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## Augmented Reality Based User Interfaces for Mobile Museum and Exhibition Guides

*Abstract:* An increasing number of museums and galleries have been recently conducting experiments with mobile, multimedia capable, handheld devices used as communication and interpretation devices. Mobile museum guides present certain advantages as they can be personalized according to different visitor profiles, deliver rich multimedia content using wireless networks and reveal visitors' attitudes towards specific exhibits or interpretation material, thus providing the museum staff with valuable data regarding visiting patterns. However, despite the fact that evaluation and assessment have proved these applications to be highly effective, there are still many challenges to address and many obstacles to overcome. In this paper we argue that the introduction of Augmented Reality techniques in mobile multimedia guides could alter the way we interact with the museum exhibits as well as with other visitors. Also we discuss some simple, key elements regarding the use of Augmented Reality techniques within the specified context.

### *Introduction*

Museums have been undergoing a transformation during recent decades. Indeed it seems that a deliberate effort is being made to strengthen the ties with the public, broaden the spectrum of potential visitors and to provide them with an experience rich in sight, emotions and educational benefits. This trend is reflected in the variety of exhibitions, services and programs offered, in contrast to the past, where museums were solely places for the already engaged visitor who was expected to decode alone the aesthetic and contextual messages carried by the museum objects displayed (MURPHY 2004). In this context, Multimedia and Information Technologies have been employed recently for documentation and interpretation purposes together with more conventional means such as guided tours, audio guides, paper guides, textual labels, educational programs, and so on. Mobile and multimedia capable museum guides are the latest incarnations of this trend.

This paper examines briefly the state of art Mobile Multimedia Guides for use in the museum setting and their possible interplay with other, already well established computer applications in the museum. Some guidelines are also presented as well as some limitations of this approach. We also argue that the introduction of Augmented Reality (AR) techniques could provide an interesting alternative within the process of conception and creation of mobile museum guides. Several issues that could favour or slow down the widespread uptake of AR techniques in

museums and other exhibition spaces are also identified.

### *Mobile Multimedia Guides in the Museum Setting: What For?*

In order to understand more fully the potential of mobile museum guides, we should consider that they make use of two different, yet interrelated entities (*Fig. 1*). They are museum interpretation and communication means which are the latest medium to be introduced in the museum setting, and thus figure among other media, like text, audio, educational programs, guided visits and fixed multimedia applications and installations. At the same time however, they are considered as part of all the other multimedia and information technologies present in the museum, that are nowadays used for a variety of tasks, ranging from ticketing and administration purposes to scientific documentation and web site dissemination of cultural heritage related information.

Mobile museum guides find themselves at the intersection of these two categories. They are multimedia capable, so they can practically combine all other existing means and at the same time they can be configured to communicate with any kind of information system or multimedia application already present in the museum. This means on a practical level that there is a wide range of functions mobile museum guides could embody, according to each museum's specific needs.

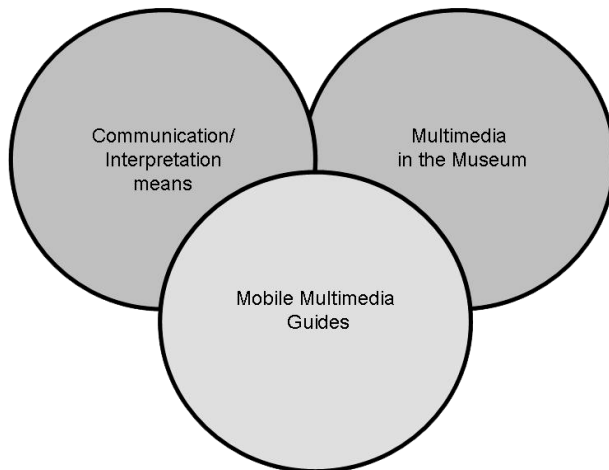


Fig. 1. Mobile guides in a museum setting.

In France, a famous historical residence explicitly requested the implementation of a special module that would allow control of visitor flow based on cutting edge geolocalisation technologies (interview with the author). In Germany, the Dinohunter application provided visitors with the possibility to take their own photos that were then forwarded to their email, while collaboration with a telecommunications company enabled visitors to order personalized souvenirs with their favourite dinosaurs on (SAUER et al. 2004). In the Netherlands, Museon and the DANAE project decided to use the mobile guide also as a remote control, in order to transfer a video from a PDA screen to a high resolution screen (BRELOT et al. 2005). We could easily imagine a mobile museum guide application communicating with a museum database to automatically import or update content created by the curators. Logging in visitors' actions is another feature, practically omnipresent in most mobile guides, as it furnishes valuable information about the use of the guide in a particular exhibition space. The list of possible modules could be long and it is not within the scope of this paper to provide an exhaustive report. However an indicative pool of ideas is provided by Fig. 2, if we attempt to combine the elements of the first column with the elements of the second.

