bachelor's thesis

Accessible UIP client for Windows Phone 8

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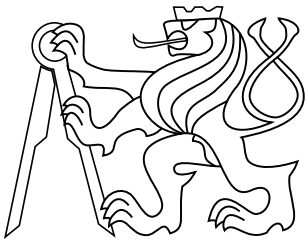

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Declaration

I declare that I worked out the presented thesis independently and I quoted all used sources of information in accord with Methodical instructions about ethical principles for writing an academic thesis.

Abstract

This work describes the development of an accessible UIP client application for Windows Phone 8.

Klíčová slova

Navigace, Generování UI, Přístupnost, Windows Phone 8, UIProtocol

Abstract

This work describes the development of an accessible UIP client application for Windows Phone 8.

Keywords

Navigation, UI Generation, Accessibility, Windows Phone 8, UIProtocol

Contents

Abbreviations

The list of abbreviations used in this document

FEE CTU	Faculty of Electrical Engineering of the Czech Technical University in Prague
UIP	UI Protocol developed for research purposes at the FEE CTU
UI	User Interface
TTS	Text-to-Speech
OS	Operating System
API	Application Programming Interface
NFC	Near Field Communication

1 UIProtocol

This chapter introduces the reader to the UIProtocol, its architecture and communication between client and server.

1.1 About UIProtocol

Universal Interface Protocol (UIProtocol) is a user interface specification language [1] being developed at FEE CTU for research purposes. At the time of writing this thesis, the specification is not publicly available. UIProtocol provides means for describing user interfaces and transferring data related to interaction between user and an UIProtocol based application. It is designed to be cross-platform, programming language independent and easily localized.
UIProtocol is an XML based application protocol that allows for describing the hierarchical structure of the GUI along with the placement and visual appearance of the containers and components. It is designed for a client-server system and for facilitating client-server applications it defines the communication rules between client and server. The communication is based on exchange of XML documents which contain all components and values needed for rendering the UI. The client first initiates the communication and receives respective XML description from the server. The description can be of four different types: interfaces, i.e. the UI components and containers, models which contain the data displayed and actions. The communication from client to server only consists of event descriptions. For example, when a user presses a button, the event information is sent to the server which responds by model and/or interface update.
An example of such situation may be a user requesting a weather app to his handheld device. As he enters his location and presses a button to request the weather information, part of the job is done directly by the client and the other is sent to the server. The part done directly at the client are easy tasks, such as visual effects when pressing the button. Even these effects can be, ahead of time, specified by information from the server. The request for weather is then sent to the server (event), which processes the information and responds by sending the interface structure, components and the weather information. This is then displayed to the user who than has other options to interact with the app.

The documents of UIProtocol can be sent in either direction usually through a single channel without waiting for a request, e.g. server can send updates to the client as soon as the displayed information needs to be updated, without having to wait for an update request. Should an application not communicate with a remote server, there is the possibility of both client and server running on the same machine although this is not a typical usage.

1.1.1 UIProtocol Client

UIProtocol client is thin, i.e. no application code is executed on the client side. The device running the client is thought to be the the one user directly uses, that is, it

renders the content to the user and receives input from them. From the UIProtocol point of view, the client device is also considered insecure, i.e. the device may be misused to send invalid data to the server and may be used to attack it. The UIP client may not implement the whole feature set defined by UIProtocol. What has to be implemented is the minimal functionality that is able to render a user interface, sending event information to the server and update the application it by data coming from it.

1.1.2 UIProtocol Server

UIProtocol is the part of the architecture which is responsible for evaluating the client events and sending a correct response - this is where the application logic is executed. It must be able to service multiple client simultaneously and is intended to run on a machine which is considered safe.

1.1.3 Elements of UIProtocol Communication

As mentioned previously, the information exchange between client and server concerns Interfaces, Models, Actions (which are sent from server to client) and events (sent from client to server). In the following subsections we will describe these in greater detail and also include more information on UIP syntax.

Syntax of UIProtocol

The UIP document syntax is shown below in Listing 1.1 which shows the four possible tags with the root element, with the actions tag being optional. The tags define the behavior of the application and are covered later in the chapter, with the exception of actions tag.

