A Multimodal Mobile Museum Guide for All

Carmen Santoro, Fabio Paternò, Giulia Ricci, Barbara Leporini
ISTI-CNR
Via G. Moruzzi 1
Pisa, Italy
{carmen.santoro, fabio.paterno, giulia.ricci, barbara.leporini}@isti.cnr.it

ABSTRACT
Museums represent a particularly suitable context in which to experiment with new interaction techniques for guiding visitors and improving their experience. This is mainly due to the large amount of digital information available, the technological resources more and more adopted in such environments, and the range of different visitors museums always receive. In this paper we present a preliminary work of a portable, multimodal museum guide also able to offer diverse accessibility options to users, so as to fit and support the needs and preferences of different users, including the visually impaired. Our work combines multiple modalities –gestures, location, graphical and voice. In particular, we will focus on how tilt gestures can be used to control and navigate the user interface in order to enhance the user experience, including the case when the users are the blind.

Categories and Subject Descriptors
H.5.M [**Information interfaces and presentation**].

General Terms
Design, Experimentation, Human Factors, Languages

Keywords
Mobile guides, Accessibility, Gesture interaction, Tilt interfaces, RFID, Museum guides, Multi-modal user interfaces.

1. INTRODUCTION
Recent technological advances (including increasing availability of various types of interactive devices, sensors and communication technology) together with the growing availability of digital information, enable novel interactive software environments to support users in several contexts for different objectives. However, such a wealth of both information and devices might become at the same time a potential source of disorientation for users, if not adequately supported, and such issues become further critical when disabled visitors are considered. The support for museum visits is traditionally limited to audio guides and interactive kiosks, which have several limitations in different ways from various viewpoints, then, it is important to exploit new technologies to identify new solutions able to enhance user experience.

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 [3], to provide users with context-dependent services, exploiting information such as the user's location, time, nearby people and devices, current task, etc.

One of the objectives of a museum guide is improving the effectiveness of the users' museum experience. For visually impaired users, the guide should not only integrate what the disabled cannot get by their own (e.g. by vocally providing the visual information in the museum), but it is also important that the users can easily interact with the application. For the others, a virtual guide should support and integrate the physical visit, not being too intrusive and then substituting or obstructing the fruition of the experience while in the museum.

In this paper, we present a preliminary work about how to provide different levels of accessibility in a museum guide through the exploitation of different modalities (vocal and tilt) in order to enhance the user experience in a museum.

Figure 1. User in the Marble Museum with mobile guide.

The organization of the paper is as follows. First, we discuss related work in the area of mobile guides; next, we provide some background information on the previous version of our guide. Then, after having presented some main features of the tilting modality, we present the different accessibility options we provided to fit the needs of disabled users. Lastly, some concluding remarks and indications for future work are provided.

2. RELATED WORK

The museum domain has raised an increasing interest regarding the support that can be provided to visitors through mobile devices. One of the first works in this area was the Hippie system [12], which located users via an IR system with beacons installed at the entrance of each section and emitters installed on the artworks. The GUIDE project [4] addresses visitors in outdoor environments supported through several WLANs.

Research on gesture interaction for mobile devices includes various types of interactions: tilt, discrete gesture interaction and continuous gesture interaction [10]. In [6] a continuous, control theory-based approach for tilt-based interaction for mobile terminals equipped with 6DOF accelerometers is presented. In [8] a study discussing the effects of ergonomics in tilt interaction is presented. An accelerometer-based tilt interaction system for scrolling and determining screen orientation is presented in [9]. Tilt interaction to be utilised in navigating menus and scrolling documents and maps is described in [13]. However, we think that it needs to be augmented with other techniques in order to make museum visitors' interaction more complete and natural. To this end, we selected the use of accelerometers able to detect tilt events, allowing users to easily select specific information regarding the artworks.

Physical browsing [1] allows users to select information through physical objects and can be implemented through a variety of tag-based techniques (e.g. RFID tags). An example of an application using RFID tags to guide the disabled in a museum is described in [2]. In this work, authors implemented a location-aware tour guide based on RFID localisation, specifically developed to guide visually impaired people in an exhibition.

