LIFEPLUS Cultural heritage dissemination on a wide range of client devices: from the simple handheld to the advanced AR platform

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ABSTRACT

Multimedia guided tours of cultural sites are beginning to appear in archaeological sites and museums across the globe. Still no commercial installation has been reported but the ever-increasing interest is bound to trigger further development. This trigger led to the advanced research for the LIFEPLUS system, which presents two novel mobile platforms featuring Augmented Reality guiding with content personalization and context and behaviour-based operation.

Introduction

Digital technologies and high quality graphics and animations brought a revolution in the way we perceive "traditional" fields like culture and art. Up to very recently, our only source of information and help before, during, and after our visit was the plain old printed guidebook. Its photographs, maps, and large text extracts gave the much-needed information for understanding and appreciating the importance and history of a site. However, this help comes at the cost of user-"unfriendliness". In other words, you have to read or browse through large pieces of text before you can locate the information you want, the available information is not always along your interests, and the findings and exhibited items are presented as dead natures with no information on their use or creation. This is where the digital revolution comes into action.

A number of commercial products have appeared in the market in the form of multimedia and interactive web portals, CD-ROMs, and info-kiosks. All these products offer the off-site or the on-line visitor the information relating to his visit together with a plethora of graphical information (including photographs, 3D models of artefacts, animations and video footage with virtual reconstructions of damaged objects and simulated scenes from ancient life in its original setting and based on excavation findings and historical sources). Despite the significant help they offer, they fail to address the needs of on-site visitors, as they cannot accompany them and offer their information when and where needed.

Portable audio guides address the mobility issue with various degrees of success. The early tape players assumed the sequential visit model along a predefined route, while audio-CD players were the first to allow random access to information based on an identification code for each point of interest. These have been largely replaced by digital audio players equipped with hard disks capable of storing several hours of narration and even personalization features and thumbnail images to complement the sound [http://www.antennaaudio.com/]. In addition, they are the first to offer automatic operation by exploiting the location tracking capabilities of a variety of sensors, ranging from infrared, to Bluetooth, and GPS receivers [http://www.rsf-europe.com/indexus.htm].

This race for an ever-increasing availability of features and functionalities led to the introduction of mobile computing in cultural heritage. Three main versions of mobile devices are now available; PDAs, web-pads, and laptops [1-8, 10-11, 14-16]. The first two can be regarded as electronic books in the sense that visual information is presented on touch-sensitive screens where the user can interact. The third type of device offers enough processing power to support complex and high-quality applications in real time, like Augmented Reality (AR).

The following sections of this paper describe the efforts of the LIFEPLUS project for the implementation of ubiquitous audiovisual and AR guides for cultural heritage sites. The project is financially supported by the EU IST FP5 and integrated the efforts and expertise of a number of leading research institutes and commercial companies across Europe (2D3, A&C2000, Bionatics, EPFL, Fraunhofer IGD, FORTH, INTRACOM, noDNA, University of Geneva, University of Milan, Superintendence of Pompeii).

Ubiquitous Interactive Audiovisual Guides

Our efforts in LIFEPLUS are driven by the goals of creating systems that will help the visitor of a cultural site better appreciate his visit, enjoy it, receive information to enhance his experience and avoid being cut-off the site and its real exhibits. Our experience with mobile devices and support infrastructures has been tested in previous research projects at Ancient Olympia [10, 16] and based on user satisfaction and feedback we opted for light version of an interactive and advanced e-book guide. The chosen platform, an off-the-shelf PDA running the Pocket PC operating system, features perfect value for money, and is very well suited to all types of potential users since it is very compact and lightweight. The device itself has built-in wireless connectivity capabilities allowing content downloading in real-time, and exchange of control and other messages with a central server or other mobile devices. It supports two modes of operation: automatic and manual.

In automatic mode, the PDA is responsible for identifying its position in the site and launching the corresponding presentation to supplement the user's perception of the surrounding ruins and possible artefacts still in situ. It relies on the universal and free GPS service to estimate its position in real time [http://www.colorado.edu/geography/gcraft/notes/gps/gps_f.html]. The accuracy of the calculations may range from, typically, 2-5m to 50-100 metres in extreme and rare situations. It depends on several factors, like the number of satellites "visible" by the receiver as a result of the presence of tall buildings and other obstacles, the quality of the receiver, and the *selective availability* feature. The last feature is an inherent property of the GPS system, which being originally designed for military applications it deliberately includes a randomly varying error in the satellite signals. This error is not detectable by ordinary commercially available receivers and to make things worse, its value increases dramatically during wartimes.

