Art and Coffee in the Museum

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Abstract. Natural interaction refers to people interacting with technology as they are used to interact with the real world in everyday life, through gestures, expressions, movements, etc., and discovering the world by looking around and manipulating physical objects [16]. In the domain of cultural heritage research has been conducted in a number of directions including (a) Personalised Information in Museums, (b) Interactive Exhibits, (c) Interactive Games Installations in Museums, (d) Museum Mobile Applications, (e) Museums presence on the Web and (f) Museum Social Applications. Most museums target family groups and organize family-oriented events in their programs but how families choose to visit particular museums in response to their leisure needs has rarely been highlighted. This work exploits the possibility of extending the usage of AmI technology, and thus the user experience, within leisure spaces provided by museums such as cafeterias. The Museum Coffee Table is an augmented physical surface where physical objects can be used for accessing information about artists and their creations. At the same entertainment for children is facilitated through the integration of popular games on the surface. As a result, the entire family can seat around the table, drink coffee and complete their visit to the museum acquiring additional knowledge and playing games.

Keywords: Ambient intelligence · Tabletop interaction · Augmented reality · Cultural heritage · Interactive surfaces

1 Introduction

Currently, Cultural Heritage Institutions (CHIs) in Europe are experiencing growth and change, they are increasing in number, expanding in size, and attracting more diverse audiences every day with heritage tourism alone accounting for more than 5 % of European GDP. New demands and challenges are emerging in every aspect of the cultural heritage landscape, making innovations in information and communication technologies an increasingly integrated part of the related strategies. Novel approaches are emerging for understanding people's art and cultural experiences and for designing interactive technologies to support these experiences. In this context, new expectations of the public are emerging with regard to the fruition of cultural experiences, focusing

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on factors such as easiness and fun, cultural entertainment, personal identification, historical reminiscences and escapism [25]. This paper, taking into account the fact that most museums target family groups and organize family-oriented events, explores the possibility of extending the usage of AmI technology, and thus the user experience, within leisure spaces provided by museums such as cafeterias.

2 Background and Related Work

The evolution of ICT has raised the expectations regarding its usage in the CH sector. Family visitors with children account for a significant segment of CHIs audiences. Most CHIs target family groups and organize family-oriented events in their programs. Table 1 summarizes five major family motivations to visit museums, including: education (opportunities for informal learning or education benefits to children), entertainment (having fun), quality family time, the need of social outings and the need of children.

Table 1. Five major family motivations to visit museums

Researcher	Key motivational themes
Falk & Dierking (1992)	Social interaction, Education, Entertainment, Family history
McManus (1994)	Education, entertainment
Hooper- Greenhill (1994) & MORI (2001)	The need of the children
Baillie (1996)	Education, Entertainment, Quality family time
Moussouri (2003)	Education, Family life-cycle, Entertainment, Quality family time
Kelly et al. (2004)	Social interaction, Education, Purposes of day out, Quality family time, Enjoyment of children
Sterry (2004)	Need of social outing, Entertainment, Educational benefits to children, Intergenerational benefit

The perspectives of adults' prevail in deciding regarding museum experiences [17–24]. Apparently, parents can articulate what they perceive as the need of their children. However, the opinion of children should not been ignored in order to reflect the nature of a family's choice. Various studies have evaluated the relationship between the motivation that families have when visiting a museum and its impact on the their learning experience [17, 18, 22]. How families choose to visit particular museums in response to their leisure needs has rarely been highlighted. Baillie criticizes that most museum professionals tend to concentrate museum missions on collection, preservation and interpretation; as a result, how effective an exhibition is delivered to visitors in terms of learning becomes a key issue [20]. Last but not least, these motivational studies were mainly investigated through quantitative questionnaire surveys. The motivational factors were defined by the researchers. Motivations are treated as the triggers for the decisions to visit museums. All these researchers studied family choices

of museum participation in an exclusive museum context without acknowledging general leisure contexts. Some researchers suggested that these motivational factors are intertwined and interrelated. However, only few attempts have been made at revealing a more holistic and detailed picture of reflecting the complex needs of families from museum products in leisure contexts.

