Designing Context Sensitive Mobile User Interface

Mao Zheng[1], Olga Ormandjieva[2], and Hao Fan[3]
[1]Department of Computer Science, University of Wisconsin-La Crosse, La Crosse, WI, USA
[2]Department of Computer Science & Software Engineering, Concordia University, Montreal, QC, Canada
[3]School of Information Management, Wuhan University, Wuhan, Hubei, China

Abstract – *With ubiquitous computing, users access their applications in a wide variety of environments. To cope with various and dynamic execution environments, the adaptive mobile user interface is desired to enhance human-computer interactions. This paper discusses the design of the context sensitive mobile user interface that will enable automatic adaptions to the environment. The challenges of this research lie in the areas of context classification and collection, context analysis and mobile user interface adaption due to environmental changes. We propose a design to address these issues and use an e-commerce application to illustrate the ideas presented.*

Keywords: Context, Mobile, User Interface, E-commerce

1 Introduction

Context awareness is increasingly gaining applicability in interactive ubiquitous mobile computing systems. According to Dey's definition [1], "a system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task". One issue for context-aware applications is to easily make use of these various services at a low development cost and with easy reconfiguration enablers. To address this issue, our research work discusses the collection and classification of the context information, and the automatic adaption based on the context analysis in the mobile user interface behaviors.

A dynamic user environment, which must respond to fast-changing contexts, can benefit from the use of a context-aware device. The e-commerce system is an example of such an environment. Currently mobile computing provides a convenient service for e-commerce systems. It ensures the user's universal access to the system.

Some usability challenges appear in real world e-commerce applications related to entering and retrieving item and user information: 1) human-computer interfaces unsuited for certain highly disruptive user environment; and 2) cognitive excess resulting from the number of steps required to retrieve correct information. We aim to address the idea of classifying the e-commerce system context as a foundation for designing and developing a context-sensitive mobile e-commerce application. The designer must incorporate context-based modifications into the appearance or the behavior of the interface, either at the design time or at run time.

It is important to point out we are separating how context is acquired from how it is used, by adapting mobile user interface features to the user's context. For example: user's technical skills or experience with a mobile device is one of the components in the user's characteristic. The user, as a composite entity, is part of the context. The mobile user interface is automatically adapted to the context information. We hope that this research work will improve human-computer interaction with the aid of a mobile user interface that responds appropriately to contextual changes.

The paper is organized as follows: In section 2, we introduce the application context, which is the e-commerce domain. Note that we do not address the important issues of security, privacy and reliability with regards to e-commerce applications in this paper. In section 3, we present our design approach. In section 4, we compare how our views are similar to those of others and how they are difference. Section 5 concludes the paper and outlines the directions of our ongoing research.

2 E-Commerce Example

In this section we present an illustrative scenario with a mobile context-aware e-commerce application.

Zoe is a client of a famous e-commerce merchant whom often makes many different purchases. Zoe's client profile is used to provide her a customized service. Zoe decides to go by train to visit her friend whom lives near the Grand Canyon. Once the train starts, she turns on her cell phone and uses its Internet connection (e.g. 3G) to connect to the e-commerce server. When connected, Zoe receives "recommendation" on: 1) hiking shoes because Zoe's hobby is hiking. 2) DVDs because today is Zoe's best friend Maddie's birthday, and Maddie's hobby is watching movies. 3) a jacket because the outside temperature measured by the weather station near her current mobile phone location is 25 degrees Fahrenheit.

Just when Zoe decided to look in detail at the products using the application product description, the train enters a tunnel. Inside the train, it gets dark. The mobile device will change to either display the result by sound or display the text in larger font. In addition, Zoe has also configured her profile to download videos only if the mobile phone is using Wi-Fi signals. Thus the application only allows images displayed at the current network environment.

This example shows that the e-commerce ubiquitous application needs to be context-aware in order to cope with different user profiles and preferences, and different elements of the environment in a distributed setting.

3 The Development of Context Sensitive Mobile User Interface

Our approach to adaption is to change the relevant mobile user interface parameters base on context. The context information comes from various sensors built in the mobile device and from the user's profile. The user's characteristic is part of the context in nature. The context information is typically classified into logic and physical categories. User's characteristic belongs to the logic category, while the time and location fall into the physical category.

3.1 Mobile User Interface Features

Our approach allows users to easily handle information on the mobile user interface which deals with the user's motion, and various environmental effects, such as different combinations of ambient conditions (i.e., light and noise levels). The user interface features, which can be changed on a modern smartphone, are listed in Table 1 [2].

