Bridging the Gap between the Digital and the Physical: Design and Evaluation of a Mobile Augmented Reality Guide for the Museum Visit

Areti Damala, Pierre Cubaud
CNAM-CEDRIC
292, rue St Martin, 75003, Paris, France
{damala, cubaud@cnam.fr}

Anne Bationo, Pascal Houlier, Isabelle Marchal
Orange Labs
Cesson-Sévigné, France
{anne.bationo, pascal.houlier, isabelle.marchal}@orange-ftgroup.com

ABSTRACT

Can Augmented Reality (AR) techniques inform the design and implementation of a mobile multimedia guide for the museum setting? Drawing from our experience both on previous mobile museum guides projects and in AR technology, we present a fully functional prototype of an AR-enabled mobile multimedia museum guide, designed and implemented for the Museum of Fine Arts in Rennes, France. We report on the life cycle of the prototype and the methodology employed for the AR approach as well as on the selected mixed method evaluation process; finally, the first results emerging from quantitative evaluation are discussed, supported by evidence and findings from the qualitative part of the assessment process. We conclude with lessons learned during the full circle of conception, implementation, testing and assessment of the guide.

Categories and Subject Descriptors

H.5.1 [**Multimedia Information Systems**]: *Artificial, augmented, and virtual realities.* H.5.2 [**User interfaces**]: *ergonomics, evaluation/methodology, graphical user interfaces, prototyping theory and methods, user-centered design.* J.5 [**Arts and Humanities**]: Fine Arts. K.3.1 [**Computer and Education**]: *Computer-assisted instruction.*

General Terms

Performance, Design, Experimentation, Human Factors.

Keywords

Museum handheld devices, mobile augmented reality, participatory design, evaluation, edutainment

1. INTRODUCTION

1.1 Mobile guides in the museum setting

Museum affinities with new technologies are not recent. Ever since the World Wide Web boom, museums and other cultural heritage institutions have been progressively investing not only on cutting edge documentation and information systems, but also on multimedia technologies fostering long-lasting relationships with their visitors. In this context, the transition from analog to digital audio guides can be considered as one of the new age revolutions that drastically changed the interpretation media landscape. Yet, another advent would occur, as an increasing number of cultural institutions around the globe offer a new alternative to their visitors: mobile, light weight, multimedia-capable devices that provide in situ interpretation material, traditionally residing on diverse media, such as books, audio guides, multimedia kiosks or even internet web sites, that promise to accompany the visitor throughout the visit; mobile multimedia museum guides are also capable of delivering personalized content depending on user preferences, age or learning abilities with the potential benefit of limitless multimedia delivery through wireless networks. From the side of museum professionals, this way of delivering information presents also advantages, like monitoring visiting patterns, real time communication with the visitors and linking of the museum visit with the pre and post-visit phases.

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1.2 Physical vs. Digital Navigation and Orientation

Ever since the introduction of mobile guides in the museum setting, several issues have aroused, mainly related with content authoring, content update and content delivery. However, despite of the choices made, location awareness positions itself as a central issue in every mobile museum guide project, while it qualifies both as a technological and a design challenge. Visitors using mobile multimedia guides, need constantly not only to "locate" themselves by navigating in the interactive application but also in the exhibition's physical space, in a synchronised manner, as both actions occur at the same time. Consequently, the two most susceptible questions museum visitors may pose themselves when using mobile multimedia museum guides are:

- Where can I find the object for which I can see there is relevant content?

Or

- Where / how can I find information for this particular exhibition object I just happened to see?

Both of these substantial questions share a common characteristic: they demand from the visitor to navigate from the digital to the physical space and vice versa. Simple geolocalization capabilities in this case are not enough, except if they are combined with 3D orientation-aware software or hardware.

