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A Novel Approach to Context-Sensitive Guided e-Tours in Cultural Sites: "Light" Augmented Reality on PDAs

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Abstract

This paper focuses on the design parameters of mobile electronic guides for cultural sites and museums. We treat issues like user interaction and portability and present practical solutions for their installation and operation in uncontrolled indoor and outdoor environments. Initial experiences from the archaeological site of Pompeii, Italy, are reported. The major contribution of the paper is the proposal of a new concept, that of "light" Augmented Reality for portable guides which we believe will dominate the field of cultural guiding in the near future. Our implementation aims at setting the standards for such applications and initial qualitative results are presented from its test use.

Categories and Subject Descriptors: H.5.1 [Multimedia Information Systems]: Artificial, augmented, and virtual realities

1. Introduction

Traditionally museums and cultural sites have been among the key institutions for the promotion of culture and the provision of fertile ground for educational activities in fields like archaeology, history, and art. Their core activity has always been the preservation, display and research on cultural treasures for the benefit of our society.

During the past century, the prevailing approach towards the public consisted of the presentation of "dead nature". In other words the visitor of a cultural site or museum could only see ruined buildings or numerous artefacts and works of art kept behind glass windows or placed against bare walls. Despite the informative value of such displays it became apparent to modern archaeologists and museologists that this approach was not suitable for the general public.

The typical visitors of such sites are tourists, families, and schools often only with very basic knowledge on archaeology and art. They are happy to view artefacts and excavated monuments but usually find it very hard to visualize them in their original glory or how they were used. Descriptive signs, guidebooks and guided tours give an answer to this problem but contain limited information or of general scope usually outside the interests of individual users.

A first step towards providing better information to cultural site visitors was made in the past decades with the placement of individual objects in their context. Sophisticated display sets were created where various objects were collected and exhibited together based on a story-telling scenario. This trend continued with the introduction of static and mobile electronic guides. The first category includes multimedia CD-ROMs, info-kiosks, virtual (VR) and augmented reality (AR) installations and web portals. Although they provide a large amount of multimedia information, interaction, and in some cases content personalization to the viewer's profile, they cannot accompany him during his visit. That is, they cannot provide the information he needs when he needs it.

The category of mobile, or portable, guides comes to rescue. These are devices like the early audio guides, and the most recent multimedia guides, which are carried by the user during his visit. The latter may provide simple audiovisual presentation on mobile devices or more advanced Virtual [Sca01], Mixed [Hal01] and Augmented Reality [VIK02], [HFT99], [WS03], http://rabbit.prakinf.tu-ilmenau.de/new_arpda.html presentations. Some of them can even provide personalized content [Roc04] and the most advanced, automatic context-sensitive operation and user navigation [Bau02], [VDI03]. Their main advantage, especially the most advanced ones, is portability, but at the cost of size and weight.

In this paper we present a new approach to portable electronic cultural guides for cultural sites and discuss their design concerns. In particular, we treat the issue of user interaction and graphical user interfaces, the limitations of these devices for on-site deployment, and present a pioneering new prototype for AR presentations on PDAs.

2. Why use PDAs as mobile cultural guides?

The existence of a variety of electronic guiding systems like those presented in the introductory section of this paper indicates the main research trends in the cultural heritage field. Our belief is that only those systems that offer portability and high degrees of freedom and satisfaction to their users will dominate the market for cultural information systems both for indoor and outdoor installations. Multimodal interaction will also be important.

As we will explain in the following sections, small portable devices offer various interesting functionalities but their limited processing power is still a significant obstacle in their development. Currently, the smallest device capable of delivering high-quality guiding applications is the Personal Digital Assistant (PDA). Despite its popularity it still has many limitations like processing power and battery life when used with peripheral sensors or a WiFi network. Nevertheless, pioneering AR applications have been demonstrated on PDAs http://rabbit.prakinf.tu-ilmenau.de/new_arpda.html, [WS03], with augmentations being produced on a central server or on the device itself.

