training session, in which they were made familiar with Objective C, the Xcode environment, socket buffering, and the general iPhone programming method (Figure 2). Initial assignments to program image, text, slider, auto-resize on rotation, connection, notification methods, and accelerometer-based interaction provided the programmers with awareness of the display and iteration methods—many of which are unique to mobile platforms like the iPhone. Then, the students built a core application to monitor weather information, intended to connect with LumenHaus.

The weather information display interfaces (Figure 3) provided an aesthetically-pleasing, iPhone specific presentation of the local weather at the location of Lumen-Haus. When the user starts the application, it aggregates web-based weather data, as well as a brief summary for the next few hours, and an extended forecast over several days. The background setting can reflect the external conditions graphically—sunny, cloudy, raining, snowing—so that users can assimilate this more quickly. Simple controls allow users to access and close the application on the move or in group settings with minimal interruption.

Fig. 3. The LumenHaus weather information displays, highlighting current and forecast local conditions. The visually appealing display shows information of general interest, but also provides opportunities to connect to in-home systems. The left display shows the initial design of the user interface. The right display shows the redesigned user interface based on the feedback and comments provided by the users in the pilot study.

The students then demoed the application to stakeholders in multiple situations: through one-on-one or small group interactions, via in-house presentations, and in an undergraduate research symposium. By making current and projected weather conditions readily available, the students and the stakeholders then brainstormed about potential uses for the information that could be integrated into the display and supported via iPhone interaction methods. More broadly, the application provided the opportunity to brainstorm about the other data that is available about the environment—both inside and external to the home—such as lighting conditions, water usage, and internal temperature. Four key classes of interaction methods that emerged from these brainstorming sessions are aggregated and presented Section 4.

3.2 Evaluation

The contacted study complements our research on interaction interoperability framework [18], [19] which provides an evaluation testbed for this type of studies.

Initially the application simply connected to wunderground.com and tailored the personalized forecast for iPhone presentation. The revised application code uses peer-to-peer based approach to create a Bluetooth data bridge between the host iPhone and a Bluetooth enabled device (i.e. another iPhone or Bluetooth capable device). This is used to transmit the weather data from wunderground.com to the host phone without that device being physically connected to Internet. The result is our LumenWaether application, which provides a web based weather service to the LumenHaus users. Users comments were crucial to this project in evaluating the initial interface (Figure 3 left) and improving it (Figure 3 right).

The pilot study included six users that were chosen were members of the Research Experience for Undergraduates in HCI at Virginia Tech [20]. They were college students who were familiar with using iPhone and similar mobile technology. However, they had no experience in mobile applications design and development.

The users were explained the purpose and features of the application but not how to use it. That was up to the users to discover. The users were then asked to pick the device (iPhone), start the application and explore its features.

They commented that the purpose of the application was not immediately clear. It became apparent that the user interface (Figure 3 left) has to be re-designed to improve clarity of the presented informational. Their comments can be summarized as follows:

- The interface was not sufficiently intuitive. The users were sometimes confused about what to do and how to activate features.
- Data layout and display were not sufficiently well organized. In other words, the information was scattered on the screen and the users were not sure what data was being shown to them.
- The cloud design/background (Figure 3 left) was confusing. The users asked questions like “why are there nothing but clouds?,” “Am I supposed to feel like I'm in the sky?”.
- Five out of six users did not access all the functionality. They did not realize on their own that they could view an extended daily forecast and seven-day forecast. The one user who did realize and used these features took almost five minutes to do so.

The received feedback was used to redesign and “cleanup” the user interface (Figure 3 right). The ZIP code selection for the weather information is now positioned at the top of the display area. The current temperature is now more emphasized and clearly visible in the upper right corner of the display area. Some weather data (condition, wind, pressure, humidity) were grouped together and displayed in the middle of the display area. The weather forecast is now clearly displayed at the bottom of the display are. The background image (clouds) was replaced with an “adaptive” image that reflects the current weather situation.

The redesigned user interface (Figure 3 right) addressed the issues discovered in the pilot study and was well accepted by the users.

4 Conclusions and Future Work

Leveraging the sample interface designed by the students, the following interface directions emerged.

Home-based interactions provide means to control the display of information from the home, as well as to control aspects of the home environment itself. For example, the students developed a method to shake the display to refresh information about the weather; important in tracking a developing storm or in planning errands. The interfaces should share certain application information with surrounding people running the same application, such as the varying desires for different in-home temperatures or lighting levels—which would impact when and for how long windows would be opened, closed, or shaded. These interaction methods are similar to the ones highlighted earlier for existing smart, green homes (e.g., [3], [4]).

A *late joiner display* would assist a latecomer to a meeting (either formal or informal) in understanding the major decisions that have been made, toward getting in a position where the latecomer can make meaningful contributions to the group without hindering ongoing group progress. Interface techniques for addressing late joiners have appeared previously (e.g., [21]), with solutions focusing on the aggregation of information and decisions into an easily digestible form and demonstration by the late joiners of an adequate level of understanding. Location-aware technology seems well-suited to advance interface techniques for late joiners, by tracking precisely when a person arrives and leaves (e.g., realizing when a person steps away to the restroom for five minutes.

An *annotation tool* would support group interaction centered around a shared visual artifact, such as a developing weather report, a home improvement plan, or a shopping list. The tool must support multimedia input (to include typed text, scribbled notes, or brief voice comments) either connected to an artifact or in a standalone form. The explosion of collaborative off-the-desktop interfaces suggests a need for techniques for annotating and, perhaps more importantly, connecting and maintaining the annotations throughout the duration of the course of the interaction time period. The knowledge map that emerges can be viewed either temporally or topically, depending on the preference of the user, and it will support user tagging to facilitate text searching. We seek to make obvious the ability to annotate at any time, through whatever media type and means is most suitable, We anticipate that these interfaces (and others like them) will be lightweight bridges to more complete notes, writeups, and reports that are generated, resulting in the added value of an overlaying knowledge annotation map of comments on a collection of more heavyweight documents.

Sustainable consciousness displays would be used to encourage an appropriate balance between individual comfort, group needs, and environmental impact. We envision suggestions regarding energy consumption, lighting methods, and heating/cooling that may change the general lifestyle decisions that users make. For example, instead of turning on a lamp, a person could remove shades and use external light, and instead of air conditioning or heating, a person could make use of differences in internal and external temperatures by venting with outside air. Appropriate presentation of this type of information—with buy-in from all local stakeholders—can lead to sustainable living.

Each of these application areas helps connect individuals and groups to the emerging environments represented by LumenHaus—architectural spaces that provide opportunities to live in a manner better for the individual and the environment. The envisioned tools and applications have promise to connect people to each other, and to raise awareness of the impacts and opportunities of lifestyle choices on the environment.

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Design and Development of Four Prototype Interactive Edutainment Exhibits for Museums

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Abstract. This paper describes the outcomes stemming from the work of a multidisciplinary R&D project of ICS-FORTH, aiming to explore and experiment with novel interactive museum exhibits, and to assess their utility, usability and potential impact. More specifically, four interactive systems are presented in this paper which have been integrated, tested and evaluated in a dedicated, appropriately designed, laboratory space. The paper also discusses key issues stemming from experience and observations in the course of qualitative evaluation sessions with a large number of participants.

Keywords: Interactive exhibits; edutainment; museum; interaction design.

1 Introduction

In the past few years, several museums worldwide started exploring new ways for integrating novel interactive exhibits in their spaces, moving beyond the typical "multimedia information kiosk" paradigm of the past (e.g., [3; 4; 9; 12; 20]). In the context of the "Ambient Intelligence and Smart Environments" Programme of the Institute of Computer Science of the Foundation for Research and Technology – Hellas (ICS-FORTH), a multidisciplinary project was set up aiming to explore and experiment with the creation of novel interactive edutainment exhibits for museums and assess their utility, usability and potential impact. This paper presents four representative systems that stemmed from this project - mainly targeted to archeological and historical museums. Since October 2010, updated, appropriately adapted, versions of all four systems are installed and available to the general public at the Archaeological Museum of Thessaloniki, Greece, as part of a permanent exhibition of interactive systems.

2 Related Work

Worldwide, there have been a number of museums that installed, temporarily or permanently, interactive exhibits in their premises. For example, the "Re-Tracing the

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Past" exhibition of the Hunt Museum was designed to show how novel interactive computer technologies could be introduced into a museum setting [3]. The "Fire and the Mountain" exhibition comprised four hybrid exhibits [4] aiming to promote awareness about the cultural heritage of the people living around the Como Lake. The Austrian Technical Museum in Vienna opened a digitally augmented exhibition on the history of modern media [9]. ARoS, an art museum in Denmark, employed four interactive exhibits targeted to an exhibition of the Japanese artist Mariko Mori [12]. The Ragghianti Foundation held an exhibition entitled "Puccini Set Designer" [20] that used new technologies to convey to the audience Puccini's work as set designer.

The creation of interactive exhibits also led to the development of a considerable corpus of knowledge related to their design. In this respect, Durbin [2] describes the design process and observation results of "interpretative devices" integrated within the displays of the British Galleries of the Victoria and Albert Museum. Lehn et al. [14] examine the ways in which visitors encounter and experience exhibits and how these experiences are shaped and affected by social interaction. Hope at al. [8] focus on issues of family interaction and cooperation in a technological-augmented museum, while Walter [21] and Heath et al. [7] provide observation study results from the use of electronic guides and interactive exhibits respectively, and identify several problems and trade-offs between interactive media use and social interaction.

The work presented in this paper builds upon and extends previous knowledge and efforts, aiming to create a set of re-usable and customizable interactive components that can support basic museum visitors' needs and requirements and accommodate a variety of content. To this end, the use of a common middleware layer by all systems facilitates the future integration of diverse add-on components, as well as the inter-communication among the exhibits.

3 The Interactive Exhibits

This section presents in detail the four prototype exhibits created after several cycles of iterative design, prototyping and evaluation. All exhibits were enriched with indicative, scientifically valid, content, mainly targeted to archeological and historical museums. When the preliminary spatial design of the exhibits had reached a fairly stable level, a dedicated space (14x6m^2) was appropriately adapted to house them. An in-house custom-made middleware layer based on CORBA was used in all the exhibits to allow the interactive applications and various software services (e.g., computer vision modules) to intercommunicate. In this context, the applications running on all systems were developed using Flash ActionScript, while the low-level services that drive the hardware sensors were implemented in .NET (C#) and C++.

3.1 Macrographia: Exploration of Large-Scale Artifacts in Real-Life Size

The system is installed in a room (6x6x2.5m^3) in which a computer vision subsystem with 8 cameras tracks the position of visitors (for more details see [23]). On one wall a dual-projector back-projection screen (4.88x1.83m^2) is installed. Behind the screen lies a control room that contains two 1024x768 short-throw projectors, stereo speakers and 3 workstations. In the main room there is also an information kiosk and a stand with mobile phones. Mobile phones run a custom application that can receive information about their holder's position and render information accordingly. Localization of persons is performed at 10Hz and has an accuracy of ~2cm. Macrographia (Fig. 1 - left) can present large scale images of artifacts, with which one or more visitors can concurrently interact by walking around, thus effectively applying interaction techniques used by interactive floors (e.g., like the iGameFloor [6]) in a different application domain, also extending previous related approaches like [12] and [20] through multi-user support and personalization. In the Macrographia demo installation, the projection screen presents a wall painting that is originally located on the façade of the tomb of King Philip II in Vergina, in northern Greece. Visitors enter the room from an entrance opposite to the display. The vision system assigns a unique id number to each person entering the room. As two help signs illustrate, visitors entering the room from the right-hand side are considered to be English-speaking, while those from the left-hand side, Greek-speaking. When at least one person is in the room, a piece of music starts to play. The room is conceptually split in 5 zones of interest, delimited by different themes presented on the wall painting. These zones cut the room in 5 vertical slices. The room is also split in 4 horizontal zones that run parallel to the wall painting, which are delimited by their distance from it. Thus, a 5x4 grid is created, comprising 20 interaction slots. Fig. 1 (right) presents an illustration of the grid, as rendered by a support application, responsible for orchestrating interaction. The image presents three users located at different slots. When a visitor is located over a slot, the respective wall painting part changes and, depending on the slot's distance from the wall, visitors can see a sketch, a restored version or a detail of the wall part, accompanied by related information.

Fig. 1. (left) Overview of the Macrographia system; (right) Macrographia zone map

Fig. 2. Macrographia: Wall painting status corresponding to the location of the users in Fig. 1

All information is presented in the user's preferred language. Since users are associated with a unique id, the system keeps track of the information they have accessed, as well as of the time they have spent on each slot. Apart from location-sensing, Macrographia also supports two more types of interaction: (a) a kiosk and (b) mobile phones. The kiosk offers an overview of the wall painting, an introductory text and two buttons for changing the user's language. All information is automatically presented in the visitor's preferred language. Furthermore, the wall piece in front of which the visitor has spent most of the time is highlighted. Mobile phones are used as multimedia guides, automatically presenting images and text (that can also be read aloud) related to the visitor's current position.

3.2 Panoptes: Browsing Collections of Artifacts

Panoptes (Fig. 3 - left) builds upon the concepts of playful [11] and aesthetic [18] interaction combining functionality with playfulness and serendipity, thus offering an alternative to information kiosks used at museums for browsing item collections. The system comprises a "wall" ($1.55x1.9m^2$) on wheels, two framed touch screens, a webcam, a light sensor and a custom windmill sensor. The larger screen (19'') presents a high resolution photo of the currently selected artifact. The smaller one (12''), presents information about the artifact and also includes some soft buttons. Different types of content were used to test Panoptes, such as famous paintings and ancient Greek jewelry. The large screen supports two types of interaction:

a. ***Hotspots*****:** Each image can include any number of hotspots. If the user touches one of them, the corresponding area is highlighted and a word balloon pops-up with related information (Fig. 3 - right). If the user touches any part of the image that does not include a hotspot, then all the available hotspots are highlighted (Fig. 3 - middle) in order to provide feedback about their position.
b. ***Magnification*****:** If the user drags her finger on the image (for a distance longer that 1cm), she starts drawing a yellow line with which she can circle an area of interest. When the user moves her finger off the screen surface, the selected area is magnified. The user can subsequently iteratively zoom into the selected area.

Fig. 3. (left) The Panoptes system; (middle & right) available hotspots & hotspot selection and information presentation

A visitor can browse all the available artifacts by blowing at the windmill (or just rotating it with the hand). The windmill's speed affects the browsing speed but also triggers alternative music pieces originating from old music boxes.

The smaller screen comprises a framed photo of the current artifact, visually linking its contents with those of the larger screen, brief information that depends on the artifact type, a descriptive title and a short text. The screen also offers buttons for browsing/navigating through the collection of artifacts, accessing a gallery of all artifacts through which the user can select one for viewing, and language selection. Above the screens there is a camera and on top of the wall a light sensor. The function of this sensor is to detect flash photography. In such a case, the web camera is used to take a photo of the visitor photographing the exhibit. This was initially meant to be just a fun "hidden" feature, but, eventually, as *in situ* observations have revealed, it became a very engaging interactive characteristic (for further details, see Section 4).

3.3 Polyapton: Familiarization with an Artifact and Information Discovery

Polyapton is a large size ($1.6x1m^2$) custom-made multi-touch screen. The system builds upon the combination of IR illumination and semi-transparent back projection screen (e.g., [13; 15]) and consists of (see Fig. 4): a grey level camera equipped with an IR filter, 8 IR illuminators, a projector that is projecting through a mirror on a rear-projection acrylic rigid screen backed up by a thick layer of glass, and a workstation. All the electronic equipment is hidden inside a control room. In addition to multi-touch, the system supports interaction using three props: (a) a "magic wand", i.e., a

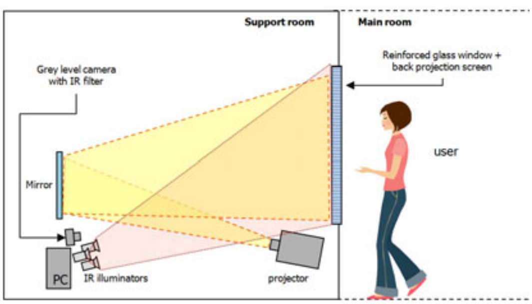

Fig. 4. Polyapton schematic installation layout

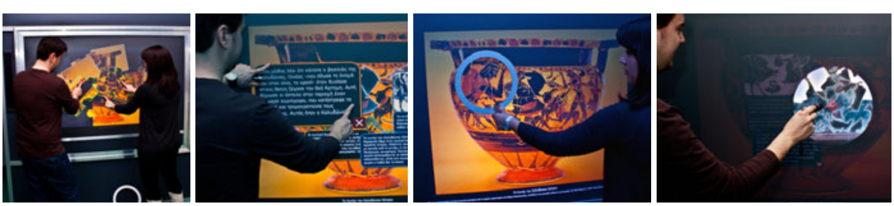

Fig. 5. (left-to-right) (a) collaborative puzzle construction; (b) information discovery; (c) prop-based information discovery, using a paper magnifying lens; (d) using an IR torch

stick with an IR led; (b) a magnifying glass made of white cardboard (working like the transparent lens in [10]); and (c) an IR flashlight (the use if which was inspired by [17]). The basic principle of operation and details of the vision system of Polyapton are described in [16]. The system initially presents a photo of an artifact (e.g., ancient vase) and a short descriptive title. When a user touches the screen, the image breaks into several puzzle pieces that are randomly scattered around. This activity was selected because it leads visitors (in a subtle and fun way) to explore and focus on details of the artifact at hand. A faded grey-scale image of the completed puzzle is shown at the background as a help guide. Multiple users can cooperate to place the pieces at their correct position (Fig. 5a). Pieces can be moved using any number of fingers, and, in order to be rotated, at least two fingers must be used. If a puzzle piece is touched by the magic wand, then it is transferred to its correct position. When the puzzle is completed, a short description appears underneath the image and several hotspots are momentarily highlighted over it. If users touch on a hotspot, an information box appears, containing text that is occasionally accompanied by an image. Users can move the boxes around and also resize them (Fig. 5b). If a user points the IR flashlight towards the screen, then the image turns black, and a circular area is highlighted, corresponding to the flashlights projected "light" (Fig. 5d). This area simulates an "X-ray" view of the artifact that includes hidden hotspots. If the flashlight stays over a hotspot for more than one second, then an information box with related information pops-up. Finally, if a user places the paper magnifying glass on the display, then the respective part of the image is magnified (Fig. 5c).

3.4 PaperView: Exploration of Terrain-Based Information

PaperView [5] (Fig. 6) is a tabletop augmented reality system that builds upon Wellner's [22] DigitalDesk concept in combination with Reitmayr et al. [19] augmentation of paper-based cartographic maps using real world objects, but taken further, since multi-user interaction, finger-based input and concurrent tracking of diverse border colors are supported. The system's main component is a table (1.8x1m^2), the surface of which is covered by a printed map. Underneath the table there are two speakers and high above it, a video projector, an IR camera and an RGB camera. Next to the table

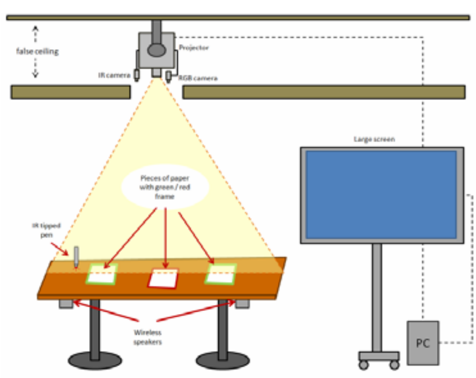

Fig. 6. PaperView schematic installation layout

lies a 56'' HD TV screen, bearing a shelf with a stack of rectangular pieces of white cardboard. One side of each piece is framed with a thick green line, while the other with a red one. Additionally, a pen with IR led tip (i.e, like a mini-torch) is available on the table, the position of which is tracked by the IR camera. Details about the vision system of paperView are described in [5].

Initially, the projector overlays on the map the location and names of sites with archeological interest (in English and Greek). If a visitor places a cardboard piece on the table surface, the area of the map located underneath the paper, as seen in Google Maps ("map mode") is projected on it. Furthermore, a circled crosshair is projected on the paper's centre. If the visitor moves the paper so that a site of interest lies within the boundaries of the crosshair, a multimedia slideshow starts ("info mode") comprising a series of pages with text, images, and video. The frame color is used as a means for implicit language selection (green = Greek, red = English). When the cardboard piece is lying on the table, a toolbar is projected at its lower bottom area, containing the current page number, and buttons for moving to the next/previous page. The user can interact with these "soft" buttons using her bare fingers (Fig. 7b). If the paper is taken off the table's surface, the buttons disappear and the user can move to the next/previous page, by tilting the paper right or left, respectively. In this case, the projection is appropriately distorted (Fig. 7c), so that the visual content registers correctly on the paper surface. In order to avoid accidental browsing actions, page change does not happen instantly. Instead, an arrow-shaped progress bar is presented on the paper (Fig. 7d) and takes about 1 sec to fill. In order to visually link information presented on a cardboard piece to the site it refers to (since it may have been moved away from it), a connecting string is used. The TV screen presents a Google Maps view of the geographical area covered by the printed map. Visitors can use the pen on the table to navigate in Google Maps. Also, if the user selects a point of interest, related multimedia information is presented. If a user keeps the pen at the same position for more than 1 second, a virtual remote control appears, through which she can zoom in/out in Google Maps and select alternative map views.

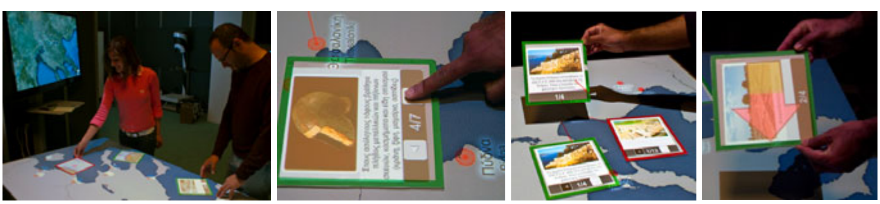

Fig. 7. PaperView usage: (left-to-right) multi-user interaction with the map; pressing the soft buttons; lifting the paper above the table surface; tilting the paper to browse content

4 Evaluation and Discussion

Ethnographic field methods [1] were adopted for the formative evaluation of the exhibits, using a combination of the "observer participant" and "participant observer" approach. To this purpose, the exhibits were installed in a dedicated space, resembling an exhibition area of a museum. Additionally, one of the exhibits (Panoptes) was installed for one month in a temporary art exhibition. During this preliminary evaluation phase, more than 100 persons of various ages and educational and technological backgrounds have participated. Overall, the opinion of all participants about the exhibits ranged from positive to enthusiastic. Usually, when visitors were first introduced to the exhibits there was a short "wow" phase, during which they seemed fascinated by the technology and tried to explore its capabilities, but, interestingly, after that, most of them spent considerable time exploring the exhibits' content. The remainder of this section summarizes some key observations and conclusions:

Playfulness vs. Controllability**:** Originally Panoptes supported browsing only through the windmill. At first, this worked great, but as visitors started to explore the content in depth, they required more deterministic interaction control – especially when they wanted to make sure that they have seen everything that was available. As a result, next/previous and gallery buttons were added.

Tangible vs. electronic interaction**:** There is no doubt that interaction through tangible objects made big and lasting impression to all participants, also gaining their preference. As numerous technological gadgets have entered everyday life, adding "magical" properties to everyday objects combines familiarity with an element of surprise. On top of that, tangibles provided simple, straightforward interactions.

Fun vs. Robustness**:** Since the exhibits were evaluated at various maturity levels, sometimes participants faced system misbehaviors, or even crashes. As it turned out, if visitors had fun while using a system, they would not abandon it even if it presented unstable or erratic behavior.

Implicit vs. Explicit Controls**:** An issue that still remains open regarding the Macrographia application, is whether the interaction slots should be explicitly marked on the floor or not. On the one hand, explicit indications would provide visible controls and more "crisp" interaction, but on the other hand, the changes that happen on the projection screen accompanied by audio cues, provide indirect feedback supporting more exploratory, casual, interaction.

Intended vs. unintended actions in location-based interaction**:** When a visitor was crossing Macrographia an avalanche of wall changes were triggered. As a solution, a minimum dwell time was adopted, in order for a user to gain control over a slot. Another "grey area" was the room's entrance. Since very often people were just peeking in on before engaging, the only functionality assigned to the zone close to the door was language selection and start of music.

Interaction fuzziness**:** Visitors standing at the boundaries of slots in Macrographia would sometimes be in a state of accidentally switching between them. To remedy this problem, the slot's area that the user is on is enlarged by 10%.

Visitor self-centeredness**:** The photo-taking functionality of Panoptes was initially conceived as a hidden function. But when Panoptes was installed at the art exhibition, one visitors accidently discovered it and then, somehow, this information became a common secret that was propagated from the older to the newer visitors and eventually, everyone would stand at least once in front of the exhibit just to have his photo taken and presented in it. Some people would call their companions and family to get a group shot, or some others would surprise their unaware friends by taking sneak photos of them in funny poses.

Level and type of instruction**:** Children were observed to experiment with the exhibits even if no instructions were available or nobody explained their use to them. Adults were more reluctant to experiment. A strong preference noted was staying in the back and looking at others using the exhibit. To the other end, there were people that seemed to enjoy explaining the exhibits to their friends, or even to strangers. In some cases, minimal prompts acted as an incentive for initiating interaction. Most participants stated they would not like to have to go through written or pictorial instructions.

Language selection**:** It was found out that different exhibits require different approaches. For example, the kiosk was initially used as a means for language selection in Macrographia. This created problems of visitor flow and erratic system behavior. The current scheme of implicit selection was a great improvement in terms of both usability and robustness. Similarly, at first, paperView users had to select their language from a dialogue appearing on the cardboard, every time it appeared over the table. By selecting language through frame color, this step was eliminated.

5 Conclusions and Future Work

As a six-month period of iterative formative evaluations with a highly diverse, group of participants has shown, all exhibits achieved the goal of providing engaging and entertaining educational experiences. The suitability towards their goals is indicated by the fact that the Archaeological Museum of Thessaloniki, one of the most prominent museums in Greece, installed an updated version of the presented systems (appropriately adapted to the museum's collections) along with some additional ones as part of a its permanent exhibition "Macedonia: From fragments to pixels"[1].

Since all exhibits use a common middleware layer, although they currently operate as stand-alone systems, future work includes their semantic connection in order to create a seamless interaction flow, offering to visitors a unified experience. By employing alternative identification technologies, all systems will be able to recognize their users, fetch interaction history with other exhibits and adapt their content, presentation and behavior accordingly. At a lower level, additional capabilities will be added to all exhibits, such as spatial sound, posture and gesture recognition to Macrographia, multi-screen interaction and gesture recognition to Polyapton, non-speech audio input to paperView, etc. Finally, future work includes investigating the application of the project's results in different types of museums.

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[1] http://www.makedonopixels.org

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Informatics as Semiotics Engineering: Lessons Learned from Design, Development and Evaluation of Ambient Assisted Living Applications for Elderly People

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Abstract. Assisted Living Systems with Ambient Intelligence technology raise new challenges to system and software engineering. The development of Assisted Living applications requires domain-oriented interdisciplinary research – it is essential to know both the domain and the context. It is also important that context-descriptive prototypes are: (1) an integrated description that describes system, work processes, context of use; and (2) a formal description. Because (1), designers, including end users, are provided with a means to investigate the system in the context of the envisioned work processes. Because (2), investigations into questions of formalization and automation, not only of the system, but also of the work processes, can be made explicitly and become subject for discussions and further elaboration. Adapted engineering approaches are required to cope with the specific characteristics of ambient intelligent systems. Elderly are the most demanding stakeholders for IT-development – even highly sophisticated systems will not be accepted when they do not address the real needs of the elderly and are not easily accessible and usable. Communication processes are essential in that respect. The evolution and, in particular, the spread of unambiguous symbols were an necessary postulate for the transfer of information, as for example in sign language, speech, writing, etc. In this paper, we report on our experiences in design, development and evaluation of computer applications in the area of ambient assisted living for elderly people, where, to our experiences, engineers highly underestimate the power of appropriate knowledge on semiotics and we demonstrate how we can emphasize universal access by thinking of informatics as semiotics engineering.

Keywords: Semiotic engineering, Informatics, Elderly.

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1 Introduction and Motivation for Research

Elderly people are the most demanding stakeholders for IT-development – even highly sophisticated systems will not be accepted when they do not address the real needs of elderly and are not very easily accessible, useful and usable [1], [2], [3].

It is very interesting, that people first expressed their ideas with cave drawings and the first figure systems and later the oldest known writing systems were developed from these drawings (Pictograms). According to Peirce (1932) [4], the basis of the communication process is a linguistically and culturally determined (established), but still evolving interpretation of signs, consequently semiotics is the basis of the exploration of subject and operation modes of communication processes. According to Nake & Grabowski (2001) [5], Semiotics is considered fundamental to the understanding of Human-Computer Interaction (HCI).

However, Nake & Grabowski go particularly further: They are of the opinion that Informatics should be viewed as technical semiotics or semiotics engineering – instead of computer science. This is a tough statement and not quite understandingly taken by computer scientists. However, if we want to change and really emphasize universal access to technology, then we have to consider that interaction between human and computer is characterized by communication, however, a type of communication that lacks decisive communicative features: it is rather a process of pseudo-communication, where the interaction is viewed as the coupling of two autonomous processes: a sign process (carried out by the end user) and a signal process (carried out by the computer system). Consequently, problems of software design (functionality and usability design) are specific problems of the coupling of sign and signal processes.

The three main goals of informatics (correctness of algorithms, efficiency of programs, and usability of software systems) turn out to be nicely related to the three semiotic dimensions: 1) Correctness is a matter of syntax to be answered by considering formal aspects only; 2) Efficiency is a matter of semantics related to the object world; and 3) Usability, taking interest and motivation of the end user into account, is a matter of pragmatics [6].

2 Related Work

Various technical based solutions to the problem of the elderly's increasing need for care have been developed throughout the world (Smart Homes, refer e.g. to [7], [8], [9]; assistive service robots [10], [11], [12] or portable emergency systems e.g. [13], [14], [15] etc.).

An interesting recent work was done by Picking et al. (2010) [16]: They performed a case study on the development of interfaces for elderly within their home environment; i.e. they developed ambient user interfaces, integrated in familiar home artefacts, such as televisions and digital picture frames, which are adaptive to users' expected increasing physical and cognitive needs; interfaces familiar to the user population were found to be a key factor for universal access in the sense of Stephanidis & Savidis (2001) [17].

De Souza et al. (2010) [18], stated that HCI evaluation methods tend to be proposed and used to verify the interactive qualities of specific systems and design strategies and the showed that, under certain conditions, inspection methods can be safely used in scientific research in HCI and extend their advantages beyond professional practice; on the example of the Semiotic Inspection Method (SIM), de Souza et al. argued that its interpretive results are objective, can be validated and produce knowledge comparable to that of more widely accepted methods.

3 Theoretical Background

Semiotics deals with the relationship between symbology and language, pragmatics and linguistics. Information and Communication Technology deals not only in words and pictures but also in ideas and symbology; Gang Zhao (2004) [19] defines semiotic engineering as: "*a process of creating a semiotic system*", which he describes as "*a model of human intelligence or knowledge or logic for communication or cognition*".

A much neglected potential tool of Information Communication, it has been a prerequisite of the sociologists, psychologists, and philologists and is now being re-discovered by the technical community (ICT) as a possible aid to acceptance by non-technically educated users. Presenting information in a recognisable symbology not only facilitates communication, it also increases intuitiveness – an important aspect of usability.

The classic example of misunderstood iconography is, of course, the much quoted use of a mobile-phone icon rather than a dial phone icon. While a great deal of usability testing is made based on the physical disabilities of the elderly, such as diminished vision, hearing and dexterity, the application of standard semiotic principles to develop a more acceptable and intuitive control system based on the adaption of symbol recognition principles is less well-researched

While the baby boomers have accustomed themselves to this ubiquitous technology and are happy and comfortable with biometrical device mechanisms, the 65+ generation – who are now beginning to need these aids – are less able to identify with those who they think of as being the technical generation. This is not made easier by the tendency to base the symbology of the interfaces on a later generation of adults. While there is no universal determining factor or circumstance responsible for an elderly person's need to leave their home and enter a care facility, there are a number of aspects of living which must be fulfilled to enable an autonomous, if not completely independent, life style.

These aspects vary with location and physical and mental health and can be ameliorated by social support systems and the integration of technical aids into their daily activity. Any scientific study on the ability and applicability of technical aids to reduce risks and facilitate sustaining a social support system must include the important area of *acceptance* on the part of the elderly user. Since suggestions for solutions involve the use of connectivity & social webs, cognitive stimulation (games) and information collectivity and familial monitoring, these concepts must also be understood by the people involved.

Some of the infrastructures that offer the most advantages for the elderly as users, such as social interaction programs, are currently designed with young people in mind as take full advantage of their ability to recognise the same symbols and to possess the same semiotic data base as the designers.

Once it is accepted that demographic pressure makes it necessary that common applications are designed for a wider age spectrum, one aspect of semiotic engineering could offer designers the key to increasing acceptability among non-homogenous groups.

Based on the results of our research, elderly users welcome methods of retaining autonomy by increasing their self-help abilities and making social interaction more risk free, whenever this is not considered "too complicated". Their families and care givers are more concerned with assessing risk factors; early detection of weakness and falls or danger situations. But no matter what their differences, it was understood that – should the elderly people fail to accept the technology, it would be of no value to them or their families and a high level of acceptance depends on good design as well as recognising both needs and fears.

4 Design Aspects

De Souza (2001) [20], suggests that designers attempt to bridge the designer/user gap by de-emphasising the computer – except as a medium – making the primary communication between *human user* and *human designer.* This approach could prove useful in designing for the elderly, since it would mean concentrating on the end users communication methods and symbology, rather than the classic *designer – interface – user* triangle.. Interface design for the elderly often concentrates on the physical aspects of design – size, manipulability, simplicity and clarity, since these are the aspects most obvious to the end users. Increased functionality and sophistication of the devices has led to the simplification of universally recognised symbols. However, the term *universally recognised* assumes a cultural homogeneity not always given, even within a single community. The use of design semiotics could also increase those metrics of usability of most importance: efficiency and acceptance.

While the design of a monitoring device interface is a different type of challenge to the design of a social networking interface for a full computer screen, the basic rules of symbol recognition and conformability still apply.

When referring to semiotics of gender, we are not referring to the symbols people use to recognise gender or gender roles, but rather the effect gender has on the symbols and signs used and the subjective feeling of the relevance of symbols. Social semiotic visual analysis, in particular the study of visual depictions of gender, has concentrated on investigating the extent to which the behaviour of a generation of people has been cognitively imprinted by symbolism – for example, that Computer Journals in the 1950s and 1960s rarely showed a female scientist. ICT is more affected by the possible influence of gender on sign recognition, familiarity and cultural acceptance. Is there a truly a difference in acceptance dependent on the gender of the user? Does the level of abstraction affect intuitiveness differently?

Are different designs required in order to obtain the same level of acceptance from a both genders? Is this affected by increasing age?

HCI Students have been using semiotics, often unknowingly, in designing web pages, user access applications and icons for some time. However, actively differentiating between their own, culturally formed, understanding of certain signs and symbols and that of their end users had been at most unconscious and usually unnecessary. It was generally assumed that any difficulties experienced by the elderly in using technological devices were traceable to physical causes. When designing web pages for people with sight problems, scalable text was a matter of course and scalable icons soon became standard. Hard of hearing users were given special adaptive programs to enable them to convert sound files to text. Since so many elderly people merely stated that ‘technology made them uncomfortable’ it seemed obvious that it was an ‘age thing’ or a cultural thing, and could only be changed by intensive education. The question of the suitability of the icons, or whether the symbols or terminology could be adapted to enable people with a different cultural background to decipher their meaning, was not often asked.

In our study, we concentrated on the extent to which adapting symbology can achieve positive feedback in ICT situations, while taking possible previous negative influences into account.

While computer interfaces have become a great deal more interactive and icons are generally accepted, a number of technical devices still use a simple abstract symbology unknown to many elderly people (see figure 1). The necessity to pack a quantity of functions onto a small space, has led to a climate of reduction.

Fig. 1. Universality of typical abstract symbols in current remote control devices (Sony & Cyclops)

Unsurprisingly, designers who have grown up with this symbolism, from computer games to TV remotes, find it rather hard to accept that not all elderly people are actually aware of the purpose of every symbol on their household appliances, let alone the controls of their more complicated devices. Since these abstract symbols have now been taken as standards by many different developers, designers must make it clear to users what they mean by these symbols and users must be instructed to understand and respond to the information.

5 Methods and Materials

The emphasis in any evaluation from an engineering point of view is on documenting and analysing the way the device works in practice. In order to identify and understand important influences on operation and achievements, *semiotic engineering* deals with the recognisability of the symbology and understanding of the language used, therefore, our usability evaluation considered how the interface design influenced the acceptance and intuitiveness of usage. For an evaluation from a behavioural view, it is necessary to consider how the elements designed interact with each other and with the user. For this purpose, scenarios are used, since with these, we were able to give the users a purpose and a goal, which was far preferred to ‘free experimentation’.

At the same time a reiterative formative evaluation was made in order to generate information that could be used to refine and improve the programmes and visual interfaces from an early stage. The participants in our usability testing groups were heterogeneous groups of males and females aged between 55 and 90. One group was completely autonomous, one group lived in a home for the elderly and the last group was in need of full-time medical supervision in a geriatric hospital. As can be expected in this age group, there were more women than men.

The devices tested ranged from low tech test applications on various hand held devices and tablets designed by HCI students of the Technical University Graz (www.hci4all.at), to a high-tech, fall sensor device, specially designed for the elderly [21]. The tests were conducted in three sections: demonstration; questionnaire; informal discussion. The students who supplied the low-fi devices were given no guidelines as to the type of symbology most acceptable to their age group. Once the testing cycle was underway, they were able to supply each other with feedback regarding understanding, competence and suitability of the symbols chosen. Analysis of the participants understanding and acceptance of the icons used in the software served to indicate users' communication symbols and translation images.

The demonstrations of the applications and devices to be tested were kept purposely simple, since we wished to evaluate intuitiveness and symbol recognition. The applications and devices used for the Geriatric Hospital were neither as complicated – nor the tests as long – as those for the other two groups. As a result, we received less direct data and more subjective information. Unsurprisingly, the most enthusiastic group were the residents of a home for the aged. They were also the most critical of the displays. The autonomous group were primarily interested in functionality and saw any misunderstanding of icons as affecting speed of use and reliability, while the residents were more critical of needing to ask for help if something was not intuitive. The questionnaire used a six-point Likert scale divided into five main areas: usefulness, attractiveness, usability, comfort and acceptance, randomly sorted. The participants were given the questions on a sheet of paper, with the request to ignore any question they were unable to answer - rather than just ticking any box. However, the main data was acquired during the informal discussion, since this was the time when the participants were no longer ‘on their guard’ and able to relax and share their subjective responses to the question of intuitive usage; ease of use; simplicity of texts and autonomous control. We were able to spend some time with the participants discussing their perception of purpose and understanding.

6 Discussion and Lessons Learned

Pleasant test environments helped towards avoiding a clinical atmosphere and enabled the participants to take part in a relaxed discussion. The students were able to get an idea of the size of the gap existing between what they considered obvious terminology and symbolism and that of their future users. The older participants were in a position to explain their difficulty with many of the icons and symbols used in modern technology. While older people often experience impairment of their fine motor skills, necessitating physical modification of any technological aids offered, the main factor in their reluctance to use some of the aids offered appeared to be their fear of not being able to understand the terminology, icons and symbols used. Language development is natural and expected; however, when combined with technology, it can cause uncertainty. Some of the devices tested were primarily designed to enable elderly people to retain, and in some cases regain, their autonomy, some to assess the willingness of the participants to play games, which aid in increasing acceptability (2010), while others were designed solely to discover the preferences of the elderly people and to start creating a sign base.

While it was agreed that the controls, whether buttons, icons or symbols, needed to be large enough to be identifiable, the form of the actual symbols were far more important. The monitoring device was able to prove this conclusively.

While the display used numbers and letters, the purpose of the buttons was denoted by pure symbols, which caused some initial difficulty among the participants (see figure 2). Even after these were explained, doubts were expressed as to whether, in an emergency situation, the correct alarm button would be pressed. The markings signs have no intuitive value, since they are not based on any recognised cultural symbols.

Fig. 2. Symbols on the fall monitoring device [21]

While the monitoring devices were of more interest to the women than the men – something that was possibly explained by one of the women when she stated that, in her generation, fewer men are required to care for elderly relatives. Some credence must also be given to the theory that that men are less willing to admit to weakness or need, or are just more wary about monitoring in general.

7 Conclusion and Future Work

One of the main lessons learned during this work can be put in one sentence: Intuitiveness is in inverse proportion to the level of abstraction. While Nake (2001) [5] concluded that people's anthropomorphisation of computers is deeply rooted in semiotics, thus providing a reason for attributing human characteristics to non-living things, we saw no evidence of this tendency among the older participants. Thus, it is possible to assume that the exchange of communication is disturbed at the level of interpretation. Whether this is due to unfamiliarity or is an integral aspect of age requires more intensive study than we were able to give it at this time. It does confirm, however, that designers must be willing to increase their understanding of the symbols familiar to the older generations and adjust their designs accordingly.

To the astonishment of the students the scroll symbol caused the most consternation; not only were many of the participants unfamiliar with the symbol, they were unfamiliar with the concept. Web pages designed for the elderly must therefore either use a page-turning format, rescale sections of the outlay to fit a single page, or carry a more explanatory symbol for continued in the next panel.

While the students who participated in the design, development and subsequent testing were able to accept and understand the difficulties felt by the older participants, there appeared little consensus as to a solution. Since many standard icons and symbols are already in place, particularly in social networking systems, developing a permanent parallel system of symbology may be neither practical nor desirable.

Many of the existing social networks & information centres have been designed with younger generations in mind, even those specifically aimed at the elderly, use standardised symbols, icons and links, which will need to be interpreted. As yet no data base of recognisable symbols has been established for translation purposes. One difficulty is the speed with which the participants accept the (to them) new concepts and symbols. Although this is an extremely positive development for our participants, it makes establishing a basis of recognised and understood symbols more challenging. While we did notice a gender-based reluctance, this dissipated rapidly and there appeared to be no bias in the levels of acceptance once the new concepts were explained and understood.

Our future work will be to investigate the practicality of designing and implementing a layered architecture system to provide a translation layer service, for social support systems for the elderly. Linking to this service would provide age-appropriate interfaces with direct connections to local networks, age-relevant social services and relevant state departments.

Acting as a conversion interface, it would be able to provide access to existing systems, currently considered indecipherable by the elderly – for example: online ticket offices. Further advantages could be achieved by using local connectivity & social webs, environmental adjustments (adaptivity, adaptability), making use of concepts including: collective intelligence, cognitive stimulation (games) and information collection, many of which are designed for use by the elderly, but which can only be accessed using standard gateway services.

One of the infrastructures under consideration is cloud computing, which offers an abundance of possibilities and advantages for the elderly, e.g. end users are able to access applications without local PC updates [22].

A further point of study will be the transparent overlay of an avatar – similar to that offered for people with hearing problems [23] – a central gateway could then provide icon-piloted access to available standard applications with an automated interaction. Whether this would provide the elderly with the aid required would depend on its sophistication and their acceptance of a 'virtual translator'.

Both the conversion interface and the avatar translator would eventually become obsolete as the level of computer sophistication rises. What is needed at the moment is the *semiotic prop,* which will allow the elderly to use – and enjoy using – the wide variety of available technology without fear of the consequences of misunderstanding a computer command.

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iAWN: Designing Smart Artifacts for Sustainable Awareness

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Abstract. This paper describes research in designing smart artifacts for sustainable awareness. The work is based on the cultural probe method by collecting primary visual data about domestic settings. A smart artifact called iAWN is designed in support of energy, health, and environmental awareness at home. We take a design probe approach to exploring design alternatives. The design probe includes mock-up experiments, functional sketch, and script writing. The methods, implementation, project findings, and lessons learned from the iAWN project are described.

Keywords: Interaction Design, Smart Artifact, Sustainable Awareness.

1 Introduction

Sustainable HCI is now a recognized area of human-computer interaction drawing from a variety of disciplinary approaches [1]. One approach is focused on the effective deployment of sensing technologies to monitor energy and resource use, facilitate awareness, and encourage conservation in daily activities. Information about sustainability (e.g. energy consumption, health and environmental conditions) can be embodied in augmented interactive artifacts for ambient awareness. A similar approach is to develop awareness tools with easy-to-use interfaces that attempt to persuade users to behave in a more sustainable way. Another approach is to track ecological footprints and make information transparent through the product life cycle. To make implicit information explicit could lead to better understanding of consumption and disposal of material resources. Information transparency is important to help users make more sustainable decisions in their daily life. The other approach is to apply green materials to sustainable interaction design that minimizes the negative impact on our environments. These approaches reflect a growing consensus that fundamental re-thinking the method of interaction design is required.

Major sustainable HCI work can be categorized into five genres: persuasive technology, ambient awareness, sustainable interaction design, formative user studies, pervasive and participatory sensing [3]. All these methods and approaches provide a rich literature of sustainable HCI, but accumulating varied knowledge for design practice has been stymied by the lack of a unified design process to guide future sustainable HCI design.

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In this paper we present an open-innovation approach to designing a smart and interactive artifact for sustainable awareness. First we use the cultural probe method by which primary visual data about domestic settings and what people value within their sustainable home environments are collected and analyzed. Next, we take a design probe approach to exploring design alternatives with respect to fun, emotional engagement, and aesthetic interaction in supporting sustainable awareness. To demonstrate the method, a smart artifact called iAWN is developed in support of energy, health, and environmental awareness in domestic settings. The result shows the implementation of iAWN project and the living laboratory experiments. New methods of combining the cultural probe, design probe, and living lab experiences are presented to explore new possibilities for sustainable awareness.

2 Methods

The method is divided into two phases: cultural probe and design probe. Cultural probe is a pre-test for understanding users' needs in domestic life. The purpose is to find the usefulness of everyday objects for technical support. Design probe is preceded by three steps: mock-up experiments, functional sketch, and script writing. Mock-up is a full-scale model of device used for design experiments and evaluation. Functional sketch is to identify possible functions of designed objects by drawing, image, or text description. Script writing is to develop a holistic living scenario that is constructed by a series of events. The methods will be illustrated by the iAWN project below.

2.1 Cultural Probe

In the preliminary phase of design, cultural probe was conducted by collecting primary visual data about domestic settings and what people value within their sustainable home environments. We use cultural probe to elicit information about user needs for future systems designed to support sustainable awareness. A photo study was conducted to record the domestic context. The cultural probe approach is combined with participatory design to provoke participators using their imaginations, expressing their ideas and thinking more creatively about possible solutions [12][13].

In the development process, we collected the perceived value images of everyday objects related to health, energy and environmental issues in domestic life (Fig 1). Then, we summarized the photos and analyzed various aspects of the content. The result of the content analysis is presented in table 1. The features of the content in domestic life include relaxation/comfort, exercise/entertainment and reminding/message. The percentage of images is presented with respect to "natural object" and non-natural object".

A total of fifteen households participated in the study. They all have limited knowledge of smart home technology. Based on content analysis result, we found that eight participators thought reminding/message is the most needed assistance in domestic life. It was interesting that nine participators pictured natural plants as a concept of natural linkage on sustainable awareness. The result inspired us to take a biomimicry approach to developing a leaf-like smart artifact for natural interaction.

Fig. 1. Collected value images of everyday objects related to health, energy, and environmental issues in domestic life

Table 1. Content analysis result from "things you value most about health, energy, and environmental assistance"

Relaxation/Comforts	5	Natural	9	60%
Exercise/Entertainment	2	Non-natural	6	40%
Reminding/Message	8			
Total	15		15	

2.2 Design Probe

Design probe is to explore the possible expressions of devices and products, issues of interaction experience, and the service assistance mediated by technology in future home environment. The experiment was preceded by three steps: mock-up experiments, function sketch, and script writing. Each step was conducted with participated households. In order to uncover the user needs, we distributed iAWN mock-ups to homes and uses projective techniques to probe subjects' inner prospective. Projective techniques helped uncover consumer attitudes, thoughts, and feelings about the iAWN project.

Mock-Up Experiments. In order to provoke inspirational responses from participant users, it is necessary to develop mock-up of iAWN devices for real-world home experiments. Inspired by bionics, we developed iAWN as an awn-like art work, composed of a natural leaf stalk and a gadget base. The initial design was a simple art work that evolved to become a more complex device by adding microcontrollers, sensors, battery, and LED (Fig 2).

To facilitate mock-up experiments, we used CAD software, laser cutter, rapid- prototyping machines to develop the shape of iAWN. In the beginning, thirty iAWN

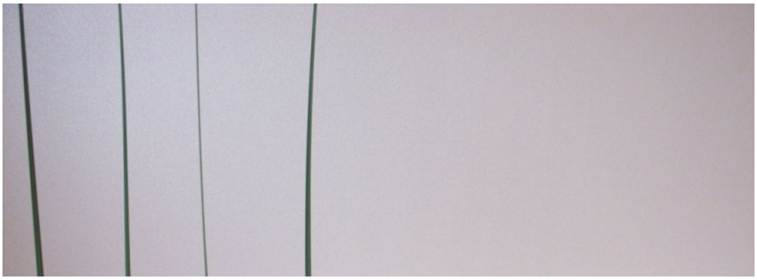


Fig. 2. The mock-ups of iAWN device

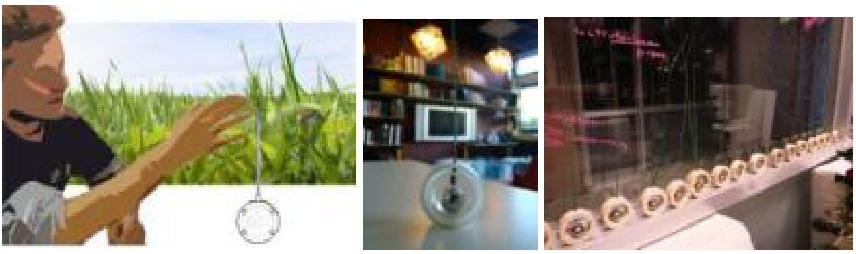


Fig. 3. The iAWN mock-ups were developed and experimented in real-world homes

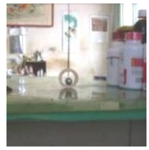
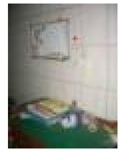
mock-ups were produced and delivered to five families for home experiments. We collected information about their interaction with the mock-up while assigning the placement, peripheral arrangement and possible usage of iAWN in their home settings. Figure 3 shows the mock-ups developed by the laboratory, which were later distributed to households for home experiments.

Functional Sketch. Functional sketch is to identify possible functions of designed objects with respect to affordance exploration, association exploration, and usefulness specification. In this stage, the iAWN mock-ups were invited to freely assign a favorable spot at homes and predict its possible use. The results are depicted in Table 2 and summarized as follows:

- Placing iAWN on the piano as a decoration with ambient lighting display;
- Placing beside the telephone as a message reminder by shaking the iAWN ;
- Placing on the TV top surface as a switch for controlling electronic appliances;
- Placing on the table for reminding things to be done (e.g. taking medicine, deliver messages, paying bills, etc.) simply by shaking the iAWN;
- Associated with the white board for family connection and awareness (e.g. for example, reminders for using coupons or the expired dates of goods);

The content analysis above served as design clues for next stage of script writing. Design clues from the home experiments lead to some possible uses of iAWN.

Table 2. The functional sketch of iAWN home experiments listed by locations, photos and uses.

On the Piano	Beside the Phone	On the TV	On the Table	Near the White-board
				
Ambient lighting display or aroma starter	phone message reminder	TV programs reminder and a TV switch	Reminder of taking medicine	family message reminder

Examples are using iAWN as an input/output device, a tool to retrieve information, an emotional toy, an ambient display, an environmental controller, and a sensor network:

Script Writing. Within one week, we gathered contextual data from six participants. That information helped discover how iAWN can be interwoven into everyday life patterns. Through open-innovation ideation, user feedbacks enriched the functional description of iAWN, from beyond our initial design ideation. The possible design features for script writing are:

- Expressiveness of physical alternatives: materials of iAWN and the modification of the shape.
- User Interfaces: The correspondence of the domestic life patterns and the iAWN's "shaking-holding-swinging" metaphor.
- Ambient Displays: What information to be displayed? In what level? Would multimedia effects be produced immediately after shaking iAWN?
- Spatial Context: Where is appropriate to place the iAWN device? Place at home has its own identity. Examples are entrance for reminding, living rooms for social activities, and kitchen for health management.

Some scripts were experimented in the Aspire Home at National Cheng Kung University in Taiwan. The Aspire Home is a smart home of the future served as a living laboratory for home experiments [9]. For the reason of simple illustration, here we describe a script scenario that used an iAWN device in the home entrance. In the Aspire Home, the iAWN device was combined with a touch screen, a webcam, and a LED-embedded lamp box. The scenario is as follows. When entering the home entrance, the user touched the iAWN device, triggering the execution of a script for smart home living. The LED-embedded lamp box lighted up. The entrance played music for relaxation. The ambient display of the iAWN device showed the level of energy consumption. The touch screen displayed the user's cardiac pulse using webcam video imaging techniques. Indoor air quality is represented by the leaf stalk of the iAWN device. The scenario in the Aspire Home is shown in Fig. 4.

Fig. 4. The iAWN Prototype is tested in the Aspire Home

3 Results

3.1 The Implementation

The iAWN device contains three components: a leaf stalk, an augmented gadget base, and a power supply circle ring. The leaf stalk embedded with an antenna sensor provides a user interface for human computer interaction. When user touches or shakes the leaf stalk, the device is activated. The augmented gadget base is a collection of an Arduino microprocessor, a LED bar, a motion sensor, a battery, and a RFID tag. The iAWN device can be customized for personal use because it embeds RFID tag with user ID. The power supply circle ring contains a change circuit, and RFID reader. When the user places the gadget onto the power supply ring, the battery is recharged and simultaneously the RFID reader will identify user's ID and request location-based services from the server database. The data, which is transmitted based on ID and Location, will trigger an ambient display on the augmented gadget base. The system implementation of the iAWN device is shown in Fig 5.

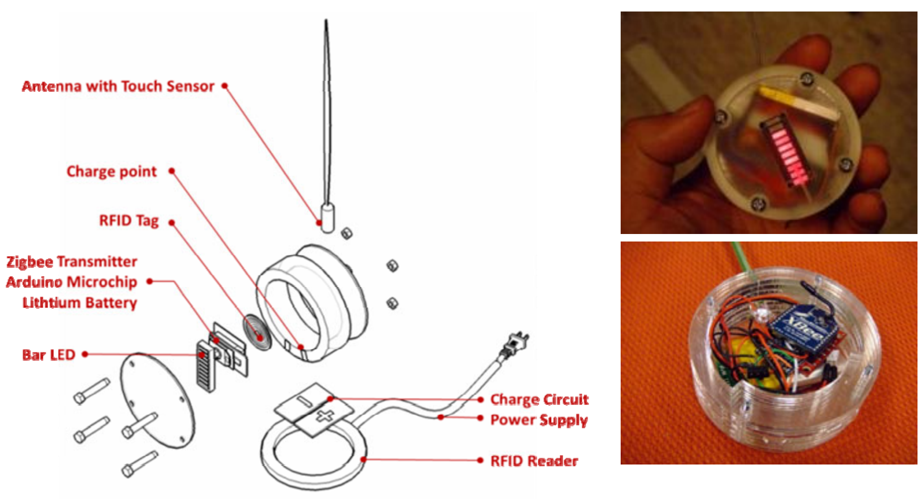


Fig. 5. The system components of the iAWN device

The iAWN project is consisted of three layers of system components: the iAWN device, location-based services, and Livindex databases. The iAWN device affords a portable user interface that combines the sensing antenna with the touch sensor. It detects user's ID and provides location-based services when and where it is desired.

The key technology of iAWN is a service platform which is consisted of the cloud computing database system called *Livindex*. The primary function of Livindex is to integrate family members' data and support the related information services. For the purpose of fitting users' daily habits and achieving higher information convenience, the system of livindex is an open architecture. The Livindex database is integrated with Google database system through Python as a bridge. It presents high accessibility because users can access the Livindex system with Google account; moreover, it also remains users' privacy based on the security of Google account. In addition, the open-end architecture combined with Google allows users to extend functions according to different life scenarios. The information types supported by Livindex are quite complex. Details about how the Livindex database is used for energy awareness are described in [2].

4 Discussion

The methods, project findings, and lessons learned from the iAWN development process are discussed in turn.

Home Service Avatar. Home is no longer to be a machine for living. Rather, it should provide service avatars to support awareness of energy consumption, environmental and health conditions. Our cultural probe study shows that energy, health, and environmental issues around sustainability are the major concerns for households. The lack of awareness tools becomes the barrier for users who seek and learn to live a sustainable life. We develop the iAWN project as an *embodied avatar* mediated communication system in which information is displayed and propagated for ambient awareness of energy consumption, environmental quality, and health conditions.

Ambient Awareness. Awareness systems have been a focus point of research in HCI since the mid-1980s. Other terms sometimes used for aspects of awareness are "ambient displays", "peripheral displays", and "notification systems". The early years of awareness research were primarily focused on computer supported collaborative work and social communication. In the last few years, awareness concepts have grown increasingly complex, involving smart artifacts, ambient displays, and tools for awareness of daily life activities [11]. Many interactive prototypes have been developed for environmental and social awareness. An example is the *Ambient Orb* that changes color in response to weather, stock prices, email activity, and traffic congestion. *Nabaztag* is another recently developed interactive toy that uses rabbit metaphor to conduct a sequence of rabbit's actions for network communication. Our work is similar to ambient awareness systems that use electronic displays or responsive actions to make people aware of both group activity and other network information [10]. Four patterns of ambient system design, citing inspiration from Weiser's vision [15], are identified as information capacity, notification level, representational fidelity, and aesthetic emphasis [14].

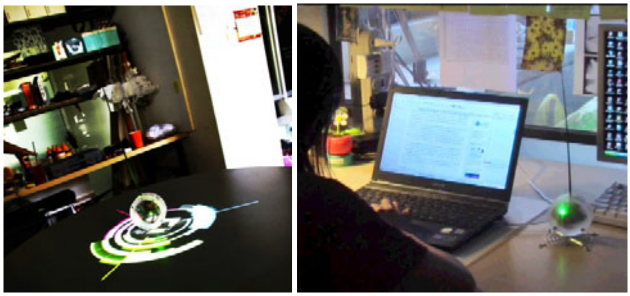


Fig. 7. The ambient display techniques for energy awareness are tested in the iAWN project

Why not Smart Phones? More recently, mobile user interfaces such as smart phones are used to provide effective feedback of energy consumption [8]. In our design probes, some valuable questions are "why not use personal devices such as smart phones for sustainable awareness?" "What is the difference between iAWN and smart phones?" Our quick response to these questions is to consider iAWN as a social device, rather than a personal device. The iAWN device encourages social interaction through sharing understanding of sustainable information. It supports ambient awareness in a social space, such as living rooms and entrances. iAWN is a location-based device where users can place it in various places in the home. The ambient display of the iAWN device reflects the quality of the corner space it occupies, such as electronic consumption and air quality of the living room. Furthermore, iAWN is a passive, non-intrusive, and always-on device for supporting sustainable awareness. Based on the result of cultural probes, the iAWN device is more appropriate than personal devices such as smart phones to provide ambient awareness and can be seamlessly integrated into domestic settings.

Ambiguous Design. In the iAWN project, designing for awareness is guided by creative principles, rather than traditional HCI measures of efficiency and effectiveness. Ambiguity is used as a resource for creative design [4]. It is particularly useful when we investigated interactive art works that encourage awareness. Three types of heuristic ambiguities are explored with respect to the design probes: ambiguities of context (e.g. where the device is placed), ambiguities of interaction (e.g. "what you feel when you interact with the device"), and ambiguities of information (e.g. "what is logically expected after the device is activated"). When we placed the iAWN mock-up in the homes, the reports from the users were particularly useful for expanding the space of design. For example, the users perceived the iAWN mock-up as a natural easy-to-use user interface because the leaf stalk of the iAWN device afford an extended touchable surface. It also encourages designers to avoid pre-occupied ideas or expected functionality on familiar products. Different from the press-on-button metaphor, the iAWN project uses natural "swing" metaphor that is beyond on/off control. The users' feedback on the "swing" phenomena corresponds to the acts of intended use of iAWN to "nature", "green" and "health" concepts. The experiments suggested that the style, shape, and emotional expressiveness of the iAWN design directly influenced to the users' speculation around the issues of sustainability.

Technical Problems. The experiments worked well in our living laboratory, but caused some technical problems for future use in real-world households. The first technical problem is seamless Integration of iAWN devices with existing sensor networks. Currently, the iAWN device can be easily programmed and connected to sensor networks using Zigbee protocol. However, it is not expected that all households have Zigbee-based sensor networks. Adaptability must be considered in further development. Battery is another challenging problem. We wish to develop a smaller iAWN device for aesthetic interaction. However, the existing rechargeable battery is not small enough to be included in a small-sized gadget. Replacing the battery is also a time-consuming process, requiring major revision of the design prototype.

5 Conclusion and Future Work

Sustainability is becoming an important research area at the interaction of human-computer interaction, building design, product design, and social behavior in our everyday practices. Due to lack of connection between sustainable HCI and professional design practices, it becomes problematic to develop sustainable HCI work to foster sustainable products, space, and services. In this paper we take an open-innovation approach to designing a smart and interactive artifact i.e. iAWN for sustainable awareness. The methods, the iAWN project findings, and how the methods can be applied to smart home of the future are discussed. Future work includes making iAWN devices as a seamlessly service platform for awareness of energy consumption, environmental quality, and households' health conditions. The development of a theoretical framework is undertaken for articulating sustainable HCI in the context of professional practice of architecture, interior design, and industrial design.

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A System for Enhanced Situation Awareness with Outdoor Augmented Reality

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Abstract. Augmented Reality (AR) is an upcoming technology focusing on the enrichment of the user's natural view by integration of text and interactive objects in real time. While indoor AR may rely on stable environment conditions and sensitive tracking devices, high-precision outdoor AR faces more challenging requirements and is thus less spread. Furthermore, constantly changing environment outdoor conditions require a robust system capable to offer different views with appropriate information density, especially in stressful situations. In this case, the correct choice of colors, text size and mark-up style may be critical for the performance of the interactive system. A concept for a new, video-based and compact Augmented Reality vision system, based on Differential-GPS, is presented. Results of a preliminary study on two different approaches for position and object pinpointing give valuable cues for interface design with optimized situation awareness.

Keywords: Outdoor Augmented Reality, Situation Awareness.

1 Introduction

1.1 Augmented Reality

Augmented Reality (AR) has been identified as an upcoming technology with many different areas of application. Many have been identified, which range from in-situ visualization of wind tunnel data [1] to industrial robot programming [2]. They have in common that cognition and productivity can be increased by enriching the human's natural view with usually invisible information. Other commonalities are constant and stable environment conditions which facilitate realization and implementation. The foremost problem of AR is accurate spatial matching of reality and virtual objects. Real-time tracking of the camera's or the human eye's transformation in 3D space is necessary for correct virtual object placement. Tracking availability, accuracy and reliability are usually the most prevailing reasons for the yet humble expansion of mobile Augmented Reality. Thus, examples for mobile AR with high accuracy can rarely be found. One of the few properly working examples is indoor commissioning [3].

In facts, problems accumulate when going outdoors. The user will mostly not come across stable surrounding conditions, but power supply is limited, temperatures as well as light conditions are constantly changing and all technical devices need

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protection against rough weather and agitation. Demonstrators for outdoor Augmented Reality like ARVISCOPE [4] or TINMITH [5] use the Global Positioning System (short: GPS), combined with additional sensors like inertia, laser distance measuring etc. for localization. This leads to compromises in accuracy and speed. Another disadvantage is the high ergonomic impact on the user wearing a helmet and carrying a backpack for all equipment. This narrows down capacities for mission-related accouterments.

Especially for soldiers, firemen, rescuing personnel and comparable occupational groups, this not acceptable because the informational advantage is compensated by an excessive additional physical load. As this is an obvious caveat, a hand-held solution has been developed in VIDENTE [6]. Since VIDENTE focuses on underground engineering, still no emphasis has been put on situation awareness, especially under stressful circumstances.

1.2 Research Goals

As primary target group, the infantryman/-woman of the future has been selected as a professional group with outstanding requirements for an outdoor Augmented Reality system. Reliability and simplicity of use are foremost requirements. Especially in confusing situations, the system must support situation awareness by augmenting the soldier's view with important, mission-relevant information into the spatial context of the situation at hand. Our research aims at developing a mobile system for three major benefits: At first sight to increase leadership by augmented situation awareness. Secondly, support of mobility by intelligent assistance in orientation and navigation. And thirdly, enhanced survivability through threat recognition at the earliest possible stage and so risk avoidance. Of course, the system shall not significantly impact the soldier's mobility. Consequently, size, weight, power consumption etc. must be taken into account carefully. Common approaches to model situation awareness like that by Endsley [7] differentiate between phases of perception of the current situation, followed by comprehension, succeeded by projection into the future as a basic for reasonable decision-making. Thus, one of the foremost requirements for the Augmented Reality display as well as the design and the amount of all displayed information is the possibility to adapt to different operating conditions (change daytime, activity status etc). Consequently, the aim of the approach is to provide an optimized situational awareness which comprises to get the most important information in shortest time, ideally at a glance.