Despite remarkable advances in mobile applications geolocalization issues, orientation in indoor spaces remains an open question. Wi-Fi and Bluetooth have been employed in the museum context for geolocalization but are inappropriate for

educated guesses about orientation, while RFID and Infrared have also been tested but mostly in a trigger-like manner for delivering or bookmarking appropriate multimedia content [17]. In addition, unlike Wi-Fi and Bluetooth, RFID and Infrared require line of sight, difficult to achieve in the sometimes heavily crowded museum spaces. It is therefore not surprising that commercial solutions employed by museums such as the Tate Modern Gallery in London [18], the Van Gogh museum in Amsterdam and lately the Louvre in Paris [13] opted for a more conventional but easy to implement solution: providing the visitor with a floor plan of the exhibition space on the mobile museum guide, while physically annotating commented objects and works of art with an audio-guide-like manner. The visitor has to tap on the touch-sensitive screen the number corresponding to the exposed exhibit. As plans are not always very easy to decipher and use by a non experienced visitor, the audio guide-approach seems to follow a fair, straightforward and coherent conceptual model [15] that is easy to understand and use in the museum context. In "Mobivisit" project a declarative geolocalization model was used. The visitor had to fill in four data base fields and then wait to see the results of the query [6]. In "DANAE" project, Wi-Fi was used in order to determine in which part of the exhibition the visitors found themselves but the appropriate content was only displayed after the visitors' explicit demand, confirming that the change of position was not accidental but intentional [3]. That was not the case in the Cite des Sciences, "That's Canada" exhibition. The environment was dark enough so as to facilitate the infrared triggering but often enough the visitor could not control the application. Infrared was also used in the Carrara marble museum [5] and the Cinema museum in Italy**.**

1.3 AR for navigation, orientation and interaction in mobile guides for the museum setting

A different approach has been employed by researchers in Xerox PARC, proposing a visual interface composed by photos of surrounding walls with "hyperlinked" objects indicating that the visitor can get further information about them [24]. However this solution was implemented in the less complex environment of an historic house. In the museum context, a much more straightforward approach would be to use the mobile guide as a "magic mirror", scanning the surrounding environment for spatially annotated objects; this is exactly one of the promises of Augmented Reality [2] applications, proposing to augment the physical space by blending it with virtual information, ranging from text to image or even 3d characters as recently proposed in Chrystiegården Oslo, Norway [9].

Cultural heritage has been inspiring the AR community ever since the last started to be thought also as a medium rather than only as a new technology. For example the ARCHEOGUIDE [22] and LIFEPLUS [20] projects have been exploring the use of Mobile AR in historical and archaeological sites using either head mounted displays or handheld devices. AR has also appeared in form of fixed installations in historical sites in Portugal and in Belgium's Ename Center [16] helping visitors to visualize how an actual site might have once looked like. Some museums, like the Limerick Museum in Ireland [10], have been also experimenting with mixed and AR installations intramuros. Another possibility was offered by the ARCO project [23], proposing to museum curators the creation of virtual replicas of the exposed and non exposed objects. An interesting "virtual" AR scenario was provided in 2003 by the DinoHunter project of the Senckenberg paleontological museum in Germany, where young visitors visiting the museum's web site could start a (virtual) mystery tour manipulating a (virtual) PDA that augmented the dinosaurs' skeletons, reconstituting how they would have been like [19]. One year earlier, Sparaccino published the "Museum Wearable". The augmentation however was provided by means of a video presentation displayed in front on one of both eyes using standard infrared location identification sensors [21].

2. PROJECT BACKGROUND

Augmented Reality has the potential to provide an interesting alternative for navigation, interaction and orientation in the museum setting as the full surrounding environment can be transformed in an interaction surface [7]. Tracking and registration in 3D -both essential components of AR applications- can be used not only for recalculating the exact position of the virtual objects that will be inserted, but also for the visitors' localization and orientation both in the exhibition space and the AR application. The ideal displays in this case would be either mobile devices or AR goggles. In this context, the "connect" project [1] is probably the most relative indoor experimentation carried out in a museum setting; it set as a goal exploring Mobile AR in science museums, providing also a comprehensive framework for the pre and post visit phase. Yet the equipment the pupils had to wear included a laptop attached to a backpack and a rather bulky headset, with an overall weight exceeding 5 kilos, while large markers had to be placed in the museum sites. A considerably "lighter" solution was proposed by the AR group in Bauhaus university, Weimar, where mobile phones were tested for museum guidance together with Bluetooth emitters and neural network-based computer vision for the identification of museum objects by means of taking a photo of the desired object [4]. However there was no communication on the full range of implemented augmentations, neither on assessment of user experience regarding orientation and navigation in the physical and digital space by using the guide.