3. BACKGROUND

Our interactive environment for museum visitors has been applied to a previously existing application for mobile devices: Cicero [5]. In its first version, it was one digital museum guides 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 (see Figure 2) and immediately activates the corresponding map and vocal comments. In addition to information regarding artworks, sections and the museum, the application is able to support some services such as showing the itinerary to get to a specific artwork from the current location. Most information is provided mainly vocally in order to allow visitors to freely look around and the visual interface is mainly used to show related videos, maps at different levels (museum, sections, rooms), and specific pieces of information.

A further extension was developed, based on a new interaction paradigm we called Scan & Tilt [11]. The concepts that were at the basis of its design came out from some considerations derived from previous experiences about users visiting a museum with a virtual digital guide. First of all, the fact that the virtual guide should be able to somehow directly interact with the available physical objects and it should not be intrusive on the user experience, by leaving the visual channel open to enjoy the artwork. Indeed, visitors in a museum would not be interested in spending much time understanding how the electronic guide works, since they will probably not visit the museum again. Therefore, it is important to improve as much as possible the naturalness of the interaction supported by the guide. In addition, a good degree of freedom should be provided to users to move around and obtaining information only when they want.

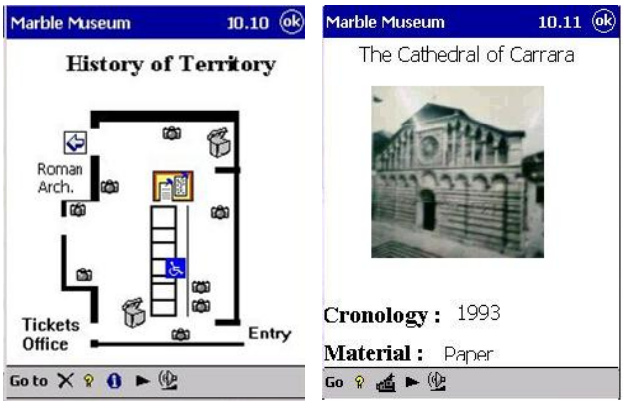

Figure 2. Two screenshots of the Cicero guide.

To this end, we looked at exploiting RFID-based solutions. They are composed of two main parts: the set of tags, or radio transponders, and the tag reader, or transceiver. Tags basically have a static identification number (ID), but can also store different type of information such as sensed data (e.g., environmental temperature). The reader scans for available tags, and, depending on their features, may interrogate them for additional information stored on their embedded memory. To make our mobile guide as small and as light as possible, we opted for a totally handheld-based solution consisting of Compact Flash (CF) RFID reader with small-sized antenna. The PDA does not need any additional expansion or adapter because the reader plugs directly into the CF slot.

In order to fulfil the above requirements, we developed the scan and tilt paradigm, which combines multiple modalities – gestures, physical selection, location, graphical and voice. The PDA was equipped with an RFID reader able to read passive tags and a 2D accelerometer able to recognise small movements of the handheld device. Physical selection is obtained by scanning RFID tags associated with the artworks, and single handed tilt gestures are used to control and navigate the user interface and multimedia information. By pointing at the artwork of interest and controlling audio information with small single hand gestures, the visual channel is not too overloaded, resulting in a less intrusive interaction technique. We performed a first empirical evaluation on this prototype. The test showed an overall good acceptance among users but, at the same time, highlighted some limitations. Indeed, the passive RFID tags used in this prototype forced the users to stand in very close proximity to the artworks, which is not very natural in museum environments. Moreover, the visitors found the tilting interaction technique not so easy, especially in their first trials.

In the new version we overcome the problem of passive RFID tags by using active RFID tags, which can reach a larger range and at the same time provide a localisation of the current position of the user without forcing them to stand in close

proximity with the artwork. In addition, we planned to investigate whether the tilt modality might be better exploited to make the digital museum guide accessible to blind and/or sight-impaired users. In the next sections, we will provide further details about the different levels of accessibility that we achieved by exploiting the features of the tilt modality also in combination with the vocal modality.

4. TILT MODALITY

The gesture modality in our approach utilizes 2D acceleration sensor hardware from Ecertech. The sensor hardware is attached to an iPAQ PDA with Pocket PC operating system and can be used also in other Pocket PC PDAs and SmartPhones. The sensor produces signals that are interpreted as events (e.g.: TiltLeft, TiltRight, TiltBackward, TiltForward, ..) by the tilt manager-data processing module of the mobile device. The movements are detected by an accelerometer and, depending on the direction and speed of such movements they are translated into suitable actions/events onto the application (selection, navigation or activation) according to the user interface at hand.