Our choice of such devices for the implementation of audiovisual guides is based on experience with prototypes tested at archaeological sites in Greece and Italy with the participation of visitors and staff [VDI03], [VIK02]. We will now explain how advanced features can be added to off-the-shelf PDAs for implementing indoor and outdoor mobile cultural guides for on-site use by ordinary visitors and not simply under highly monitored and constrained environment or by special user categories.

3. The System

The electronic guiding system we present in this paper can be configured either as client-server pairs or as standalone mobile devices. We will briefly mention the first configuration and then concentrate on the second that will be presented together with feedback from a pilot installation at Pompeii.

In the client-server configuration, a standard PC server is used to provide an ORACLE-based multimedia repository. The data are stored in the database along with metadata descriptions according to the Dublin Core Cultural Metadata Element Set and other XML-based descriptions of spatiotemporal and profiling nature. Special software for tour authoring, tracking of mobile users and remote monitoring of PDA parameters (like battery level, etc.) has been implemented in EJB and C++. The same software allows statistics collection on visitors' preferences, visibility of monuments and objects, and other information that can be used by the museum staff for rearranging their exhibitions and suggested guided tours. Real-time messaging to the mobile users and content downloading [DVI04] are also supported.

This setup can be regarded as the full version of an integrated system, which caters for all the needs of cultural sites and museums and can be integrated with other existing systems like ticketing. In other words, it forms the backend and the front-end of a cultural IT system. Similarly, the mobile devices form the front-end that is visible by the site or museum visitors. Our approach to the design of such devices is based on off-the-shelf components in order to reduce cost, implementation time, and promote upgradeability and replacement of peripheral sensors etc. We have tested and evaluated a number of popular devices each offering similar features. They are listed in Table 1.

PDA Device Type	Processor	Memory	Storage	Bluetooth	WiFi	OS
Toshiba Pocket PC e800	Intel PXA263 400 MHz	128MB RAM, 32MB ROM	Expandable with CF and SD Card slots	YES	Integrated 802.11b	Pocket PC 2003
IPAQ Pocket PC 2220	Intel XScale 400 MHz	64 MB RAM, 32MB ROM	Expandable with CF and SD Card slots	YES	SanDisk 128MB WiFi CF Card	Pocket PC 2003
Siemens PocketLoox 610 BT	Intel XScale PXA 255 400 MHz	64/128 MB ROM/RAM	Expandable with CF and SD Card slots	YES	Integrated 802.11b	Pocket PC 2003
IPAQ Pocket PC 3850	StrongArm 206MHz	64 MB RAM 32 MB ROM	Expandable with CF Card slot	NO	Expansion Pack & Orinoco Gold PCMCIA 802.11b	Pocket PC 2002
GPS Device Type	**Channels**	**Accuracy**	**DGPS Accuracy**	**I/O**	**Cold start**	**Warm start**
Rikaline GPS-6020	8	5m	1m	CF card	120sec	42sec
Teletype World Navigator TCF1358	12	3m +	N/A	CF Card	48sec	
Fortuna Clip-On Bluetooth GPS	12	7m	1-5m	Bluetooth	45sec	38sec

Table 1: List of devices and characteristics

The devices have similar sizes and weight around 200gr or less making them suitable for mobile applications and use by all types of visitors, including children. The smallest PDA, the iPAQ 2220, and the older 3850 have the disadvantage of no built-in WiFi connectivity and require external 802.11b WLAN cards at the penalty of using the single CF slot or adding an expansion jacket. For this reason, they are less favourable when network connectivity is a prerequisite as they become bulkier and require protection against accidental damage.

Regarding GPS connectivity, three mini receivers were tested featuring NMEA compatible wired (CF card) or wireless (Bluetooth) connection to the PDA. Their accuracies are of the order of 5-7 metres with a best value of 3 metres under optimal conditions (flat reception area with no obstacles, clear skies, fully charged batteries, and external antenna). Their performance is largely affected by their acquisition times at cold and warm start. These values are related to the elapsed time and the distance from the point where the receiver powered for the last time. Large inactive periods or transition to distant areas while not in operation necessitate the download of the GPS almanac (http://www.trimble.com/gps/how.html) from the satellites and the recalculation of the receiver's position. The Rikaline GPS-6020 achieved the best overall performance despite its somewhat larger dimensions. In our situation inaccuracies of the order of 5 metres are sufficient for most cases since archaeological sites, in general, offer fairly unobstructed views of the orbiting GPS satellites. Nevertheless, extreme situations like areas with tall obstacles (e.g. high walls) or war zones (where the GPS selective availability feature deliberately introduces large positioning errors) limit the practical accuracy of the calculated position. In such situations a Differential correction (DGPS) can be used as was tested under real conditions. Two of the three receivers we tested supported the use of such mode where the correction signal was fed to them and helped achieve accuracy around 1 metre.