Since the first known mobile guide, iGo, was introduced at the Minneapolis Institute of Art in 1994, many cultural institutions have been experimenting with mobile museum guides. PROCTOR (2005) lists 101 handheld tour projects throughout the world implemented from 1994 to September 2005. Unfortunately in many cases the guides are discontinued, either because they are part of experimental projects

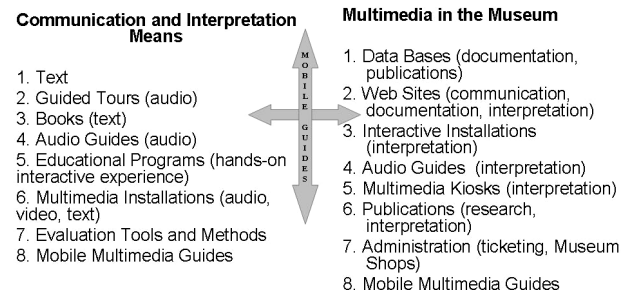


Fig. 2. Mobile guides at the crossroads of tradition and innovation.

or because they were created for temporary exhibitions with relatively few of the final outcomes of these projects being published in conferences or journals (DAMALA / KOCKELKORN in press).

On this point, the two “electronic guidebook” forums organized by the Exploratorium, in San Francisco, at which many active professionals within the domain participated, are a valuable source of ideas, experience and guidelines (<http://www.exploratorium.edu/guidebook>). Other projects with a relative continuity in time are the CIMI Handscape project ([http://www.hci.cornell.edu/projects/cimi\\_handscape.htm](http://www.hci.cornell.edu/projects/cimi_handscape.htm)), and the Tate Modern Multimedia Tour (<http://www.tate.org.uk/modern/multimedia-tour>). Taking into consideration the current state of the art present in museum handheld devices, it seems useful to mention some of the companies and institutions that are most active in that domain, like Antenna Audio, Expedeo, Sycomore as well as the Cité des Sciences in Paris.

### *The Pleasures and Pains of Integrating Mobile Multimedia Guides in the Museum Setting*

Using mobile museum guides as interpretation and communication means has certain advantages in regards to other ways of delivering information about museum exhibits. Their multimedia character allows the presentation of exhibit related material, regardless of whether this belongs to our tangible or intangible cultural heritage (ICOM 2004), at the right moment. Wireless networks and live streaming allow the simultaneous update of the guides' content whilst providing progressive and potentially unrestrained access to more and more layers of information. Valuable information can be gathered regarding visiting patterns and preferred multimedia sequences or exhibits. The possibility to connect with other multimedia applications, for example the

ability to personalise museum web sites, favours building long lasting relationships between the museums and the public, before, during and after the visit.

Most importantly, the content can be personalised. Different applications can be designed according to age groups, for example children, adolescents and adults or according to the level of visitor's knowledge (FILIPPINI-FANTONI 2003). Personalization according to language is a common characteristic already present in most contemporary digital audio guides, a feature easily implemented in mobile guides. Thematic visits is another criterion according to which tours could be tailored to match specific interests. Another characteristic, that many visitors seemed to appreciate, appeared in the guide implemented for the Museum of Fine Arts in Lyon, and consisted of proposing different tours according to the duration of time visitors wanted to dedicate to their visit (DAMALA / LECOQ 2005). It is also important to note that the audiovisual capabilities present in mobile multimedia guides could enable visitors with different learning abilities to approach the exhibited objects. An interesting experiment in this field has already been carried out in the Great Blacks Wax Museum in Baltimore, United States and in Tate Gallery, London (PROCTOR 2004). The mobile museum guide gave visitors the opportunity to bookmark favourite exhibits allowing them to take them home (TOPALIAN 2005) and personalized merchandise could also be recommended. The potential to encourage the creation of special interest communities is also a possibility that should be mentioned, as visiting the museum is in most cases a social experience (FALK / DIERKING 1992). Finally, it could be interesting to examine whether existing learning or museum learning theories could inspire applications and activities to encourage individual involvement. As far as the visitor is concerned, it is important to always bear in mind that there is a need for simple and easy to use interfaces which aid the task of navigation. It has also been observed that visitors can easily get frustrated by non robust and unreliable applications. Also of primary importance is the fact that in museums as well as in galleries, the exhibited object is thought to be the major form of pedagogy, therefore an application should not favour a heads down approach, and should also prevent – if possible – visitors' isolation.