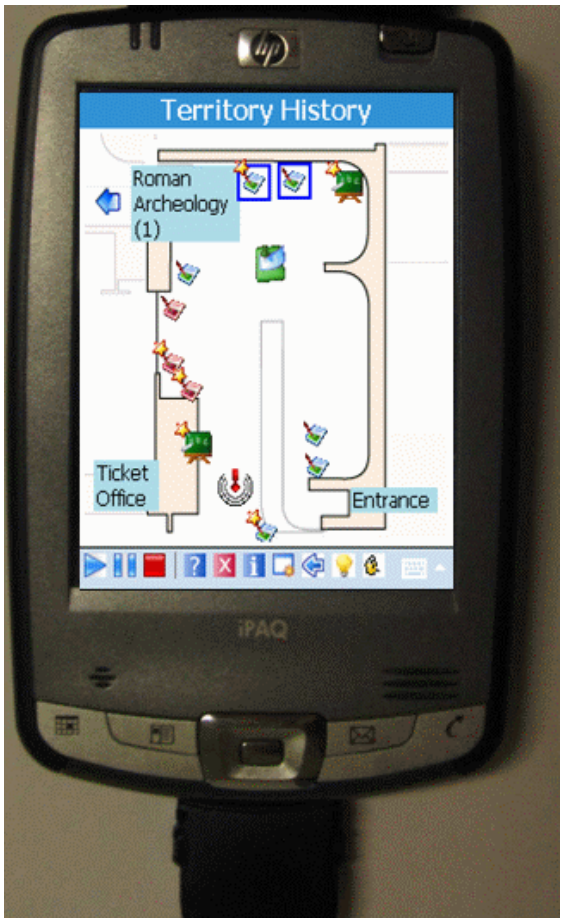

Figure 3. The Museum Mobile Guide equipped with accelerometer

In general, the tilt interface follows a simple to learn pattern: horizontal tilts are used to navigate through different pieces of information at the same level or to start/stop some activity, vertical tilt down events are used to go down in the information hierarchy and access more detailed information, whereas vertical tilt up events are used to get up in the information hierarchy. Since there are different levels of information supported (the museum, the thematic sections, the artworks, and the information associated to specific artworks and its rendering), when a specific artwork is accessed, it is still possible to navigate by horizontal tilting to access voice control (to decrease/increase the volume), control the associated video (start/stop), and access information regarding the author. The first version of the software prototype used a tilt monitoring algorithm based on static angle thresholds and taking into account the initial tilt angle of the device when the application starts. The tilt of both horizontal and vertical axes were measured every 1/10 second. These values are then compared to the original tilt measurement performed at application start-up time, and if a 15 degree threshold was exceeded for over 500ms in one of the axes, this was interpreted as the appropriate tilt gesture for that axis. At that time the possible tilt events considered were just 'forward', 'backward', 'left' or 'right'. In the new version of the prototype we have performed some improvements to the tilt algorithm, also introducing the possibility to handle further tilt events (for instance, also a *diagonal* tilt is considered).

5. ALLOWING DIFFERENT ACCESSIBILITY LEVELS

In order to enable different users to use the software application according to their needs and preferences, the new version of the application has been designed so as to support different levels of accessibility. In this context we mean with “accessibility” the set of graphical and vocal features that are provided to the user for interacting with the application.

We planned to support different levels of accessibility in our tool. Depending on the level selected, a different application configuration is provided to the users, who then interact differently with the software prototype.

- *Basic Navigation*: this option is aimed at allowing user to use the application through the classical buttons/pen of the PDA
- *Navigation with Audio Feedback*: in this option, which represents the minimal level of accessibility and can be considered helpful for both partially-sighted and blind users, the user’s navigation is facilitated by a vocal feedback that is activated when necessary. For instance as soon as a button is selected, the corresponding label is vocally reproduced by means of a TTS (Text To Speech) engine. The Loquendo Embedded TTS (www.loquendo.com) has been used as vocal engine in our software prototype.
- *Navigation using Tilt*: in this modality only the tilt modality is active (the voice is not used). Therefore, there might be tilt movements to which no action is associated anymore. The navigation is carried out by using small inclination movements of the PDA, which substitute the use of PDA pen and buttons.
- *Navigation with Audio and Tilt*: in this option the tilt is used together with the voice. This type of navigation allows the users to use the museum guide and navigate within it using the tilting options and, at the same time,

to have a vocal feedback from the application. This configuration option is especially aimed at supporting the blind.

