ImogI: Take Control over a Context-Aware Electronic Mobile Guide for Museums

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ABSTRACT

Cultural/Tourist mobile guides are becoming common aids to combine information transfer with a guidance service. Mobile guides for pedestrians provide their users with location-specific information, e.g. based on GPS coordinates. In certain situations the process of giving location-specific information is relatively static, such as in a city where the buildings and tourist sites are not likely to move over time. In a museum on the other hand, artifacts will move around the available area as exhibitions change. In this case information can not be related to a particular location but has to be related to the proximity of certain artifacts. Moreover, besides the proximity of physical objects there are also other parameters that constitute the context of use like the user profile, speed of the user,. . . . In this paper, we propose ImogI, a mobile guide that incorporates context-sensitive user interfaces. We explain how the design of ImogI is inspired by ambient intelligent environments, and which parts of the system/tools have been realized up to now. ImogI explores the boundaries of context-driven adaptivity of the user interface, and therefore we conclude this paper with a description of the preliminary results of a formal user experiment.

keywords: Mobile Guides, Context-aware systems, Adaptive User Interfaces, Intelligent User Interfaces

1. INTRODUCTION

Mobile guides for pedestrians provide their users with location-specific information. Besides other application domains, mobile guides are used in cultural/tourist settings such as museums. Being interested in HCI issues in Mobile Computing and Ambient Intelligence (AmI), we decided to explore the use of a mobile guide in an AmI environment. The AmI nature of the environment becomes obvious from intelligent objects in the environment which push information to the mobile guide when it approaches the object. The adjusted information area around the mobile guide may cause its user interface to adapt. We found an excellent occasion to investigate our ideas regarding this mobile guide by studying the requirements of its (currently fictive) integration in two museums in our neighborhood. Exploration of the museum sites and discussions with museum staff allowed us to consider the context of realistic museum visits, even if not all of the AmI technology is currently installed.

The two museums that are located nearby our department are the *Gallo-Roman Museum* of Tongeren and the open air museum *Bokrijk*. The former is an indoor as well as an open air museum and gives an historic overview of the archaeological findings in the region, while the latter is solely an open-air museum that depicts the life of the farmers in Flanders 150 years ago. Both represent certain *artifacts* that have some historical value. Artifacts can be old farmer houses, jewelry, covert wagons, ancient tools,. . . that have some specific information which is related to these objects.

In our requirements study we learned a museum exposition is *designed* to maximize learning: both museums we visited carefully selected the information that was available per artifact. This was done to maximize the learning process and to allow visitors to “experience” the discovery process. A mobile guide throughout the museum may not reveal all possible information, but only a carefully selected subset of that information. In addition to the information related to an artifact, the location of the artifacts with respect to each other is also from particular importance.

A mobile guide should take this into account. It is up to the museum designer to decide what information should be shown in a particular context of use (context being defined in Sect 1). To unite the way the museum designer thinks about a museum setup and how information is spread throughout the museum, all information that belongs to an artifact can only be accessed (at least in a real AmI setup) when the visitor is nearby that artifact.

In contrast with fixed positions of objects in a navigation system for a city, artifacts in a museum will move around the available area and information can not be related to a particular location but has to be related to the proximity of certain artifacts. Moreover, besides the proximity of physical objects there are also other parameters that constitute the context of use like the user profile, speed of the user,. . . .

In this paper, we describe ImogI, a mobile guide that incorporates context-sensitive user interfaces and explores the boundaries of context-driven adaptivity of the user interface.

The contribution of this paper exists out of three parts:

Designer control : instead of being bound to a pre-installed map or map design, the museum designer has control over the information that will be communicated to the user.

Ambient intelligence : the mobile guide can use information stored in its environment at runtime.

Adaptivity : adaptability of mobile guides is twofold: first of all the information changes according to the location of the user, and second the applications user interface adapts according to changes in the context of use.

As the definition of "context of use" we refer to the CoDAMoS context ontology [12] which is available at `http://www.cs.kuleuven.ac.be/cwis/research/distrinet/projects/CoDAMoS/ontology`. The context ontology is built around four main entities: *user*, *environment*, *platform* and *service*. These cover the different aspects that have to be taken into account to construct a context-sensitive mobile guide. General resource-awareness has been tackled in [2]; this mobile navigation system for pedestrians adapts to the context of use (the available resources) and supports adaptivity of the data presentation. It uses several "obtrusive" accessories to get information from the user's environment, like a 3D-pointing device and a clip-on camera. Nevertheless, it is one of the most advanced context-sensitive mobile guides.