However, this improvement comes at the cost of additional hardware resulting in bulkier and heavier mobile devices. Two setups were tested. First a DGPS server was installed at a central PC in the vicinity of the area visited by the users of the mobile guiding system. It calculates in real time the corresponding correction signal, which is then transmitted wirelessly to the receivers connected to the mobile devices. Transmission is possible either via an IEEE 802.11b WiFi network, or using an RF modem pair. The second setup uses a commercial DGPS service over a GSM/GPRS cellular telephony networks and was implemented with a mobile telephone acting as receiver and feeding its data to the PDA and the GPS receiver. Both setups offer reliable operation and comparable costs in the long run. The control of the overall operation and communication of the PDA is implemented in the .NET framework.

In order to protect the devices a raggedized locking and water and dust-resistant sleeve is used, which also prevents the user from detaching the device or switching off the PDA. Nevertheless, should this happen, or in cases where no data are received from the GPS (e.g. at indoor areas) the control software attempts to read the GPS data like reading a serial port until they become available again.

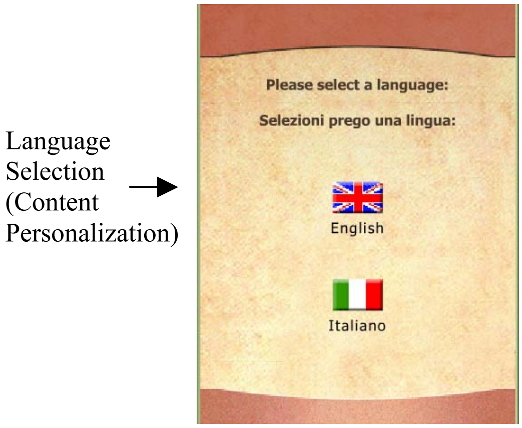

Figure 1: *Example user interface*

4. User Interface design and Interaction considerations

A key aspect of the presented guiding device is its operation and its relation to the user categories it addresses. For this reason the design of an appropriate user interface (UI) and interaction mechanisms are of paramount importance. The typical user of the guiding system is the visitor of a cultural site. His profile may be virtually any but typically he is not a professional related to the cultural sector but an adult, or child, willing to devote a limited time to his visit. Let us now consider the main considerations we took into account when designing the user interface.

Primarily, such an interface should allow easy use by all visitors it is expected to serve. We have to bear in mind that the average visitor of an archaeological site or museum is not a computer expert and most probably has never used a PDA or mobile computer before, not to mention the particular e-guide software. For this reason we structure our interface so as to offer as much as possible intuitive operation and simple interaction that does not impose steep learning curves. Our goal is for the user of the mobile guide to master its operation in no more than 5 minutes. To achieve this goal a special help presentation is launched automatically prior to the guided tour. It sets the framework of the guided tours and presents step-by-step the functionalities and available features.

The UI should also be visually appealing so as to attract the visitor and add to his experience. A technically sound design and functionality of such an interface may not be the ticket to success. As an example consider a graphical interface designed with flashy colours and special effects that are tiring to the eye, or the use of small font and long text. These are hard to read on a small screen especially when walking and in effect distract the visitor's attention from the reality that is the exhibits or the monuments surrounding him. To avoid such shortcomings we took into account in our design experiences from related projects [VDI03], [VIK02] and commercial products in areas like web design, mobile computing, and prototype cultural information systems [Bau02], [Hal01], [HFT99], [HJK02], [PSC-03], [RM02], [Sca01], [SRA01], [ZSA03]. The result is illustrated in Figure 1 and is governed by three principles; convey the maximum amount of information, adapt to the user's preferences and interaction style, and offer scalability for use on a variety of mobile platforms and visualization applications.