The importance of family leisure needs as outlined by researcher has led museums to turn their interest to the introduction of ICT technology within their premises. Worldwide, there have been a number of museums that have installed, temporarily or permanently, interactive exhibits. The "Fire and the Mountain" exhibition comprised four hybrid exhibits aiming to promote awareness about the cultural heritage of the people living around the Como Lake [11]. ARoS, an art museum in Denmark, employed four interactive exhibits targeted in an exhibition of the Japanese artist Mariko Mori [12]. The Austrian Technical Museum in Vienna opened a digitally augmented exhibition on the history of modern media [13]. The Archaeological Museum of Thessaloniki hosts "Macedonia from Fragment to Pixels" [14], an interactive exhibition of prototypical interactive systems with subjects drawn from ancient Macedonia. The Panoptes system allows the browsing of artefact collections, while Polyapton offers multi-touch, multiuser gaming experiences with archaeological artefacts [10]. The ArtEFact Project [2, 4] has developed a generic platform for interactive storytelling in Mixed Reality that facilitates access to a knowledge base of objects of art and art history. One installation was placed in the Bargello Museum (Soprintendenza Speciale pei il Polo Museale Fiorentino).

In the same context, interactive surfaces are today more broadly facilitated in CHIs. The etx surface[1] is an art exploration system that uses an infrared camera system to track reflective-taped wooden paddles on a table surface. Located at the Indianapolis Museum of Art, etx uses the PercepTable [26] recognition and display system developed at Indiana University's Visualization and Interactive Spaces Laboratory, which is part of the Pervasive Technology Laboratories. A permanent display (see http://www.asiasociety.org/about/buildingtour/) at the headquarters of the Asia Society and Museum in New York gives a visual way for visitors to explore six aspects of Asian culture, region by region. A small, round table supports six palm-sized stones, variously labelled food/cuisine, news, art, country profiles, Asian Americans, and Asia for kids. The Churchill Lifeline is a permanent, central exhibit at the Churchill Museum and Cabinet War Rooms (visit http://www.churchillmuseum.iwm.org.uk) in London. Projected from above onto this 40-foot-long table are summaries of events in the statesperson's life, arranged in chronological order. A series of touch-strips (force-sensitive resistors) on both long sides of the table gives visitors greater detail about these events, via access to more than 4,000 relevant digital documents. The Dialog Table at the Walker Art Centre in Minneapolis, Minnesota, presents further insight into items in the centre's collection and serves to stimulate discussion among visitors. Part of the permanent exhibit, it is one of the few table-top displays using rear projection: images are projected via a system of mirrors inside a kiosk onto two horizontal, head-to-head displays [27]. Floating numbers is an associative presentation

[1] http://www.ima-art.org/xRoom.asp#etx

of information that's part of a temporary exhibit at the Jewish Museum Berlin. Floating numbers presented a dynamic river of digits that flow from one end to the other.

The work presented here expands the potential contexts where such technology is typically installed by promoting the usage of interactive displays within the leisure spaces of cultural heritage institutions (restaurants, coffee shops, etc.). To this end, the Museum Coffee Table expands the visiting experience for parents while providing entertainment for children targeting to general leisure markets and contexts within CHIs.

3 Museum Coffee Table

The Museum Coffee Table facilitates the beverage coaster metaphor to provide access to the life and works of famous artists. A number of augmented beverage coasters have been developed integrating tags to be recognised by the Microsoft SUR40 surface device. This augmented beverage coasters present on their front side (where the beverage is placed) a famous artist while the tag for object recognition is located on the back side (see Fig. 1 left). When a coaster is placed on the table surface, it is augmented by a digital menu of options. This menu offers access to the life and works of the selected Artist (see Fig. 1 right). Another set of augmented beverage coasters which are smaller in size and more playful in terms of appearance (circle, triangle, star, rectangle etc.) are also contained in the collection. These beverage coasters are meant to be used by children and are employed by the table to adapt and personalise its content to children. The adaptations currently supported include the limitation of menu options (simplified access to collections of paintings, memory and puzzle games are available for children) and the adaptation of information presented (only a simplified text description of the painting is presented to children). Using separate collections of augmented objects for interaction was a conscious decision aiming at getting implicit input from usersin order to provide personalised content. Each coaster is not only linked to information about the artist but also to a specific age group.

Fig. 1. Left: Collection of augmented beverage coasters, **Right:** Augmenting a coaster with a menu of information

Through the aforementioned artist's menu a variety of information about the pictured artist can be accessed such as demographic details (name, movement, art period etc.), the artist's collection of works and a timeline of the artist's life (that presents

important events in conjunction with artistic accomplishments). The Artist's collection is a library bar that contains the works of the selected artist (see Fig. 2). It presents a list of thumbnails containing all the artistic accomplishment of an artist's lifetime. From this library users can select (drag on the surface) and manipulate paintings.