Listing 1.1 UIP document Syntax

```
<?xml version="1.0" encoding="UTF-8"?>
<UIProtocol version="1.0">
  <interfaces>
    <!-- interface deinitions -->
  </interfaces>
  <models>
    <!-- model definitions -->
  </models>
  <events>
    <!-- event definitions -->
  </events>
  <actions>
    <!-- action definitions - optional -->
  </actions>
</UIProtocol>
```

Every UIProtocol document must contain an XML header with the version and encoding (UTF-8 recommended).

Interfaces

Interface describes the structure and components of the user interface. Every interface can nest containers and elements that form a part of user interface. An example can be seen in Listing 1.2. The listing includes containers and elements of different types, for

example "public.input.text" is a standard component which will be rendered as an element into which a user can enter text. It also shows how interfaces can be embedded. This is done by including an element or container with class name corresponding to different interface's class. The interfaces are uniquely identified by the class attribute (unlike most other objects in UIProtocol and other markup languages identified by id attribute). Note that element tag can have an id attribute, as shown.

Listing 1.2 Interface Description Example

```
<interfaces>
  <interface class="ui.Interface1">
    <!-- interface description -->
  </interface>
  <interface class="ui.Interface2">
    <container class="public.container.panel">
      <element class="public.input.text" id="nameTextBox">
        <property name="text" value="Enter first name" key="gui:fstName
            "/>
      </element>
      <element class="ui.Interface1"/>
    </container>
  </interface>
</interfaces>
```

Events

Events inform the server that some action was triggered at the client side (e.g. a button press) or that there was some other update (e.g. change in sensor readings). This is the basic mechanism of client to server communication and therefore has to be supported by client. The event element contains a unique id which specifies the event source. An event can contain any number of properties which describe it more closely. An example is shown in Listing 1.3.

Listing 1.3 Events Example

```
<events>
  <event id="login">
    <property name="username" value="user"/>
    <property name="password" value="pass"/>
  </event>
</events>
```

Models

Models serve as the storage for data that is displayed to the user. A model contains data in properties which are uniquely identified by key attribute. The key is separated by colon into two parts - first referencing a model and second referencing a property within the model. When changing the contents of a model, all of the UI elements bound to the model by the key attribute are updated. UIP provides support for this binding and therefore updating the app contents is made easy. For example, there may be two representations of humidity level in a given environment (text and a graphical representation). If they are both bound to the same model, changing the respective property within that model will be immediately reflected.

Properties

Properties are the most nested elements of an UIP document and define the visual appearance, positioning of GUI objects and more. Every property has to have a name, which defines what feature of the connected object is described by this property. For example the property in Listing 1.2 with name text defines the text displayed in the text field. Value is a constant that will define the text. The mentioned property also contains the key attribute which binds the displayed value to a model. The part before the colon references a model and the part after colon references a property within the model. That is, if there is a model gui with property fstName, the value of the property is used. Moreover, whenever the value of the referenced property is updated, the update is automatically reflected in all other bound properties.

2 Accessibility of Current Mobile Platforms

In this chapter we will analyze the accessibility features of today's most common mobile platforms. Since this thesis is about development of a UIP client for Windows Phone 8, we will put emphasis on this OS.

2.1 Windows Phone 8 Accessibility

This section covers all of the features for ease of access that are included in the Windows Phone 8 operating system. For the purposes of this project, we are particularly interested in features that may help disabled users. From this point of view, one of the most important are the voice commands and speech recognition features which Windows phone 8 has built-in and which support a wide range of languages.

2.1.1 Windows Phone 8 Speech Features

Users can interact with the phone using speech. There are three speech components that a developer can integrate in her app and the user can take advantage of them: voice commands, speech recognition, and text-to-speech (TTS). We will explore these features in the following paragraphs. At the time of writing, the speech features support 15 major languages ranging from English to Russian or even English with the Indian accent. Czech, however, is not supported. To use the speech features the user has to download a language pack.

Speech Recognition

Users can give input to an app or accomplish tasks with it using speech recognition. An example usage can be dictating content of an SMS. This is very similar to the Voice Command feature, but the key difference is that speech recognition occurs when user is in the app, and Voice Commands occur from outside of the app [2]. The second key difference is that the Voice Commands are defined on a finite and usually small set of words (commands), whereas the Speech Recognition should recognize words from a much larger dictionary – in ideal case a whole human language.