Our system operates satisfactorily with the accuracy of 2-5m being sufficient. In extreme situations an optional Differential GPS (DGPS) system may be used. Its function is the calculation of the position of a fixed GPS receiver in real time, and the extraction of the error in the position calculation based on a priori knowledge of the exact geographic coordinates of the receiver. This correction (differential) signal is then wirelessly broadcasted or transmitted to the receivers of the mobile devices in its vicinity. We have used three different settings for the DGPS system; a dedicated server transmitting the correction signal with an RF modem pair, or over an IEEE 802.11b Wireless Local Area Network (WLAN), or an existing public DGPS service where the correction signal is received via a GSM/GPRS telephony network.

When the user is tracked at any point of interest, the device automatically launches an audio description of the ruins and objects of interest in his field-of-view. Since the device cannot calculate the user's heading and consequently his field-of view (it can only estimate it from his walking direction assuming he does not turn around), it guides him to stare at the right direction by presenting to its screen a photograph of the ruins and objects he should see from his position. This is then automatically followed by the presentation of more elaborate information like virtual reconstructions of the ruined buildings or presentation of artefacts originally found on-site and now stored or displayed at museums (please refer to Figure 1).

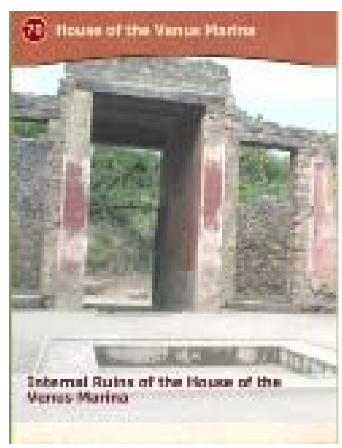

Figure 1: The pocket guide and example screenshots

A digital map of the site is displayed on the PDA screen, indicating the user's position in the site in real time and an indication of adjacent points of interest. The current area of interest to be described is highlighted for helping the user to better navigate and stare in the right direction.

In manual mode the user may select the information related to his current location simply by tapping on the device's touch-sensitive screen. This way he can get full control of the flow of the data and even preview data from other locations in the site before he even visits them. This mode of operation can also prove useful in situations where GPS signal reception is problematic e.g. near a wooded area or next to a tall wall.

Light AR on Pocket Guides

The visitor of an archaeological site may get interesting information from his PDA and chose to consult his screen whenever he wants to view virtual reconstructions and navigation information. In order to avoid distracting his attention from his real surroundings, the AR guide has been designed to offer vocal navigation (e.g. "Turn left at the junction"). This way, it may be used as a simple audio guide and the user occasionally consults the visual information whenever at a point of special interest.

In order to counterbalance these limitations and avoid cutting the visitor off his tour, we implemented a novel visualization paradigm and user interface. The device is equipped with an off-the-shelf VGA adapter upon which a miniature transparent display is plugged. The display is attached to the frame of any ordinary spectacles (illustrated in Figure 2). Its operation is to present images and animations, synchronized with the narration, in the user's field of view. The effective display is of small dimensions so as to occupy only a small fraction of the user's field-of-view. However, due to its proximity to the eye, it offers VGA resolution and high image quality. The user may become accustomed to focusing to the display or to his natural view and back. In effect, when he focuses far in front of him, the display becomes almost unnoticeable and he can experience the real view in front of his eyes. Changing his focus to the display he can see any type of graphical presentation. An interesting situation occurs when he is presented with photographs from the same perspective, which have been mixed with rendered 3D reconstruction models of buildings, etc. This way an illusion similar to AR is created. In contrast to true AR systems, the presented mixed image is static, i.e. it does not change as the user moves or changes direction. If the change in his perspective is not very big, the perceived quality is of high quality and quite realistic. If significant motion or rotation is involved then new images could be loaded to match it. This is a topic requiring more attention in the future.