As navigation and orientation in both digital and physical space remains largely unexplored, particularly in the mobile and multimedia museum guide context, we undertook the creation of a first AR mobile museum guide prototype based on a marker based approach, but one that instead of adding markers in the exhibition space would rather use the actual museum objects as markers. This approach does not demand any additional installations in the museum premises, apart from the visitor terminals, and therefore qualifies as a both more discrete and less costly solution in terms of necessary museum infrastructure.

The design process of the very first prototype included the definition of educational scenarios and a possible functions' list, as well as a first pilot application based on a simple, marker-based approach. Demos were subsequently presented and discussed both with information technologies specialists and museum professionals. We then took a step forward, contacting the local Museum of Fine Arts in Rennes, Brittany, in order to make a proposal of a common project for the conception and implementation of an AR enabled mobile multimedia guide that the museum kindly accepted. Numerous on-site tests were subsequently conducted in the museum premises in order to verify to which extent the already used algorithms were effective under

the real museum conditions. An initial list of a dozen paintings was dressed; all of them had characteristics enabling an easy and accurate tracking that would not risk frustrating museum visitors.

As AR is a relatively new computer scientific discipline, one of the design challenges was to assist stakeholders with a non technical background in expressing their needs in terms of AR based scenarios. We were helped however by the museum's prior experience in the FRAME project that resulted in the development of an interactive internet game for children, "The Room of Wonders" [12, 14]. As several brainstorming sessions were organized with the participation of interaction designers, ergonomists, Virtual and Augmented Reality engineers and museum curators and educators, progressively, the museum stakeholders started to feel more at ease regarding the technologies that would be employed and ready to propose their own AR scenarios and ideas.

From the museum point of view, the AR approach can provide a more intuitive and discrete way for interaction with the displayed objects, while for the AR scientific community, museums provide contextually rich indoor environments for experimentations with AR applications, which as opposed with others, are open to a wide public, of different Information Technologies (IT) skills and backgrounds. In addition, as AR remains a computer science discipline with many technical challenges to overcome, an indoor environment -in our case the museum- is usually much easier to control and therefore less error prone than an outdoor environment. Eventually, a successful solution could then be modified and implanted in many other indoor environments, like exhibitions or other attractions.

3. DESIGN PROCESS

3.1 Design and content creation in the museum

Because of the experimental character of this first, on-field, intervention, the target group for which the application would be designed was put forward by all stakeholders from the very beginning. The museum team suggested that we profile and target young people, in between 18 and 30 years old, an age group considered as a critical public for many museums and thought as presumably more at ease with IT.

Regarding the guide content, four paintings were finally retained, forming a thematic visit related with the iconography of costumes and dressing. It was also necessary to agree on the themes that would be presented in each painting. Museum professionals were advised at an early stage to try to think of presentation scenarios consistent with all of the selected paintings. The five themes that were eventually selected were the following:

- A "Description" theme, providing a detailed description of the painting.
- A "Technique" theme, including the technique employed as well as restoration interventions.
- An "Iconography" theme, treating the depicted theme while highlighting affinities with other paintings.
- A "Context" theme, gathering information relative with the artistic and social context of the examined period.
- An "Artist" theme, containing all relevant artist information.

An evaluation methodology, favoring a mixed method evaluation process was also proposed to the museum stakeholders. In order to prepare the content for authoring in the lab, regular meetings were held in the museum, at the convenience of the museum professionals. The primary source of information came from the physical archive of the museum. This element proved important for further evolving the visit scenario, as, in many cases, non-digitized documentation material further inspired the creation of scenarios around the visit in sometimes unexpected ways.