Table 1 Mobile User Interface Features

Mobile User Interface Features	Values
Font size	Small, medium, large
Font color	RGB color, black & white
Font format	Times New Roman, Tahoma, etc.
Background color	Auto adjust, changing manually
Data Entry	Typing, tapping, voice
Display information	Text, sound
Message delivery	Text, voice, alert, silent, pre answer
Brightness level	Increase/decrease
Ring volume	Low, medium, high, alert, vibration
Sound level	Mute, regular, loud

Adapting mobile user interfaces to the various basic contexts involved, such as location, time and ambient conditions, will enhance the user's experience of a context-aware device.

3.2 Define User's Characteristics

We considered two general sources for charactering user: domain experience and experience using mobile devices. Our research goal is to adapt the mobile user interface to individual users, while at the same time assigning each user to one of a number of groups. The user's characteristics helped us achieve this goal successfully. For this research, we needed to consider two aspects of modeling: categorization, and differentiation. Through categorization, the differences between people are simplified, and the individuals are assigned to membership groups. Through differentiation, the differences between groups are enlarged, and the differences between individual members of the same group are minimized [3].

In an e-commerce application, the user's domain experience is defined in terms of **VIP** (has been active for more than two years or paid the premium membership) and **client** (has been active for less than two years and did not pay the premium membership). Here *active* means the total value that the user has purchased is over a certain threshold. The mobile experience is defined in terms of **Basic** (less than 1 year), **Intermediate** (more than 1 year and less than 2 years), and **Advanced** (more than 2 years). Example: if a user is in the client group, and his/her mobile experience is basic, then "tapping" is enabled as a default data entry feature in the mobile user interface.

3.3 Rule-based Approach

Our work depends on the internal sensors of a mobile device, user profile and the adaption of mobile user interface features for both entering and accessing data. The key point of the approach is to capture and represent the knowledge required for the mobile user interface to self-adapt at run time or to implement the adaptions at design time. The rule-based approach representation is what we proposed.

A user interface is the link between the software system and the human user, and the software is a tool that helps a user perform his/her task. Rules at different stages can be developed independent of each other. At each stage, different contextual information is included. Example: Zoe is a VIP of the e-commerce application. She wants to 1) check the latest recommendations, and 2) order a DVD for her friend Maddie in a dark and noisy environment. Then the mobile user interface can display the result in large font text, increase the brightness level of the screen; accept the order given by Zoe by tapping, rather than typed on the keyboard, or by voice.

In this scenario, the user interface features adapted or modified (temporarily) are: change to large text output while the environment is dark and noisy; change to tapping since Zoe used all the information that is stored in her profile to place the order. Due to her VIP status, a 10% discount and free shipping are applied to her purchases automatically.

All the condition attributes presented in this work are based on basic context, which consists of the location, time, ambient conditions and the noise level. Domain-based context consists of the user and the tasks. The tasks that a VIP most frequently perform can be summarized in two categories, input tasks and output tasks, as follows:

- Output tasks: review recommendations, watch product video and animations.

- Input tasks: select product, place order, and enter purchase information.

Some sample conditions in the context-aware e-commerce application are listed below:

C1. The mobile phone is in a Wi-Fi environment
C2. The level of light in the room is bright
C3. The level of noise in the room is low

The rules will be based on the match context value. For example,

For a VIP, if [C1] is satisfied, then the mobile user interface features will follow rule 1 as the action A1 and A2 described. It is shown in Table 2.

Table 2 Sample Rule Table for Output Tasks (VIP)

Conditions		**Rules**	
		1	2
C1	The mobile phone is in a Wi-Fi environment	Y	N
C2	The level of light in the room is bright	Y	N
C3	The level of noise in the room is low	N	N
Actions			
A1	Adjust the font size for displaying information to "user default", playing product video and animations	X	
A2	Adjust the display brightness to "user default"	X	
A3	Adjust the display brightness to "high"		X
A4	Receive information by sound		
A5	Receive information by tapping	X	X

Similarly Table 3 shows the sample rule table for input task when the user is a VIP.

Due to the time limit with the current project, we are still in the stage of developing the prototype of the context-based e-commerce application. Table 2 and table 3 are only a sample of the conditions and hence rules. The complete conditions and rules need to be explored and verified through analysis and development. Once we get all the conditions, the complete set of rules is 2^n combinations, where n is the number of conditions. Rule analysis later on will be focused on consistency and applicability of the proposed rules.

For the same reason, we have not yet been able to research on the impact of the user's mobile experience in the development of the adaption rules for the mobile user interfaces. For example, an advanced VIP user may desire a more complicated, but efficient mobile user interface.