2 Mobile Outdoor Augmented Reality System

The components of a conceptual functional demonstrator are presented in this section. Basis of an Augmented Reality system is a computer to render artificial content like text, symbols and graphics. For mobile Augmented Reality, a portable, small-scaled, lightweight computer is essential. Its power consumption must be low to grant a maximum of operating time and a minimum of cooling effort. Generally, the emission of heat, light, noise and movement must be avoided wherever possible for operation safety reasons. Thus, an ultra-mobile fit-PC2i [8] with passive cooling serves as platform. Its power consumption is 8 Watts and its dimensions are 115 x 101 x 27 mm only. It runs standard Windows 7, so no special embedded software development is needed. It is powered by a redundant power supply, consisting of three independent batteries where each can be exchanged during run-time. Any high resolution USB web camera can be attached to the computer; a LifeCam Cinema [9] is used here. To provide outdoor tracking accuracy in centimeter range in real time, the Differential-GPS device GRS-1 [10] tells about the translation of the system. The GRS-1 receives both the American GPS as well as the Russian GLONASS signals. Beside the standard frequency L1, the additional frequency L2 can be processed with an external antenna attached. The GRS-1 uses a real time correction data stream by SAPOS [11], a local German correction service. The suitability of this solution in fields of research has already been proven by Letsch & Kircher [12]. For rotation (azimuth, roll, pitch), the 3DOF InertiaCube3 [13] is employed. All components are integrated in one "stack" (Figure 1 left). The output display can be, for example, an ocular display attached to the stack for safe operation in unsafe regions (Fig. 1 right).

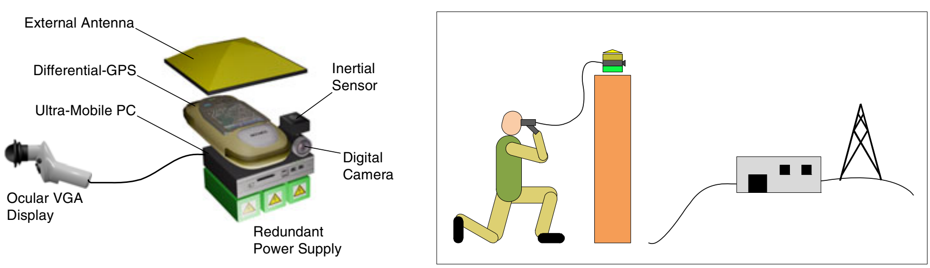

Fig. 1. Augmented Reality system components (left) and example of safe usage (right)

The Augmented Reality application basically grabs a live video stream from the USB camera and sets it as background for OpenGL renderings. According to the research aims (chapter 1.2), our research focuses on the design of the artificial elements augmenting the scene for best situation awareness. For this, one main function is to graphically pinpoint a location and to give information related to it. An empirical study with a desktop-based setup has been conducted. Its design and results are presented in the following chapter.

3 Empirical Study on Situation Awareness

Safety-critical situations leave narrow margins of time because decisions may have to be taken within seconds. This is why situation awareness of a soldier using a vision system is of crucial importance for the total system design. Pinpointing a certain location or object visible or concealed in the soldier's field of view should be one of the major functions of an Augmented Reality system. With respect to the high importance of an undisturbed view of what is going on around a leader's squad, a basic question must be brought forward: should the graphical mark-ups be drawn directly into the augmented view or rather at the views borders? What are the benefits of an in-view mark-up (e.g. with a rectangle) compared to a mark-up at the image's border (e.g. with arrows)?

3.1 Experimental Setup

A sample of ten participants (five female, five male) with an age, according to the future system's target group, between nineteen and forty years volunteered for the experiment. All participants had a minimum viewing acuity of 80% and passed Ishihara's [14] color perception test. They participated in a coincidental sequence. For this, they sat down in front of a standard laptop PC (Fig. 2 a), with an eye-to-display distance of 500mm in average. A string of four lowercase random letters were shown to them once with a request to keep those four letters in mind.

Then, controlled by the experiment's supervisor, a random sequence of twenty images of an exiguously cultivated landscape was shown for two seconds plus half a second for fading in and out (to generate temporal stress). Overall, one out of ten possible locations (Fig. 2 b) was marked on each image either by two arrows at the border of the image (left or right and top or bottom, depending on the location's image position; see Fig. 2 c) or by a rectangle marking the location directly (Fig. 2 d). Additionally, a random string consisting of four lowercase letters was shown either next to the top or lower arrow or above the rectangle respectively. Actually, only ten different locations were marked, so each location was marked with arrows on one image and with a rectangle on another so that mark-up type (arrows or rectangle) was balanced. As the human eye's sensitivity in the fovea is best at a light wavelength of 530 nm [15], green has been chosen as mark-up color and text color while the landscape was grayscale. The images' size on the screen was 330x220mm, the arrows' length and the rectangles' edge length was 25mm. The arrows' line width was 4mm, the rectangles' line width 2mm on the display and the font size of the letters was 22pt.

As a main task, the participants marked the pinpointed location on a slide placed on a printout of the landscape with a cross just after an image had faded out. There was no time limitation for this main task. As a side task, based on Sternberg's memory test [16], the participants decided whether one or more of the letters shown initially to the participant occurred in the last mark-up's string. If so, the subject had to write down the letter "j" at the slides upper right corner, if not, the letter "n" had to be written down. Overall, when categorizing situation awareness measuring into explicit questioning (mid-run or post-run), implicit measuring (e.g. task performance analysis) and subjective methods (e. g. self-rating), those two tasks can be seen as a combination of explicit and implicit measuring. For each image, a new slide was used. On average, the experiment took ten minutes per participant.

For the main task, the type of mark-up (arrows vs. rectangle) and the ten uniformly distributed locations' were the two independent variables and the individual error of a checked location to its true position on the image was the dependent variable. For the side task, the randomly generated string was the independent variable and the answer if one or more of the given letters was included in the string was the dependent variable.

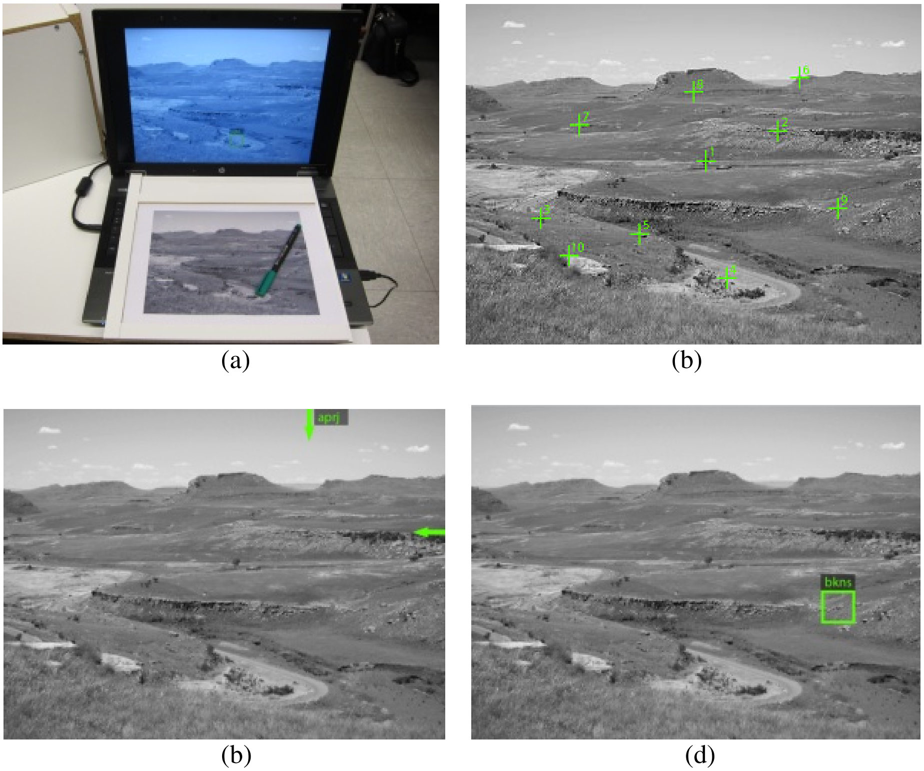

Fig. 2. Setup (a), different locations (b), arrow mark-up (c) and rectangle mark-up (d)

3.2 Results

Table 1 shows the mean, the standard deviation and the difference of means (short: DOM, difference between arrow mean and rectangle mean) of the error between manually checked locations and originally marked locations in millimeters. The Kolmogorov-Smirnov test indicates only for two of the ten locations a normally distributed error for both the arrow mark-up and the rectangle mark-up. Thus, statistically founded comparison of means requires analysis with a nonparametric test, e.g. the Wilcoxon signed-rank test.

As highlighted (white letters on black background) in the table, the difference of means is statistically significant for six locations. In these cases, the rectangle mark-up led to significantly more reliable location identification in comparison to the arrow-based mark-up. The strongest difference turned out for location number one which was coincidently exactly in the center of the image. On the other hand, the sample size is not sufficient to show that reliability of the rectangle-based solution is constantly higher for locations in the image's center: location number two, for example, where the arrows mark-up leads to slightly better results, was nearly as close to the image center as location number one.

Table 1. Means (M), standard deviations (SD) and difference of means (DOM) in millimeters for the arrows mark-up and the rectangle mark-up over all ten locations; the z-values and effect sizes are for p < 0.05

Location	1	2	3	4	5	6	7	8	9	10
Arrows M	11.5	6.6	5.3	6.6	11.2	4.2	6.8	9.4	9.9	5.0
Arrows SD	7.71	4.95	3.27	4.45	7.98	3.82	7.05	4.79	5.9	2.45
Rect. M	3.9	7.7	1.3	5.4	2.9	1.8	2.4	3.4	7.9	2.0
Rect. SD	5.43	5.89	0.82	3.53	2.6	0.79	0.7	2.37	5.8	1.56
DOM	7.6	-1.1	4.0	1.2	8.3	2.4	4.4	6.0	2.0	3.0
z-Value	-2.25		-2.71		-2.68		-2.38	-2.61		-2.41
Effect Size	-0.5		-0.6		-0.6		-0.53	-0.58		-0.54

Table 2 shows that the amount of errors for the string memory side task. While the overall rating is fairly balanced for the arrows and the rectangle mark-up, there is an irregular appearance of outliers for certain locations: When position ten was marked with arrows, three subjects gave a wrong answer to the string memory test and when positions seven and nine were marked with a rectangle, at least three subjects failed.

Table 2. Total number of errors done for each location in the side task

Location	1	2	3	4	5	6	7	8	9	10
Arrows	0	2	2	2	0	0	1	0	0	3
Rectangle	0	1	0	0	0	1	4	1	3	1

4 Conclusions

The fields of application for high-precision outdoor Augmented Reality are manifold. But the design of the system's user interface needs the same amount of care and consideration like choice and composition the hardware parts, especially when optimized situation awareness is required. The results of an empirical study shows that generally a clear preference towards an in-sight position and object marking should be followed. The rectangle used for marking always had the same size, shape etc, so future research will focus on variation of symbolism, colors etc. for better recognition. Results also show that textual information transmittance can be deficient, especially in mentally demanding and hectic situations. Alternatively, multimodal approaches, e.g. situation-related combinations of shapes, symbols, colors, text and sound need further investigation for better situation awareness and increased information perception.

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Implementation of the ISO/IEC 24756 for the Interaction Modeling of an AAL Space

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Abstract. This paper presents the results of the implementation of an accessibility verifier tool for AAL systems using the ISO/IEC 24756 standard. The accessibility verifier tool is based in an interaction model where the Common Accessibility Profile (CAP), as defined by the standard, is used to perform the checking of the accessibility constrains of the system configuration against the user capabilities. The paper gives information of the major design decisions in developing the tool, the context of use in the VAALID project and the relation with the standard.

Keywords: AAL Systems, Accessibility verifier, Common accessibility Profile, ISO/IEC 24756, interaction modeling.

1 Introduction

AAL is a concept which aims to prolong the time people can live decently in their own homes by increasing their autonomy and self-confidence, the discharge of monotonous everyday activities, or monitoring and caring for the elderly or ill person, in order to enhance their security and save resources [1]. AAL embraces all the technological challenges in the context of Ambient Intelligence to face such problem. A common term used when referring to AAL technologies is the "AAL space" or the physical space, the environment, in where the AAL products and services are deployed. The AAL space is a core component of any AAL solution and may be seen as the sum of sensors, actuators and user interface devices through which the user interacts with.

The user interaction with the AAL services must be carefully designed by the usability engineers. AAL spaces refers to electronic environments that are sensitive and responsive to the presence of people and provide assistive propositions for maintaining an independent lifestyle, so here the challenge for the designer is to experiment with new and innovative modalities of interaction that must be, of course, accessible

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and usable[2]. Some examples of the different interaction modalities between the user and the AAL environment are speech recognition systems, gestural systems, context-sensitive systems, visual interaction, auditive interaction, tactile interaction, etc.

When designing such AAL spaces there is a need to model the context in which the user is involved, being this need one of their main goals. The information managed by context is related to the environment, to the user and to the devices plus a description of available services. Among others objectives for the modeling, the evaluation of the interaction between the environment and the user in terms of the accessibility facets and, more concretely, the information related to the interaction capabilities and its accessibility is a very important need to cover.

This paper describes the implementation of the ISO/IEC 24756[3] for the interaction modelling of an AAL space. The recently approved standard has been used to define a Common Accessibility Profile (CAP) on the topic of defining interaction and accessibility, and in order to deal with the description of all the possible features of a user and the functionalities provided by devices and systems in terms of accessibility constraints. The CAP concept as presented by Fourney[4] and later adopted as a basis for the standard has been used by the VAALID project to perform the accessibility constrains verification.

In the next section an introduction to VAALID project can be found. The main objective of the VAALID project is to develop a 3D-Immersive Simulation Platform for computer aided design and validation of User-Interaction subsystems that improve and optimize the accessibility features of Ambient Assisted Living services for the social inclusion and independent living.

The paper describes in details the results of the implementation and how is being used in the framework of the VAALID project.

2 The Accessibility Constrains Verification in the VAALID Project

VAALID project [5] aims at creating new tools and methods that facilitate and streamline the process of creation, design, construction and deployment of accessible technological solutions for Ambient Intelligence to face the problem of the aging population.

These tools support the adoption of Human Centered Design methodology to create AAL solutions that are easily accessible for the user, technically and economically viable for the producers, and affordable and sustainable for the welfare system.

To fulfill this vision, VAALID project addresses the development of an Integrated Development Environment (IDE) for the designers of AAL solutions. VAALID IDE focuses on the design of the interaction between an elderly (called *"beneficiary"* in VAALID project context) and the AAL solution. Also, VAALID IDE provides the designer with tools to evaluate the accessibility and usability aspects of such interactions.

VAALID IDE consists of two environments that provide tools to the designer:

- An **Authoring Environment** (AE), that allows the designers to create and deploy the components that constitute the interaction structure of an AAL solution.
- An immersive **Simulation Environment** (SE), that allows the designers to simulate previously created AAL solutions; and the beneficiaries to experience the AAL solutions in virtual and augmented reality.

VAALID IDE target users are the professionals who are in charge of the conception, design, testing and validation of the human aspects of AAL solutions. They are collectively defined as AAL solution designers in VAALID project context.

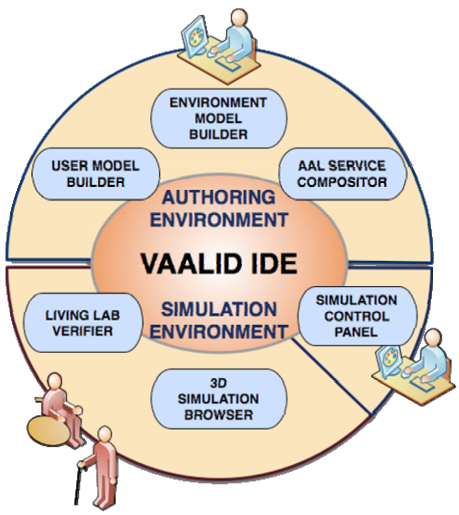

Fig. 1. VAALID IDE Tools

The VAALID IDE supports the AAL designer in adopting a Human Centered Design (HCD) process for the development of AAL Services. It is a kind of a rapid-design-prototyping tool that allows an iterative development of AAL solutions embedded into the HCD process. It empowers designers to create AAL solutions of a higher quality faster, easier and inexpensively by giving attention to the needs and limitations of the end users at each stage of the design process.

The accessibility constraints verification done with the Accessibility verifier is used during the design and implementation phase of an AAL HCD process and it allows the designer to automatically detect accessibility issues derived from matching accessibility profiles of the virtual beneficiaries with the different elements included in the simulation.

3 ISO/IEC 24756. Common Accessibility Profiles and VAALID Interaction Model

The Accessibility Verifier is built following the guidelines described in the ISO/IEC 24756 standard. This International Standard introduces a model of accessibility as a basis for understanding access issues with the interactions between users and systems in various environments. The model shows that users and systems must share capabilities of communicating. The standard provides a framework to specify a profile of common access capabilities (the CAP) of interactive systems, users, and their environment that are necessary for accessibility to be possible. [3]

The CAP is a key concept in the VAALID project since it is the base for the interaction model. This model was developed to collect the concepts that describe the capabilities of each element present in the interaction being developed by the usability engineer. The interaction model is the bridge or link between the user model (the model that describes the user abilities, preferences, etc) and the environment model (the model that collects the concepts related to elements presents, devices, dimensions, environmental conditions (lighting, humidity, noise, temperature, etc.)).

The CAP and the interaction model are the mechanisms used to match the user's interaction capabilities against the interaction capabilities of the devices, sensors and user interfaces. The standard defines the Interacting Components (ICs) as the actors of any interaction communication. In VAALID the ICs are the users, the devices and the environmental conditions that are part of an AAL Solution so the Overall CAP is the sum of the $CAP_{USE} + CAP_{SYS} + CAP_{ENV}$ (VAALID is not considering Assistive Technologies). The following figure shows an example of the matching between the CAPS with the nomenclature used in VAALID.

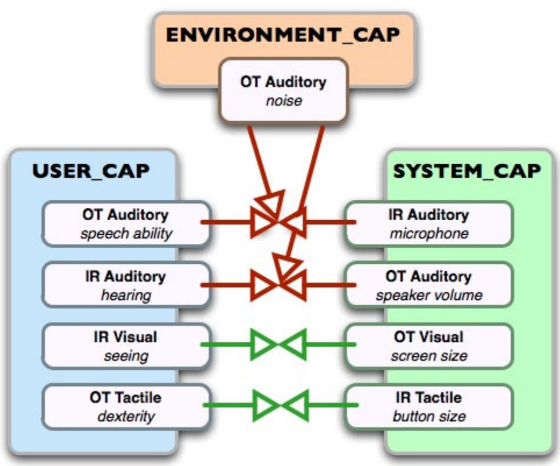

Fig. 2. Example of matching CAPs

The CAPs have been implemented as ontology classes. The ontology classes represent the hierarchy and relationships between the CAP, the ICs, the Component Features (CFs) and the Type specific information (i.e modality (CAP_M), capability (CAP_C), and processing (CAP_P)). See the standard for a detailed explanation of these terms.

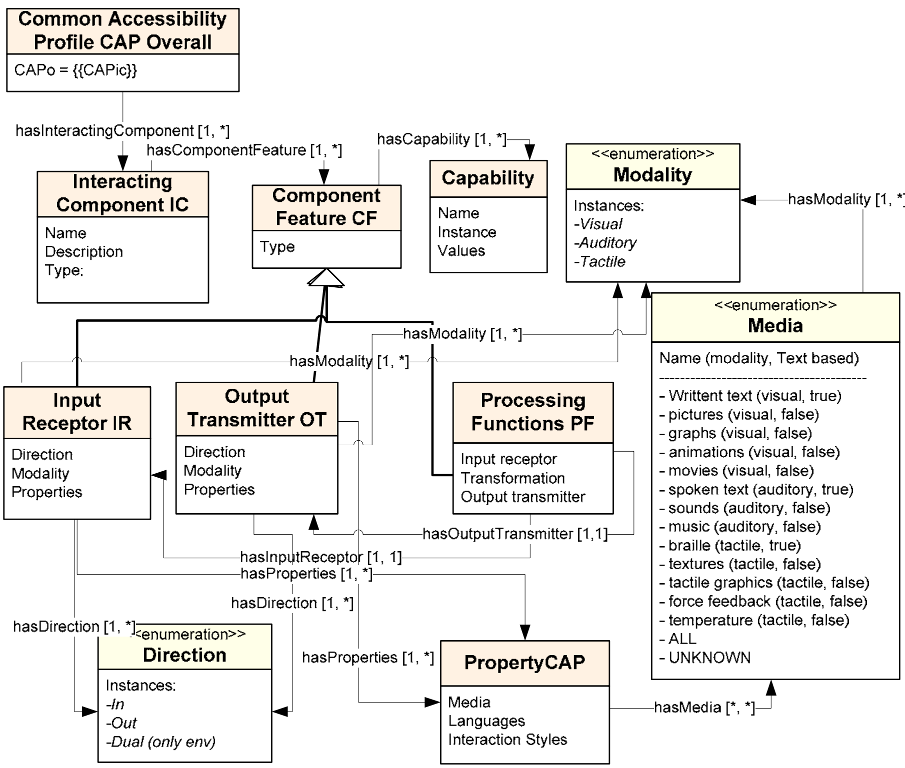

Fig. 3. Interaction Model

In the following tables the different entities and the relationships of the ontology are described following the structure described in the standard.

Table 1. CAP

Relations
Has Interacting Component → Interacting Component: A CAP overall has at least one Interacting component.

Table 2. ICs

Attributes
Name: A string defining the context of use of the service.
Description: A string with the description of the service.
Relations
Has Component Feature→ Component Feature: An interacting component has at least one Component Feature.
Has CAP type → CAPType: Defines the type of the IC described: CAPuse (user), CAPsys (system), CAPat (assistive technology), CAPenv (environment)

Table 3. CFs

Relations CF
Has Capability → Capability: Optional information that it's used to set a certain capability of the element described.
Relations Input Receptor (IR), Output Transmitter (OT)
Has Interaction component → Interaction Component: Optional information. The CAP of an IR could be composed by other ICs.
Has Direction → Direction. To set the direction.
Has Modality → Modality Sets the modality of the IR.
Has Property → PropertyCAP. defines the properties (not for capabilities) of a IR/OT.

4 Results: The Accessibility Verifier

The main goal of Vaalid Accessibility Verifier is to check that the interaction capabilities of the environment, spaces and devices are adequate to the interaction requirements of the user. In order to perform this checking, the Vaalid Accessibility Verifier is based on the interaction model described above.

The user model is the basis for creating the CAP_{USE}. The CAP_{USE} (or USER_CAP class) encapsulates the accessibility capabilities of the user model representing the user target for the validation.

In the same way, the interaction capabilities of the environment and spaces are also defined. Each device is modeled and specified in the environment model[1] and constitutes the input for the CAP_{SYS} or SYSTEM_CAP.

4.1 Entry Description

The information that is needed for the verification is defined and stored in the ontology classes (Fig. 3). Fig. 4 shows the high level class diagram used to implement the

[1] The environment model in VAALID must not be confused with the CAP_{ENV}. The environment model represents the space, sensors or user interface devices that are part of the simulation. CAP_{ENV} defines the conditions that can reduce the accessibility of a system.

CAP and the related concepts (for simplicity only visual capabilities are shown). Each CAP defined for each interacting component (IC) includes a set of component features (CF). In addition, the CFs have a collection of capabilities (CP) which increases the accuracy of the given information for every feature.

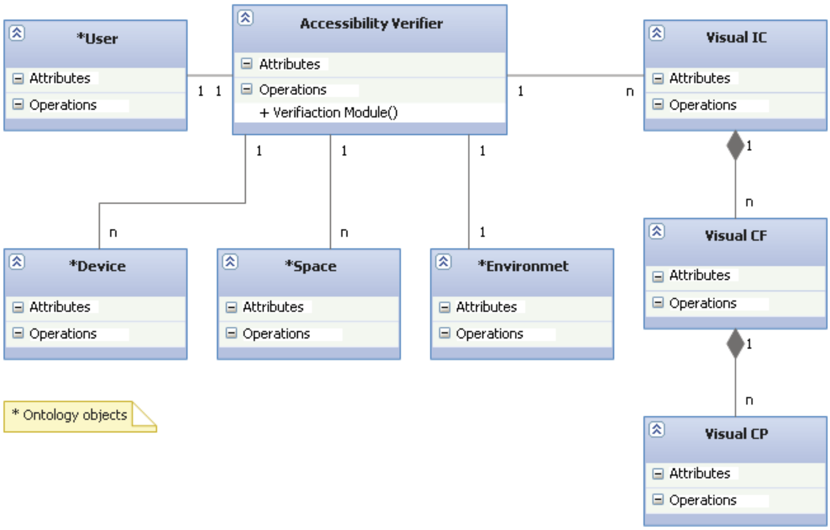

Fig. 4. Accessibility Verifier main classes diagram

A CF include the information regarding the direction ("In" or "Out"), defines a language, a modality ("Tactile", "Visual" or "Auditory"), and finally specifies if a media is used and which one.

CPs provide information about the units, maximums and minimums values used in the CF.

In the current implementation of the Accessibility Verifier, some features are created automatically on specific CFs. The remaining features, due to the amount and complexity of the elements, must be entered manually by creating the proper CFs. For instance, we can model a user with a hearing impairment who is unable to hear bellow 60 dB (Fig. 5) and also model a space that contains a loudspeaker configured to produce sound between 60 and 120 dB.

4.2 Data Processing

Once the entries are introduced, information regarding the ICs of all the elements is stored in the ontology classes. The consistency of the information is then checked since it is possible to rule out any inner discrepancy.

The main feature of the Accessibility Verifier module is to check the accessibility for all the CFs that have been defined in the project based on specific rules. User's CFs are compared one by one against the CFs of the remaining items (environment, spaces and devices), paying particular attention to the criteria based on direction and modality of such items.

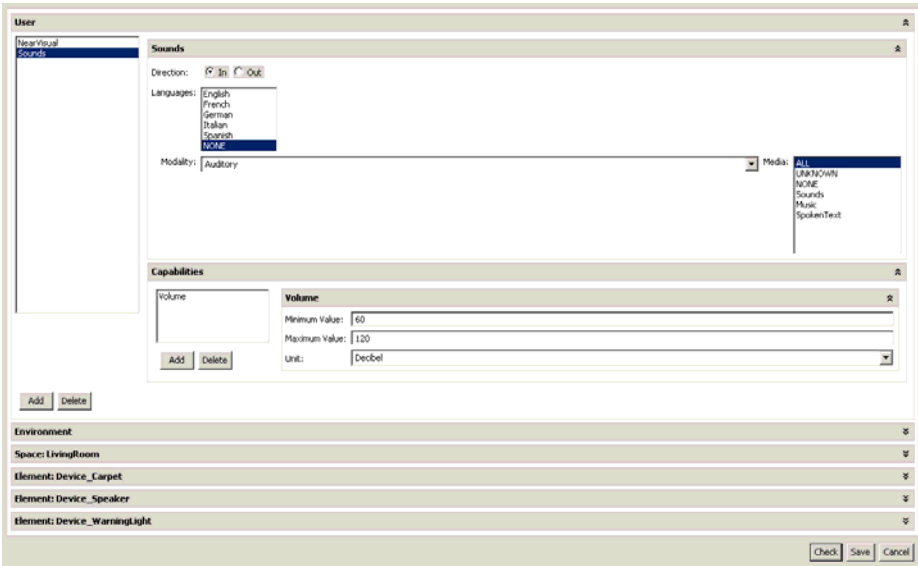

Fig. 5. User's CF

If during the checking no items are found satisfying the condition of the CF, the unmatched feature is registered to be prompt. In this step the module verifies that every item in the environment fulfills the needs of the user. In fact, the AV verifies that the user is able to interact with the device. In the previous example we are ensuring that the user will hear the fire alarm in case it is triggered.

4.3 Outputs

The Accessibility Verifier shows a message according the evaluation done in the verification module. Three options are possible.

The first one indicates that "there is nothing to evaluate". This is possible because there is no definition of a user and/or he has no CF, or it could be because the present elements in the application have no defined CF, and therefore there is no possible evaluation for the system.

The second message indicates that "no errors have been detected". That means that for each CF of the user, there is at least a CF in one of the elements (environment, spaces and devices) with the same modality and opposite direction. Backwards is the same, for each CF of the elements on the Project the user has to have at least one CF with the same modality but opposite direction.

The third message shows us that "some accessibility issues have been detected". This is the more important result since it gives us a clear indication that an accessibility problem is arising in the proposed AAL solution. It also provides information about the specific accessibility issues with the current configuration of the AAL system. It retrieves the registered unmatched features to help to the resolution of those accessibility issues (Fig. 6).

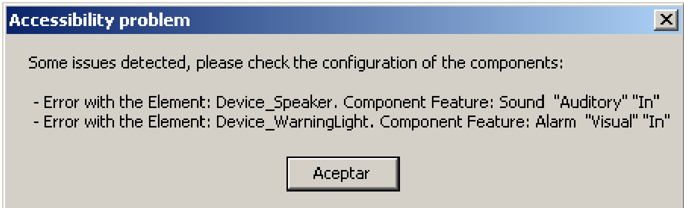

Fig. 6. Verification output

5 Conclusions

The Accessibility verifier is an important tool in hands of the designer to ensure that there are no major accessibility issues in the solution he or she is testing. The use of the standard provides a solid framework for the development of the module and guarantees the maintenance and extension of future versions of the tool. The standard can also be used in order to formalize the exchange of CAPs between different platforms or simulation tools.

Although in this first version the verification can be considered just as an indication of potential accessibility problems, it has been proven as a useful tool in the assessment of complex systems when a lot of devices are deployed in the AAL space. It allows the designer to rely on this verification for avoiding accessibility problems and concentrate in the solution itself. The designer does not longer need to care about the increasing number of interaction parameters and the different user interaction profiles that are used during the verification of this type of systems.

This tool, in conjunction with the rest of the VAALID IDE, allows the designer to create an AAL solution with no prior knowledge about the different facets of a disability; no special expertise is required for designing the system since the tool supervise the accessibility constrains that must be taken into account.

The design of AAL spaces free of accessibility constrains contributes to the AAL paradigm of solutions that fit the persons' needs and improve their dignity and quality of life.

In the time of writing this paper (January 2011) only preliminary results are available; the validation phase will conclude in April 2011 and some results will be given in the presentation of the paper in July 2011. The preliminary results give us a great support to continue this research.

Future work must be focused in the development of more intelligent algorithms to provide a more sophisticated and powerful verification. The automatic extraction of data from the user and system models is also a field for further research.

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Virtual Reality for AAL Services Interaction Design and Evaluation

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Abstract. AAL Solutions are not part of mainstream industry yet, being one of the main reasons the complexity of the technologies involved in relation to its targeted beneficiaries, the elderly, and its acceptance by them. Applying HCD methodologies for user involvement and creating physical prototypes is both costly and time consuming, particularly in this domain that combines software artifacts, devices and physical environments. VR techniques are very suited to create Virtual Prototypes that offer the beneficiaries the possibility to visualize and interact with proposed solutions before they exist. This paper presents the results of VAALID project in developing this approach of creating tools for design and simulation of AAL Solutions using VR and Mixed Reality, supporting the early involvement of beneficiaries in the process.

Keywords: AAL systems, Virtual Reality, Mixed Reality, simulation, user involvement.

1 Introduction

Ambient Assisted Living (AAL) solutions are technological solutions to support elderly and people with disabilities in their everyday lives allowing them to live self-sufficiently at home for a longer period of time.

Currently, the level of deployment of these solutions in real life is still very low, as well as their acceptability by elderly, being one of its main barriers detected the complexity of the technology involved. [1]

In order to overcome this barrier, an integrated user centered design vision is needed. HCD process requires the direct involvement of future beneficiaries from the initial concept through systems design and integration to the prototypes and business models and a continuous revision and adaptation of proposed solution designs.

In AAL domain, where software artifacts, all kind of devices and physical environments are interacting with the beneficiaries, the creation of prototypes is both

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costly and time-consuming, which restricts the development of high-quality solutions that require several iterations through the HCD process.

As an alternative for physical prototyping and testing, Virtual Reality can offer to the beneficiaries the capability to explore and interact in a realistic manner with AAL Solutions before they exist in reality [2].

The VAALID project [3] is a Specific Targeted Research Project supported by the European Commission with the goal of creating an integrated development and simulation environment (VAALID IDE), which can speed up the iterations through the Human Centre Design cycle. The central idea is to create an AAL solution virtually first and then refine this virtual solution with beneficiaries and other stakeholders before turning the prototypes physical.

This paper presents the results of the implementation of such VAALID IDE, focusing on the developed tools for VR representation and simulation of AAL Solutions.

2 Proposed Approach: VAALID IDE

VAALID IDE offers an advanced, integrated, computer aided design environment, consisting of the following, components

- An Authoring Tool (AE), that allows designers to create and deploy the components that constitute the interaction structure of an AAL solution. It enables a good overview of the services offered and the ability of fast editing and adaptation to changes, which will occur as the solution goes through the iterations of the HCD process. It is composed by:
  - A virtual reality scene supported with virtual devices and sensors, simulating the physical build-up of the environment.
  - A modeling framework [4] to describe the active parts available within the simulated solution. It supports models of users, environments, interactions and services. These models provide the functional basis for the simulation of the environment.
- A Virtual Reality Simulation Environment (SE) in which users can navigate through and interact with the simulated scene to test the developed services in its virtual stage. At this point, the designer can already incorporate his target users into the process by letting them experience his solution in the simulation and give valuable feedback for further improvement.

  On top of the virtual representation, the simulation environment is also capable of incorporating real devices into the simulation, which improves the range of services that can be tested and gives the developer the opportunity of gradually moving from the virtual to the real implementation of his solution and conduct user tests along the way.

The major innovation of VAALID IDE consists in the special combination and integration of the Authoring Environment and the Simulation Environment, which makes it possible to progress through a virtuous cycle of design-deployment-testing, that provides a tremendous support in the conception, tuning and implementation of AAL solutions.

In fact, the system allows the dynamic change and fine-tuning of different interaction models within the Authoring Environment and their immediate deployment and testing in the Simulation Environment, thus implementing a *rapid application development* paradigm within the AAL design process and favoring the application of the HCD approach.

In this way, VAALID IDE will help to bridge the gap between the planning phase of AAL solutions and their testing and evaluation in reality (e.g. in a living lab), bringing in several important advantages:

- Possibility of early, "in silico" detection of potentially costly flaws, before resources are actually committed to implementation and production
- Faster decision making, due to the reduction of the time spent in the design-deployment-testing loop
- Improving the research of innovative solutions, through the conduction of efficient "what-if" analysis
- Potential to address the needs of a vast number of senior citizens' categories, by fast switching among different beneficiaries' interaction profiles at design time
- Management of new types of information not achievable with traditional means, as for instance information on beneficiaries' reactions

These advantages foster a significant advancement of the AAL design process, resulting in higher product quality and innovation, reduced time-to-market and decreased implementation costs, in a relatively young industry, the take up of which is crucially dependent on the improvement of the cost/benefit ratio.

3 Implementation of Authoring Environment

The AE groups the development tools that allow the designer to define and describe the individual elements that intervene in the AAL solution. Some of them have been already the subjects of publications [4, 5] so we are going to focus on describing the Environment Model builder that is directly related with the VR capabilities of VAALID IDE.

This tool provides the designer with the capability of defining the environment in which the AAL solution will take place includes both physical space and objects placed there.

In order to model the physical space, this editing tool imports the 3D scene from a previously created VRML file, and allows the designer to identify the elements that are relevant for the interaction with the AAL service and assign them the desired properties and behaviour.

Devices are modeled from three different perspectives:

- Semantic: That is the properties the device has (type, location, reference to visual and behaviour representation, functions…)
- Visual: That is the 3D representation of the device. In the VRML it's also defined the interactions it can handle in Virtual Reality simulation by means of animation scripts that are parts of the simulated scene, which can be triggered by external programs and effect changes within the scene, like displaying certain media, opening a door or closing the shades of a window for example

- Behaviour: That is the workflow associated to the device. It represents the dynamic it offers to the elderly in the AAL solution, defining the possible states of the object, the inputs that will make it change it state and the outputs it will provide to the system [6].

In next figure, two screenshots of AE Environment Model builder are shown; on the left it is the device editor with the semantic properties and the visual representation, while on the right it is the workflow editor to define the behavior.

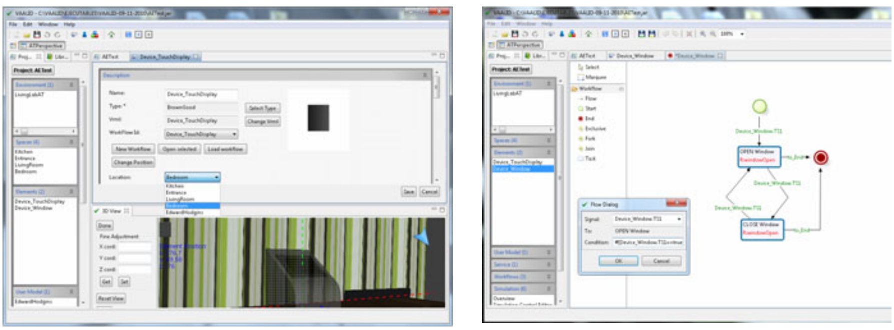

Fig. 1. VAALID Authoring Environment – Device editor (left) and workflow editor (right)

4 Implementation of Simulation Environment

The VAALID Simulation Environment serves the simulation of AAL services provided by intelligent environments. This requires the simulation of the physical environment as well as the functional simulation of the devices contained therein and finally the AAL services using the devices available in the environment to provide the environment's system intelligence.

Displaying the 3D-model is only a part of the simulation environment. Figure 2 gives an overview of the different components and their connections. The simulation environment is composed of five main elements:

- The **InstantReality Player**, which displays the 3D-environment including all simulated devices and sensors and receives end-user inputs through simulation controls.[7]
- The **Workflow Engine**, which simulates the developed AAL services and the functionalities of the simulated devices and sensors as workflows (similar to state-machines moving from one state to another through a set of predefined available transitions)
- The **Process Choreographer**, which is the core of the simulation as it connects the Workflow Engine with the simulated equipment in the 3D-scene and the real equipment in the Living Lab [6].
- The **Logger**, which receives data from the Process Choreographer about the actions of the simulated services and equipment and from the Instant Player about end-user input (like movement through the scene and interaction with the active

components of the simulated environment) and saves all these results in a file for later analysis.

- The **Simulation Control Panel**, which allows the user to set the parameters of the simulation environment and view the workflow states and the Logger output while the simulation is running. The user can also manually change the workflow states and thus interact with the running simulation.

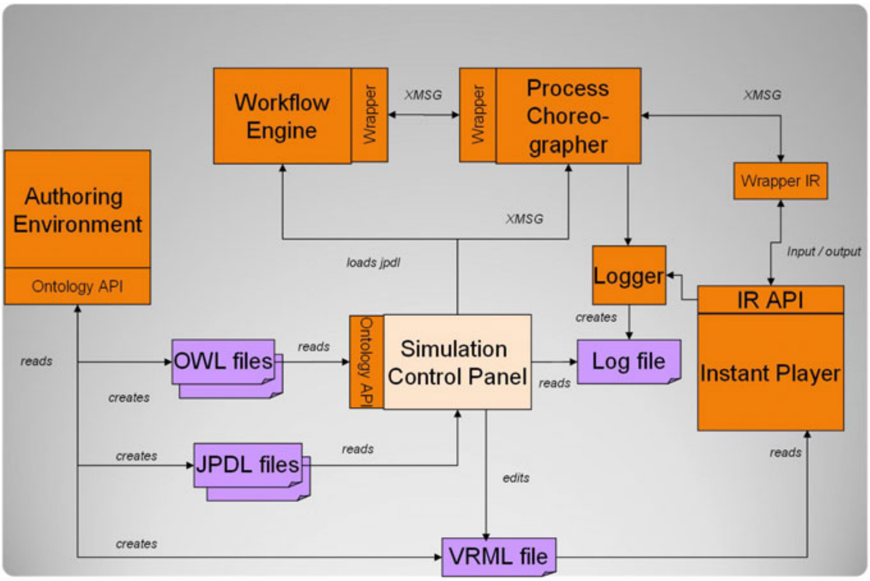

Fig. 2. VAALID Simulation Environment functional architecture

4.1 Connection between 3D-Simulation and Workflow Engine

The 3D-Environment running in the InstantReality Player is connected to the workflows running on the workflow engine. The InstantReality Player provides an interface for external programs to exchange events with the running simulation through a network connection. This connection allows the retrieval of events from user inputs to the simulation.

All 3D-models of devices and sensors are created according to a set of specific templates, which allows external applications access to all the active components within a simulated environment. For easy access to the simulation environment an API was developed which connects to the existing interface of the InstantReality Player but allows easy access to the simulated devices and sensors' reactions to user inputs and simulated functionalities.

Figure 3 shows how the connection between devices and sensors in the simulation and external programs is done in detail. Sensors and devices running in the InstantReality Player send data through the API to an external program. To support a flow of information in the other side, too, the external program can then call the devices' services (like opening a door, turning on a light, showing a certain message on a display, etc.).

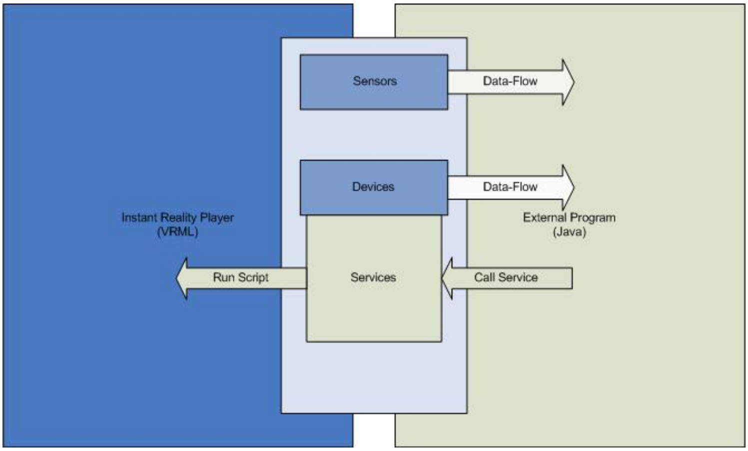

Fig. 3. Interaction between external programs and simulated equipment

4.2 Simulation Controls Support

The 3D-simulation serves the purpose of giving an end-user of an intelligent environment a realistic impression of the developed solution to receive feedback on the ongoing development in a fast and cost-effective manner. To give the user a realistic impression of the environment and provide useful feedback to the solution designers, the end-user testing the solution in the simulation environment needs to be able to interact with the solution in a simple and understandable fashion. Since most AAL systems are built with elderly people in mind as end-users the interaction with the simulation environment faces a big challenge in terms of interaction. The user interaction with an intelligent environment is a challenge of its own. On top of this, the simulation environment itself places another barrier between the user and the solution, which makes it necessary to develop a solution that takes different interaction modalities into account and supports a variety of different interaction devices. This ensures the adaptability of the simulation system to further developments in the user interaction field and lets the designer pick the interaction modality most suitable for the evaluation of a specific AAL solution.

To support different interaction devices, a layer was set in between the device and the simulation mapping the inputs from the device to the simulation environment. The interactions with the simulation take place in two ways. The first is the navigation through the environment, which allows forward and backward movement and rotation at different speeds. The second is interaction with devices and sensors in the environment. For this, a virtual hand in the environment is being controlled, which allows the user to open doors, press buttons etc. in the environment.

To ensure adaptability to different interaction modalities, this interaction has been tested so far with different devices both for interaction and navigation. Devices include a gamepad, a special wheelchair, a dance mat and a mobile phone and a space mouse for navigation as well as a Novint Falcon and a gamepad for interaction.

The designer can choose among the different devices supported so far in the Simulation Control Panel, which lets the user configure the simulation before it is started.

Initial conditions for devices can be set. During a simulation run, the user can take screenshots of the 3D-simulation, interact with the simulation by changing the states of the simulated devices and track the simulation run, logging all user interaction and device and sensor activations.

4.3 Connection to the Living Lab Verifier

For improved realism and support of devices and sensors, which cannot be simulated for user interaction testing like on-body sensors, the simulation system also supports the connection to real world devices. In the Simulation Control Panel, the user can choose if the simulation run should contain a real device or its simulated counterpart. This allows the gradual movement from a pure VR simulation to a mixed reality simulation and a complete test of the AAL services in a real living lab with all sensors and devices being real.

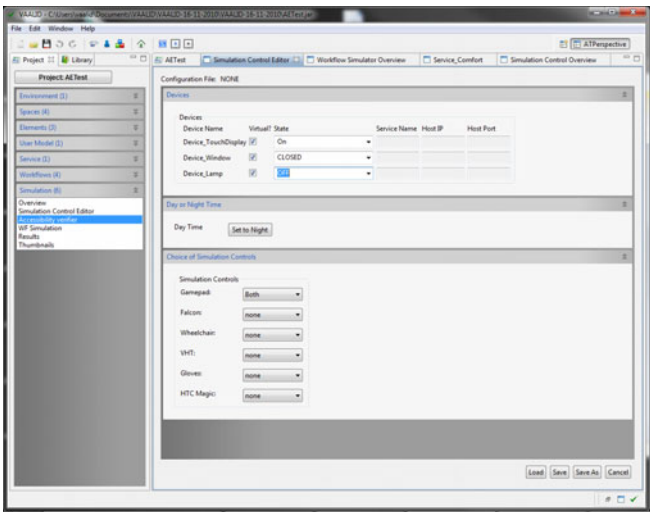

Fig. 4. VAALID Simulation Environment control panel

Real and simulated devices share the connection to the workflow engine running the AAL service. A layer between devices and workflow engine allows a standard interface for in- and outputs from devices to the system intelligence, which simplifies the switch from a virtual to a real device and thus further increases the speed of solution development.

4.4 Running the Simulation

The work done by the designer in the Authoring Environment is saved in three types of files: the first set of files are workflow-description files (JPDL-files), which contain the descriptions of the AAL-services as well as the descriptions of the functionalities of the different kinds of devices; the second set of files are ontologies (OWL-files), which contain a semantic description of the environment, its devices and the user model; and the third type is a VRML-file which contains the 3D-representation of the environment including all scripts and simulation control connections.

Before the simulation can be started based on this input from the Authoring Environment, the user configures the settings for the simulation using the Simulation Control Panel (SCP). When the user chooses the simulation controls to be used to interact with the simulation, the SCP edits the VRML-file accordingly by adding the code necessary for connecting these input devices with the components of the 3D-model. Also, changes in the device initial state result in editing the VRML-file accordingly.

When the user starts the simulation, the Simulation Control Panel loads the JPDL-files into the Workflow Engine, the VRML-file into the Instant Player and starts the Process Choreographer and the logger. The Process Choreographer exchanges XML-messages with the workflow engine and the Instant Player, thus mediating between AAL-services and simulated equipment. During the simulation, the logger receives input from the Process Choreographer and the Instant Player, collecting data on all user inputs through the simulation controls and the system's reactions to them, resulting in a complete log of the entire simulation procedure.

During the simulation, the user can view the workflows simulating environment, equipment and AAL-services in action and see the system reactions to user input live in a graphical display. For this display, the SCP loads the graphical representations from the JPDL-files created by the Authoring Environment. The user can also send messages within the simulation while it is running using this graphical display, which results in sending corresponding messages from the Simulation Control Panel to the Process Choreographer.

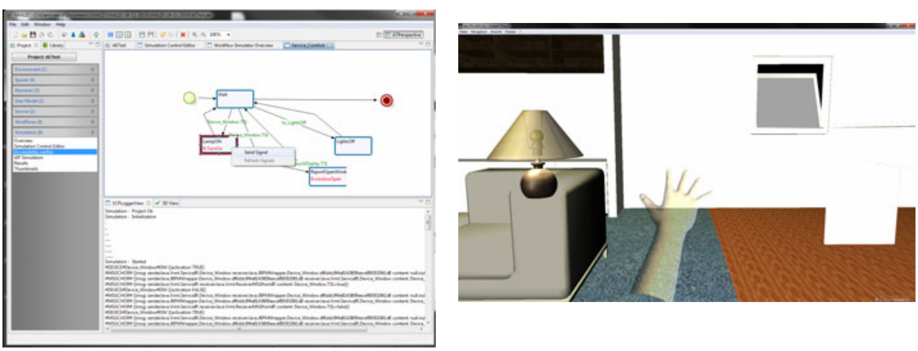

Fig. 5. VAALID SE – workflow simulator (left) and InstantReality Player (right)

After the simulation is complete, the Simulation Control Panel reads the log-file and analyses the simulation results, giving concise feedback to the user based on this analysis.

5 Conclusions

In this paper, the results of VAALID project related to the development of a Simulation Environment for AAL Solutions design and evaluation using Virtual and Mixed Reality have been presented.

The simulation environment is adapted to fit the needs of the most likely test subjects: elderly and people with disabilities, for whom AAL solutions are being developed. They find themselves in an immersive environment equipped with intuitive interaction devices and can thus provide valuable feedback on the developed solutions without being distracted by the simulation environment itself.

Building a virtual Ambient Assisted environment starts with the existing virtual reality model of the physical environment to be simulated. It is equipped with representations of sensors and devices like a real environment is currently set up for AAL-system testing. The simulation of the intelligent services is done using AAL workflows and ontologies, which are modeled graphically and thus allow both for fast set-up and editing of solutions.

The VAALID IDE supports the necessary transition from virtual representation to real environment. It allows the creation of a deep sense of presence within the simulation, which is needed for a realistic evaluation of the proposed solution. Connected to this visual system are interaction devices tailored to the use of elderly and persons with disabilities allowing even stronger immersion in the simulation and making the 3D-simulation accessible to a wide variety of test subjects. This is necessary so that the solution is being properly evaluated without much interference from the simulation itself.

Thus VAALID aids in the challenge to develop meaningful AAL solutions, which are available for a wide variety of subjects, making the design process faster and more efficient.

In the time of writing this paper (January 2011) the developed VAALID IDE prototypes were undergoing user evaluation from different perspectives:

- AAL designers and developers were involved to evaluate the user experience of the Authoring Environment,
- Human Factors experts together with elderly were involved to evaluate the user experience of the Simulation Environment
- Key stakeholder of AAL domain were involved to evaluate the impact of such tools in the overall process of designing and building AAL solutions

Only preliminary results are available; the validation phase will conclude in April 2011 and some results will be given in the presentation of the paper in July 2011. The preliminary results give us a great support to continue this research.

Acknowledgments. This work has been partially funded by the European Union in the context of the VAALID project. Our gratitude to the VAALID consortium composed of the following partners: Fh-IGD, UniPR, VOLTA, UPM, UID, SPIRIT and ITACA.

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Young by Design: Supporting Older Adults' Mobility and Home Technology Use through Universal Design and Instruction

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Abstract. The dominance of computer technology in work and leisure poses particular challenges for older people. Specifically, their lack of computer literacy impedes their ability to explore and use new interactive systems. To investigate the effect of computer literacy and two approaches to compensate a lack thereof, 62 older (M=68 years) and 62 younger (M=25 years) participants were split evenly into three groups: the video group watched a brief instructional video immediately prior to solving eleven tasks using a simulated ticket vending machine, while the control group did not and the wizard group used a redesigned wizard interface instead of the original simulated ticket vending machine to solve the same eleven tasks. Results indicate that both age groups benefited from watching the video, while older adults benefited more, so much so, that they were as effective as the younger non-video group. For the wizard condition age differences were practically eliminated. Particularly efficacy and satisfaction of the older group increased substantially. This result suggests that the careful design and integration of minimal instructions or wizards into interactive devices could contribute to maintain independent living and societal integration for older people.

Keywords: Human-computer interaction, universal design, computer literacy, video instruction, ticket vending machine, design for all, interaction knowledge.

1 Introduction

Mobility and independent living at home are two essential contributions to life satisfaction in old age; Considering age differences in technology use performance and the potential benefits of technology use, it seems fair to say that careless design might incapacitate people regardless of age and make them feel “older” than they are and that careful “universal” design might contribute to make older people effectively “young by design”.

This paper presents an overview of two research projects investigating such a “universal design” approach in the context of Information and Communication Technology (ICT): The first, called ALISA, exemplifies this approach with the use of a ticket vending machine and has been completed, the second (SMILEY), aims to apply this approach in the context of Ambient Assisted Living (AAL) and is work in progress.

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Technology could support older adults in their desire to maintain a self-sustained lifestyle, for it can extend our range of possible actions [1] and delay cognitive decline by providing „cognitive enrichment" [2]. However, older people are often reluctant to use modern computer technologies: In their lifetime, they have had less opportunity to use them and gather the necessary interaction knowledge and the knowledge they have acquired becomes obsolete quickly as technology develops faster and faster. Hence, it is important to acknowledge that the very design of technological artifacts can contribute to a growing digital divide as well as reduce it, e.g. by following a "universal design" approach.

2 Method

Following such an approach, the ALISA research project used a ticket vending machine (TVM) to investigate in a 2x3 factorial experiment (age (young/old) x experimental condition (original TVM/video/wizard), which user characteristics best explained age differences in successful TVM-interaction ("computer literacy" was the best predictor) and whether age differences could be mitigated by a brief video-instruction and by a user interface redesign (Wizard).

2.1 Participants

Participants were recruited in two age groups; The older comprised of a total of n=62 adults (M=68.2 years, SD=4.8, 35 female, 27 male) and the younger of n=62 younger adults (M=24.5 years, SD=4.14, 29 female, 33 male). Both age groups were well educated, with a slight advantage for the younger group (old/young: 21/11 College (Fach-/Hochschule), 5/34 Highschool (Abitur), 12/17 Intermediate Secondary School (Realschule), 19/0 Secondary General School (Hauptschule)). The older group consisted mainly of pensioners (51), while people in the younger group were mostly students (34) or working (18). Most participants used the TVM once a month or less (old: 23/ young: 46) or never (old: 35/ young: 6). The majority (71%) of the older group avoided the use of TVMs, while most of the younger group (74%) did not.

Instruments and procedureThe age groups were split evenly into three experimental conditions. The video condition differed from the control condition only in one aspect: participants watched a short instructional video immediately prior to solving the same eleven tasks using the simulated TVM. In these eleven tasks, participants had to select tickets for purchase using a simulated ticket vending machine (TVM) of the BVG (Berlin Public Transportation), which was built in Squeak/Smalltalk (see [3] for an introduction) and presented on a 19" touch screen monitor; **Fig. 1** shows three screenshots of that simulated TVM.

The eleven tasks were all realistic (i.e. „Please purchase a single ticket for Berlin ABC, reduced fare") and differed in difficulty: Without the instructional video, the younger group solved 84% and the older group 52% of them correctly. Fig. 2 shows the frequency of correctly solved tasks in the order they were presented. The necessary domain knowledge (i.e. "What does Berlin **ABC** mean?") was provided in the instruction (ABC are tariff zones). The experiment lasted about 60-90 minutes, with the task section embedded in questionnaires and interviews.

Fig. 1. Screenshots of the simulated Ticket vending machine

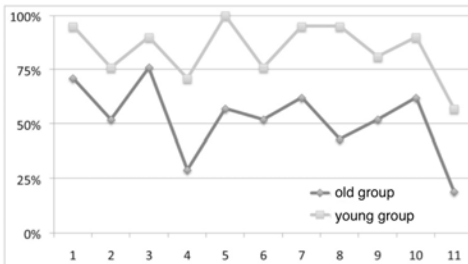

Fig. 2. Frequencies of correctly solved tasks without instructional video (control condition)

In the wizard condition, participants received no video instruction and solved the same eleven tasks using a modified Graphical User Interface that had been designed to require less computer literacy.

Instructional Video. In the brief instructional video (2:37), a narrators voice provided basic interaction knowledge for the use of the ticket vending machine and pointed with his finger to the objects of reference on the graphical user interface (GUI). The GUI resembled the TVM simulation, but to avoid teaching domain as well as interaction knowledge, all ticket button descriptions had been removed. Fig. 3 shows screenshots from the video. The video finished with the same image it had started with so it could be looped. Participants were instructed to touch the screen to stop the video and start with the tasks when they saw fit.

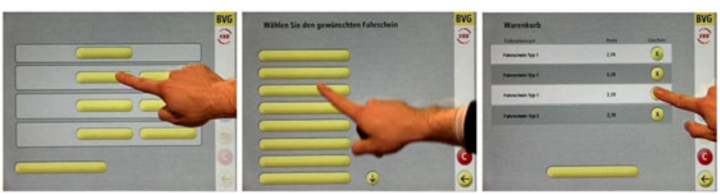

Fig. 3. Screenshots from the brief instructional video

Wizard. In the wizard condition, the TVM-GUI was re-designed to require less computer literacy. For that purpose, the users' task of ticket selection was analyzed and taken as the basis for a wizard design that guides the user through the selection process. The wizard was not meant to humanize the machine, but rather refers to a design pattern that guides the user through complex tasks by decomposing them into a set of manageable steps [4]. There is an immanent trade-off in the use of such a wizard, as we tried to increase the chance of successful interaction (increasing efficacy) by reducing the complexity of screens and providing simple and meaningful choices at the cost of increasing the number of screens and necessary steps and time to solve the task (decreasing efficiency).

This design pattern should benefit older users in particular by reducing cognitive requirements on visual search and working memory, which tend to decrease in old age [5]. Another guideline in the wizard UI-design was to provide goal oriented status feedback in the shape of an actual ticket filling up with choices made and to avoid interaction principles and symbols that might be unknown to older users as much as possible without compromising functionality. Finally, since older and younger users are experts at the task of purchasing a ticket in general (e.g. at the ticket counter) the process of the ticket selection was decomposed into four main questions from the user's perspective: Who wants to go? Where? How long should the ticket last? How many tickets are needed? Fig. 4 illustrates these wizard design elements.

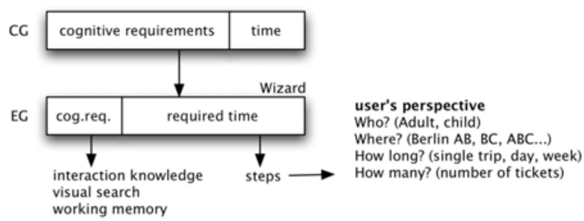

Fig. 4. Wizard design elements

After the wizard had been designed as a paper and pencil prototype [6] it was programmed as a new user interface for the same TVM simulation used in the control and video groups and presented on the same 19" touch screen monitors. Thus, the wizard was built to be functionally equivalent to the original TVM and differed only in the user interface. Fig. 5 shows screenshots from the wizard GUI of the TVM simulation.

Fig. 5. Screenshots from the wizard-GUI of the TVM

2.2 Dependent Variables

The experimental conditions were compared regarding their impact on efficacy, efficiency and satisfaction of the participants. Efficacy was measured as the number of correctly solved tasks, ranging from one to eleven. Efficiency was measured separately as the time and the steps (button clicks) it took to solve a task. Satisfaction was measured as the sum score of 13 items selected from the QUIS [7], asking about the user satisfaction in five applicable fields: general impression (three items), on screen presentation (three items), logical sequence (three items), choice of words (two items) and feedback (two items). All dependent variables were transformed to percent. Consequently, each score of 50% means that a participant had correctly solved half of the tasks, taken twice the time of the best participants and twice the steps necessary, while scoring half of the possible points on the satisfaction questionnaire, respectively.

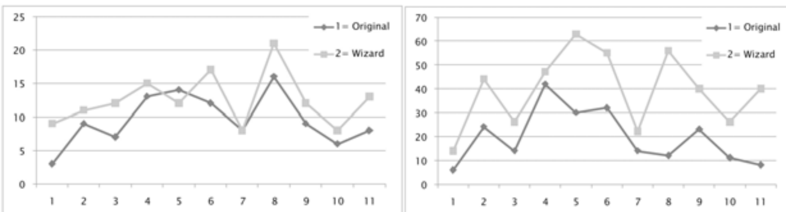

Fig. 6. Number of necessary steps (left) and fastest times (in seconds) to solve the eleven tasks

When comparing efficiency data for the original TVM and the wizard condition one has to keep in mind that they are based on a different minimum of steps and times, as shown in Fig. 6.

3 Results

3.1 Learning through Video Instruction (Manipulation Check)

To find out whether participants had actually learned from the brief video instruction, a knowledge test consisting of seven questions regarding the meaning of buttons that were shown directly on the screen immediately after the experiment (e.g. "What is the meaning of the red button?") was administered as a short interview. Participants who did not watch the video (Mdn = 35.18) already knew most of the correct meanings of buttons, yet those who watched the video (Mdn = 48.99) knew them even more frequently ($U = 574.50$, $p < .01$, $r = -.38$). Hence participants gained TVM specific interaction knowledge through watching the video instruction.

3.2 Computer Literacy and Experience

Since it was hypothesized that participants‘ computer literacy and experience influence their performance using the TVM, the respective differences in the groups were tested. While participants’ computer literacy (CL) and experience (CE) should not differ between experimental and control groups, it was expected that they differ between age groups. To measure CL and CE, the Computer Literacy Scale (CLS) [8] was administered at the beginning of the experiment as a paper and pencil questionnaire. As expected, older participants (Mdn = 34.73) had significantly lower scores on the knowledge part of the CLS ($U = 200.00$, $p < .001$, $r = -.78$) than those in the younger group (Mdn = 90.27). The same is true for computer experience (diversity of use): Older participants (Mdn = 27.73) had significantly lower scores (U = 246.50, p < .001, r = -.69) than those in the younger group (Mdn =69.39).

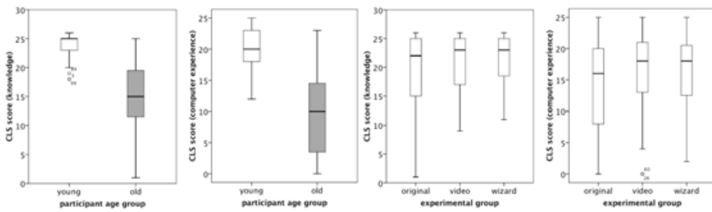

Fig. 7. Computer literacy and experience in the age and experimental groups

Performance differences between the video, wizard and control group should not be attributable to CL and CE, for participants who did not watch the video (Mdn = 60.11) did not differ significantly in computer literacy (H(2) = 1.68, n.s.) from those who watched the video (Mdn = 68.40) or from those who used the wizard (Mdn = 59.05). Again, the same is true for CE: Participants who did not watch the video (Mdn = 46.70) did not differ significantly in computer experience (H(2) = 1.82, n.s.) from those who watched the video (Mdn = 54.29) or from those who used the wizard (Mdn = 55.04). See Fig. 7 for an overview of these results.

3.3 Dependent Variables

Efficacy. The older group benefited from watching the video and even more from using the wizard, while the young group had very high efficacy in all three conditions. A MANOVA revealed a significant main effect of age group on the efficacy of using the TVM, F(1, 118) = 26.92, p < .001, η^2=.19 and a significant main effect of experimental conditions on the efficacy of use, F(2, 118) = 16.93, p < .001, η^2=.23. The Games-Howell post hoc test revealed that efficacy was significantly lower for the control group than for the video group (p<.01) and the wizard group (p<.01), while video and wizard group did not differ significantly. The interaction effect between age group and experimental condition on the efficacy of use was significant, F(2, 118) = 12.67, p < .001, η^2=.19. This indicates that the older group did indeed benefit more from seeing the video or using the wizard. Specifically, participants in the older group who watched the video (M=79.90, Mdn = 18.75) benefited so much that they did not differ significantly in the number of solved tasks (U = 165.00, n.s., r = -.19) from participants in the younger control group (M=86.61, Mdn = 23.14). The same is true for participants in the older group who used the wizard. They benefited so much from the new design that there was no significant difference (U = 209.00, n.s., r = -.00) in efficacy between them (M=89,46, Mdn = 20.59) and the participants in the younger wizard group (M=88.10, Mdn = 21.05). Fig. 8 gives an overview of the results for all six groups.

Efficiency Measured in Time. Both age groups profited from seeing the video in their efficiency measured in time. There was a significant main effect of age group on the efficiency (time) of using the TVM, F(1, 118) = 141.46, p < .001, η^2=.56 and there was a significant main effect of experimental conditions on the efficiency (time) of use, $F(2, 118) = 12.28$, $p < .001$, $\eta^2=.18$. The Games-Howell post hoc test revealed that efficiency (time) was significantly lower for the wizard group than for the video group ($p<.05$) but not for the control group, while video and control group did not differ significantly. The interaction effect between age group and experimental condition on the efficiency (time) was not significant, $F(2, 118) = 0.07$, n.s., $\eta^2=.001$. This indicates that the older group did not benefit more than the younger group from seeing the video or using the wizard. As expected, participants in the older group who watched the video (M=18.48, Mdn = 13.95) still differed significantly in efficiency (time) ($U = 69.00$, $p<.001$, $r = -.57$) from participants in the younger group who did not watch the video (M=34.02, Mdn = 27.71) and participants in the older group who used the wizard (M=22.33, Mdn = 12.67) still differed significantly in efficiency (time) ($U = 35.00$, $p<.001$, $r = -.71$) from participants in the younger wizard group (M=45.77, Mdn = 29.75). This finding is consistent with research showing that the speed of information processing declines with age.