3.2 Design and content creation in the lab

However, the downfall of this approach was that almost all application content (more than 80%) had to be built from scratch. That mainly happened in the lab, where "rough" digital material (including text and illustrations), as well as the visiting scenarios were transferred for content authoring. The different media employed were text, audio, video, slideshows as well as 2D and 3D digital overlays in order to create the illusion that elements and details of the pictured "jumped out" of the paintings (Figure 1c).

The interface design and the overall "look and feel" of the application were kept simple. A three layer navigation scheme was employed. At the first level, once a painting was detected, visitors could navigate in the five defined themes –"description", "technique", iconography", "context" and "artist"- which were represented as simple 3D ellipsoid overlays with inlaid text (Figure 1a-1b). At a second level, once a theme was activated, familiar media pictograms (Figure 1b-1d) represented the nature of the available for consultation interpretation material. Finally, once at the top-down navigation level, visitors could pause, forward or go back in the 2D and 3D multimedia presentations.

Figure 1a-1d: Navigating in a painting's themes and in available interpretation media

4. MAIN COMPONENTS OF THE SYSTEM

The evaluation testbed used for the experimentation consisted of three elements: The mobile AR prototype, a system to record and later observe users' actions with the prototype and a system to observe users' behavior during the evaluation sessions.

The AR prototype was executed on an Ultra Mobile PC (UMPC) Samsung Q1 running on Windows XP and equipped with an ordinary webcam (Figure 2a, 2d). The AR system is powered by the MAGIC Engine software framework ("Mobile Augmented Reality for Indoor Collections"), built on top of OpenCV for video acquisition, ARToolkitPlus for tracking the paintings, OGRE3D for the insertion of the virtual objects, Open AL for the

audio output and XERCES for xml document parsing. During the visit, the visitor holds the AR prototype system in such a way that the attached webcam (Figure 2d) is directed towards the paintings. The captured video is displayed in real time on the screen of the UMPC (Figure 2c), augmented with 2D or 3D virtual objects (Figure 1a-1d) with an observed frame rate of about 15 frames/second. The user can access these objects interactively either by using the UMPC buttons or the touch-sensitive screen thus giving access to other digital documents (text, audio, video, 2D and 3D graphics), arranged in a tree structure as described in section 3.2. Provided that the painting is entirely visible on the screen, the system is robust enough to entirely support the augmented visit and all of the available presentations.

Figures 2a-2d: The equipment used for the experimentations. The belt bag (2b) contains the multimedia recorder (2c)

A digital video camcorder on a tripod centering the whole scene was used so as to record and further analyze users' interaction with the AR system, the painting and the museum space (Figure 3b). Finally, in order to capture in detail the interaction of the users with the AR prototype, an ARCHOS 404 multimedia recorder (Figure 2c) placed on a belt bag (Figure 2b) was used, equipped with a mini cam attached on a headband strap (Figure 3c). Because of this additional equipment that had to be adjusted on the participants, the design choice made regarding the audio was to use the UMPC speakers and not a headset for the audio delivery.

5. ASSESSMENT OF THE AR GUIDE

5.1 Methodological considerations regarding the evaluation process

The evaluation of the mobile AR guide had many inherent difficulties. The first one is related with a major issue observed in the field of AR, where user studies are still clearly underutilized. Gabbard and Swan report that in a total of 1,104 articles on AR recessed, only 2% included a user based study [11]. This creates an enormous hiatus in between AR as a computer science discipline informed by a continuous progress in engineering, and AR as an emerging technology that has a potentially tremendous impact not only on the way we interact with computers but also with our environment and with each other.