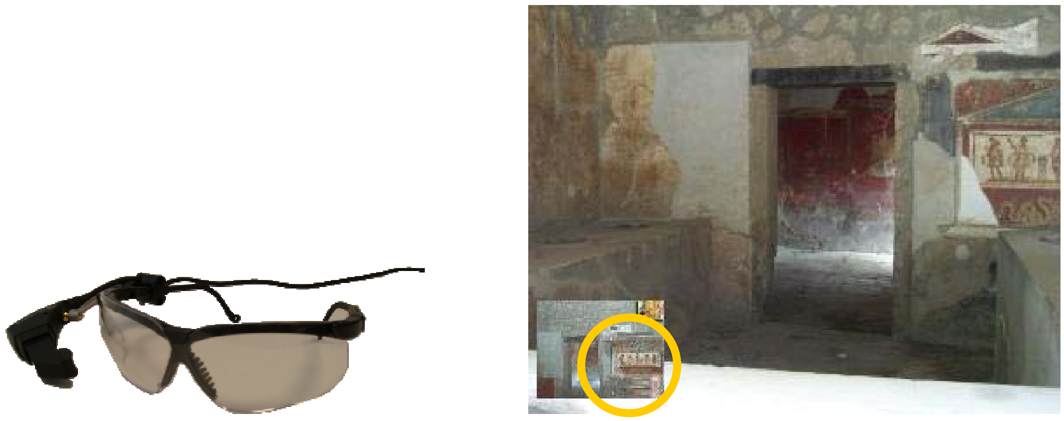

Figure 2: The miniature display and the light AR experience.

In contrast to existing PDA-based AR [12,13], our light AR prototype has the disadvantage of only approximately matching the augmentation's perspective to the real perspective of the user and, currently, no adaptation during user's rotation and nearby motion. However, it avoids image lag, jerkiness and registration errors typical in those systems as a result of their limited processing power and the high requirements for real-time video tracking. This way, light AR does not create any false expectations to its user, who may easily get used to its operation, and which does not create dissatisfaction from the perceived AR animation experience.

The operation and the user interface of the light AR pocket guide are similar to that of the standard PDA guide. Automatic presentation and navigation are possible with the GPS system letting the user free to walk and simply store the PDA in his pocket. Interaction and manual operation are also supported with the help of the PDA's screen and visualization can be done on the same screen and, once a selection is made, on the miniature display. Finally, to facilitate the user and to protect the device against shock, water and dust, a special ruggedised case with cord is user to house the PDA (illustrated in Figure 2).

Mobile AR Guides

The same content presented with the pocket guides can be adjusted for presentation with a standard off-the-shelf notebook-based mobile AR device. The device has enough processing power to perform real-time 2D marker-less video tracking and rending [9]. As a result it can render 3D graphics and reconstruction models, and animations on the user's natural view and adjust them in real time so that they align with it and create the illusion of seamlessly blending with the real objects. For every motion and rotation of the visitor the device automatically scales, translates and rotates the graphics to augment his field-of-view. The presentation of the AR experience is done through a pair of AR glasses or binoculars with integrated camera. Both devices are opaque and are practically made up of a pair of small displays, effectively covering his field-of-view. Their user can see in front of him by watching on these displays (one for each eye) the signal recorded by the aligned web camera. The AR illusion is created by rendering the aligned graphics on the video signal captured by the camera (please refer to Figure 3).

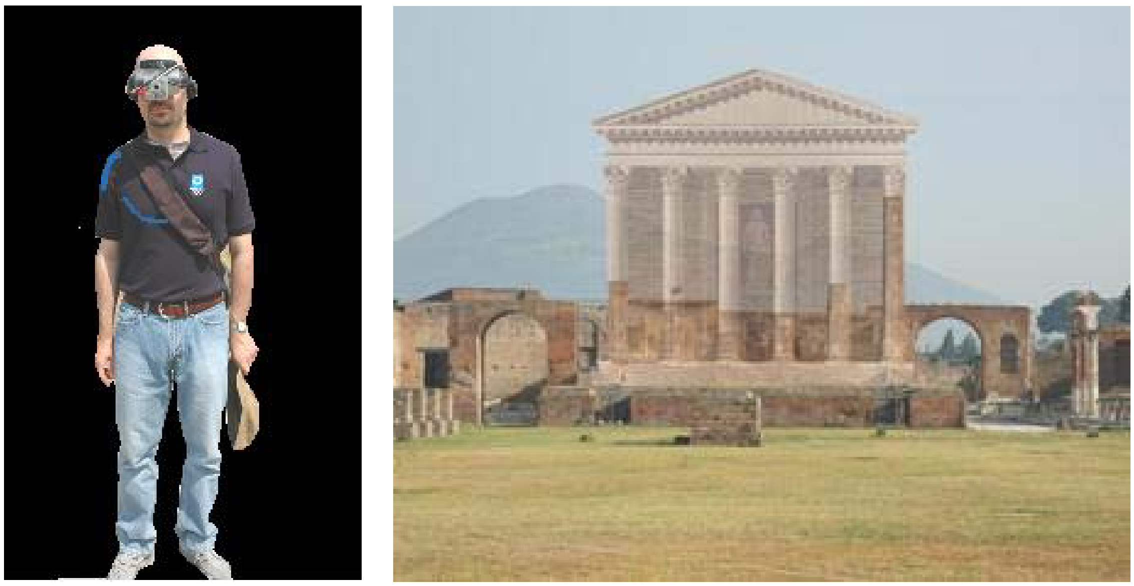

Figure 3: The AR Guide at Pompeii and the AR reconstruction of the Temple of Zeus.