Efficiency Measured in Steps. In efficiency measured in steps, much like with efficacy, even the young group benefited from seeing the brief video and the older group again benefited much more. In the wizard condition, both age groups were equally efficient in steps. There was a significant main effect of age group on the efficiency (steps) of using the TVM, $F(1, 118) = 27.33$, $p < .001$, $\eta^2=.20$ and there was a significant main effect of experimental conditions on the efficiency (steps) of use, $F(2, 118) = 8.17$, $p < .001$, $\eta^2=.13$. The Games-Howell post hoc test revealed that efficiency (steps) was significantly lower for the control group than for the video group ($p<.05$) but not for the wizard group, while video and wizard group did not differ significantly. The interaction effect between age group and experimental condition on the efficiency (steps) was significant, $F(2, 118) = 9.71$, $p < .001$, $\eta^2=.15$. This indicates that the older group did indeed benefit more from seeing the video or using the wizard. In fact, participants in the older group who watched the video (M=59.92, Mdn = 17.65) benefited so much that they did not differ significantly in efficiency (steps) ($U = 143.00$, n.s., $r = -.27$) from participants in the younger group who did not watch the video (M=66.82, Mdn = 24.19). The same is true for participants in the older group using the wizard, who benefited so much that there was no significant difference ($U = 186.00$, n.s., $r = -.10$) in efficiency (steps) between them (M=59.92, Mdn = 19.86) and the participants in the younger wizard group (M=60.38, Mdn = 22.20).

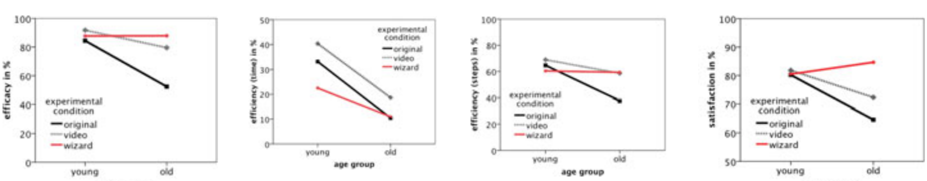

Fig. 8. Efficacy, efficiency (measured in steps and time) and satisfaction in all six groups

Satisfaction. Satisfaction ratings were rather high overall and video had little effect on the users' satisfaction, but particularly for the old group the wizard did. There was a significant main effect of age group on satisfaction with the TVM, $F(1, 118) = 5.26$, $p < .05$, $\eta^2=.05$ and there was a significant main effect of experimental conditions on the satisfaction, $F(2, 118) = 4.41$, $p < .05$, $\eta^2=.07$. The Games-Howell post hoc test revealed that satisfaction was significantly lower for the control group than for the wizard group ($p<.05$) but not for the video group, while video and wizard group did not differ significantly.

The interaction effect between age group and experimental condition on satisfaction was significant, $F(2, 118) = 4.31$, $p < .05$, $\eta^2=.07$. This indicates that the older group did indeed benefit more from seeing the video or using the wizard.

3.4 Summary

Watching a brief instructional video or using a wizard to select the desired ticket proved to be beneficial for both age groups. Specifically, the experimental groups solved more tasks in less time and less steps than the control group and the older group benefited more from the video and the wizard than the younger group in efficacy, efficiency measured in steps and satisfaction. As expected, video and wizard could not close the generation gap in efficiency in time, which largely depends on the decreased speed of information processing (see [9] for an overview of relevant age related changes in cognitive abilities). Also, the video had little effect on user satisfaction, which was a) rather high in all groups and b) based on items about characteristics of the TVM that did not change with the video. However, the wizard had a positive effect on user satisfaction, particularly for the older group.

For practical purposes, the younger generation might not want or need to switch to a wizard or to watch an instructional video for a simple machine as the TVM investigated. However, if the older generation had such a video available to them and actually watched it right before the tasks or switched to the wizard, our findings suggest that they could use the TVM as effectively and efficiently (measured in steps) as the younger generation does without watching the video.

4 Discussion

Both interventions, video and wizard, proved to be suitable approaches to a "universal design", yet they are not equivalent. In particular rarely used "walk up and use systems" in public spaces should be designed so that they can be used spontaneously (without instruction) by anybody, including older adults. Even a simple device like the TVM can pose a challenge for older users. Generally, they have less computer literacy that can guide them in the use and exploration of new technology and since the face of technology changes quickly, generational differences will persist.

However, research shows that for the younger-old many of the age differences in users success can be mitigated by proper instruction and this article has shown specifically, that a brief instructional video presented immediately before the use of a ticket vending machine can eliminate age differences found in efficacy and efficiency of use measured in steps. The advantages of such a brief video are twofold: they are easily produced and they can be integrated into many devices where they can provide help on demand precisely when needed, so the user is ready for the information when he receives it and can practice right in the task he was motivated to do to begin with [10]. For many devices, this concept could also be extended to complete training programs as shown for mobile phones by [11].

Another, perhaps more costly way to compensate for lacking computer literacy is to redesign the interface to require less CL to be used successfully. One way to achieve this goal is to follow a wizard design pattern, which has proven to eliminate age differences found in efficacy and efficiency of use measured in steps as well as or even better than the instructional video. Moreover, the wizard yielded significantly higher satisfaction than the original TVM, particularly for older users. The main advantage of such a wizard lies in the efficacy of its use. While on average the older group was able to select the correct ticket with the original TVM in 53% of the cases, the instructional video increased efficacy to 80% and the wizard even to 89%, which is about the same efficacy the younger group had in all conditions. It can be concluded, that the wizard needed little prior interaction knowledge and was easy enough to be used successfully by all age groups. This effectiveness comes at a price of decreased efficiency. While for the purchase of a single ticket the wizard is still faster than the instructional video plus the original TVM, the knowledge gained in the video can be transferred to future uses, while the knowledge gained through the use of the wizard cannot easily be transferred to the original TVM.

For practical purposes, to support older users it seems appropriate to combine the approaches and their advantages. For rather rarely performed tasks that focus on efficacy rather than efficiency, a wizard design pattern proved to be a good fit. Wizard and instructional video could be integrated into existing machines to provide information and instruction on many levels [6] to be available when and how they are needed.

Two caveats shall be mentioned regarding the generalizability of the findings. First, the investigated TVM can be classified as a "walk-up-and-use-system" that anyone should be able to use without prior training and other, more complex interactive systems (such as project planning software [12]) might pose problems for older users that are not as easily mitigated. Secondly, the video was designed to teach only interaction knowledge, while often it will be of interest to teach domain knowledge as well. Accordingly, the ALISA-project also investigated a comprehensive training environment for the TVM, including the teaching of domain knowledge via video instructions [13]. Further research is also directed at the effect of computer literacy on the successful use of other electronic devices.

Since both interventions proved to be successful, the same concepts were incorporated into a new project in the context of Ambient Assisted Living (AAL) called SMILEY, investigating ways to foster social integration and access to medical and other services through a unified application following two central ideas:

1) Reciprocity: Older adults are receiver and provider of help.
2) Layers of integration: From the apartment to the house and neighborhood and from family and friends to professional service providers.

Based on core themes for desired support extracted from a literature review, such as social isolation, safety and security, forgetfulness etc. [14], results of a requirements analysis for an integrated application and user interface will be presented along with paper and/or working prototypes.

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Towards an Evidence-Based and Context-Aware Elderly Caring System Using Persuasive Engagement

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Abstract. Due to the rapid growth of the aging population, numerous countries have been attaching importance to establishing the well-being of the elderly. However, long-term healthcare is labor intensive. To alleviate the possible social costs associated with manpower and physical resources, we propose an evidence-based caring system which can inconspicuously and automatically monitor the health status of the elderly by continuously analyzing their real-life long-term living patterns deduced from activity recognition. In this way, caregivers can get hold of the behavior changes even the elderly is not under caregivers' supervision. Moreover, we adopt a persuasive policy to provide timely reminders and encourage the elderly to achieve a healthier life. In the primary stage, we do preliminary experiments in a nursing room. Based on the experiment, we conduct several interviews aiming to improve our system in the next phase.

Keywords: Context-aware, persuasive technology, elderly healthcare.

1 Introduction

Aging population is a critical global issue. Evidence [9] shows that approximately 10 percent of the world's population is over the age of 60, and the proportion will have doubled by 2050. By 2010 United Nations for Human Rights claimed that aging population has become a national issue rather than merely local problems. An increasing number of countries have been attaching importance to establishing the well-being of the elderly. To alleviate the possible social costs associated with manpower and physical resources, it is necessary to develop assistive technology to help elderly people live independently.

Knowing the activities of daily living (ADLs) plays an important role in elderly healthcare. Traditionally, daily living reports are obtained from periodical interviews and manually recorded reports/data obtained by caregivers or self-reported by elderly patients. Without objective evidence from other sources, medics have to completely trust the reports. Such a problem obstructs the medics from knowing the real situation about the elderly. This motivates us to design an *evidence-based report system* to automatically collect and analyze daily living data of the elderly. In addition, with

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limitations in manpower and available resources, it is hard to ask caregivers to attend the elderly all the time. To resolve this difficulty, we design a virtual caregiver which can timely remind and encourage elderly people. The actions and reminders of the virtual caregiver are one metaphor of the caring behavior of a human caregiver.

Since our system is now in the primary stage, the setting of our evaluation focuses primarily on a bedroom-scale environment. We perform preliminary experiments in National Taiwan University Hospital and set our target activities of the elderly at *Sleeping, Sitting, Leaving Bed, Interactions with caregivers,* and *Using Walking Cane.* Instead of purely focusing on technology, we attempt to acquire the true feelings of the elderly when they interact with our system. Hence, we conduct several interviews aiming to acquire directions and suggestions for the improvement in the next stage.

2 Methodology

The framework of the entire evidence-based and context-aware healthcare system is shown in Figure 1. An inhabitant interacting with the ambient intelligence (AmI) enhanced environment is not only a sensing data producer but also a service consumer.

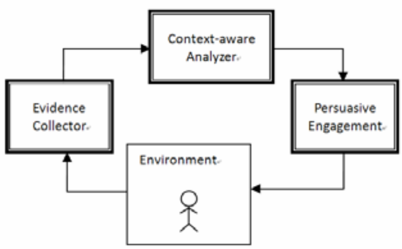


Fig. 1. The proposed evidence-based and continous health improving framework

One's ability to perform activities of daily living (ADL) can be used to document some health related statuses. For instance, an abnormal living pattern may reveal some physical or mental problems. In our framework, *Evidence collector* truthfully collects each daily living clue of the inhabitant; this can be achieved by various ways such as automatic recording technology from the sensed environment or in-time observation from a caregiver. After acquiring evidence of daily living information, *Context-aware analyzer* outputs meaningful features based on the information from *Evidence collector*. Some living problem may appear after further analyzing those features. The *Persuasive engagement* gives prompt assistance or encouragement whenever the *Context-aware analyzer* brings out interested situations. Ascribing to the appropriate intervention of *Persuasive engagement,* we expect the improvement in health condition. If the inhabitant follows the suggestions and services supported by *Persuasive engagement*, the changing living pattern will be perceived by *Context-aware analyzer* since it continually analyzes evidence coming from *Evidence o collector*. In the end, the *Persuasive engagement* will appropriately interact with the inhabitant according to his/her ameliorating health condition.

2.1 Current Implementation

As one realzation of the continous health improving framework, in the primary stage, we implement a healthcare system for the elders in a bedroom as shown in Figure 2. For the *Evidence Collector*, we create non-obtrusive sensing module to collect clues regarding ADLs when the elderly people interact with the ambient sensors. Sensory data will first be translated by the *Raw Data Analyzer*, the first component in *Context-aware Analyzer* into features. Feature data will then be fed into two-layered *Activity Recognition Engine*.

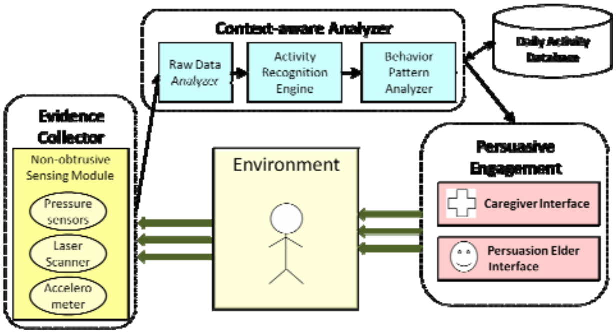


Fig. 2. Implementation architecture in current phase

High-level activity data will be further analyzed by *Behavior Pattern Analyzer*, which is the last component in *Context-aware Analyzer*. Living patterns such as the total sleeping time or the number of leaving bed within a specified duration will be discovered by the *Behavior Pattern Analyzer.* All the living data will be stored in *Daily Activity Database* so that caregivers can access historical living data in the past. There are two user interfaces in *Persuasive Engagement* module. For the caregiver, system automatically generates health report about the elders. And for the elders, system will timely encourage or remind them in some situations which can be detected by *Context-aware Analyzer*. Evidence shows that the sleeping patterns are important both in physical and mental aspects for the elderly [6][7]. Poor sleeping patterns are usually comorbid with medical illness and are associated with increasing risk of morbidity and mortality [6]. In addition, it has high risk of tripping when the elder is getting out of bed [7]. Therefore, we choose five activities which are *Sleeping, Sitting, Leaving Bed, Interactions with caregivers,* and *Using Walking Cane.*

2.2 Non-obtrusive Sensing Module

Our non-obtrusive sensing module inconspicuously collects all clues about how and when an elder interacts with his/her surrounding objects. The term *non-obtrusive* here means not interrupting the daily task of an elder. We choose three non-obtrusive sensors in our system: pressure strap, accelerometer, and laser scanner. We use the *NTU Taroko* node as the wireless sensor network (WSN) node and each of them can connect to pressure straps and accelerometers using a sensor daughter board. In Figure 4 (b), one accelerometer has been connected to one *NTU Taroko* node, which has been

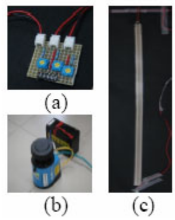


Fig. 3. (a) A pressure daughter board. (b) A Laser Range Finder. (c) A pressure strap.

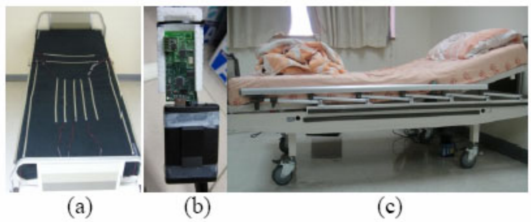


Fig. 4. (a) Deployment of pressure mat. (b) A *NTU Taroko* node connects to an accelerometer and a battery box. (c) Snapshot of our deployed sensing bed. The LRF is put beneath the bed and the pressure sensor mat is covered by the bed sheet.

connected to the battery. An accelerometer is attached to a walking cane, which can be used to detect the walking state (e.g. walking pace) of the elderly.

Pressure sensors have been used in a smart environment to monitor the elders in many ways since these sensors are among the most inconspicuous ones which can be seamlessly attached to the furniture or on the floor [2]. As for bed-related activity monitoring, various layout formats of pressure sensors have been tested to compare monitoring performance. For example, previous work [1] weaved 336 circular pressures into the bed mattress. Since these pressure sensors resulted in a large feature set (336 features in their work), they took advantage of Principle Component Analysis to reduce its feature dimension. Though they achieved promising accuracy rate, the labor power and power usage for later maintenance is costly. Therefore, we try to strike a balance between the manpower of maintenance and the activity recognition accuracy. We conducted pilot trials on sensor deployment and finally determined deploying eleven pressure straps on a single bed. The deployment is shown in Figure 4(a). Briefly speaking, we segment the bed into four parts, which are shoulder part, waist part, left edge part, and right edge part respectively.

Owning to the fact that a pressure mat can only detect on-bed activities, the Laser Range Finder (LRF), shown in Figure 3(b) is incorporated to provide location information about persons surrounding the bed, including both the elder of interest and his/her caregivers. Previous work used a camera to monitor situations around the bed [3]. Though visual systems can give rich information regarding human postures, it may violate one's privacy which is crucially concerned in a bedroom. Moreover, when inhabitants sleep or take rest, they tend to turn off the light. Unlike visual system, the performance of LRF won't be affected even under low illumination. Therefore, we adopt our prior work [4] and do human detection in the vicinity of the bed by LRF.

2.3 Raw Data Analyzer

A *Raw Data Analyzer* preprocesses sensory data into higher-level contexts (or features) according to the characteristics of each sensor. For pressure straps, each sensor reading will be discretized into binary state {*On*, *Off*} based on pre-defined thresholds; raw data receiving from the accelerometer will be analyzed by observing the pattern of square sum of all axes value; the result is used in detecting human walking activity. Lastly, for the LRF, aiming to do the path tracking, candidate human coordination detecting from laser sensors will be translated into location grids shown in Figure 5. The area label *L1* stands for the first (nearest) area in the left side of the bed. Segmenting the areas according to the distance helps in considering temporal movement of a person. For instance, caregiver coming from outside the room may cause a sequence such as {*L2, L1*}.

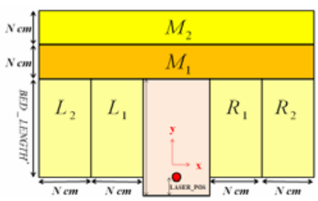


Fig. 5. Location grid layout for our location feature

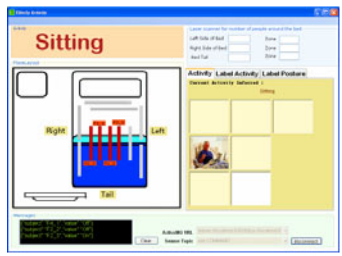


Fig. 6. Monitoring interface for caregiver

2.4 Activity Recognition Engine

The aforementioned Analyzed contexts will be further fed into our Bayesian network inference model. The model adopts a two-layered structure so as to achieve a higher accuracy rate since some noisy sensor data will be filtered out after the first-layered inference task. We use open-sourced WEKA [5] as a tool to implement our activity recognition engine. The pressure state and accelerometer contexts coming from the *Raw Data Analyzer* are the inputs of the first layer engine which is used to infer primitive actions of activities. The engine is a multi-class Bayesian network model which estimates five class labels, including *Sitting on Bed, Lying on Bed*, *Sitting near Right*, *Sitting near Left*, and *Walking Step*. We name the output (estimated) label of the first layer *action*. The estimated *actions* will be further fed into the second-layer inference stage. The second-layer stage is composed by six individual spatiotemporal Bayesian models, each of which represents one of the target activities included *Sleeping, Sitting, Leaving Bed, Interactions with caregivers,* and *Using Walking Cane*. Since an activity may be comprised of a sequence of actions. For instance, the *Leaving* activity consists of an action sequence such as {*Sitting on Bed* →*Sitting near Right, Sitting near Right* →*R1*} (please refer to Figure 5). Hence, we take also these temporal features into account both in the training and testing phase. Whenever a sequence of actions occurs in a predefined time window, these actions will be composed and formed up a new temporal feature. Figure 6 demonstrates the monitor interface for the caregiver. The red straps on the bed figure are represents those pressed pressure straps. The red word shows the on-going activity inferred by our system is *Sitting*.

2.5 Behavior Pattern Analyzer and End Persuasive Engagement

Each inferred activity will be stored in a database and fed into *Behavior Pattern Analyzer*. Firstly, successive and same activity records will be aggregated into one episode. The starting time and the length of one episode will be recorded. Secondly, expert domain knowledge from the geriatrics is used to diagnose whether there exist targeted activity patterns. If such pattern appears, system will promptly interact with the elder people using persuasive strategy. Moreover, a health report for caregivers will be automatically generated. Therefore, caregivers can capture the evidence-based activity report of the elder regardless human supervision. Details of persuasive engagement component are depicted below.

Persuasive and Reminder System for Elderly. Aiming to support appropriate assistance for the elderly people, we design a persuasive and reminder mechanism to promptly interact with the elderly based on their on-going activities. To make the interface much more attentive, we create a friendly social agent, *Home Keeper Rabbit*. The animations and voices of the *Home Keeper Rabbit* serve as the avatar of a given caregiver. The *Home Keeper Rabbit* shown in Figure 7(a) is counting the steps of the aged walking using our enhanced walking cane. The number on upper right corner displays the total steps the aged has walked up to current time. When the elderly keeps walking for sufficient steps, the *Home Keeper Rabbit* will praise to his/her work (shown in Figure 7(b)) and cheer on the elderly to exercise as much as possible.

(a) (b) (c)

Fig. 7. (a) The *Home Keeper Rabbit* is executing counting task when an elder walks using the enhanced walking cane (b) Firework animation usd to praise the elderly for reaching a predefined number of walking steps. (c) The animated rabbit sits when the elderly is sleeping.

Table 1 shows the currently implemented functions of our *Home Keeper Rabbit*. Whenever an activity of interested in the table is detected, the system will automatically provide its corresponding feedback. In addition to timely interacting with the elderly in the event of detecting a specific activity, some other meaningful activity episodes should be considered. We consulted experts in eldercare and they mentioned that the length of daytime sleeping would closely influence the sleeping quality at nighttime. Furthermore, sufficient exercise does help the elderly live healthier. Based on the suggestions, we consider two additional meaningful activity episodes which are *walking duration* and *sleeping duration*. Table 2 represents the persuasive policies we design for the interested activity episodes. Note that the degree of preference about each service for the elderly is acquired by several interviews, which will be discussed in the next section.

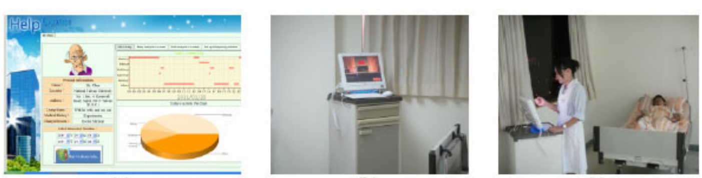
Table 1. Timely reminders or encouragement for target activities

Detected Activities	Description of system feedback
Sleeping	If a sleeping behavior is detected, the system automatically plays music for a while.
Sitting on bed	When the elderly wakes up and sits on the bed from sleeping, the *Home Keeper Rabbit* performs an animation with a cheerful greeting.
Using Walking Cane	Current number of steps will be shown at upper right corner of the screen.
Leaving bed	When the user is about to leaving the bed, the *Home Keeper Rabbit* reminds its potential hazards (i.e. tripping) and inspires the elderly to do more exercise.

Table 2. Persuasion policies supported for interested activity episode

Activity episode	Description of system feedback
Sleeping	When an elderly sleeps more than one hour in the *daytime*, the *Home Keeper Rabbit* speaks loudly to wake him/her up
Walking	Four levels of walking states are evaluated. Higher level means more steps the elderly has walked via the walking cane. *Home Keeper Rabbit* encourages the elderly when the elderly reaches a higher level

Evidence-based Health Report for Caregiver. As for realizing an evidence-based report system, we worked closely with some medical researchers from National Taiwan University Hospital and home caregivers (hereafter referred to as medical consultants) with the aim of navigating the real needs of caregivers. One problem we ask the medical consultants is the trustworthiness of some commonly used medical scales (such as Barthel Index [8]) which are often evaluated based on some pre-designed oral questionnaires. The medical consultants pointed out the difficulty for elderly people to recall precisely about their daily activities when they meet doctors or caregivers. Moreover, some elderly people may exaggerate their condition in order to get more social resources or attention. In order to provide more objective and reliable observations for caregivers, our system can translate all collected evidence of the elderly into easily comprehensive health reports with the statistics regarding their ADLs. We further design a website as a personalized healthcare portal (or *Help Center*) for the caregivers to help themselves easily get health reports via the Internet. Figure 8 shows the front page of the Help Center.



(a) (b) (c)

Fig. 8. (a) The front page of the evidence-based health report website. (b)(c) Scenarios of our proposed system in practical use.

Available information provided from this portal is as follows:

1. Activity statistics in a day: The starting time and interval for each activity episode performed in one day is presented in the form of a Bart chart. The Pie chart will further reveal the ratio of each activity in all day long (as shown in Figure 8).
2. Sleeping and walking pattern analysis in a week: Variations of time interval regarding walking and sleeping activities in the last week are expressed in a histogram. For the Sleeping activity, daytime and nighttime sleeping interval will be separately shown in two histograms.
3. Leaving frequency: Leaving frequency as well as is time instances in the past one week are rendered as a point map.

In addition, by choosing a start and an end date, caregivers can get a health report in the specified period.

3 User Study

What the elderly really think should be the core guidelines for any researches on eldercare. Instead of purely focusing on technology, we also attempt to acquire the true feelings of the elderly when they interact with our system. We do several interviews to collect suggestions from some seniors. Due to the limitations of the environment setting, we took a video to demonstrate a potential application of our system. We carry a notebook and play the video to interviewed seniors who we met in a public place. The video serves as an inspiration for the seniors to reflect upon their real-life needs through the proposed technologies.

There are three sections in our video which include *Sitting on Bed* event, *Leaving Bed* event, and the *Using Walking Cane* event as well as walking episode. Each section shows how the user interacts with the system.

3.1 Participants

There are three interviewers in our field study. One is the first author of this work who is in charge of answering the technical questions during each interview. The other two are students from the department of nursing. Both of the two nursing students have the experiences in taking care of the elderly. One of the two students has cooperated with our team, so she also understands our work.

For the interviewees, we totally interviewed nine older people, three men and seven women. Each senior underwent a quarter-to-one hour interview process. Two of them were interviewed directly in their own houses; the other seven were interviewed when they were waiting in the hallway of National Taiwan University Hospital. All elderly participants are more than 65 years old. Three of interviewees are the volunteers of the hospital. Four of them live alone independently in the city.

3.2 Feedback of the Persuasion Mechanism

Our system is now in a preliminary stage where the setting of our evaluation focuses primarily on a bedroom-scale environment. To inquire the experience of elders' bed-related habits and to inspire them to think more about their real-life needs, we started the interviews with some sleep related questions: "*Do you have the habit of taking a* *nap?*", "I*n daytime, approximately how long will you spend on the bed*?", and "*what do you usually do on the bed in daytime?*"

Next, we played the section regarding the *Sitting on Bed* service supported by our system, and we asked, "*Imagine that you wake up and nobody besides you, will you feel attentive when the rabbit saying cheerful greetings to you though it is a virtual figure?*" Among all of our interviewees, five elderly people like our virtual caregiver. "*It will be a wonderful idea if the rabbit can say something when I wake up, but it will even preferable if the rabbit can gives different greetings.*" *(Female, 68s, hospital volunteer, living independently*) Suggestions about providing additional information such as date and weather are mentioned by the interviewees. These will be altogether considered in our second stage system implementation. A statistic is that most of those elderly who live independently lik to hear greetings when they wake up. The other four interviewees didn't like our *Home Keeper Rabbit* mainly cause by their low interest in computer technologies. They rather chose a real human assistance who can pat their backs or turn lights on for them. "*I'd rather like the system accomplish what I really want when I get up, not just say hello.*" *(Female, 65s, house keeper)*

Regarding the *Sleeping* service which is an automatic music playing service*,* six of the interviewees are looking forward to this service since all of them can listen to the music while they are sleeping. Three of the interviewees disliked the service owning to some personal concerns such as their health states or economic conditions. Another participant likes being at liberty to turn on/off the music service by his/herself rather than being automatically provided the service without any notification.

As for the *Leaving Bed* reminder service, although all our interviewees are in good mobility, seven of them gave positive feedback and looked forward to the service in their future lives. They pointed out the importance of such a reminder before leaving bed especially for those who suffer from dementia or Parkinson's disease.

Lastly, we inquired opinions about our *Walking* service, which is a counting task according to the number of steps up to now; six interviewees were fond of this service. In addition, they indicate the need of a virtual sport coach, *"I hope the system can stop me doin*g an excess of *exercise; besides, I need encouragement to do more exercise via appropriate suggestions." (Female, 73s, Hospital volunteer)*

3.3 Discussion

We obtain an unanticipated lesson from our preliminary questions that almost every elderly people we interviewed do not like to sleep on bed in the daytime and they go to bed early at night and wake up early in the morning. Based on this observation, we will alter the design of the original *Sleeping* service which calculates the total span of sleeping and then wakes up the elderly if the span exceeds a pre-defined threshold. By asking some in-depth questions, we also learned that the core idea in an assistive technology for the elderly should be more human-centric. Many interviewees suggested that our system should be able to improve their social connections. "*I hope the system can automatically help me contact my children when I get up.*" *(Female, 68s, living independently*) and "*I'd like to contact my friends and discuss whether we c*an hang out today." In addition, the deployment cost and whether the system is easy to use are highly concerned by the elderly people. *"It sounds complicated. I am not familiar with the computer."(Female, 68s, volunteer)* and *"This service sounds too expensive for me. I am not rich enough to own such a smart system" (Male, 80s,* *living dependently).* However, most of our participant showed optimistic expectation on the system and were willing to visiting our lab.

4 Conclusion

In this work, an evidence-based caring system along with a persuasion strategy is proposed. To generate an evidence-based health report regarding an elderly, we seamlessly deploy ambient sensors in a context-aware environment and recognize the on-going activities based on these sensed data. Such an inconspicuously monitoring system lessens the labor manpower for the caregivers since they do not need to constantly supervise the elderly. Moreover, some behavior changes reveal the potential health problem; therefore, we can collect long-term data such that an abnormal behavior change can be detected as early as possible. In addition, to promptly give appropriate assistance to the elderly, we design a virtual agent who can interact with the elders based on the on-going activities. We have conducted pilot experiments in a nursing room and proceeded several in-depth interviews based on the results of our current system. Future directions towards the next-staged system have been derived from these interviews and we can continuously enhance our system based these valuable suggestions.

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Part III

Driving and Interaction

Towards an Integrated Adaptive Automotive HMI for the Future

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Abstract. The EU 6th Framework Programme Integrated Project AIDE (Adaptive Integrated Driver-vehicle interfacE), was a 50 month project, with 31 partners, including all major European vehicle manufacturers, the main suppliers and a range of leading research institutes and universities. The general objective of the AIDE Integrated Project has been the generation of the knowledge and the development of methodologies and human-machine interface technologies required for safe and efficient integration of ADAS, IVIS and nomad devices into the driving environment. The third sub-project of AIDE aimed at the design, development and demonstration of the innovative adaptive and integrated driver-vehicle interface concept. This entails a unified human-machine interface that resolves conflicts and exploits synergies between different in-vehicle systems. The paper focuses on the presentation of the work emanating from the third sub-project of AIDE presenting the general features of the innovative human-machine interface realized within AIDE, including the results achieved with the demonstration of the system in three prototype vehicles.

Keywords: human-machine-interaction, vehicle, adaptive, integrated.

1 Introduction

Every year, about 45 000 people die and 1.5 millions people are injured in traffic accidents in Europe. The Tri-level Study of the Causes of Traffic Accidents [1], shows that the great majority of road accidents (about 90-95%) involve human error in the causal chain. Recent empirical work, such as the US 100 car naturalistic field study [2], provided an increased understanding of the nature of these errors, pointing to the key role of inattention. For example, 93% of the lead vehicle crashes recorded in the study involved inattention to the forward roadway as a contributing factor. While conventional vehicle safety measures (e.g. seatbelts and airbags) have contributed significantly to the reduction of fatalities in the last decades, their safety contribution is reaching its limits and currently further improvement is difficult to achieve

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at a reasonable cost. Today, the development of Advanced Driver Assistance Systems (ADAS, e.g. collision avoidance-, lane-keeping aid- and vision enhancement systems) offers great potential for further improving road safety, in particular by means of mitigating driver errors.

In addition, the number In-Vehicle Information Systems (IVIS) increases rapidly in today's vehicles. These systems have the potential to greatly enhance mobility and comfort (e.g. navigation aids & traffic information systems, media players, web browsers, etc), but at the same time increase the risk for excessive and dangerous levels of inattention to the vehicle control task. Furthermore, many IVIS functions are today featured on portable computing systems, often referred to as nomadic devices, such as PDAs or advanced mobile phones, which are often not designed for use while driving.

These new technologies have great potential for enhancing road safety, as well as enhancing the quality of life and work e.g. by providing in-vehicle access to information and communication resources. However, this proliferation of systems and functions that interact with the driver in one way or another leads to a number of challenges, both technical and human factors related, for the designer of the future automotive HMIs. These challenges include the HMI design for the individual systems as well as the question how to integrate a range of such different systems into a functioning whole with respect to their interaction with the driver. Another challenge concerns how to best exploit the technological possibilities of adaptive interfaces in the automotive domain. For example the safety benefits of ADAS may be significantly reduced or even cancelled by unexpected behavioural responses to the technologies, e.g., system overreliance and safety margin compensation.

The general objective of the AIDE Integrated Project has been the generation of knowledge and the development of methodologies and human-machine interface technologies required for safe and efficient integration of ADAS, IVIS and nomad devices into the driving environment. In order to reach this goal, the project involved sub-projects on (1) behavioural effects and driver-vehicle-environment modelling, (2) development of a generic human-machine interface (HMI) evaluation methodology and (3) design and development of an adaptive and integrated human-machine interface. Moreover a fourth sub-project was assigned with horizontal activities such as project management, training activities, dissemination and development of HMI guidelines and standards.

The current paper presents the design and development work employed in sub-project 3. The paper discusses the specification and design of the adaptive interface as well as the generic HMI software architecture. Moreover, it presents the techniques developed within the sub-project for real time monitoring of the driver-vehicle-environment state which enable the real time adaptivity of the HMI. Finally, the paper presents the main output of the sub-project, the three demonstrator vehicles and concludes with a discussion on the findings and proposals for future work in the relevant research domain.

The paper is organised as follows: In Section 2, the AIDE concept is briefly presented together with the main issues that the system addresses, whereas in Section 3 the design and the implementation of the AIDE concept and its consisting modules are explained. Section 4 provides an overview of the vehicle demonstrators developed within sub-project 3 and Section 5 provides the main conclusions and proposals for future work in the relevant research domain.

2 The AIDE Concept

As already discussed in the previous Section, the project aimed at addressing a number of present and future challenges within the area of driver-vehicle interfaces, regarding maximisation of safety benefits of advanced driving assistance systems (ADAS), minimisation of the workload and distraction imposed by in-vehicle information systems (IVIS) and nomadic devices (portable consumer electronic devices which drivers use while driving) [1], as well as issues related to the currently rapid growth in numbers of such systems within vehicles, both in terms of associated integration difficulties in the development phase and in terms of increased risks of driver information overload.

The general goal of the SP3 sub-project has been the design, development and demonstration of the Adaptive Integrated Driver-vehicle Interface concept (fig. 1) in three vehicles: a heavy truck, a luxury car and a city car. This entails a unified human-machine interface that resolves conflicts and exploits synergies between different in-vehicle functions. As illustrated in the figure, some key features of the AIDE concept are:

- *Multimodal HMI I/O devices* shared by different ADAS and IVIS (e.g. head-up displays, speech input/output, seats vibrators, haptic input devices, directional sound output)
- *A centralised intelligence* for resolving conflicts between systems (e.g. by means of information prioritisation and scheduling).
- *Seamless integration of nomadic devices* into the on-board driver-vehicle interface.
- *Adaptivity of the integrated HMI* to the current driver state/driving context.

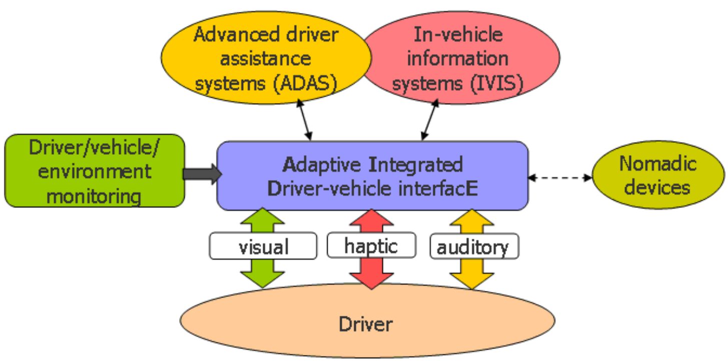

Fig. 1. The AIDE concept

3 Design and Development of the AIDE Concept

Since HMI strategies, I/O devices, and applications differ between different vehicle manufacturers and between different car segments, modularity and flexibility have been considered as the most important requirements. This has strongly affected the principle design decisions, the specification of the interfaces and the communication flow.

3.1 General AIDE Logical Architecture

The AIDE architecture describes a functional structure and semantic communication independent from a concrete implementation, because the implementation varies widely between the OEMs.

The AIDE architecture focuses on the functional structure of the AIDE software components and their communication. The individual components are specified in terms of their tasks, responsibilities and dependencies that are necessary to provide adaptive functionalities for an integrated, in-vehicle HMI system [3]. In order to realize the I/O management of interfering output events and adapt the driver system interaction to the driver status and preferences and as well to the driving situation, the following main components were identified:

Applications: These are components offering a specific functionality to the user such as navigation, phone, lane departure warning, music player, radio, etc. The application should be as independent as possible and should, in principle, work independently of the HMI management functions. It includes an AIDE interface adapter offering the AIDE specific functions (such as communication to the ICA and the DVE) and performs a priority mechanism.

I/O Device Control: This includes the specific I/O devices such as LCD displays, head-up displays (HUD), haptic input/outputs, loudspeakers or buzzers. It also includes pre- or post- processing units such as speech recognition system and Text to Speech engine.

Interaction and Communication Assistant (ICA): An intelligent assistant that performs the management and adaptation functionality. It contains the rules governing the system behaviour or HMI strategy that is perceived by the user.

Driver Vehicle Environment (DVE) Module: A module that monitors the driver and the driving situation and derives condition information about the driver, the vehicle and the environment that is used by ICA to adapt the driver-system-interaction. It is also used by the applications to adapt application-specific functionalities such as changing priorities and adapting warning strategies.

Nomadic Device Gateway: Nomad devices connect to the in-vehicle system through the Nomadic Device Gateway. Thus the functionality of the nomad device in terms of data, applications and I/O devices can be used by the in-vehicle system and vice-versa. The in-vehicle system contains virtual application software connected to the nomad device functionality via a gateway that provides the user interface software (views) that accesses the I/O devices.

All interfaces between the above mentioned components have been specified using generalised content to guarantee the modularity. For example, the ICA has to assign priorities to each output request from the applications. This is done using informing parameters sent by the application to the ICA. These parameters objectively characterize the output message which has to be done in terms of their importance for the driver like “driving relevance”, “safety criticality”, etc. All parameters are defined unambiguously and do not include application-specific aspects. Thus, the communication flow between the ICA and application components remains simple. Moreover, the DVE Vector and the PM Vector provide condition information and driver preferences that are used by ICA for all general valid adaptive functions and by applications for the application specific functions [4], [5].

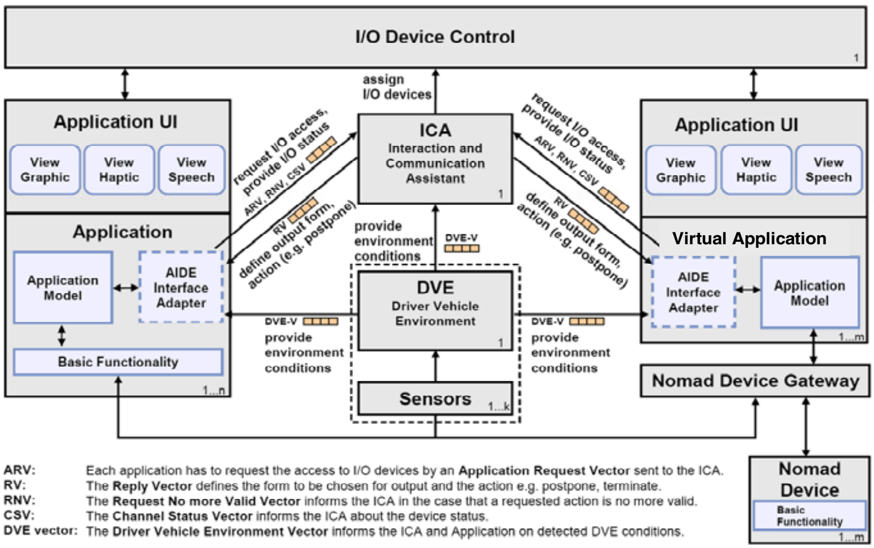

Fig. 2. AIDE Functional Reference Architecture (where UI stands for User Interface)

3.2 Driver – Vehicle – Environment Monitoring Modules

Within the AIDE concept, the perception of the current driving scenario and its impact on the driver is considered to be represented through the following triptych: the Driver-Vehicle-Environment (DVE) state. Towards that end, a set of modules were developed, called “DVE modules”. These modules have been defined with the purpose of computing in real time the set of parameters needed for enabling the AIDE adaptive interface functions according to the AIDE design scenarios descriptions and the relevant criteria for HMI adaptation to certain driving conditions [6].

The DVE modules perceive the driver the vehicle and the environment by the common DVE sensor set in order to give the AIDE system a description regarding the driver’s ability and availability to drive the vehicle. Each module addresses a different dimension of the Driver Vehicle Environment state:

– *The Traffic and Environment Risk Assessment Module (TERA)* which estimates in real time the total level of risk related to traffic and environmental parameters [7], [8].
– *The Driver Characteristic module (DC)* which includes the definition and estimation of the driver typical profiles.

- *The Driver Availability Estimator (DAE)* focusing on the analysis of the primary task activities [9].
- *The Driver State Degradation (DSD)* module which is monitoring the driver's fatigue and hypo-vigilance [10].
- *The Cockpit Activity Assessment (CAA)* module is considering the availability effects of a secondary task [11], [12], [13], [14].

Real-time monitoring of the driver the vehicle and the environment is considered essential in order to assess a multi-dimension DVE state. This includes obtaining real-time information on the traffic environment, the driver state and activity and the driver characteristics and preferences. Following that consideration, the proposed system provides a rich DVE state vector [15], featuring a large number of DVE state parameters, which allows for a flexible and transparent process of defining adaptive HMI function.

3.3 Interaction and Communication Assistant - ICA

The ICA is the central intelligence of the AIDE system, as it is the responsible for controlling -according to drive safety criteria - the information flow between the driver and the vehicle [16]. The aim of the ICA is to coordinate the overall in-vehicle information flow and manage visual, auditory and haptic channels, like displays, audio devices, and others, that are shared among various services.

The ICA is a centralized decision management unit that decouples the services from the channel [17], [18]. In this view, services become generic applications with which the user can interact through I/O channels that can be shared among applications. The ICA decisions are taken keeping into account the DVE values, considering parameters about the real time status of the driver, the vehicle and the surrounding environment.

The computational logic of the ICA consists in a 4 stage processing of each request; Priority Management (PM), Filtering (F), Modality Selection (MS) and Channel Selection (CS). Every processing module implements a rule-based logic. Rule templates are different from module to module, according to its specific target. The rules parameters' involve the requested action's ARV data, the DVE values, and the status of the controlled channels.

The PM module computes the priority of the received action request. The F module accomplishes the action prioritisation and scheduling; it includes the rules to enable or postpone the presentation of the incoming actions, according to the current driving scenario. Blocked requests are addressed to the Waiting list. Successful requests, instead, proceed to the MS module, that defines the most suited modality in which the message should be provided to the driver. The last processing step involves the choice of the output channel by the CS module. The architecture supports pre-emption. In case of conflicting channel requests, a high-priority request pre-empts the low-priority ones, that are inserted in the Suspended list.

The ICA is a generic system that is not tied to a particular car or HMI implementation. So, it can be used to control a variety of HMI configurations. A specific car model's features have to be specified as configuration parameters when the system is instantiated for that car. Configuration parameters include (1) the description of the

HMI, which is abstracted as a set of, possibly correlated, I/O channels, and (2) the whole set of rules for all the processing steps.

In order to be controllable by the ICA, the applications have to include an additional layer, which is responsible for managing the communication with the ICA (ARV, CSV) and interpreting the ICA responses (RV).

4 Demonstrators

In order to prove the feasibility of the AIDE system, and in order to provide a platform for its evaluation and demonstration, the developed AIDE system components were integrated into three demonstrator vehicles from different market and customer segments:

1. A luxury car (Fiat Croma).
2. A city car (SEAT Leon).
3. A heavy truck (Volvo FH12).

The three demonstrators have implemented the entire AIDE system including I/O devices, Nomadic device gateway, Driver Vehicle Environment (DVE) monitoring modules and the Interaction and Communication Assistant (ICA), which constitutes the central HMI coordination module. Existing in-vehicle functions as well as some additional functions have been integrated in the AIDE system solution, such as Curve Overspeed Warning, Forward Collision Warning, Lane Keeping Support etc. The systems integrated in the three demonstrator vehicles included a wide range of active safety functions, information and communication functions, entertainment functions, as well as standard vehicle information functions.

All three demonstrators used a TELENOSTRA Haptic Barrel Key (HBK) multifunctional input device and a Nuance speech input system, but besides this HMI strategy and implementation varied. The system integration task besides proving the implementability of the AIDE system it provided a test platform both for technical purposes and for evaluation of the potential benefits of the AIDE system. After being technically verified, the demonstrators and therefore the AIDE system were evaluated in terms of safety, usability and comfort and thereby some of the major final conclusions of the AIDE project were drawn.

We may note that the demonstrator vehicles successfully integrate a large number of HMI components, of which more than ten are completely or to a substantial level developed within the project itself The demonstrator setups reflect the level of complexity of HMI implementations in modern vehicles, with the added dimension of also implementing AIDE type adaptivity and integration features.

Therefore, the AIDE system solution and logical architecture provide a means of implementing the AIDE envisioned HMI concepts in a flexible manner, allowing brand/vehicle specific design choices, and that it does so without adding unacceptable extra overhead in terms of timing or bus loads. Therefore it could be said that AIDE provides a common standardized platform for development. Manufacturers could build on this, whereas standardisation would allow for smaller players to develop products that work and could be integrated with the system

Regarding the extent to which users accept the AIDE HMI of the demonstrators, and the extent to which it may improve safety, the on-road evaluations indicate that a number of further improvements would be valuable; however the overall evaluation results indicate positive response to the proposed in-vehicle HMI concept, for an integrated and adaptive driver-vehicle interface, that enhances safety.

5 Conclusion

The AIDE project integrated, for the first time in Europe, major efforts on in-vehicle HMI development in a single multidisciplinary project. The results presented in this paper constitute important steps towards a future integrated and adaptive automotive HMI, both from a technical and human factors point of view. The AIDE concept has been demonstrated and validated via on-road tests in three prototype vehicles.

The design principles are chosen such that ordinary components like applications or I/O devices do not have to be changed principally but only extended by encapsulated specific functionalities. Generalized interfaces have been proposed, implemented and verified, especially between ICA and applications. This allows to easily changing and upgrading the set of rules implemented in the ICA and representing the HMI strategies, because this change only implies storing different data in the ICA's database and no other components have to be touched.

The proposed in-vehicle integrated and adapted HMI comprises a central intelligence controlling the interaction between driver and system, specifically integrated IVIS and ADAS applications and the availability of knowledge about the driver status, the driving situation and driver preferences. This functionality and knowledge is used to manage the driver-vehicle interaction in order to increase driving safety and comfort. The system provides a flexible and modular architecture which is able to match to arbitrary implementations. Thus, it could be the basis for a future standardisation work.

Summarising, one could note that the main effects of the AIDE system, are the management of the in-vehicle functional growth, by an improved in-vehicle HMI, causing less workload and distraction and therefore leading to a safer driver behaviour, while providing increased comfort and therefore user acceptance with reduced development cost and time.

Building on AIDE results, further research on function/HMI individualization, development of I/O devices (e.g. natural speech) and intuitiveness is needed. In addition, next generation of nomadic device integration visions, should address seamlessness scenarios. Finally, one could mention that driver instruction and training methods should be further improved for maximisation of e.g. safety system benefits.

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Lessons Learned Regarding Simulator Sickness in Older Adult Drivers

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Abstract. The present paper examines simulator adaptation syndrome (SAS) as a barrier to simulator use for older adults. A brief description of the phenomenon is provided and its history discussed. There are generally three domains in which to make changes to alleviate the problem. Changes to the simulator, the scenarios, and the participants are viable avenues to reducing the effects of SAS. The experiences of the author's attempts to deal with high attrition rates among older adults in research and in a driving evaluation scenario are described and successful strategies are presented.

Keywords: Aging, Driving, Simulation.

1 Introduction

The number of U.S. licensed drivers who are over the age of 65 rose by about 6 million between 1998 and 2008. This trend is expected to continue as drivers in the "baby boomer" generation reach retirement age. One of the difficulties of this rapid increase in age is that the associated cognitive declines [1-8] may affect driving performance. Initially, researchers feared that the confluence of the increase in the population of older drivers and age-related cognitive declines could lead to an increase in traffic-related deaths and injuries. This led to an increase in research on driving performance of older adults. Although some recent research suggests that reduced driving abilities in older adults may not be as great a problem as originally feared [9], researchers have found it incumbent upon themselves to determine the severity of the effects of age-related decreases in cognitive abilities on driving performance.

In recent years, driving simulators have become more and more prevalent in driving research. Increased in simulator fidelity, as a consequence of advancing computing technology, has played a significant role in the rise of simulator use. These technologies are particularly useful for driving evaluations. For instance, in on-road evaluations traffic density differs greatly by time of day, even over the same route, making it nearly impossible to obtain a consistent evaluation across clients. Further, it is both unethical and dangerous to lead clients into dangerous traffic situations in order to test reaction times. Finally, if a person's driving ability is in question, it may be difficult to conduct an on-road driving evaluation and maintain safety requirements.

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1.1 Motion Sickness and Simulator Sickness

Money [10] described motion sickness as a condition brought on by exposure to motion stimuli and most frequently characterized by the experience of pallor, cold sweating, nausea and vomiting. Benson [11] noted that motion sickness is an all-inclusive term which subsumes sicknesses named for the respective environments or vehicles which provoke it (e.g., carsickness, seasickness). Simulator sickness, or simulator adaptation syndrome (SAS) as it will be referred to here, is a type of motion sickness in which the absence of motion leads to motion sickness symptoms. SAS is an unfortunate side effect of using simulators with less than full motion capabilities. As is commonly noted in the literature, SAS was first written about by Havron and Butler in 1957 [12] with a military helicopter simulator.

Much of the early research on simulator sickness used military flight simulators, because other types of simulators were not in use until relatively recently. Indeed, much of our understanding of how to avoid simulator sickness comes from studies in flight simulators. Reducing lag times between motion cues and visual cues [13], limiting field of view [14], reducing the visual complexity of the simulation [13] and increasing the frame rate of the display are all effective techniques to reduce SAS. However, some methods can severely limit the utility of the simulator. For instance, in a driving simulator reducing the forward field of view from 150º to only 50º can eliminate views of the left and right approaches to an intersection. Reducing visual complexity by eliminating scenery items or ambient traffic may limit the ecological validity of the simulation.

A 1985 review by Kennedy and Frank [15], citing Benson, noted that motion sickness effects decreased with age, all but disappearing after the age of 50 years-old. Benson noted that the age-related decrease in susceptibility to motion sickness might be due to long-term adaptation. That is, older adults have had more exposure to riding in moving vehicles and this exposure may be responsible for their reduced susceptibility. However, recent work suggests that older adults (over the age of 65 years) may be *more* susceptible to SAS than younger adults [16]. Indeed, the authors have noted considerable attrition among older participants in several studies which indicate that SAS presents a significant problem for driving simulation.

For example, while working on a simulator research project in graduate school, the first author and his colleagues pilot-tested a collision-avoidance scenario on a post-doctoral fellow who experienced severe nausea and was subsequently nauseated for half a day recovering. This occurred in spite of the fact that he reported no prior experience with motion sickness of any kind. Any measure that can be taken to reduce these symptoms should be taken, particularly with clients seeking driving evaluation.

2 Remedies

Having outlined the issues and problems involved in utilizing simulators, we now turn to ways to avoid this problem. There are at least three general means to this process: changes to the simulator, changes to the scenarios, and changes to the participant/client. Each approach is discussed briefly.

2.1 Changes to the Simulator

First, we will discuss changes to the simulator. The simulator itself can induce sickness due to a disconnection between the real world and the virtual world. That is, a difference between the visual motion cues (virtual world) and the absence of vestibular motion cues (real world). One issue with the images of most low-cost simulators is that they are displayed by standard projectors or flat-screen displays. While they do provide high-resolution images, the displays are usually only veridical from a specific viewpoint. For instance, in a simulator that uses a built-up cab (BUC) with a passenger seat, conducting research with a passenger in the vehicle can be difficult. Anecdotal evidence suggests that the non-veridical view of the scene from the passenger's seat can increase the likelihood of simulator sickness in the passenger. Similarly, differences in the driver's head position while conducting some secondary task could produce simulator sickness effects (although to a lesser extent than in the first example). This problem can be alleviated by the use of collimation. Collimated light is light whose rays are nearly parallel to one another and therefore spread minimally over distance. Indeed, many high-end simulators, particularly full-flight simulators used in aviation, use collimated optics. Because the light in the image is composed of parallel rays, the image appears "correct" to a viewer in any position, thus solving this particular problem. However, the use of collimation in a simulator significantly increases the cost and the space requirements. A large collimating mirror is generally required and must be positioned such that it encompasses the entire visual field at sufficient distance from the viewpoint. The added cost and space of collimation are barriers to implementation and most commercially available driving simulators do not include this as an option.

On the other hand, many simulators do offer some degree of motion platform to provide the missing vestibular motion cues to go with the visual motion cues. Perhaps the most visible example of this is the National Advanced Driving Simulator (NADS) in Iowa City, Iowa. The motion platform in use at NADS boasts a 13-degree of freedom motion platform which moves about a 64x64 foot bay to provide true acceleration cues [17]. Researchers using the NADS have reported a 2% simulator sickness rate [18], which is a significant improvement over the 50% or so rate of attrition encountered in some cases by the present authors. However, it is clear that even with such an advanced simulator, the problems of motion sickness are not completely eliminated.

While collimation and motion platforms can do a very good job at reducing simulator sickness, for the most part these are expensive options. Further, as we have seen they do not guarantee success. It is probably fair to say that most research and clinical facilities do not have the funds to purchase and operate simulators of the size and complexity of the NADS. Luckily, there are still a number of approaches involving scenario design and participant interactions which can be taken to minimize the problem.

Another potential change which seems to help anecdotally is adding cooling fans or air conditioning vents to the cab. One of the main symptoms of SAS is elevated temperature and sweating. A cooling fan or room A/C vented into the simulator cab can help participants feel cooler and therefore less symptomatic.

2.2 Changes in Scenario Design

In terms of scenario design, there are several dimensions which one can manipulate to reduce the likelihood of simulator sickness. These dimensions include the duration of the scenario, the visual complexity of the scenario, and the topographical layout of the scenario (i.e., straight roads, curvy roads, 90º turns). In our initial attempt at a driving evaluation scenario, we created a scenario which lasted approximately 25 minutes and took the participant on winding country roads, onto freeways, into residential roads and back onto the freeway. This long, all-inclusive scenario was later dubbed a "monolithic" approach. A considerable number of participants were not able to complete this long drive and dropped out due to simulator sickness. In contrast, our present approach is to have a number of discrete, self-contained scenarios which capture one to three specific driving behaviors in very short scenarios, typically less than five minutes in duration. After each scenario, the simulation is stopped and the participant rests while the experimenter performs the tasks necessary to start the next scenario. This provides for a respite from the conflicting sensory information and for a period of recovery before continuing to the next scenario. We have found this to work well for our application in driving evaluation.

Scenery changes are also a useful approach. When a scenario includes scenery which is plentiful and located close to the roadway as is the case in an urban area, there is a consequent increase in the amount of optic flow information. Optic flow is the pattern of apparent motion of scenery objects as a result of motion of the viewpoint. Increased optic flow has been shown to be related to simulator sickness [19]. This conforms to the predictions of sensory conflict theory [20]. Increased visual cues in the absence of vestibular cues mean more sensory conflict and therefore more sickness. Similarly, faster speeds and turns and/or curves mean more optic flow and can thus produce more symptoms of sickness. Thus, unless the situation specifically calls for it, we avoid urban settings, turns, and scenery close to the roadway. Of course driving evaluation is not complete without turns and highway driving. Because these are necessary components of an evaluation, but known to cause symptoms of simulator sickness, we leave the scenarios of the evaluation that involve urban areas and turning until the end of the protocol. This ordering of scenarios gives the person greater opportunity to adapt to the simulator under conditions least likely to evoke symptoms. When coupled with short scenarios and breaks between them, this ordering has proven to be a useful strategy to minimize SAS.

2.3 Characteristics of the Individual

One potentially useful approach to simulator research with older adults is to develop a pool of older adults who are able to tolerate the simulator. While this is certainly convenient, there are two rather obvious problems with this approach. First, there is sampling bias introduced in a research sample selected by this approach. Second, driving evaluations are performed for paying clients, who expect to be able to have a complete evaluation performed.

Other approaches to reduce SAS may also be employed, such as medication for motion sickness, or even placebo treatments such as the use of wrist-pressure bands. These methods are less than ideal. Asking participants/clients to take medication prior to their experience in the simulator may actually prime them to experience sickness [21]. In addition, there may be issues of liability involved as some motion sickness medications may not be compatible with the an individual's medication regimen. Placebo treatments are only as effective as the user believes them to be and are therefore not a reliable means to reduce SAS. It should be noted that medications that are intended to reduce the effects of motion sickness (e.g., Dramamine) can have undesirable side effects which may skew the results of evaluations or research [22, 23].

In our experience, however, the most effective approach to reducing simulator sickness harkens back to Benson's [11] proposal that long-term adaptation is responsible for lower rates of motion sickness in older adults. We have found that providing exposure to driving in the simulator in short durations and over time reduces simulator sickness in older adults. Results from several studies have shown decreased simulator sickness symptoms with repeated exposure within and between days [24-27]. This reduction in simulator sickness symptoms due to time delay between simulator sessions has been shown to persist up to a month or longer [25]. Howarth and Holder [24] found that simulator sickness symptoms decreased over 10 days of simulator exposure with a session on each day. Teasdale et al. [27] found that older adults' (ages 65 to 84 years) simulator sickness symptoms decreased over subsequent simulator sessions. They found that older adults acclimated to simulation over several sessions. After the fifth session the older adults did not differ from the initial baseline condition on simulator sickness scores. These studies indicate that a time delay and adaptation could be used to attenuate simulator sickness symptoms as measured by a subjective questionnaire.

2.4 Our Driving Center's Approach

Our current approach involves a two-day evaluation protocol with a lag day between them. Each day starts with a brief adaptation scenario which lasts about 15 minutes or so. The participant or client drives a series of drives along straight roads with little to no scenery. The session ends with practicing left and right turns at an intersection. These practices consist of a single turn after which the simulator stops and, depending on performance, may be restarted as many times as necessary for the participant/client to attain a level of proficiency at making turns. Indeed all of the adaptation scenarios are repeated as often as the participant requests. The remainder of the first day is spent doing other testing. On the second day there is about a 1-hour period of testing between the adaptation and the final hour which is spent in the simulator performing the evaluation scenarios.

To date, we have had greater success with this approach in experimentation and have had zero attrition from paying clients. We adopted this procedure before opening the center to paying clients, so there is no means of comparison. Although the clients are essentially self-selected, they are generally not there to be evaluated because they want to be there --- they are there because family members are concerned about their driving. Our approach has also worked with clients who have co morbidity issues such as Parkinson's disease.

In order for an adaptation protocol to be amenable to research and client evaluation schedules, it needs to be well defined and it must lead to the most beneficial outcomes for the given amount of time. This means that it is necessary to define the number of exposures, time between exposures, and persistence of the adaptation in order to maximize SAS attenuation. Fortunately, SAS research conducted with other simulators shows reduced symptoms over multiple exposures sometimes resulting in plateau effects [24, 25]. Still, this research needs to be more precisely identify which SAS adaptation delays are most appropriate for research and evaluation schedules. For instance, if two days of adaptation results in significant reductions in SAS symptoms and attrition but subsequent days only result in marginal gains it would be more beneficial to use a two-day adaptation. Another obstacle to implementing a SAS adaptation protocol is determining the persistence of adaptation. Hu & Stern [25] found that adaptation could last well over a month. Examining these characteristics of an adaptation protocol would help find the most beneficial way to increase the well-being of research participants and clients.

One source of confusion in determining the likelihood of withdrawal from a simulator study or evaluation is a number of differences in the attrition rate between research participants and evaluation clients. In a research situation, we were able to find an age-related trend in attrition (Domeyer, Cassavaugh, & Backs, in preparation) but with evaluation clients we have not experienced any withdrawal. This result corresponds to accounts from other researchers who do work with driving simulators and may be attributed to several factors. First, there are differences in the motivation to complete between research participants and evaluation clients. Clients have more at stake considering that, many times, the evaluation is used by a physician to determine driving fitness, whereas research participants are paid by the hour for their participation. Second, participants may base their choice of withdrawal on something besides the primary indicators of symptoms. Alternative symptoms, such as fatigue, may play a greater role in a participant's reaction to the simulator. Unfortunately, these factors make it difficult to determine whether a reduction in SAS symptoms will reduce attrition in research. Indeed, the goal of much of the research into SAS should be to reduce the symptoms and consequently the withdrawal rate regardless of the status of the individual as a participant in research or an evaluation client.

3 Conclusions

It seems clear to us that the protocol at our facility using habituation in the form of relatively short adaptation scenarios performed over two days is a highly effective way to ensure that older adults have access to simulation facilities. In conjunction with changes to the scenarios discussed above, this protocol seems to provide the greatest effect on reducing SAS at the lowest cost. Increased access to simulator-based driving evaluation and simulator-based driving research will help older adults maintain driving independence longer and to be safer while doing so.

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Design of Human Computer Interfaces for Highly Automated Vehicles in the EU-Project HAVEit

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Abstract. As vehicle and computer technology are more and more merging, new forms of assistance and automation in vehicles open up the potential to increasing safety and improving comfort. In HAVEit, an EU-FP7 Integrating Project, car and truck manufacturers, suppliers and research organizations explore highly automated driving applications, where the automation can take over substantial parts of the driving task, but where the driver is still in the loop. The interaction between the human and such an automation becomes a crucial part for a successful, dynamic balance between human and machine. Starting with design explorations, generic interaction and display schemes for highly automated driving were derived, implemented, tested in assessments and experiments, and finally applied to the demonstrator vehicles of HAVEit.

Keywords: Human machine interaction, human computer interaction, automation, assistance systems, interaction schemes, pattern, display design.

1 The Challenges: Design of HMI and Vehicle Automation at the Beginning of the 21st Century

In general, one of the big differences between humans and other life forms on planet Earth is that humans are inventing and using artefacts and machines. Some of these machines are used as an extension of the human body, e.g. in the form of vehicles. Other machines are more extensions of the human senses and brain, e.g. in the form of computers (see. e.g. [11]). The decades from the end of the 20th century into the 21st century brought a tremendously increasing computer power and connectivity. Moreover, computers gained more autonomy e.g. in the form of robots. Starting with aviation, computer and vehicle technology are more and more merging into vehicle assistance and automation technology.

Computer and vehicle technology open up a design space that is only partially compatible with the human (e.g. [8], [15]), leaving a non-trivial task to Human Computer Interaction to bridge the gap between humans and computer. Especially with

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growing complexity, the outer compatibility of the interface between technology and the human, but also the inner compatibility between humans and machines e.g. regarding common goals and mental models become crucial factors.

Applied to vehicle automation, the challenge is to use a higher connectivity with more available information, and the increasing capability of computers together with a driving task that is already quite demanding for humans. How can computers help without making things worse? While assistance systems support the driver in the driving task by information and warnings (e.g. parking assistance, lane departure warnings), automation takes over one or more parts of the driving task. One example for such automation is the Adaptive Cruise Control (ACC); an automation that controls a set speed and the distance to a vehicle in front automatically. Figure 1 shows a simplified distribution of control between the human and the computer, split up between longitudinal and the lateral axes of vehicle control.

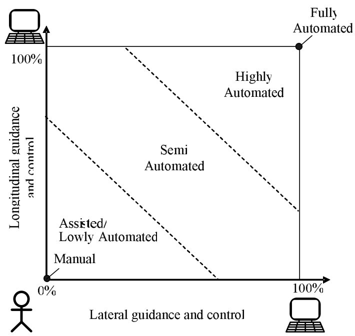

Fig. 1. Distribution of control between human and computer on longitudinal and lateral guidance and control

When the driver does most of the driving task, with contributions from the technical system, this can be defined as assisted driving. In case the driver activates a technical system that automates only one of two axes, e.g. an ACC system or a LKS system (Lane System) this can be defined as semi automated driving. A highly automated vehicle is a vehicle that allows assistance and automation up to highly automated or fully automated driving, but that is usually operated up to highly automated driving. In highly automated driving, the automation does a majority of the driving task both on the longitudinal and lateral axes, but compared to fully automated driving the driver is not only a passenger, but still actively involved in the driving task [4]. Highly automated vehicles and concepts originated in aviation, where highly automated aircrafts are flying for decades with a high safety record. Highly automated cars and trucks are under research and development in a couple of projects, e.g. HAVEit (e.g. [7]), H-Mode (e.g. [10]), EASY ([13]) or IMOST ([22]).