The second difficulty, and one more challenging, was relevant with the assessment of the AR interface, as our target group was neither familiar with the notion of AR nor had ever used other mobile multimedia guides. Therefore, the evaluation protocol had to be designed carefully and had to include research questions that would also arouse in the evaluation of a non AR mobile museum guide. For the same reason, employing qualitative methods, such as the direct observation of the visitors interacting both with the paintings and the mobile guide was judged necessary as well as conducting a semi-structured interview right after the visit. The post visit protocol would also include a survey and two workshops to which consenting students would participate. At the same time, the exploratory nature of the study as well as the protocol retained, favored a sample consisting from about 10 to a maximum of 16 museum visitors. Twelve participants were finally recruited from two different local university faculties, the School of Fine Arts and the Department of Social Sciences. This profiling further refined the age profile of our sample from 18 to 30 to 18 to 22 years old. Unlike many other AR user-based studies, an equal representation of male and female participants was achieved.

5.2 Before and during the visit

In the time span of approximately two weeks, 12 visitors were observed, interviewed and video recorded (Figure 3a-3d). After meeting the research team and following a short tutorial, the necessary additional equipment -the head camera and the belt bag containing the ARCHOS player- was appropriately adjusted.

Despite the fact that all sessions were recorded both by the video camera as well as by the ARCHOS recorder, all participants were also observed throughout the full visit by one of the researchers (Figure 3b). The first task visitors were asked to perform was to locate the works for which further resources were available. Once the painting was detected, the visitors were asked to freely navigate in the content according to their preferences and preferably exactly as they would do if they were alone. The duration of the visits ranged between 25 and 60 minutes according to visitors particular interests. A 15-minute interview then followed. The first interview questions helped as a warm-up and included general questions regarding museum visiting while the second part focused more on their visitors' impressions while using the guide. Interviews were also very helpful in reshaping the issues that would be later treated during the focus group sessions.

Figure 3a-3d: Observing the user experience and positioning of the main actors (3b)

5.3 After the visit

A few days before the focus group sessions, the survey was posted on the web and participants were reminded to fill it in, if possible before our second meeting. The questionnaire was composed by 45 questions divided roughly in 5 parts and took approximately 5 to 10 minutes to fill in. The questionnaire sections largely reflect the presentation of the results in sections 6.2 to 6.5.

The last phase of the experimentations, the two workshops, took place one and a half month after the museum visits. Both focus group sessions were video recorded. Because of the limited time available (approximately an hour and a half) the discussion had to be moderated so as include some of the major issues that had been observed or discussed during the interviews, like the implications resulting from the multimedia nature of the guide, users' navigation in both the museum and the application, and the simultaneous interaction with the guide, the painting and the museum space. Students were encouraged to express all the positive or negative feelings this mediated visit provoked (Figure 4a-4d).

Figure 4a-4d: The focus group sessions; attributes of an ideal guide provided by the participants (4d)

Shortly before leaving the room, all participants were asked to write on sticky notes one or more of the characteristics they would like the ideal guide to include or not, creating a collage that provided spontaneous and interesting in nature feedback (Figure 4d).

6. ACCEPTANCE OF THE AR GUIDE

6.1 Methodological considerations

In order to test the usability and acceptance of the AR guide, it was sometimes necessary to use more than one way in formulating the questions. For this part of the study, we opted – when judged essential- for a psychometric, summative, Likert-like, 4-point scale. The 4-point scaled was preferred over a 5-point, as the 5-point scale -which includes a neutrality statement- may create confusion between the statements "I am neutral" or "I don't have an opinion". Therefore, our scale consisted of the "Mostly Agree" statement, followed by the "Somewhat Agree", "Somewhat Disagree" and "Mostly Disagree" statements that during the analysis were attributed a 1 to 4 score. Attention was given in alternating the positively and negatively worded statements, in order to control the "acquiescence" effect.

6.2 Participants and New Technologies

All participants own a mobile phone that they obtained from the age of 15/16 years old. Despite the fact that the majority stated using a PC every day, there is a slight gender cap, with males using more often a PC in their everyday life in comparison with female participants. As Augmented Reality is a relatively newly coined term, the term "Virtual Reality" was used as a reference point, during the presentation of the study, mainly as a mean of comparison with "Augmented Reality". However, the answers of the participants turned out to put in question our assumption, as more than half stated not having heard of the term "Virtual Reality" before. Less surprisingly, all participants were certain that they had never heard the term "Augmented Reality" before.