According to our first principle, the UI should offer the maximum amount of information that the user should receive in order to enhance his visit and not flood him with irrelevant detail that will result in loosing his interest or putting additional effort in identifying the significant one. For this to function, the information is presented in a concise way avoiding jargons, slang and abbreviations that are not understandable by every user. Consequently language choice is of paramount importance as many users, especially of elderly, children and certain nationalities like Spanish speaking, do not speak or have sufficiently good command of English that would allow them to follow and understand without effort the presented guiding information.

So far we have already defined one choice, that of the language of the presentation. Before setting new options and features in our UI, we should pay attention so as not to sacrifice its simplicity. Accordingly, we follow a hierarchical approach into our design and implementation so that the user is presented only with a minimum amount of information and options, which he can expand should he wish to get into a more interactive guiding mode. The key to this approach is the standardized presentation of the information and the functionalities. It includes both the definition of information presentation and interaction segments on the PDA screen, as well as, certain behaviour paradigms for intuitive interaction. These aspects of the UI are put together and integrated with the overall guide operation in the following sections of the paper.

The second design principle, "adapt to the user's preferences and interaction style", is closely linked to the way the information content is conveyed to him. We have already mentioned the choice of the language of the presentation but other options can be selected by the user so as to adapt the guiding to his liking. Of major importance is the choice between automatic and manual operation. The user may leave the burden of identifying his position in the site and selecting the corresponding presentation to the device itself. In this mode he simple walks and stares at any object and the system automatically launches an audiovisual presentation explaining the history, characteristics, etc. of the object. Alternatively, he may select the manual mode and take the responsibility of identifying his location on a digital map and selecting the corresponding presentation.

On top of that, he may chose from thematic tours covering certain aspects and areas of the visited site. The content of these tours may match his interests (e.g. put emphasis to history or social life at a specific era) and available time (e.g. short visit, or long visit with detailed presentations). Or he may bypass the tours suggested by the device and simply make his own choices during the course of his visit. Finally, he may select to deepen the level of detail he wishes to receive, either by spending more time in the vicinity of an object of interest (intuitive interaction) or by selecting it via the graphical interface on the device's screen (manual interaction)

The third principle deals with scalability. Our interface is designed in a way that allows the easy adaptation of the presentations and the interaction methods to a variety of mobile platforms. Examples include the porting of the guided tours to mobile Augmented Reality (AR) devices, mobile web-pads acting as e-books, and even PDA-like cellular phones. These devices have different processing power, presentation methods (miniature screens, touch screens, AR glasses, AR binoculars) and interaction devices (multifunction buttons, joysticks, gamepads, touchpads, touch screens, position and orientation tracking devices). According to these characteristics they may support certain types of operation. For instance, a PDA or a mobile phone cannot support high quality and resolution graphics. Similarly, an AR device is not conveniently operated in manual mode with an interaction device as its user is wearing a Head-Mounted Display (HMD) in front of his eyes.

These limitations necessitate the use of a versatile framework for building the presentations and adapting them to each specific device. This requirement is satisfied using metadata descriptions for the individual multimedia objects (sound, images, animations, annotations, etc.) and a synchronization framework built on SMIL files (http://www.w3schools.com/smil/default.asp). This forms a basic description of how the audiovisual information is presented, in which order, where, when, and how the user can interact with it. This versatile descriptive scheme allows each device to interpret the relative information and adapt it to its characteristics. At the same time it allows adaptation to mach changes in its hardware setup, like the visualization, sensory and interaction modules.

Finally, this approach facilitates reuse of existing content from other applications like multimedia archives and web sites, which are common for most major cultural institutions.

5. Story-telling

Moving away from the technical point-of-view of the mobile guide we will now consider it as a tool for passing across the message of a cultural institution. Cultural institutions ordinarily employ signs, paper guides and trained human guides to inform the user and direct him towards the intended message (e.g. the superior cultural contribution of an ancient civilization, or the genius of a sculptor). As these means bear a lot of limitations, which were already mentioned in the introductory section of the paper, portable electronic guides offer an attractive medium for achieving this goal.

