Enhancing Mobile Museum Guides with Public Displays

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ABSTRACT
Recent technological advances enable novel interactive software environments to support users in several contexts for different objectives. Museums are a particularly suitable context in which to experiment with new interaction techniques for guiding visitors and improving their experience. In this paper, we discuss a multi-device and location-aware museum guide. It is a mobile guide able to opportunistically exploit large screens when they are nearby the user. Various types of games are included in addition to the museum and artwork descriptions, including games involving multiple visitors. The mobile guide is equipped with an RFID reader, which provides information useful to detect the current user position. By taking into account context-dependent information including the current user position, the history of user behaviour, and the device(s) at hand, more personalised and relevant information is provided to the user, enabling a richer overall experience.

Author Keywords
Mobile Guides, Multi-device Adaptation, Multimodality, Location-awareness.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Recent technological advances (including increasing availability of various types of interactive devices, sensors and communication technology) enable novel interactive software environments to support users in several contexts for different objectives.

In the edutainment area, museum domain is receiving growing attention due to the large amount of digital information, together with the technological resources that are ever more available in such environments, nowadays often equipped with large and small screens (i.e. mobile and stationary devices).

Traditionally, the support for museum visits is limited to audio guides and interactive kiosks, which are limited in different ways from various viewpoints. It is important to exploit new technologies to identify new solutions able to promote social interaction and to enhance user experience. Many studies, such as [8], have underlined that the interaction with exhibitions as well as communications and interactions between visitors are key points for a successful learning environment. Games for mobile guides can provide an interesting and amusing way to enrich user interaction and promote their collaboration. In this regard, the use of different types of devices within the museum (e.g.: mobile devices and large screens) can be seen as a means to enrich user experience by enabling further functionality, such as presenting the visitors' position and different ways to represent individual and cooperative games exploiting the large screen.

Here we present a new environment aiming to support multi-device interaction, cooperation and games to improve museum visitor learning. UbiCicero allows both individual and collaborative games together with location-aware support in multi-device environments. The goal is to make museum visits more interactive. To this end, the proposed environment provides information about user location in the museum, as well as ways to exhibit and test knowledge learned about the artworks in the museum during the visit.

RELATED WORK
In recent years, there has been growing interest in the development of mobile guides, thanks to the spread and increase in the performance of PDAs and mobile phones, the progress of wireless communications and improvements in localization technologies. The main advantage of these applications is the possibility, by following the context-aware computing paradigm [5], to provide users with context-dependent services, exploiting information such as the user's location, time, nearby people and devices, and current task. One of the first examples of mobile guides with context-aware features is Cyberguide [1], which supported navigation inside buildings or outdoors, visualizing a schematic map of the area, automatically updated according to the user's position, determined by means of infrared sensors (indoors) or GPS (outdoors).

The GUIDE project [6] has been developed in order to provide city visitors with an intelligent and context-aware tourist guide. User position enables an automatic information delivery service: each point of interest is associated with a geographic area, supported by a Wireless LAN. When the user enters an area, the corresponding information is automatically provided as text descriptions, images and audio comments. The notion of context

considered in GUIDE includes information related not only to users location but also their personal profile as well as environmental conditions (e.g.: opening times of city attractions). However, differently from our approach no multi-device support has been deployed in this guide.

Among other examples of mobile guides that exploit various kinds of information to adapt the services they provide, we mention Hippie [11], which combines the user's location with other information to provide museum visitors with additional details on the exhibits. It provides the visitors of an art exhibition with comments on the artworks in sight, adapting the information to user's location, interests and knowledge that is derived from the interaction. However, solutions based on automatic generation of comments on the closest artwork may sometimes be judged annoying by the user. CRUMPET [12] personalizes its services, both on PDAs and mobile phones, not only according to the position of the user and her interests, but also according to previous interaction with the system.

VeGame [3] is another project that uses mobile technology to explore the city of Venice and to learn about its history and its architecture through games based on observation, reflection and action (e.g. video games). The system enables wireless communication but, due to limited bandwidth, communication between two peer PDAs is realized for real-time exchanges as in video games. Visitors may play in teams and the only goal is to achieve the best score. In addition, each team can have multiple members but only one PDA. Firstly, there is loose collaboration, because the high score is the unique objective and, considering our project, the visitors do not have to engage in real cooperation such as in a treasure hunt. Secondly, within a team, the collaboration is only face-to-face collaboration around a "single-user" application: the system does not provide any means to support the collaboration.

However, all such approaches have not considered the use of large public displays as a support for their mobile guides. While some research work has been carried out on multi-user mobile application and a public display (for example [10]), little attention has been paid to exploiting this possibility in the museum guide domain, which is the main contribution of our work.