Highly automated vehicles create special challenges for the design of the Human-Machine-Interface to allow safe transition between different levels of automation, to avoid potential mode confusion and to bring the driver back into the loop if necessary.

2 The Process: Design and Evaluation Methodology

2.1 General Aspects of a Design and Evaluation Methodology

In general, the most fundamental mechanism in the design and development of machines are 1.) Enablement by e.g. societal circumstances, like an open discussion culture or an economic stability, 2.) Push by scientific and technological progress, and 3.) Pull by demands of e.g. market and society. This interplay between shaping forces is constantly changing: In the second half of the 20th century a potential imbalance towards a focus on technology led to movements like user-centred system design (e.g. [15]) and to valuable methods focused on the user or the use of a product. A synthesis between technology centred and human centred perspectives and beyond can be found in the general idea of a (dynamic) balance of dichotomic factors like human and technology, critical and constructive approaches, quantitative and qualitative methods etc. (see e.g. [14], foreword of [15], [5]).

Design and development especially of new artefacts and machines is often an exploration and discovery process. To mitigate the risk of unsuccessful developments, an iterative approach of designing, implementing and testing can be used, starting with simple, generic ideas, working this into more concrete concepts and increasingly complex prototypes that can then, based on studies in increasingly realistic environments, be iteratively refined (see Figure 2).

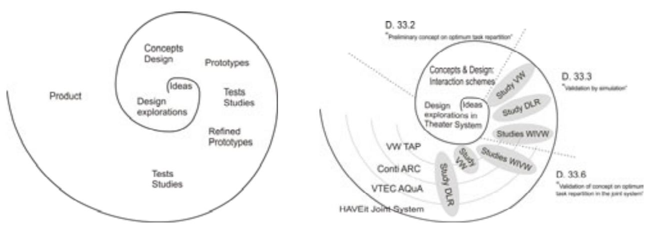

Fig. 2. Iterative development process. Left: generic approach; Right: applied to HAVEit

2.2 Application: Design Process for Highly Automated Vehicles in HAVEit

The EU-IP (Integrating Project) HAVEit (Highly Automated Vehicles for Intelligent Transport, 18 partners led by Continental, 27 Mio € project budget, 2008 – 2011) was enabled by the process of European unification after World War II, that led to an increasingly integrated European research, including EU-projects on vehicle assistance and automation like Prometheus, Prevent, SPARC, HAVEit or InteractIVe. The technological push for HAVEit came from increasing sensor, computer and actuator capabilities that enable automated driving but leaves the option, and in many use cases also the necessity, to have a human operator still in the control loop. Further pushes came from base research like H-Mode (e.g. [10]) and Conduct-by-wire [25] or SPARC [9]. The societal pull came from the need for safe, economic and efficient transportation. HAVEit is a lot about architecture and technology (which is not in the focus of this paper), in a constructive interplay with human factors and design of human-system interaction (see Figure 2 for the iterative development process).

One of the challenges and chances of HAVEit was the diversity of industry and academia partners, who all brought their own ideas and mental pictures what highly automated driving could be. The design process in HAVEit started with conjoint exploration and design sessions of the partners to find out which mental picture the partners have for their demonstrator vehicles. With the help of the theatre-system technique ([6], [19]) the partners showed and discussed which assistance and automation functions and which preliminary interaction design and interaction elements (e.g. visual display, haptic information, switching devices) should be in the vehicles.. A major challenge of HAVEit was to align the different ideas for the demonstrators while leaving enough freedom for a manufacturer specific design.

Based on this structured discussion, generic interaction schemes were extracted and documented that built the starting point for an individual interaction design for each demonstrator vehicle. These interaction designs were used for building up the software prototypes for the demonstrators that were tested in several human factor studies in driving simulators and in a test vehicle. Based on the results of the studies the design was further discussed in workshops, aligned and improved up to the final design of the demonstrators. The design, development and test process of HAVEit is further documented in the HAVEit deliverables ([2], [3] or [20]).

3 The Product: HMI for Highly Automated Vehicles

3.1 Generic Design for the HAVEit Human Machine Interface

For the alignment of the design, generic interaction schemes for the HAVEit demonstrators were defined. The most fundamental scheme covers the grouping of the different assistance and automation functions: To keep the mental model of the user about the assistance and automation as complex as necessary but as simple as possible, all assistance and automation functions were grouped on a one-dimensional scale. There are *discrete levels of automation* which can be distinguished from each other (see Figure 3).

Fig. 3. One dimensional scale of assistance and interaction (based on [5])

This scale has to be visible on the display either in a horizontal or vertical orientation and should follow one of the logical schemes “Up means more automation” or “To the right means more automation”. For intuitive transitions the configuration of the switching device should be compatible to the orientation of the scale on the display.

Another interaction scheme *"interlocked transitions"* was about the transitions of control in a way that mitigates mode confusion and ensures safe driving. "Interlocked" means that there should always be an explicit feedback for successful or refused transitions and a check for drivers' activity when a transition from highly automated driving to lower automation levels is requested. Transitions where the automation just drops control without assuring that the driver has control again should be avoided as far as possible.

For the visual feedback to the driver three *display elements* for the instrument cluster were defined (see Figure 4). These were the *Automation Monitor* containing information about the current automation level and its functionality, the *Automation Scale* indicating the current automation level and available automation levels and a *Message Field* for text messages and warnings.

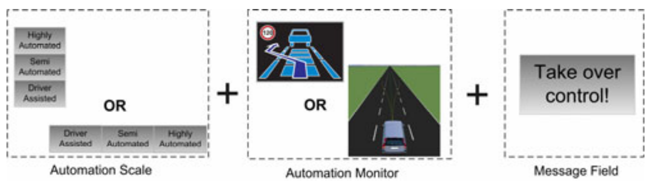

Fig. 4. The three generic display elements for the HAVEit demonstrators

3.2 Detail Example for Generic Design: Interaction for Mode Transitions

In the HAVEit demonstrators the driver can select higher or lower levels of automation by using buttons or a lever. In addition, drivers input like braking, accelerating or strong steering can lead to a transition to lower levels of automation. Following *the interlocked transition scheme* there is always an explicit feedback to the driver about successful or refused transitions. The *Automation Scale* and the Automation Monitor indicate the current automation level visually so that a change of these display elements show a change in the automation level. If the driver choose a higher level of automation which is not available (refused transition) a text message and a sound are given to assure that the driver recognizes that the automation has not taken over control as intended. For take-over requests of the automation an explicit take-over procedure was designed. The take-over request starts with an acoustic and visual warning that escalates if the driver does not take over control (see Figure 5). As the HAVEit demonstrators allow hands-off driving in the level Highly Automated a hands-on sensor on the steering wheel is used as an indicator of take-over of control by the driver. It is also conceivable to use other measures like drivers' attention allocation or steering input. If the driver does not take over control despite of the escalating warning the vehicle will go to a Minimum Risk Manoeuvre. This could be for example a stopping manoeuvre or any other manoeuvre that brings the vehicle to a state of minimum danger. A more comprehensive introduction into the HAVEit interaction schemes can be found in [3].

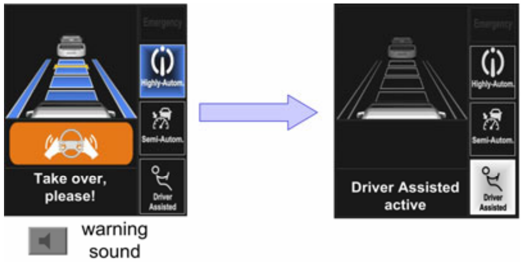

Fig. 5. Interaction design for a transition from Highly Automated to Driver Assisted

3.3 Detail Example of Generic HMI: Interaction Based on Driver State Assessment

In case of an inattentive driver (drowsy or distracted) the HAVEit system has to assure that everything is done to bring him/her back into the loop. The identification of driver inattention is based on the outputs of the so called Driver State Assessment (DSA) component which is able to detect different levels of drowsiness and distraction online by means of direct (camera-based) and indirect (driving performance based) measures (for further information see e.g. [18]).

The general interaction strategy for these use cases is a stepwise escalation of the situation (Figure 6) starting at first with a less urgent information message to either take a break (in case of drowsiness) or to attend to the road (in case of distraction), followed by a. more urgent warning that leads to a take-over request from Highly Automated to Driver Assisted if the driver does not react. If the driver does also not react to that take-over request the so-called Minimum Risk State is triggered (e.g. to bring the vehicle to a safe stop).

Both the algorithms for the driver state assessment as well as the interaction strategies were validated by several simulator studies in the WIVW driving simulator.

Fig. 6. Test driver detected as drowsy by the Driver State Assessment DSA (left); drowsiness warning message via the HMI (right)

3.4 Applied HMI: Automated Assistance in Roadworks and Congestion (ARC) of Continental

The HAVEit ARC demonstrator of Continental uses the generic HMI concept to provide a sophisticated number of functions in an ambitious environment. The demonstrator shows how the driver can be supported in uncomfortable situations like roadworks and congestions. The ARC-system is based on existing serial production radar and vision sensors, mounted and directed to detect the front, rear and side of the car. Based on their signals, an extended fusion approach [1] delivers a consistent grid description of the environment to the different subsystems. Several new functions are necessary for the realization of comprehensive support. Additionally, existing assistance functions are enhanced for the usage in roadwork areas. For example ‘Lane Departure Warning’ (LDW) and ‘Heading Control’ (HC) are not applicable to inform the driver about low distances to guide walls or other vehicles. The counter torque in the steering system has to be higher and superposed as long as the situation is critical. Therefore an algorithm called ‘Virtual Wall’ (vWall) has been developed at Continental. It provides a loose guidance in the center of the lane and a high counter torque close to the guide walls.

With LDW, HC, vWall and ‘Lane Centering Assistance’ four lateral control modes are available. With ‘Full Speed Range ACC’, ‘Forward Collision Warning’ and ‘Emergency Brake Assistance’ 12 different control modes are possible. To increase the usability for the driver, the assistance and automation scale described in chapter 3 is used. The automation modes are broadcasted on the bus systems, displayed in the cluster instrument and on an additional touch screen. The driver can switch the mode via touch screen and ACC stroke.

Fig. 7. HAVEit Display in the instrument cluster (left) and on an additional touch screen (middle) and accelerator pedal for haptic feedback in the HAVEit ARC demonstrator

Due to the narrow situations, the speed for the ‘Highly-Automated Mode’ is limited to the speed allowed in the roadwork area. It is not possible to activate the system at higher speeds. If the driver tries to accelerate over this speed limit, he gets a counter force in the accelerator pedal and a warning. If the driver ignores this, a transition is started to ‘Semi-Automated’.

3.5 Applied HMI: Automatic Queue Assistance (AQuA) of VTEC

One application within the HAVEit project is the AQuA system. AQuA is a highly automated system designed to driving a truck in congested situations (traffic queues). AQuA has an automation strategy structured into three levels. First level is regular manual driving; the driver is in full control of the vehicle. The second is a semi automated state of ACC; the longitudinal control is taken over by the AQuA -system and the third and highly automated state of AQuA; both the longitudinal and lateral control of the vehicle is taken over by the AQuA-system, with the driver in the role of a supervisor. All three levels are grouped in an assistance and automation scale that is also part of the display (Figure 8).

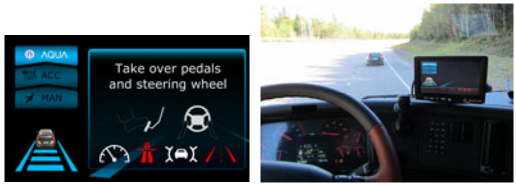

Fig. 8. HAVEit AQuA display and implementation in a Volvo truck

The automation monitor (lower left part of the display) illustrates the amount of assistance and automation that the driver receives in the different levels. Lane markings indicate lateral support and the horizontal markings indicate longitudinal support. A vehicle symbol indicates that a target vehicle is present. The time gap for ACC is set by changing the number of longitudinal markings using arrows on the steering wheel. When setting the time gap, the position and size of the car changes, e.g. small car gives large time gap and larger car gives smaller time gap.

To activate AQuA, four preconditions (a max. speed of 30 km/h, on highway, clear target vehicle and lane markings) need to be fulfilled. The preconditions are represented as four icons, giving the driver information of their fulfilment as well as guidance and instructions of how to act when handing or taking over control.

3.6 Applied HMI: Temporary Auto Pilot (TAP) of VW

The Temporary Auto Pilot (TAP) is a passenger car application which supports the driver on motorways and similar roads with different levels of automation in longitudinal and lateral control of the vehicle at speeds between 0 and 130 km/h. In the highly automated level, steering, accelerating and braking is almost completely managed by the TAP. Lower levels of automation include other assistance systems like ACC and/or Heading Control. The highly automated level will be offered to the driver only if certain pre-conditions are fulfilled, e.g. the vehicle is driving on a motorway with less than 130 km/h. Therefore the driver has to be always aware of what he is responsible for and which level of automation is active. There is also a need for knowledge about pre-conditions for activation and deactivation.

The HMI of the HAVEit-TAP was derived in a balanced design process including the generic design schemes of HAVEit and VW studies including a wizard-of-oz vehicle ([17], [21]).

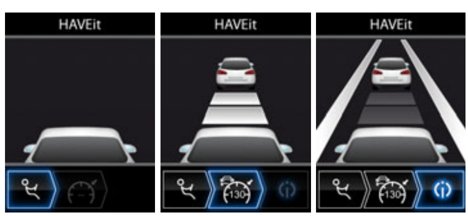

Fig. 9. HMI for the different automation levels of the HAVEit - TAP

Central element is the assistance and automation scale, where three modes "Driver Assisted", "ACC" and "HAVEit TAP" are shown. Availability is shown in grey, activation of an automation mode is shown in blue (Figure 9). The automation monitor shows the ego-vehicle, in ACC mode a distance bar to the next vehicle, and in TAP/Highly Automated mode a combination of distance bars and side rails. Further information on the HMI of the TAP and test results can be found in ([16], [17]).

4 Conclusion and Outlook

Starting point of this paper was the gift of humans to develop machines like vehicles or computers to extend the human body, senses or brain. Vehicle automation as a fusion of vehicle and computer technology, and an extension of body, senses and brain all together comes with high demands on a sufficient inner and outer compatibility between human and computer. In HAVEit a new way of automated driving, highly automated driving, was explored. The human-machine interfacing principles were iteratively developed in a design, implementation and test approach, balancing human and technical factors, and base and applied research questions. Interactions schemes like the assistance and automation scale or interlocked transitions were defined, implemented and tested in simulators and test vehicles, and demonstrated in the vehicles of Continental, Volvo/VTEC, VW and DLR. While the research on the human computer interaction of highly automated driving is continuing, the user acceptance gained in HAVEit is already quite promising.

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Towards User-Centred Development of Integrated Information, Warning, and Intervention Strategies for Multiple ADAS in the EU Project interactIVe

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Abstract. In the increasingly fast strive for new advanced driver assistance systems and a continuously higher automation of the driving task, it is essential not to lose sight of the most important factor: the driver. Therefore, we have to develop interaction strategies that center around the user perspective without loosing sight of the technological availability. Individual design for a certain assistance function must be balanced with the integrated and compatible design of multiple functions in several vehicles. This paper details the iterative interactIVe approach and details how the strategy space was structured to find possible common elements, derive generic interaction strategies universal to several or all systems, and identify the main research questions for the further course of the project.

Keywords: human-machine interaction, balanced design, user-centered design, interaction strategies, highly automated driving, active safety systems

1 Introduction

Today's road vehicles already offer the driver a significant amount of different assistance systems to increase comfort and enhance road safety. Yet the era of advanced driver assistance systems (ADAS) and highly automated driving just seems to be beginning, as available computer power and sensor technology is being further enhanced and the ensuing possibilities are explored for an ever increasing number of new safety and assistance systems and functionalities.

While the technological availability of such systems is a necessary prerequisite to the continued enhancement of road safety and further reduction of accidents and fatality rates, the driver remains the most essential actor also for the foreseeable future: The driver must be able to control the vehicle and understand and accept the assistance and automation offered by the various ADAS. Technical systems and drivers have to be compatible.

Therefore, it is crucial to carefully balance the technical capabilities with the characteristics of the driver. The driver and the driver's interaction with the assistance

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systems must be taken into account from early development stages on, in order to achieve a high compatibility between the technical systems and the driver. Compatibility can be decomposed into outer compatibility, e.g. via a human-machine interface compatible to the human physiology, and equally important inner compatibility between the driver and the technical system, e.g. concerning the structure, such that the driver intuitively understands the offered assistance, [1].

This compatibility issue extends also to the sum of all assistance systems in a vehicle, addressing the need to harmonize and integrate the different functionalities. Even further, compatibility between different vehicles is important, such that the driver is able to easily change from one vehicle to the next without having to relearn every interaction with the vehicle. This can be achieved by standardization and the development of common interaction strategies.

This paper describes the approach in interactIVe towards a user centred development of integrated IWI strategies for all ADAS in the different demonstrators. The paper further details how the strategy space was structured to find possible common elements, derive generic IWI strategies universal to several or all systems, and identify the main research questions for the further course of the project.

2 Interaction Design in the EU Project interactIVe

The EU project *interactIVe – Accident avoidance by active intervention for Intelligent Vehicles* covers a very wide range of functionalities from collision mitigation over accident avoidance by autonomous braking and steering to continuous support by warnings, interventions, and highly automated vehicle guidance. Seven demonstrator vehicles – six passenger cars of different vehicle classes and one truck – will be built up to develop, test, and evaluate the next generation safety systems.

In contrast to other projects in the past, interactIVe places a very high emphasis on the integration of the human-machine interaction (HMI) aspect. One of the seven subprojects (SP3-IWI Strategies) is exclusively dealing with information, warning, and intervention strategies for all systems and demonstrators. This allows the project to integrate the user-centred approach of designing and testing the most beneficial *information, warning, and intervention (IWI) strategies* for the HMI design. These IWI strategies can serve as guidelines or recommendations for the concrete HMI design of the individual demonstrators and cover more than just look-and feel aspects.

The development of the IWI strategies follows an iterative design-prototyping-testing cycle, displayed in Figure 2, to cope efficiently with the high degree of freedom and uncertainty, [2]. Starting with the definition of *use cases* based on target scenarios as detailed in Section 3, initial requirements are derived together with the vertical subprojects. Then an iterative cycle starts, where the developed *IWI strategies,* Section 4, and *IWI requirements*, Section 5, are iteratively tested and updated. For interactIVe three iterations are planned to balance convergence of the iterative process with the available time and resources. The final set of IWI strategies is complemented by a set of final requirements and specifications.

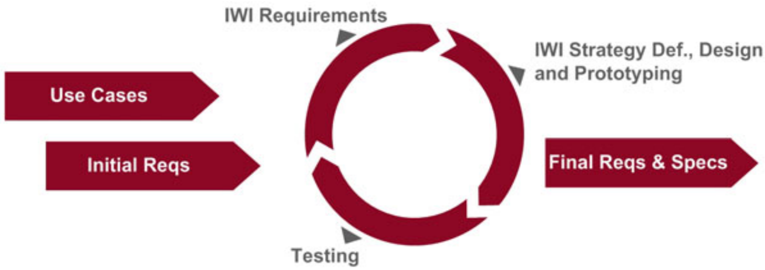

Fig. 1. Development process as iterative design-prototyping-testing cycle

This iterative design process focuses on the future user and involves both technical and human factors experts also from the other subprojects to ensure applicable solutions for the different demonstrators.

3 Use Cases

Based on existing work in [3, 4], a general methodology was developed to define use cases based on the actual problems to be solved, that is, accidents or other undesired outcomes such as traffic rule violations. These problems were defined as *target scenarios*. Since accident prevention is the main focus of InteractIVe, the focus lies on accident-related target scenarios (although the general methodology is equally applicable to other undesired outcomes). The first step was thus to define these problems in terms of the target scenarios addressed by interactive.

Target scenarios were defined on two levels. At Level 1, prototype accident scenarios were described in general terms, along with statistical data such as frequency, severity and typical contributing factors. By contrast, Level 2 scenarios provided further detail on kinematic conditions and causation factors. All target scenarios for passenger vehicles were based on data from the German GIDAS in-depth accident database, while target scenarios for trucks were based on the ETAC database [5]. At Level 1, the target scenarios were described based on simple pictograms illustrating the accident type, a general narrative (a short "story" describing a typical flow of events together with general statistics on the frequency and injury levels associated with the accident type. At Level 2, three complementary representations were used: (1) A narrative, (2) a sketch and (3) a sequence diagram. The narrative was a short story describing the general diagram, while the sketch provided a birds-eye view on the scenario configuration and how it developed. Finally, the sequence diagram defined the sequence of interactions between the involved actors (e.g. drivers and infrastructure elements) over time.

The use cases then defined *how* the problem stated in the target scenarios should be solved. That is, how an assistance or automation function is intended to prevent or mitigate the accidents in interaction with the user (e.g. function x prevents rear end collisions by informing or warning the driver or by intervening by doing y). Use case descriptions were directly based on Level 2 target scenarios and used the same representations (narrative, sketch and sequence diagram).

The definition of use cases was aided by the use of a *theatre system technique* where a human confederate emulated different potential ways to address the target scenarios in simulated driving (see Figure 3). In particular, the theatre system was used in a *use case workshop* where IWI- and demonstrator developers together could discuss different IWI concepts based on the emulated scenarios. A general user needs survey was also carried out as input to the use case definition.

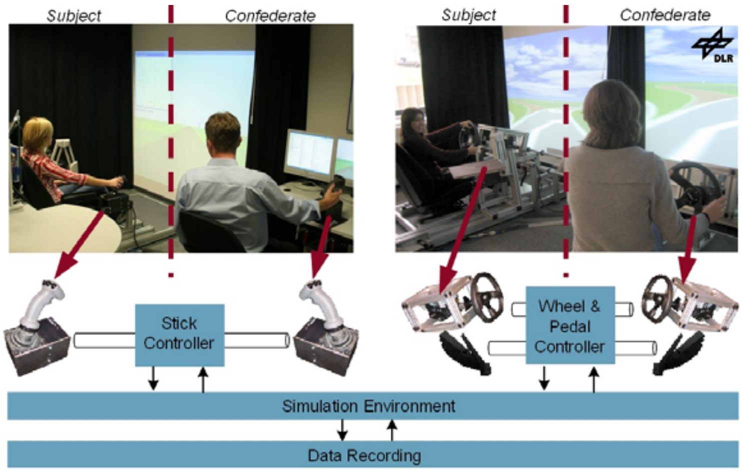

Fig. 2. Theatre system (Schieben et al., 2009)

The following provides an example of a use case narrative for a Rear-end Collision Avoidance (RECA) function addressing a related target scenario:

"*The host vehicle (HV) is driving behind a lead vehicle (LV) in a rural area at a speed v of about 50 kph at a time headway (thw) of about 2 s. Both vehicles are lightweight cars. The HV driver briefly looks towards an in-vehicle display. During the off-road glance, the LV brakes sharply to stop with deceleration a<-2 m/s*^{2} *due to a traffic queue ahead. The RECA function detects the LV closing and issues a warning to the driver. If the RECAS determines that automatic braking alone will not be sufficient to prevent the crash and there is a sufficiently wide shoulder to the right, the system performs an automatic steering manoeuvre towards the shoulder. When stopped, the hazard lights of the HV are turned on.*"

Once defined, the use cases were categorised in terms of a taxonomy of unintended outcomes. The categories include a set of general accident types (e.g. rear-end collisions, head-collisions, lane change collisions etc.), but also non-accident related "problem" categories such as traffic rule violations. In addition, a number of use cases not directly related to target scenarios were included (e.g. related to fuel economy, activating functions, misuse, system limits, etc.). This constituted the use case catalogue that formed the basis for the further definition of initial requirements and the subsequent work on IWI strategies.

4 IWI Strategies

IWI strategies refer to how, when and where driver information, warnings, and interventions should be activated and represent a set of guidelines, recommendations, or options for the targeted demonstrator vehicles to achieve the goals of a compatibility and user centred design. The definition of IWI strategies is based on initial requirements that stem from the use cases, technical limitations and especially user inputs. Input from potential users is acquired by the means of a user needs analysis, and a user expectation assessment to involve the future user in the design process, [6]. As described in the iterative design-prototyping-testing cycle, the requirements and strategies are updated based on test results and a close cooperation with the function developing and implementing subprojects

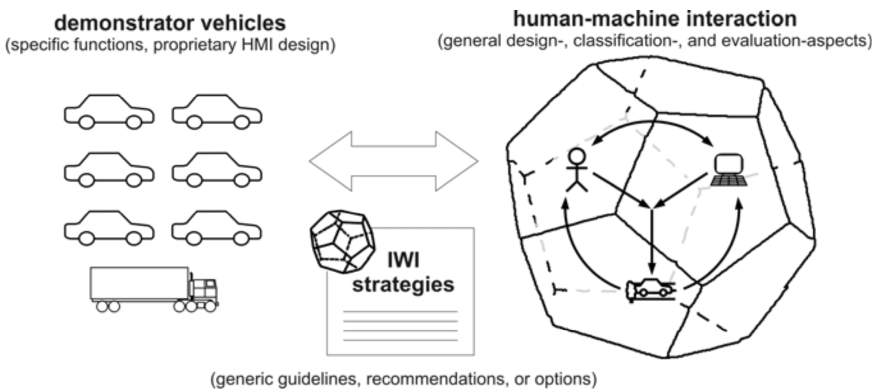

Fig. 3. IWI Strategies for different aspects as facets of the human-machine interaction

Based on the concepts of problem space and design space [7], the concept of *strategy space* was established. First the space of human-machine interaction was structured into a number of *aspects* which represent different dimensions, perspectives, or facets, see Figure 4. These aspects organize the discussions about possible IWI strategies into *strategy aspects* and thereby facilitate the comparison or harmonization of human-machine interactions in the different interactIVe demonstrators, the identification of the important open research questions, and later evaluations of prototypes. The aspects do not have to be neither disjunct nor all on the same level of detail or hierarchically structured. This maintains a great flexibility while still providing the aspired structural backbone.

The development of IWI strategies and its structuring in strategy aspects is performed in interplay between the analysis of possible human-machine interaction for specific demonstrators and assistance functions and their synthesis and generalisation (bottom-up) on the one hand, and a top down approach of formulating meaningful IWI strategies based on the before mentioned inputs and existing knowledge on human-machine interaction e.g. from standards, previous projects, or other scientific literature. In the course of the interactIVe project the IWI strategies are therefore also going to be iterated in interplay with the function-developing subprojects.

The following strategy aspects have been identified so far.

System purpose: Which general goals does the system (technical system and human driver together) have? Towards what end do the assistance functions support the driver?

Layer of Driving Task: On which layer (navigation, guidance, stabilization) of driving task is the driver supported by the technical system?

Level of Assistance and Automation: How much assistance and automation is offered to the driver for which phase in the recognize-act-cycle (perception, response selection, response execution)?

Range of Operation and Availability: What meaningful range(s) of operation should the technical systems and their assistance functions have?

Modes and Mode Transitions: Which modes shall exist for the overall system? Which is the default mode after the ignition cycle? Which transitions are there and who triggers them how?

Communicate System Status: What information about the current system status (mode, availability, dynamic state, failures, detected objects, …) is communicated to the driver and how? What elements could an integrated display design have?

Communication Channel: Which communication channel (e.g. visual, auditory and haptic) is used how by the system to communicate with the driver?

Sequence of Interaction: How does the assistance evolve (in certain situations)?
Arbitration: Which strategies are there concerning the arbitration between driver and automation, when conflicts occur that need to be negotiated and decided?

Adaptivity & Adaptability: When and how does the system adapt itself? When and how can the system be adapted by the driver?

Harmonisation & Prioritisation (Machine-Machine): What strategies are there to harmonise information, warnings, and interventions of several concurrently or subsequently active systems? What strategies are there to prioritise or integrate signals from different systems?

Situation Awareness: How can the situation awareness of the driver be improved?

Driver's mental model of technical subsystem: What strategies are there to help the driver to build a good mental model of the assistance system to foster his system understanding?

Trust: What strategies are there to create the right level of trust and prevent over-, mis-, or undertrust?

Mental workload: How can the mental workload of the driver be optimized?
The following subsections exemplify a few important strategy aspects and detail some of the major issues and open questions that arise there.

4.1 Strategy Aspect Modes and Mode Transitions

This aspect covers the individual *modes* which exist for the different assistance and automation systems, the *transitions* between these modes and the *grouping* of the individual modes of multiple assistance and automation systems into overall system modes. Important discussion points refer to the driver's mode awareness, e.g. [8], which is very important because if he is not aware of the current system mode a mode error [9] or mode confusion can occur, e.g. [10]. Mode awareness is determined by the driver's knowledge and understanding of the system's actual and future status based on the current mode [11]. The understanding of the system is thereby influenced by the driver's mental model of the technical system which develops and is modified through the interaction with the system [12].

In order to ease system interaction and enhance system understanding and mode awareness, a grouping or integration of single subfunctions, subsystems or modes could be beneficial. Furthermore, a transparent, intuitively understandable feedback and communication of the current mode and relevant transitions is crucial – which is a tight link to the strategy aspect Communicate System Status.

One example strategy belonging to this aspect could be: "Functions can be temporarily disabled or muted via a button or other action." An advantage of this strategy is the minimization of annoyance in certain situations. This strategy could still allow a default-activation of the functions. Additionally, with this strategy no alteration of the settings for warnings is absolutely necessary, since they can be temporarily disabled. For emergency intervention functions, such as collision mitigation systems, legal aspects require the possibility to override and/or turn off the function at any time.

4.2 Strategy Aspect Communicate System Status

Not all system states need to be communicated to the driver. For this job an intelligent interaction & information architecture needs to determine which state should be communicated when and in which way.

Typical states of high relevance are system status *on, off, active, warning, intervening, standby, available, unavailable,* and *failure*. It has to be considered in detail, in which way, when and how long these states need to be indicated visually, haptically or acoustically.

Most ADAS systems have a limited operation range, the system function is only *available* e.g. inside a certain speed range. Above or below a specific speed threshold the system function is *unavailable*. One general example strategy could be "Communicate the system status to the driver." Further analysis shows that some states for certain systems are more important for the driver to know than others. Lane Keeping Support systems for example rely on detecting the lane markings and will therefore more often switch between availability and unavailability status depending on the accessibility of lane markings. For these systems it is crucial to indicate the availability status permanently in order to inform the driver when he can expect system support and when not. Therefore, the necessary affordance of the status indication might depend on the probability and consequence of status changes, e.g. "The communication of the system status depends on the status confusion risk."

4.3 Strategy Aspect Communication Channel

The strategy aspect Communication Channel covers what modalities the system should make use of during interaction with the driver (i.e. visual, auditory, haptics) as well as what combinations (e.g. vibrations and visual) that should be used. Additionally, its important to define more exact details in how the specific information/warning and/or intervention is designed with respect to e.g. location of visual output, level of steering wheel torque, tonal or verbal auditory information etc. Well chosen IWI strategies here could mean enhanced perception and interpretation of e.g. a warning and assistance for action selection and implementation as a consequence. Proper information indicating e.g. the location of the dangerous situation could enhance the information process by directing a driver's attention, e.g. [13, 14]. Overall research questions with regards to communication channels would be (i) what specific modality channel to choose for specific use cases, (ii) what characteristics to use for the specific modality channels (e.g. strength of steering wheel torque, type of sound), (iii) what combination of modality channels be present or whether to use a single modality.

4.4 Strategy Aspect Sequence of Interaction

The strategy aspect Sequence of Interaction looks at how the assistance evolves, and when (i.e., depending on changes in the environment, the system capabilities, and the driver behaviour) certain information, warning, or intervention elements are presented. A special focus lies on escalation (and de-escalation) sequences in critical situations as the lateral or longitudinal approach of an obstacle.

ISO 15624 indicates the following types of information as relevant for the driver [15]: a) instruction for action, b) attention, c) explanation of present situation, d) forecast of situation. These types of information support the driver in his different stages of information processing and decision making, see e.g. [16].

Considering the wide variety of addressed assistance and automation functions it could be possible to identify 4 general levels or stages that, as a strategy, can be selected or combined for the implementation of a certain system:

1. Pre-warning stage: prepare the driver to react (himself)
2. Imminent warning stage: urge the driver to act immediately
3. Intervention stage: technical system intervenes to assist driver or take over control of the vehicle in critical situation
4. Explanation stage: present information to explain interventions to driver

5 IWI Requirements

The functional aspects of interaction as described by the IWI strategies must be completed and complemented by non-functional requirements, in order to guarantee that the interaction serves effectively and efficiently the driver-vehicle system in order to accomplish the IWI strategies. A series of actions has been identified in order to come to a relevant and feasible set of requirements.

First of all, each demonstrator identifies the preferential interaction channels and modalities (in interplay with the definition of the IWI strategies), and in quite a few cases devices and components are already identified, typically based on previous experiences in similar applications. For this, the set of candidate solutions has been defined, in particular related to hardware features. This set has been used to define the initial set of requirements, which are guiding an extensive phase of literature analysis, based on existing standards and best practices, state-of-the art of the market, and available results from recent and running collaborative initiatives. Relevant examples include EU Projects such as Prevent and Aide, to quote only a few.

This analysis has produced a first version of the HW requirements, which has been anticipated to the demonstrator teams, to be crossed with the candidate solutions, in order to (i) support the definition of the component characteristics and (ii) pinpoint the areas where further investigation is needed. Existing accessible requirements are available related to several interaction channels (visual, haptic, sound and vocal, manual and vocal input) and corresponding modalities (e.g. text vs. graphics or tonal sounds vs. vocal messages). The requirements will be updated according to the sketched iterative process upon results from simulator studies addressing specific strategy aspects and further information e.g. from the evaluation of certain demonstrators in other subprojects.

Eventually, a final version of the IWI requirements is planned to be valuable also beyond the duration of the project. It is expected that here requirements related to hardware will be complemented by more systemic and configuration related requirements such as e.g. response times, guidelines and criteria related to modality and coding choice, as well as related to the interaction design as a whole, to support general design goals such as to promote adequate situation awareness and the avoidance of errors.

6 Conclusion and Outlook

It was shown how the goal of a user-centred development can be addressed in a large and diverse project such as interactIVe by means of an iterative design-prototyping-testing cycle and the definition of IWI strategies in as structured strategy space around the human-machine interaction.

At the current stage of the project, the elaborated methodology for the definition of appropriate use cases based on target scenarios has been applied. Initial user needs have been described as well as initial requirements. The strategy space has been spanned and successfully structured using the flexible concept of strategy aspects.

Future stages in the project include the described iterations of IWI requirements and strategies by means of extensive testing and continued close collaboration with the function-developing subprojects. Available testing facilities are two static vehicle simulators and 1 truck simulator (all with dynamical traffic and environment simulation), one real cab moving based simulator, and one test vehicle with full drive by wire capability. Overall it is planned to execute 12 experimental studies with more than 200 test persons.

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The Comparison of Different Sensory Outputs on the Driving Overtake Alarm System

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Abstract. Most car accidents are caused by improper driving behaviors. Studies have shown that changing lanes improperly is one of the main causes of traffic accidents. This shows that drivers need an assisting alarm system to help them avoid the danger during overtaking. We also found that the existing alarm system and researches try to use different sensory outputs as the alarm signals. However, there were no studies to compare how the different sensory alarm signals affect the drivers. Therefore, in this study, we have setup three kinds of alarm signals (visual, sound, and haptic alarm signals) to see which one is more suitable at the high speed context. On top of that, the sensitivity of the alarm system may be the other key factor that affects drivers' behaviors. So, we manipulate two most commonly shown alarm signal frequencies when the driver feels threatened. The results of this study have proven that the sound and haptic signals are better than visual outputs when drivers are put in a high visual loading situation. This result could be the guideline for future designers of a driving alarm system.

Keywords: Overtake, Alarm System, Haptic signal.

1 Introduction

With the development of economy, we have more roads and more convenient traffic systems. However, traffic accidents are also increasing. According to the data of Taiwan's Ministry of the Interior that between January and October 2010, the main cause of car accidents is driver negligence (96.07%). The top three causes of driver negligence are drunk driving (20.1%), lack of attention (19.5%), and negligence to traffic rules (13.8%). Furthermore, by the report of Taiwan area Freeway Bureau in 2009, we can see that the first cause of accidents is improper driving, which includes changing lanes improperly and not paying attention to the road, (18.8%). From the information we understand that car accidents usually happen when drivers want to overtake someone. These factors are due to the fact that drivers could not see the situation of the lane that they are transferring to (sometimes they can not see the following car from the side mirror or rear vision mirror). If there were a system to provide driver alarm signals, it might help to prevent accidents. But, what exact

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components should this alarm contain, and how to present the alarm signals when drivers are in situations of high speed and limited attention? Therefore, in this study we would like to summarize the present researches to understand how to observe and evaluate the participants' driving behaviors and problems by reviewing the existing alarm systems, and try to design a new alarm system to decrease the number of accidents by providing the warnings appropriately.

2 Driver's Attention and Alarm System

2.1 Driver's Attention Allocation

Human attention could seem as a multi-resource [1], it means that people could arrange their attention to things that are parallel. But, it may be constraint by the physical world. Such as the deployment of central control system, if the switch or button is not arranged by their operational steps or functions, it would add to driver's loading.

Furthermore, driving is a special activity that requires both dividing and focused attention. The impact factors of attention harmonious could be inference from some basic study. For instance, Patrick and Elias [2] made a dual-task performance as it relates to driving, such as tuning a radio or manipulating a cellular phone, drive on the right side of the road: perceptual asymmetries for judgments of automobile proximity. It forces drivers to divide their attention between the traffic demands and the in-car task. The current study examined how mental navigation (spatial distraction) affected accuracy and response time for depth judgments on vehicular stimuli in each visual field. These were compared to a control condition in which no distraction was present, as well as when a semantic (non-spatial) distraction was present two centered tabs, and so on.

2.2 Relative Issues of Alarm System

Many alarm systems have already been made and studies. Some studies suggested some principles for alarm system design. For example, Nass et al., analyzed the advantages and disadvantages of the existing systems and propose to focus on signal characteristics, frequency, amplitude, older, compatibility [3]. Some research had pointed out that the modalities of input signals would also interference driver's performance. For instance, some studies find out that compared to visual warning signals, auditory and tactile signals are more effective and have less reaction time at drawing cross modal attention for particular positions, such as rear-end collision situation [4] [5]. Furthermore, some papers indicate that tactile signals were better than auditory and visual [6]. Even talking on the cell phone would shorten the tactile reaction time of drivers [7].

Some studies discussed the location of tactile system in depth. For example, tactile warnings delivered by gas pedal [8] or in the driver's safety restraint or seat [9] [10] [11] is also effective to alert the driver. Atsuo Murata et al. [12] both point out that the driver will respond faster when the tactile signals is shown by the foot vibrator than the steering wheel.

As for the direction of tactile warning, Cristy Ho et al. [13] indicated that the response was significantly faster with no spatial prediction of vibrating alert. De Vries et al. [14] also showed that the correct rate is not consistent with directional alarm.

From the related work we can know that most of the car accidents is cause by driver negligence. And, the faults of the negligence usaually happens when the drivers try to change lanes. However, this kind of accidents are correalted with the visual attention limitation. Based on the present studies, we can understand that there are many types of alarm systems such as tactile, visual, and auditory. From the existing papers we can arrange them into the following paragraphs.

About the haptic standard, Van Erp has mentioned that they use 250 Hz vibration in their experiment [11]. On the other hand, Ho and Spence use red and blue LED light for visual warning in their alarm system. Also, many papers discuss the auditory warning system [10] [15] [16]. Most of their auditory warnings are between 75 and 88dB. And all of them also took environment noise into consideration (about 60 dB).

2.3 Brief Summary

In this study we would like to summarize the review the existing alarm systems, and try to design a new tactile alarm system to afford drivers different perceptual signals and manipulate the context that when the alarm signals appear. There are two main issues of discussion. Is the driver's attention limitation restricted by the loading of perceptual pathway? We use either visual or tactile signals to see what kinds of perceptual signals would take less effort, and afford driver a useful alarm. The other issue would be the salience effect of the alarm signals. Actually, some of the existing alarm systems present alarm signals when drivers want to change their original way. But, there are still some systems with present alarm signals when the drivers want to change their route "and there are other cars in that route". Therefore, comparing these two situations may prove if the salience effect of the alarm signal interferes with our vigilance.

3 Method

3.1 Participants

There were 3 male and 3 female graduate school students, age ranging from 25 to 31 (mean=27), served as participants in this experiment. Two strict eligibility requirements to increase the likelihood of all participants having the adequate driving safety knowledge: (a) Have valid driver's license. (b) At least 1 year driving experience within the city.

3.2 Apparatus

For the purpose of comparing three kinds of sensory outputs of the overtake alarm system, we have to build up a safety experimental environment for all participants. Therefore, we employed 3DsMAX 2009 software to build up the whole driving environment and render different animations as different treatment levels. There were four segments of the animations and all the films would be taken by the first person view which concluded the front, left and right side of the car. We also use a piece of street sound (60 dB) as the background noise in all animations.

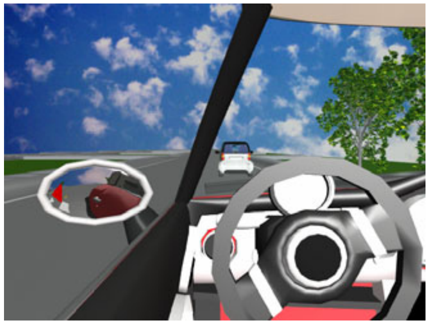

Fig. 1. A sample scene from the driving environment with visual alarm signal

The visual alarm signal was drawn by Photoshop CS3 that was a red triangle with the size of 24x24 points. The sound alarm signal was a 1000 Hz pure tone voice with the volume controlled at 80 dB. The haptic alarm signal was made by a motor vibrator that setup on the participants' hands. The location of the haptic signal was decided by our pilot study that the driving wheel was the best location. And, the haptic signal presented was controlled by Arduino. Arduino is an open-source physical computing platform based on a simple microcontroller board. We can write programming script to make the connection with the motor vibrator, and receiving the different trigger as different conditions that are sent from the E-Prime software.

Experiment environment was administered on a projector running at 1280x720 film resolution. Participants control the brake which was made by a keyboard and a pedal by their right foot on the floor.

3.3 Experimental Design and Procedure

There were two independent variables we would like to manipulate. First, the alarm signal characteristics (perceptual pathway) either the visual, sound or haptic signals. Second, the frequency (salience effect) of alarm signals: once the other cars would threaten or alarm signals constantly appear. As shown in the figure, the left one indicates that the driver is only threaten while overtaking. However, the right figure shown no matter there were a threat or not, the alarm signals would appear anyway.

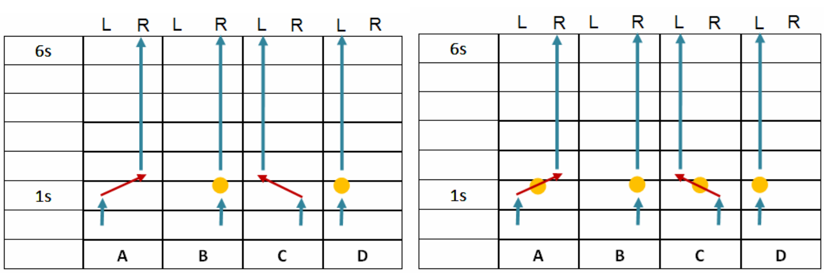

Fig. 2. Eight kinds of possible conditions of experimental design

A two factors repeated measures of within-participant design was applied as experimental design. Two independent variables were: three kinds of alarm signals (visual, sound, haptic alarm signals); two levels of frequency when the alarm signals appear constantly and when the alarm signals only appear when the driver is under threat. Therefore, the whole experiment contains 96 trials, and it was separated into 6 blocks which contains three kinds of sensory inputs and two kinds of signal frequency. The participants would take different sequences to accomplish the tasks by following the former car under those situations, and they may have to stop the vehicle after each trial. The braking response would be the dependent variable which was the reaction time between the onset of the alarm signal and the braking time.

4 Result

As the dependent variable was the reaction time between the onset of the alarm signal and the braking time, we can see the description statistic result as table 1. In the different sensory outputs, the haptic alarm signals induce the shortest reaction time, and the visual output signals induced the fastest reaction time. In the different levels of the frequency that the alarm signals appear, when the alarm signals constantly appear the participants showed faster reaction times.

Moreover, a two factors repeated measures ANOVA was executed. The result shown on table 2 and figure 5 states that the different alarm signal outputs have main effect ($p=.047<.05$). But, the different frequencies of the alarm signals do not show significant difference. However, the non-significant difference comes from the huge difference of the visual outputs.

Table 1. Description statistic

Variables	Conditions	Reaction Time (MS)
Sensory outputs	Visual	848.79
	Sound	540.34
	Haptic	428.54
Frequency	Constantly	617.06
	Threaten	617.07

Table 2. Statistic results of repeat measure ANOVA

Variables	SS	df	MS	F	p
Sensory outputs	591995.10	2	295997.55	5.29	.047*
Output frequency	5969.58	1	5969.58	.28	.632
Sensory outputs* Output frequency	31676.65	2	15838.33	.95	.438

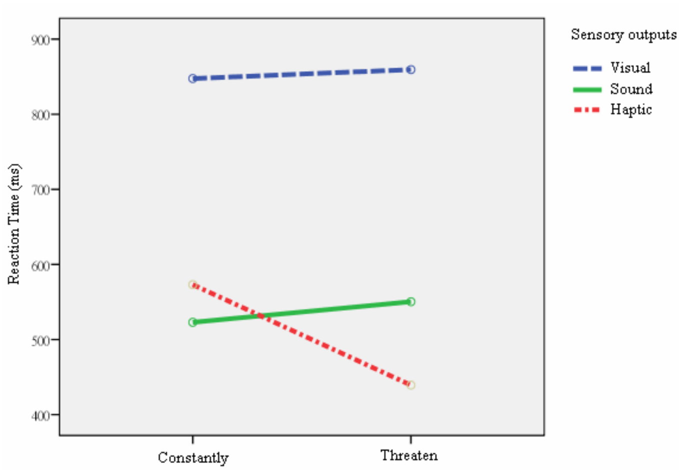

Fig. 3. Reaction time in different conditions

5 Discussion

In this study, we used different kinds of the alarm signals which were collected from the existing alarm system and pervious researches. Then, we used three kinds of sensory outputs to compare which one is the most suitable for the overtaking behavior. Therefore, we build up a virtual driving environment and render different animations as our experimental conditions. All participants had to do was to focus on the driving situations and step on the brake when they receive the alarm signals. As the result shown, we can find out how the additional visual alarm signals would interfere with the participants' reaction time when they are under a situation of high visual loadings. Instead, the participants respond more quickly to sound and haptic alarm signals. This result could be corresponding to the Wicken's attentional theory that the human attention is regarded as a multi-resources system [1]. Therefore, when the visual attention is exhausted, we should use other sensory signals as our alarm signal.

However, there are still other extending issues for other sensory outputs, for example the sound and haptic alarm signals do not afford the orientation cues for the participants. And, the strength of the sensory outputs may be interfered by the different driving environment.

The second issue we would like to test was the different frequencies (salience effect) of alarm signals. The signals on the alarm system would either constantly appear or only show when the driver is threatened. We did not find the salience effect. It may be caused by the lower difficulty of the task. Contrast to the real driving situation, in this experiment the participants only have to step on the brake as soon as possible. They did not have to control the gas pedal nor the steering wheel. Also, the experiment was executed trial by trial. Participants may keep the arousal level of alarm signals. Based on those differences of task difficulty and awareness of alarm may immerse the salience effect.

6 Conclusion

In this modern age, the density of personal vehicles is getting higher and higher, also the number of traffic accidents. Studies have shown that changing lanes improperly is one of the main causes of traffic accidents. These factors are due to the fact that drivers could not see the situation of the lane that they are transferring to (sometimes they can not see the following car from the side mirror or rear vision mirror). Some new technologies have emerged to help drivers avoid accidents. However, the engineers who innovate the overtake alarm system did not realize how the different signal outputs could interfere the drivers. So, in this study, we try to compare the different outputs of the alarm system. According to the experiment result, when drivers face high visual loading tasks, the sound and haptic are more suitable than the visual alarm signals. Although the virtual driving environment and the task difficulty could not externalize completely to the real situation, this study still provide some guideline for the driving overtake alarm system.

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I Can't Hear You? Drivers Interacting with Male or Female Voices in Native or Non-native Language

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Abstract. Many vehicles today are equipped with navigation systems, and all of these systems use speech or a combination of speech and graphics to provide drivers with directions to their destinations. This study investigates the effect of gender of voice when providing driving instructions in English to drivers that are non-native speakers of English. In a 2(native/non-native) by 2(gender of voice) between participant study, 40 participants in age group 18-25 drove in a driving simulator for 25 minutes with navigation information system that gave drivers directions to a set destination. Results show that gender of voice did not affect native English speaking drivers. For non-native speakers, however, a female voice worked better for both female and male drivers. Non-native speakers consistently missed to act on navigational information give by the male voice. Design implications for voice systems are discussed.

Keywords: In-vehicle Information System, Navigation systems, Voices, Gender, Non-native speakers, Driving Performance.

1 Introduction

Navigation systems are becoming more and more common in vehicles, rising from 5.5 million installed units in 2004 to an estimated 16.2 million units in 2009 [1]. Users of navigation systems doubled from 2006 to around 50% of drivers in 2009 [2]. Whether it is a portable unit or built into an automobile's dashboard, navigation systems that use radio signals from global positioning satellites to pinpoint an exact location, or plot travel directions are becoming popular items for drivers. They come as standard in high-end vehicles from manufacturers like BMW, or Mercedes, and can be bought as optional extras in many other makes of vehicles. Navigation systems have still not seen the same market share in the US as it has in Japan or Europe. This could partially be explained by how the layout of cities and roads follow uncomplicated grid patterns in the US but not in Europe and Japan. It is however worth to note that navigation systems are most often offered and in demand by rental car companies and trucking fleets. It makes sense to offer navigation systems since car renters are often not local to or familiar with the area where they rent the car. Navigation systems in trucks potentially save both time and money when drivers don't get lost. Drivers using navigation systems are most often provided driving direction to a destination by

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speech or a combination of speech and graphics. Some solutions also enable you to select and change the voice used by your navigation system.

When renting a car in a foreign country, drivers often have to use a navigation system communicating in their non-native language. In the vast majority of cases this happens to be English for non-native English speakers. In previous studies it has been shown that first and second language users of English voice systems have different voice preferences [3, 4]. A limitation of previous work is that it has been solely concerned with attitudes towards the information presented. But in car navigation systems it is even more important that the users are able to take in and act on the information presented.

To select female voices for navigation systems is based on old studies from the aviation industry where it was found that the higher pitch of a female voice was easier to understand in a noisy environment [5, 6]. However, recently it has been argued that this is not is not a general feature of female voices, but a consequence of specific situational factors.

"It has nothing to with acoustics or taste," said Judy Edworthy, a professor of applied psychologist at the University of Plymouth in England who specializes in "alarms, auditory warnings, beeps and buzzer"[7]. "They used female voices because they were different from most voices heard in the then male dominated aviation sector," said Dr. Edworthy, "and the men were more likely to pay attention to them, particularly in combat situations."[7]

Professor Clifford Nass, Stanford University offered a similar explanation. "The main reason you have female voices in cars is not the technical qualifications like hearability," said Dr. Nass. "It's that finding a female voice that is pleasing to almost everyone is infinitely easier than finding a male voice."[7]

The present study investigates these assertions in a single experimental study where either a male or a female voice was used by a navigation system driven by native and non-native English speakers. The study also addressed other factors such as the spatial abilities of participants. In this paper, however, we only report on those aspects of the study concerned with male and female voices for native and non-native speakers.

2 Method

2.1 Experimental Apparatus

To investigate issues of using male or female in navigation systems we used a driving simulator - STiSIM - from Systems Technology Inc. Drivers were seated in a real car seat and 'drove' using a Microsoft Sidewinder forced feedback steering wheel and pedals consisting of accelerator and brake. The simulated journey was running on a laptop and was projected onto a six-foot projection screen. The same simulator set-up was used for both the training course and the main driving course.

Two tests from Woodcock Johnson's battery of cognitive abilities tests (WJ-III) [8] were used for auditory processing. The two tests on Auditory Processing were the following: First, test 4 on Sound Blending that is a test of synthesizing language sounds where subjects are asked to listen to syllables and phonemes and then to construct words from them; and Second, test 8 on Incomplete Words that is a test of auditory processing where subjects are asked to listen to words where phonemes are missing and then re-create the correct word. The cognitive abilities tests were administered according to WJ-III instructions using a stopwatch, earphones and WJ-III test booklets [8].

2.2 Design and Participants

The experiment was a 2 (English speaker: native or non-native) by 2 (gender of car voice: Male or Female) between-participants design, with random assignment to condition. Gender was balanced across conditions.

There were a total of 40 gender-balanced participants in the age group 18 to 25. 26 of the participants were native English speakers (12 Male and 14 Female), and 14 were non-native English speakers (8 Male and 6 Female). All participants were students at Oxford University, and as such, non-native English speakers are required to present a certificate with a high level of English Language skills before being accepted [9]. All participants had a driver's license and between one and five years of driving experience. Participants gave informed consent and were debriefed after the experiment.

2.3 Procedure

Each participant started the experimental session by signing the consent form. They were then seated at the driving simulator and drove the training course with verbal guidance from the experimenter. The training driving course was 5 000 feet and took approximately three minutes to finish. The purpose of the short introductory driving session was to familiarize participants with the control and feedback from the driving simulator. This course also provides screening for participants that suffer from simulator sickness [10].

None of the 40 participants felt nauseous or discomfort during or after the training course, and continued to fill in the first questionnaire with general information such as gender and age in addition to driving experience. After the questionnaire, the Auditory processing tests were administered before the participants sat back down into the driving seat again.

All participants used the same simulator configuration and the same driving course in the experiment. The course was 52 000 feet long and took on average 22 minutes to complete. All drivers completed the same driving scenario since a driving scenario in STISim is static and predetermined; it has a specific length and will take all drivers along the exact same road regardless of left and right turns. Based on this feature of STIsim all participants are guaranteed to drive the exact same route.

The driving scenario was scripted to take the driver along a road with a navigation system that gave directions to five destinations. The content of the driving directions were designed based on a storyboard description. A simulator road scenario was designed to include the scripted destinations and the simulator was instrumented to generate reports on when drivers followed instructions at choice points.

The road scenario was divided into 38 driving sections, where directions or suggestions prompted 32 sections, and 6 sections were prompted by facts about the immediate surroundings. Directions and suggestions were designed to guide the drivers to 5 pre-programmed destinations. The facts were added to investigate how much attention the drivers were paying to the system. The 38 speech prompts were recorded in a male voice and a female voice. The Participants were randomly assigned to one of two conditions, the navigation system with the female voice or the navigation system with the male voice.

After completing the course, participants filled out a post-test questionnaire assessing their own driving and the navigation system.

2.4 Measures

Auditory Processing. This measures the average of the Woodcock Johnson's cognitive abilities tests on sound blending and incomplete words.

Driving Performance. This is a collection of measures that consists of accidents and adherence to traffic regulations. The measure for *Accidents* is comprised of collisions and off-road accidents. *Swerving* is defined as drivers crossing centre-line or entering shoulder. *Adherence to traffic regulations* is comprised of speeding violations, running red lights and stop signs.

Navigation System. This is a collection of measures that consists of instructions followed, time to destination, and facts remembered. The measure *Instructions followed* simply counts how many of the driving instructions drivers followed. *Time to destination* measures drivers' time to complete the driving scenario to the last destination. *Fact remembered* is a measure of how many of the driving scenario facts that drivers remembered after the driving session ended.

3 Results

The effects of the male and female English voices, when used in a navigation system by native and non-native English speaking drivers, were measured by a two (Gender of Navigation System voice) by two (Native and Non-native English speaker) between-participants ANOVA.

3.1 Auditory Processing

The results from the WJ-III tests on Auditory processing show a significant difference between native and non-native English speakers, $F(1,38)=12.5$, $p < .001$. There were no gender effects in auditory processing.

Table 1. Auditory processing for native and non-native speakers of English

	N	Auditory processing	
		Mean	SD
Native speakers	26	49.26	7.32
Non-native Speakers	14	39.86	9.23

3.2 Prior Driving Experience

To ensure that there were no initial differences between drivers in experimental conditions, drivers' prior driving experience was used. Data from the 2 most recent years of driving was collected, such as the number of accidents, and the number of tickets. This data was averaged for each group of drivers, and no significant differences were found across conditions.

3.3 Driving Performance Measures

Adherence to Traffic Regulations. There were no main effects of Native and non-Native English speakers or gender of voice used by navigation systems for speeding, and stopping at stop signs and traffic lights. This confirms the results from the data on prior driving experience. See Table 2.

Accidents. When driving with the navigation system, non-native English speakers had significantly more accidents than native English speakers, $F(1,36)=8.5$, $p < .006$. There was no effect of gender of voice. See Table 2.

Swerving. There is a main effect where non-native English speakers swerve more than native English speakers. $F(1,36) = 8.5$, $p < .007$. There is no main effect of gender of voice.

More interesting, there is an interaction effect for swerving. Where non-native English speakers driving with the Male voice in the Navigation system swerve significantly more than Native English speaking drivers $F(1,36)=10.8$, $p < .002$ Native English and non-native English speaking drivers with the Female voice swerve equally much, see Table 2.

Table 2. Measures of Driving Performance

		Native Speakers		Non-Native Speakers	
Gender of Voice		Male	Female	Male	Female
Accidents	M	2.4	2.4	4.6	3.3
	SD	1.1	1.7	2.4	1.7
Swerving	M	18.2	30.9	51.4	28.9
	SD	3.7	26.3	13.0	11.4
Adherence to traffic regulations	M	3.9	7.2	4.8	5.2
	SD	2.4	47	3.0	4.5

3.4 Navigation System Measures

Instructions Followed. This data show how well drivers followed driving directions such as turn right, turn left or continue straight, show two main effects; Gender of Voice, with Female voice better than Male $F(1,36) = 40.3$, $p < .001$, and Native speakers follow direction better than Non-native speakers, $F(1, 36)=46.0$, $p < .001$.

Once again we have interesting interaction effect. Non-native English speakers that drove with a navigation system with a male voice did not follow directions as well as drivers in other conditions, $F(1,36) = 66.0$ $p < .001$. There were no significant differences for drivers that heard the female voice. See Table 3.

Table 3. Measures for Navigation System

		Native Speakers		Non-Native Speakers	
Gender of Voice		Male	Female	Male	Female
Following instructions	M	18.8	17.4	6.6	18.4
	SD	1.7	2.7	2.1	3.0
Time to Destination(s)	M	1310	1304	1552	1275
	SD	198	273	59	81
Facts remembered	M	2	2.2	.8	2.3
	SD	1.3	1.7	.8	1.2

Time to Destination. Data show that it is a main effect of gender of Voice, where drivers with the Female voice reached their destinations quicker than drivers with a Male voice, $F(1, 36)=4.6$, $p <.05$. There were no effects of being a native or non-native English speaker. There was however an interaction effect so that non-native drivers listening to a system with a Male voice took significantly longer to reach their destinations than other drivers, $F(1,36) = 4.2$, $p < .05$. See Table 3.

Facts Remembered. There was also a non-significant but interesting trend in the data that show that fewer facts are remembered when uttered by a Male voice than when uttered by a Female voice, $F(1,36) = 3.2$, $p < .08$. There were no other effects. See Table 3.

4 Discussion and Conclusion

In the study presented in this paper this we addressed two aspects of voice interaction. First differences between native and non-native language users, and second, differences between information presented with a male or female voice.

For differences between native and non-native speakers of English, it is clear that native and non-native English speakers do not share the same preferences for gender of voice. Or rather, the data show that for a non-native English speaking driver in general a female voice works better. Whereas for native English speaking drivers, the general pattern is that gender of voice does not matter, with a small but insignificant trend towards gender bias.

It should be admitted that there are exceptions from this pattern on some variables. We suspect that this probably is due to the small number of subjects in the study, and as a consequence, lack of statistical power. But since the data show a pattern that goes against previously established beliefs, we present them here to initiate discussion and not the least to inspire further work on these issues.

These results support the results previously reported by Dahlbäck et al [3, 4]. An important difference between the results presented here and previous work, in that this is to our knowledge the first time that it is shown that the differences between native and non-native speakers also affect performance measures. This is true both for direct measures, as shown by the results on the *instructions followed* and the *facts remembered* measure (though not significant in the latter case), and for indirect ones, measuring a secondary task, as shown by the results on the *swerving* and *time to destination* measures.

The results show that there is some truth to the assumption that female voices are better than male voices in information systems. On the measures (*swerving, instructions followed,* and *time to destination* the data show that drivers that had a navigation system with a female voice performed better. But the significant interaction effects found in the data also show that the female does indeed not work best in all cases. In fact, the results clearly indicate that the advantage gained by using a female voice only holds for non-native English speakers. For native speakers, on the other hand, our data largely support the views of Nass and Edworthy [7].

This suggests that designers, at least when designing systems for predominantly native language users, should base selection of male of female voices more on other considerations including gender bias than on the intelligibility of female voices in noisy environments as presented in this paper. For instance, conforming to gender bias, a male voice could be used for male drivers and a female voice by female driver.

Jonsson, Nass and Harris indicate gender bias as a possible explanation for their results in a driving simulator study with native English speakers from 2008 [11]. The most striking result presented in their research is the dramatic difference between female and male drivers with respect to the effects that the in-vehicle system (that used a female voice) had on driving behaviour. Female drivers showed improved driving performance on all driving and attitudinal measures when driving with the in-vehicle system. The situation for male drivers was very different. The in-vehicle system had a positive effect on only two of six performance and attitude measures. Gender bias, related to the voice of the in-vehicle system, was offered as a plausible explanation for these differences.

Another strategy would be to divide the information into different categories, and use different voices for different categories. A male voice, could for instance, be used to convey critical security information in an in-vehicle system. A female voice, could for instance, be used to inform drivers of points of interest along the way.

It is also possible to match the voice of the in-vehicle system to states and traits of the drivers. Results from previous studies show that matching the emotional colouring of the in-vehicle voice to the emotional state of the driver has positive effects on driving performance and attitude [12]. Jonsson et al [13] also show that older drivers can benefit enormously from driving with an in-vehicle system with an appropriately selected voice, while a less appropriate voice can result in weakened driving performance.

It is however clear, from the results presented in this paper, and from previous result on voices used by in-vehicle systems [11, 12 13], that in designing voice interfaces, there is no one solution that fits all users on all occasions. One voice does not fit all!

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Monitoring User Distraction in a Car by Segmentation of Experimental Data

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Abstract. We present in this paper results of research conducted on evaluation of speech user interfaces in cars. The approach is based on segmentation of the driver's attention data based on user activity and attention. The methodology applied is based on the proposed standard of Lane Change Test (ISO proposal #26022) which is extended by splitting the data based on operation performed. We summarize first results obtained while larger scale study is ongoing.

Keywords: UI Elements, cognitive load, driving, distraction.

1 Introduction

The applications in a car are specific by their safety concerns. It is less important to conduct the task fast. More important are the safety hazards resulting from performing the secondary task (manipulating the UI) while performing the primary task of driving. This is also the primary concern of study described in this paper.

We describe here an approach of monitoring user distraction based on observation of UI elements. We derived our approach based on data analyses which were part of testing a research prototype of a dictation application. We mention here the functionality of the application just very briefly, while focusing on the methods of observing drivers distraction by subtask operations.

2 Related Work

Impact of distracting the driver can be fatal. Significant effort has been devoted worldwide to analyze and reduce impact of various in-car activities to driver's attention. [3] provides systematic review of literature about this topic. Study by the AAA foundation [4] provides comparison of several types of distractions. Other work based on LCT has been presented in [2].

Throughout the time, a set of standard testing tasks has been developed. The most common are the Lane change test (LCT) [1], or the car following test [5]. Some of them even approached standardization stage (ISO proposal #26022 for the LCT).

Meanwhile, progress is made on understanding how human mind works and what are the relevant limitations of human cognitive system [6,7,8,10].

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3 Goals and Concepts

Most automotive UIs are evaluated by examining selected parameters over the whole UI task. Cumulative results for the dictation task examined in this study are reported in [9]. When developing a new application, we need to get deeper understanding of what is happening at the elementary level. The approach we describe here is focused on decomposition of the overall task to time segments corresponding to particular UI operations. We analyze those time segments separately and try to gain more insight to how elements of the UI influence overall user's performance on the primary task.