Voice Commands

When a user installs an app, they can automatically use voice to access it by speaking "open" or "start", followed by the app name. The range of actions that can be triggered by Voice Commands is much wider, the full list of available speech commands that are provided by the operating system is listed in table 1. A developer can also define her own set of voice commands and allow users not only to open the app using voice but also to carry out more advanced tasks within the app. This is very important for our work since it allows for exposing a wider range of commands to the visually impaired user. Note that technically, this still happens from the outside of the app, as described in the previous section.

Text to Speech (TTS)

TTS can be used to speak text to the user via the phone's speaker or headset.The spoken text can be simple strings or strings formatted according to the industry-standard Speech Synthesis Markup Language (SSML) Version 1.0. TTS is also used in some of the other features for ease of access which are covered in the next section.

Other Speech Features

A feature named Speech for phone accessibility allows the following: 1) Talking caller ID When getting a call or receiving a text, the phone can announce the name of the caller or the number. 2) Speech-controlled speed dial User can assign a number to a person from the contact list and then say Say "Call speed dial number" (where number is the assigned number) to call the person. Assigning the speed dial number is also speech-enabled. 3) Read aloud incoming text messages Similarly to 1, the phone can read the content of a text.

2.1.2 Other Tools for Ease of Access

Windows phone 8 comes with more features for ease of access which can help lightly visually impaired users. User can change font size in apps (not in the tiles of the home screen), switch the display theme to high-contrast colors and use the screen magnifier. Mobile Accessibility is a set of accessible apps with a screen reader, which helps use the phone by reading the application content aloud. The applications include phone, text, email, and web browsing. When Mobile Accessibility is turned on, notifications like alarms, calendar events, and low battery warnings will be read aloud. This feature, however, is only available in version 8.0.10501.127 or later. For an unknown reason, an update to this version is not available for our phone.

2.1.3 Conclusions

Windows Phone platform offers some features to make its accessibility to disabled users easier. However, there are still gaps to be filled such as the non-existence of a built-in screen reader. Its absence puts Windows Phone usage out of the question for visually impaired users. There is an screen reader available from version 8.0.10501.127 but this only works with some apps and update to this version is not available to all devices at the time of writing. The platform has recently been experiencing slow growth in some world markets but is stagnating in others [3] and it cannot be estimated how much effort will be put into the development of more accessibility features. It should be noted that the other two major platforms, iOS and Android both include the screen reader.

2.2 Android Accessibility

Similarly to the previous section, here we will analyze the accessibility options for devices running the Android operating system, with the emphasis on visually impaired users. We will analyze the features of the latest Android OS released, which is version 4.4, code name KitKat. It should be noted that there were no major updates to the accessibility options since Android 4.2.2 Jelly Bean.

2.2.1 Speech Features

Android also offers the option to interact with the device using speech and has some interesting accessibility features and compared to Windows Phone 8 offers a wider language support. Similarly to Windows Phone, an Android developer can take advantage of speech recognition and text-to-speech (TTS). Android comes with a number of built-in voice commands but unlike the Windows Phone, Android does not allow developers to expose their own voice commands. The last important feature on Android is TalkBack. At the time of writing, the speech recognition supports more than 40 languages including several accents of English, and even minor languages such as Czech. Other functions do not have such a wide support.

Speech Recognition

Users can give input to an app or accomplish tasks with it using speech recognition. An example usage can be dictating content of an SMS. As mentioned before, this feature supports many languages but on the other hand required internet connection. There is not an option to use the recognition offline. We do not consider this a major drawback, as nowadays a mobile internet connection is more available than ever.

Voice Action Commands

In Android, Voice Action Commands are closely related to the Google Now feature. Google Now has a wide range of uses not specifically designed for visually impaired. It can, however, serve them well by allowing them to get information using voice. In general, google now should provide the user with relevant information when they need it. Google describes it by the phrase "The right information at just the right time". This includes telling the user the weather forecast, showing the best route to work, calling someone, creating a reminder and much more. The full list of Voice action Commands is in Table 2.

Note that for some commands, the system gives you a spoken answer. The current drawback of the system is that it only supports English, French, German, Spanish, and Italian. With other languages, user can only make a voice-induced Google search with no voice response.

Text to Speech (TTS)

TTS can be used to speak text to the user via the phone's speaker or headset. The spoken text can be simple strings. The industry-standard Speech Synthesis Markup Language (SSML) is supported only in a limited scope. TTS is also used in TalkBack which is described in the next section.