Based on this framework, the mobile guide presentations obey an integrated framework of information delivery instead of merely presenting extracts of historical texts, photographs and descriptions of archaeological and art objects. The use of story-telling allow the implementation of integrated audio-visual tours which present the history, use, and social parameters associated with a specific objective. Instead of giving a simple description of "dead" and static objects, they put them into their original context, recreated with virtual reconstructions, architectural drawings, photographs, etc. all synchronised with the voice of a virtual human guide mimicking the work of professional guides. The added advantage of this approach is the provision of personalized information, matching the user's preferences and not just a standardised description addressing any group of tourists.

The storytelling is based on archaeologists' and museologists' information and is implemented with interactive functionalities to facilitation information personalization and to allow comparison of the presented objects with other exhibits on remote museums or sites. This feature is very import as it is common for significant exhibits of an excavation or artwork by famous masters to be scattered geographically to museums and collections. In many cases they are not even accessible by the public but only by collectors and researchers. The electronic guides give the advantage of virtually reuniting all these items and giving on-site information on a context-sensitive basis.

6. How was all put together?

Our experience with PDA-based mobile guides started with prototype applications at ancient Olympia, in Greece, and continued with the development of improved versions for indoor and outdoor use. These models are suitable for use in museums, archaeological and other cultural sites. They are based on the hardware setup described above and feature the functionalities already mentioned. There are, however, details that we took into account for facilitating their use by all potential users.

The current hardware setup allows the determination of the user's position in real time via a GPS receiver for outdoor applications or a WiFi system indoors. However, orientation estimation absence does not allow the accurate determination of the user's perspective and occasional inaccuracies occur in position determination as a result of loss of the WiFi or satellite signal in areas near large obstacles. To overcome these problems we assume that the last valid position-fix holds true until a new value can be determined. Although the direction of motion of the user may be used as an estimation of his heading, accurate calculations cannot be made, as rotation when standing at a fixed point cannot be detected. Our approach consists of two levels.

First, the estimated position is used to select the closest match from a pool of multimedia material locally stored on the PDA or downloaded from a server (e.g. near viewpoint 5, the corresponding multimedia content is selected). To guide and indicate to the user the actual object the presentation refers to, his position is indicated on the map and photographs from his estimated point-of-view are then presented on the device's screen. This is followed by audio-visual story telling (refer to Figure 3).

The content at each point-of-interest is presented hierarchically, starting with a general description and followed progressively by detail matching the user's profile. The presentation of this detail is controlled by the user's behaviour as it is dictated by his presence at a point-of-interest or his interaction with the device via an interactive map or selectable detail zones in the visual presentation. Examples can be seen in Figure 2.

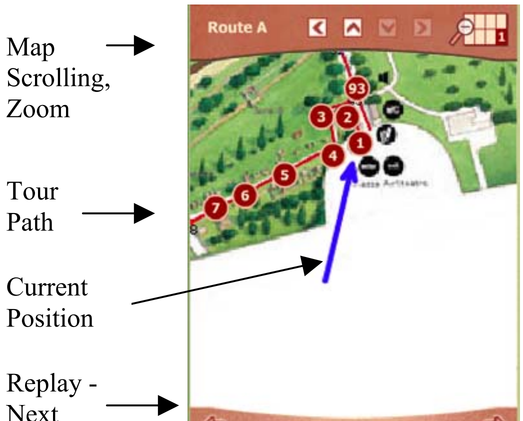

Figure 2: *The digital map UI with navigation aid and route planning functionalities*