It is also equally important that, on a more technical level, personalization could also mean to adjust different styles of presentation and different

interfaces to different terminals, for example mobile phones, personal digital assistants or tablet PCs. At the moment this is somewhat premature but in the near future we might see visitors bringing in the museum their own terminals and being able to use them in the museum by downloading interpretation resources. Several museums are moving towards this direction already by providing podcasts that visitors can download from the museum website.

It would be an omission however not to mention that the development of a mobile multimedia guide is a time, money and resources consuming process. There exists practically no "off-the-shelf" solutions for the creation of mobile museum guides and consequently no dedicated authoring tools to enable museum professionals to create their own applications. Therefore, an interdisciplinary approach and an iterative design process including all involved stakeholders is needed. Evaluation in this case is of utmost importance and should be introduced from the early stages of a project as the sooner the problems are identified the less expensive they are to amend. Another major issue for which little research has been done concerns the design of applications destined to be viewed by different terminals and platforms or even by different means, for example tablet PCs and PDAs or smart phones. Moreover, the consulted resources might be revisited through the museum website, once the museum visit is over. Other issues that need to be examined are the maintenance and security of the devices as well as the possible impact on the number of museum personnel required to assist visitors with this task. However, it seems that the most crucial question to begin with is to determine the interplay of the mobile guide with already existing educational policies and infrastructures.

#### *From Theory to Practice: Two Mobile Museum Guides Case Studies*

Our lab participated in two related projects, in 2003 and 2005 respectively, and the creation of an AR based museum guide is now on under way. The first guide, Mobivisit (DAMALA / LECOQ 2005), is the combination of an indoor and outdoor portable tourist guide. Currently the outdoor version of Mobivisit is commercialized both for Pocket PCs and mobile phones. The first experiments took place in Lyon, in 2003, and the indoor guide was tested in

the museum of Fine Arts in Lyon. During the first three months of the experiments, approximately 500 tourists tested the indoor and outdoor guide for a period of one to three days. A second experiment took place in the museum, with three different target groups: tourists, students and senior citizens belonging to the “Friends of the Museum” association. DANAE is a more recent project that was terminated in June 2006 (BRELOT et al. 2005). Our lab was the coordinator of the European project to which 11 other partners were added, including Museon Museum in Hague ([www.museon.nl](http://www.museon.nl)). One particular part of this project was that the design and implementation of the guide was run parallel to the construction phase of the new exhibition. This factor was considered an advantage as it provided us with much flexibility regarding the final decisions concerning the conception and design of the guide, even though sometimes the uncertainty of how the final exhibition would look impacted upon the process of the guide creation. One of the concerns both projects shared was the issue of geolocalisation. In the case of Mobivisit we opted for a declarative geolocalisation. The visitor was expected to fill in four fields regarding the place he/she was in. The system then returned the position of the visitor on the PDA museum plan. In DANAE the decision was to use WI-FI. The geolocalisation in this case served a double purpose. A group of visitors who registered together could see where other visitors were located within the exhibition whilst at the same time the system informed the visitor of the theme zone (thematic unit of the exhibition) he/she was in. Our results from front end and summative evaluation confirmed most of the guidelines mentioned in the preceding section. However, four points attracted more attention:

- 1) When PDAs are used, the small interaction surface causes problems selecting, navigating, viewing and manipulating information about featured objects. When larger displays are used (eg. Tablet PCs) the burden of the equipment becomes considerable and difficult to deal with throughout the duration of a visit.
- 2) Geolocalisation possibilities become more and more accurate. However, the feature alone is not sufficient in helping the visitors locate themselves both in the exhibition space and the application, as the issue of orientation is not sufficiently addressed. In many cases, visitors are provided with ground plans of the exhibition room that are rarely easy to decipher and use.

- 3) The “gap” between the computer and the real world make the constant fluctuations from the physical object to the corresponding, digital object a difficult task. Moreover, in the museum where the object itself is of primary importance it might be interesting to test an object oriented approach, where the visitor would be offered the possibility to navigate with the mobile application using the exhibited object as a starting point, and not vice versa.
- 4) Interaction is in most cases restricted and does not allow the annotation of viewed objects, a feature that could encourage a public dialogue about exhibits.

The introduction of AR techniques in the design and implementation of mobile museum guides could provide an interesting alternative regarding these issues. But what exactly is Augmented Reality and how could its use help in dealing with these issues?

### *Introducing Augmented Reality in Mobile Museum Guides*

AR is considered part of the Mixed Reality Environments. Unlike Virtual Reality, where a user is completely immersed in a computer generated, three dimensional world, Mixed Reality environments favor the co-existence and blending of Real and Virtual Worlds. According to Milgram’s Virtuality Continuum (MILGRAM et al. 1995), in AR a real environment is “augmented” by virtual objects.