This choice of video see-through AR display ensures high-contrast and high-quality images even in the presence of direct sunlight (the video signal is also internally treated with luminance adjustment software).

The device operates in automatic mode with the help of a GPS receiver and a digital compass for estimating the user's position and orientation, which are then automatically refined by the video-tracking algorithm. The user may alter the flow of information in an intuitive way simply by turning away from the augmented object or by walking away from it, or with manual interaction. The latter is implemented with the help of three buttons (integrated on the binoculars casing, or with a gamepad for the AR glasses) controlling a graphical menu displayed on the AR visualization device.

The system is bulkier and heavier (about 2 kg) than the pocket guide. The processing and power units are carried in a small backpack while the visualization devices are either worn in front of the eyes or carried in one hand.

AR Guiding in the archaeological site of Pompeii

LIFEPLUS has been installed and tested as a pilot guiding system in Pompeii, Italy. The installation and system deployment involved the following steps.

A detailed site survey was conducted to create a geo-referenced map of the ancient city. The existing site plan used in the official tourist guides was calibrated and corrected to rectify inaccuracies and deviations from the actual city layout. The same map was then used for the definition of thematic tours according to the storytelling authored by the archaeologists and site curator. Two tours were defined, covering different parts of the city and different aspects of community life (e.g. the market and trade, and the amphitheatre and sports). The same map also served as a reference in defining tours of certain duration. This way, tour personalization can be achieved resulting in higher user satisfaction and minimisation of manual user interaction.

A photographic survey of the site was then conducted with reference to the corrected map and the pre-defined tours. The photographs correspond to the proposed points of interest and illustrated building etc. ruins from the visitors perspective as he moves along the tour paths. These photos serve a double purpose: they help the user navigate and orient himself, and they are used to create virtual and augmented reconstructions that convey the additional information to the visitor.

The accuracy of the position tracking mechanism is then measured along the predefined tour paths and the optional wireless communication channels are installed and tested for serving the DGPS and data traffic. The location of the antennae is then determined according to the topology of the site, the coverage area, the availability of mains power and the permissible installation locations for minimising the aesthetical disturbance and damage to the protected monuments. Following permission and under constant supervision by the scientific staff of the site of Pompeii, temporary antennae installations were made at rooftops of buildings where antitheft and other modern equipment already existed, so as to gain access to mains power and avoid damages.

Finally, new digital content was created and organised together with existing content in order to make integrated audio-visual, personalized AR guided tours. The synchronization and location and orientation-based presentation of this content were adjusted on-site under real operating conditions.

This process can be simplified if existing data on the particular installation site is available. This can be easily retrieved and reused as a result of the support for a number of common imaging, multimedia, archaeological, and museological standards.

Conclusions

The work presented in this paper is based on the LIFEPLUS project and its pilot operation in the archaeological site of Pompeii. The system has been trialed by a limited number of site visitors, archaeologists and staff. Initial feedback indicates its potential for future exploitation with the main attraction being the AR reconstructions of ruined buildings, closely followed by the provision of continuous guiding and provision of synchronised and personalized multimedia information.

The use of multimodal interaction techniques and especially the fully automatic operation are well suited to users with little or no previous computer experience, including young children and the elderly. The pocket guide and the light AR were particularly favourable as they are very compact, lightweight and well protected so as not to induce any fear of mistreatment or accident to computer-phobic users. The AR device received very good comments for the high quality and realistic AR presentation but was less favourable when weight and size were concerned especially for children and, up to a certain extent, women.

Our effort now concentrates into further developing the light AR Guide and in optimising the hardware setup of the standard AR platform and its software to include 3D tracking for better results. This is expected to give is user more freedom to walk around while viewing the AR presentation.

The prototype systems will go under more intensive in-site testing with the participation of large numbers of visitors and scientists covering all the spectrum of potential users. Their feedback will provide valuable help in adjusting system parameters and making it more appealing to the public. A full-scale installation and initial commercial exploitation is expected to take place within the next year at a major European cultural site. Our future plans also include the replacement of the pocket guide with 3G mobile telephones acting as guiding platforms.

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