The accessibility level is selected just after the application starts (see Figure 4, left) by displaying a form allowing the user to select which is the accessibility level preferred by the user. However, depending on the current configuration of the device it may happen that not all the possibilities are really available, because e.g. the accelerometer is not connected to the PDA, or it is connected by it does not work properly, etc.. In this case, the application automatically detects the concerned situation and does not make available the corresponding options.

As soon as the accessibility level has been selected, the user accesses the proper application (see Figure 4, right). If in the first form the user selected an accessibility level including one (at least) between voice and tilt modality, the "Accessibility" link will be available, allowing to configure and use the tilting and voice options.

In the Main Menu there are four links for accessing the different information sections. They provide respectively general information, describing the meaning of the different icons used in the software application, information about the infrared emitters in the museum, and a link providing the possibility of selecting the specific level of accessibility to be provided. The user is supposed to visit all the sections in order to get the related information, otherwise a pop up message will alert about it.

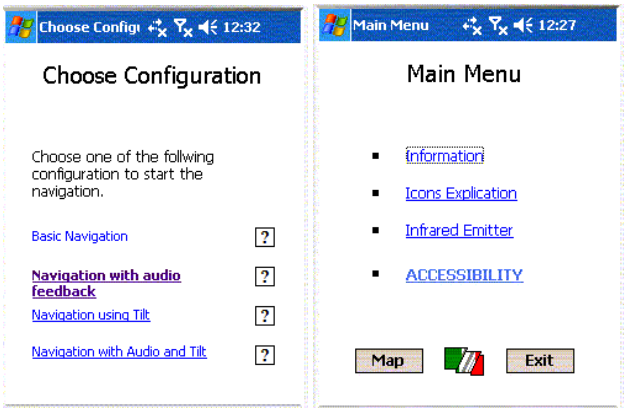

Figure 4. The Form for Selecting a Specific Type of Navigation (left) and the Main Menu of the guide (right)

5.1 Tilt and Voice

In this section we provide an overview of the tilting features when both tilt and voice are selected. Within the various forms, three main sections can be identified: the title, the "body" of the form and the toolbar. Using the vertical tilting it is possible to navigate through the different elements: depending on the element currently selected, further actions are available. For instance, if the title is selected, it is automatically rendered using the vocal modality; if the body is selected using a vertical tilt, further horizontal tilting possibilities are available for navigating within the body.

In addition, we judged useful to use a combined axis movement (i.e. diagonal tilt) to further improve the interaction richness between the user and the application. For instance, in the initial welcome form, a diagonal movement (right-up) allows the user to execute the action associated to the currently selected button. Conversely, a diagonal tilt movement (left-up) might be used to interrupt the vocal summary, as well as a left-down tilt movement might be used to change the language of the guide.

In the form showing the map of the museum (Map form), apart from the tilt functionalities already indicated before, more advanced tilting functionalities are provided, in order to interact more completely with the form:

- *Vertical tilt*: it is possible to move among the different subsections of a form. As soon as a new subsection is reached, it is vocally rendered to the user.
- *Horizontal tilt*: this movement is associated with several actions. Indeed, if the audio menu has been selected, with an horizontal tilting it is possible to control the audio volume, or moving within the map or the toolbar.
- *Diagonal tilt*: different options are provided depending on the movement selected. For instance, a *right-up* movement allow the users to execute an action; a *Left-up* movement interrupts the vocal summary or stops the automatic advance, while a *left-down* movement allows the user to change of the language of the guide.
- *Central PDA Button*: depending on the current state of the software prototype, it can be used in different ways. For instance, it works as Play/Pause button if a video is currently being played. Alternatively, it enables the user to deactivate/re-activate the tilting modality, also allowing to reset the initial coordinates.

An empirical testing session with real users has been already planned and it will be carried out in the next future. Through it, we hope to collect useful insights regarding the usability and the accessibility of the museum guide.

6. CONCLUSIONS AND FUTURE WORK

We have proposed a new interaction paradigm for mobile museum guides aiming at enabling more effective interactions through the combination of multiple modalities – gesture, location, graphical and voice.

Our solution for a mobile museum guide considerably extends interaction towards more natural ways of interacting with the environment, also enabling users with visual impairments to benefit from the guide. Future work is planned to consolidate and improve the prototype which has been described here in its preliminary stage.

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