Other Speech Features

TalkBack is an important functionality that strives for more accessible phone control for visually impaired. Basically, it is a touch-controlled screen reader. When enabled, user can drag finger across the screen selecting the components and getting their acoustic description. By double tapping anywhere in the screen, user can open/use the last selected item. TalkBack also supports gestures. This way, a user can get a complete description of the user interface. The blog post of a blind accessibility engineer from Mozilla Foundation [4] claims that visually impaired users of this system still have to overcome some obstacles.

2.2.2 Other Tools for Ease of Access

Android too comes with more features for ease of access which can help lightly visually impaired users which include change font size and the screen magnifier.

2.2.3 Conclusions

Compared to Windows Phone, Android has better accessibility options. It includes the usual functions, such as text to speech, speech recognition or font size settings. It also offers a built-in screen reader, called TalkBack. Android is therefore fairly usable even for visually impaired.

2.3 iOS Accessibility

In this chapter, we will cover the accessibility of Apple's iOS. Again we consider the latest iOS released, which is version 7.0.4. Overall, the accessibility features of iOS are very similar to those of Android and therefore I will describe the features more briefly.

2.3.1 Speech Features

As with the previous two platforms, iOS also offers users o interact with a device using speech. Apple was the first one to introduce the features for people with disabilities, such as VoiceOver. iOS supports speech recognition and text-to-speech in 15 major languages (the same number as Windows Phone 8). iOs also comes with a number of built-in voice commands but does not allow developers to expose their own voice commands.

Speech Recognition - Dictation

Users can give input to an app or accomplish tasks with it using speech recognition. An example usage can be dictating content of a text. As mentioned before, this feature supports 15 languages and requires an internet connection.

Voice Control - Siri

Siri in iOS can be thought of as an equivalent to Android's Google Now. Siri can send emails, set reminders and more. If asked a question, it can read aloud the answer.

Text to Speech (TTS)

TTS can be used to speak text to the user via the phone's speaker or headset and this feature was added only recently, in iOS 7.0. The spoken text can be simple strings. The industry-standard Speech Synthesis Markup Language (SSML) is not mentioned in the API documentation.

Other Speech Features

It could be said that Google's TalkBack is Apple's VoiceOver. Both offer very similar functions and the reason for existence is reading the content of the screen based on touch input and control of the device by gestures. The mentioned blog post of the blind accessibility engineer from Mozilla Foundation favors VoiceOver over TalkBack [4].

2.3.2 Other Tools for Ease of Access

iOS too comes with more features for ease of access which can help lightly visually impaired users. The user can change font size, invert Colors and use the screen magnifier (Zoom). iOS devices also support more than 40 Bluetooth wireless braille displays out of the box. User can pair their braille display with the device and start using it to navigate it with VoiceOver. In addition, iPad, iPhone, and iPod touch include braille tables for more than 25 languages.

2.3.3 Conclusions

Apple's iOS was the first to offer advanced accessibility features and the first to become usable for visually impaired users. The accessibility features are comparable with the accessibility feature set of Android. iOS allows developers to create apps acesible for a wide range of users.

3 Navigation Systems Analysis

There is a number of interesting papers in the field of navigation systems for disabled. A large number of them is oriented toward visually impaired or people with movement disabilities. Generally speaking, there are ongoing efforts to create maps for indoor environments, with the Google Indoor Maps being the head of this movement. Currently, the Google Indoor Maps are in beta and are not a priori intended for navigation but merely to provide the user with an approximate idea of where they are. In this chapter we will analyze some of the existing works which specifically address the problem of indoor navigation.

3.1 Current Systems

NaviTerier [5] is a research project at FEE CTU which aims at the problem of navigating visually impaired inside buildings. This system does not require any specialized technical equipment. It relies only on mobile phones with voice output, which is a non-problematic way of communicating information. The navigation system works on a principle of sequential presentation of carefully prepared description of the building to the user by the current mobile phone voice output. This system does not keep track of the user location. Instead, it breaks the directions into smaller pieces and then sequentially gives the pieces to the user who follows them and asks for next portion when ready. This system was tested with visually impaired users.
Recently this system was combined with UI Protocol platform, which is another research project of FEE CTU developed for the purpose of creating user interfaces customized to abilities and preferences of individual users. The result is navigational system called NaviTerier UIP (NUIP) [6] which combines the navigational part of NaviTerier and the ability of UIP to generate and deliver customized user interfaces that can fit better people with disabilities.