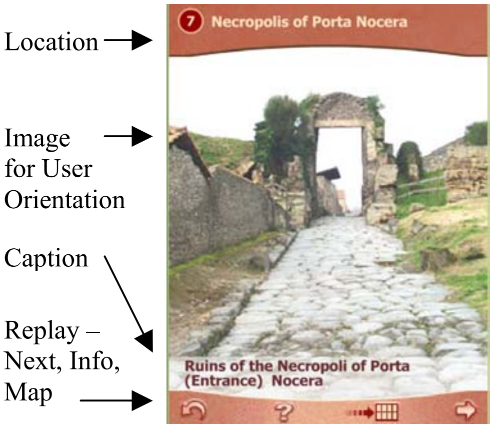

Figure 3: *Example screen at a point-of-interest.*

7. The pilot application in Pompeii and its socioeconomic implications

The initial application of this system takes place in the archaeological site of Pompeii in Italy. The site is of particular importance being a major cultural monument for Italy and the world in total and due to the fact that we deal with an entire city fairly well preserved if we consider its turbulent past with its destruction by the eruption of Vesuvius in 79 AD. Despite the good condition of the excavated buildings and artefacts a lot remains to the visitor's imagination since, for preservation reasons, many objects have been removed and stored or exhibited at museums while many buildings remain in ruins. In addition, the size and street layout of the city pose difficulties to the tourists in finding their way and locating the many points of interest.

This is a very challenging scenario for the guiding system. The site is an outdoor location but contains several covered buildings and many tall walls depriving the GPS system of satellite signals at these areas. At the same time no WiFi exists for indoor locations as no invasive work is allowed in the protected area. As opposed to most AR systems, our applications to cultural sites does not allow the use of markers for optical-based position and orientation tracking or for augmenting the user's view, or the installation of RFID tags, IR sensors or other hardware. These peculiarities of the site proved the usefulness of the presentation of photographs of the ruins for helping the user orient in the site when his position cannot be tracked with accuracy or when he enters roofed buildings. This design and setup of the installation and the trials involved extensive surveying and photogrammetric studies of the site and its monuments followed by 3D modelling and archaeological research in relevant sources for data collection and adaptation to the story-telling. The creation of the multimedia content was based on common representation standards for enabling the reuse and exchange of information between existing applications and its adaptation for presentation on various mobile platforms [VDI03], [VIK02].

The abundance of visitors with no computer skills tested the functionality of the user interface. The choice of a simple interface with optional manual interaction and standardized layout proved easy to understand and use (refer to Figure 3) following the briefing of the user through the automated help functionality. The absence of textual presentations was particularly important as it would pose serious problems and would be ignored by the users while walking in the presence of large crowds. The only text presented on the device is an indication of the current position (top of the screen) and a caption below the visual presentation.

Other functionalities like replay and skip/next are controlled by buttons at the bottom left and right corners of the screen. Their resemblance to REW and FF functionalities on cassette players and the intuitive relation between LEFT and BEFORE, and RIGHT and AFTER make them easy to use.

The question mark at the bottom centre of the screen makes it an easily identifiable functionality for receiving help on the operation of the device or the offered tours. Two thematic tours are presented covering different parts of the site and various aspects of ancient life.

The map button at the bottom of the screen provides navigation information at any point along the selected tour and indicates the current position and adjacent points-of-interest. A zoom-in and out operation allows the user to get a better view and plan his tour should he wish to deviate from the suggested path. Route planning is also facilitated by manually previewing available presentations at every point along the route and by the thematic presentation of the information (Figures 2, 4 and 5).

All operations that require interaction on the touch-sensitive screen can be effected with a stylus provided with the device or simply by touching it with the tip of a finger. The latter is naturally preferable but many users found it hard to click on the right spot. This drawback is caused by the limited space on the screen and the amount of buttons we included to offer the functionalities. However, we remind the reader that these interactions are optional and address the needs of those users who either have used PDAs before or are willing to try to use a novel type of interaction.

The system is still in prototyping stage and under evaluation. The initial feedback we received is positive but a series of trial sessions need to be performed before sound statistical results and conclusions can be drawn.

The full-scale implementation of the e-guiding system is expected to add a strategic advantage to the site of Pompeii. Currently there are several pilot installations using PDAs in museums around the world and in some outdoor sites. However, no installation is currently using a fully automated guiding story-telling paradigm in a complex scenario like that of Pompeii. Its installation and use is expected to add a first-class attraction to the site and increase visibility and visitor numbers. The additional revenue is expected to come from increased ticket and souvenir sales instead of rental fees for the mobile devices. Their rental prices are expected to cover the expenses of installing and running the system and not create a profit. Only a small nominal fee (around 5-10 Euros) could be charged if they are to become popular with visitors. This could change in the near future when the related hardware becomes more affordable. In brief, the guiding system could act as a development lever and provide, in the long run, revenue for research and restoration efforts. Finally, its operation can also include e-learning scenarios combining education with recreation.