THE MOBILE GUIDE

Our interactive environment for museum visitors has been applied to a previously existing application for mobile devices: Cicero [7]. In its first version, it was a digital museum guide developed for a PDA platform and freely available to the visitors of the Museum of Marble located in Carrara, Italy.

It provides visitors with a rich variety of multimedia (graphical, video, audio, …) information regarding the available artworks and related items. This application is also location-aware. This is implemented through a number of infrared beacons located on the entrance of each museum room. Each of them is composed of several infrared emitters and generates an identifier that can be automatically detected by the application, which thus knows what room the user is entering and immediately activates the corresponding map and vocal comments. This level of granularity regarding the location (the current room) was considered more flexible and useful than a finer granularity (artwork), which may raise some issues if it used to drive the automatic generation of the guide comments.

The Visit

We used active RFID tags with beacon behaviour, that continuously broadcast their ID within an area of 5 meters of range. Figure 1 shows the museum guide implemented on the PDA device equipped with the CF (Compact Flash) RFID reader. Tags and readers were provided by Identec Solutions (http://www.identecsolutions.com/).

Figure 1. The museum mobile guide

Each museum artwork is associated with a tag ID and each tag has a unique ID number. Note that a single tag can be associated with more than one neighboring artwork, when they are very close. This is due to the difficulty of distinguishing two or more tags that are too close to each other. Indeed, if two tags were placed in a very small area, the reader would see both of them with the same RSSI (Received Signal Strength Indication). The use of RFID technology for localization and the problems related to tag density are also discussed in [2].

The continuous monitoring of the tags signal allows the guide to calculate artworks closest to the user inside the room.

It is worth noting that, with respect to the work regarding the Scan and Tilt interaction paradigm, on the one hand here the use of active tags does not force the user to be in very close proximity to the artworks of interest, as in that solution, where the covering range of RFID signal communications was about 5 cm. Active tags are able to transmit signals over longer distances than passive tags. On the other hand, the use of active tags makes it a bit harder to precisely localize the user within the room, since the signals of several tags may be simultaneously detected by a reader.

The application logs any interesting event, such as section and area changes (in terms of nearby artworks) and how much time the user has remained. It is then possible to know the path covered by the visitor through the museum during the visit. The time taken by the user to access an artwork description is also logged. Logged information is used to keep the user model updated. At each section change, the user model calculates which artwork of the new section is closest to the user preferences.

The application uses several sources of information to estimate user preferences. The time spent on the description of an artwork is attributed a specific weight to the values of the artwork's fields in the user model: author, chronology, material and type (sculpture, painting, photo/picture, marble block) are considered in the preferences computation. If the user has also physically been in front of the artwork (i.e. the application has logged at least entry to the corresponding artwork RFID tag area) then a higher level of interest is recorded. Whether the user has correctly solved the games corresponding to an artwork or not, provides a further indication of the corresponding level of interest and knowledge. Local suggestions are also available on request: as the light-bulb button of the toolbar is clicked, the areas neighboring artworks which have not been visited yet are considered as possible next candidates. A light-bulb icon would indicate the most interesting artwork among the physically nearest ones.

The games

In order to increase the learning experience, the environment supports six types of individual games:

- The *quiz* is a multiple-choice question.
- In the *associations* game (see Figure 3) users must associate images with words, e.g. the author of an artwork, or the material of an artwork.
- In the *details* game an enlargement of a small detail of an image is shown. The player must guess which of the artwork images the detail belongs to.
- The *chronology* game requires the user to order the images of the artworks shown chronologically according to the creation date.
- In the *hidden word* game, the users have to guess a word: the number of characters composing the word is shown as help.
- In the memory game, the user has to look at an image (which then disappears) and s/he has to answer to a question associated with the previously shown image.

Games in cooperative environments

In order to heighten social interaction, it was judged useful to implement not only individual games, but also group games able to stimulate cooperation between visitors. To this end, users can be organized in teams. A number of group games have been implemented to date. One example is the shared enigma composed of a series of questions on a topic associated with an image hidden by a jigsaw puzzle [9]. Each player can solve an individual game and thus remove one piece in the puzzle and thus facilitate answering the corresponding questions. As soon as an individual game is solved, the group earns seven points. The goal of the game is to stimulate interaction and cooperation among players in order to find the answer to the shared enigma. This favors numerous groups (the maximum is five members) since they can earn more points, and is a stimulus to cooperate. When a member of the group answers the corresponding question, such question is no longer available to the other players in the team as well. This stimulates interaction among visitors so that they can first discuss the answer and agree on it. The PDA interface of the shared enigma has two parts (see Figure 2): the first one shows the current players' scores and the hidden puzzle image, the second shows the questions (with possible answers). Various players in a team can have mutual awareness of each other: coloured circle icons are placed beside the presentation of the different artworks, and they are associated to the various players in a team, so that a player can see which artworks have already been accessed by the other players.