Table 3 Sample Rule Table for Input Tasks (VIP)

Conditions		**Rules**	
		1	2
C1	The mobile phone is in a Wi-Fi environment	Y	N
C2	The level of light in the room is bright	Y	Y
C3	The level of noise in the room is low	Y	N
Actions			
A1	Adjust the font size for displaying information to "user default", playing product video and animations	X	
A2	Adjust the display brightness to "user default"	X	X
A3	Adjust the display brightness to "high"		
A4	Receive information by voice	X	
A5	Receive information by tapping		X

In summary, our proposed rule-based approach is described in the flow chart below.

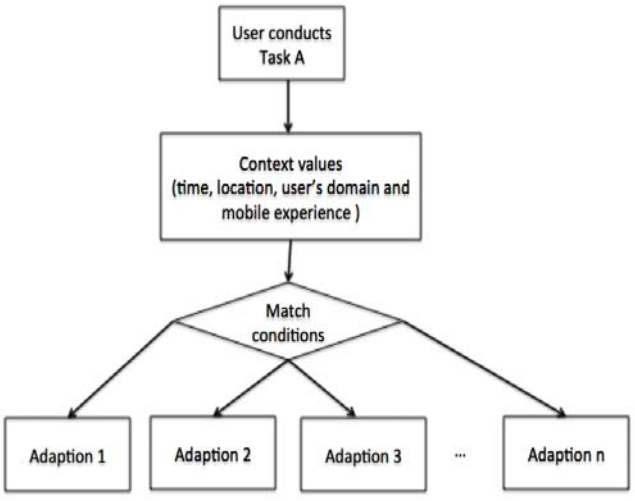

Figure 1 Approach Flow Chart

4 Related Work

Some researchers define context as the user's physical, social, emotional or informational state, or as the subset of physical and conceptual states of interest to a particular entity [4]. The authors in [4] have presented the definition or interpretation of the term by various researchers, including Schilit and Theimer [5], Brown *et al.* [6], Ryan *et al.* [7], Dey [8], Franklin & Flaschbart [9], Ward *et al.* [10], Rodden *et al.* [11], Hull *et al.* [12], and Pascoe [13]. In Dey and Abowd [4], the authors are interested in context-aware systems, and so they focused on characterizing the term itself. In Pascoe [13], the author's interest is wearable computers, so his view of context is based on environmental parameters as perceived by the senses. Our work depends on the internal sensors of a mobile device, and the adaption of the mobile user interface features for both entering and accessing data. Our model is based on separating how context is acquired from how it is used, by adapting the mobile user interface features to the user's context.

Most of the research in this area has been based on analyzing context-aware computing that uses sensing and situational information to automate services, such as location, time, identity and action. More detailed adaption has been generally ignored. For example, input data based on context. In our research, we attempted to build the user's characteristics from both domain experience and mobile technology experience, and to collect all the context values corresponding to the user's task and then to automatically adapt the mobile user interfaces to the context information.

The process of developing context-based user interface has been explored in a number of other projects. Clercks *et al*. [14], for example, discuss various tools to support the model-based approach. Many studies have been conducted on adaption using a decision table. In [15], an approach is proposed for modeling adaptive 3D navigation in a virtual environment. In order to adapt to different types of users, they designed a system of four templates corresponding to four different types of users. Our work differs in that our adaption technique is based on composite context information that extracts values from sensors in smartphones and relates with the user's domain and mobile technology experiences. Then we develop a set of rules for the mobile user interface adaption.

5 Conclusions

Each context-aware application has its own set of behaviors to react to context modifications. Hence, every software engineer needs to clearly understand the goal of the development and categorize the context in the application. We have proposed a rule-based approach and illustrate the idea in an e-commerce application.

The contributions of this research work lie in 1) considering both the user's domain and mobile technology experience in context, 2) detailed modeling inclusion on both input and output data, 3) using the rule to present acquired knowledge in the application. The adaption built into a mobile user interface can enhance the accessibility in the e-commerce domain. The additional benefits are a) increase usability. For example, if the mobile user interface only supports one interaction model, such as typing or voice input/sound output, the usability of the service would be drastically decreased. b) increased awareness of social ethics, e.g. in a quiet room after midnight, the sound could be turned off automatically. c) improved workflow productivity.

The future work of this research will fall into three directions: 1) researching on how the user's mobile technology experience will impact the adaption of the mobile user interface. 2) discovering and verifying the completeness of the conditions and rules. 3) conducting effective testing for the context-aware applications. 4) building a context model and reconfiguring the model for other applications.

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