Fig. 2. The Artist's collection library bar

The Artist's timeline is designed to present important events of the artist's life in conjunction to artistic accomplishments (see Fig. 3). Users can manipulate through touch these timelines using basic gestures (touch from left to right to move the timeline forward and from right to left to move the timeline backwards). Selection of an event results in the display of extra information. At the same time duration of events is visualised by bar on top of each event.

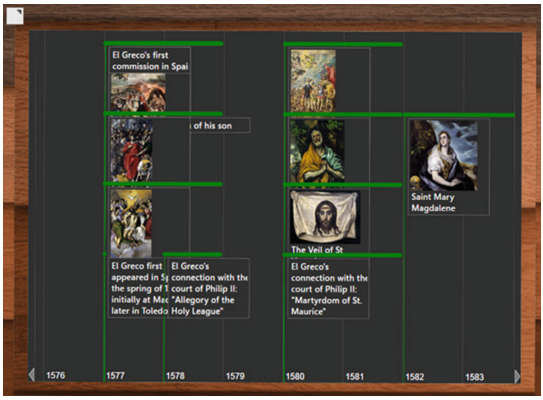

Fig. 3. El Greco's timeline

A manipulated painting provides extra information using the embedded menu as shown in Fig. 4. Information includes details about the creation of the artefact, techniques used by the artist, the composition scheme followed etc. At the same time users can access a very large scale digital image of the painting where deep zooming can be employed to present the details of the original masterpiece (that are traditional lost by low resolution digital copies).

Games are considered an important add-on to the interactive table as long as they allow parents to get more information about art while their children get entertained through games. In this sense the Museum Coffee Table can be considered as a facility for the whole family and a valuable partner of their museum experiences. Currently two games are supported a cards based memory game and a puzzle game. The cards game is a simple memory game where children are prompted to locate the same pairs of cards within a collection of initially hidden cards (see Fig. 5 left). The game gets added value when integrated to the museum coffee table where the game cards are coupled with the selected coaster offering access to a vast number of alternative gaming possibilities. For example if the coaster represents Domenikos Theotokopoulos a game is randomly generated by his works. In the same manner the puzzle extracts information from the currently selected artist to produce a collection of puzzles using the artist's works (see Fig. 5 right).

Fig. 4. The painting's menu

Fig. 5. Left: memory game, Right: Puzzle game

"Museum Coffee Table" is currently deployed for demonstration purposes on a Samsung SUR40 at FORTH-ICS Ami facility [1] and is considered part of the work conducted in the field of Ambient Intelligence for Learning and Education [2]. Samsung SUR40 is the new generation of Microsoft® Surface® experience featuring PixelSense™ technology, which gives LCD panels the power to see without the use of

cameras [3]. Figure 6 presents the educational facilities provided by "Museum Coffee Table" running on the aforementioned device while Fig. 7 presents the entertainment facilities. At the same time the usage of physical augmented objects for accessing these facilities is highlighted.

Fig. 6. Education facilities

Fig. 7. Entertainment facilities

4 Implementation

For implementing the Coffee Table a quite straight forward architecture was used that contains four distinct layers (Fig. 8).

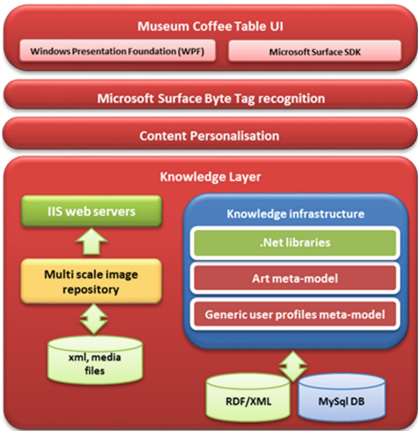

Fig. 8. Architecture

The upper most layer stands for the UI of the system building on two UI frameworks, the Microsoft Windows Workflow Foundation and the Microsoft Surface 2.0 UI library [5]. The Microsoft Byte Tag recognition layer provided by the device through the Microsoft Surface SDK offers access to information about beverage coasters to be in turn used by the Content Personalisation layer to form the appropriate queries to the Knowledge layer. The Knowledge layer contains the models to represent art and generic user profiles. These models have been defined in RDF [6] and were developed with the Protégé ontology editor [7], while SemWeb [8] was used for querying the ontology using the SPARQL syntax [9]. The Art Model is based on CIDOC-CRM, a domain standard for CH extended accordingly to support the purposes of this research work. Finally to support scaling of media content in extremely large resolution multi scale representations of paintings are stored in the appropriate format (converted through the usage of appropriate tools such as the Microsoft Deep Zoom composer) and served to the application through an IIS web server.