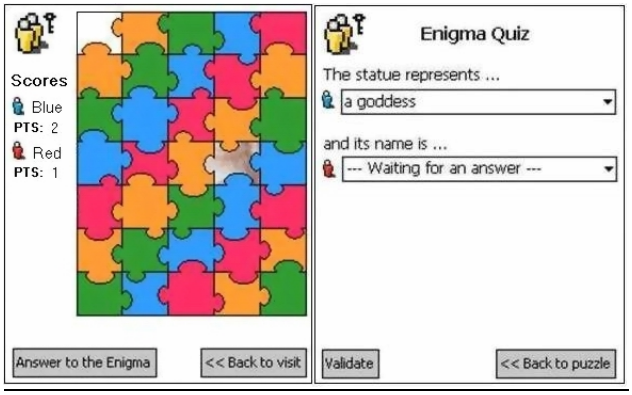

Figure 2. The shared enigma visualized on the PDA

THE MOBILE GUIDE ENHANCED WITH PUBLIC DISPLAYS

The main feature of our solution is to support visit and game applications exploiting both mobile devices and public displays. The typical scenario is users freely moving and interacting through the mobile device, who can also exploit a larger, shared screen of a stationary device (which can be considered a situated display) when they are nearby. Shared screens connected to stationary systems can increase social interaction and improve user experience, otherwise limited to individual interaction with a mobile device. They also stimulate social interaction and communication with other visitors, though they may not know each other. A larger shared screen extends the functionality of a mobile application enabling the possibility to present individual games differently, to share social game representations, to show the positions of the other players in the group and also to perform a virtual pre-visit of the entire museum.

Each shared display can be in different states:

- *Standalone*: the screen has its own input devices (keyboard and mouse) and it may be used for a virtual visit of the museum. It can be exploited by visitors who do not have the PDA guide .
- *Split*: indicates that one visitor has taken control of the display through the PDA, which shows the name and group of the controller.
- *Search*: the display shows the last artwork accessed by the players of a group and their scores.
- *Game*: the display shows one individual game.
- *Social game*: the display shows the state of one social game.

Since a shared display has to go through several states the structure of its layout and some parts of the interface remain unchanged in order to avoid disorientating users. This permanent part of the user interface provides information such as the current section map and its position in the museum, an explanation of the icons used to represent the artworks and the state of the shared enigma. In standalone mode users can select from three kinds of views of the section map, using the toolbar on its top-left corner. These views are:

1. *Icons*: the artworks are represented by an icon indicating the type.
2. *Thumbnails*: the icons are replaced by a small photo of the artwork
3. *Thumbnails and icons*: small artwork photos are accompanied by icons on their bottom-left corner.

Exploiting the user model data from the connected PDA, the large screen application generates an interest evaluation for each artwork in the selected room. The user may look up the ratings, which are expressed by “led bars” on a scale of 0 to 5 .

When an artwork or a game is selected, the screen interface changes in layout adapting its focus: it magnifies the correspondent panel and shows the artwork details (see Figure 4) or the game interface (see Figure 5).

The screen changes its state to split when a player selects the connection through the PDA interface. In this case the large screen is used both to show additional information and also to focus the attention of multiple users on a given game exploiting the screen size. When a player is connected to the large screen, its section map view is automatically changed to thumbnails, while the artworks types are shown on the PDA screen. The artwork presentation uses a higher resolution image on the large display, adding more information to the description.

The game representation on the large screen is used to share and discuss it among multiple users. In the split representation, the game answer choices are shown only on the PDA interface, while questions and higher resolution images are shown on the larger screen (see Figure 4). The result of the user answer is shown only on the PDA interface.

In case of social games (e.g. the shared enigma), the shared screen is used differently. For example, if only the PDA is used, the shared enigma interface is composed of two presentations visualised sequentially: the hidden image and the associated questions) on the PDA. If the larger shared screen is available then the hidden image is shown on the large display, while the answers are presented on the PDA user interface.

Providing an effective representation of players’ position on the PDA is very difficult because of the small screen, especially when they are in different rooms. Thus, the large shared screen is divided into sections, one for each player. Each part shows the name and the room where the player is located and the artworks closed to the player are highlighted by rectangles (see Figure 5).

EVALUATION

We performed a user test of our mobile guide involving 12 users, with an average age of 36,4 years old; 3 of them with secondary school education, the others with laurea degree. Users were requested to read a short introduction about the application and were instructed on the tasks to accomplish. They were asked to visit some sections of the museum, accessing and solving some games, and to perform at least one splitting between PDA and a large screen available in a museum section. Afterwards, they had to fill in a questionnaire. Games were judged interesting and useful in that they stimulate learning, entertainment and improve user attention. The possibility of detecting the current position of the user was judged useful for orientation purposes. The users also noted that this feature might be appreciated in large museums.