In this section we gave an overview of the actual requirements for the mobile guide. The remainder of this paper is structured as follows: section 2 gives an overview of the relevant related work. Next, in section 3 our context-sensitive mobile guide ImogI is introduced. Section 4 shows that ImogI is being developed for "ambient intelligent" environments after which section 5 illustrates how this complicates usability issues of a mobile guide. Finally, section 6 draws up the conclusions and discusses the current state of ImogI.

2. RELATED WORK

Cultural/Tourist mobile guides are becoming common aids to combine information transfer with a guidance service. "Traditional" mobile guides, like (commercial) car navigation systems and city guides offer information solely based on the location of the user. This location is determined using a Global Positioning System (GPS) in combination with a Personal Digital Assistant (PDA).

Since the PDA is powerful enough to serve as a mobile guide, there was a real boom in the research *and* development of these kind of applications. Kray and Baus give an overview of existing mobile guides in [11]; they compare mobile guides on 5 aspects: basic features, situational factors, adaptation capabilities, user interaction and architecture. Only few mobile guides take *context* into account, with context being location, user, environment,. . . . The GUIDE system from Cheverst et. al. [7, 5] is such a system that offers context-aware content: the provided information is linked to the location of the user.

Ciavarella and Paternò discuss the description of location-aware indoor PDA applications in [6]. They provide an overview for indoor location identification of the PDA, which remains a difficult problem. In our approach the indoor location is determined by the *proximity* of objects; the group of objects that communicate their information with the PDA (see Sect. 4). the Infrared Data Association (IrDA) protocol seems currently the most reasonable way to have a reliable indoor location positioning system though, e.g. [4].

From an historic perspective, the concept of using the proximity of physical objects and the location of the user for context-aware mobile computing originated from the Xerox PARCTAB[1] project [1, 13]. This shows *indoor* positioning systems today (e.g. [6]) are actually the same as ten years ago.

Electronic Mobile Guides are not new, but there is still an important threshold for introducing them in a touristic environment. Even more than normal desktop applications they require extensive user testing, which turns out to be a real challenge [3]. An electronic mobile guide is very obtrusive: the success and benefits depend on its ease of use, the users and the kind of tours it tries to replace or enhance. One such example is provided by Goodman et. al. [9]: the success rate of introducing new technologies for common (mobile) tasks is highly dependent on the target groups. This dependency increased when the technology was not a necessity to execute the tasks.

3. IMOGI: A REGION-BASED MOBILE GUIDE

ImogI is our own implementation of a Context-Aware Mobile Guide for outdoor as well as indoor locations. It uses GPS to identify its location in outdoor environments, communicates with other objects in the environment through Bluetooth and is programmed with the .NET Framework in C# [16] on the Microsoft Pocket PC Operating System. The information that is shown in the user interface can be obtained in two different ways: on the one hand it can be stored on the mobile guide, on the other hand it can be queried from the artifacts that are in the direct surroundings of the mobile guide through wireless communication. In contrast with other approaches we have no built-in support for GPRS information retrieval, though this could be added in the future.

ImogI actually consists out of *three different interactive tools* that help to design, configure and use custom maps and information in a user-centered way:

Desktop Design Tool Fig. 1(a) shows the ImogI desktop design tool. It enables the designer to load a custom map and annotate it with different information. There

[1] `http://sandbox.parc.xerox.com/parctab/`

is also graphical support for route annotation and map overview (not shown in the screenshots). In the future we want to expand this in order to support ontology-based information that can be related to the map. In Sect. 4 we will show how rich semantic information can help to construct the proper relations between different artifacts.

Mobile Configuration Tool Since ImogI is meant to be a generic solution for mobile guides, it is not limited to a particular map. It allows the user to load custom maps (e.g. downloadable custom maps from the Internet) and provides an initialization tool that scales and aligns the map with the correct GPS coordinates.