Our research targets the following goals, which are at least partially addressed in this paper. We would like to learn how to decompose UI interaction to time segments corresponding to individual UI elements, and to measure each UI element's impact on safety of driving. By observing sequences of UI elements we want to study habits of the user and find whether there are some particular patterns of use of the application. Obviously, we want to utilize this knowledge in order to redesign the UI towards a safer version. Figure 1 below depicts how the observed measures correspond to the state of the application and to the user's state.

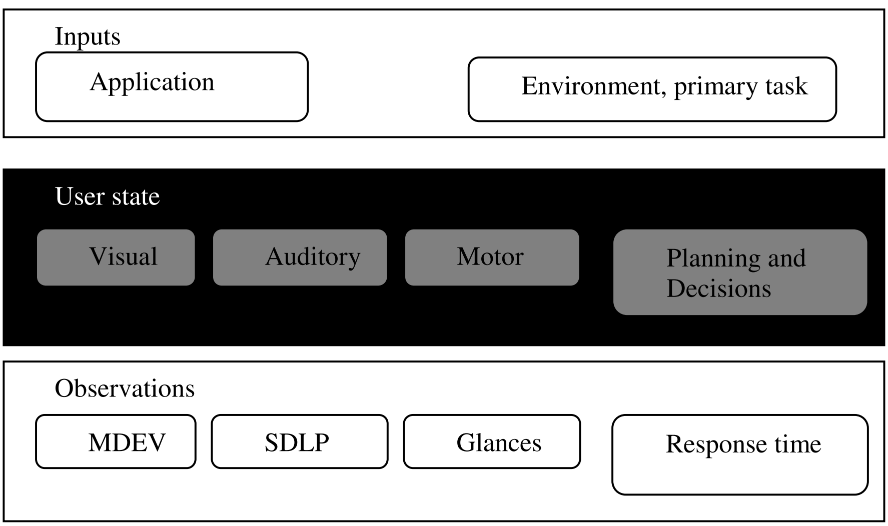

Fig. 1. Observing and influencing user state, main components

User and his/her state are represented by the black box in the middle of Figure 1. User state is modeled as if consisting of four independent blocks for Visual, Auditory, Motor, and Planning/decision components. This is an approximation (more precise models are described for example in [10]), which only reflects the fact that a person can easier process information coming in parallel through more different communication channels.

By observing the user (lower part of the figure) we gain partial understanding of his/her internal state. Since each observation provides just partial clues to what the internal user state is, we typically observe multiple features and their time development. User state is influenced both by the primary task of driving and by interaction with the tested application and environment, which represents both handling the car and responding to situation on the street. The usual approach is to evaluate driver's performance on the primary task while driver is also performing a secondary task. Performance on the secondary task (measured e.g. by task completion time) is of interest but not so critical from safety point of view.

In addition to the primary task, user's attention is split between the application and the environment. Due to the extra load imposed on the user by interacting with the UI, the quality of driving deteriorates. The quality of driving is not a simple measure and it is usually measured by a set of parameters. The typical measures are response times to various events, mean deviation of the difference between ideal and actual track (MDev) or standard deviation of the car's lateral position (SDLP) [1], and many others.

Upper part of Figure 1 depicts the application and environment in which the user is acting. Environment represents both handling the car and responding to situation on the street.

The method mentioned here suggests, when evaluating the application, to take into account not only the observations in the lower part of the figure, but also to segment these observations based on application state and environment state in the upper part of the figure.

4 Data Collection

To simulate driving environment and to measure driver's performance, we use the de facto standard lane change test [1].

The user is asked to drive a car simulator for 3 minutes. He/she needs to respond to requests (communicated by signs at both sides of the road) to change lanes. His/her driving is compared against an ideal track.

To reflect the habits of the user, the user is asked to drive first without performing any secondary task. The ideal track is then computed based on the user's collected data. Subsequently the user is asked to drive while handling the evaluated application. The output of LCT processing is a timeline of the car's position and current deviation from the estimated ideal track.

Apart of LCT data, we need to collect information about the operations performed with the application. User state obviously depends not only on the current type of UI operation but also on their sequence and timing.

In our evaluation architecture, this part of data collection is taken care of by the User and Environment Activity Monitor (UEAM). UEAM merges LCT data to a single pool, on which the analyses are performed. Figure 2 below describes interactions of the UEAM with its environment.

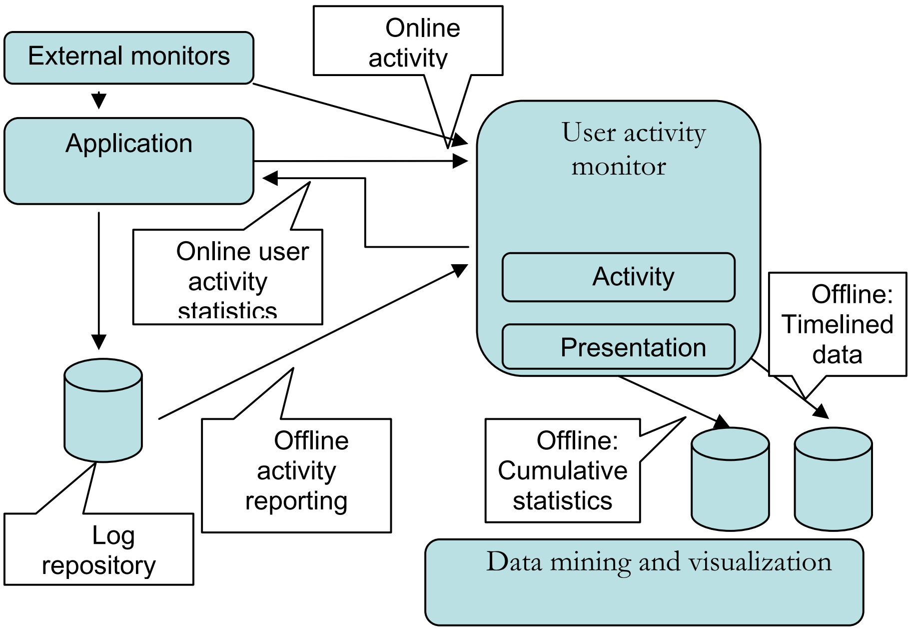

Fig. 2. The User and Environment Activity Monitor

UEAM is an independent module collecting information from application and from external sources (gaze tracking, LCT simulator). It collects information about user activity and about the context, in which the user activity appears. In online mode it provides immediate feedback to the application. In offline mode it extracts data from log files and generates a timeline of aligned events. For the purpose of this evaluation, we used UEAM in offline mode only.

The output of UEAM is represented as a single multicolumn comma-separated file. Each column represents one set of activities which is then analyzed by means of standard contingency tables.

In this paper, we demonstrate our evaluation method on a dictation and error correction application. The application serves as a test bed to evaluate various techniques of dictation correction in a car environment. For the sake of better understanding of the measured data, we describe here briefly contours of the dictation functionality.

The user can create and edit messages by voice. Messages can be dictated in parts with immediate or latter corrections. Order of operations performed is entirely up to the user. Overall operation is a sequence of dictations and corrections. Each dictation is introduced by pressing a speech button on the steering wheel. Single dictation is terminated manually by pressing the speech button again or automatically using a speech activity detector. Each dictation is followed by waiting for recognition results and by playback the recognized text. User can follow by replaying, deleting or editing the recognized text, by browsing and editing existing text, or by dictating further text. The application may run in a multi-modal mode (with display) or in voice-only mode (without any visual output).

5 UI Elements

Before getting to description of results, we should explain what we mean by UI elements. There are many ways how we can break down user interaction with UI to elements. Modeling at higher granularity (macro operations) is usually easier but provides less insight to application behavior.

Our first attempt was based on main logical operations. It is roughly described by the following examples of UI elements.

- Entering text
- Text Deletion
- Correction of type A, B, C
- Browsing forward, backward

Later we realized that this set of UI elements does not quite fulfill our needs. Although distraction can be measured for each operation, the reason of the distraction is not clear. The operations are too complex. To give an example, entering the text consists of pressing the speech button, uttering the sentence, waiting for response, listening to feedback. We can not determine if the observed driving distraction is primarily caused by listening, talking or by composing the message.

The beauty of breaking down UI elements at the macro-level described above is that the operations do not overlap and interaction with the UI translates to a simple sequence of operations.

Our latter definition of UI elements used in the results section is finer. Table 1 below summarizes some UI Elements mentioned later in this text. Acronyms are accompanied by explanation.

Table 1. Acronyms of UI Elements referenced in this text

ASR_DICT	interval of dictation end-pointed by pressing button
ASR_DICT_SIL	interval of dictation end-pointed by silence
ASR_WAIT	waiting for result of dictation (to be played back by subsequent TTS-ECHO)
Unknown ASR	interval when non of the other ASR UI elements is active
TTS-EARCON	interval when an earcon (short sound) is played
TTS-ECHO	interval of playing back text that was just recognized
TTS-OTHER	interval of playback of all other utterances (e.g. when browsing, playback of active segment)
Unknown TTS	intervals when non of the other TTS UI Elements is active (non TTS can be active)

Although for example listening to a prompt seems to be the same operation, we distinguish between several types of listening (TTS-EARCON, TTS-ECHO, TTS-OTHER). The current model does not incorporate intervals when user is planning and deciding about his/her further actions, as these activities are hard to identify and measure. Therefore, we consider these phases to be part of all other UI elements and we distinguish between several versions of UI elements depending on their context.

The drawback of selecting finer granularity is in raised complexity. The overall interaction does not translate to a simple linear sequence of operations but some of the operations overlap. Typically the visual, haptic and auditory operations can be performed at the same time. To simplify final evaluation, we group the UI Elements based on how they appear in time. UI Elements not overlapping in time belonged to the same group. We observe three parallel streams of operations (ASR, TTS and other), each represented in a comma-separated data file by separate columns.

6 Results

We summarize here some of the results collected for 9 users during the first round of testing. Each user was driving 3 minutes while attempting to compose unlimited number of text messages with predefined content. Cumulative results are summarized in [9].

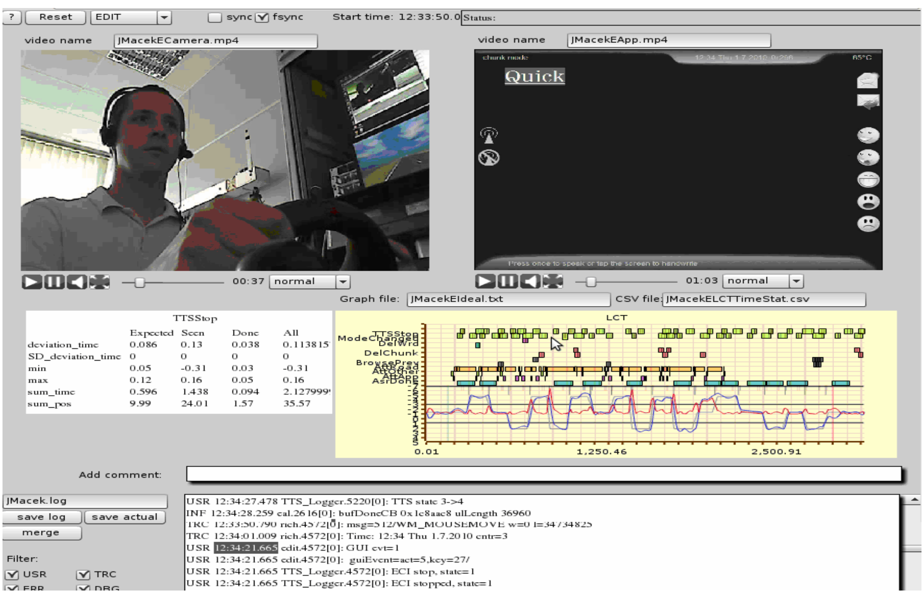

Fig. 3. The usability monitor tool

The first analyzes were performed by visualizing the timeline of the data. For this purpose, we developed a dedicated application allowing us to observe video streams (of both the user and the application UI), in parallel with the current position of the car, deviation from ideal track, operations performed, attention (measured using eye gaze information) and detailed characteristics of the operations. Example of the visualization is depicted in Figure 3. Such visualization proved to be very valuable and helped us to discover some regular patterns of behavior.

When analyzing the visual data, we observed some typical driving errors exhibited by the drivers while handling a secondary task (for example drifting from lane, missing a lane change sign, late response to signs). Typically, deviation peaks appeared close to lane changes. Behavior in the vicinity of lane change points was significantly different from lane keeping. One interesting observation is related to how the users planned their tasks. They typically started their UI activity shortly after the lane change, hoping they would complete the activity before the next lane change.

By observing the habits of users we can see particular patterns of use. The users tend to dictate and correct right after discovering an error. Two main patterns can be observed. One group of users tended to correct particular words, the others (roughly the same number of users) tended to re-dictate a whole erroneous segment.

Next, we present selected observations over statistics calculated on a per UI element basis. The first observations, summarized in Table 2, show how much time the user spent during each type of UI element (first two columns). The time is measured in numbers of samples which are approximately 33ms long. We only consider dictation and listening elements, as the rest was not sufficiently covered by the collected data. Users had two options to complete dictation of single utterance – either to press the speech button again or let the system detect the end of utterance. In lane keeping segments, the users preferred pressing the button, since this speeded up the interaction. During lane changes, it appears that users did not have sufficient capacity to handle the speech button and they preferred to pay more attention to driving. Times spent by speaking the text (sum of ASR_DICT and ASR_DICT_SIL) were about the same as the times spent by waiting for dictation results (ASR_WAIT).

Table 2. Cumulative times spent during UIElements and attention paid to the application

Lane keeping	Duration (number of 33ms samples)		AttApp %
TTS_operation	Lane keep	Lane change	
ASR_DICT	3818	1452	19
ASR_DICT_SIL	2392	1477	7
ASR_WAIT	4549	2957	13
TTS_EARCON	512	145	19
TTS_ECHO	3003	2048	21
TTS_OTHER	2084	963	23

The last column of Table 2 depicts how much time the users spent by looking at the application UI. Figure 4 illustrates attention distribution on an example of the ASR_DICT UI element. Attention is collected by manual annotation of the video recording of the user. Looking at the application, road and other places (mostly buttons and notes) is denoted by AttApp, AttRoad and AttOther, respectively. Results are similar for most of the UI elements. Slightly higher values of AttApp can be observed for TTS operation (users double-check acoustic feedback by looking at the screen). Highest AttApp is for TTS_OTHER. TTS_OTHER appears in feedback demanding operations; for example during browsing or delete operations.

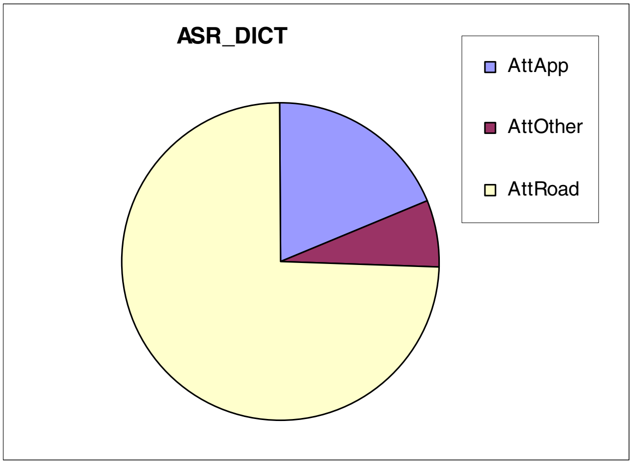

Fig. 4. Example how attention is distributed for ASR_DICT operation

Interesting are observations of the mean deviation (MDev). We hoped to see clear peaks during some operations. This was not true. We hypothesize that since the users were aware of the primary task's importance they minimized and slowed down their interaction with the application whenever they were overwhelmed by driving. Distraction was hereby auto-regulated.

However, we can still see interesting clues in data depicted by Figure 5 and Table 3. Fig. 5 depicts how mean deviation corresponded to each UI element.

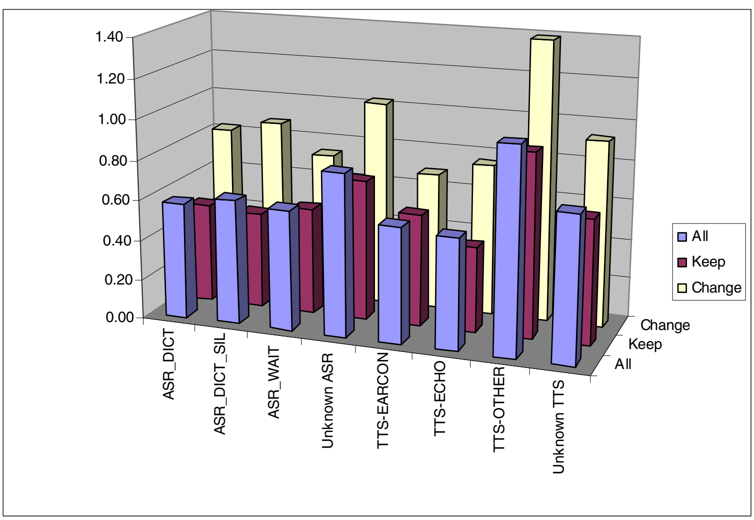

Fig. 5. Average mean deviation during each type of UI element (both for lane keeping and lane change segments)

The exact averaged values of MDev are reported below in Table 3.

Table 3. Cumulative times spent during each type of UI operation.

Operation	MDev Both	Lane keep	Lane change
ASR_DICT	0.58	0.50	0.82
ASR_DICT_SIL	0.62	0.48	0.88
ASR_WAIT	0.60	0.53	0.74
Unknown ASR	0.81	0.70	1.02
TTS-EARCON	0.58	0.56	0.69
TTS-ECHO	0.55	0.43	0.76
TTS-OTHER	1.02	0.92	1.39
Unknown TTS	0.73	0.63	0.93

As expected, MDev values measured for lane-change segments were consistently higher than those during lane-keeping. When comparing MDev of TTS-ECHO and TTS-OTHER, the second is larger. TTS-ECHO corresponds to intervals of echoing dictated text fragments after the recognition, TTS-OTHER corresponds to all other playbacks (for example after delete, browse, replay, and browse). MDev for TTS-Other is impacted by high cognitive load related to thinking and planning. TTS-ECHO comes after interval of waiting for ASR result during which the user is typically idle.

Interesting is also that ASR operations show higher MDev in intervals when no operations are performed (Unknown ASR). We originally suspected that distribution between lane keeping and lane change is different for ASR/TTS operations and/or operation impact is delayed. Both theories where refused by more detailed analyses of the data. Current suspicion is that the reason is that users are simply not using application when driving requires higher attention.

7 Conclusions

We presented in this text a method for evaluation of detailed features of automotive application UIs. The method is based on observing segments of driving correlated to particular operations. The results obtained so far were collected on a small set of participants. Even such a small set is however sufficient to help understanding main principles and patterns of application use. Larger tests are ongoing.

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On-Road Pilot Study on the Need for Integrated Interfaces of In-Vehicle Driver Support Systems

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Abstract. An on-road experiment has been performed with an equipped vehicle, to study whether the effects on driving behaviour and acceptance of a forward collision warning system and of a lane deviation warning system are different when the systems are isolated or when they are used in parallel. 24 participants were assigned in three experimental and one reference group and were asked to drive the equipped vehicle for 15 consecutive trips on a highway at similar traffic and environmental conditions. The effects of the two isolated systems improve the longitudinal and lateral driving behaviour respectively and are rated as useful and satisfactory, while the use of the systems in parallel does not have a positive effect on driving behaviour. In the latter case the systems are not considered satisfactory and cause frustration to the drivers, thus the need emerges to integrate systems and interfaces.

Keywords: integration of interfaces, forward collision warning, lane deviation warning, on-road study, long-term effects, evaluation.

1 Introduction

There exist today a variety of in-vehicle driver support systems in the market and a lot more are being developed with the primary objective to enhance the driver's ability to cope with traffic complexities. Findings from previous studies confirm that such systems can be beneficial in terms of road safety and driver's performance. For example, driving with Adaptive Cruise Control (ACC) was found to decrease speed [1,2], short time headways [3,4] and the perceived workload of a driver compared to driving without ACC [2]. A system providing warnings in case of a forward collision risk was found to reduce the number and severity of such collisions [5]. Also, a system providing lane departure warnings has been estimated to reduce the number of unintentional lane crossings by 35 % [6] as well as the number of road departure crashes in large trucks by 17-19% [7].

The above studies have evaluated the use of isolated systems, while the time of exposure to the systems is usually limited, e.g. up to four weeks for ACC [8,9].

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However, the effects on driving behaviour when using various systems in parallel may be different than the effects of isolated systems. Parallel warnings from different systems may result in driver's overload and even confusion, possibly resulting in effects adverse than the desired ones [10,11,12]. Also, system evaluation studies are mostly performed in driving simulators and not in real traffic conditions.

The objectives of the work presented in this paper were to study in real traffic conditions the effects on driving behaviour and acceptance of two systems, namely a Forward Collision Warning (FCW) and a Lane Departure Warning (LDW) system, when the systems are isolated and when they are used in parallel, and to study how effects and acceptance evolve in the long-term. To our knowledge there is no published report about a long-term on-road study of the effects from the parallel use of two systems, providing both longitudinal and lateral support.

2 Method

A one-way, unrelated samples experimental design was used. The independent variable was the warnings provided to the participants with three alternatives, warnings provided only by the FCW system (Group FCW), warnings provided only by the LDW system (Group LDW), warnings provided by both the FCW and LDW systems in parallel (Group Both), whereas the reference group (Group None) did not receive any warnings. During the experiment both systems were operating and the generated warnings were recorded in all four experimental conditions. However the participants were receiving only warnings according to the group to which they had been assigned. The primary dependent variable was the number of warnings generated by each system. Other dependent variables were calculated from vehicle-related measurements as explained below and subjective ratings.

In total, twenty-four experienced drivers, 14 males and 10 females, aged between 21-50 (mean=32.9 sd=7.6), participated in this study. They were holding a driving license for at least 3 years (mean=12.4 sd=6.9). Their annual mileage ranged between 5000 to 100000 km (mean=27583.3 sd=23564.7). Participants were recruited through an announcement in local newspapers. The 24 participants were equally allocated into the four groups: two groups experienced one isolated system (Group FCW, Group LDW), a third group experienced both systems in parallel (Group Both), while in the reference group participants experienced no system (Group None). To eliminate the effect of confounding variables, participants in the four groups were matched in terms of age and driving experience.

The experiment was performed using an equipped research vehicle (Lancia Thesis 2.4 Emblema), belonging to the Centre for Research and Technology Hellas, under the framework of the AIDE European project (contract IST-1-507674-IP). This vehicle is equipped, among others, with a front obstacle detection radar, a lane recognition camera, a central PC, a special central mirror with integrated warning lights, enabling the simulation of several driving assistance systems, using various activation criteria and HMI alternatives.

Two systems were simulated in this experiment, a frontal collision warning (FCW) system and a lane departure warning (LDW) system. The criterion for the activation of the FCW was:

$$D_w = (v_{driver}\, T_{driver}) + (v^2_{driver} / (2\, d_{driver}) - (v^2_{drone} / (2\, d_{drone}))\ . \quad (1)$$

where: D_w [m] is the warning distance, v_{driver} [m/s] is the speed of following driver; T_{driver} [s] is the assumed driver's reaction time to an event set to 0.5 s for imminent warnings and to 1.5 s for cautionary warnings, d_{driver} [m/s^2] is the assumed deceleration of the driver's vehicle (was set to 5 m/s^2), v_{drone} [m/s] is the speed of the lead vehicle, d_{drone} [m/s^2] is the assumed deceleration of the lead vehicle (was set to 5 m/s^2). When the actual distance was less than the warning distance, a warning was given in two levels, as a yellow light on the central mirror for cautionary warnings and as a red light on the central mirror plus an auditory alarm for imminent warnings. The LDW system provided a warning when the time-to-line crossing was less than 0.4 s. This system was active only for speeds greater than 50 km/h. The warning consisted of a sound, like the one heard when a vehicle drives over rumble strips.

The duration of the study was 15 weeks. After an initial familiarization trip with the research vehicle and after being informed about the systems functionalities, participants were asked to drive the vehicle once a week for 15 consecutive times along a standard route. The highway route in each trip was 79 km with a speed limit of 120 km/h., thus trip duration was around 1 hour. Additionally, each trip of the same participant took place along the same highway route and on the same day of week and time of day, so that distance travelled, traffic conditions and exposure time to the systems tested were as much as possible similar for all trips of each participant.

With this design, we collected and analysed in total 360 trips (90 trips per group, 6 trips per week per group). Trip number was used to study effects of exposure to the system(s).

3 Results

The following vehicle-related measurements were directly recorded from the experimental vehicle with a frequency of 10 Hz: vehicle speed, lateral position, lead vehicle distance and number of warnings generated by each system. Based on these measurements, the following parameters were calculated: mean trip speed, percentage of driving time spent at headways less than 1 s, standard deviation of lateral position, number of lane changes per trip and percentage of lane changes performed with the use of direction lights per trip. During the analysis only data recorded during the highway driving were considered, while data recorded on the roads to and from the highway were excluded from the analysis.

Separate two-factorial ANOVA's and t-tests were performed for each group combination for the total sample of 90 trips and per trip within each group.

3.1 Effects on Speed

The mean speed per trip in the FCW group in the total sample (90 trips) was significantly lower than in the reference group None ($p=0.034$). No difference was found between all other combinations of groups. There was an effect of trip number, only in the group Both ($p=0.061$), where we note a mean speed increase with trip number.

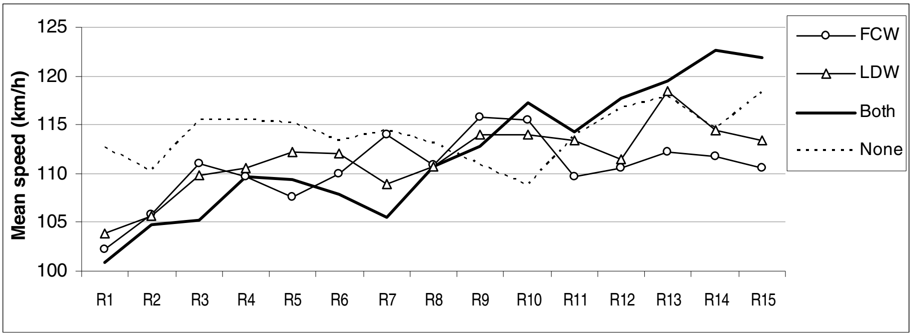

Fig. 1. The mean speed per trip and group

3.2 Effects on Longitudinal Driving Behaviour

The mean number of imminent forward collision warnings (Fig. 2) generated by the FCW system per trip was significantly lower in the FCW group than in all the other three groups (FCW / LDW p=0.001, FCW / Both p=2.063 10^{-7}, FCW / None p=2.559 10^{-8}). The mean number of forward collision warnings that would have been generated for the LDW group per trip was significantly lower in relation to the group Both (p=0.0057) and the reference group (p=0.0046). No difference was found between the Both and the reference groups. No effect of trip number was found.

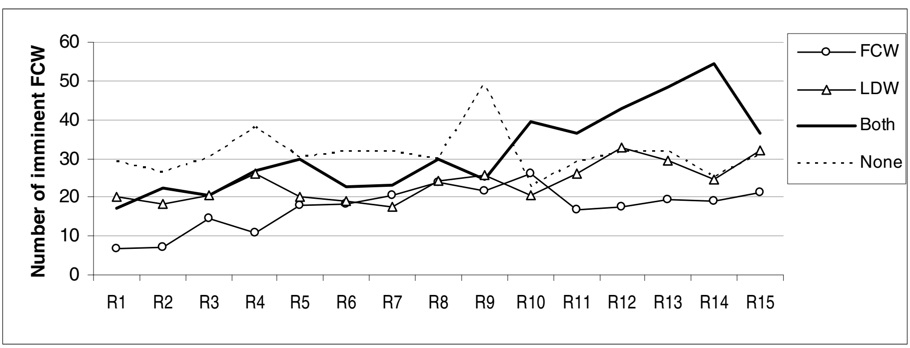

Fig. 2. Mean number of imminent frontal collision warnings per trip (visible/audible for the FCW and the Both groups only)

Participants in the FCW group spent significantly less time driving at short headway of less than 1 s (Fig. 3) compared to all the other groups (FCW / LDW p=0.099, FCW / Both p=2.382 10^{-5}, FCW / None p=0.0005). Participants in the Both group spent significantly more time driving at short headway of less than 1 s compared to all other groups (Both / FCW p=2.382 10^{-5}, Both / LDW p=0.018, Both / None p=0.0229). Some effects of trip number were found for the Both group (p=0.098), where the percentage of time driving at short headway increases with trip number.

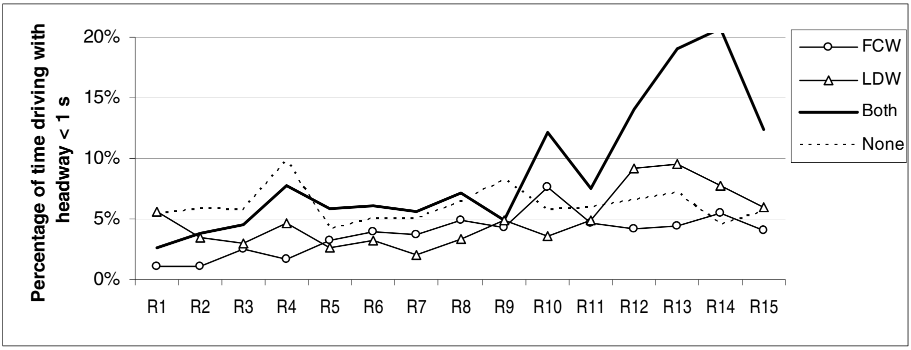

Fig. 3. Mean percentage of driving time at headways less than 1 s

3.3 Effects on Lateral Driving Behaviour

The mean number of lane departure warnings (Fig. 4) generated by the LDW system per trip was significantly lower in the LDW group than in all other groups (LDW / FCW $p=3.91\ 10^{-33}$, LDW / Both $p=7.238\ 10^{-13}$, LDW / None $p=4.79\ 10^{-16}$). No difference was found among all other group combinations.

The lateral driving behaviour has been examined by using the mean standard deviation of lateral position per trip and the percentage of lane changes performed with the use of direction lights. Lane positions recordings during lane changes have been excluded from the analysis regarding lateral position. Therefore, the high values of mean standard deviation of lateral position (Fig. 5) found in this study compared to the ones in the literature should be attributed to the fact that in the present study, participants were asked to drive normally and were not instructed to maintain a steady lane position while driving.

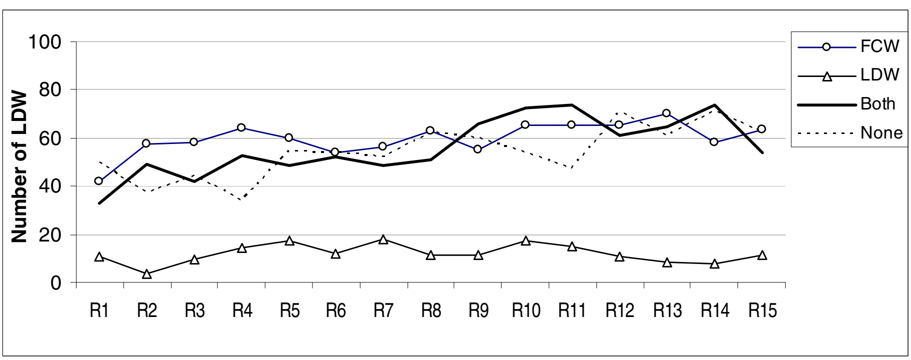

Fig. 4. Mean number of lane departure warnings (audible for the LDW and the Both groups only)

The mean standard deviation of lateral position per trip was significantly lower in the LDW group compared to all the other groups (LDW / FCW p=1.048 10^{-22}, LDW / Both p=5.687 10^{-8}, LDW / None p=7.564 10^{-11}). The mean standard deviation of lateral position per trip was significantly higher in the FCW group compared to all the other groups (FCW / LDW p=1.048 10^{-22}, FCW / Both p=0.00335, FCW / None p=2.285 10^{-6}). No difference was found among the Both group and the reference group.

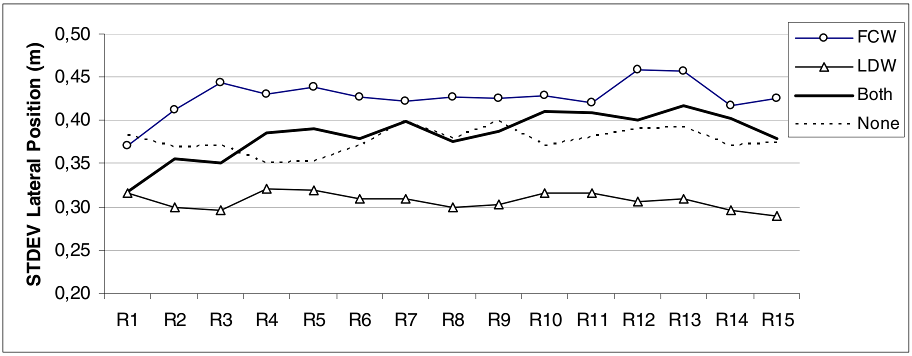

Fig. 5. Mean standard deviation of lateral position (distance from lane centre) per trip (excluding lane changes)

No effect of group or trip number on total number of lane changes per trip (Fig. 6) was found. Participants in the LDW group performed a significantly greater percentage of lane changes using direction lights (Fig. 7) compared to the other groups (LDW / FCW p=1.0245 10^{-15}, LDW / Both p=2.527 10^{-9}, LDW / None p=8.74 10^{-9}). No other difference was found among the rest groups combinations.

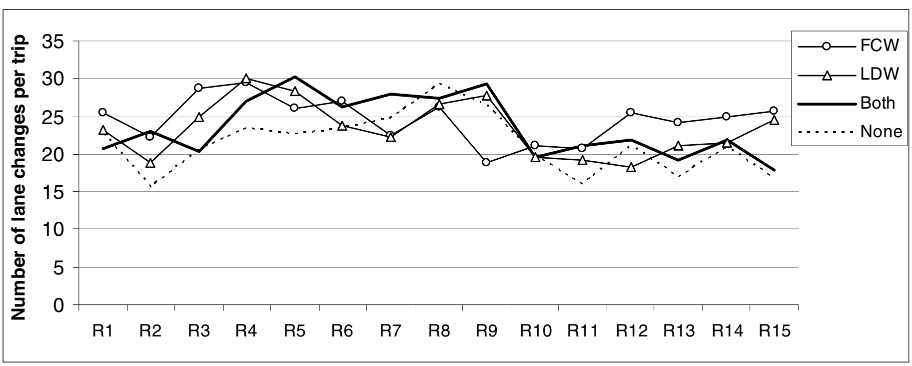

Fig. 6. Number of lane changes per trip.

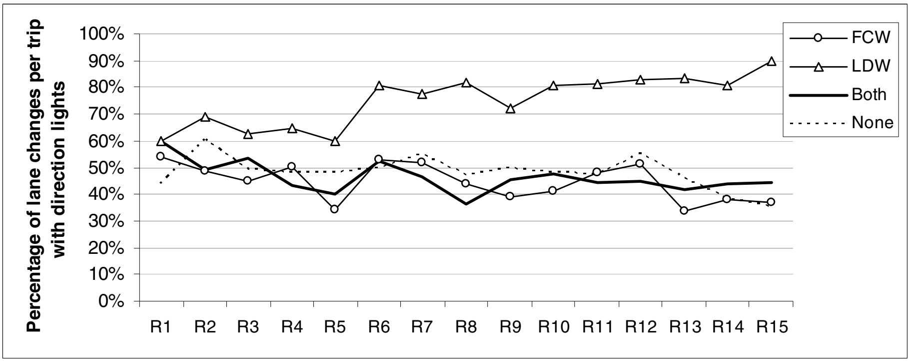

Fig. 7. Percentage of lane changes per trip with the use of direction lights

3.4 Subjective Ratings

Subjective evaluation of the system(s) experienced was done by the participants of the groups FCW, LDW and Both after the end of each trip. The acceptance scale of Van der Laan et al [13] was used, through which the participants ratings are synthesised in two dimensions: usefulness and satisfaction. Participants in the FCW and the Both groups rated the FCW system as useful (Fig. 8), the ratings are higher in the FCW group. Only participants from the FCW group rated the system as satisfactory, while participants from the Both group rated it negatively regarding satisfaction (Fig. 8), implying that the parallel use of the two systems may have caused irritation.

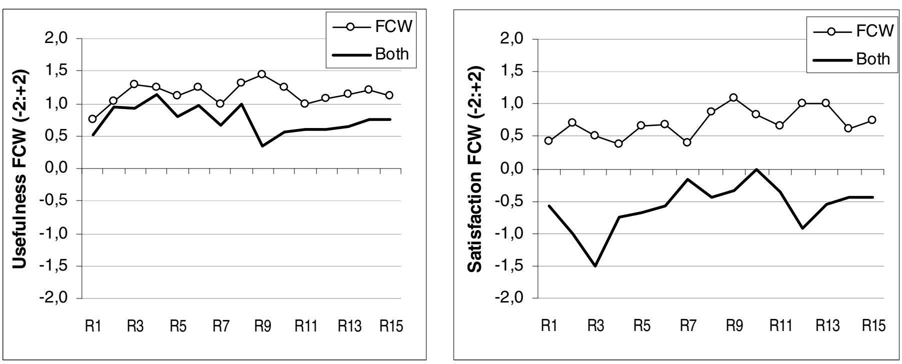

Fig. 8. The usefulness and satisfaction scores for the FCW system (visible and audible to FCW and Both groups)

The same was also found regarding the LDW system (Fig. 9). The participants in the LDW and the Both groups rated it as useful, but only participants from the LDW group rated it as satisfactory. The usefulness scores from the Both group are most of the times lower than those from the LDW group. The participants in the Both group have always (except from trip 10) rated it negatively regarding satisfaction.

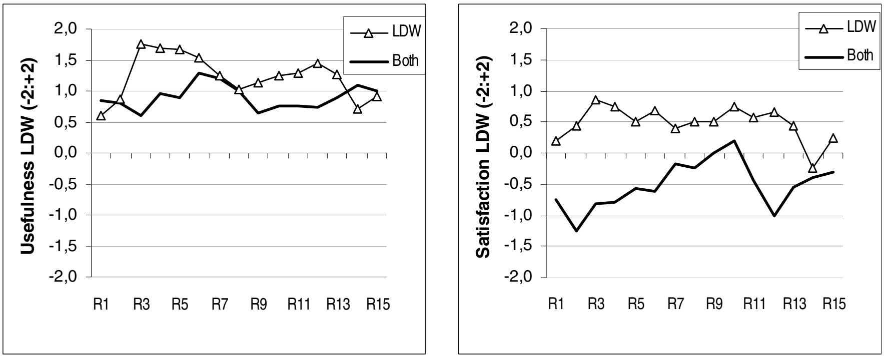

Fig. 9. The usefulness and satisfaction scores for the LDW system (audible to LDW and Both groups)

FCW and LDW systems are considered as both useful and satisfactory when experienced as isolated systems. When experienced in parallel, they are both rated as useful in terms of traffic safety but unsatisfactory. This could be simply, because the two parallel systems produced a rather noisy environment, causing a lot of irritation to drivers.

4 Discussion

Although the number of participants per group was small, the total number of trips analysed per group was 90. Keeping in mind the possible inter-personal differences among participants in each group, results from this study indicate that there is a difference regarding the effects on driving behaviour and acceptance of the two systems that were tested, when these systems are isolated or are functioning in parallel but independently of each other.

When the FCW and the LDW systems were operating isolated, there was an improvement of longitudinal and lateral behaviour respectively. Participants in the FCW group were trying to minimize system warnings due to close-following, as shown by the lower number of warnings, and were driving less time at short headways (<1s) than the other groups. This effect however did not last in time, as the percentage of time of driving at short headways (<1s) during the last five trips was higher than in the first trips, possibly due to drivers' personality and familiarization with the system. On the other hand, the total number of lane changes in this group was not different from the other groups, implying that the less time spent driving at short headways was not due to more frequent lane-changing. This suggests that the isolated FCW system had certainly a positive effect on longitudinal behaviour without inducing potential unwanted driving behaviour changes, e.g. increased number of lane changes in order to avoid FCW activation. A negative side-effect in this group was that the standard deviation of lane position was higher than in all other groups, possibly due to their concentration on longitudinal behaviour. The isolated FCW system was rated by them as useful and satisfactory.

Participants in the LDW group showed better lane keeping performance from the other groups, as the lower standard deviation of lane position and lower number of LDW warnings indicate, and they were using more often the direction lights during lane changes. These behavioural changes remained unaffected through trips, possibly due to drivers' personality. The number of FCW activations in the LDW group was less than in the reference group, possibly due to their more conservative driving style compared to the rest groups. These participants also rated the isolated LDW system as useful and satisfactory.

In the Both group in contrast, there was essentially no positive effect either in respect to longitudinal behaviour or in respect to lateral behaviour, in terms of number of warnings, driving at short headways and lane keeping performance. It seems like participants in the Both group paid no attention to the provided warnings. Their lane keeping performance was similar to the reference group. They drove at short distances more often than the reference group, possibly due to their driving style. Participants in this group rated both systems running in parallel as useful but not satisfactory.

Considering, the double number of warnings that participants in the Both group were receiving compared to the FCW and the LDW groups, and the resulting noisy environment that participants had to drive in, it was inexplicable why they did nothing in order to minimise the warnings. To answer this question, a follow-up telephone interview was conducted. From the answers to these interviews, it was found that trying to cope with both systems, generated a lot of frustration to participants, because the systems excessively delimitated their latitude of control compared to their usual driving style. Due to this frustration, several participants stated that they tried to pay attention to at least one of the two systems, but they soon abandoned this strategy as it was not effective, since the two types of warnings were not relevant to each other and were provided in different means, which created even more irritation and confusion to them.

These findings highlight the need for integration of the interfaces of in-vehicle systems. Several current and previous research efforts have been trying to design and develop integrated interfaces for in-vehicle systems. The key issues for an integrated interface could include the implementation of multimodal interface elements used by different systems, for example head-up displays, speech input/output, seats vibrators, haptic input devices, directional sound output, the prioritisation of warnings from multiple systems and scheduling of warnings according to the assigned priority level, thus avoiding conflicts between systems and the possibility for interface adaptivity according to the environmental scenario and the specific driver's state and preferences, taking always into consideration possible impact on driver's workload.

Further to this, it should be mentioned that the development of support systems has until now been based on a decomposition of the driving task and focuses on specific subtasks only. The most important outcome of our study is that such an approach imposes excessive delimitations to the driver, thus the real need is not to integrate all distinct systems, but to develop one unique system, that considers the entire driving task.

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Part IV

Interactive Technologies in the Physical and Built Environment

New Design –Integration of Art and Technology

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Abstract. Over the past years, many research methods have been developed to improve designing systems. There is, however, great need for research in this field in order to find new techniques and solutions appropriate for modelling structures of innovative products. This paper puts forward methodological and practical evaluations of some aspects of design creation. Author presents main principles that underline methodological perspectives for a closer integration of art and technology in design of innovative products. The paper presents two key research problems: a) possibility of combining traditional design methods with new computing tools. b) design methodology as a basis for multidisciplinary innovation process. Examples used to illustrate the methodology include design of an architectural structures.

Keywords: Design creation, design methods, creativity, parametric software.

1 Introduction

This paper presents a method of supporting creativity of architects-designers by employing parametric computer software.

The method was tried out in a form of an experiment at the Faculty of Architecture of Poznan University of Technology in course of student workshops on "architectonic design of innovative spatial structures."

2 Preliminary Assumptions

Used method belongs to a group of heuristic methods. Its purpose is to stimulate sub-consciousness, imagination, fantasy and emotional engagement of students. Extending a reason-effect examination, the method aims at obtaining wide range of new fields of creation while solving architectonic problems. It develops ability of creative thinking and creativity itself. The method is a synthesis of long time didactic experience based upon use of Synectic Methods [1] and Brainstorming [2], widened by new opportunities provided by computer parametric software. Heuristic operators are abstractive graphical compositions carried out by students who use parametric software.

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Interactive graphical forms observed at a computer screen are interpreted as symbols which are supposed to stimulate creativity. We assume that inspirations established by such forms enable to unearth and express even the most hidden sub-conscious connotations. Pictures generated by computers, due to their contraction and variety, may make minds free from any unimportant details and apparent restrictions. Diversity of inspirations is crucial at the beginning of a process of creation and it poses a type of a platform between a description of task and a solution of problem. Stimulation of creative thinking forces unconventional connotations between ideas and it increases probability of finding of an innovative solution [3].

3 Methodical Stages

The method consists of six separated stages:

1. Determination of a 'search' field.
2. Inspirations and analogies (supported by use of computer parametric graphics).
3. Connotations.
4. Generation of ideas, making a field of use more precise.
5. Analysis of practical opportunities.
6. Practical designing solution.

Scheme of relations between above-mentioned stages is presented in the Fig. 1.

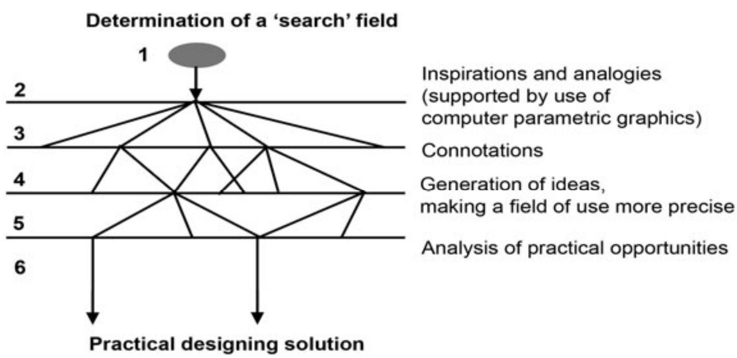

Fig. 1. Scheme of relations between main stages of the method

When determining a field of search two rules are taken into account: at first, a problem must be accurately and clearly described, nevertheless, on the other hand a task must not be too restrictive. It is necessary to remember the more detailed task is the more restricted authors of ideas are.

At the stage of inspiration the work is carried out in form of 45 minute group sessions. A group consists of 4-5 students. One of them, using a computer, creates interactive parametric pictures. Other participants, on the basis of the computer graphics generated parametrically note their connotations related to observed pictures.

The purpose of this stage is obtaining the largest number of solutions of a particular problem.

At this stage it is important to release sub-conscious connotation processes, look for inspirations from different fields of intellectual activity, even those ‘located’ quite far away. An effective activity is a trial of assignation of names to graphical compositions, similarly like it takes place when names are assigned to pictures of non-objective art type. Such names also stimulate other language-based connotations derived from metaphors, poetic symbols, a world of fantasy and fairy tales. A significant element of this stage is generation of a large number of connotations which could be used as basis for more practical ideas in terms of a problem solving.

Next stage is an operational action. It lies in ‘excavation’ of those elements which must be retained, and their gradual modification to a more realistic forms. Analogies and metaphors stimulated by abstractive computer picture are subject to intellectual transformation. Anything unclear or questionable must be accurately explained and be understood by all members of a group. At this stage one uses the Checklist method which helps to select the most promising ideas [4].

At the next stage an individual work begins - it leads to development of a practical design solution. Each student randomly selects an idea which will pose basis for further independent work. Depending on specificity of a problem students use one of the standard designing methods: Method of Successive Approximations, Decision Trees, Value engineering (VE), Multi-Criteria Decision Analysis (MCDA).

4 The Examples of the Method in Practice

The examples presented hereunder illustrate effects of the method used to solve the following problems:

1. Buildings in seismic areas.
2. Suspended Housing Project.
3. Mobile roof and wall structure.
4. Self-changing facade.
5. “Building - chameleon”: a building reacting to variable environment and functional parameters.

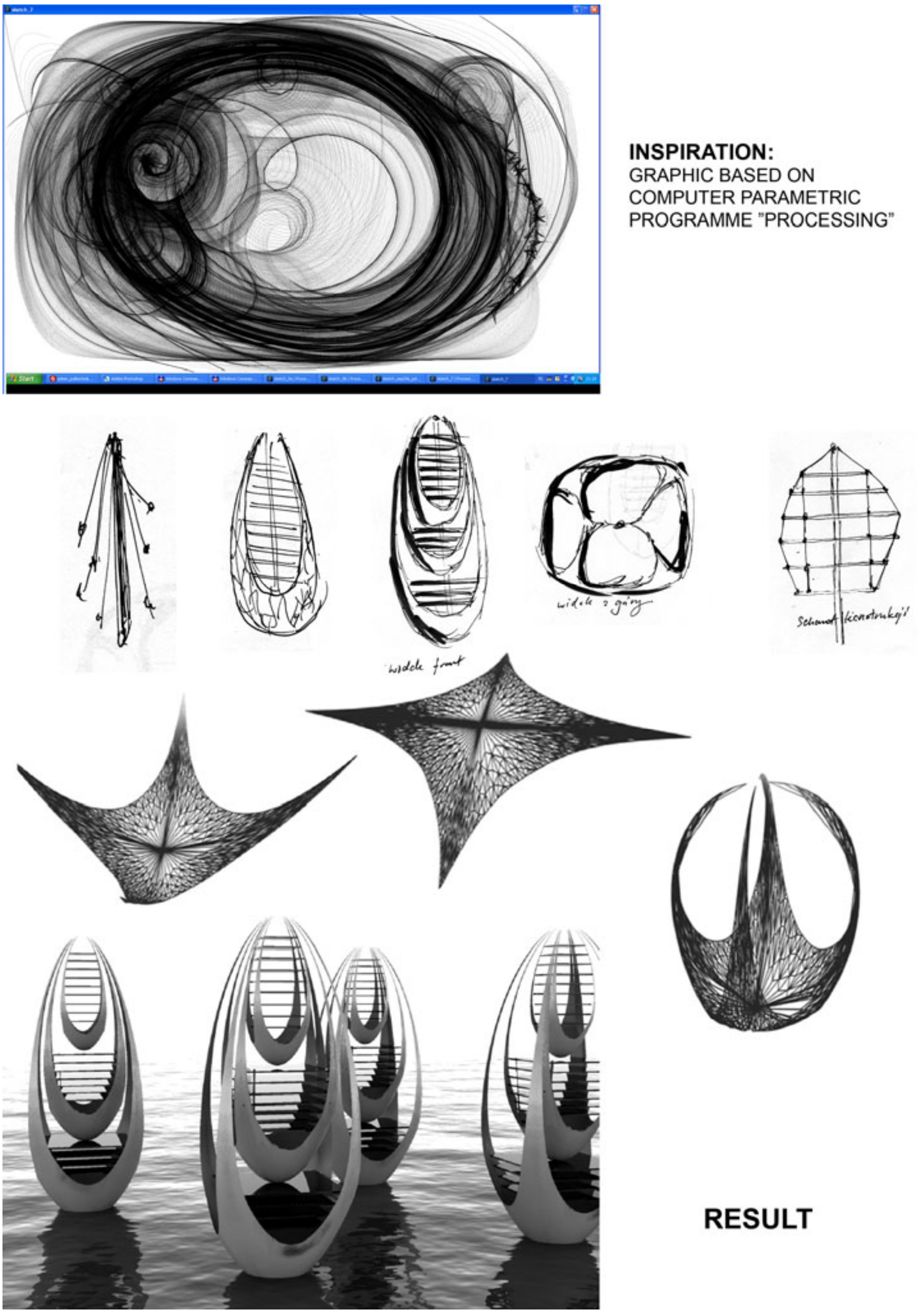

Fig. 2. Example 1: Buildings in seismic areas. Project developed at the Faculty of Architecture, Poznan University of Technology, by R. Lesniczak, under supervision of W. Boneberg

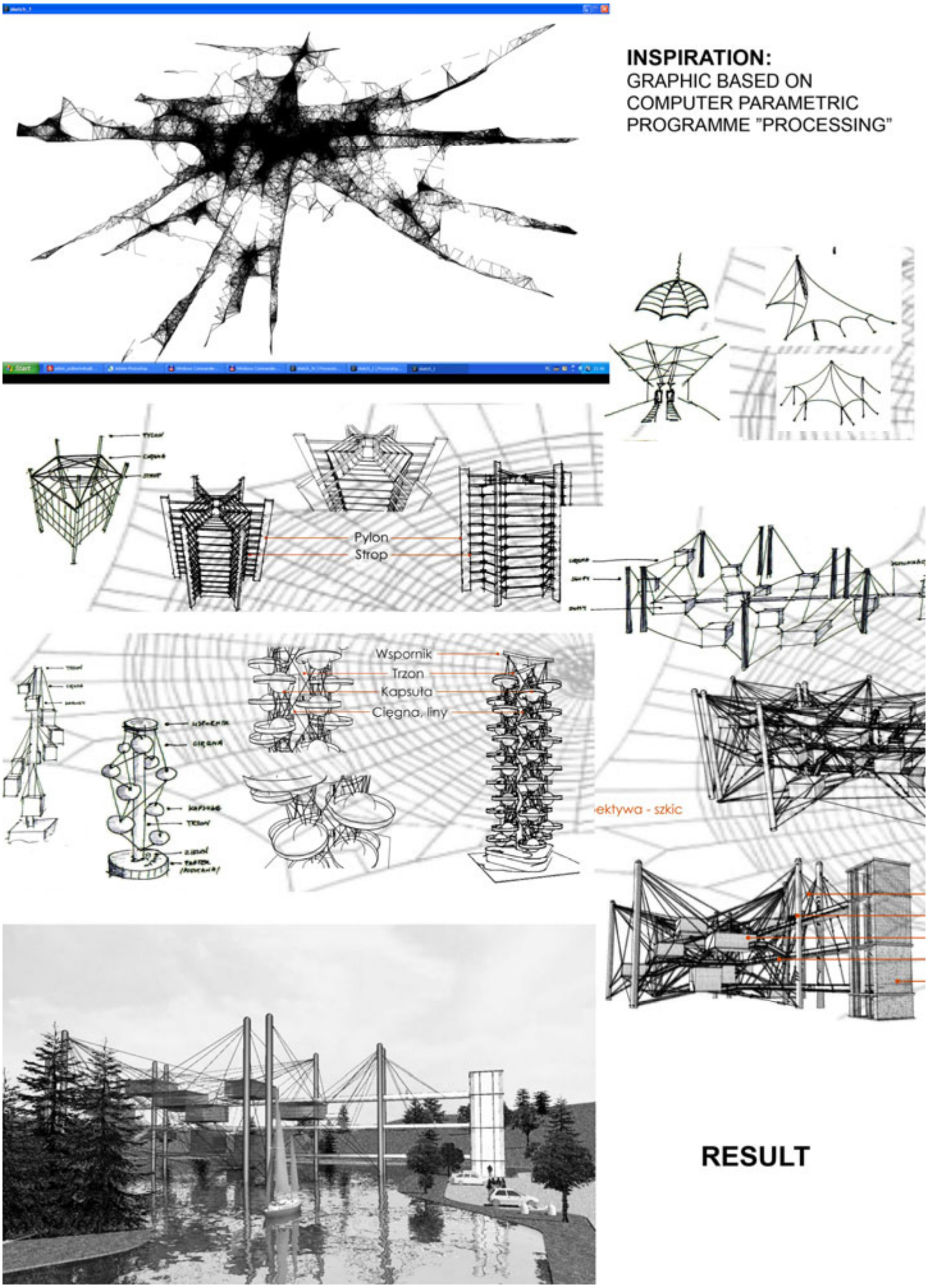

Fig. 3. Example 2: Suspended Housing Project. Project developed at the Faculty of Architecture, Poznan University of Technology, by M. Karolczak, under supervision of W. Boneberg

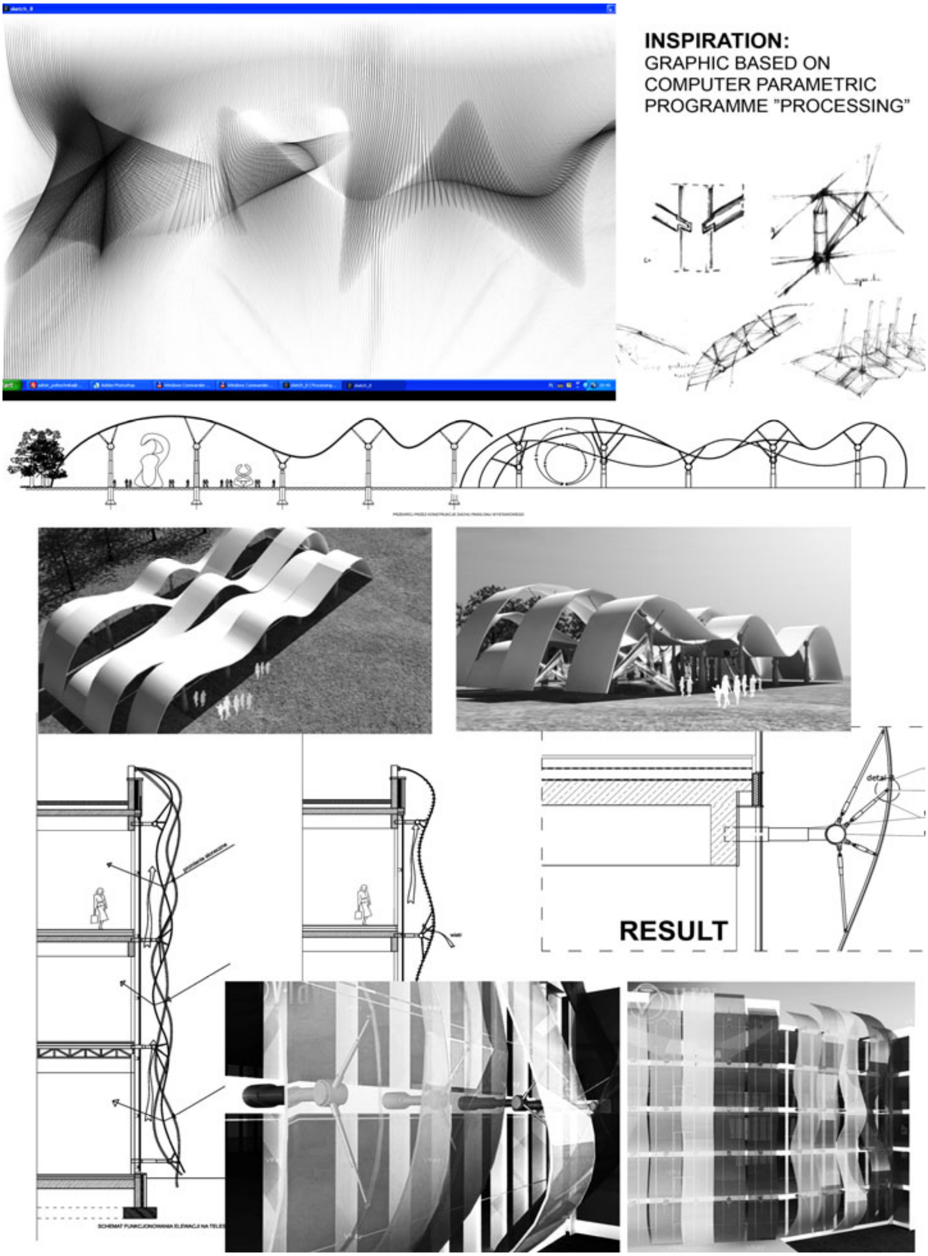

Fig. 4. Example 3: Mobile roof and wall structure. Project developed at the Faculty of Architecture, Poznan University of Technology, by I. Mlodzikowska, under supervision of W. Boneberg

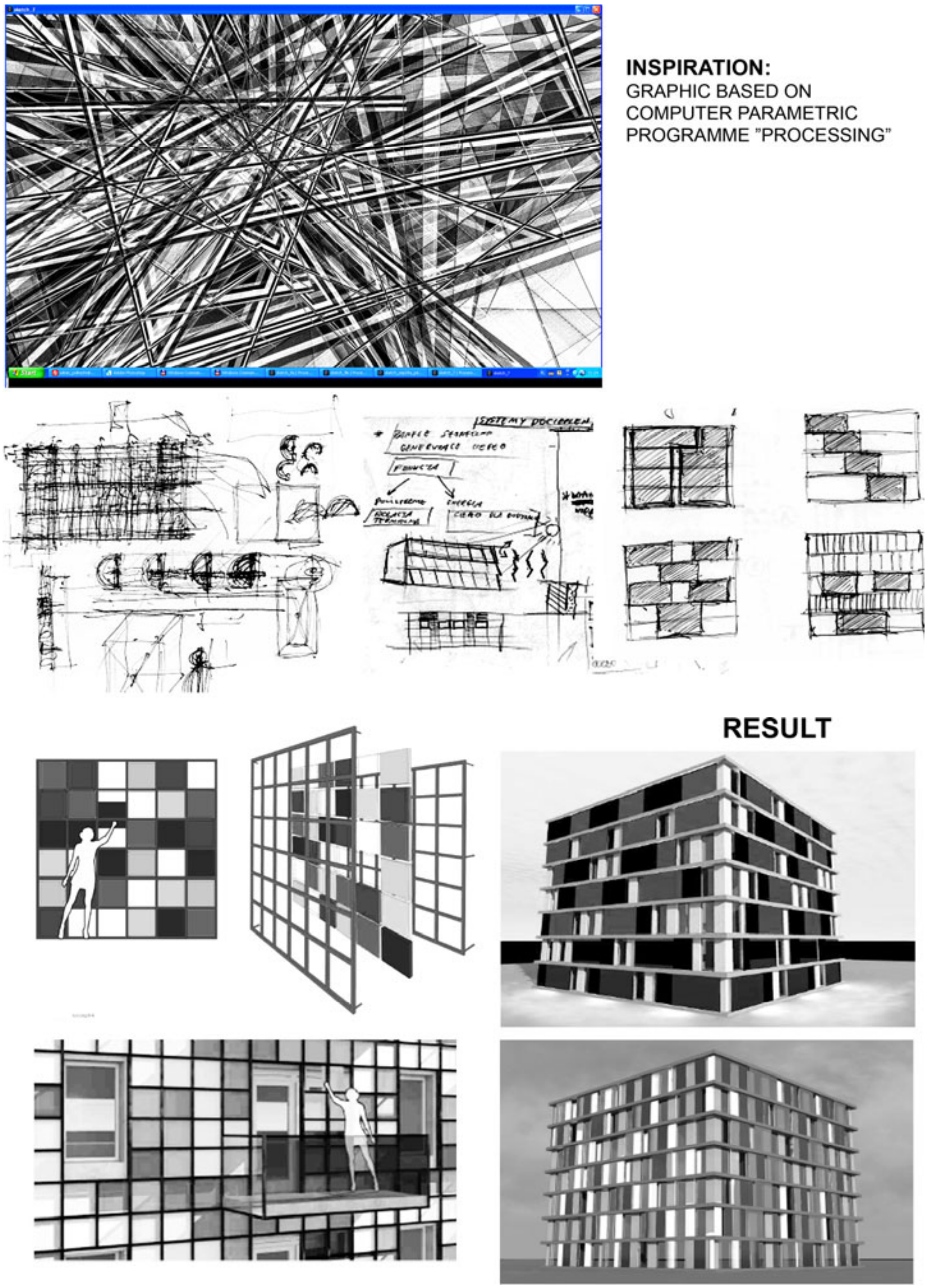

Fig. 5. Example 4: Self-changing façade. Project developed at the Faculty of Architecture, Poznan University of Technology, by J. Pieprzyk, under supervision of W. Boneberg

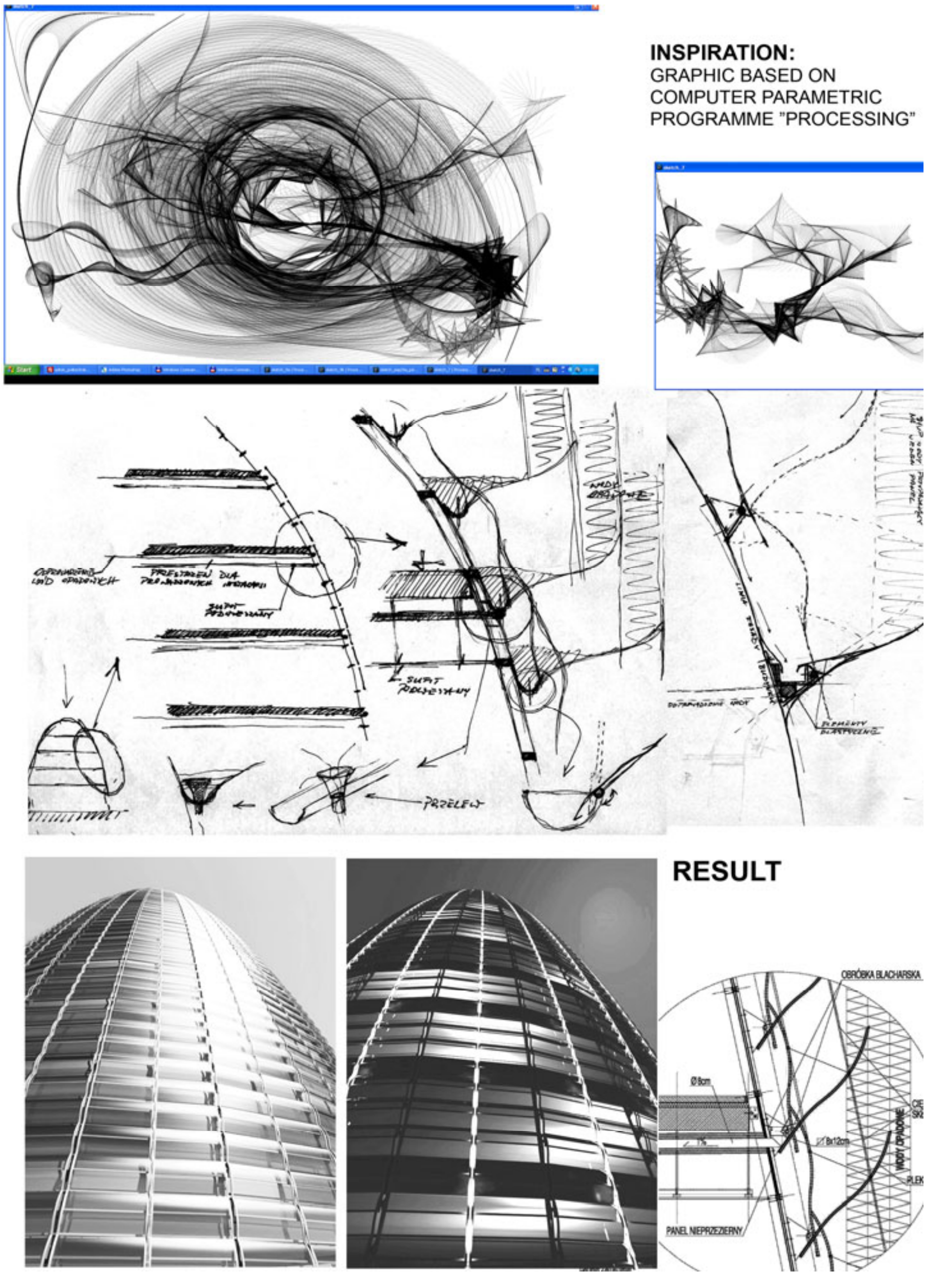

Fig. 6. Example 5: "Building - chameleon": a building reacting to variable environment and functional parameters. Project developed at the Faculty of Architecture, Poznan University of Technology, by W. Skowronek, under supervision of W. Boneberg

Summary

The above examples obtained during the experiment show effectiveness of the proposed method in comparison with the solutions of the same problems received in traditional way. Concluding, it is worth emphasizing that this is an original way of use of parametric software in the earliest stage of designing process. Current use of the parametric software is limited to advanced stages of the designing process that refer to functional, structural and compositional elements. Essence of the presented method lies in integration of abstract parametric graphics (treated as non-objective art), with idea-stimulating phase of design work which is a source of new technical solutions.