Also the way in which the functionality was split between

the PDA and the large screen was rated good. However, a suggestion for a better use of the large screen space was reported from a user and another one complained about the not very high quality of images rendered there. All in all, the application was acknowledged useful, intuitive and interesting. The adaptation features were well received by users, who also suggested to enrich even more the information with other history data, in order to further personalize the presentation.

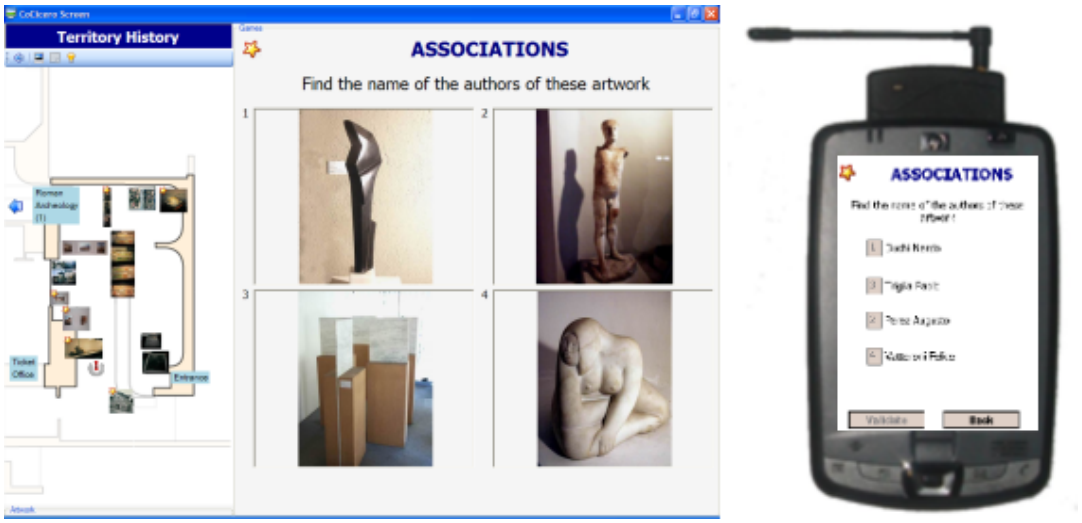

Figure 3. Example of game distributed mode: large screen (left part); PDA (right part)

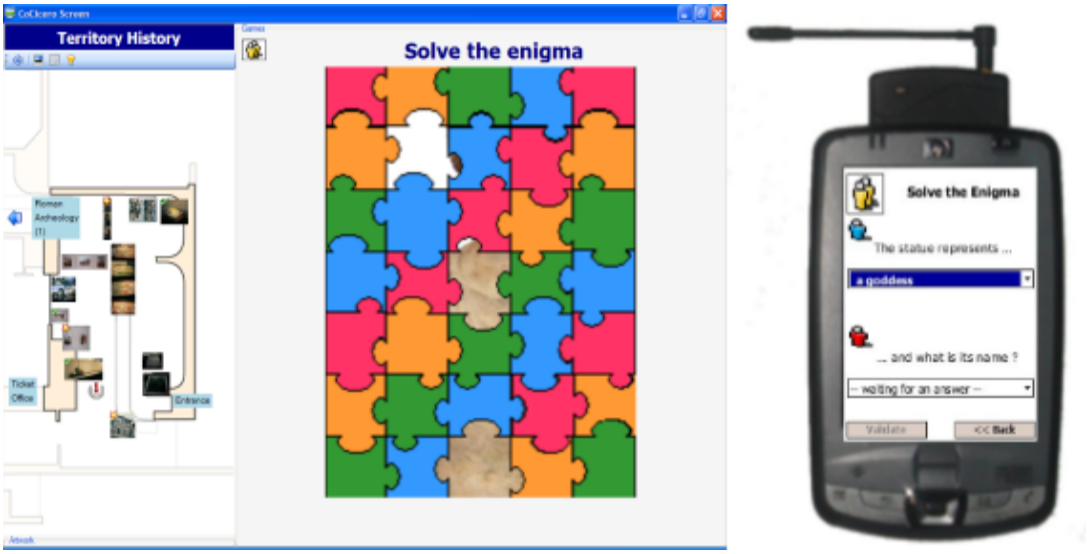

Figure 4. Presentation of shared enigma split between two devices

CONCLUSIONS

In this paper, we propose a multimodal, multi-device, and location-aware guide supporting museum visits, including the possibility of cooperation among museum visitors through games. Its main contribution is in the ability to exploit multi-device environments, in which users can freely move about with their mobile guide but also exploit large screens connected to stationary PCs when they are nearby. Both the access to museum information and the associated games can benefit from the availability of multiple devices as well as additional services, such as the presentation on the large screen of the locations of other visitors, which are detected through RFID tags.

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Figure 5. Example of visualization of players' positions

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