Luis et al.[7] propose a system which uses a infrared transmitter attached to the white cane combined with Wiimote units (the device of the Wii game console) placed so that they can determine the user's cane position using triangulation. The information from Wiimote units is communicated via Bluetooth to a computer which computes the position and then sends the directions to the user's smartphone via wifi. TTS engine running on the phone converts the directions to speech. The system has undergone preliminary testing with five blindfolded users.

An indoor navigation system to support the visually impaired is presented in [8]. The paper describes creation of a system that utilizes a commercial Ultra-Wideband (UWB) asset tracking system to support real-time location and navigation information. The paper claims that the advantage of using UWB is its resistance to narrowband interference and its robustness in complex indoor multipath environments. The system finds user position using triangulation and consists of four parts: tracking tag to be worn by the user, sensors that sense the position of the tracking tag, handheld navigator and

a server which calculates the location of the tracking tag and communicates it to the navigator. The handheld device runs software which can produce audio directions to the user. In tests, the system proved useful; It was, however, tested only on blindfolded people.

Treuillet and Royer [9] proposed a vision-based localization for blind pedestrian navigation assistance in both outdoors and indoors. The solution uses a real-time algorithm to match particular references extracted from pictures taken by a body-mounted camera which periodically takes pictures of the surroundings. The extraction uses 3D landmarks which the system first has to learn by going through a path along which the user later want to navigate. It follows that the system is not suitable in environments that are visited for the first time. For the case when it has learned the way, the system performs well.

A promising approach is shown in the PERCEPT [10] project. Its architecture consists of the three system components: the Environment, the PERCEPT glove and Android client, and the PERCEPT server. In the environment there are passive (i.e. no power supply needed) RFID tags (R-tags) deployed at strategic locations in a defined height and accompanied with signage of high contrast letters and embossed Braille. The next part of the environment are the Kiosks. Kiosks are where the user tells the system her destination. They are located at key locations of the building, such as elevators, entrances and exits and more. The R-tags are present here and the user has to find the one she needs and scan it using the glove. The glove is used to scan the R-tags and also has buttons on it that the user can press to get the instructions for the part of the route, repeat previous instructions and get instructions back to the kiosk. Also, after scanning the R-tag the gloves sends its information to the app running on user's Android phone. The app connects to the internet and downloads the directions from the PERCEPT server. These are then presented to the user through a text-to-speech engine and the user follows them. The system was tested with 24 visually impaired users. Another example of RFID use is presented in Lopez et al. [11] where user is navigated by following paths marked by RFID labels on the floor. The white cane acts as an RFID reader and communicates with a smartphone which, as in other projects, uses TTS to give directions.

There are also research works in the fields of robotics and artificial intelligence that study the problem of navigation. More specifically, they tackle the problem of real time indoor scenes recognition [12], [13], [14]. Some of these solutions allow for creating the reference map dynamically. Even though they proved to be useful in the domain of robotics and automotive industry, their applications to navigating people are limited, as they require expensive sensors and powerful computing resources. Wearing these devices would make the traveling of the users more difficult and limited. For these reasons, the solution proposed by Hesch and Roumeliotis [15] is interesting because they integrated these devices (apart from the computing) into a white cane. However, the solution has the limitations in being too heavy and large, and the laser scanner being directional.

Authors of [16] developed a system for general navigation and propose to use NFC tags. They claim the NFC navigation system is low cost and doesn't have the disadvantages present with the systems which use dead reckoning or triangulation. The proposed system consists of NFC tags spread in key locations of the building and a mobile device capable of reading the tags. The device runs an application which is connected to a server containing floor plans. The application is able to combine the

information from the sensor with the floor plan and able to navigate the user using simple directions.

3.1.1 Conclusions

There are two main approaches to the problem of navigation. In the first, the navigation system consists of active parts which, using triangulation or other methods, are able to determine the user's position at all times and then give her directions based on knowing where she is.
In the second approach, the system does not possess the information about user's position at all times. Instead it synchronizes the position at the beginning of the navigation task and then gives the user directions broken into small chunks. When the user believes she reached the destination described by the first chunk, she asks for the next one and etc. The disadvantage of this approach is that the user can get lost and not end up at the expected location. This problem can be solved by adding more "synchronization points" to strategic locations of the building. These "synchronization points" are often done through NFC tags.