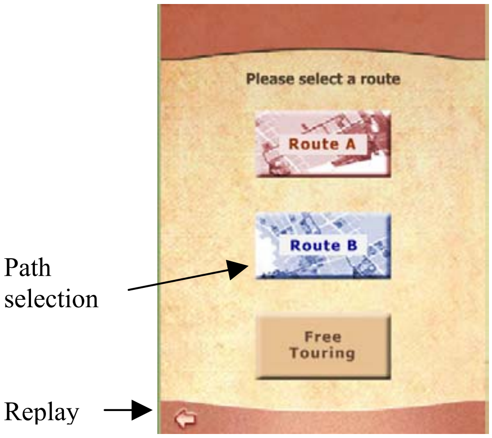

Figure 4: *Suggested predefined thematic routes and free touring options*

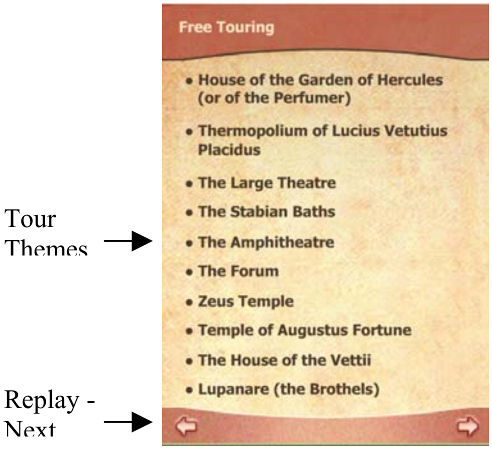

Figure 5: *A preview of thematic touring*

8. Taking the technology one step ahead

The presented application of the mobile guiding system incorporates many features common to other similar prototypes [BM01], [Kra03], [Pet01], [Roc04], [VIK02]. It goes, however, one step beyond its competition by presenting fully automatic operation in indoor and outdoor environments, while at the same time allowing its user to select his preferred mode of interaction (intuitive or manual-graphical). The system also offers a graphical UI mechanism based on paradigms borrowed from traditional audio and video presentation systems.

The previously presented functionalities constitute an application more like a Mixed Reality pocket guide where photographs of ruins and objects are mixed with graphical reconstructions and representations of the ruined building and artefacts. The device is used more as an intelligent electronic book where the user's view is enriched with graphical information on the PDA screen.

The main breakthrough of the proposed system is the implementation of a "light" Augmented Reality (AR) presentation on the mobile guide. Our approach to the AR dimension of the guided tour moves away from the e-book concept and uses the PDA as the processing and optional interaction device. The presentation is no longer done on its screen but on a miniature, single-eye Head-Mounted Display (HMD) manufactured by micro-Optical corporation (http://www.microopticalcorp.com/Products/vga.html#SV6) (illustrated in Figure 6). The device accepts VGA signals and provides an effective resolution of 640x480 pixels, crisp-clear images, and can be adjusted on most spectacles frames for left or right-eye viewing. It connects to the PDA via an off-the-shelf VGA adaptor available for major PDA makes.

In contrast to "traditional" AR displays (both glasses and binoculars) it does not cut the user off his natural environment. Its miniature size, half that of a small stamp, and its see-through nature render it almost invisible to the user's eye. This is the case despite its presence in his field-of-view. The display becomes visible when the user focuses on it and covers approximately 16º horizontal, 20º diagonal of his field-of-view. Although not a true AR application in its full sense (i.e. covering the entire field-of-view of the user and using optical tracking and rendering to augment the user's view in real time with aligned graphics) it provides a very good substitute. The device simply provides static photographs, MR images and animations, and synchronised sound.