Mobile Information System Fig. 1(b) shows the mobile information system part of ImogI where the map view is selected (The map is zoomed out to give a clear overview). Notice the map we use in Fig. 1(b) is a "touristic" map where interesting spots are larger w.r.t. the scale of the map.

The Mobile Configuration Tool and the Mobile Information System are actually integrated on the mobile device.

4. CONTEXT-AWARENESS: INSIDE AN AMBIENT INTELLIGENT ENVIRONMENT

This section focuses on the Mobile Information System part of ImogI, which aims to be a context-aware information system. As mentioned in section 1 "context" is not limited to location, but also includes the physical environment, the user and the usage of the system. ImogI takes advantage of the intelligence that is stored in the direct surroundings of the mobile guide. Artifacts can provide their own information and specify their relations with other artifacts. Because of the dynamics of museums (there often are "visiting" expositions), this alleviates the task of the system maintainer: there is no need to update a central repository or database with the new or changed information. The exposition artifacts deliver their own information.

Because the museums currently have no intelligent artifacts which broadcast their information, we simulate the envisioned AmI circumstances in our lab and its surroundings. We explored the use of Radio Frequency Identification (RFID) tags [14] to annotate artifacts with digital information, but this was not feasible because of the restriction to short range communication (10 á 30 cm) between the PDA and RFID tag (and other issues [8]). RFID tags are small sticker-sized objects that can respond to radio-frequency queries. We replaced the RFID tags by autonomous processing units with Bluetooth support, and query their information over Bluetooth. One advantage of this system is the processing units are "active": e.g. they can react to events, change their information,. . . . The disadvantage of Bluetooth is its communication range: which is in fact too wide for this application. Like suggested in [6, 4] the IrDA protocol seems the most reasonable choice. IrDA is a communication protocol for short range data exchange using infrared light (which makes it sensitive for reflective materials).

Since physical objects can be tagged with their own information, this information should be visualized appropriately by the mobile guide. For the surrounding physical objects it will create their virtual representation which can take the transferred information and visualize it in the user interface. When the mobile guide moves away from physical objects the proximity manager will destroy their virtual representations on the mobile guide. Fig. 2 gives an example of the dynamic context-object heap, where virtual representations of physical objects (the letterbox in this example) are created by the proximity manager. The proximity manager could be enhanced with a profile that specifies the behavior of the virtual objects: there is no obligation to use or visualize all information that exists in the dynamic context-object heap. How the information behaves should be decided upon by the museum designer. This aspect needs further research by observing how users react on location dependent information visualization.

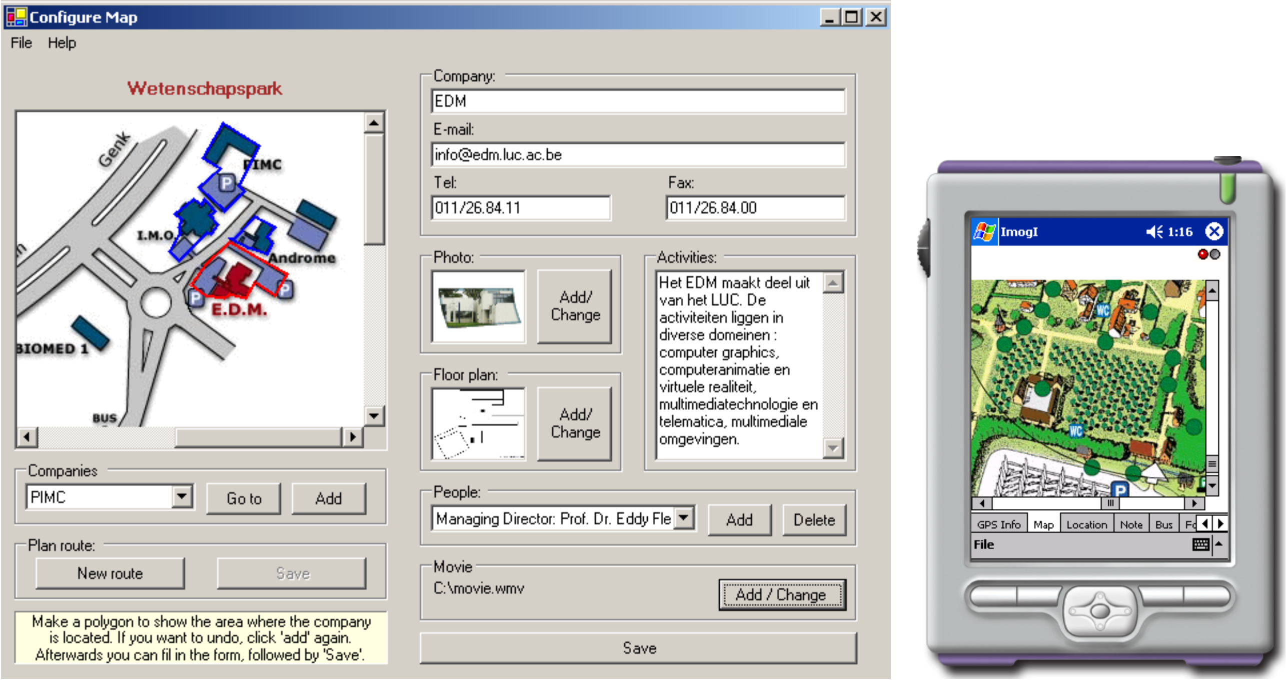
The proximity range is different for different objects; our proposition is to scale the proximity range linear with their volume and importance. The virtual counterparts of large physical objects, which will stay longer in the visual scope of the visitor, will be created on a further distance than smaller objects. The dynamic context-object heap reflects the visual scope of the visitor, unless the designer specifies otherwise by defining the region of importance (see also Fig. 1(a), importance region is EDM building with two parking lots) or by assigning a particular importance rate.