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Chetoe.com: An Integrated Web 2.0 Service for Automatically Travel Planning

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Abstract. With the constant upgrading of the quality of human life, naturally the demand for travel continues to increase. People are no longer satisfied with the old standard travel plans, and they prefer to make their own personalized travel plans from the gathered information within the Internet. In this paper, we design to setup one integrated tourism platform based on the concept of Web 2.0. It will allow users to share the experiences, pictures, and description of various locations though our designed platform. Users can have an automatically generated trip planning before the trip, have an automatically generated tourism manual during the trip, and share the experience of the whole tourism after the trip. Though the integrated travel web site, one user can retrieve the popular tourism locations recently by browsing the site. The user can also have a personal travel plan that match his preferences by easily selecting some options. After the travel, the user can record and share the travel experience of one single tourism location or the whole travel route to others.

Keywords: Automatically Travel Planning, Web 2.0 Service.

1 Introduction

With the constant upgrading of the quality of human life, naturally the demand for travel continues to increase. In the traditional solution, we can acquire pre-planning travel packages from local travel agencies or follow the suggestion travel routes from the travel books. However, with the rapid growth of Internet and Web 2.0, it is becoming an easy job to obtain the latest and most famous information from search engines or online forums. People are no longer satisfied with the old standard travel plans, and they prefer to make their own personalized travel plans from the gathered information within the Internet. It can best meet the needs of travelers with planning their own travel itineraries, but it is a very time-consuming work to surf various kinds of travel sites and experience sharing blogs.

According to the report of Taiwan Tourism Bureau [1], the total number of trips and the travel times of individual person are both increasing. There are almost 90% of

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the trips are the type of the self-guide trip. It displays that most of Taiwanese have the preference to have a trip by self-guide. Although there existing a lot of travel Web 2.0 services on the web and the functions for a travel within the individual web site are not completed enough. People who can plan their self travel in a web site, but they need to share their experiences among the travel to another web site. Not to mention the automatically travel planning.

In this paper, we will propose a Web 2.0 services that will classify the travel locations into four major types, they are delicacies, attractions, accommodations, and shopping. People can share the travel locations they have visited or visit them on our service through the Google Map. People can also recognize the geographically nearby locations through the map to arrange the travel plan. Our proposed service will automatically plan users' trips according to the travel locations and users' preferences to reduce the time-consuming work.

2 Related Works

Web 2.0 is not a standard technique. Engineers put too much emphasize on new technology researches and ignore the importance of community powers from the users themselves. Users can make a web site be abundant and diverse relative to the traditional Web 1.0 services by contributing and sharing personal experiences and knowledge. Therefore, a Web 2.0 service provides a platform for users to participate. The content of the web services are produced by the user's participation. A user in the service can have his unique page through his design of personalization. The web services will grow in a rapid speed and keep freshness according to the peer to peer sharing concepts by the users in the site. Through the power of the entire community, the entire platform will be into an autonomous self-government environment for data quality monitoring and maintain the best condition.

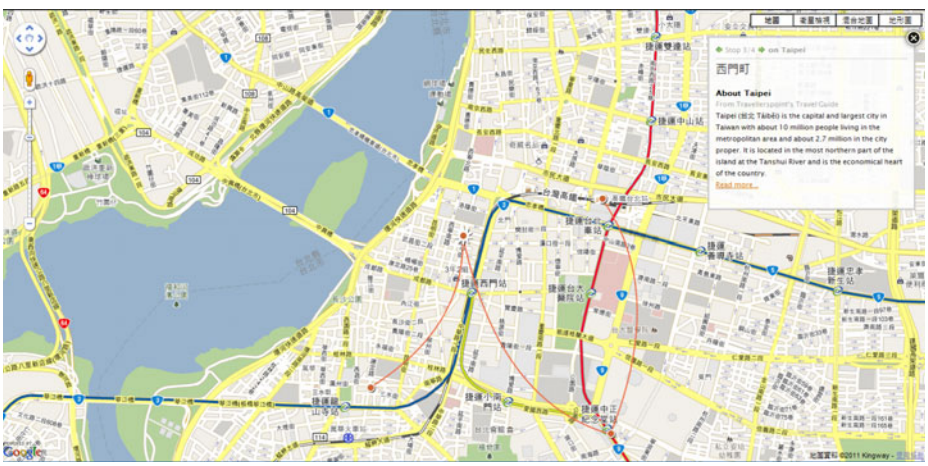

Fig. 1. A snapshot of travellerspoint.com

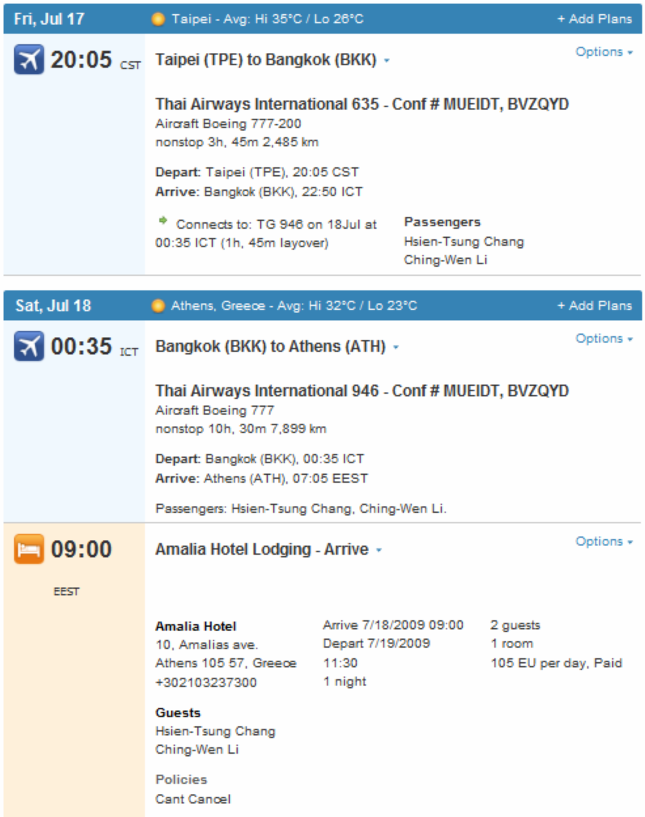

Fig. 2. A snapshot of tripit.com

Travellerpoint.com [2] is a Web 2.0 service that provides a wiki system for users to create and edit the location information like humanities, features, and histories. Users can share the pictures they took and the experiences after visited the location to the public domain. The can also manually plan their travel plan by click the "Add New Trip" bottom. The travellerpoint.com will line up the selected locations as demonstrating in the Fig. 1. Unfortunately, it only provides manually trip plan.

Tripit.com [10] is another Web 2.0 service that provides rich physical connection to other services, like global flights schedule and status system, Google Map, and hotel information, attractions information. It can help users to create their own travel planning in detail. Fig. 3 demonstrates a travel plan from Taipei to Athens. The advantage of tripit.com help user to print out the plan or access the plan via mobile devices. It can provide detail information for the user to reference when they need some help. However, tripit.com is also a kind of assistant service for travel planning, user can only plan his own trip manually.

There is no total solution for a travel plan existing in the WWW nowadays, especially the automatically travel planning service. Research is currently the only known discussion of the literature, the traditional thesis about the tour route planning try to use its own conditions and considerations of many factors. For example, Chang [4] try to identify the most time-efficient shortest path according to the time factor. However, travelers really think about the direction that is diverse, and when more factors are considering then there are more limited, so the formation of the so-called multi-criteria decision making problems. It is utilized in the research of “Dynamic criteria evaluation for tour scheduling optimization” [5]. In the researches of Shih-Jui Lin [6] and L. Coyle [7], they make appropriate recommendations according to the weights of the users to indicate the degree of attention to their preferences. Ying-Hui Lien [8] tries to use Artificial Intelligence Decision Model and human professional knowledge in the area of travel to plan and evaluate a travel route. However, it is a computing power consumption task.

In this paper, we will import the concept of Web 2.0 to build our platform, through the user an endless supply of creative energy and community strength to ensure the freshness of the information. We will also provide automatically travel planning mechanism according to users’ preferences.

3 Our Proposed System

We try to propose a Web 2.0 service that can be a total solution for a traveler. Fig. 3 is the concept flow chart of our proposed web service. Before your trip, you can visit our service to surf the experiences sharing from others in within the service. You can also join the discussions of some locations that you have visited before. When you have time to start a trip, you can easily setup your preferences, and our service will automatically generate a travel plan for you. Of course, you can adjust and modify the overall plan as your wish. After the planning step, our service will generate a detail trip manual for you. The manual will include the detail information of each location, for example, the position of the location in the Google Map, the telephone, the address, the distance between two attractions, and ticket price etc. The information was created by wiki system from users. You can print it out for your reference within your happy trip. After your trip, you can share your whole trip plan or the experience of a single attraction to others through our services. It will be a positive cycle, a user utilizes the information from our service and the information will help him to generate more information. This cycle will keep the information in the service freshness and useful to new users

Fig. 3. Concept of our proposed system

3.1 Location Information

The location information is the most important data in our services. Although the wiki system can provide a platform for users to create the location information, it is a service with empty location information in the beginning. Users almost do not have the passions to contribute their experiences or knowledge in a service with poor content.

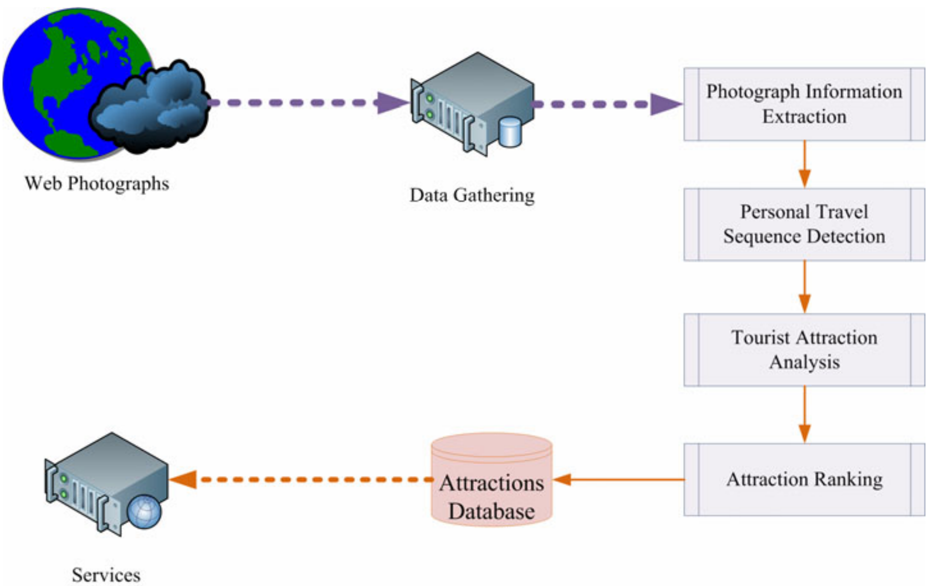

Fig. 4. The system architecture of the scenes detection

In our past research result [9], we gather photographs published by users on the Internet, with the sources encompassing the entire network (such as Internet photograph albums, groups and blogs, etc.) as well as more concentrated sources such as Flickr and other online communities for sharing photograph albums. We use the photograph with GPS information which may be embedded by camera or manually. By analysis the photographs we collected, we can easily detect the attractions around the world. Fig. 4 is the system architecture of the scenes detection. The photographs for detecting the attractions will be a good source of pictures to show on own initial attractions information in the wiki system. The descriptions and the sentences around the photographs are also can be utilized as the initial introduction to the attraction. As to the tourist ranking algorithm proposed in the research is also a good hint for the automatically travel planning. We can select the locations by the rank score generate by the algorithms.

With those initial locations information, users can help the service to adjust and modify the data about the locations through the wiki platform. This solution can solve the embarrassment situation for the empty data in the beginning of the web site.

3.2 Ranking of a Location

As we mention above, the tourist ranking algorithm proposed in our past research can be a hint for ranking a location. The second clue to rank a location can be the recommendation system in our service. When a user has visited a location, he must have his own opinion to the place. Therefore, he can assign a score to it. If the number of users to assign the score is enough, it will be a significant ranking source for the locations. The recommendation system is widely used in the Web 2.0 services, and it can easily judge the good or bad according to the power of community.

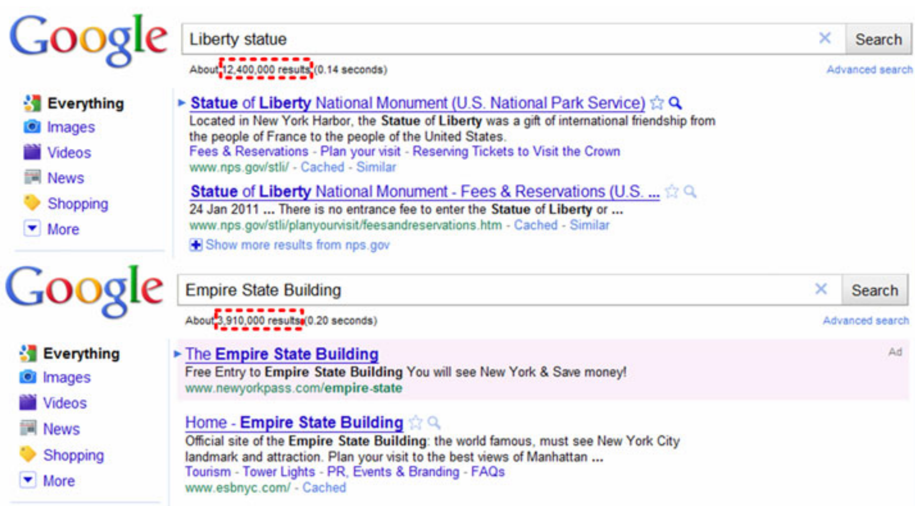

Fig. 5. The search results from Google

The number of the search results from Google is also good for ranking a location. As Fig. 5 displays, we submit the query terms "Liberty Statue" and "Empire State Building" to the Google. There are approximate 12,400,000 search results for the Liberty Statue, and 3,910,000 for the Empire State Building. The number of Liberty Statue is more than Empire State Building, this also happens to match the rank with the very people in mind. It is not just a coincidence of course, a location with more results in a search engine means that more people discuss about it. It applies that the location is also an important for traveler to visit. Therefore, the number of search results is a good clue for ranking a location for the travelers.

3.3 Automatically Travel Planning

Automatically travel planning is a complicated problem to solve. There are a lot of route types between two locations. For examples, a loop from beginning and destination locations, destination area loop, and single direction via the same route etc. In order to minimize the complexity of the problem, we have an assumption that the travel route is single direction from the beginning location to destination one.

Our proposed algorithm is a greedy one as the concept of Fig. 6. If we now in the location marked as the red balloon “A”, there are a lot of locations within the distance of predefined ***k*** kilometers. If there exists no location within the distance, we will larger the distance from ***k*** to ***2k*** even ***4k*** till we have locations within it. We will calculate the score for each location according some vectors they will be discussed latter. The location with the highest score will be chosen as the next location to be visited. In the Fig. 6, the Sun Moon Lake in the bottom of YuChih will be chosen as the next location. We will continue the process till we meet our destination location. The chosen locations are the results from our proposed automatically travel planning algorithm.

Fig. 6. The concept of the automatically travel planning

Ranking Score. The first vector for the score calculation is the ranking score. As we mention in the above section, we will use the tourist ranking algorithm, recommendation system, and the number of search results from Google to gather the ranking score for each location. The ranking score represents the major part of importance for each location.

Distance Score. There are two parts for the distance score, one is the distance from the calculated location to the destination and the other is the distance from the current selected location which is the red balloon “A” in the Fig. 6. If the distance from the calculated location to the destination is shorter and the score is larger, it will make the location selection trend to the destination. And the distance from the current selected location is shorter the score is also lager. It is because we appreciate not to travel long distance from one to another.

Angle Score. We will calculate the angle between the current selected location to the calculated location and the current selected location to the destination. If the angle is too large, for example the angle is larger than 90 degrees, and the angle score will be negative for the penalty. It is because the calculated location is away from the destination.

User Preferences Score. User can setup preferences for the automatically travel planning. If users love to visit locations that never visited before, the new locations will have positive score. Or if users love delicacies, and the delicacies locations will have higher weights.

Random Adventure Score. Our algorithm will generate a random score for each location. This score is designed to prevent that the travel plans are always the same when users set the same start and destination locations. This random adventure score won't influence importance locations. However, if the score of some locations are similar, this design will generate different travel plan for different users. There is a benefit that more locations can be visited and written with experiences if different attractions can be for different people to travel. If you are an adventurous person, you can set the random adventure as the maximum weight, and that trip planning is completely random decision.

Following is the algorithm of automatically travel planning.

```
TravelPlan(start, destination)
  Result:= {start};
  Current:=start;k=PreDefinedk;
  while(Current!=destination)
    SelectedLocation:=NULL; MaxScore:=-1;
    For all locations x distance < k KM from Current
      LocationScore(x)=RankingScore(x)+
                       Distance(x)+
                       AngleScore(x)+
                       UserPreferenceScore(x)+
                       RandomAdventureScore;
      If MaxScore < LocationScore(x)
        MaxScore:=LocationScore(x);
        SelectedLocation=x;
    If SelectedLocation==NULL
      k:=2k;
    else
      k:=PreDefinedk;
      Current:=SelectedLocation;
      Result:=Result+Current;
  return Result;
```

4 Results

We name our system as chetoe.com. The chetoe means play and travel in Taiwanese pronunciation. Fig. 7 is the snapshot of our system when users click on the Taiwan President Office. Our system will display the location around the selected place, and users can continue click the location they desired to surf. The different color represents the different type of locations. Fig. 8 is the snapshot of the automatically travel planning system. Users can easily setup the preferences and have the travel plan. The user can easily adjust or modify the travel planning though our platform, and then generate the detail tourism manual. It will be very useful for the user to reference during the trip.

Fig. 7. The locations around the Taiwan Presidential Office

Fig. 8. The results of automatically travel planning

5 Conclusions

In this paper, we design to setup one integrated tourism service named chetoe.com based on the concept of Web 2.0. It will allow users to share the experiences, pictures, and description of various locations though our designed platform. Users can have an automatically generated trip planning before the trip according to user preference by our proposed algorithm, have an automatically generated tourism manual during the trip, and share the experience of the whole tourism after the trip. Though the integrated travel web site, one user can retrieve the popular tourism locations recently by browsing the site. The user can also have a personal travel plan that match his preferences by easily selecting some options. After the travel, the user can record and share the travel experience of one single tourism location or the whole travel route to others.

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Evolution of Domestic Kitchen

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Abstract. Domestic kitchen area is the most important, most intensely used functional area in the apartment. With regard to laboratory nature of kitchen works, equipment and users of different age and physical fitness, kitchen is a potentially dangerous place. From the beginning of its existence kitchen has influenced family integration and socialization processes. For centuries the kitchen area has been changing its equipment, shape and location with regard to other rooms in a home. The appearance of ergonomics and anthropometry sciences made it possible to do a research, in order to simplify kitchen work. American housewives initiated an improvement of the kitchen area. The technical progress enabled an infiltration of functional areas, an integration of equipment functions and their grouping, which is seen in models of the open kitchen and the island-shaped kitchen. The evolution of domestic kitchen is a constant process, and because of that fact, it needs to be ergonomically analyzed. It is necessary to take into consideration the ergonomic criteria of both planning and correcting the existing kitchen solutions. Ergonomic education of statistic user contributes to the reduction of accidents and the facilitation of kitchen work.

Keywords: domestic kitchen, technical progress, ergonomics, socialization.

1 Introduction

Domestic kitchen area is the most important, most intensely used functional area in apartment. It's not only a place of food preparation and consuming, but also a place of household members spending time together, tightening the family bounds and developing the social connections. Some house works which are not connected with the kitchen work take place there. Regardless of size, functional type and layout, the kitchen is a multifunctional area. Domestic kitchen is no longer strictly the domain of housewives – thanks to the changing lifestyle, men cook or help in kitchen work more often and more willingly nowadays. Inviting guests into the kitchen area is synonymous with inviting them into the center of family life. The equipment in an open kitchen is exposed and kitchen works are no longer hidden, just the opposite, guests and the rest of family members participate in those works more and more often. The way of domestic kitchen usage confirms its multifunctional nature and emphasizes its necessity in the apartment structure. The usage of a kitchen is connected with health

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hazard. Food preparation process has a laboratory nature and the kitchen resembles a certain laboratory, where some more or less complex activities help compose ready to serve meals. The kitchen and lab analogy is more visible through its specific equipment, like a stove or an oven that generates high temperatures, sharp utensils, kitchenware, electric kitchen appliances, household detergents and the neighborhood of water and the electric current. It is easy to have an accident in the domestic kitchen with a health hazard. Falls are included in the most common threats, not connected with the kitchen equipment, e.g. as a result of slipping on water spilt on the floor. Threats associated with using the kitchen may have effects delayed in the time, e.g. food products and kitchen waste in combination with dampness and warmth, create a favorable environment for harmful pathogenic micro-organisms to multiply. Both, fit people and the disabled, older people, crippled people or moving on wheelchairs as well as children are users of the kitchen. Especially the disabled and old people need more communication-motor space, and equipment located on an appropriate height. If that is not fulfilled, the risk of accidents is grows significantly. The presence of children in the kitchen requires additional precautionary measures and securities, as well as the supervision of adults. The common lack of an optimal connection between the kitchen area and the rest of functional areas in an apartment, makes it difficult to communicate and causes collisions. The earliest experience in contacts with other people takes place in the family house. The family is the smallest social group, within which the first relations are being built between household members. The milieu, an appearance and a spatial-functional arrangement of an apartment, can influence the intensity of these relations. Domestic kitchen is one of the fundamental areas, which affect the socialization process. In houses, where the kitchen area is not only a workplace, but also a space of being together, a very important task is social integration, and deepening relationships with family members and friends. Children watched by the mother, grandmother or the rest of family members, may participate in small kitchen works, learn or play, and by that, acquire the ability of peaceful coexistence in the community. The rapid pace of life, the career, the education or extracurricular activities more and more often cause the lack of the time for spending time together with the family. Therefore, the process of preparing meals and eating them more and more often become the only moment, when the family can talk, discuss family affairs or simply be together. Common family contacts are an inherent element of the family life, and they have a big influence on human psychophysical comfort, especially for children (education, upbringing process) and for older people (the feeling belonging, being needed etc.). Domestic kitchen is a special area in an apartment – on the one hand it is this so-called heart of the house and center of the family life, often called the hearth, on the other hand it is a place potentially dangerous, which is what the users and designers often forget about.

2 Shaping of Domestic Kitchen – From Prehistory to Present Time

Food preparing area goes hand in hand with mankind, from the moment people started to use fire. Before people started to settle, they would gather with family members around the bonfire finding warmth, safety and thermally treated food. The prehistoric (period from the beginning of the history to about 3500 BC) kitchen area was the immediate surroundings of the bonfire. The originally nomadic lifestyle soon turned into settled, the kitchen area became the hearth. It was the only element of permanent equipment [1]. The conversion of primary bonfire into the form of the centrally situated hearth was the first step for establishing the functional layout of the homestead, in which the food preparing area constitutes the superior role. The period called Antiquity (from 3500 BC to 5th century) initiated the division and zoning of the homestead, in which the location of kitchen area was conditioned mainly by the social status of the householder. The possibility of having slaves resulted in the isolation of the kitchen area from the formal part of household. Modest homesteads continued the model of a centrally located hearth. A stove made of sundried bricks was elementary permanent equipment. A specialization of the kitchen equipment took place, and the grade was dependant on the wealth and financial possibilities of the user. The outside stoves didn't require ventilation systems. Ventilation was held in closed compartments through door openings, comparatively through the hole in the roof, or more rarely through a window opening [2].

Medieval kitchen area (period from 5th century to 15th century) in its early stage was located in the central point of a homestead [3]. The multifunctional nature of that area was characteristic particularly in climatically cooler regions of Europe. Urban housing development initiated the division of homestead into individual functional areas, and once again in history, the material status and exploiting servants for kitchen works, have separated the kitchen from the rest of the rooms. Other matters which caused resignation from the central location of the kitchen area was among others a fire hazard, problems with carrying out smoke and implementing additional sources of heating [4]. The change of kitchen area location did not reduce its importance, which was emphasized by the variety of equipment, work place organization and specialization of kitchen tools, like the rotational spit, pots, and grilling tools [5]. A hearth or an open fireplace was a basic component of permanent equipment in a medieval kitchen area. Inside cottages of poor people it was usually a hearth or a huge clay stove, at first without the exhaust system [6]. The ventilation was held in rich houses and castles, through window openings, hoods, sometimes through the roof holes, or rarely by the doors. The hood, which enabled to carry out smoke outside the building by the chimney-pot, was a novelty [7].

The so called modern era is a historical period initiated by the age of the Renaissance (15th century) and spanned to 19th century. The appearance and equipment of contemporary kitchen was conditioned, above all, by the material status of the owner. The migration of the rural population into cities caused the growth of service employed as servants, and that fact caused the tendency of separating the workplace like kitchen area from other rooms. A diffusion of ventilation by hood and chimney, and stoves providing the usage of new kind of fuel – hard and brown coal, made it possible to locate kitchens in any place in a household layout [26]. The kitchen areas moved away from the residential areas into the basements of houses (England), to the backyards with separate entries (France), or into the separate buildings next to houses (Poland) [8]. The different attitude to domestic kitchen area was observed in Dutch homesteads, where a very few, or none of servants, shared the work with a housewife, and the decoration and kitchen equipment confirmed its leading meaning in the house structure. The integrating function of kitchen area was kept in the countryside, where the stove often took up the entire corner of the only chamber [9].

The rise of the contemporary model of kitchen area (so-called present times: period from 19th century up to first half of 20th century) initiated the development of technological progress known as Industrial Revolution. An intensive expansion of factories caused the depopulation of villages, people's migration to cities, and the formation of working-class' housing estates [10]. Still, a contrast was noticeable between the kitchen area in rich residences, kitchens in homesteads of the country poor and flats of the new municipal working class. A kitchen development as an interior took place, and kitchen area gained attributes of today's kitchen. The growth of kitchen ranges contributed to more kitchen improvements. The research on more spectacular, and more economical usage of current fuel, like wood and fresh released on the market coal, grounded the construction of easy to use closed cast-iron stoves, with the possibility of temperature adjustment and reduced dimensions [11, 12]. The next step forward was an introduction of new sources of the thermal energy: the fuel oil, gas and the electricity. Stoves of those types gradually entered into households [1, 13]. The reduction of servants in American houses forced the carrying out of duties on housewives. That inclined searching for new concepts of residential interiors, particularly the laborious kitchen area. Permanent kitchen equipment has changed, organizing the order of carrying out successive meal preparation stages.

Enforcement of food pasteurization methods, next to accessibility of frozen food, revolutionized the previous way of meal preparing [14, 15]. Appearance of new materials, appliances made of stainless steel or aluminum, and household detergents, contributed considerable improvement of hygiene in kitchen area [12]. Water supply systems, gas piping and wiring systems, appeared in large numbers in cities [16]. Gradual reduction of kitchen area space was caused by the expansion and variety of kitchen equipment, fittings and wiring presence, reduction of servants and housewives employment. Thanks to numerous kitchen improvements, women did not have to spend nearly all day in the kitchen. Increased housing demand for the working class was solved through the development of multi-family residential buildings, and by so-called Frankfurt Kitchen - work kitchen designed like a laboratory [17].

The birth of prefabrication took place in early period of 20th century in United States. In many countries of Europe, including Poland, the prefabrication was popularized after the World War II, when housing demands in destroyed European cities were filled up with blocks of flats [18]. Regardless of apartment size, the small work kitchen was isolated from other functional areas. Beginning in the second half of 20th century, the model of laboratory kitchen became a standard [19]. The isolation of a housewife during kitchen works met with criticism, what later lead to changes in the functional layout of new and renovated apartments. The open kitchen, partly or entirely connected with a living room, appeared soon in. Entering of more and more excellent materials and modern forms of design influenced further functional changes in the kitchen. The kitchen regained its meaning as the multifunctional center of the apartment, gathering household members like a prehistoric hearth.

3 The Domestic Kitchen Rationalization

From the beginning of civilization people tried to make improvements in their surroundings by applying primitive - at first - inventions, like simple forms of tools and furnishing. All improvements of kitchen area, which took place from the beginning of humankind to crucial 20th century, confirmed the existence of the so-called intuitive ergonomics – also called the unconscious ergonomics. It was a way of shaping the tools or residential area, in order to adapt them to dimensions of human body or other special needs [20]. An evolution of thermal processing area illustrated the example of such action, like raising and encasing the hearth, so that there was no need to bend over it, then a medieval rotational spit made for more efficient and more comfortable grilling, and finally stoves with the heating plate from 18th-century, which eliminated the need of suspending pots above the fire [21].

The 19th-century North America was a cradle of efficient and functionally designed kitchen. With Industrial Revolution, a rapid development of industry and mass production took place. That released the need of bringing up issues associated with adapting the omnipresent machine to dimensions of the human body and initiated such studies like ergonomics, anthropology and anthropometry [22]. Research on work organization, the functionality of devices at workstation, and appliances level of adaptation to the employees, was commenced. The scientific methods of work organization were used for the first time in the United States [23].

The forerunners of the introduction work organization rules to the domestic area, were the most familiar with kitchen work housewives. The need of self-sufficiency on many levels of everyday life, caused by lack of housemaids, initiated deliberations about housework rationalization in kitchen area. The purpose was to make it possible to perform all housework by one person – a housewife. In 1841 Catherine E. Beecher wrote "A treatise on Domestic Economy for the Use of Young Ladies and at School", where she precisely described the appearance of a kitchen, determined accurate location of kitchen range and sink, and suggested a lot of practical conveniences. In 1869 Mrs. Beecher and her sister Harriet published "The American Woman's Home", in which they promoted reduction of house space to minimum, in order to spend less time for clearing it up.

Christine Frederick in 1912 wrote the article about improvements: "The New Housekeeping: How it Helps the Woman Who Does her Own Work", in which she defined the adequate height of worktops to eliminate the need to bend down, usage of drain boards and driers next to sinks in order to eliminate the need of wiping the dishes, and rational kitchen tools location. She was also an author of so-called household without housemaids. In 1923 Mrs. Frederick wrote "Household engineering: scientific management in the home", in which she reduced the kitchen works to two essential procedures: preparing and cleaning [24].

Margarete Schütte-Lihotzky was an author of the laboratory kitchen. In 1926 the laboratory kitchen was used in about ten thousand social flats in Frankfurt. From that time it was called the Frankfurt kitchen, and this model of kitchen area became a standard in social flats until the end of 20th century. The simplified model of laboratory kitchen was equipped with indispensable devices and utensils, and provided comfortable work in spite of small work space. It was a standard solution in multi-family prefabricated residential buildings, of which the full bloom in Poland fell in 1970s [21]. While using them, it turned out, that the model of the closed work kitchen was not an optimal resolution because of limited space and separation of functional area, however the carried out research and the improvements notably simplified the kitchen works by sequencing the kitchen technology.

4 Contemporary Model of Multifunctional Kitchen: The Open Kitchen and the Kitchen Island

Domestic kitchen has changed during the last thirty years – it has evolved to the most important functionally area in apartment. The attitude to kitchen works has changed relatively lately, but its role in tightening the family and social bounds was noticed long time ago. The conception to join the small closed kitchen with the daily area was presented at first in single-family housing in the USA. In 1934, a house plan, designed for Malcolm Willey by Frank Lloyd Wright, had the kitchen partly open into a living room. Although the kitchen area was called the work room, it was connected with the social area, divided only by furniture. The idea was to merge the cooking, dining and home entertainment areas in order to encourage the husband and children to participate in kitchen works [25]. Of course, it was working on relations between family members. On the contrary, in common block of flats, the small isolated kitchen was a dominant till almost late 80s of 20th century. Functional changes in the kitchen area in apartments' were initiated by unsatisfied users – housewives enclosed in small kitchens, suffering from psychological and social discomfort. In Europe, those changes took place later in relation to the North America, where as early as in 1960s a window located between the closed kitchen and living room, or the dining room, was used to serve meals, and to take back the dirty plates. This connection paved the way for walls elimination between those rooms, and it contributed to the introduction of models of the so-called open kitchen afterwards [26]. The multifunctional kitchen area, often opened and connected with a living room, was no longer a neglected, hidden part of the flat.

The appliance, changed by the influence of technological progress, which enabled the introduction of the open kitchen, was the kitchen electric hood. Keeping away from the rest of apartment all unwanted smells, accompanying the cooking process, was one of the reasons to close the kitchen. Inside the above-mentioned Malcolm Willey house, the kitchen was well aired by windows and chimney hood, and that enabled opening the kitchen area [25]. Most flats had no such conveniences and possibilities. The electric hood made it possible to remove unwanted kitchen smells, and by this, encouraged to open the kitchen area in each type of apartment.

Effective ventilation systems and high-tech ventilation hoods have been improved, and they can work efficiently in the close circulation system - there is already no need to connect the kitchen ventilation hood to a flue [27]. That allows a free location, e.g. on the ceiling or on the furniture equipment near the cooker. The example of advanced equipment is "De Dietrich" hood, which is mobile, and can be slipped into a worktop after the cooking process [28]. A hood can be equipped with an intelligent system – thanks to the CSI technology it turns on when the sensor detects any smell. Some of models have other features, which simplify work, like height regulating systems [29]. The ventilation hoods take visually interesting forms; they can be equipped with additional functions, like lighting points. Although lighting points mounted into a hood became a standard, there are some other additional functions of the kitchen hood. Few years ago "Siemens Media Hood" appeared - a hood with a 17" LCD screen, CD and DVD, and with the Internet connection. That kind of hood is not only kitchen equipment, it connects the kitchen to the outside world [30].

The manufacturers are trying to get ahead of each other in selling competitive solutions for kitchen devices. A universal computerization of kitchen equipment is taking place. There is a possibility to control the electric kitchen equipment from a distance by the Internet. Some devices, like hoods and fridges ("Screenfridge" by Electrolux), provide a possibility of watching TV and surfing on the websites [31].

The kitchen furniture is no longer associated with the kitchen, and more frequently with the living room. The kitchen evolved to the rank of the kitchen room. Kitchen rooms are equipped with representative furniture, merged into furniture of the living room, and the only thing indicating that it is a food preparing area, is the presence of kitchen accessories, like the sink or the heating top. An attractive design is characteristic for kitchen equipment details, and because of that fact, they are exposed more willingly. The technological progress causes the disappearance of visual borders between the working and relaxation area. The contemporary kitchen equipment is more and more frequently designed by well-known designers, and it becomes recognizable. One of the most recognizable kitchen tools, available in most schops, is a citrus squeezer "Juicy Salif" by Philippe Starck, designed for Alessi [32]. Other example of well known futuristic kitchen equipment is "Z.Island by DuPoint" – the kitchen designed by Zaha Hadid [33].

There is also a great choice of technically advanced equipment, and everybody can choose an optimal solution. That kind of a kitchen model encourages the users to spend time on cooking with the family or friends - kitchen works become a pleasure, nearly a relaxation. It is possible to apply the model of the open kitchen both in bigger flats and houses, and in cramped flats with existing closed kitchen. Limited space of the kitchen, connected with the daily area, causes an optical enlargement and improves the apartment quality.

A so-called kitchen island is a common element of open kitchen furniture. The location of the kitchen island on the border of kitchen and living room, and divides those two areas and simultaneously joins the space of work and rest. The kitchen island means detaching some elements of furniture and equipment from the walls, and situating them in central location of kitchen area. It is possible to locate a worktop, a cooker, an oven, cupboards and a sink on it. Elastic wirings enable to apply these all elements of kitchen equipment and furniture, and it induces increasing of work space on the kitchen island.

The kitchen island can be applied in all types of kitchen interiors. The kitchen island is most suitable for bigger rooms, but even in relatively small kitchen it is possible to use it. Small modular kitchen island, designed by Kristin Laass and Norman Ebert, can be folded after cooking, and at its most minimalistic dimensions it only uses one square meter of space. The "Small Kitchen" contains everything needed to prepare meals: a sink, a cooker, an oven, a refrigerator, kitchen cupboards with kitchenware and all necessary utensils [34].

Central position of the kitchen island generates proper accessibility, improves it, and makes kitchen works more attractive. The kitchen island can combine individual functions, and become a main work space. An example of efficient kitchen island includes a sink, an electric or induction cooker, and storage cupboards or shelves. Such elements as cookers, kitchen sinks, countertops of diversified height, create comfortable conditions for all kitchen works. The kitchen island can be connected with the living room or can be a room - a change in previous kitchen equipment installation, so far usually placed by the wall, is characteristic for both models of the kitchen island. This transformation improves the communication between functional areas, and by exposition of equipment, which previously was seen as unworthy to expose, raises the rank of the kitchen. There is a very wide range of diverse designs of the kitchen island, determined by required features. The kitchen island is an attractive solution, which assures very good conditions of performing all kitchen works, and supports the tightening of family bounds. Devices and furniture of the kitchen island often takes over the majority of functions required, including the function of accessories and food storage. The shelves on the kitchen island can be opened, in order to simplify location of tools and kitchen utensils, but in most cases the island looks like a representative furniture, without possibility to see what it contains. The storage space is usually located under the worktop, but can be placed above it, within comfortable reach.

More and more often kitchen islands are designed as an independent center of food preparation, especially the thermal processing. The eventual storage area is located separately, by the wall. Progress in the field of kitchen equipment manifests itself among others through its mobility, and the kitchen island is perfect for that. There is no need to keep close to service riser. Even more, some kitchen islands are easy to move and relocate; a good example of such kitchen is “Tokyo Kitchen” – the compact kitchen is attractive and gives a possibility to arrange the two separates islands optionally, or to put the islands together in one, perfectly fitting piece [35].

The island kitchen doesn’t have to look like an integrated kitchen equipment. Some of those ideas let not only to relocate it, but to fold it in a sort of sculpture, which looks like a sculpture, not identified with kitchen equipment. The Brazilian futuristic “O kitchen” with a spherical shape, after the meal preparation, can be folded, and looks like a giant mysterious white ball, which encourages exposing it [36].

The kitchen island found a permanent place amongst the functional arrangements of kitchen area. Its constant evolution seems to be setting the future of an optimally designed kitchen.

The open kitchen model, in analogy to the primitive multifunctional homesteads, unites the family in the food preparing area. However, unlike them, that gathering is not forced by the presence of fire, but it is a conscious action to integrate the family members. It is very important nowadays, because of the reduction of family meaning as a basic social unit.

5 Summary

Combining the work kitchen with the social part of apartment, is connected with some functional-spatial changes of kitchen area, which opens to the daily area more and more often, creating an open common space. The tendency to improve the kitchen appearance and details’ quality is an effect of those changes, as well as initiating the solutions, which exalt the kitchen’s meaning and increase the daily comfort of its usage. Future design tendencies are more and more frequently based on ergonomic criteria, which provide the correct realization of technological processes, with the simultaneous consideration of the technical progress, and the assurance of the convenience and the safety for users. The widely understood technical progress generates the changes in domestic kitchen.

The evolution of domestic kitchen is a constant process, and because of that fact it changes continuously. Modern equipment, which found a permanent place in the kitchen area, needs to be analyzed because of appearance of still unexplored designing and ergonomic relationships, in order to eliminate the safety hazard. Designers should enhance their knowledge in domain of ergonomics, not only to modernize existing, wrong resolutions, but most of all to apply the prevention of design mistakes in new built apartments. It is necessary to bring in some kind of kitchen operating instruction manual, which will make it easier to use, safely and comfortably, for both healthy and disabled users. Specifying threats is very important, showing the ways of avoiding them, and explaining the meaning of the accident prevention. The necessity of the widely ergonomic education of household members seems to be the priority. The usage of the conceptual ergonomics in designing process, including the steps necessary for the adaptation of the kitchen area to the changing needs of the user, minimizes or even eliminates the need of further modernizations in the future. The existing solutions, thanks to the corrective ergonomics, can gain features of the optimally designed kitchen. Because of the changing range of kitchen works, which is connected with technical progress, functional changes and technological innovations, a research continuation is needed, as well as a periodic verification of the kitchen equipment and the technology of kitchen work.

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Perception and Illusion in Interior Design

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Abstract. Beside physical methods to modify the limits of interior space, there are also some design decisions and tricks that can change the perception of a visual space. Therefore, it's possible to correct interior without redesigning or destructions – breaking old walls and making new ones, for example, with the help of optical illusions that change visual perception of interior space. A room can be visually enlarged, deepened, broadened, heightened, narrowed, or lowered. Things like color, lighting, interior elements placement, integrated – horizontal or vertical – lines, shapes, mirrors and even style of interior equipment and finishing materials can correct the interior space because they can have a significant impact on the size, proportion and mood of a space. It's possible to achieve great effects by combining knowledge of perception and knowledge of design.

Keywords: interior design, sense of vision, visual perception, optical illusion.

1 Introduction

There is considerable scope to achieve great and sometimes surprising effects in interiors formation by combining knowledge of perception, knowledge of optical illusions, visual tricks and knowledge of contemporary interior design.

By optical illusions we mean those changes in visual perception of a room size and proportions that occur under the influence of psychological phenomenon, visual memory, visual impressions, color perception, contrasts, brightness intensity and focal brightness, glare, visibility of task detail, illumination. These are the major factors comprising the performance requirements for the visual environment. These are also basic factors influenced our perception of space and our emotional response to space.

Proper planning, interior elements, furniture and mirrors placement can correct every space, while color and lighting considerations can be used to emphasize the space or place.

With understanding the effect of color and light on the perception of space designers can shape and modify the visual experience of room, for example, by manipulating the perceptual role of lighting – both to facilitate visual tasks and to define the visual boundaries and hierarchy of a space, area, or activity. Designers can also manipulate the psychological role of lighting to help establish a sense of intimacy, privacy, coziness, cheerfulness, or somberness in the room.

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The use of color in interior design should be based on knowledge of color perception and knowledge of color impact on human. Optical effects of colors are a visual effects associated with the perception. They also include various types of optical illusions and visual tricks. Psychological effects of colors are felt in emotional and related to feelings, and impressions.

Color of light is also significant. Subtle changes in the color tone of light can influence the subconscious judgment of interior space.

A mirror and mirror illusions are an excellent and specific way of modification, in particular enlarging of room space. This effect is created thanks to reflection and optical illusions. Experiments with a mirror and mirror surfaces are justified especially in small-scale rooms like bathrooms, halls, staircases etc.

One more thing that also causes the room can be changed and corrected is the style and kind of interior elements and finishing materials. The effect can be a result of material type (wood, metal, glass, plastic, textiles etc.) or material features and characteristics (pattern, texture, ornament, color, gloss etc.). [1, 2]

2 Vision

The sense of vision is based on the eye's ability to absorb and process selectively portion of the electromagnetic spectrum. That electromagnetic spectrum we call light. This sense is particularly essential, because is used for most functions that require a understanding of spatial relationship and detail. First of all, vision includes the process of orientation and the formation of spatial impressions. But it also involves scanning a variety of information cues, making simultaneous or successive comparisons, and assigning mental priorities regarding importance. Vision is used for identification of significant information sources and the subsequent getting of right quantitative and qualitative information. Finally, vision is connected with perception and interpretation movement and rates of change.

Perception of color, response to brightness (adaptation, judgment of brightness differences, glare, effect of aging), the visual field (perception of fine detail in the visual field, detection of movement), the luminous environment – are just some of the areas that should be considered.

With understanding of the basic aspects of vision and perception and knowing how the human visual system works, designers can create a great variety of different interior feels. [1]

3 Lights

Light affects the visual quality of a space and the sense of well-being experienced by users of that space. Light patterns and structures influence our sense of space, our impressions, and consequently our actions. Therefore, the designer should become sensitive to the uses of sparkle, silhouette, intensity, color tone, and other forms of spatial light. The designer must recognize that the correct use of light structures is fundamental in satisfying some space-activity requirements, such as reinforcing attraction or attention, emphasizing impressions of visual clarity and spaciousness, enhancing impressions of privacy and relaxation, stimulating sensations of spatial intimacy, warmth or coziness, or reinforcing impressions of cheerfulness. [1]

3.1 The Effect of Light on User Orientation and Room Comprehension

Some lighting patterns affect personal orientation and user understanding of the room. Spot-lighting or high-contrast focal lighting affects user attention, consciousness and, for example, user ability of concentration. Wall lighting and corner lighting affect user understanding of room parameters like size, height and shape, determining or modifying the sense of visual space limits. [1]

3.2 The Effect of Light on Impressions of Activity, Setting and Mood

Other lighting models seem to suggest that light can be a medium that assist communication of spatial ideas, impressions and moods. In this sense lighting patterns can assist the interior designer in creating impressions of playfulness, pleasantness, seriousness, tension, and other qualities. The designer can also use light patterns to affect psychological and social impressions such as intimacy, privacy, warmth and coziness. Lighting can be used to produce a solemn and festive atmosphere for ceremony, party and show or to produce an austere and sober atmosphere for meditation, relaxation. Lighting can produce a cold, impersonal public place or reinforce an impression of a warm, intimate place where a greater sense of privacy is required. These impressions or moods creating by light are often fundamental in satisfying experience and activity requirements in a designed space and they are essential condition of well-being experienced by user of that space. Lighting in this case should be seen not only as an aesthetic aspect shaping the human environment but rather as a tool for influencing human behavior, performance, and activity. [1]

3.3 Color of Light

Subtle differences and changes in the color tone of light can influence the subconscious judgment of the general environment. Perceptual awareness of this aspect of lights is most intense and noticeable when a change first occurs or when the individual first enters a space, before the eyes has time to adapt to the new condition.

Subtle shifts in the perceptions of surface tones and colors affect the sense of warmth or coolness associated with the visual space. People tend to associate a warm visual atmosphere with hues of yellow through orange and red to red-purple. Warm light sources like the sun, many incandescent lamps, and some new fluorescent lamps tend to create a dominant impression of visual warmth by emphasizing these hues while graying others. On the other hand, cool light sources, such as skylight and some fluorescent and metal halide lamps emphasize the colors that tend to create a cool visual atmosphere, from hues of blue-purple through blue and blue-green to yellow-green.

Detailed observation of these phenomenon may lead to definitive guidelines on the color atmosphere and its impact on sensory responses. Recent research in this area indicates, for instance, that the color tone of an environmental may affect perception of environmental temperature. Designers may be in a position to conserve energy through careful analysis of visually modified sensory responses. [1]

4 Light Illusions

Designers can shape and modify the visual experience of room, for example, by manipulating the perceptual role of lighting – both to facilitate visual tasks and to define the visual boundaries and hierarchy of a space, area, or activity. Designers can also manipulate the psychological role of lighting to help establish a sense of intimacy, cheerfulness, or somberness that is appropriate as background for the intended activity. Apparently light and dark are not antagonistic but rather complementary phenomenon. Without shade light can lose much of its effectiveness as a communicating medium. Through the careful manipulation of light and dark or correct using of light stresses designers can shape and modify the visual experience of interior space.

When using optical illusions for visual correction of the space, a significant effect is achieved by the correct use of light stresses. Change in the brightness of some room sections resulted, for example, from their different functions, is essential procedure.

The effect of increasing the visual height of a room is made with the help of ceiling decoration with integrated lamps. Besides, designers can gain this effect with the use of the 3-D structure of suspended ceilings, mirror glass, illuminating in the top part of a room, or by creation of a shiny surface.

Light cold colors and shiny textures visually level ceiling up. Illumination of ceiling with integrated lamps, can create interesting effect – ceiling “dangling” above a room.

It’s also possible to evenly illuminate walls and lower corners of a room with small lamps. In this case it will visually look wider. If the space, on the contrary, must be narrowed, designer should illuminate upper corners.

To make a right-angled room look more square, to a monotonous and equally illuminating of the three walls designer can add an expressed light stress on the forth wall, the farthest one.

Besides that, designers can change visual proportion of the room through the experiments with the light underlying of some interior objects.

All the illusions of brightness-contrast may be produced by lighting. Surfaces, forms and details may appear larger or smaller, harsh or almost obliterated, heavy or light.

In fact, lighting plays an important part in influencing the mood or expression of a room.

A ceiling may be “lifted" by light or it may hang low and threatening when dark, due to relatively little light reaching it. Columns may appear dark on a light background or vice versa, and these illustrate the effects of irradiation.

Designer can also create the perception of a larger space with the use of lighting. Just as a lighter colored ceiling creates the sense of openness and spaciousness, so too, can bright windows and natural light. Blinds and window covers minimize window exposure and moderate natural light, so the window coverings should be used sparingly in smaller rooms. Maximizing the natural light will emphasize the space and make the room appear larger and brighter. It’s possible to use the reflection of light to make a space look larger. Strategically placing a mirror, or even a collection of mirrors, in the relevant, appropriate part of the room is an easy way to use the reflection of light to advantage in decorating a small space.

Decorating a small room with the goal of making limited space feel more spacious can be easy when designer consider the impact of color and light on user perception of space. By using color and light to user advantage, designer can emphasize the space in the room and make small room feel more open and spacious.

Space of room may be given a variety of moods or expressions by varying the lighting. The various moods may be considered to be illusions because in fact the room and its physical characteristics have not been altered in reality. It should be obvious that lighting is a factor with high potential of interior creating. [1, 3]

5 Creating Spaciousness with Color Illusions

Color and color combinations are an extremely effective and many-sides instrument available for designers. It's possible to visually change the space in all three dimensions by correctly controlling ground-colors and color stresses.

It is necessary first to examine the effects of light and dark colors within a small space. Light colors make rooms and objects look larger than they are, while darker colors make them look smaller and heavier. Lighter colored ceilings and floors create the effect of a higher ceiling, whereas traditionally dark colors make ceilings lower. Light colors visually broaden the space and a room seems wider and larger. The same applies to wall color, so using light wall colors with matching light trim and baseboards will also make space seem larger.

Although lighter colors do create an airy sense, this does not mean that interior designers are limited to using lighter colors when they arrange and decorate a small room. In practice, contrasting dark colors with lighter colors further emphasizes the effect of spaciousness. For example, a dark couch on light colored flooring and on light wall behind it, as a single dark element against a light background, will seem smaller than it actually is and not very large room will appear more spacious. It is possible to use dark colors to create the sense of openness and spaciousness in a smaller space. The essential consideration is to use darker colors in contrast with lighter colors to create the illusion of more space. It is also important to reduce of dark colors to a few small items.

Irrespective of the use light and dark contrasts, designers can shape and modify the visual experience of interior space through the careful and correct manipulating the warm and cool colors. For example, if a room is not big, they can "broaden" its walls by using light cool colors in finishing – grey-blue, pearl, or pale green. If a room is larger, pastel or deep colors in a warm spectrum will be appropriate for it.

To the colors that visually broaden the space the following ones belong: neutral white, light beige, warm beige-orange, different shades of yellow, cold light blue, blue, cold blue-green. To the colors that create the effect of restraint and closeness of the space the following ones belong: black, dark brown, blue-green, blue-violet, rich red, yellow-red, orange-red, warm reddish colors. There are also neutral colors that don't quite change the space perception. These are green, purple-red, violet and grey.

The broadening of visual living space can result from a common color - grade of a sitting room, a kitchen, and a dining room. Especially the color of floors and walls in this area should be the same as the main colors of major part that is usually living room. Application of light and warm colors in the main room makes the flat look wider, larger and more spacious. The effect of a bigger height is achieved by coloring the floor in rich and saturated colors. Red and all shades of red effectively accentuate horizontal lines and planes of the floor.

Blue and all its shades on the floor are cold and unpleasant in the reception, especially on the large part of floor, but, at the same time, it seems big and wide. Warm yellow and all its shades on the floor make a room spare, bright and sunny; however, light color visually doesn't give a stable support for legs and heavy elements of interior. [1, 2, 4]

6 Mirror Illusions

The mirror increasingly becomes a material, or rather a tool for creation of interior space. There are many mirror tricks that can improve the real interior proportions, modify the room in terms of spaciousness. The first, and perhaps the most famous trick is gaining of enlarged room through the large mirror surfaces. This procedure can be used in living rooms, separated or combined with a kitchenette, and rooms that should be a large, spacious, bright and elegant. However, it is particularly justified in the small-scale rooms like bathrooms, halls, staircases etc. They are usually small and quite tight, so any extra space, even created using help of mirror reflections, increases their attractiveness.

Mirror tricks and methods is especially appropriate in the interior of a small-scale bathroom. It follows from the specific facts:

- mirror is one of the necessary functional items in the bathroom – the mirror is bigger, the better,
- users spend a lot of time in the bathroom where engage in many different activities, and this place should be comfortable and aesthetic, light and airy, they have to feel good in it,
- the bathroom normally is organized on the very little space, usually devoid of windows.

Therefore, instead of a small mirror over the sink, background off wall can be covered with a mirror, that will make bathroom seem much bigger, and additionally brighter through the impression of increasing of reflecting lights amount.

The effect of increasing the visual spaciousness of a room is made even with the help of mirror on a part of the wall or mirrored closet doors. It is possible to improve the real proportions of the room, taking into account principles that the vertical surfaces of the mirror make effect of bigger room height, and horizontal surfaces of the mirror make room seem lower, but wider. The mirror located opposite the window effectively causes brighter interior. Reflection can also be used to create a different kind of spatial tricks. For example the plants located against a mirror background will visually look more impressive.

Two mirrors mounted at right angles create amazing illusion of a four-times increased space. However, the set of mirrors facing each other can be used to create endless "tunnels of reflections."

The mirror, properly fitted on the wall or ceiling, may give the impression of increasing the number of light points. This trick can not only brighten a room, but often make the interior more interesting, richer, or more representative.

The mirror embedded in the ceiling visually lifts it up, optically increases the room and opens them up. These tricks can be used in residential rooms such as bedroom and bathroom, as well as public institutions such as shops, boutiques, clubs or restaurants.

The mirror in the interior is connected with the ability to create optical illusions, reproductions, distortions-to-measure "distorting mirror" used to emphasize the importance, validity, attraction of place, and often in order to stimulate the imagination of the viewer, to take him by surprise with curiosity form and space that are not always realistic and comprehended.

Number of mirror combinations, statements, invoices, systems, methods of their connections, as well as the number of possible effects and impressions seems to be unlimited. However, the matter of a mirror through its neutral colors and texture seems to be a corresponding element for almost every kind of space. [2]

7 Style and Decoration Illusions

One more thing that also contributes to the change and correction of the interior space is the style of applied finishing materials and interior articles. The effect can be a result of material pattern, texture, color, gloss etc.

For example, horizontal lines visually stretch a room, creating the effect of space increasing, but, at the same time, lower it. Vertical lines, on the contrary, narrow the space on the level, visually increasing it vertically.

Small element of interior decoration visually makes a room wider, a big one – smaller.

White objects on a dark background optically make the space bigger, widening and lengthening it. Checkered, striped or filled with a repeated pattern surfaces, sections or elements seem bigger than self-colored ones that are equal in size.

The use of the vertical patterns and ornaments in the wall decoration visually makes a room higher. The same effect remains if there is a vertical in the form of pictures, paintings or vertical divisions on the walls, which “elongate” the height. The effect of more room height is achieved by the use of the pattern that is on the background and of finishing materials with gloss varnishing. [2]

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Spaces of Mutable Shape and the Human Ability to Adapt

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Abstract. Life in our present world demands of man an increasing degree of mobility, and increasing flexibility from his environment. Users and recipients demand more and more from architects. Architecture should be a reflection of specific individual characteristics of its user. Introducing dynamic aspects to architecture is rooted in history. It always had its causes, since architecture functions as a mirror of social phenomena. Man's social and environmental evolution maintained equilibrium. However, the application of mechanisms for mobile facades, or mutable shapes in general, exposes the individual to even more dynamic conditions in his or her immediate spatial surroundings. This prompts us to consider human's actual adaptive capabilities, so as to maintain optimal conditions for live in such a dynamic environment. By introducing artificial control over the intensity of changes in the space surrounding us, do we risk disturbing the evolutional equilibrium of the individuals living in that space?

Keywords: architecture of mutable shape, dynamic, perception, identification with the user, modern mechanical systems, mobility of form.

1 Introduction

It is not obvious whether the human need for change is a need inherent in every individual or results from the necessity to adapt to a changing environment. Giving spaces and surroundings the ability to change their shape or location could conceivably unbalance their reception and make their intended use difficult. At the same time, previous research shows that permanent stimulation of our senses can improve the quality of our lives by creating highly luxurious conditions. Architecture by itself can, through mutability of shape and space, respond to the questions and anticipate the needs of its recipient.

"Not only is man part of a considerably more mobile world than the rest of nature, but he also treats the basic idea of mobility in a completely different way. For man, the norm is living in changing conditions – changing of lifestyle." [1, own translation]

"Representatives of the technology cult overestimate the role of changes caused by technology, while being convinced that man is fully able to accept [those changes]. (...) Therefore, the adequate thing is a quest for compromise between that which is constant and that which is changeable, which [the quest] would consider the evolution of external conditions as well as man's mental preferences." [2, own translation]

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The subject of mobile architecture is at present widely considered. Currently existing objects of mutable geometry delight and interest the observer. Architects aim for more and more daring applications of mobile architecture, but is man able to fully adapt to such unstable conditions? Do the signs and symbols present in architecture give testimony to man's continued need to experience change? By examining the problem of mutable space in confrontation with man's nature and predispositions, through his way of comprehending the world we can try to find a recipe for consciously forming that space without harm to his psyche.

2 Factors Inhibiting Adaptation

2.1 Change and Tradition

"Humanity eventually became a recipient of information – after having been only a carrier of immutable and genetically determined information. This in turn prompted for an ongoing update of the coding system, which should constantly be present in the mind of the sender (…)" [3, own translation]. The nomadic lifestyle constantly reasserted the human ability to adapt, demanding of man full flexibility and the skill to adapt while maintaining cultural identity, with constancy and immutability being the leading principles in building culture (cf. [4]). Tradition and history are without doubt the roots of our social existence: "The pre-industrial eras, beginning from the middle ages up to the emerging of primal forms of capitalism, were ages that contributed to the association of constancy with history – the identification of that which is unchangeable with that which is valuable, important and binding."[2, own translation]

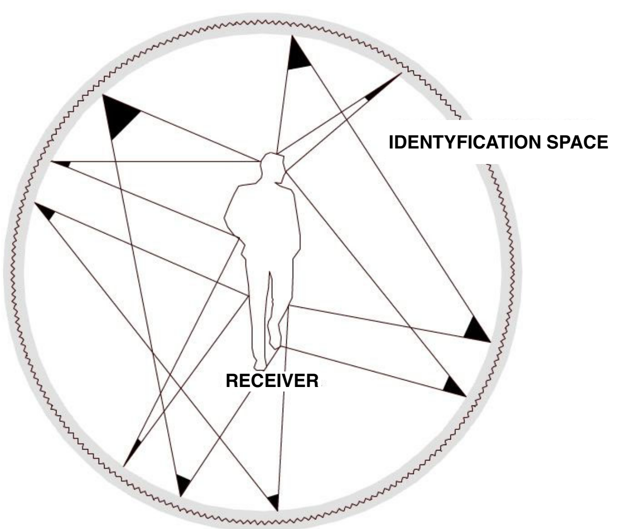

Fig. 1. Obszar przestrzeni identyfikowanej

2.2 The Mind's Limit to Absorb

Every individual has adaptive capacities unique to him or her. How can we find a balance and formula for creating mutable spaces, suitable for each and every recipient? Though the use of systems controlled by parameters derived from a given person it should be possible to create an interior that this person can identify with. The individual and the space surrounding them could then become an entirely compact 'unit'. The user could then perform a larger number of activities in the same amount of time; the flow of information would increase. Automation of performed actions, application of rules between changes – the mutable space would be an additional tool, facilitating life and work (cf. [5]).

2.3 Spatial Memory and Feeling of Security

One particularly important factor for promoting a feeling of security is the possibility of the recipient to identify with the place. It manifests itself when seeing and experiencing familiar scenes, sounds or smells. Familiar places allow the individual to prepare for a number of situations and events while affording the possibility to assess possible threats. Therefore, mutability of spaces should have clear and visible limits, so as to allow for conscious use without inducing an experience of chaos and instability.

On an urban scale, a system of multiple object being subject to a change of their geometry can create new spaces, new systems of communication. Such transformations should be finite in number, so that the basic layout of objects and functions within the city always remains recognizable.

A space with the ability to undergo a large number of mutations would be best suited as a place used repeatedly by the same persons. Every transformation would eventually become know and predictable.

Change of the surrounding shape stimulates and sharpens the senses, and prohibits the task of going from place A to place B from becoming a routine. Such a mutable place would be a place of ongoing activity, increasing the efficiency of e.g. workers or consumers (cf. [6]).

3 Motivations for Adaptation to Mutable Shapes

A space of mutable shape can influence the human being in different ways. Depending on its radius of influence it operates on a different scale of detail that man is able to recognize and process.

3.1 Private Space – Small Scale

The degree of mutability of a space is constrained by its size. In the scale of the closest surroundings a multitude of arbitrarily complex constructs can be realized, while the size of the objects being geometrically mutated can concievably be very small.

Possibly mutable properties include the position, shape, transparency, function or size. Mutation can be controlled either automatically, e.g. by interpreting the movements or biochemical state of the recipient, or conciously through explicit actions of the recipient. Such systems are currently applied in places where space is limited but suitability for a wide range of activities is required. A small apartment can, by use of sliding and telescopic elements, be transformed to perform many functions, e.g. bedroom, living room, kitchen or bathroom. While this is an excellent example of a flexible space, it mainly is a result of necessity and limitation of available space, and not so much of inherent human need. This prompts us to consider present experiences and extend the area of application of such solutions (cf. [7]).

3.2 Public Space – Large Scale

On an urban scale, on the other hand, mutability must operate on larger shapes, in order for the idea of the change to become visible. By applying objects of mutable geometry, it is possible to communicate with the recipient and thereby facilitate their conscious use of the urban space. Such communication must necessarily be capable of addressing a larger group of people, and constitutes an intrusion into both public and semi-private space. An aggregation of objects with similar capabilities for change can constitute a mutable, flexible space, assisting the recognition of the changing function of this part of the city. Today's streets are increasingly more closed, narrow spaces, maximizing the built-up area and overwhelming their inhabitants. By introducing buildings of mutable geometry, we can allow the passer-by to be drawn into the function of the building, or alternatively, to open the function up to him (cf. [8]). The form of the objects can serve the role of a road sign to relevant places and facilitate the use of the city space (cf. [9]).

The presented examples (Fig. 2-9) are a schematic representation based solely on horizontal and vertical transformations of the basic form of a cube. They illustrate the comprehensibility of different layouts and the multivariant characteristics of a single space.