6.3 Participants and museum visiting

Inspecting the relation of participants with museum visiting was equally import, in order to examine whether already established visiting patterns or habits are related with user acceptance of the mobile museum guide. The answers in this section, validated the initial assumption that our target group rather belonged to the category of the "frequent museum goers", as almost 58.3% of the sample claimed visiting museums four or more times per year; it is worth noticing however that this result is influenced by the answers of the students in Fine Arts, who stated visiting museums very often in their totality, as compared with a corresponding 16.7% of the second group. As many visitor studies report that visiting a museum is also a social experience [8], participants were also asked whether they prefer visiting museums alone, with friends/family, or in a group. This assumption was found to be more coherent with the students of the Social Sciences, two thirds of whom answered that they prefer visiting with family or friends, compared to the other group where five out of the six participants stated that they prefer visiting alone. Of course the results obtained in these last questions do not imply that one or the other group is more social in nature but rather that one of the two groups maybe frequents museums more often because of the specific nature of the undertaken studies.

A strong polarity was observed in the answers given as to whether participants generally use or not interpretation material throughout the visit; only half of the participants answered that they always do so. The answers were equally divided both between the two university groups as well as in between male and female. However all participants chose to fill in the question regarding the interpretation material they are more susceptible to use. As to the nature of the interpretation material used, text provided by the museum comes in 1st place with 60%, followed by on site multimedia kiosks, museum web sites and printed guides of a museum's collection (20%), and finally audio guides (10%). No student opted for the guided visit answer.

6.4 Usability and content effectiveness of the AR guide

6.4.1 Ease of use and navigation

Interestingly, the best score obtained in this section was related with the ease of spatial identification and localization of the commented works of art in the gallery space (mean=3.4), obtained by a 58.3% of the participants that strongly agreed, with the

remaining 41.7% mostly agreeing. Good scores were also obtained regarding the easiness of navigation (mean=3.25). A somewhat lower score was obtained when participants were asked to judge the overall easiness of use of the guide (mean=3.08); we believe however that the additional equipment used for the study, might have somewhat influenced the obtained score. The lowest score in this section was observed in the statement regarding whether the "augmentation" of the true objects with virtual ones facilitated the access to the content. Despite the fact that this question is strongly linked with the much better performing assertions of the two first questions, the mean obtained was only 2.25, with participants equally divided in between the "strongly agree", "somewhat agree" and "somewhat disagree" statements. This is a good example of the importance in the formulation of the research questions and the impact this can have in the results and findings of surveys.

6.4.2 Content Effectiveness

The question regarding the intuitive comprehension of the included thematic axes, ranked 1st in this section with a score of 3.5. Next followed the quality of the audio recordings together with the quality of the multimedia presentations (mean=3.16). A polarity was observed in the question regarding the length of the audio comments, which in most cases exceeded the standard 1.30 minute audio guide comment: half of the participants found the audio recordings to be too long and the other half satisfactory. This second group is mainly composed by male students and Social Sciences students. Unanimity is observed as to the length of the provided texts and multimedia presentations with 91.7% of the participants judging them satisfactory. Another interesting question was relevant with the ways participants used the multimedia guide and its content. Despite the fact that all the media provided were eventually used by the students, the audio content as well as the reference 2D and 3D images came in top with 66.7%, followed by the texts (41.7%), the 2D or 3D multimedia presentations (33%) and the video (25%).

6.5 Attentional balance and post visit effects

The last part of the questionnaire was composed of statements regarding the interplay between the museum object and the guide as well as some questions regarding the post visit effect. Participants were asked whether the reference images used for the multimedia presentations in 2D or 3D interfered with their appropriation of the painting contemplated or helped them better approach the painting, having as a third possibility to give their own answer. Half of them answered that they were helped, while the other half was equally divided between the "interference" choice and the open ended answer, to which all implicated participants answered that they were sometimes helped and some other not.