4 Architecture

This chapter will go through the design of the application architecture of the UIP client for the selected platform - Windows Phone 8.

4.0.2 About Windows Phone 8

The Windows Phone 8 is the first of Microsoft's mobile platform to use the Windows NT Kernel, which is the same kernel as the one in Windows 8. Therefore some parts of the API are the same for both systems. A significant subset of Windows Runtime is built natively into Windows Phone 8, with the functionality exposed to all supported languages. This gives a developer the ability to use the same API for common tasks such as networking, working with sensors, processing location data, and implementing in-app purchase. Therefore there is more potential for code reuse.
Also, Windows Phone 8 and windows 8 share the same .NET engine. This is to deliver more stability and performance to your apps, so they can take advantage of multi-core processing and improve battery life. Most new devices are now multicore, and the operating system and apps are expected to be faster because of this technology. The development for this is done in Visual Studio 2013 and we chose the language of development to be C#.

4.0.3 Requirements

The application should perform well in terms of performance. There will be a delay present in the application's reaction time, which is a consequence of the client-server architecture ie. the need of internet connection. The delay should be reasonably small to allow for a comfortable usage of the application.
The application should run on any device powered by the Windows Phone 8 OS.

Non-functional requirements:

- UI components have platform native look
- App will be will be written in C#
- The client should not use much phone resources when idle
- App should be stable and able to process valid UIP documents
- Compatibility with UIP standard, draft 8
- UI loading times below TODO s

4.0.4 Design

5 Appendix

Table 1 Windows Phone 8 Speech Commands

Operation	Say this
Call someone from your contact list	"Call contact name" (where contact name is the name of someone in your contact list) If the person has only one phone number in your contact card, the call will start. If he or she has multiple phone numbers, you'll see an option to choose one.
Call any phone number	"Call phone number" (where phone number is any phone number, whether it belongs to a contact or not)
Redial the last number	"Redial"
Send a text message	"Text contact name" (where contact name is the name of someone in your contact list). This will start a text message to that person. Then you can dictate and send the message—hands-free.
Call your voicemail	"Call voicemail"
Open an application	"Open application" or "Start application" (where application is the name of any application on your phone, such as "Calendar," "Maps," or "Music")
Search the web	"Find search term" or "Search for search term" (where search term is what you're looking for). If you say "Find local pizza," for example, Bing will bring up a map of nearby pizza places.

Table 2 Android Speech Commands

Say	Followed by	Examples
"Open"	App name	"Open Gmail"
"Show me my schedule for the weekend."		Say "What does my day look like tomorrow?" to see tomorrow's agenda.
"Create a calendar event"	"Event description" & "day/-date" & "time"	"Create a calendar event: Dinner in San Francisco, Saturday at 7:00PM"
"Listen to TV"	Displays TV cards relevant to the TV show that's currently being broadcast	While a TV show is being broadcast, say "Listen to TV"
"Map of"	Address, name, business name, type of business, or other location	"Map of Golden Gate Park, San Francisco."
"Directions to" or	Address, name, business name, type of business, or other destination	"Directions to 1299 Colusa Avenue, Berkeley, California" or
"Navigate to"		"Navigate to Union Square, San Francisco."
"Post to Google+"	What you want posted to Google+	"Post to Google+ I'm going out of town."
"What's this song?"		When you hear a song, ask "What's this song?"
"Remind me to"	What you want to be reminded about, and when or where	"Remind me to call John at 6PM."
"Go to"	Search string or URL	"Go to Google.com"
"Send email"	"To" & contact name, "Subject" & subject text, "Message" & message text (speak punctuation)	"Send email to Hugh Briss, subject, new shoes, message, I can't wait to show you my new shoes, period."
"Note to self"	Message text	"Note to self: remember the milk"
"Set alarm"	"Time" or "for" & time, such as "10:45 a.m." or "20 minutes from now," "Label" & name of alarm	"Set alarm for 7:45 p.m., label, switch the laundry"
"Listen to"	Play music in the Google Play Music app by speaking the name of a song, artist, or album	"Listen to: Smells Like Teen Spirit"
"Call"	The name of one of your contacts	"Call George Smith"

Bibliography

[1] V. et al. Slovacek. "UIProtocol specification, draft 8". In: *CTU in Prague* (2010).