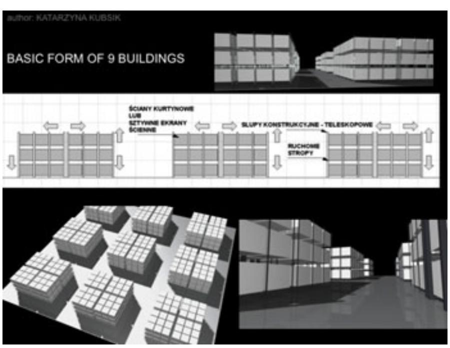

Fig. 2. Basic form in the case of 9 objects of mutable gemoetry and similar capabilities

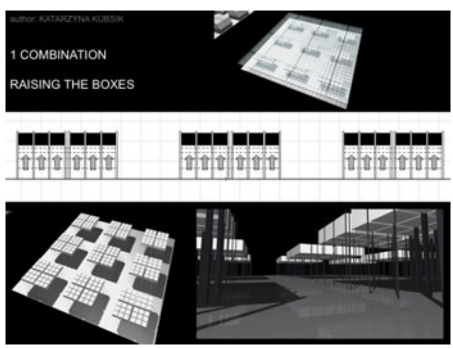

Fig. 3. Free ground floor

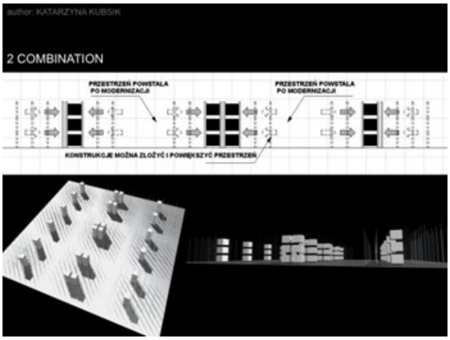

Fig. 4. Maximization of open space

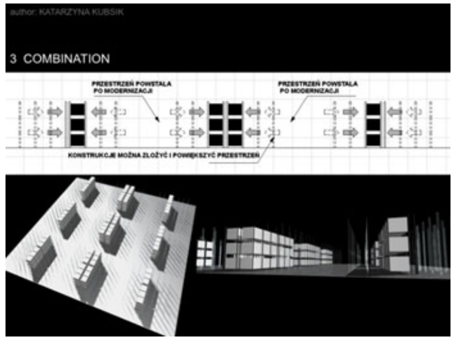

Fig. 5. Creating new paths

The objects forming the rows can create a tunnel, drawing in the users and accelerating their movement to the destination at the end of the tunnel. By minimizing the built-up area, on the other hand, the objects can create a free space e.g. for exhibition purposes. The environment is able to serve and communicate with its users, without any effort on their part to search for information. In an era where time is an increasingly scarce resource, such solutions can be a salvation (cf. [10]).

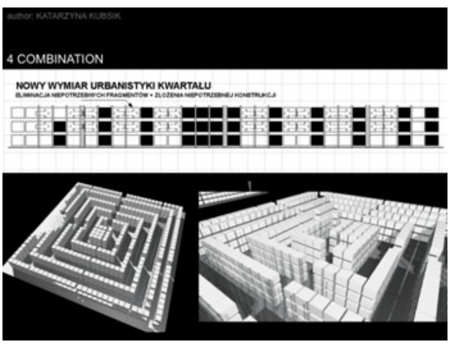

Fig. 6. Casual space

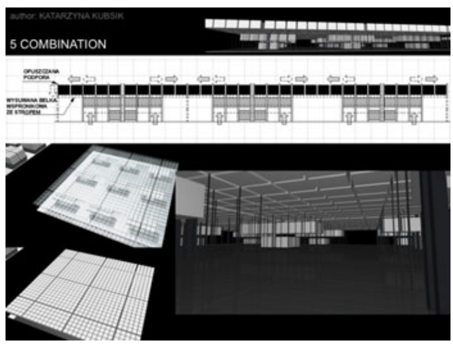

Fig. 7. One roof - asylum

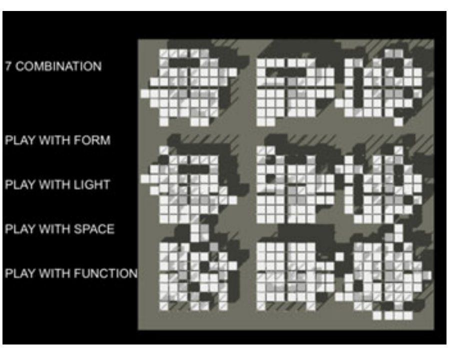

Fig. 8. Creating individual spaces – ground plan

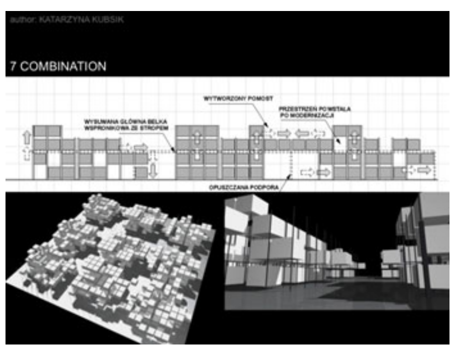

Fig. 9. Creating individual spaces

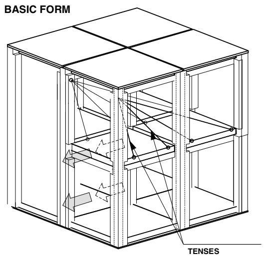

Fig. 10. Detailed solution – basic form

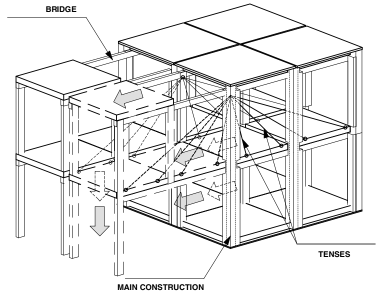

Fig. 11. Detailed solution - transformation

Objects of mutable geometry can respond to atmospheric conditions as well and perform transformations protecting the users, with multiple objects forming e.g. a temporary roof or wall.

4 Summary and Discussion

Analysis of the arguments advocating mutability of space as well as those opposing it prompts us to be mindful of the emerging problem that is conscious manipulation of man's private space. Subjecting the recipient to artificially modified shapes and rules can disturb their autonomy and independence. However, preceded by proper analysis of the effects, it can offer a significantly higher standard of perceived reality.

Dynamism in architecture is a response to man's changing needs, who – owing to his adaptive capabilities – is in constant movement and ceaselessly searches for new elements accompanying him in life. The possibility of change encourages him to search for new solutions capable of improving quality of live. These need not be perfect from the start, as the conditions that initiate progress themselfes tend to be inharmonic and full of contradictions. However, even these first solutions bring man a step closer to finding a surrounding perfectly suited for him.

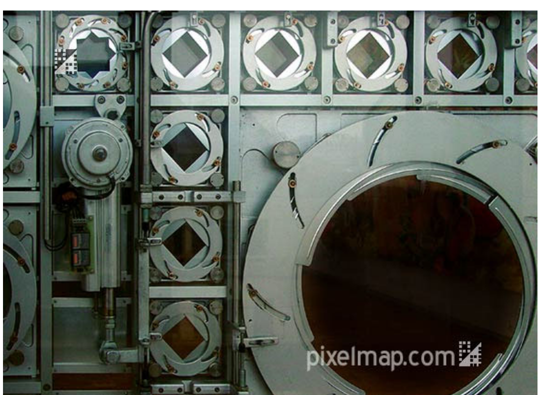

Fig. 12. "Camera Lens" Window at Institut du Monde Arabe, Paris

Analysis of human sociology and psychology allows us to confront ongoing civilizational changes with new requirements imposed on architecture. Application of mutable shapes can be a salvation or hurt man in his evolution. Therefore, it is imperative to constantly monitor the reactions to innovative procedures of intrusion into the recipients space. The conscious influence of spatial form and architectural procedures on the recipient touches the significant problem of morality in manipulating the user.

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Using a Visual Assistant to Travel Alone within the City

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Abstract. Technology can provide personalized support to improve overall functioning of individuals with an intellectual disability. Among the wide diversity of available technologies, several can be specifically used to promote the emergence of self-determined behavior. These are referred to as "self-determination support technologies". Among others, PocketPC and Smartphone applications can be use to help people traveling within a city. These applications provide step-by-step assistance along predefined routes. Consequently, the goal of our study was to adapt and field-test one of this Smartphone application *(Visual Assitant).* A pilot study was conducted with a 19 years old adult with Down syndrome. Main results showed that the participant was happy, excited and surprisingly confident. He only needed 3 trials to be able to use the technology to travel alone within the city. Parents and caregiver recognize the effectiveness and relevance of the technology and claimed that it can be use to assist not only with learning new travels but also to complete tasks such as house chores or work tasks.

Keywords: Intellectual disability, technology, self-determination, traveling.

1 Introduction

1.1 Context

Technologies are increasingly used to support individuals with an intellectual disability [1] and these tools are often considered to be innovative methods of intervention promoting the expression of personal potential. They also provide personalized support measures to improve the overall functioning of these individuals [2]. Indeed, the model of human functioning of AAIDD illustrates the importance of supports. According to this model, the following five factors interact and influence personal functioning: intellectual functioning, adaptive behavior, participation, health and context. With appropriate personalized supports over a sustained period, the life functioning of the person generally will improve. In this context, technologies can certainly prove to be a very useful mean of support.

Among the wide diversity of available technologies, different solutions for people with ID provide support that promotes more specifically the emergence of self-determined behavior. They are referred to as "self-determination support technologies

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(SDST)" where self-determination is defined as “acting as the primary *causal agent* in one’s life and making choices and decisions regarding one’s *quality of life* free from undue external influence or interference” [3]. Person who acts in a self-determined manner do so independently, believe that they exert some control over their life and rely on their strengths to maximize their personal development. Although SDST research is still a fairly new area [1], some studies tend to demonstrate their effectiveness [4,5,6,7,8]. Indeed, SDST greatly facilitate learning, independence, mobility, communication, control and exercise of choice [9] as well as community integration [10]. Among others, there are assistance tools that can help traveling alone that can be installed on handheld computers or Smartphone [1].

1.2 Research Goals

The general goals of our study was to (a) translate into French and adapt “Discovery Desktop” and “Visual Assistant” technologies, (b) field-test these applications and assess its utility to help a person go back and forth, alone, from four different locations, and (c) determine if these technologies can help a person in choice-making, decision-making and problem solving. We evaluated the usefulness of these applications through a pilot study involving a 19 years old person with Down syndrome. Our main goal was to offer the support needed to walk safely back and forth from four different locations within the city of Montreal.

2 Method

2.1 Material

Participant was provided with a Smartphone equipped with the two applications to help him completing his travels. These applications are *Discovery Desktop* and *Visual Assistant* designed by *AbleLink Technologies Inc*. *Discovery Desktop* is a simple application that overrides *Windows Mobile* and simplifies the use of an handheld computers or a Smartphone. It was combined with the *Visual Assistant* application which is an images and voice prompts system that was used to present to the participant some step-by-step procedures required to achieve specific targeted tasks. In this study it was used to support the person remembering what to do and where to go next until he completed different travels back and forth from home to four different locations in the city. Although we initially planned to use a PocketPC, it was decided to use a Smartphone to secure the participant’s parents since it made possible to call home for assistance if needed.

2.2 Instruments

Prior to experiment we conducted a semi-structured interview with the participant’s parents and the caregiver to (1) gather information about his profile, (2) identify travels habits and travels he could realize and (3) learn about their perception in regard to the proposed technology. Post-test interviews were also done with the participant’s parents and the caregiver about four topics: (1) the first contact with the assistance tool, (2) the first use of the assistance tool, (3) independent use of it and (4) general impressions. Qualitative data were analyzed through a qualitative thematic analysis procedure.

The participant self-determination was assessed with the French Canadian version of the the *Arc self-determination scale* [11] This 72-item scale is divided in four sections. Section 1 measures autonomy, including the individual's independence and the degree to which he or she acts on the basis of personal beliefs, values, interests and abilities. The second section measures self-regulation in two sub-domains: interpersonal cognitive problem-solving, and goal setting and task performance. Higher scores reflect effective social problem-solving and goal-oriented behaviors. The third section is an indicator of psychological empowerment. High scores reflect positive perceptions of control. The final section measures self-realization, including self-awareness and self-knowledge. The Arc's scale, normed with 400 adults with cognitive disabilities, has adequate construct validity, discriminative validity, internal consistency (Chronbach alpha = 0.83), and factorial validity [12]. The French Canadian version has also been shown to have adequate reliability and validity [13].

The participant was also asked to complete the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST 2.0) [14]. This is a scale consisting of two parts. First, satisfaction in regard with the technology is evaluated through 8 statements asking to indicate satisfaction level on a 5 points Likert type scale ranging from "very dissatisfied" to "very satisfied ". The second parts provide 8 characteristics and ask that the person considers which are the most important. This instrument was developed specifically to measure the degree of satisfaction of a person in relation to the assistive technology she used in regard to the technology itself ((1) size, (2) weight (3) facility to adjust, (4) security, (5) durability, (6) ease of use, (7) comfort, (8) efficiency) and quality of maintenance services (delivery procedure, time, repair, after-sales services ...). The quality of maintenance services was not assessed in this project. This instrument has satisfactory psychometric properties [14].

2.3 Participant

The participant is a 19 years old male with Down Syndrome and moderate intellectual disability. He has no associated behavioral disorder or mental health problem. He showed some physical problems that limited his ability to walk for an extended period and had some language difficulties. He is attending school and participates to work training settings. He likes going to movies, listening to music and watching ice hockey. His family described him as cheerful, curious and open.

In regard to transportation, he makes independent use of the city buses for some predetermined routes. These trips are made on regular basis (school, visiting her sister, etc.). Finally, the participant is already familiar with several technologies, including a computer and a digital camera. He is also using the Internet.

2.4 Experimentation

Experiment began by asking the participant to choose the sequence of travels he wanted to do. Four new destinations were identified according to his personal interests. Those were going to his sister's apartment, the national library and 2 discs and books selling shops. For each trip, a script of every needed step was written.

Representative photographs were taken and the task was then configured with audio and picture prompting. The participant was asked to choose the sequence of travels he wanted to do. Except for some minor challenges (noise within the subway, sun reflection on the screen) the results were highly positive. The participant only needed help for the first two routes. Then, he became confident and successfully made remaining routes alone.

3 Results

At first sight, it seemed that the use of the technology didn't change much in regard to the participant's self-determination since the pre/post-tests score were almost the same. By looking carefully to it though, we believe that it only confirms that this scale can't be use in short period of time. The overall level of self-determination of a person his too complex to change significantly over a 1 month or less period. The parents, caregiver and participant comments, when asked, were all highly positive and showed that there was an important impact on choice and decision-making and problem solving skills. In regard to his satisfaction about the technology (QUEST 2.0), he scored all 8 items with a 4 or 5 meaning that he estimated that they were satisfying or very satisfying. He also ranked dimension of the device, ease of use and efficacy as the top three components.

Qualitative analyses of parents and the caregiver pre/post interviews were done using QSR N'Vivo 8. Pre-test interviews conducted with parents and the caregiver raised their perceptions about the technology and its relevance for the participant. They recognized being enthusiastic about the experiment and shared that they had a positive feeling. Father added "*I am very optimistic, I foresee several possible uses with that*". Caregiver however shared some apprehensions about the risk of being robbed or losing the Smartphone. Therefore, the participant was sensitize about those risks and trained on how to react safely if those situations arose. Otherwise, they expressed expectations of great benefits of using the technology such as increasing level of autonomy and freedom and becoming able to travel without the need of someone else to be there with him.

Main results showed that the participant was happy, excited and was surprisingly confident. More specifically, the first travel chosen by the participant was the one that was anticipated as the easiest one to do (going to his sister's place). Father said that after this first use of the technology, his son said "*It's easy to use... I love it and it went just fine*". The second use was to get to National Library. Back home, he claimed that he could now do it alone... with the technology! Although he was accompanied by the caregiver on his first two travels, he didn't need help about using it. The caregiver said that the participant was very excited, enthusiast and quite effective at using the technology from the very first travel... just like he seemed to have played with the technology before... The participant was then able to travel alone for all four targeted travels. Mother said that she loves the size of the technology but was a bit anxious about safety (aggression) of her son. However, she was positively impressed when her son once went to a stranger in subway to ask for help. Father said that after the first use (to get to sister's place) his son said «*It's easy to use... I love it and it went just fine*»… The second use was to get to National Library. Once back home participant claimed he could now do it alone... With the technology! Father adds "*I am convinced of the effectiveness of this assistant for independent travel. I sincerely believe that the tasks assistant can significantly promote the development of self-determined behavior of people with disabilities. In addition, it can help increase self-esteem for the person who finds it can quickly and easily perform a task without assistance or supervision of a teacher or parent. Thanks to his electronic personal assistant, the participant is able to move autonomously!*".

Post-test interviews revealed that the participant responded very positively to the device and the applications. His parents noticed that he is proud saying that he owns such a device. Before experiment he was happy, excited and surprisingly confident. Mother says that "*this experience was reassuring for me and I believe my son is able to travel alone in the city*". She adds that she would let him make longer travels with his assistant. Caregiver and father also believe it can help increase self-esteem because he could quickly and easily travel alone without assistance or supervision.

4 Discussion

Although the technology turned out to be quite effective, it does not seem necessary to use it for all travels. Indeed, everyone agreed on the fact that the assistant is actually relevant when a new or more complex route needs to be learned. This means that careful and periodic planning of the use of the technology is required otherwise the user will lack interest and will stop using it. Despite the success of the experiment, some minor issues were raised by parents. Among these, the participant once faced a screensaver issue after a prolonged absence of use and another time he was challenged with the fact that he had difficulties hearing the prompts while being in a subway station with a lot of people and noises. These difficulties have highlighted unavoidable glitches of technology. To this regard, it seems appropriate to develop an "In case" procedure of technological glitches and whenever possible, train for it. Other challenges identified include the reflection of sunlight on the screen that could sometimes make the image hard to see. In addition, to use his technology, the participant sometimes stopped walking in crowds. Interventions with him were necessary to teach him how to identify a spot where he could step aside and use his technology freely.

Overall, parents and caregiver recognize the effectiveness and relevance of the technology. Moreover, not only do they believe that it can be use to assist with learning new travels but they are also convinced that it could help achieving tasks such as house chores or work tasks.

5 Conclusion

This study was one of the firsts realized within the Self-Determination Support Technologies (SDST) research chair program (www.chairetsa.ca). One of the great outcomes of the study is that a French version of a technology is now available to assist persons in using public transportation and making his community more accessible. Moreover, this application can help people perform various activities of daily life and preliminary results of a subsequent study showed that it was useful to assist achieving tasks within home and work settings.

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The Computer – A Tool That Makes Human Environment: Technosphere*

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Abstract. The 21st-century man spends more than half of his time in the environment of artificial light and technology tools, such as cellular phones, computer, TV, radio etc – they build the contemporary living environment – a technosphere. Therefore, a question should be asked whether the technosphere has not become a "natural environment" for the contemporary man? In this context people's attitude towards the environment is becoming an even more important issue. It has to be remembered that the natural environment is susceptible to and dependent on human activity, whereas the technical environment/technosphere reflects the intentions present in the process of technology creation. Technology does not have to be controversial in relation to the natural environment. It may become an integral part of the environment as a whole, without a division into a natural and artificial/built environment.

The aim of the publication is therefore to present the role of computers in the process of creating a technosphere which is friendly both for the nature and the human being.

Keywords: computer, technosphere, environment.

1 Introduction

The 21st-century man spends most of his time – as much as 90% [3] - in a closed environment, surrounded by artificial light, complex technologies and technology tools, such as mobile phones, laptops, computers, photocopiers, electronic media, audio-visual equipment or cars, and in the future interstellar vehicles – they build a contemporary living environment – a technosphere. Therefore, a question should be asked whether this technosphere has not become a "natural environment" for the contemporary man.

The natural environment is susceptible to and dependent on human activity, while the technosphere reflects human intentions present in the process of creating the technology. In order to make the technosphere friendly both for the natural environment and the human being, it is important to reach a certain level of knowledge and become

* Technosphere – Greek *Techne* – an art, craft + Latin *Sphaera* – a sphere. According to [4]: The sphere of human interference with nature. The development of technology in a natural environment.

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engaged in pro-ecological activity. Every endeavour should be made so that the technology will not be aggressive towards the natural environment and may become an integral part of the environment, without a division into natural and artificial. Therefore, the relationship between the man, technology and environment becomes even more important.

At every stage of their social and professional activity, people should be open to high-tech and ICT technologies, but at the same time they ought to bear in mind the principles of sustainable development. Computers provide people with tools which help technological and civilisation problems to be solved, support interpersonal communication, create widely used virtual reality technology and are an invaluable cognitive tool.

We live in the era of Information Technologies as well as Information and Communications Technologies (ICT), the aim of which is to provide tools and technological innovations so that progress in communication systems can be maintained and developed.

The ICT era enables communication and global access to the Internet. Since the middle of the 1990s, a dynamic development of the Internet has been noted in nearly all spheres of life [1]. Together with Word Wide Web (www.), it is an indispensible source of knowledge and facilitates an exchange and flow of information on an unprecedented scale. There are three rules governing the Internet which stimulate its development: Fast, Easy, Free. It is estimated that the Internet has ca 300 million users, and the list of websites exceeds one billion [6]. The engineering of software (utility programs and program systems) is one of the key elements of ICT branch. Equally important is ICT hardware (design, production, operation, maintenance of electronic, telecommunications and computer devices and tools) as well as peopleware (people and processes related to the development, delivery, maintenance and disposal of hardware and computer systems).

The technology of virtual reality, similarly to ICT, is applied in nearly all fields – scientific, economic, functional and entertainment areas. It enables enriching the space in which the man has stayed until now with a virtual space, parallel to the real one. It combines the real word with a cyberspace, which facilitates implementation of many projects and creates simply unlimited possibilities. Virtual reality technologies enable creating mathematical models and software based on these models to safely carry out research and simulations which after testing may be implemented and used in real reality without any risk. Among others they allow testing innovative building and construction solutions (models of buildings and construction simulators), medical programs (testing the reactions of organisms to different stimuli and impulses), as well as educational programmes (flight simulators, simulators of vehicle movement trajectory etc.,). Also unpredictable elements of the natural environment, which frequently result in threats and disasters (climatic changes, floods, volcano eruptions), are tested and corrected.

Virtual reality models are also used in areas which may seem less serious, but are not less important from the point of view of societies' full development, i.e. areas related to entertainment. The industry relying on mathematical models on the basis of which software for computer games is created, is flourishing owing to the enormous interest of the users, not only children and youth, but also adult people, thus providing inspiration for dynamic works on further development of computer software. Many of these programmes are related to broadly understood education, also based on mathematical models, computer tools and access to the Internet. Many schools and open universities ensure access to education (lectures, workshops, classes etc.) through the Internet tools and links. Undoubtedly, the wide range of the Internet has intensified the process of globalisation [6]. The Internet facilitates integration, the flow of knowledge and stimulates innovations. However, easy access to different kinds of information as well as the lack of objective evaluation may enhance wrong interpretation, and in consequence lead to unrealistic solutions.

2 The Computer versus the Concept of a New Built Environment

Over the last 50 years the world population has grown three times, and the industrial production has increased as many as several times. The current model of civilization development leads to irreversible degradation of the natural environment. Apart from different, broadly understood threats which occur or may occur in human settlements, a matter of great importance seems the relationship between the built environment and the natural one. The quality of our lives depends on the environment in which we live. The current knowledge indicates that care over the natural environment in all kinds of human activity is important for both our own and future generations' standards of living.

Creation of the contemporary built environment should be based on the assumptions of sustainable development, which among others include: optimisation of raw materials mining technology, optimisation of building materials production and buildings construction, optimising the use of buildings thanks to assuming the comfort conditions adjusted to the needs as well as minimisation of energy consumption, reduction of pollution emissions and making use of renewable energy carriers. Economic, social and cultural factors should also be taken into consideration.

Currently, one of the criteria of evaluating the contemporary built environment quality is the assessment of its impact on the natural environment, and in consequence, the influence on the users' health. Attempts are being made to change the applied technologies and build new, profitable, effective and lasting tools to optimise the management and consumption of energy in all economy branches.

The construction industry consumes ca 50% of electrical energy (45% - use of buildings, 5% - construction) and 50% of materials, 70% of wood products, 40% of water; it employs more than 100 million workers and has a 10% contribution in total production [2], and exerts a very big influence on the quality of both natural and built environment. In view of the threat that it poses to the environment, in the author's opinion, some principles of implementing the sustainable development ideas in this area are worth analysing.

Decisions taken at the stage of design concepts have a direct influence on the quality of both built and natural environment. For this reason, the design process, aimed at working out an optimal design solution which takes into account contemporary functional, technical, material, ecological and energy needs, requires interdisciplinary participation of a panel of experts. In so integrated design process, the quantity and variety of information to be interpreted and decisions to be taken require the use of tools supporting a designer. Supporting the work of the man, as a creator, with computer tools and computer programmes based on mathematical models becomes a necessity.

Different simulation methods and programmes (e.g. CABD – Computer Aided Building Design subsystems) allow testing and evaluation of solutions in the context of an assumed model of evaluating the rationality of the adopted solutions. They support localization decisions, functional-spatial and formal solutions, energy effectiveness and optimisation of technical equipment elements. They allow optimising the form of structures in ecological and energy terms.

Programs implementing the ideas of sustainable development may be divided into basic thematic groups concerning:

- thermal optimisation,
- optimisation of the environment – programmes related to buildings LCA – Life Cycle Assessments, e.g. LEED, BREAM, ECO-PRO,
- design optimisation – e.g. Solarch written as part of EU THERMINE and
- programmes for sustainable investments design – SpeAR [6].

Owing to innovative high-tech technologies supported by mathematical models, the commonly applied technology does not have to pose a threat to the natural environment, it is transformed into an eco-technology.

The advancement of automatic control engineering brought a possibility of creating a new type of buildings – intelligent buildings, which owing to the installed automatic devices, control and ICT technology, react to external and internal stimuli. Thanks to ICT, there is a possibility of controlling a building from outside. Simulations and analyses of a building's work and its devices make it possible to program the internal conditions that allow reducing the costs of the building use and reducing the influence on the natural environment [7].

Two integrated systems of building technology function in intelligent buildings: a system of the technical service of a building, responsible for internal comfort, and a system of building intelligence, i.e. a system for controlling all the installations, devices and equipment. A system of technical building service ensures the safety of use, utilities delivery and mechanical equipment work. A building intelligence system ensures electronic control and management of a building, its mechanical devices, installations and technical equipment as well as communication with the building via computer data, voice, image, tele-transmission.

Building automatic devices make it possible to regulate the lighting, heating, ventilation etc. Computers and automatic monitoring programmes optimize the work of these devices. Facility Management computer programmes, which are applied in intelligent buildings, support the attempts to reduce maintenance costs while keeping a high quality standard of use and internal climate. Sustainable intelligent buildings, the idea of which is to reduce the influence on the natural environment, are even more advanced solutions.

In the existing, modernised buildings, the innovative solutions leading to an improved energy efficiency of buildings are based on ICT technologies and monitoring systems, e.g. "smart metering". Their work is among others aided by: feedback information systems (F.I.S.) enabling a precise measurement of the consumed energy, transmission and storage of data, provision of methods and tools for data analysis in order to find the ways of energy optimization and selection of building and monitoring automatics using intelligent tools for ventilation and air-conditioning control systems - HVAC, lighting, protection against overheating or excessive cooling, while taking into consideration individual needs of the users [3]. The users have to be properly prepared, and above all, they need to be interested in pro-energy activity. In this case it is necessary to popularise knowledge and provide general access to information and education.

The relationship between ICT and communication - ICT technologies enable employees, customers and other users to communicate, acquire knowledge and information from a distance, make arrangements and do business without having to move. Owing to the use of computers, most human activities (work, education, contact with other people, entertainment) may become decentralized. The resulting limitation of the need to move leads to a reduction in the number of transport roads. For economic and ecological reasons such as solution is beneficial. It has an influence on the reduction of environment pollutions and CO_2 emissions caused by road transport and allows reducing the costs of transport infrastructure construction and means of transport production. Another advantage is the optimal organization of work and time savings.

3 The Computer as a Design Tool

Computer technologies have become a tool of a contemporary designer's work. Starting with interior design aided by virtual graphic programmes, through designs of single-family houses and finishing with multi-branch facilities and complicated engineering constructions, the use of advanced software for analysis and simulation and consistent coordination of multi-branch design works becomes a necessity.

It was among others digital models and virtual reality technologies that led to the appearance of the phenomenon of extreme engineering, presented in ambitious architectural and construction designs with fascinating architectural forms, shocking constructional and technological solutions, using the achievements of material engineering. The examples include: the Burj Khalifa in Dubai – the highest skyscraper in the world (828m high), Millau – the highest 8-span cable-stayed viaduct in the world (length – 2460m, the tallest support height – 245m, pylon height – 98m) or Three Gorges Dam on the Jangcy River (2300m in length, 40-155m in width and 185m in height).

Only a few years ago all the drawings came from flat CAD systems. At the moment a flat drawing is often generated from a three-dimensional model of a designed structure. Also the data generated from a model is used to carry out strength and thermal calculations, generate lists, etc.

Companies dealing with 3D design software (Bentley, Autodesk, Graphisoft and specialist Aveva or Intergraph), propose a wide range of programmes to support particular design tasks. Such products include e.g. Generative Components – which enable modelling at the stage of body design, Bentley Architecture, AutoCAD Architecture, AutoCAD Revit Architecture for architectural designs, 3D MaxDesign AutoCAD allowing spectacular design visualizations, Structural Modeler for construction design or Building Mechanical Systems, Electrical Systems for systems design. There are also other programmes which are used for strength and thermal calculations or evaluating the energy efficiency of buildings. There are programmes enabling team work in many disciplines e.g. ProjectWise Project Team Collaboration and BIM Server.

A data library and elements directories make it possible to automate and accelerate the design process when supplementing documentation with lists, charts and tables. Moreover, automatically generated documentation on the completed model guarantees the updateness and higher quality of the design, as well as coordination of all its elements. Also, tools of communication with specialist applications and tools for exporting the complete design documentation to external systems, e.g. to the office of an investor or contractor are applied on an increasing basis. The idea is to make use of information concerning the whole database which is contained in a 3D model. This is done by the systems of Building Information Modeling (BIM) in the building branch and Engineering Design and Management (EDM) in building engineering, which are related to the systems of facility management and service or the systems of production control. NET programmes also ensure the integration of design data with a database used for the management and use of facilities (Smart Plant Enterprise) [5].

The currently used 3D models of design documentation in a form of digital files are supposed to facilitate management of buildings in use, reduce the costs of maintenance and enable control over the influence on the natural environment. The functionality of databases for buildings used in the future will depend on the system of modelling applied in the design. Both in case of architectural structures (residential, public etc.), where the leading role belongs to the conceptual work of architects, and in case of industrial, production facilities in which the processes are subject to technology and systems, the process of designing is now based on systems, and not only single programmes.

With such a wide range of computer software applications in designing, coordination between different products is enabled by OpenPlant software, which supports cooperation in various programmes. Plant programmes (Plant Design and Management (Aveva), Plant Design System (Intergraph) or the latest Smart Plant 3D, allow 3D modelling of whole industrial plants, their construction together with technical equipment and technology.

The fact that a high number of design support and optimisation programmes are being used is proved by the necessity of creating software which is an interactive database of the software applied in the design process [6].

4 The Computer and the Shaping of Interior Microclimate

For many years research has been done to establish the influence of different environment parameters on the health and thermal comfort of recipients. In both modern residential and public buildings the tendency is to use hybrid ventilation methods, which consist in combining natural and mechanical systems. Mathematical models are applied, which allow predicting the quality and parameters of an internal environment in various conditions and its effect on the man as well as consequences of various design variants. They are therefore important for the overall optimisation of the buildings' influence. The crucial aim is to develop models creating principles of sustainable development to be used by specialist construction engineers, architects as well as designers of heating , ventilation and air-conditioning systems in the process of taking final decisions [3].

Another important issue is the influence of thermal conditions, the quality of air and noise on comfort, heath and work efficiency. Among others due to economic considerations, particularly in workplaces, an emphasis is placed on determining the relationships between the internal environment and the health and work efficiency of the users. It is known that badly designed buildings may harm their users through the unhealthy microclimate of interiors. According to the data of World Health Organisation, users complain about eye and ear disorders, throat irritation, dry mucous membranes, fatigue, headaches, nausea etc. Absence due to incapacity for work is on the increase. The most frequent cause of these disorders is the wrong work of ventilation and air-conditioning systems, overheated rooms, the lack of a possibility to regulate the air temperature and open the windows, wrong lighting or its absence as well as building materials. Single elements of the man's physical environment (temperature, humidity, air flow velocity, noise, lighting, colours, interior design etc.), especially in a closed environment like the interiors of buildings, affect the users simultaneously and interact with one another. In the context of the amount of consumed energy, comfort and work efficiency, enabling a user to individually regulate basic parameters responsible for the microclimate/microenvironment is an extremely important element. This requires the use of individual environment control systems and installing a local personal ventilation system with individual regulation [3]. It is necessary to arouse pro-ecological awareness among the society.

The observations indicate that user-dependent control over individual systems in a building, due to the lack of users' awareness and commitment, causes a situation in which the input data and computer simulations concerning a limited consumption of energy in buildings, which are conducted at the stage of concept and design works, adversely differ from the measurements at the stage of building use.

5 ICT versus Economy

Both for individual recipients and enterprises in all sectors of economy, computer networks and access to the Internet have become an article of everyday use. Advanced infrastructures and communication services often go beyond the systems and technologies themselves. They play an important role in contemporary economy, stimulate new management methods, new models of activity in digital economy, as well as competition-based development of businesses.

One of the most popular ICT products in economy is e-Business, the development of which was determined by the first Internet breakthrough at the end of the 1990s (e-Business 1.0) and the introduction of new economics principles involving a reduction of costs (e-Business 2.0) at the beginning of the 21st century [10]. Its current version, e-Business 3.0, is very closely related to another popular ICT product, e-commerce.

Apart from reducing the costs, current ICT technologies in economy are used as innovation tools for introducing new services and work methods within "value chains", to create new economy sectors dealing with company services within the scope of business focused on customer service and outsourcing, involving the exchange of data between companies.

The investigations conducted by Sectoral e-Business Watch indicate that ICT products, e-Business, and especially e-commerce (e-supply and e-sale) via the Internet are used to the greatest extent in the United States, whereas the use of ICT for internal operations management is similar in Europe and the USA[10]. The situation concerns five sectors of economy subjected to research: the chemical industry, metallurgical industry, retail, transport and bank sector.

Also the role of ICT in the implementation of sustainable development ideas in economy and industry sectors is increasingly important. The potential of ICT allows improving the energy efficiency and reducing the amount of energy consumed. An increase in energy costs and pro-ecological policy are catalysts for introducing new ICT systems, which among others are used for energy management in companies.

The fact that new ICT models reduce the costs and increase the transparency of processes and operations influences their wide use in business and economic activity. To facilitate it, we use software (e.g. Open Office) enabling the coordination of activities in different environments.

Companies replace document-based, manually conducted business processes with electronic systems of data exchange. They carry out direct electronic transactions thanks to communication with a client via e-application.

Design offices and production companies use CAD software and 3D tools in design and production processes.

In the bank sector there are now two common models of customer service – provision of basic, traditional bank services via the Internet by means of transmission networks, and advanced services provided while maintaining direct contact with a client.

Analyses of microdata collected in investigations conducted by Sectoral e-Business Watch in the years 2007-2008, prove that 55-70% of the surveyed companies in five economy sectors: the chemical industry, metallurgical industry, retail sector, transport and bank sector, forecast that ICT technologies introduced in their companies will have a positive influence on their development to a large, or at least medium extent.

On the one hand, the availability of software and the skills to use it enable applying the latest multimedia technologies [1][6], and on the other hand, considerably accelerates business and economic processes. It also allows increasing the effectiveness of work organization and automation of some activities.

Analyses of the effect of ICT application in various economy sectors show that owing to computer devices application, the general effectiveness of energy use is reduced, but it grows due to the IT infrastructure itself. This refers to computers, monitors, printers, scanners and other IT equipment. It has been demonstrated that limiting the consumption of energy in a stand-by mode by unplugging the equipment as well as a proper selection of equipment efficiency to suit the real needs, has a considerable influence on reducing this problem [9].

The investigations conducted in Poland in the year 2009[1],which concerned the awareness of Polish business people of the effect of IT technologies' introduction on the environment and energy consumption level, show that the vast majority of entrepreneurs are aware of the effect on the natural environment (94%) and take into consideration the energy efficiency of equipment (46%). However, the main factor influencing the purchase of equipment is quality (84%) and price (85%) [9].

[1] IDG investigations ordered by D-link sp. z o.o. in 2009.

6 ICT in European Research Programmes

The progress of science is often inspired by technological needs. Sometimes prototype solutions require scientific justification. The significance as well as economic, ecological and social benefits resulting from marketing ICT solutions which make use of revolutionary IT and computer technologies are among others proved by governmental and international projects.

Investments in IT and communications technologies are crucial for the global economic growth and the increase of businesses' innovation and competitiveness, as well as for the provision of new jobs. The European Commission carries out programmes which support the use of IT and communications technologies' achievements by small and big European companies. One of the programmes is "The ICT Policy Support Programme" (ICT PSP) followed in years 2007-2013. Its aim is to support innovation and competitiveness by popularising the effective use of ICT by citizens, administration institutions and enterprises [8].

The elimination of organizational barriers and promotion of innovative technological solutions' application in order to increase the level of digital contents' availability in a multi-language environment is the aim of eContentplus programme, followed in the years 2005-2008. It refers to market areas in which progress is slow [8].

7 Ending

The man adapts to living in a new environment which he has built himself in the natural environment through the development of technology and technological elements. A statement might be risked that the man has even taken a liking to this environment as it is more predictable compared to the natural one. The problem lies in the fact that the extent of human interference in the nature results in dangerous threats and failures. The aim is to create a triad – Nature – Man – Technology, which maintains an equilibrium of all the elements. It has to be remembered that given the numerous imperfections of the modern technology, the wish to replace the ecosphere with the technosphere may be tantamount to a disaster for the mankind.

Taking into consideration the fact that we have complex design tools and advanced computer technologies, it seems that an obstacle on the road to eco-technology development are mental and economic reasons, and not technological problems. Despite unceasing efforts to reduce the costs, ecological solutions are still more expensive that conventional ones, and currently prevailing mentality is too narrow-minded to overcome this barrier. Therefore, what we need is a mental revolution which would change the living standards in consistence with the natural environment.

In knowledge-based economy the matter of particular importance is the skill in benefiting from the growing resources of information, technological means of its collection, processing and transmission of information. This requires a high level of education and creativity on the part of researchers, especially in such areas as biotechnology, genetics, microenergetics, new materials technology, renewable energy sources etc. as well as technological innovation, especially in IT and telecommunications branches.

The use of solar energy as a renewable source, genetic engineering enabling the use of solar energy without location limitations and the Internet, which ensures fast and easy access to any information [1], provide a chance for creating economic and social structures which will become an inherent part of sustainable development ideas. Moreover, when properly used, new ICT technologies contribute to a significant economic growth.

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Machinery Design for Construction Safety in Practice

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Abstract. Increasingly today more and more complex machinery are designed, produced or maintained. It causes that the requirements of machines operators in the scope of assurance protection are progressively higher. As a result new laws, standards and practices are introduced. These regulations concern all the machines which are placed into the EU market. In this paper the practical verification of construction design for safety is done on the example of shaping machines such as: loathes, milling machines, drilling machines and horizontal boring machines with the application of existing law. The investigated machines were offered for sale on Polish market by Internet.

Keywords: machinery design, safety design, Machinery Directives, harmonized norms, regulations.

1 Introduction

Modern technology has imposed profound need to use knowledge derived from different fields into machinery design. Both ergonomics and disciplines connected with technical or economic issues have become equally important. It follows from the fact that regardless of increasing technological advance of machinery there is still necessity to assure machinery and operators' safety [13, 14]. In order to fulfill this requirement, new principles involved in the machinery design have been introduced. In most cases they were due to safety requirements connected with the introduction of new materials and manufacturing techniques [15]. Furthermore, the machines need to be designed for using in more and more severe exploitation conditions. Their safety should be assured regardless of appearing of disturbances in working environment i.e. affects of humidity, environmental temperature changes, influence of chemical factors, corrosion, fluctuation and asymmetry of voltage [12, 13, 18]. Moreover, the meaning of the safety values, which relies on matching the operating obligations of the machine with the ability and physique characteristics of the operator, has also increased [15]. As the safety awareness and improved safety performance have grown, people become more concerned with economical, political and social effects of accidents and fatalities [5, 6, 8]. Therefore, safety of machinery has become risk based and relies on indicating the level of required protection. It appeared that dealing with the subject of machinery safety means to combine the problems of design, manufacturing and the use of machinery, systems of working and plant layout [15, 16].

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In the paper the issues of construction design for machinery safety are highlighted. The application of safeguarding requirements into practice is discussed on the basis of standards and legislation in force. The final part of the paper is devoted to the investigation of machines from assuring safety point of view. The research is conducted on the basis of shaping machines such as: loathes, milling machines, drilling machines and horizontal boring machines.

2 Fundamentals of Design for Safety

Increasingly today more and more laws, regulations and standards, which aim at ensuring an appropriate level of protection, are put into practice. It is expected from producers to provide machinery which guarantee protection to its operators. Thus, the designers should be aware that conditions or activities, which do not assure safety, are very often symptoms of abnormalities which should be predicted in the majority of accidents. Therefore, engineers engaged in safety issues should be motivated to cooperate with designers' teams in all the design stages of machinery design [3, 9, 21]. It is advisable that all the aspects of safety machinery usage should be taken into account on drawing board [2, 3, 7, 20, 21].

As the research results show [4, 19, 20], the effectiveness of producers' activities in the scope of safety decreases in the sequential stages of technical production preparation. Thus, the activities taken up in the conceptual design or early design stages have the greatest impact on final product safety as it is shown in figure 1.

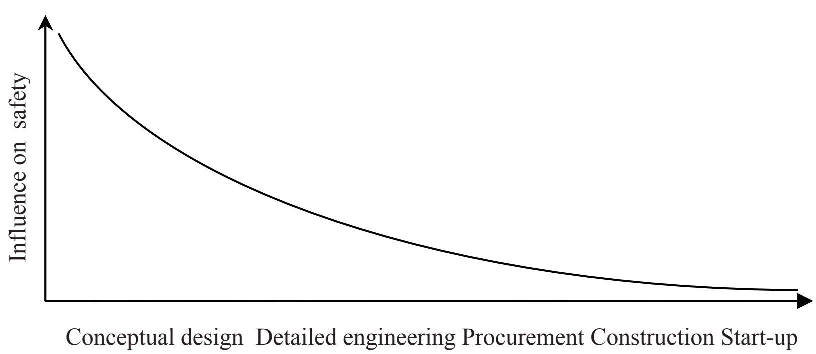

Fig. 1. Phrases of product design versus ability to influence safety (adapted from [20])

Furthermore, it is indicated that considering safety, which encompasses ergonomic, fire, health and environmental aspects, is very beneficial and necessary to companies from the financial point of view. It influences on the cost of implementing safety requirements in the next stages of life cycle of the machine [4]. It is depicted in figure 2.

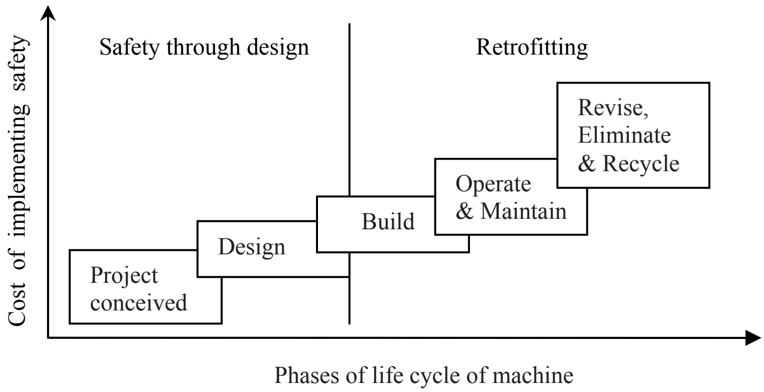

Fig. 2. Safety requirements and its costs (adapted from [4])

The more extended investigation was carried out by the Institute for Safety through Design (ISTD). They noticed that treating safety as forethought enables to reduce operating costs. The other benefits of addressing safety in the conceptual design and early stages of design are the following:

– improved productivity,
– avoidance of expensive retrofitting to correct design shortcomings,
– significant reductions in injuries, illnesses, environmental damage and attendant costs [7].

Moreover, it is noticed [16] that eliminating the hazard provides better results to safety improvement than reducing the hazard or giving personal protective equipment to workers. Manuele [10] proposed a list of activities influencing safety in the order of decreasing priority and effectiveness:

– design to eliminate or avoid the hazard,
– design to reduce the hazard,
– incorporate safety devices after the fact,
– provide warning devices,
– institute training and operating procedures.

The similar safety activities suggested Andres [1] and they are as follows:

– eliminate the hazard,
– provide engineering controls,
– warn,
– train,
– provide personal protective equipment.

In order to ensure that all safety aspects are taken into account in the process of designing machinery, Ridley and Pearce [16] proposed a pro-forma procedure. It comprises the following four stages:

1. Design hazard identification and elimination.
2. Risk assessment of residual hazards.

3. Risk reduction through provision of safeguards.
4. Warning to users of any remaining residual operating risks.

The implementation of the suggested strategy requires knowledge of the machine use from the designer and also manufacturer who have to establish recommendations how to operate and maintain the machine. All the possible to foresee uses of machine should be also considered by them. As it can be noticed the safety aspects involved in each stage of the machine life should be considered during the design process. Design assessments of the risks should be made as the design of the machine develops.

3 Machinery Safety Design in EU Regulations

There is a variety of guidelines to machinery safety legislation. As well as the moral obligation to avoid harming anyone can be differentiated, there are also laws that require machines to be safe. In the EU the major impact on safety has the Directive of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast) called Machinery Directive (2006/42/EC). According to this Directive machine manufacturers or their authorized representatives within the EU, must ensure that the machine is consistent with its requirements in the scope of health and safety relating to the design and construction of machinery. Such aspects as principles of safety integration, materials and products, lightening, design of machinery to facilitate its handling, ergonomics, operating positions, seating, control systems, protection against mechanical and other hazards, required characteristics of guards and protective devices, maintenance and information are taken into account. In order to conform that the machine is in accordance with this Directive a technical file is prepared, CE marking is affixed and a Declaration of Conformity is signed before the machine is placed on the EU market. During exploitation of machines, users have to ensure that they use, inspect and maintain machines in accordance with the manufacturer's instructions. Furthermore, any modification of machines can be treated as manufacture of a new machine if the risk assessment requires revision. The need to revise a risk assessment arises if modification concerns a change in the machine's function or its limits (e.g. position, speed, size). Therefore, the company, which modifies a machine, needs to realize that in such situations a need of issuing a Declaration of Conformity and CE marking appears [17].

The requirements of the Machinery Directive in the aspects of safety and work hygiene are rather general. Thus, in accordance with so called "New Approach Directives of the European Union", detailed technical solutions are included in European harmonized standards. The structure of the European standards for the Safety of machinery is shown in Table 1.

As it can be seen three types of safety machinery standards are differentiated. The categorization into one of these groups depends on the subject of the standard. These EN standards are adopted by member countries of the European standards bodies as a national wide with the prefix preceding "EN". In a case of conflicting with any national standard, it must be withdraw to keep a common standard applied across Europe.

Table 1. European standards for safety of machinery

Type of standard	Scope	Examples
Type A	Basic safety standards	EN/ISO 12100-1, EN/ISO 12100-2 EN/ISO 14121-1 EN 614-1, EN 614-12
Type B	Generic safety standards	
Type B1	Safety aspects	EN/ISO 13857 EN 349 EN 999
Type B2	Safeguards	EN 574 EN 1088 EN 1760-1, EN 1760-2, EN 1760-3
Type C	Machine safety standards	EN 201 EN 289 EN 692

The Machinery Directive (2006/42/EC) is enforced on the territory of Poland by the Regulation of Ministry of Economy on fundamental requirements for machinery published in Dziennik Ustaw No. 199, item 1228 of 21 October 2008. It is obligatory from 29 December 2009. Before this time, so for machines produced in years 2003-2009, the Directive 98/37/EC of the European Parliament and of the Council of 22 June 1998 on the approximation of the laws of the Member States relating to machinery is in forced by Dziennik Ustaw No. 91, item 858 of 10 April 2003. The comparison of the revised Machinery Directive 2006/42/EC with the old Machinery Directive 98/37/EC shows that it does not cause any revolutionary changes. It combines the achievements of the Machinery Directive as far as free circulation and safety of machinery are concerned. Nevertheless, the scope of the new one is extended (e.g. inclusion of construction-site hoists and cartridge-operated fixing). The most important changes cover requirements relating to:

– risk assessment,
– risks associated with machinery serving fixed landings extended by construction site hoists and slow-moving lifts,
– noise and vibration emissions,
– application of certain guidelines used to mobile machinery or machinery for lifting to all machinery presenting the risk concerned [11].

In the case of machines produced before 1 January 2003 the mandatory regulation is the Directive 2009/104/EC of the European Parliament and of the Council of 16 September 2009 concerning the minimum safety and health requirements for the use of work equipment by workers at work (second individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC). It is introduced into Polish law by the Regulation of Ministry of Economy of 30 October 2002 with changes in 30 September 2003 (Dziennik Ustaw No. 191, item 1596 of 18 November 2002 and No. 178, item 1745 of 16 October 2003).

4 Investigation of Machinery Design for Construction Safety

4.1 Research Objectives and Methods

The purpose of this study was to determine construction design practices in accordance with safety standards in force. For this purpose, three primary activities were undertaken: a literature review, a review of European standards containing references to machinery design and a survey of machines and their salesmen. The researchers took an attempt to assess sales' knowledge about fundamental or minimal requirements for machinery resulting from the adoption of the Machinery Directive 2006/42/EC, 98/37/EC or 2009/104/EC, respectively. They considered viability of demands to be related to the introduction of machines into market. They also asked their respondents about their attitude to the design-for-safety concept.

The study was done on the example of shaping machines such as: loathes, milling machines, drilling machines and horizontal boring machines. All the investigated machines were offered for sale on Polish market by Internet. As a small, pilot-level effort, the study was intended to be the starting point for a more comprehensive research project which would encompass more types of machines in the whole European market.

For the purpose of this research, the machines were analyzed in two groups. The division was done on the basis of their origin (the EU countries and others). Moreover, a new approach how to assess construction of machinery for the sake of safety was applied. It was considered on the basis of five groups of tasks distinguished by the authors, which are as follows:

- safety of technology and machinery exploitation,
- safety of work process,
- safety of work space,
- safety of information, signal and control elements,
- safety of work environment.

Each group of the tasks was analyzed with the application of a checklist prepared on the basis of the Regulation of Ministry of Economy or Regulation of Ministry of Economy, Labour and Social Politics on fundamental requirements for machinery (Dziennik Ustaw No. 199, item 1228 of 21 October 2008 and No. 91, item 858 of 10 April 2003) or minimal requirements for machinery (Dziennik Ustaw No. 191, item 1596 of 18 November 2002 and No. 178, item 1745 of 16 October 2003). Following these regulations, only machines which fulfill the provisions should be placed on the market and/or put into service.

4.2 Results and Discussion

If it is required that the machines, which are launched or sold in the EU market, should conform the provisions of the appropriate Directive, not only the manufacturers or their authorized representatives should be aware of this fact but also second hand suppliers. They should know it to be able to provide correct and full information to potential buyers. The results of the research show that of the 42 respondents interviewed, 35 (83%) were judged to be knowledgeable of the overall concept. When they were asked in details it revealed that only 27 (77%) knew the answer. On the basis of this data two groups of suppliers can be distinguished. The first one, who offered a great number of machines which were previously used, knew what conditions should be fulfilled to exploit the machine in industry. The second group wanted to sell a single product which in most cases was exported by their own or was applied for their own use in the past. They had a slight idea about the problem and it was difficult for them to determine if the machine which they offer should fulfill the minimal or fundamental requirements. In many cases they did not have a full documentation concerning introduction of the machine into use. Moreover, the technical documentation was not translated into national language for two machines. Additionally, when all the respondents asked, “What is your attitude to design-for-safety concept?”, 40% of them were negative (Fig. 3).

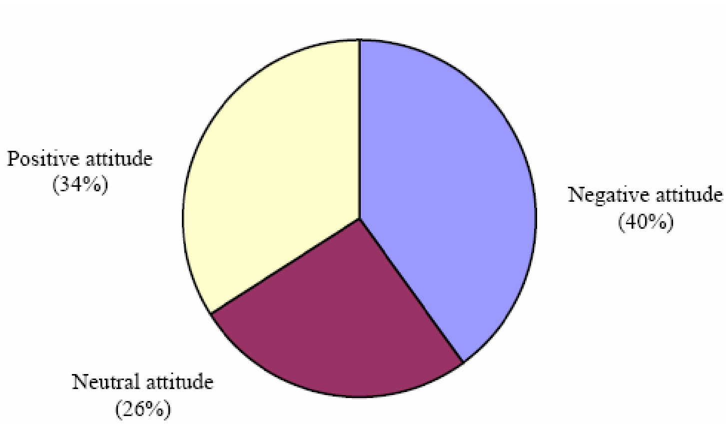

Fig. 3. Attitude to design-for-safety concept

They perceived it as making trouble in using cheap second hand machines, particularly, those which were placed on the market and/or put into service after 1 January 2003 from non-European countries (e.g. China, Russia or South Korea). However, many suppliers had a positive attitude (34%) and only 26% had no opinion about it.

Although legislation forcing the adoption of the Machine Directives (2006/42/EC, 98/37/EC or 2009/104/EC) is restricted by Polish regulations, in some aspects construction design for safety is not always fulfilled in practice. This phenomenon is particularly visible when offers for sale on Polish market by Internet are analyzed. In Table 2 there are shown the results of survey of machines which were offered and/or put into service before 2003.

As it can be seen the greatest amount of discrepancies between the construction of the investigated machines and the minimal requirements was for the first and fourth aspects of safety. As far as technology and machinery exploitation are concerned, lack of guards and application of materials not resistant to corrosion occurred. In the case of the requirements for information, signal and control elements such differences were distinguished as lack of warnings on the machinery, buttons without hollows and improper colour of control elements (white). The other problems concerned work

Table 2. Assurance of construction safety by minimal requirements

Aspect of safety	EU countries (n=12)	Non-EU countries (n=8)
1. Technology and machinery exploitation	42%	50%
2. Work process	92%	88%
3. Work space	92%	75%
4. Information, signal and control elements	67%	50%
5. Work environment	75%	75%

environment (no extractor), work space (no protection of the operator and the other workers against hot shavings) and work process (no supporting elements).

In Table 3 there is presented data concerning assurance of construction safety of the machinery in accordance with fundamental requirements.

Table 3. Assurance of construction safety by fundamental requirements

Aspect of safety	EU countries (n=11)	Non-EU countries (n=11)
1. Technology and machinery exploitation	54%	45%
2. Work process	45%	36%
3. Work space	90%	72%
4. Information, signal and control elements	100%	100%
5. Work environment	81%	72%

The results of the study showed that it is very difficult to assure safety work process. The investigated machinery was not supplied with all the special equipment and accessories necessary to adjust, maintain and use it safely. The lack of them was justified by wearing them up and on the other hand, the possibility of purchasing new one (e.g. back centre or rotary backstay). The second aspect, which was far from the desired, was technology and machinery exploitation. Considering it, the particular attention was paid to guards and protective devices. The necessary steps were not taken to prevent accidents as they were in impropriate condition (e.g. it was possible to open them without using tools) or were not fixed. The another problem occurred in the case of assuring safety from work environment point of view. The machines were not supplied with appropriate lighting for internal parts requiring inspection, adjustment and maintenance. In some cases it did not have an integral lighting suitable for the operations. It was also possible to find the machinery with no adjustment of space for shavings.

The analysis of the machinery offered for sale by Internet allowed to indicate the weakness points of their construction in comparison to the present legal requirements. The data showed that the problem of fulfilling fundamental requirements is more difficult as these guidelines are more precise. However, it must be emphasized that the condition of machines from construction safety point of view, which were placed on the market and/or put into service after 2003, is significantly better than those from earlier time but still not satisfying. The attention must be paid to the fact that almost half of the investigated machines, which should be in accordance with the provisions of the Machinery Directive, did not have a Declaration of Conformity and CE marking. They should be adjusted to these requirements before being put into market and in service.

5 Conclusions

As safety has become a matter of valuable importance in machinery design, the number of safeguarding requirements has been enlarged. New regulations which ensure that the manufacturer is responsible for any damage or harm caused by a defective product have appeared. The best examples of them are EU Directives. Such provisions provide the best practices how to support conformity with local and national regulations and contribute to fulfillment of the demands of the operator and the employer. Moreover, they provide the basis for the design procedures.

On the basis of the Directives enforced in Polish law by Regulation of Ministry of Economy on fundamental requirements for machinery and Regulation of Ministry of Economy, Labour and Social Politics on minimal requirements for machinery the investigation concerning design for construction safety was carried out. The results of it indicated that a significant discrepancy between the legal requirements and the state of second hand machines can be noticed, particularly, in the case of those produced 20 years ago in EU and non-EU countries. Unfortunately, such products are still available on the market. On the other hand, the machinery, which was launched after 2003 into EU countries, seems to fulfill some of essential health and safety requirements. However, the use up of particular elements of construction does not allow to apply for EC declaration of conformity of the machinery and CE marking without being adjusted.

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The Design and Manufacture of Functional Micro-stationary PCR Chip

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Abstract. This study presents a novel microfabricated polymerase chain reaction (PCR) chip based on silicon. A microheater utilizing doped semiconductors as heating resistors and a temperature sensor made of Pt are integrated on the chip to make up a thermal module. The micro-stationary PCR chip is fabricated on a silicon wafer using photolithography, wet etching and ion implantation technology. The package is created without complex processes. Three types of configurations for the microheater are designed and simulated to analyze the temperature distribution by the finite element analysis so as to enhance the temperature uniformity in the reaction chamber. With this approach, the microheater is optimized. Finally, the simulation results are validated by infrared images from experiments.

Keywords: PCR, doped semiconductor, temperature distribution, temperature uniformity, MEMS.

1 Introduction

Polymerase chain reaction (PCR) has been an effective method for amplifying nucleic acid molecules, which typically modulates repeated thermal cycling to complete the procedure, involving denaturing (90–95°C) for separation of double-stranded DNA, annealing (50–65°C) for hybridization of primers, and elongation (70–75°C) for replication of the DNA targets [1]. The PCR technology is widely used in many fields, including clinical diagnostic, life science, forensic medicine, military affairs and aerospace. However, the conventional equipments based on PCR are usually bulky, time-consuming and require a large number of samples and reagents, which limits their practical applications. Therefore, the development of a micro-PCR chip has great practical significance.

Bio-micro-electro-mechanical-system (Bio-MEMS) technology, integrating biological sciences and MEMS technology, has enabled the miniaturization of biomedical devices and systems. Micromachined biomedical devices or systems have several advantages over their large-scale counterparts such as a shorter assay time, disposability, low reagent and sample consumption, portability, and lower power consumption [2]. Since the first demonstration of a functional PCR device, various types of microdevices have been presented in the literature [3,4]. Typically, micro-PCR chips can be

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classified into two major categories in accordance with the method of changing temperature, namely micro-stationary PCR chips [5,6] and micro-fluidic PCR chips [7,8]. Compared with the micro-fluidic PCR chips, the micro-stationary PCR chips have simple structure, smaller volume and lower power consumption, which is important for practical application.

However, the disposable usage of the micro-PCR chip would cause high operational cost. Besides, the temperature uniformity and power consumption of the micro-stationary PCR chips also need improvement.

To tackle these problems, the present study proposes a novel micro-stationary PCR chip which integrates microheaters utilizing doped semiconductors made by ion implantation technology as heating resistors. The relationship between the configuration of microheaters and the temperature uniformity of micro-chips is simulated and validated by experiments. A simple and feasible packaging method is designed. The development of the new micro-stationary PCR chip may provide a practical tool for the rapid and accurate amplification of the nucleic acid.

2 Design and Simulation

2.1 Design of the Chip

In order to increase the heating efficiency and enhance the temperature uniformity of the reaction area, a new design for microheaters made by ion implantation technology is adopted and integrated into the PCR chip. As shown in Fig.1, the PCR chip is comprised of four micro reaction chambers and four thermal modules corresponding to the chambers.

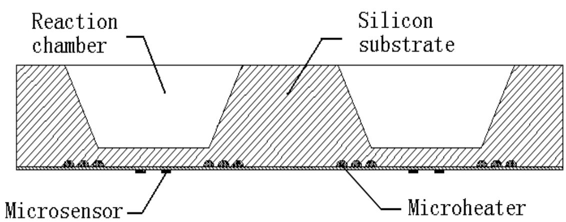

Fig. 1. One exploded view of the micro-PCR chip

The chambers with 2.5 mm in side length of upper surface, about 2.0 mm in side length of lower surface and 350 μm in depth are distributed symmetrically on the silicon substrate. Each of them has a volume of about 1.8 μL. To facilitate temperature calibration, open-type reaction chambers are adopted. It is reported that some materials such as silicon would cause the inhibition of the DNA amplification and silicon oxide could weaken this inhibition, so a silicon dioxide (SiO_2) layer is deposited on the inner surface of the chambers.

Corresponding to each chamber, a thermal module composed of a microheater and a temperature sensor is integrated underneath the reaction chamber to maintain precise and uniform temperature conditions for the PCR processes, including denaturing, annealing and extension. The microheaters utilize doped semiconductors made by ion implantation technology as heating resistors, so they can be embedded into the silicon substrate, which increases the heating efficiency for the heat dissipation is reduced and the heat conduction is enhanced. Besides, the thickness of the silicon where the microheaters are located is only 50 μm and the thermal conductivity of silicon is as high as 128.6 w/(m·k), so the heating rate is increased and the temperature hysteresis of PCR mixture is decreased. Pt is used to make the sensitive element of the temperature sensor for its resistance value is linearly dependent on temperature. The heating resistors of microheaters are located underneath the reaction chamber apart. As shown in Fig 2, three designs for the microheaters are used in this study.

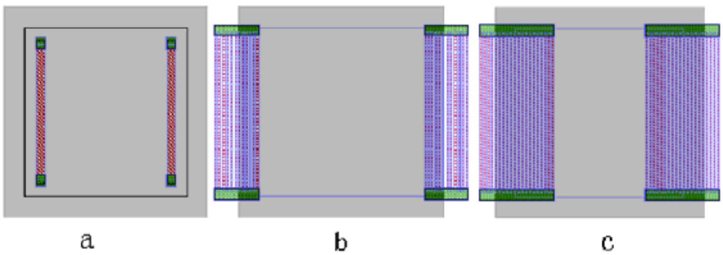

Fig. 2. Three designs of the microheaters

2.2 Simulation on Temperature Distribution

The simulation on temperature distribution of three designs is carried out by finite element analysis. In the simulation, the heat transfer between the chip and air is natural convection at the heating process, and is forced convection at the cooling process. The boundary conditions are as follows: natural convection heat transfer coefficient h_1=10 W/(m^2·k), forced convection heat transfer coefficient h_2=100 W/(m^2·k), ambient temperature T_f=26℃. In order to simplify the simulation, water is used to substitute the PCR mixture. The physical attribute of relevant materials is shown in Table 1.

Fig 3 shows the analysis results of each design. Fist, two heating resistors are used to heat the reaction area, and the result shows that non-uniformity of the temperature is obvious because the temperature decreases rapidly with the increase of distance away from the heating resistors. In order to reduce the drop in temperature around the resistors, twenty-four heating resistors are arrayed apart underneath the reaction area with an interval and width of 20 μm. According to the simulation, this design has effectively improved the temperature uniformity. Then, forty heating resistors are used and the two areas with highest temperature in the second design have connected together. Therefore, the third design could provide a quite uniform temperature for PCR processes.