After a few minutes most users become familiar with the necessary change of focus of their eyes between distant real objects and the display bearing a mixed view from the same or similar perspective (here we assume the user identifies the direction for viewing a presentation by the photographs of a building etc.

that is presented on the glasses prior to the remaining presentation). The resulting illusion is similar to AR and suitable for low processing power devices such as PDAs (please refer to Figure 7). These devices cannot handle real-time video analysis and camera tracking for adapting the virtual objects to the scene of the augmentation but rather a scaled-down version of 2-5fps and with a lag of a few hundred milliseconds, which tend to cause frustration and dissatisfaction to many users.

Our approach provides a sufficiently good augmentation of static images with the same perspective as the user. The same image is displayed even when the user changes his position and orientation by an amount not detectable by the GPS reader. Again this problem can be treated by guiding him to the correct spot with a photograph from the proposed point-of-view. Although not a truly AR application it avoids the shortcomings of PDA-based AR systems which cannot provide true AR operation, i.e. in real-time. The user of the proposed system gets accustomed to static images or animations instead of tracked AR images. As a result he does not expect the graphics to change as he moves his head and avoids disappointments.

This approach to "light" AR presentations contrasts those by other researchers who employ wearable computers [Spa04], [HJK02], [Kre01], [RM02] or mobile telephones (http://www.uni-weimar.de/~bimber/research.php). These devices are either bulkier than a PDA or in the case of mobile telephones, they provide very low quality images. They perform sub-real-time tracking and rendering of simple objects on natural images captured by miniature cameras. Their results are along the lines of AR systems but the limited processing power does not allow yet the creation of high quality AR presentations and smooth motion and graphics rendering. This gap in quality is targeted by our approach at the cost of static augmentations.

The initial reaction of the users of our prototype are very positive (again large-scale on-site evaluation remains to be done) with complaints mainly about the loss of contrast at outdoor use under direct sunlight. In order to limit this discomfort we opted for the modification of textual indications (position and caption) and the use of 2-3 words in large font for easy readability or completely remove text. This modification resulted in improved readability while in indoor applications the original textual descriptions are easily read due to the crisp image provided by the display. It is an example of the scalability of the UI presented earlier and demonstrates how the same content can be reused in a different presentation framework.

This new UI mechanism is expected to play a leading role in future developments of the system. Currently interaction functionalities in the form of the graphical buttons appearing in the PDA's screen have been omitted from the "light" AR presentation so as to facilitate visualization and not distract the user.

In conclusion, the light AR guide prototype is currently operating in automatic mode based on GPS readings. Optional user interaction is possible on the PDA screen for manual operation and previewing viewpoints further along the tour path.

Figure 6: *The ruggedised Light AR PDA Guide with the lightweight AR display and screenshots from the Auto-Manual operating mode selection and fresco presentation.*

Figure 7: *Example "light" AR presentation. The small inlay image presents the reconstruction of the user's view in the background. Change of eye focus between the two images creates the required illusion.*

9. Conclusions

The work we present in this paper aims at unravelling the design and implementation of portable electronic guides for cultural guiding applications. We presented practical considerations and emphasized on their usability and UI. A novel principle, that of “light” AR for the implementation of augmented reality paradigms on PDAs was introduced and initial evaluation results were presented.

Our aim is to continue research in this exciting new field and perform large-scale on-site tests. The UI issue remains a high priority and a hot topic for this application, as well as, the value-added services that can be provided by these guides in association with centralized management systems.

Our plans include the integration of a digital compass for estimating the user’s heading. It will be used to load and present mixed views aligned to the user’s natural view (e.g. 1 view per 20º) and scroll mixed panoramic views from his viewpoint as he rotates about it.

The system. Both in its PDA guide and light AR guide versions is suitable for any open-air site of any museum and cultural site in general. Its installation is not intrusive, does not interfere with the normal operation of the site and can reuse existing digital content, e.g. from websites, CD-ROMs and other digital systems. Its installation can be scaled to the needs of every site (indoor-outdoor configuration, standalone or client-server, quantity and mix of multimedia content, content personalization, and expandability for future needs. The installation process involves site survey, creation of a calibrated site plan, content and tour authoring, and on-site system calibration.

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The system described in this paper forms part of the technology marketed by INTRACOM as an integrated cultural site management and visitor guiding system under the name intCulture.

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