[2] *Speech for Windows Phone 8. Speech for Windows Phone 8 - development center.* 2014. URL: http://msdn.microsoft.com/en-us/library/windowsphone/develop/jj206958(v=vs.105).aspx (visited on 01/01/2014).

[3] *iPhone market share shrinks as Android, Windows Phone grow. Speech for Windows Phone 8 - development center.* 2014. URL: http://news.cnet.com/8301-13579_3-57616679-37/iphone-market-share-shrinks-as-android-windows-phone-grow/ (visited on 01/06/2014).

[4] *Android and iPhone accessibility comparison. Switching to Android full-time – an experiment.* 2014. URL: http://www.marcozehe.de/2013/04/05/switching-to-android-full-time-an-experiment/ (visited on 01/01/2014).

[5] *NaviTerier. navigation system in buildings for the visually impaired.* 2013. URL: http://usability.felk.cvut.cz/naviterier (visited on 01/01/2014).

[6] Zdenek Mikovec Jan Balata Miroslav Macik. "Context Sensitive Navigation in Hospitals". In: *30th Annual International IEEE EMBS Conference* (2013).

[7] Luis A. Guerrero, Francisco Vasquez, and Sergio F. Ochoa. "An Indoor Navigation System for the Visually Impaired". In: *Proceedings of Sensors 2012*. 2012, pp. 8237–8258. URL: http://www.ncbi.nlm.nih.gov/pubmed/22969398.

[8] N. A. Giudice T. H. Riehle P. Lichter. "An Indoor Navigation System to Support the Visually Impaired". In: *30th Annual International IEEE EMBS Conference* 30 (2009), pp. 4435–4438.

[9] SYLVIE TREUILLET and ERIC ROYER. "OUTDOOR/INDOOR VISION-BASED LOCALIZATION FOR BLIND PEDESTRIAN NAVIGATION ASSISTANCE". In: *International Journal of Image and Graphics* 10.04 (2010), pp. 481–496. DOI: 10.1142/S0219467810003937. eprint: http://www.worldscientific.com/doi/pdf/10.1142/S0219467810003937. URL: http://www.worldscientific.com/doi/abs/10.1142/S0219467810003937.

[10] Aura Ganz et al. "PERCEPT Indoor Navigation System for the Blind and Visually Impaired: Architecture and Experimentation". In: *Int. J. Telemedicine Appl.* 2012 (Jan. 2012), 19:19–19:19. ISSN: 1687-6415. DOI: 10.1155/2012/894869. URL: http://dx.doi.org/10.1155/2012/894869.

[11] Diego López-de-Ipiña, Tania Lorido, and Unai López. "Blindshopping: Enabling Accessible Shopping for Visually Impaired People Through Mobile Technologies". In: *Proceedings of the 9th International Conference on Toward Useful Services for Elderly and People with Disabilities: Smart Homes and Health Telematics*. ICOST'11. Montreal, Canada: Springer-Verlag, 2011, pp. 266–270. ISBN: 978-3-642-21534-6. URL: http://dl.acm.org/citation.cfm?id=2026187.2026232.

[12] P. Espinace et al. “Indoor Scene Recognition through Object Detection.” In: *Proceedings of the 2010 IEEE International Conference on Robotics and Automation*. 2010, pp. 1406–1413.

[13] A. Quattoni A.; Torralba. “Recognizing Indoor Scenes.” In: *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*. 2009, pp. 413–420.

[14] Anna Bosch, Xavier Muñoz, and Robert Martí. “Review: Which is the Best Way to Organize/Classify Images by Content?” In: *Image Vision Comput.* 25.6 (June 2007), pp. 778–791. ISSN: 0262-8856. DOI: 10.1016/j.imavis.2006.07.015. URL: http://dx.doi.org/10.1016/j.imavis.2006.07.015.

[15] J.A. Hesch and S.I. Roumeliotis. “Design and analysis of a portable indoor localization aid for the visually impaired.” In: *Int. J. Robot. Res.* (2010), pp. 1400–1415.

[16] B. Ozdenizci et al. “Development of an Indoor Navigation System Using NFC Technology”. In: *Information and Computing (ICIC), 2011 Fourth International Conference on*. Apr. 2011, pp. 11–14. DOI: 10.1109/ICIC.2011.53.