The next arduous question demanded from participants to position themselves on the negatively worded statement of interference of the guide with their contemplation of a work of art. Opinions were also divided, with 25% of the participants choosing the "mostly agree" option, 33.3% the "somewhat agree" option, 33.3% the "somewhat disagree" option and 8.3% the "mostly disagree" option, giving an average score of 2.25. However further analysis indicated that frequent museum goers, felt more distracted (score 3.4) in comparison with participants visiting museum less often, who felt much less distracted by the use of the guide (score 1.8). Also, students using a PC very often marked in a more pronounced way their distraction from the real work of art (3.0 versus 2.25 for the rest of the participants) as well as male in comparison with female (2.2 versus 3.3) . The statement asking participants whether they found the use of the guide playful provoked less division, achieving one of the best scores of the survey (3.5) with all participants either mostly or somewhat agreeing. It is also interesting to check the answers on the statement "Using the guide helped me better approach and appreciate the paintings", where 91.7% mostly or somewhat agreed with the remaining 8.33% somewhat disagreeing (score: 3.1). The same results were also obtained when participants were asked whether they think having learned more using the guide rather than if they hadn't used it at all.

We were also interested in including some questions regarding the post visit effect, like for example the number of works included in the guide. Almost six weeks after the visit, 75% of the participants were able to remember correctly. However even participants who didn't remember correctly could name one or more of the subjects depicted and/or the artists represented. Despite the altercation in the responses of several of the questions of the survey, all participants answered that they would use a similar guide of it was available in a museum; 44% unconditionally, and 64 % adding some personal criteria ("yes, if I was alone", "yes, but according to the featured exhibition", "certainly, if it was free of charge").

6.6 Lessons learned during the field study

It would be useful to highlight some of the main interesting points of the field study as they provide additional key points susceptible to have a positive or negative impact on these first –quantitative in nature- results.

The first important remark concerns the surrounding environmental conditions during the guided visits of the participants. The affluence of many school visits, observed principally during the morning testing sessions, sometimes deprived participants of choosing their own itinerary towards the one suggested by the researchers, waiting for the galleries to get calmer. For the same reason, audio, delivered by means of the UMPC integrated speakers, was sometimes hard to hear. Visitors' opinion against this deficiency found its way to us, despite the fact that there was no particular question on the survey: the problem was reported during the interviews and was included in some of the survey answers.

Another crucial remark is that visitors demanded even more consistency regarding the multimedia presentations. This was discovered by means of an intentional inconsistency regarding whether the included in the multimedia presentation texts were transcripts of the audio content or not. All of the participants that happened to first discover that the text was the same with the audio they had previously listened, made the reasonable assumption that whenever a text and an audio comment were both included, they revealed the same information.

In terms of content presentation many participants indicated that the somewhat more playful presentation approach employed in one of the four paintings appealed a lot to them. It is of course not by a hazard that this particular painting benefited by the direct input of the museum educators. As far as the adaptation in maneuvering the application is concerned, it soon became obvious that stressed visitors, particularly those that considered themselves

not having a "considerable" ease in using such a guide, usually needed more adaptation time than the more confident -regarding IT- students, usually not exceeding a couple of minutes. This initial difficulty did not influence in a negative way the participants as it was this last group that found considerably more rewarding the use of the guide.

7. DISCUSSION

Clearly, some of the findings of the survey need further discussion. For example, it turned out that despite common assumptions about museum visiting as a primarily social activity, in our sample, a strong proportion of participants visit museums alone. Another polarity observed was that interpretation material is not consistently used during museum visiting, but when this is the case, the students use interpretation means coming from the full spectrum of available material, with museum provided texts coming first, though other interpretation media, like multimedia kiosks, audio guides, web sites or books are also used during or following the visit. These remarks, suggest that even within a stratified sample like ours, the need for personalization of the multimedia application according to different profiles is more than a necessity.