Table 1. The physical attribute of relevant materials

Material	Specific Heat Capacity [J/(kg·k)]	Thermal Conductivity [W/(m·K)]	Density (kg/m^3)
silicon	737.8	128.6	2210.0
water	4201.0	0.6410	974.3

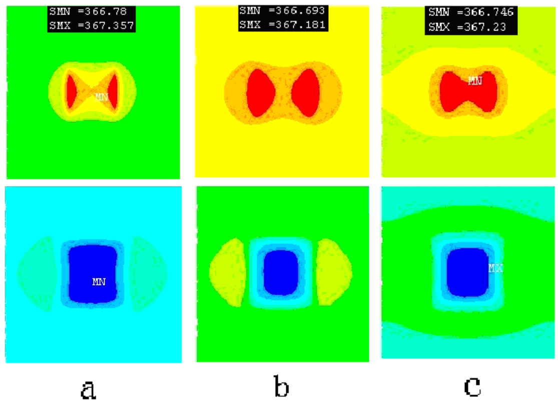

Fig. 3. The temperature distribution of three designs

3 Fabrication and Packaging

3.1 Fabrication

The PCR chip is fabricated using MEMS technology, as shown in Fig 4. A 4 inch silicon wafer with a thickness of 400 μm is used as the substrate. First, the thermal module is fabricated on the silicon. A positive photoresist is spin-coated and patterned on the cleaned silicon substrate using a standard photolithography process. Then heating resistors with a width of 20 μm are formed using ion implantation technology. The same ion implantation technology is used once more to form an area with low resistivity as a junction at the end of the heating resistors by increasing the concentration of boron ion. A silica layer is then deposited to protect the resistors mentioned above by LPCVD. A Pt layer with a thickness of about 100 nm is deposited by an electro-beam evaporation process. Prior to this process, a layer of Al Cu Bimetal is deposited and used as a sacrificial layer. The Pt layer is then patterned using a standard lift-off process to form the temperature-sensing resistors. A layer of 200 nm Au is deposited and patterned as electrical leads. Next, four open chambers are formed by wet etching. Finally, a silicon dioxide (SiO_2) layer is deposited on the inner surface of the chambers by PECVD. The size of fabricated PCR chip is 12000 μm × 12000 μm × 400 μm.

3.2 Packaging

The packaging of the micro-PCR chip is important for its application, which provides the mechanical and electrical connection with the equipment for the chip. However, the electrical leads are not on the operating side but the back of the chip, and it is unsuitable to achieve mechanical connection on the operating side, so a simplified flip-chip bonding method is adopted, as shown in Fig 5. Fist, electrical leads are welded on the bonding pads of the chip. A bit of adhesive is then dripped around the solder joint. After the adhesive solidifies, the chip is bonded with the Printed Circuit Board (PCB) by adhesive with a glass block between them. When the adhesive is solidified, the electrical leads are welded on the bonding pads of the PCB.

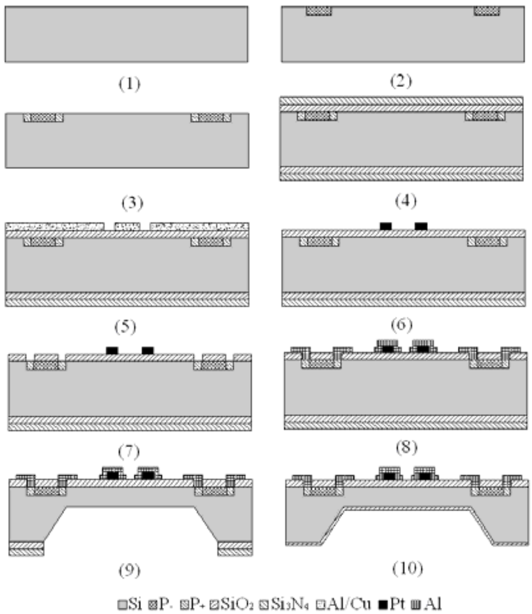

Fig. 4. Simplified fabrication process of the chip

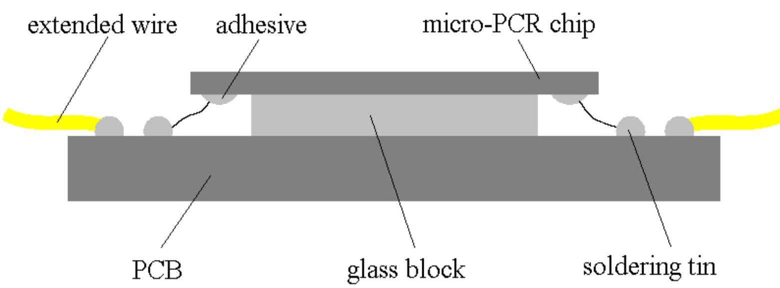

Fig. 5. Structure of packaged chip

4 Results and Discussion

The temperature uniformity and distribution in the reaction chamber can affect the efficiency of the PCR process. Hence, it is important to improve the temperature uniformity, which could increase the PCR efficiency.

Experiments are carried out in order to validate the simulation results which are mentioned above. It must be declared that four microheaters are supplied with the same power but only one of the temperature sensors is connected with the temperature control system. In other words, only one thermal module is in the normal working condition. Fig 6, Fig 7 and Fig 8 show the infrared images of the temperature distributions for three types of microheaters respectively while operating at the elongation

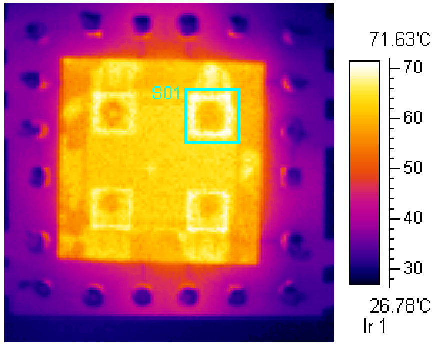

Fig. 6. The infrared image of the temperature distribution for two heating resistors

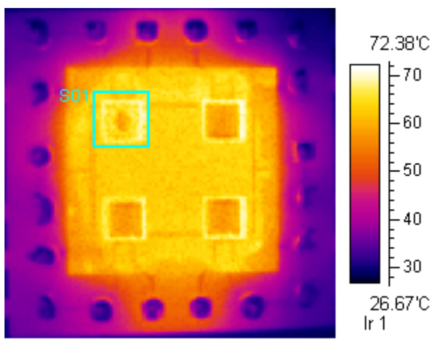

Fig. 8. The infrared image of the temperature distribution for twenty-four heating resistors

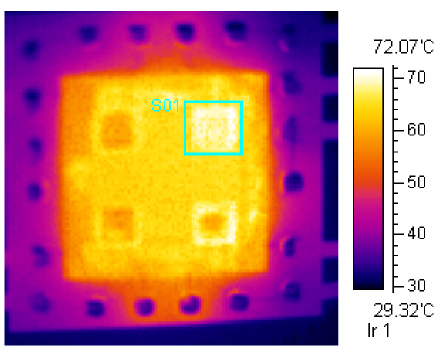

Fig. 9. The infrared image of the temperature distribution for forty heating resistors

temperature of 72°C. In the images, the thermal modules marked with green square frame are working normally. It is obvious that the results of the infrared images accord with the simulation results mentioned above. The well-distributed microheaters would enhance the temperature uniformity in the reaction chamber. For a same chip, there exist evident temperature differences between the four thermal modules under the same power supply. The reason may be the differences in resistances of the microheaters caused by non-uniformity of the chip fabrication process.

5 Conclusions

This study developed a new micro-PCR chip, including the design, fabrication and packaging. Three types of configurations for microheaters are designed to enhance the temperature uniformity which is important for the PCR procedure. Finite element analysis is used to simulate the temperature distribution of the three designs. The simulation results are then verified by infrared images from experiments, which reveals that the temperature distribution is related to the configurations of microheaters and the well-distributed microheaters would enhance the temperature uniformity. This work is crucial for further modification of the micro-PCR chip.

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Thermal Preparation of Food and Its Influence on Shaping the Old and Modern Kitchen

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Abstract. Fire, first open and then closed, was kindled and maintained through the ages. Fire started in hearths allowed for lighting and heating rooms and thermal processing of food. It considerably changed the quality of the domestic life (thus the English term "hearth" stands not only for a fireplace itself but extended its meaning into the concept of home.). Emergence of fire contributed to emergence and development of economy, including industry. High temperatures were obtained initially by burning wood, and later coal and gas. Electrification also enabled application an electric arc, microwaves and electromagnetic induction for the same purpose of obtaining high temperatures. Fire and high temperature have always played a significant role in households. They have been used for heating living spaces as well as for thermal processing of food, thus affecting spatial arrangement of rooms and a sequence of household activities and housework. Striving for comfortable conditions in flats inspired specific actions, which consequently were directed towards subduing and maintaining fire, removing smoke and ash, etc. The research paper discusses a historical evolution of appliances for thermal processing of food and their influence on organization and arrangement of contemporary kitchen work.

Keywords: fireplaces, stoves, home kitchen, home comfort, ergonomics.

1 Introduction

Fire belongs to the integral and permanent elements of the natural environment. Nearly from the dawn of time it has been a desired attribute of people. Controlling fire, especially its lighting and maintaining, has been for ages one of more difficult challenges to stand up to. Its light and warmth have always charmed people, and also raised respect and even fear. Initially people used fire to warm up their bodies and the environment. However, with the passing of time they began to appreciate a high temperature to process food. Opportunities to boil hard grain, vegetables and fruit as well as to roast meat and fish considerably enhanced taste values and improved the ability of body to process and assimilate them. The warming effect of hot food and drinks and of fire itself may be thus considered one of basic means of ensuring elementary sense of comfort, whereas acquisition of warmth can be ranked among one of the first

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ergonomic activities in the relation of a human being versus the natural elements that were both tamed and materialized with the passing of time. The ability to light fire any time should be considered a significant achievement of the prehistoric times. Lighting a fire then and emitting warmth around considerably enhanced a life standard by providing an opportunity to improve thermal comfort of interiors and prepare warm meals [5].

2 Double Role of Fire

Practically until the end of the nineteenth century lighting either an open or a close fire was connected with such considerable loss of warmth when cooking that people decided to regain the warmth in cooler periods in order to heat up the living interiors. However, effective heating was limited to one room only – the kitchen, where the whole activity of household members was concentrated (sometimes in the harsh winter including even the whole livestock). Such a situation mainly concerned houses with one hearth only – the countryside houses.

3 The Oldest Kitchen – The Hearth Smoke Kitchen

A primeval form of a house kitchen was a hearth lit on bare ground. First it was a hearth in the open air and with time it was moved into the interior of a simple household. Smoke was channeled out through cracks in the roof and sometimes through a regular hole in the top of a shack or a house (a smoke hole in a cottage without a chimney). In fact, it was permeating the whole room, quickly getting the walls and the roof dirty. Therefore, a room with an open hearth was frequently referred to as „the black chamber" or "black, smoke kitchen". Additionally, acrid smoke deteriorated the comfort of living in the chamber. Cumulated smoke lying heavy over the room at its top required a bending and stooping position in order to avoid watering eyes and choking. The hearth was normally placed in the middle of a room or near its corner and it was usually a separate detached element, which should have ensured as even and smooth heating up the interior as possible and allowed the household members to gather at the bonfire.

Nowadays the significance of an open hearth in the middle of a chamber as a place of the household members gathering and as the heart of home is a bit idealized. Actually, inconvenience at the kitchen work caused by a sitting, squatting and bending position, in smoke and fumes, should be pointed out here. For ages, in the cottage houses in particular, there were no chimneys venting smoke outside, and all the walls, the ceiling and objects in chambers were dirty and even nearly black. Clothes, fabrics, curtains, objects of daily use, food and even the household members themselves reeked of burning. Additionally, all the holes outside and leaks caused considerable cooling of the chamber, particularly felt after the fire died out. To improve comfort and efficiently venting smoke out of chambers, in the tenth and eleventh century people started to use wooden and later stone ventilation hoods, which vented smoke out to the attic, and even further, thanks to the chimney, and above the roof.

Paradoxically, as early as the end of the eighteenth century, the smoke vent was not in common use, for example in hall houses, built in the northern Germany.

Over an open fire in the hearth, meals were cooked in pans stably placed on metal trivets to prevent burning the food. There was always a cauldron placed over the hearth to keep warm water. It was hanging on a chain or a wooden crane.

4 Encased Hearth – A Fireplace

The first encased fireplaces appeared in Europe between the tenth and twelfth centuries. In fireplaces the hearth was placed nearer to the wall and in recesses sticking out of a wallface, and covered with a smoke attics or, later, ventilation hoods ("hanging chimneys"), venting smoke out of the chimney. For that reason, holes in roofs were not needed any more (smoke holes). Use of ventilation and chimney ducts then enabled erecting multi – storey buildings. Initially, the ducts were made of wood, and later – of bricks or stone.

Lighting the fire in a fireplace was more comfortable than an open hearth place in the middle of the chamber. A hearth recess and a ventilation hood ensured effective channeling smoke and smaller heat losses when cooking. Thanks to moving the hearth closer to the wall, the room became more spacious and some kitchen annexes connected with preparing meals appeared. Fireplaces have been used up to now in an almost unchanged shape. In the sixteenth century, they lost their function of cooking and were used only for heating up rooms [1,2].

However, use of either hearths placed low at the floor or the encased ones required assuming uncomfortable squatting, bending or kneeling positions, etc during cooking.

5 Specialized Equipment for Cooking – Masonry Kitchen Blocks

An alternative more comfortable in use to a fireplace were masonry kitchen blocks. Their widespread use was an important step towards a functional separation of space for preparing meals – the kitchen room. A kitchen block was a peculiar platform, built at a height of ankles, knees, and more rarely the waist. A ventilation hood for smoke and fumes was placed over it, and pots, saucepans and frying pans and other metal dishes were hung around it. Several hearths could be placed on its surface and thus lit at the same time. At the base, under the vault of the platform, wood for fire was put in stacks to let it dry.

Despite the fact that kitchen blocks were explicitly designed to prepare warm meals, they still served as an additional source of heat for house interiors. That warming function was used for a long time (even at the time of using kitchens with enclosed hearths), for example for heating rooms, drying towels or washed clothes.

6 Preparing Meals on Open Fire

Preparing meals on an open fire was not an easy task. Lighting a fire, reaching and maintaining certain temperatures and their regulation were particularly troublesome. To have a range of different temperatures at their disposal, people had to light several hearths at the same time. They most frequently lit one bigger hearth, on which water or soup was boiled, and from which embers were taken for several smaller hearths for frying and roasting meat and fish. Intensity of heating could be regulated by raising and lowering a pot over a fire with the help of adjustable hook, in form a toothed hanger, resembling a long saw.

Cooking several meals simultaneously on a large kitchen block and maintaining constant temperatures required a great effort and commitment and persistent work even of several people, constantly exposed to assuming and changing uncomfortable positions (a bending position in particular). The proximity of fire caused blinding and overheating as well as poisoning by smoke and fumes rising freely in rooms [2].

7 Kitchen Utensils

Origins of first pots, saucepans, frying pans etc. are not known. The ancient drawings show them and proved that the pans were already in common use at that time. In Roman kitchens bronze pans, pots and cauldrons were used, and in the Middle Ages - mainly copper and iron ones. They were hung over a fire on a wooden beam or a rotating crane, or they were placed on trivets, directly on hearths. In large pans and pots (boiler), without lids, almost all ingredients were cooked and served in a form of soup or pulp, etc. Lack of lids made the smell of cooked meals waft in a house, and also caused loss of valuable nutritients. In Europe until the nineteenth century such soup kinds comprised a main warm meal, among the poorer social classes in particular. Also smaller pans for stewing and frying comprised additional equipment [4].

The kitchen equipment also included a rotating spit roaster placed above a fire, on which meat, poultry and game was roasted. Sometimes spits were placed one above the other or next to each other, and they were rotated by a mechanical drive from one point of the system of toothed wheels or transmission connectors. Preparing and serving meat roasted on a spit was a rare activity in the old times and reflected wealth and a peculiar privilege of the affluent. Additionally, it was a good way of preventing loss of fat and retaining juiciness of meat.

Variety of equipment, kitchen dishes and utensils for ages resulted from a level of affluence of households and therefore it conditioned variety of prepared meals and a number of people working in the kitchen [1].

8 Kitchens with an Open Hearth and Ergonomic Quality of Houses

Departure from open hearths lit on a bare ground and popularization of kitchen blocks may be considered as a significant achievement in a functional and spatial development of houses and in organization of the kitchen workflow. The most important include:

- designing special equipment for preparing warm meals – the kitchen blocks;
- separating a room (however still multifunctional) – the kitchen;
- enhancing heating conditions and venting smoke, regarding the fire lit on the ground;

- raising the working surface, enabling work in a standing position (however, still assuming a bending and stooping position when necessary);
- a better organization of work around the cooking fireplace, for example by a proper arrangement of dishes and pots around the ventilation hood;
- the beginnings of work mechanization and automatization, for example by applying a mechanical drive for rotating spit – roasters coupled with toothed wheels;
- enhancement of nutrition values and aroma of prepared meals.

9 First Kitchens with a Closed Hearth

A direct contact with fire was necessary to cook dishes in pans or roast meat on a spit – roaster. In order to meet this requirement, from the fifteenth century people placed pots on heated coals or stones in an open hearth chamber in a stove. In order to decrease heat losses and to direct the heat, people started to line open hearths with stone or brick and encase them around their three sides, and further cover them with metal sheets. Such a system ensured, in comparison with open hearths, a better concentration of fire and heat (in consequence consumption of fuel and firewood was reduced) and fewer sparks in the interior (better fire safety).

In the eighteenth century various rationalizing actions were taken to entirely close a hearth. A crucial improvement in this matter was a hearth by the French architect F. de Cuvillies (1735) called a "castrol range", and also an outstanding economical range by an American physic B. Thompson, the count of Rumford (approximately 1800). In the castrol (pot) range by de Cuvillies a hearth encased around its four sides was covered with a thick sheet with holes, where pots were placed. According to a similar principle, special pots were placed in holes on a brickwork fireplaces by Rumford. In that kitchen, however, they employed a system of horizontal built up channels venting heat and flames from separate hearths to pots in the holes, which was a very innovative solution for that time [3].

A "U" – shaped work surface in Rumford's kitchen enabled a comfortable and easy control of several dishes cooked at the same time in one place without covering long distances along the kitchen work surface. This arrangement can be considered a prototype of a „laboratory kitchen" designed only in 20. of the twentieth century.

The above mentioned solutions were even in the nineteenth century applied occasionally, mainly in palace kitchens and in kitchens of affluent townsmen.

10 Cast – Iron and Steel Coal Stoves

The development of industry made cast – iron and steel products more accessible and allowed their mass production. Since the half of the ninetieth century in more and more American and European countries households were equipped with the coal – fired kitchen ranges. They most frequently comprised an iron cubical body, with a system of burning inside similar to Rumford's system. Fire was burning on the grates inside a hearth closed with a door. Coal was used more often than wood, since it was burning longer and was more efficient energetically. Through the grates, ashes fell to a lower chamber in the range. Then it could be easily removed with a shovel through the next door on the stove front body. Fire was distributed under the heating board through a system of channels, and smoke – via a pipe – connecter went to a chimney built of stone or brick. In the heating board, there were holes different in diameter, covered with stove – lids which to a large extent enabled regulation of the heating intensity.

Coal stoves to a considerable degree improved conditions of lighting a fire, and enhanced conditions of work when cooking as well as enabled preparing more sophisticated dishes.

Transition from kitchen blocks, built from stone or brick with an open hearth, to coal stoves was also in accordance with the social and economic changes of that time. Industrialization of production and development of factories caused a dynamic expansion of cities in the nineteenth century and migration of the rural population from the countryside households with open hearths to cramped tenement houses equipped with coal stoves. Domestic ranges were of much smaller size than open fireplaces or kitchen blocks. Surface requirements in houses, restricting time free of work and also fire – fighting considerations provoked rationalized undertakings and made the kitchen work shorter, and as a consequence contributed to popularization of metal coal ranges in the kitchens [4].

Along with popular use of coal ranges with a closed hearth and stove – lids for placing pots, a way of preparing warm meals changed, too. An open fire disappeared from a kitchen and therefore a big pot (boiler) for preparing multi – ingredient soup disappeared as well. Several smaller pots could be placed on a coal range, covered with lids (for keeping heat in) and also saucepans, frying pans and kettles were used freely. Quicker cooking processes were also important for shortening the time spent on the kitchen work in general.

Arrangement of burners on a coal stove enabled preparing several meals at the same time and in different ways (boiling, stewing, frying, roasting, heating) and provided an easy control by one person only. Closing and isolating a side hearth considerably improved thermal comfort in the direct environment, and channeling smoke eliminated iritating mucous membranes. A thermal and chemical microclimate in the kitchen was considerably enhanced and stabilized. Depending on size, a body of large coal stoves was placed on platforms, and the smaller ones just stood on metal legs. Thanks to this, a work surface was raised to a level of waist, ensuring work conditions in a standing position. Reaching both an oven and the hearth door and the ash container in order to light and maintain a fire and clean chambers required bending, stooping, squatting and kneeling. These positions, however, lasted quite short time in relation to the whole kitchen work.

Coal stoves were at that time a modern kitchen appliance which considerably changed a kitchen room and even appearance and arrangement of the whole house. Visually, however, they were treated as a kind of traditional furniture that has been known for ages. Mass industrial revolution enabled giving them various forms and visual values. Special designs emerged then employing decorative motifs known for ages, now applied in new forms of appliances resulting from new technologies. Cubical stove bodies were decorated with press – formed or cast ornaments with plant, geometrical shapes and figural motifs. Front doors were decorated with decorative hinges and handles, sometimes made of porcelain. Basic constructional elements were made of cast – iron or steel and frequently completed with tiny copper or brass elements. The appliances were usually black. The situation changed at the end of the ninetieth century, when the technique of metal enamel became popular. Since then stoves were white and had smooth shiny surfaces, gaining a bit immaculately clean, „sterile" character deprived of decorative ornaments. Those simple geometrical forms without decorative ornamentation may be deemed the first signs of the future modernism in 20. of the twentieth century.

Metal coal stoves eliminated an open fire on stone or brick hearths. That, however, contributed to a considerable enhancement of work comfort in the kitchen and improvement of a general ergonomic quality of houses, for example by:

- improving energetic efficiency during the cooking process (better directing of burning, less heat loss);
- facilitating lighting, maintaining and putting out a fire;
- easy and „clean" removing ashes, and easy keeping the household neat, clear and tidy;
- channeling smoke out, without filling a house with smoke and polluting the air;
- enabling work in a comfortable straight and standing position without need for long – lasting bending, squatting, kneeling, etc.;
- better functional and spatial arrangement in a kitchen of a relatively smaller size, which enabled effective arrangement of kitchen workflow and introduction of other functional annexes;
- diversifying types of warm dishes by use of various pots and pans of different sizes;
- use of heat generated by coal stoves for other kinds of work in a household (ironing, washing clothes, heating water for bed warmers, etc.);
- use of heat for heating up water in appropriate containers meant for washing dishes, clothes and bathing;
- integrating household members by influence of warmth emitted by stoves.

11 Coal Stoves versus Gas and Electric Stoves

The nineteenth century was an exceptional for implementing new techniques of preparing hot meals and shaping types of kitchen appliances. Within a hundred years a transition occurred from cooking in a pot over an open fire, through coal ranges with a closed hearth and small pots and saucepans to stoves without a traditional fire, in which a heating medium was gas burning with a small flame, or electric burners in a form of solid disc elements powered by electricity.

The first gas stoves appeared already at the end of the nineteenth century, and the electric ones at the beginning of the twentieth century. However, the new cooking techniques became popular only after several dozen years. Hybrid stoves, which had some burners powered by gas and some placed above a traditional coal hearth, were still produced in the half of the twentieth century [4].

Although advantages of cooking on gas burners such as elimination of dirt, soot, and the kitchen work done with a tremendous amount of effort were soon appreciated, people still willingly used coal stoves for heating water, for washing, heating an iron, for bed warmers and wafer machines, for burning waste and rubbish and drying clothes and bed linen. Coal stoves thus comprised multifunctional kitchen appliances supporting various household chores requiring a lot of thermal energy. Nowadays those chores are performed using separate specialized appliances.

A coal stove was the only constant source of heat in a house during the heating season. Nowadays, the charm of burning fire can be admired only in a fireplace or in a barbecue garden.

12 Contemporary Gas and Electric Stoves

As it was mentioned, traditional coal stoves were not immediately supplanted by gas stoves. Gas as an alternative to coal source of energy for stoves has begun to be applied in England since 1830. Popularization of this energy medium occurred slowly for two reasons: a tremendous popularity of coal stoves and slow building gas networks (mainly in large cities).

Cooking on gas again required an open fire, however its lighting, regulating and putting out became very easy – it was enough to turn an appropriate control button. Gas stoves considerably improved work comfort. Servicing of the appliance did not require much effort. It also enabled assuming a comfortable straight standing position, without a need for frequent bending and stooping. Gas eliminated all the necessary works connected with lighting a fire in a hearth.

Electric stoves became popular nearly at the same time. They were first presented at a world exhibition in Chicago in 1893. Their widespread popularization however came after in 30. of the twentieth century. They owed their success and popularity to rapid electrification, a better than gas – supply service, and their use safety. Common use of gas caused a risk of poisoning, explosion of leaky gas fittings, and just sheer human neglect [2].

Free and immediate regulation of heating intensity considerably facilitated and improved the course and intensity of thermal processing of food. It became possible to immediately switch over an intense boiling or frying function to a delicate warming up or stewing.

Thanks to gas and electric stoves, time required to cook dishes became considerably shorter. Other technical improvements in the kitchen overlapped the advantages concerning cooking time, for example running water (more and more frequently warm), sinks, and mechanical and sometimes electric household appliances. Mechanization and automatization of household chores, and those performed in the kitchen in particular, had a considerable influence on the occurring social changes, and a lifestyle, especially in circles of the middle class townsmen. Shortening and facilitating of household chores caused a mass resignation from servants, employed for performing painstaking kitchen duties described earlier in the paper. That period was also a time of women's emancipation and professional activation. Former housewives and female servants could freely take up gainful employment beyond their households. Departure from a traditional fire at home caused giving up the integrating role of hearth also.

Popularization of gas and electricity contributed to many improvements in individual households as well as a global economy. They included:

- shortening the time of kitchen chores;
- opportunity to work in a straight standing position;

- access to the source of energy without specialized service;
- workflow nearly sterile, not spreading dirt and pollution;
- freedom of regulation the intensity of heating, allowing to maintain nutritious values and a good taste of dishes;
- opportunity to prepare more sophisticated and varied meals;
- proceeding reduction of gas and electricity consumption (the environment – friendly actions).

13 Microwave Ovens

An opportunity to heat food with electromagnetic waves was discovered by P. Spencer in the USA in 40. in the twentieth century. Microwave ovens were more and easier disseminated in households of the western countries only in 70. for technical and economic reasons. However, they still comprised an additional and secondary supporting heating medium in the kitchen, after the traditional gas and electric stoves. Microwaves provided an answer to a change of quality and pace of lifestyle. They allowed to heat (and sometimes grill) earlier packed and frozen multi – element dishes and compound meals. Common haste and lack of time (for household work and kitchen chores in particular) inspired the market answer to this sign of times in a form of a wide range of frozen food – both the whole dishes and separate ingredients, properly processed and ready for a nearly immediate consumption [2].

Heating up an earlier precooked dish in a microwave is nearly effortless. Its time is limited just to a few minutes. Further, use of precooked dishes in the kitchen requires special equipment for its preservation and keeping at home. A more frequent use of a microwave is thus connected with a need for a bigger freezer.

Dietitians, however, more and more frequently indicate poor nutritious values of food heated up by microwaves, and psychologists raise the alarm pointing to a disintegration of families deprived of opportunities to spend time together also performing kitchen and general household chores.

14 Summary

Transition from a prehistoric bonfire lit with a tremendous effort on a bare ground to a microwave oven as a means of preparing warm meals reflects a general civilization development. Each new manner of cooking contributed to new distinct improvements to better conditions and shorter time of kitchen work. Until the half of the twentieth century these conveniences belonged to a trend of intuitive and rational ergonomics, where the main motivations for rationalizing actions were:

- improving efficiency of cooking in the kitchen and decreasing consumption of firewood and energy;
- shortening kitchen work time;
- lowering effort and tiredness;
- diversified menu;
- tightening family bonds.

Since several dozen years within scientific ergonomics the following activities have been and should be taken:

- a full and integrated facilitation of the whole kitchen workflow;
- arrangement kitchen work in relation to gainful employment and various household chores;
- activation all household members in the kitchen work;
- change in perception of household chores and perceiving them as a pleasant way of spending free time.

The contemporary kitchen reflects technological advancement in the world of robotization and informatization. However, a role of man in this world and their decreasing participation in the household chores reflects more serious social and cultural problems of civilized societies such as disintegration and atomization of families, anonymity of behavior, unification, and globalization of menu and food (e.g. fast food), etc.

Paradoxically, in the industrialized countries spending free time around an open fire promotes and supports tightening family bonds and make them easier, following the example of prehistoric people. Nowadays, camping at a bonfire and garden barbecues belong to popular forms of spending free time.

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mGuides, Design and Usability of a Mobile System to Assist Learning in Critical Situations

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Abstract. This work presents the usability evaluation of the mGuides system, which emerged as a response to the educational needs of students affected by the earthquake that hit Chile in the year 2010. With this system, teachers generate working guides through an editor, including learning guides and questionnaires for their learners. At the same time, students visualize and complete these working guides on cellular phones. The objective of this work is to present the impact of usability evaluations as part of the process for the development of the mGuides system, contributing mainly to the validation of the functionalities and the detection of errors. The results show that the mGuides system was highly accepted by both teachers and students, and that it is an intuitive and easy-to-use tool.

Keywords: mobile learning, learning guides, usability, web editor.

1 Introduction

On February 27, 2010 in Chile there was a very strong earthquake in the central-southern area of the country [5], which had the effect, among other consequences, of altering the normal development of school-related activities in the affected area just when the school year was supposed to be starting. The students that were in their last year of high school were the most affected, due to the fact that by the end of the year they had to take the Chilean university entry exam, the deadline for which cannot be postponed. In this way, until the situation was to return to normal, the need to make up for the lack of classroom infrastructure and lost class time for the students in the affected areas emerged. In this context, the mGuides (mobile Guides) system was created as a response to the previously described needs, involving the participation of teachers and students as users of the system.

Cellular phones were chosen as an objective platform because these devices are characterized by being lightweight and portable, most teachers and students own one, because they are appropriate for working while mobile, and due to the fact that they can be used while in uncomfortable places [1]. This means that they can be used both inside and outside of the classroom, providing the student with the flexibility needed to work with an educational application in any place and at any time. At the same time, the fact that cellular phones have some significant limitations also had to be

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taken into consideration [1]. Such limitations include a low processing capacity and the reduced screen size, both of which are aspects that limit the kind of content that the system can support. This dilemma also invites developers to explore the best possible way to present data, which can be determined primarily through usability evaluations.

In the literature, there are applications that take advantage of the characteristics of mobile devices for emergency, on-site situations, such as MobileMap [7], which supports decision making and collaboration among firemen, and another tool that aids in collecting and manipulating medical care information during emergencies [8]. The Southern University at New Orleans proposed a system based on m-learning in order to be able to continue making progress after the destruction produced by Hurricane Rita and Hurricane Katrina [9].

The development of the mGuides system was influenced by some previous projects such as BuinZoo and Museo [2], which are interactive software for learning that can be run on a Pocket PC and a Classmate PC, and Mobile tourism [10], which allow for the creation of tourist content for mobile devices. Another prior influential project corresponds to the creation of an educational RPG videogame engine for cellular phones presented in [3].

The purpose of this work is to introduce mGuides and presenting the impact of the usability evaluations performed as a part of the development process of the mGuides system, and as a mechanism for the validation of the system's functionalities and the detection of errors.

2 mGuides

Structurally, each guide behaves as a learning guide and a working questionnaire. Each learning guide is made up of a certain number of pages, in which each page contains a title, an image and a paragraph of text. In turn, each questionnaire is made up of a certain number of multiple-choice questions, in which each question includes a certain statement, an image and five answer choices.

The mGuides system is made up of two modules: (1) A project editor to be run in a personal computer, designed for use by teachers (see figure 1) and for which two different prototypes were developed: "Editor 1.0" and "Editor 2.0", and (2) An engine that executes the projects generated by the editor to be run in a cellular phone, designed for use by students (see figure 2) and for which one prototype was developed, called "Engine".

2.1 Editor 1.0

This version of the editor was a PC application implemented by using C# language in Visual Studio 2008, in which the teacher can create learning guides and working questionnaires. In the case of the learning guides, the editor provides two buttons: one that allows the user to add and another that allows the user to erase content pages. In the form on each content page the editor displays two text fields, in which one is where the title is added and the other is for adding a paragraph of text. In addition, there is an area that shows the images that can be added to the page. Under this area there are also two buttons: one to add an image that is available on the computer and another to remove the image that is already linked to the page.

In the case of the questionnaire, the editor provides two buttons: one that allows the user to add and another that allows the user to erase questions on the questionnaire. In the form for each question, the editor provides six text fields: one for the text of the question, and the other five to add answer choices. There is also a radio button in order to mark the correct answer. In addition, there is an area that shows the image that can be added to the question. Under this area there are two additional buttons, in which one can be used to add an image that is available on the computer, and the other is to remove the image that is already linked to the question.

The teacher can save his learning guide or questionnaire to a file on the PC, whenever it is deemed necessary.

Once the learning guides and questionnaires have been generated with the editor and saved onto the computer, the teacher can generate a working guide with the "Export" option on the menu, which allows him to search for one learning guide and one questionnaire on the computer, which are combined through the engine that is described later in this paper. This generates an application for cellular phones that can be stored in the computer and which can be distributed by the teacher through a certain tool to his students.

2.2 Editor 2.0

In the second version of the editor a web application was developed, which was implemented in Adobe Flex and PHP, and which maintained the end-user positively evaluated characteristics of the first editor and improved certain aspects that were deemed insufficient. New characteristics were also incorporated, which were necessitated by the web-based context of the new system.

User authentication and an administrator for the learning guides and questionnaires were also added (see Fig. 2 (II)), which corresponds to the main screen of the application. This administrator shows a list of learning guides and questionnaires created by the teacher and which are available to be exported to the cellular phones. In the administrator, the teacher can add, edit or eliminate learning guides and questionnaires.

The option to export a learning guide and questionnaire to an application for cellular phones is now available through a button on the upper-level panel of the projects administrator. This option, just as in the first version of the editor, allows the teacher to search for a learning guide and questionnaire; but in the new edition, two lists are generated and grouped into two comboboxes, each one connecting the user's respective learning guides and questionnaires. Through this new feature, the teacher is able to choose those guides and questionnaires that most interest him more quickly, facilitating the process considerably. In this way, another significant characteristic that was incorporated was that the application exported to the cellular phones was made available through the web on a space for projects exported by the teacher, thus facilitating the distribution of the application.

2.3 Engine

The engine of the application for mobile phones was implemented with J2ME language on NetBeans. The engine is built in such a way that it is able to combine itself

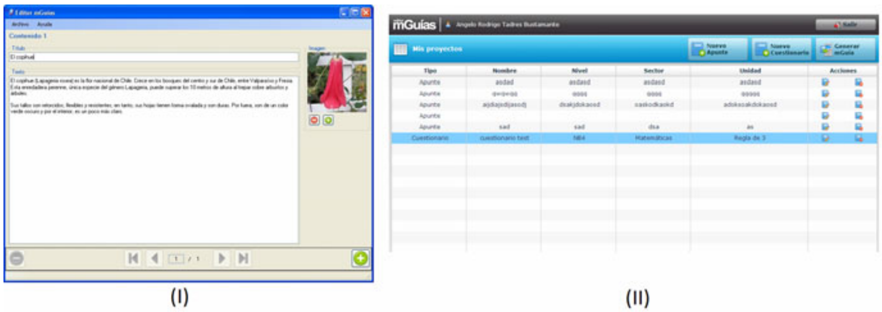

Fig. 1. (I) Editor 1.0, content page form. (II) Editor 2.0, learning guides and questionnaires administrator.

easily with the structured learning guide and questionnaire data exported from the editor, allowing the students to work with the working guides created by the teachers. This implies that the students are essentially working with the learning guide and questionnaire, which are combined in the working guide.

One important characteristic of the engine is that it adjusts the texts to the size of the device's screen. As such, for interaction with the user the engine utilizes the Up, Down, Left, Right and center buttons of the telephone's joystick, and provides the option of using the 8, 2, 4, 6 (directional) and 5 (as the center button) keys to replace the joystick in special situations in which the cellular phone does not recognize the buttons.

On a page of the learning guide, or for one question on the questionnaire, the Up and Down directional joystick buttons are used to change the focus between the selectable elements of the interface. In turn, the center button on the joystick is used to confirm the selection of an element and to perform the associated action.

On a page of the learning guide the student can change the focus between the title, the image, the body of the document, the forwards link and the back link. In pressing the center button with the focus on the title, a text scroll is displayed in the case that the area provided for the title is not sufficient to show the entire text. In pressing the center button with the focus on the image, the image is displayed in full screen, allowing the user to explore the image by using the Up, Down, Left and Right keys. In pressing the center button with the focus on the body of the document, a text scroll is displayed in the case that the area is not large enough to show the entire text. Whenever the user enters into the title, the image or the body of the document, he can go back to the normal screenshot by pressing the center button. Finally, the forward and back links help the user to navigate freely through the learning guide. When the center button is pressed with the focus over either of these options, the page advances forwards or goes back according to which option was selected.

For a question on the questionnaire, the student can change the focus between the text of the question, the image, the answer choice field, and the answer link. In pressing the center button with the focus on the text of the question, a text scroll is displayed in the case that the area is not large enough to show the entire text. In pressing the center button with the focus on the image, the image is displayed in full screen, allowing the user to explore the image by using the Up, Down, Left and Right keys.

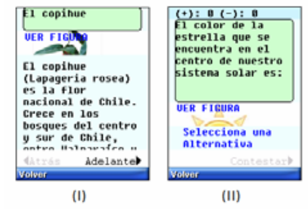

Fig. 2. Engine. (I) Contents page. (II) Multiple-choice question.

When the user presses the center button with the focus over the answer choice field, he is able to move the focus over the various answer choices using the left and right buttons on the joystick, and a text scroll with two visible lines is shown in case the area is not large enough to show to entire text of the answer choice. In order to choose an answer, the user has only to press the center button on the joystick again. When the user enters into the text of the question or the image, he can return to the normal screenshot of the question by pressing the center button. Finally, the continue link is used to confirm the answer as the selected answer choice, and move on to the following question.

3 Methodology

The usability of the system modules was evaluated [4] with end users (teachers or students, depending on the module under evaluation). In the following section, the methodology utilized is explored in more depth.

3.1 Sample

Two independent samples of teachers were selected in different regions of Chile affected by the earthquaque, called "teacher sample n°1" and "teacher sample n°2". Two independent samples of students were also selected, similarly named "student sample n°1" and "student sample n°2". Both the teachers and students were given permission to participate by their schools, in accordance with their availability, which was a factor that determined the quantity and characteristics of the sample users independently. Through the instruments administered, the age, gender, computer knowledge and cellular phone use knowledge of the users was obtained.

The teacher sample n°1 was made up of 17 users (8 female, 9 male), who teach at the Liceo Abate Molina and the Liceo Marta Donoso Espejo located in the city of Talca, as well as the Colegio Talcahuano, the Liceo Comercial de Talcahuano and the Colegio Inmaculada Concepcion located in the city of Talcahuano. Regarding the level of computer knowledge declared by the teachers in the sample, 3 stated having a basic level of knowledge, 10 declared having an intermediate level and 4 asserted an advanced skill level. The age range varied from 22 to 64 years of age.

Teacher sample n°2 was made up of 11 users (6 female, 5 male) from the Liceo Diego Portales located in the city of Talca. The level of computer knowledge declared by the teachers in this group came out to 1 declaring basic knowledge, 8 admitting to intermediate level knowledge, and 2 asserting advanced level skills. The age range varied from 24 to 60 years old.

The student sample n°1 was made up of 104 users (52 female, 52 male), enrolled in Liceo Abate Molina and Liceo Marta Donoso Espejo located in the city of Talca, and the Colegio Talcahuano, Liceo Comercial de Talcahuano and Colegio Inmaculada Concepcion located in the city of Talcahuano. The level of cellular phone use ability declared by these students resulted in 4 declaring a basic level of knowledge, 62 stating an intermediate level and 38 declaring an advanced level of knowledge. The age range varied between 13 and 18 years of age.

Student sample n°2 is made up of 5 users (3 females, 2 males), between 17 and 18 years of age, and enrolled in the Liceo Polivalente Guillermo Labarca Hube A78, located in the city of Santiago.

3.2 Instruments

Two adaptations of the end-user usability questionnaire [6] were used, in which one was designed for use of the editor and the other for the engine. The original questionnaire consisted of statements that the user must evaluate on a scale between 1 and 10, in which 1 is 'a little' and 10 is 'a lot', in addition to fields in which the user registers his "age", "gender" and "level of computer knowledge". The adaptations were made by changing the word "software" to "editor" in the statements included in the questionnaire for evaluating the editor, and by increasing the number of questions and replacing the field "level of computer knowledge" with "level of cellular phone use knowledge" in the case of the questionnaire used to evaluate the engine. The questionnaire utilized to evaluate the usability of the editor consisted of 10 statements that were evaluated by teacher samples n°1 and n°2. In turn, the questionnaire to evaluate the usability of the engine consisted of 24 statements that were evaluated by student sample n°1 (the statements used in both questionnaires can be seen in the results section). Through the use of these questionnaires, it was sought to evaluate the quality of the editor and engine, measuring the respective users' satisfaction in terms of control, use, acceptance and design.

An observation guideline was utilized with the participants from student sample n°2, with sections designed to measure efficiency, error and the level of learning regarding use of the engine. With this guideline, a facilitator recorded the time that the students took to perform the tasks. In addition, the guideline included a section in which the evaluator recorded the most common errors that the users made, such as not expanding the text scrolls and not expanding the image in the learning guide and the questionnaire. In order to record learning of the interface, there are indications in the guideline that request the user to execute specific tasks to be performed after having completed the global tasks; some of these tasks include expanding the specific texts and images and changing pages in the learning guide, and finding, selecting and answering a question with a specific answer choice. In addition, this guideline included fields for recording the "age" and "gender" of the users.

3.3 Tasks

Regarding use of the editor by the teachers, three tasks were established: Task 1. Create a learning guide, Task 2, Create a questionnaire and Task 3. Export a project with the learning guide and questionnaire created. For the first two tasks, digital material with texts, questions and images was provided. For the use of the engine by the students, two tasks were established: Task 1. Read a learning guide and Task 2. Answer the questionnaire.

3.4 Procedure

The editor 1.0 was installed in a laptop computer, which was equipped with a mouse and an external keyboard. In addition, the digital support material for the construction of learning guides and questionnaires was included within the saved files on the computer. Facilitators worked individually with each user in the teacher sample n°1, who was asked to perform the 3 tasks corresponding to the editor. Once the tasks had been completed, each user was provided with a printed copy of the end-user usability questionnaire, adapted for use with the editor, and was asked to fill out the questionnaire.

During a second stage, an application that had been generated with the editor and which had three pages of text and a questionnaire with three questions was installed in three different cellular phones. The content of the questions was related to science learning, which allowed the research team to test the engine's characteristics. Facilitators worked with groups of three users at a time from student sample n°1, who were asked to perform the two tasks corresponding to the use of the engine individually. Once these tasks had been completed, each user was provided with a printed copy of the end-user usability questionnaire adapted to use of the engine, and was asked to fill out the questionnaire.

During a third stage, a test server environment was installed in the laptop in order to allow the editor 2.0 to be executed, simulating internet connection through the local host. In addition, the digital support material for the construction of learning guides and questionnaires was included in the saved file system on the computer. Facilitators worked with each user from teacher sample n°2 individually, who were asked to perform the three tasks corresponding to the editor. Once the tasks had been completed, each user was provided with a printed copy of the end-user usability questionnaire adapted for use with the editor, and were asked to fill out the questionnaire.

Finally, in the last stage an application generated with the editor that included a learning guide made up of five pages and a questionnaire with five questions was installed on a cellular phone. The questions contained mathematics learning content, which allowed researchers to measure the efficiency, errors and the users' learning regarding how to use the engine. Facilitators worked with each user from student sample n°2 individually, who were asked to perform the two tasks corresponding to the engine, which were measured by an evaluator, who filled out the efficiency and errors sections of the observation guidelines. Afterwards evaluators proceeded to the learning section of the observation guideline, by asking users to perform the specific tasks included in the guideline one at a time, recording whether or not these tasks were successfully completed.

4 Results

Regarding the evaluation of the editor 1.0 and editor 2.0, results showed that the mean scores attributed to each statement on the guideline improved for the editor 2.0. In order to prove whether or not this improvement was statistically significant, a Student T test for independent samples was utilized, which showed that for each statement, the increment was not statistically significant. It is worth pointing out that the results for each statement demonstrate the high level of the users' acceptance of the editor. In the following, details regarding the results for each statement are provided: "I like the editor" (mean editor 1.0=8.24 (out of 10); mean editor 2.0=8.91), "I would work with the editor again" (mean editor 1.0=8.76; mean editor 2.0=9.09), "I would recommend the editor to other teachers" (mean editor 1.0=8.76; mean editor 2.0=8.82), "I felt in control of the editor" (mean editor 1.0=7.63; mean editor 2.0=7.82), "I knew what to do in every section of the editor" (mean editor 1.0=6.82; mean editor 2.0=8.36), "The editor is interactive" (mean editor 1.0=8.47; mean editor 2.0=8.82), "The editor is easy to use" (mean editor 1.0=8.41; mean editor 2.0=9.18), "The editor is motivating" (mean editor 1.0=8.65; mean editor 2.0=9.00), "The editor adjusts to my rhythm" (mean editor 1.0=7.88; mean editor 2.0=8.36) and "The images, colors and brightness of the editor provide me with information" (mean editor 1.0=8.71; mean editor 2.0=8.82).

Regarding the evaluation of the engine, the following results for each of the statements were obtained: "I like the software" (mean=7.17 (out of 10)), "the software is fun" (mean=6.68), "the software is challenging" (mean=7.50), "the software makes me active" (mean=6.95), "I would work with the software again" (mean=7.85), "I would recommend this software to other students" (mean=8.46), "I learned from using the software" (mean=6.39), "the software has differing levels of difficulty" (mean=7.19), "I felt I could control the situations in the software" (mean=6.80), "the software is interactive" (mean=7.46), "the software is easy to use" (mean=8.36), "the software is motivating" (mean=7.40), "the software adapts to my rhythm" (mean=7.28), "the software allowed me to understand new things" (mean=6.36), "I like the images in the software" (mean=5.07), "The images in the software provide me with information" (mean=5.98), "I understand the questions that were asked" (mean=7.25), "it is easy to visualize the answer choices" (mean=7.97), "it is easy to select an answer" (mean=7.86), "it is easy to use the buttons on the cellular phone" (mean=8.62), "I can read the long texts easily" (mean=8.17), "the size of the text is adequate" (mean=7.22), "the size of the images in adequate" (mean=4.70) y "it is easy to read a large piece of text" (mean=7.40). In general, the results obtained show that the students expressed a high level of acceptance of the engine, except for some aspects such as manipulating and visualizing the images on the application, which given the characteristics of cellular phones (small screens), is a difficult problem to remedy.

The results regarding the observation of the use of the engine demonstrated that the students were able to complete the tasks in the amount of time that was expected for each task. In this way, for task 1 regarding the learning guide, the expected time was 5 minutes, and the average time it took the users to complete the task was 4 minutes and 12 seconds. For task 2 regarding the questionnaire, the expected time was 10 minutes, while the average time the users took to complete the task was 10 minutes and 12 seconds. As far as the observation of errors, the results show that in general the students reduced the number of errors as they progressed through the various questions. If they originally did not expand the texts or the images in the learning guides or questionnaires, by the end of the session they no longer made such errors. Observation regarding learning of the interface showed that the students failed only on the first specific tasks, and that they did well on the later tasks. As a result, the users diminished their errors progressively, until reaching zero errors when performing the tasks with the engine.

5 Conclusions

The objective of this work was to present the impact of usability evaluations as part of the process for the development of the mGuides system. The usability evaluations were useful for validating the elements that had been designed and implemented in each module, and also served to detect design problems that led to a redesign of some elements in the following development iteration. As a result, the usability evaluations supported the development of the mGuides system by validating the current design and calling on the developers to improve the system in the following iteration. This was achieved through feedback provided by the results obtained in the usability testing, and by always using the guiding principle of providing the end users with a simple and usable tool in each module of the mGuides system.

The results of the editor show that in the version 2.0, the editor improved in each of the usability indicators utilized, and that although the increments or gains were not statistically significant, the results pertaining to both evaluations (for the editor 1.0 and editor 2.0) showed that these elements were clearly accepted by the teachers. The evaluations demonstrated that the editor is a usable and understandable tool, which validates the design of its components. The editor allows the teacher to easily create, edit and generate a working guide project for his students; however, it is the teacher's job to make sure that the content notes are presented in a logical order, and that the questions in the questionnaire are related to the contents presented in the learning guides.

The results regarding the engine, shown through the usability indicators, demonstrate a high level of acceptance in general by the students. The lowest score was obtained for manipulating and visualizing the images, which is probably due to the reduced size of the screen on cellular phones. The most interesting aspects observed regarding the students' use of the engine were the fact that it allowed the users to perform tasks within the expected timeframe, that it is very intuitive, and that it is not at all difficult to learn to use. The design of this system was very accurate from the point of view of the autonomy and freedom of work achieved by the users, given the context and the critical situation on which it is focused. However, for future work it is proposed to continue improving and extending the system's characteristics. In addition, the research team plans to widen the possible uses of this system to other contexts, and take advantage of the educational potential of the tool, as it can be integrated directly into the development of courses in various contents of learning and on differing levels. This would necessarily involve new system usability evaluations.

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Smart Cities, Ambient Intelligence and Universal Access

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Abstract. The future of universal access is very much determined by considerations that reflect also the changes at the global level. One of the key changes is the shift towards an Urban Age. In this paper it is addressed from the perspective of how information and communication technology, in particular ambient intelligence, will influence the future of our cities. The paper presents the concepts of Hybrid, Smart and Humane Cities and their dependencies. They are also used as umbrella scenarios for developing new research lines for ambient intelligence. The paper closes with presenting twelve of these research lines that were developed in the EU-funded InterLink-project.

1 Introduction

When addressing future perspectives for universal access, one also has to include considerations that reflect changes of the situation at a global level. It is not anymore mainly about how to design an interface for users with disabilities at a given computer. It is much more the approach of "designing for all" in an evolving information and knowledge society and providing a technology substrate for eInclusion (Stephanidis, 2009). While this is an important and on-going grand effort, we like to add another perspective in this paper. We argue that the shift towards the so-called Urban Age will be key for many discussions in this realm. The origin and the consequences of this development will be elaborated in more detail in the next section. On the other hand, we have to consider the developments in different technology areas that have strong implications for universal access. Ambient Intelligence is certainly one of these technology areas that will be increasingly relevant. These two developments meet in the concept and realization of so called "Smart Cities" and their transformation into being "Humane Cities".

2 Urban Age

Already in 2008, half of the world's population lived in urban areas and about 70% will be city dwellers by 2050, with cities and towns in Asia and Africa are contributing the biggest growth, according to the latest U.N. projections. Thus, the year 2008 was a turning point in human history, as more than half of the world's population lived in cities. According to the U.N. estimate, world population is expected to increase from 6.7 billion in 2007 to 9.2 billion in 2050. During the same time period,

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the report stated that the population living in urban areas is projected to rise from 3.3 billion to 6.4 billion. Greater Tokyo is currently considered to be the largest mega city with 35 million, which is greater than the entire population of Canada. Cities are becoming increasingly the most relevant places to be observed and understood for instantiating and influencing changes in all fields of economy and society. For example, in 2006 Tokyo generated about 40% of the GDP of Japan and Buenos Aires generated 45% of the GDP of Argentina. Already today, cities are the world's centers of excellence, bringing together people from many areas of life acting as important opinion leaders and initiators of change and providers of new opportunities. At the same time, they are also the target and then home of many people – often with socially deprived backgrounds - hoping for new chances and a better life for themselves and their children. Cities provide opportunities, economies of scale, a future with more choices. On the other hand, cities are also seen as being responsible for creating and exhibiting the divide between rich and poor, diminishing their quality of life, for marginalizing communities, and for causing environmental hazards. They have been castigated as centers of disease, social unrest, instability, and insecurity. Because cities host many more people compared to their originally planned dimensions and grow faster than their infrastructure, cities face high risks from industrial hazards, natural disasters, and the spectrum of global warming.

When speaking of an Urban Age that we have entered, people predict that the economic prosperity and quality of life will largely depend on the abilities of cities to reach their full potential. But the issues mentioned above are at a general level and span a wide spectrum of challenges that are beyond the theme of this session and the limits of this paper. In order to be more specific and make the connections to the role of information technology, we have to orient ourselves via sample application scenarios. The theme of Urban Life Management in Smart Cities was selected as an umbrella scenario. Based on this, we developed the concept of "The Humane City" as our vision for the City of the Future and the future of Urban Living. Within this context, we can observe a development from real cities via virtual/digital cities to Hybrid Cities and then transforming them into Smart Cities. Obviously, there are many ways of addressing the challenges and issues of Hybrid and Smart Cities. One way to orient ourselves is to ask "what kind of city do we want to have? A technology-driven and technology-dominated one? Probably not! So, we developed the vision of a city where people enjoy everyday life and work, have multiple opportunities to exploit their human potential and lead a creative life. We called it "The Humane City". More details about this approach can be found in the deliverables of the InterLink project (InterLink, 2009). In the next chapters, we will especially focus on the information technology aspects of these activities.

3 Ambient Intelligence

The evolution towards a future information and knowledge society is characterized by the development of personalized individual as well as collective services that exploit new qualities of infrastructures and components situated in smart environments. They are based on a range of ubiquitous and pervasive communication networks providing ambient computing and communication at multiple levels. The collective services are provided by a very large number of "invisible" small computing components embedded into our environment. They will interact with and being used by multiple users in a wide range of dynamically changing situations. In addition, this heterogeneous collection of devices will be supported by an “infrastructure” of intelligent sensors and actuators embedded in our homes, offices, hospitals, public spaces, leisure environments providing the raw data (and active responses) needed for a wide range of smart services. Furthermore, new and innovative interaction techniques are being provided that integrate tangible and mixed reality interaction. In this way, the usage and interaction experience of users will be more holistic and intuitive than today. It is anticipated that economics will drive this technology to evolve from a large variety of specialized components to a small number of universal, extremely small and low-cost components that can be embedded in a variety of materials. Thus, we will be provided with a computing, communication, sensing and interaction “substrate” for systems and services. We can characterize them as "smart ecosystems" in order to emphasize the seamless integration of the components, their smooth interaction, the "equilibrium" achieved through this interaction and the "emergent smartness" of the overall environment.

This area of technological development is besides ambient intelligence also known under different labels, e.g., ubiquitous, pervasive or proactive computing, disappearing computer (Streitz, et al., 2007). In this paper, we will mostly and wherever appropriate use the term Ambient Intelligence (AmI) and adopt the characterization by the ERCIM Working Group SESAMI (Streitz & Savidis, 2006):

“Ambient Intelligence represents a vision of the (not too far) future where "intelligent" or "smart" environments and systems react in an attentive, adaptive, and active (sometimes proactive) way to the presence and activities of humans and objects in order to provide intelligent/smart services to the inhabitants of these environments. While a wide variety of different technologies is involved, the goal of Ambient Intelligence is to hide their presence from users, by providing implicit, unobtrusive interaction paradigms. People and their social situations are at the centre of the design considerations.”

Of course, there exist other characterizations and definitions of AmI, for example an early one by the IST Advisory Group (ISTAG, 2001) of the EU based on the development of different scenarios. With respect to the connection between univercal access and ambient intelligence it is worthwhile to note that “The Universal Access Handbook” (Stephanidis, 2009) has in its Part IX which is devoted to ‘Looking in the Future’ a chapter on ‘Ambient Intelligence’ (Streitz & Privat, 200). In the provided context of universal access, they discuss new perspectives and propose seven alternatives about AmI as the main core of this paper.

4 Smart Cities

We are proposing now to combine the general issues of cities in an urban age addressed above (of course, only in a limited way) with the motivation to formulate challenges for future research agendas for information and communication technology (ICT) in general and in particular with a focus on ambient intelligence. This was the main charter of the Working Group 2 in the InterLink project (Interlink, 2009). It resulted in the question:

"How can the realization of a Smart City contribute to reducing and potentially even avoiding some of the problems that are faced by today's cities and in the future?"

Or in other words:

"How can ambient and ubiquitous ICT help to contribute to Urban Life Management?

This can be analyzed and has to be investigated from the following two perspectives:

1. How to manage a person's / a group's life in today's and future cities?
2. How to manage the urban environment of today's and future cities?

While formulating it as two perspectives, it should be clear that they are not independent; but it helps to identify the different user needs depending on who are the users:

- The users are the citizens living and working in the city; searching, checking, evaluating and then utilizing the services that are offered by the urban environment with respect to the different aspects of life
- People who are organizing and administering the urban infrastructure so that the services are available for citizens and visitors.

Examples of how the smart city of the future could operate are: taking care of its individual inhabitants by offering personalized services (e.g. for security, health and administration, but also for leisure, shopping, …), by providing optimized opportunities of transportation by combining various sources of traffic information at the same time and integrating different means of transportation, by providing opportunities for the involvement of people in the community, e.g., by matching people on the basis of common interests and suggesting common activities or in other words: offering multiple opportunities to be an active part of society. These are only a few examples and more are being developed.

One also has to note that there are already some efforts to realize Smart Cities, in particular in Asia. For example: the "u-Cities" (ubiquitous cities) program in Korea, the Ubiquitous Networking Forum and the notion of a "U-Japan" in Japan, and the iN-2015 Masterplan of an "Intelligent Nation Singapore". Research in this area is concerned with the creation of a future society in this kind of Smart Cities. In Europe, one can mention examples like the EU-funded integrated project IPCity addressing interaction and presence in urban environments and the T-City Friedrichshafen, Germany, a practice experiment of the German Telekom. In many projects primarily technical issues such as the usage of different broadband networks and interoperability of devices are in the foreground. Other European activities are using the label "smart cities" with a focus on establishing administrative and social collaboration networks between cities fostering innovation and e-services. They address partially also issues of eInclusion. We argue that social impact and social mobility combined with universal access in Smart Cities should be more in the focus of the research efforts. This includes also the change or even disappearance of the traditional orientation "metaphors" based on place and time. The definition of methods for data provision and privacy and security restrictions, the identification of new stakeholders, and the understanding of upcoming new social interaction principles will have to be discussed intensely.

5 Humane Cities

We have the vision that our cities should be places and environments where people enjoy everyday life and work, have multiple opportunities to exploit their human potential and lead a creative life. We call them "*Humane Cities*" in order to add another dimension (e.g., addressing values that guide the city's development) on top of the more technical notions of a "smart" or "hybrid" city. As a side effect one, 'users' are now being viewed as 'citizens'(with all the implications) because that is what they are actually are.

The notion of a "Humane" City describes the character of what it should be in terms of requirements for the communication, interaction, collaboration and social networking opportunities for the citizens. In this context, it is useful to distinguish the following three dimensions for investigating the issues of smart cities and their transformation into Human Cities (see fig. 1).

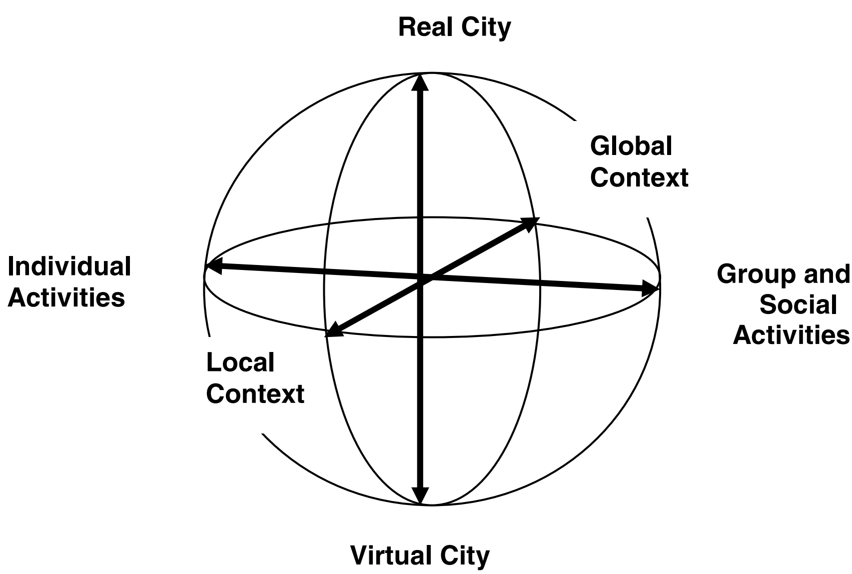
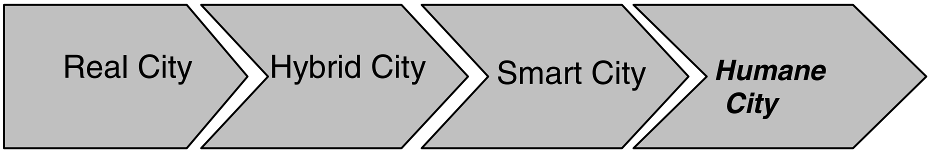


Fig. 1. Three Key Dimensions of Humane Cities (there are more but not depicted here)

In a nutshell and necessarily simplified, one can summarize the development from an 'ordinary' city to a 'humane' city by the following progression:



Extrapolating from what we know today, the development towards a Humane City will be based on the following three progressive steps which in some areas and to some degree can be realized in parallel.

1. The first step is (or was, because it is already happening today to some degree) the extension of the real city into the virtual world. The integration of real and virtual parts – complementing each other – results in the *Hybrid City* which is also characterized by the equal importance and interconnection of both worlds.
2. The second step is the transformation of the different types of services that are available in our current cities into smart services and thus the city into a *Smart City*
3. The third step is the adoption of certain requirements during its realization so that we do not end up with a technocratic Smart City which is monitoring and controlling its citizens in the interest of only a few stakeholders creating a "big brother" society. Thus, privacy is becoming an increasingly important issue. The realization of a Humane City facilitates opportunities to keep the citizens in the loop of decisions, to empower them and to provide socially aware smart environments where privacy and trust are respected values and provide the basis for fostering a creative, all-inclusive and humane society with a high quality of life.

6 Social Awareness and Privacy

The approach to design Smart and Humane Cities by creating ambient intelligence environments evidently faces a large number of issues and challenges. Having to be selective, two grand themes are highlighted here: "Socially Aware Ambient Intelligence" and "Privacy, Trust, and Identity". They were also identified in the EU-funded project InterLink (2009).

6.1 Social Awareness

Social aware people are community minded and socially active in their social context. Communication between humans as part of a more comprehensive social dialog can also involve different artefacts as part of a socially aware system. Whereas embedded sensors and devices are already common in today's environments, the future challenge is the creation of intelligent or smart environments which behave in an attentive, adaptive, and active way to provide specific services in these environments. Applications and services will behave in a "socially aware" way. This means that they will provide a sense of involvement and knowledge about the social behaviour of other persons, e.g., their degree of attention, desire for customization and control, their emotional state, interests as well as their desire to engage in social interactions. Socially aware ambient environments will be composed of a collection of smart artefacts understanding social signalling and social context, resulting in the capability of improving social orientation and collective decision making.

6.2 Privacy

In today's connected world, where computers mediate frequently our interaction and communication with our family, our friends and the outside world, many people suffer from the 'Big Brother' syndrome. Especially "privacy" is an elusive concept, because not everyone's sense of privacy is the same. Moreover, the expectations of privacy are unstable, because people's perception of privacy is situation-specific, or more general, context-dependent. The issues of changing views on privacy, trust and identity are mainly a result of the tricky trade-off for creating smartness. We distinguish here between a) System-oriented, importunate smartness and b) People-oriented, empowering smartness where they Human is in the Loop. (Streitz et al., 2005). It is becoming more and more obvious that there is an interaction and balance/ trade-off between a) being able to provide intelligent support based on collecting sensor data for selecting and tailoring functionality to make the system "smart" and b) the right of people to be in control over which data are being collected, where, when, by whom, and how they are being used. This calls for the development of Privacy Enhancing Technologies (PETs) and especially for making it a standard part of system design by addressing the conflict of ubiquitous and unobtrusive data collection/provision with human control and attention in an open fashion and at an early stage of design.

7 Proposals for a Future Research Agenda

In order to contribute to overcoming the gap between today's situation and the vision of the future as expressed in the goal "Towards the Humane City: Designing Future Urban Interaction and Communication Environments", we developed in the InterLink project twelve research lines (R1-R12) as constituents of a future research agenda. Due to space limitation, only their headings can be listed here:

R1: Rationale for Humane/All-inclusive Cities (users are citizens)
R2: Tangible Interaction and Implicit vs. Explicit Interaction
R3: Hybrid Symmetric Interaction between Real and (multiple) Virtual worlds
R4: Space-Time Dispersed Interfaces
R5: Crowd and Swarm Based Interaction
R6: Spatial and Embodied Smartness (distributed cognitive systems, outside-in robot)
R7: Awareness and Feedback (sensors, physiological, environmental …)
R8: Emotion Processing (affective computing)
R9: Social Networks and Collective Intelligence
R10: Self-Organization in Socially Aware Ambient Systems
R11: Realization and User Experience of Privacy and Trust
R12: Scaling (as the major horizontal issue)

The interested reader will find detailed descriptions of each of the twelve research lines in the final report of the InterLink project (2009).

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Author Index