AR applications have to combine the real and the virtual, be interactive in real time and registered in 3D. This widely accepted definition of AR helps the identification of the sine qua non components of mobile, AR applications: A computational platform; displays, for the fusion of the real and the virtual; wearable or portable input and interaction devices to interact with the augmented world, among which a video camera captures digitally the physical setting which will be augmented with overlays; and of course data storage and access.

In terms of equipment the ideal configuration would be the use of a light and discreet, yet powerful computational platform where input and interaction devices would be connected together with light weight, optical see-through AR spectacles (special AR glasses) with an integrated camera. Translating this into a plausible, yet futuristic, museum visit scenario, the visitor would enter the museum, pick up from the reception desk a dedicated terminal linked

with a pair of see-through glasses or just the see-through glasses that would be linked with his self owned personal terminal. A tiny camera, integrated in the pair of glasses the visitor would wear, would act as an input for a video of the real world. This data would then be transmitted to the computing platform that would calculate, according to one or more methods, at which exact position to place the digital object, so as to “augment” the scene viewed by the visitor with relevant information. With an advanced tracking mechanism almost any surface (for example the palm of the hand) could act as an input device.

This is clearly one of the main potential advantages of AR applications: the total surrounding environment has the potential of becoming the interaction surface. Tracking, one of the most essential components of AR, can be used not only for recalculating the exact position in which the virtual objects will be placed but also for the visitors’ orientation in the gallery as well as in the digital application. As the video view of the real world serves as the interaction surface it is easier for the user to create liaisons between the real object and its digital counterpart much alike audio guides, that use appropriate signposting to inform the visitor about existing audio sequences, though in the case of AR, it is viewing the real environment that provides these hints. This very same possibility could give the opportunity to spatially annotate the environment, e.g. by leaving personal messages for works of art or artifacts that would be activated and visible once another visitor approaches the annotated area. Enriching the museum experience with AR interactive features could further improve communication between visiting groups and engage the visitors more with the exhibited objects. It is for these reasons that it was decided to examine the possibility of introducing AR in the 3<sup>rd</sup> museum guide prototype currently under deployment (DAMALA et al. 2007) and testing which we expect to test in a real museum context during the autumn of 2007.

### *Current Limitations of the Augmented Reality Approach*

It would be an omission however not to refer to current limitations of the AR approach. The absence of authoring tools and WYSIWYG solutions for the conceptualization, design and implementation of mobile AR guides imposes an interdisciplinary

approach from the very beginning of a project. At the same time, AR is a relatively new scientific field, so it is quite difficult to work with the stakeholders involved as they are not at all aware of the novelties they could expect. Consequently, it is difficult to make them express their needs in terms of AR based scenarios. Maybe the most serious factor causing reluctance towards the widespread uptake and acceptance of AR systems for the museum setting are some of the current technical constraints as well as the cost for developing and maintaining AR applications. Accurate and performing tracking is an important issue. Many AR applications use fiducial markers and sensors for tracking, sometimes combined with image based tracking. Implanting large, indiscrete markers in an exhibition space would risk perturbing the aesthetics of the exhibition. At the same time, museum studies and common sense prevent the use of bulky, heavy and isolating equipment, like computer bag packs, data gloves or head mounted displays, used in many cultural heritage related and educational projects. Finally the constant evolution of AR technologies and hardware requires a large budget for buying and maintaining the necessary equipment.

### *Future Work and Conclusions*

Mobile museum guides offer a tempting alternative to other, well established communication and interpretation means in the museum. There is a huge variety of applications that could be created for museum visitors, museum educators and museum curators. To determine whether or not implementing such a guide is the best suited solution is a matter that needs thorough examination, as this alteration might prove very demanding on human and financial resources. Publications and conclusions resulting from various projects provide valuable guidelines on this matter.

However, there are still issues that demand the attention of the scientific community, such as the small interaction surface, the geolocalisation-orientation issue and the gaps in the interaction of the user with the digital and the physical environment simultaneously. We believe that the use of AR techniques could provide interesting insights within these issues. We have undertaken work to produce a mobile, context-aware guide, where AR will play a major role as an element of navigation and interaction and where novel human computer interaction

metaphors will be created to bridge the real and digital environment. Of course there are still several drawbacks as AR technologies are still developing. With the necessary technological progress and the expansion of light, mobile or wearable input and output AR system components, consideration of this alternative approach has many chances of becoming not just an experimental but a viable and legitimate way of coping with some of the current drawbacks in the uptake and use of mobile guiding systems within the museum setting.

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