5 Evaluation

One of the most important considerations during an evaluation procedure is to prepare the environment in which the user testing will be performed, since the context of use can greatly affect a product's usability [28]. In the case of the Museum Coffee Table, the test has been performed within an in vitro setup of the coffee table in of the simulation spaces of FORTH-ICS's AmI research facility with the participation of twelve users. Five of them were children aged from eight to twelve years old. Adults were requested to fill in a pre-test questionnaire containing demographic information and information regarding their attitude towards CHIs in general and the usage of modern technology within CHIs. Subsequently, the users were requested to complete a number of interaction scenarios through the system and then fill in the post-test questionnaire. The second phase of the evaluation and the completion of the post-test questionnaires was conducted by all users including children. In the case of children, a separate questionnaire was used to assess playability while for adults the assessment concerned usability and educational value.

Interaction of users with the system was recorded for offline analysis by the evaluators. The scenario conducted by users in the context of the usability evaluation contained 5 tasks (adults). Additionally in the case of children three tasks were used. An example of one of the tasks is presented below:

The **pre-test questionnaire** has shown that $\sim$ 66 % of the users visit a museum once a year. At the same time their interest in paintings and modern art covers a percentage of $\sim$ 53 % but they do not follow some specific art style or trend. More importantly, $\sim$ 56 % of the users have visited a museum with some form of interactive exhibits. Regarding their satisfaction from museum visits, $\sim$ 89 % are not satisfied from the information gathered from museum while, $\sim$ 67 % feel that museums are boring. Additionally, $\sim$ 85 % of the participants stated that interactive technology within museums can improve their museum experience, especially when visiting with family.

In the case of adults the results gathered through the **post-test questionnaire** are used to calculate four factors (see Fig. 9). The OVERALL factor expresses the overall

satisfaction of the users regarding the system. The SYUSE factor measures the satisfaction of users when using the system, while the INFOQUAL measures the information quality provided by the system. Finally, INTERQUAL is a factor that captures user satisfaction regarding the interface provided by the system. The OVERALL factor, shows that the users were generally satisfied ($\sim$ 87 % of the users are within the range 5 to 7 while 30.56 % of the users provided a grade of 7 to all questions) by the overall usability of the system. However, there are 5 % of the users that state that were not satisfied. According to the SYUSE factor users were generally satisfied ($\sim$ 85 % of the users are within the range 5 to 7 while 37, 04 % of the users provided a grade of 7 to all questions) by the overall satisfaction by using the system. However, there are $\sim$ 14 % of the users that state that they were little to medium satisfied. Regarding the quality of information (INFOQUAL), users were generally satisfied ($\sim$ 88 % of the users are within the range 5 to 7 while $\sim$ 25 % of the users provided a grade of 7 to all questions). However, there are $\sim$ 43 % of the users that scored 6 which implies that are is a substantial amount of users that requires some form of improvement in the way that information is presented. To identify this aspect, a more detailed analysis of questionnaire data is reported below. The interaction quality (INTERQUAL) shows that the users were generally satisfied ($\sim$ 83 % of the users are within the range 5 to 7 while $\sim$ 35 % of the users provided a grade of 7 to all questions). However, there are $\sim$ 25 % of the users that scored 5 and $\sim$ 24 % that score 6 which implies that are is a substantial amount of users that requires some form of improvement in the interaction.