The major drawback is the current technical support for indoor position detection: the accuracy of most modern systems is too low to achieve this. With new emerging technologies like more powerful RFID tags, Bluetooth communication and WLAN positioning systems, support to deploy the system described in this paper for outdoor as well as indoor sites becomes available. The REAL project [4, 2] presents a solution to support indoor position detection and provides outdoor positioning as well. Special attention is given to the seamless transition between indoor and outdoor positioning in the REAL mobile guide.

5. DETERMINING USABILITY BOUNDARIES

Since our electronic mobile guide is context-sensitive, the interaction with the device can differ during the time the user uses the guide. It is important to recognize the "adaptivity boundaries": the parts of the user interface that can be adaptive without having a negative influence on the user interface's usage. Since there is only little known about the effects of adaptivity of the user interface structure on mobile devices w.r.t. existing knowledge about adaptivity on desktop computers, this is an area that should be explored carefully. Notice we discuss both the adaptivity of the user interface *structure* (e.g. navigation through the user interfaces, available widgets,. . .) and the *information visualization* (e.g. map rotation). The former is related to the way the users interact with the software, the latter relates to the way data is visualized and interpreted according to the context of use. We expected that an adaptive interface would help to cope with the limited screen size of a PDA. Context-awareness can imply rather unintentional changes in the user interface that need to be considered carefully in order to design a usable interface.

To determine the adaptivity boundaries of the user interface



(a) Desktop Design Tool

(b) Mobile Information system

Figure 1: ImogI screenshots

we conducted a formal user experiment. The field tests were carried out with partially functional prototypes. Usability testing in the field for mobile devices is not trivial though [3]. The test persons had to carry out a set of predefined tasks. Each task emphasized the use of a single adaptive feature of the user interface. Different prototypes were made, each having its own peculiar adaptive feature which can be related to a part of the context of use:

1. location-aware adaptivity (e.g. other "styles" of maps according to the user's location like a touristic map, a topographic map or road map);
2. time-aware adaptivity (e.g. auto-focus on the bus stop 5 minutes before the bus will arrive);
3. orientation-aware adaptivity (e.g. rotating the map according to the orientation of the PDA such as "tilted 35 degrees" and "landscape").
4. usage frequency-aware adaptivity (e.g. sorting of tabs in the user interface according to their usage);

These four features were chosen because the first three use the context to offer the adaptive behavior, and the last one is known to be not very effective on desktop PCs. We started our experiments from the viewpoint that adaptive features that are not well received for a desktop PC environment still could be good candidates for a mobile computing platform because of the limited input/output capabilities it offers. During the trial they were asked to think aloud and they were recorded (audio and visual) for later analysis. Fig. 3 shows a snapshot of the user tests that have been executed.