Concerning the use of the Augmented Reality approach the results are very encouraging. All of the participants indicated either a moderate or a strong positive attitude as to whether the identification of the commented works was an easy task. The same holds true regarding the ease of navigation in the application, based consistently on the Augmented Reality metaphor, at all levels of information retrieval. It is characteristic that one of the visitors mentioned, both during the interview as well as during the focus group, that the detection was far too easy and that a more "difficult" or playful way of discovery should maybe be present. As to whether the guide and the reference multimedia material provided interfered with visitors' own appropriation of the work of art, frequent museum goers as well as those of the participants using a PC very often -meaning at least daily for the needs of our survey- indicated being more distracted than the rest of the participants. The slight gap between male and female is here reversed in comparison with the frequency with which participants use new technologies, as female participants indicated being distracted much less (mean=2.2) than male participants (mean=3.3). These findings could indicate that whenever there is a well established pattern of interaction, being it with a PC or a museum object, one is more hesitant in adapting a new, alternative strategy of apprehension and communication. But the positive side of this remark is that it seems probable that new audiences could be attracted in the museum premises if a variety of interpretation means was to be provided. Additional evidence pointing towards this direction is that despite the fact that half of the visitors indicated using textual information when visiting museums over other interpretation media, the predominant use of text over other media is not at all reflected in the answer presented in section 6.4.2, where visitors were invited to explain how they used the multimedia guide. This finding is quite significant as it could indicate that whenever and wherever alternative material is proposed it does not risk not to be appropriated by museum visitors.

8. PERSPECTIVES

Despite the fact that mobile museum guides are sometimes suspected for distracting visitors' attention, our study proved that visitors were very careful as to what they saw and listened while using the mobile museum guide. It also became apparent that using alternative interpretation media might have the potential of attracting new publics. The non-familiarity with IT applications proved not to be a drawback in the overall appreciation of the AR assisted mobile guide. Additionally, visitors strongly expressed themselves putting in question aspects of the overall design, like for example the design choice concerning the audio delivery. Another important finding of the full experimentation was that despite the fact that constant cross disciplinary collaboration can considerably stretch the time needed for the design and implementation phases, it was principally the mostly benefited from this approach content that came first in the list of visitors' preferences.

However it seems that the most important finding is that AR assisted interfaces can indeed successfully facilitate visitors intuitively switch their focus and attention from the physical to the digital space and vice versa, even in the complex context of the museum space. Apart the results of the survey, the direct observation of the visitors proved the AR interface not only to be intuitive but also accompanied by a fast learning curve, even though none of the participants had either used a mobile museum guide before or a UMPC. Another important element is that the solution proposed is discrete and non-invasive regarding the museum ecology, as apart from visitors' terminals, no other particular equipment or IT infrastructure is needed in the museum premises for a successful navigation, orientation and interaction both with the physical and the digital environment. These findings get even more encouraging as the sample consisted by participants who did not have prior experience or knowledge on AR and AR applications.

Future work includes the full analysis and formalization of the qualitative part of the research, in order to extract the most regarding the enhancements that can be brought to a new prototype and address all elements that might favor or slow down the acceptance of mobile AR enabled multimedia applications. Based on a detailed analysis of all results, a new prototype will also be implemented and tested in the same context, with the ambition to come closer to a guide which should ideally be "playful", "accessible for a larger public", "original", "motivating" "interactive", "curious", "surprising", but also "subjective" and "sensitive", some only of the adjectives attributed by the participants during the focus group sessions.

With the continuous advent in computer processing power and size, the intrusion of mobile technologies in all aspects of our everyday life, and the constant evolution of AR technologies, it seems probable that in the maybe not so distant future, museum visitors might have the possibility to enjoy a rich multimedia but also emotional experience, using their self-owned mobile, AR-enabled devices, providing thus museums educators and curators with an alternative method of delivering rich and diverse exhibit-related, in situ, interpretation material.

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