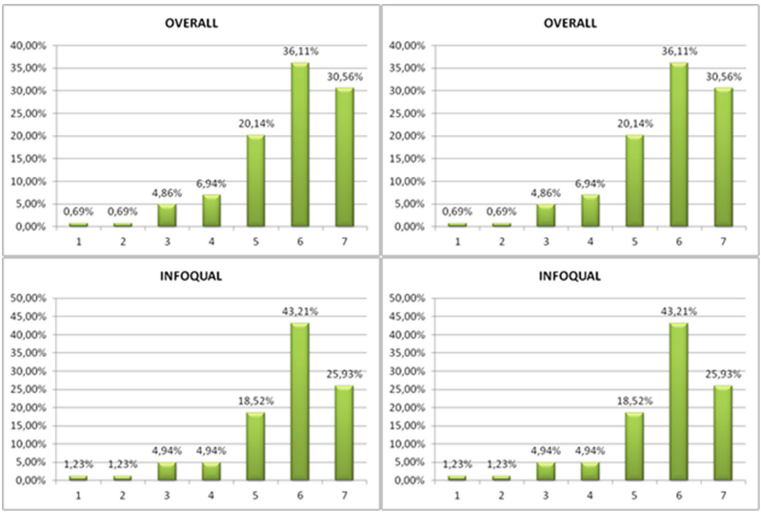

Fig. 9. Usability factors

A more in depth analysis of the questionnaire data was conducted in order to highlight potential areas of improvement. To do so the questions where categorised, analysed and presented graphically:

General User Satisfaction: Regarding the general user satisfaction ~ 12 % of the users score a medium satisfaction while also ~ 76 % score 6 while only ~ 12 were fully satisfied. These results also empower the need for identifying areas of improvement.

Interaction Metaphors: In this section the questions relevant to the interaction metaphors employed by the system are analysed. The touch and byte tag recognition metaphors scored high grades in all questions but some of the supported gestures were not well appreciated by users. For example the dragging gesture required to remove an item from the list of artist's works and place it on the surface was not always understood by users. On the contrary most of the users were trying to tap or double tap the item. This resulted to a satisfaction rate of ~ 50 % for gestures.

Augmented Objects for Interaction: As long as augmented objects are used for interaction users were in general very satisfied (~ 90 % in question 12 and 100 % in question 9 scored within the range 5 to 7). In both cases there is a percentage of ~ 33 % that scored 5. An analysis of the feedback received by users pointed out that in some cases faced difficulties identifying the usage of augmented objects.

Information Representation and Extraction: Regarding the ways that information is represented and extracted users were in general very satisfied (~ 85 % scored from 5 to 7 in all questions). Nevertheless there is a percentage of ~ 55 % that are not fully satisfied in the way that information is browsed in general. For example 33 % scored 5 in the way that information is browsed through the timeline (in some cases events overlapped with multimedia content).

General System Use: Finally in questions that affect general system use the results pin point that the system in general was very well received while living a percentage of ~ 24 % scoring 5 and 6 pointing the need of further improvements.

In the case of children the results of the questionnaire were employed to assess the playability of the games and partially the usability of the provided interface. The results were analyzed together with the recording of the children interaction and informal interviews with children. The outcome of this process were compiled in the form of problems encountered together with suggestions for improvement. More specifically, some usability issues identified by children were:

- The coaster menu does not seem playful. Text labels should be replaced with icons or just include also icons for each of the available games
- The difficulty bar on the puzzle is not easily understood by children. Children use to judge the difficulty of puzzles based on the number of pieces
- In some cases especially in the case of the cards game input from children with small fingers was lost. Touch interface should be made more responsive for children
- In some cases especially when the original paintings have unconventional dimensions (the one dimension is proportionally many times larger than the other) puzzle pieces are not well formed and appear stretched. Dynamic rendering of puzzle pieces should be improved

Additionally there were comments regarding playability:

- In some cases regardless of the game children elbows on the surface were producing false input. Is it possible to make touch available only of the game surface?
- In the puzzle game pieces can get out of the puzzle surface. This seems confusing and should not be allowed
- On the cards game you cannot rearrange cards. It would be useful to have at least the option to rearrange matched pairs. Another suggestion was to hide matched pairs of cards.
- Some children also suggested that the cards should increase in size because the painting were not easily distinguished
- Some children (especially the older ones) requested that the table should also integrate games that have a more "arcade" character using the rational that they could easily get bored.

6 Discussion and Future Work

The work presented by this paper aimed at augmenting the user experience within museum leisure spaces focusing both on information and entertainment. Targeting family visitors of CHIs within leisure spaces the Coffee Table offers extra information about the CHI's exhibits to parents while providing an entertainment environment for children. At the same time the usage of a standard's compliant knowledge base provides extensibility and scalability. The Museum Coffee Table falls into the research line currently conducted within FORTH-ICS to use AmI technologies in CHIs contexts so as to enhance the museum experience at large. In this context, one of the most important goals for future work is to seek possibilities of practical exploiting the proposed functionality and concepts in vivo. To do so the improvement of the current instantiation is a prerequisite starting with the comments received from the initial user based evaluation.

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