Figure 3: ImogI Usability testing

In spite of what we expected, offering an adaptive user interface structure to cope with the limited screen space of a PDA has no positive effect in the usage of the interface. On the other hand, whenever the adaptive part emphasized a feature *that is available on a mobile device but traditionally not on a desktop PC* (e.g. a rotating map), this was received positively by the users. The observed results can be explained by the exploratory behavior people

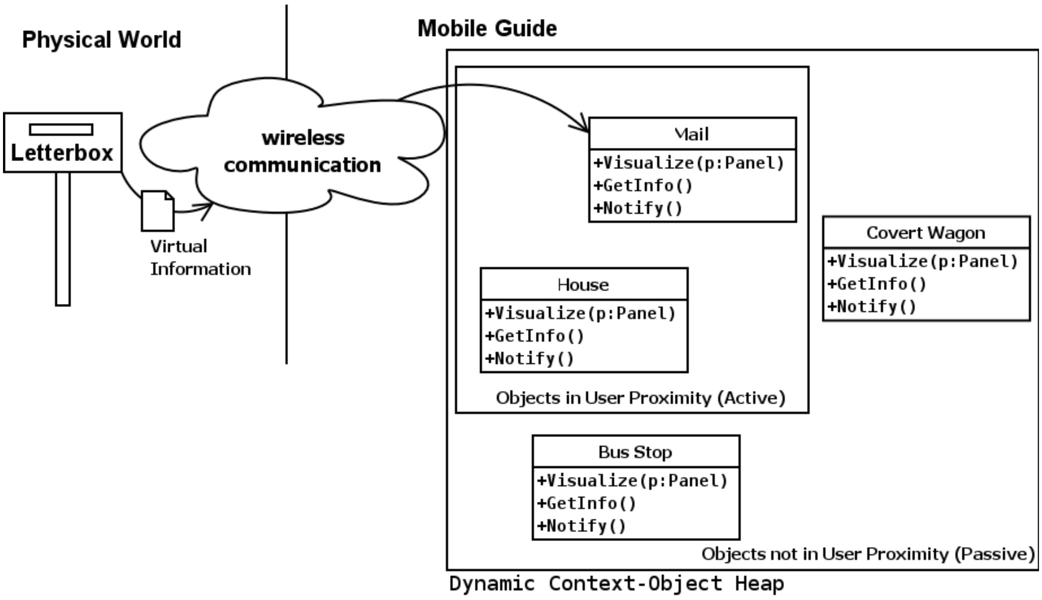


Figure 2: The Dynamic Context-Object Heap and its relation to the physical world

show when using mobile guides. More detailed results can be found in [10] and are provided on a separate webpage: `http://research.edm.luc.ac.be/imogi`. We can conclude that adaptivity in the user interface works better and is better received when it is related to the external context of the software usage (e.g. location, orientation, time,...) but is less effective when the usage profile is taken into account. In general users don't like to loose control over the user interface, but they are willing to give the environment they are operating in more control to execute changes in the user interface on their behalf.

6. CONCLUSIONS AND FUTURE WORK

We have introduced the foundations of the context-aware mobile guide ImogI in this paper. The design and development of ImogI target a generic mobile guide that integrates context in its user interface. Since a mobile guide is used by a wide range of users with different backgrounds, it is important to explore the limits of the context-driven adaptivity of the user interface. These adaptivity boundaries were determined by field tests with (partially) functional prototypes.

At the time of submission, ImogI can be used as an *outdoor* mobile guide and can query information from physical objects. It has been tested extensively in the science park our research institute is situated in, and has been tested preliminary in Bokrijk, an open-air museum. In the current stage of development, Bluetooth is used to communicate with physical objects that are in the direct neighborhood of the PDA. We are working on the proximity manager, which can control a limited set of virtual objects in the dynamic context-object heap for now. The major problem we face is the indoor positioning system: although the literature shows some usable alternatives, none of the existing techniques allows fine-grained control over the position detection.

ImogI is almost fully functional for outside environments, where the GPS signal can be used for positioning. Because of the information-by-artifact approach and by integrating an indoor positioning system we can provide smooth transitions when users enter and leave a building.

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7. ADDITIONAL AUTHORS

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