

# From personalization to adaptivity - Creating immersive visits through interactive digital storytelling at the Acropolis Museum

Laia PUJOL<sup>a1</sup>, Akrivi KATIFORI<sup>b</sup>, Maria VAYANOU<sup>b</sup>, Maria ROUSSOU<sup>b</sup>, Manos KARVOUNIS<sup>b</sup>, Marialena KYRIAKIDI<sup>b</sup>, Stamatia ELEFATHERATOU<sup>a</sup>, Yannis IOANNIDIS<sup>b</sup>

<sup>a</sup>The Acropolis Museum

<sup>b</sup>The University of Athens

**Abstract.** Storytelling has recently become a popular way to guide museum visitors, replacing traditional exhibit-centric descriptions by story-centric cohesive narrations with references to the exhibits and multimedia content. This work presents the fundamental elements of the CHES project approach, the goal of which is to provide adaptive, personalized, interactive storytelling for museum visits. We shortly present the CHES project and its background, we detail the proposed storytelling and user models, we describe the provided functionality and we outline the main tools and mechanisms employed. Finally, we present the preliminary results of a recent evaluation study that are informing several directions for future work.

**Keywords:** archaeological museums, digital interactive storytelling, personalization, adaptation.

## 1. Introduction

The Acropolis Museum displays a number of information-rich exhibits with associated stories to tell. However, these stories are not immediately available to visitors, due primarily to the gallery's design, which emphasizes the original archaeological objects and therefore consciously prefers non pervasive mediators. Yet, the museum's curators also strive to maintain a mode of "respectful" interaction between visitor and exhibits, according to which the gallery should integrate harmoniously different approaches and modalities of communication.

---

<sup>1</sup>Corresponding author: Principal Project Officer, The Acropolis Museum, DionysiouAreopagitou 15, Weiler Building, 11742 Athens, Greece.

This is where CHESS comes in. CHESS (Cultural Heritage Experiences through Socio-personal interactions and Storytelling) is a research project funded by the European Commission's 7th Framework Programme. Its aim is to research, implement and evaluate an innovative conceptual and technological framework that will enable both the experiencing of interactive and adaptive stories for visitors of cultural sites, and the authoring of narrative structures by the cultural content experts.

The present paper focuses on how CHESS is building a seamless intelligent environment where visitors are immersed in stories related to exhibits in the Acropolis Museum's Archaic Gallery. These stories are tailored to their interests and adapt in real time to the changing parameters of the visit. The following sections will present the context of research; the goals of the project; its initial implementation; the results of an evaluation conducted with museum visitors; and the current developments that push the project forward towards full real-time adaptation.

## **2. Background**

Until recently, storytelling had been an implicit aspect of a museum visit expressed through human guides or more recently through audio guides. A review of storytelling in museum contexts may be found in [1]. The adoption of an explicit storytelling approach to exhibition design contributes to make collections more accessible and engaging for different kinds of audiences. It creates a relaxed environment that raises self-confidence [2]; it establishes a universal way of communication; and because it invites the audience to fill in the blanks with their own experiences, it helps to set emotional connections, which are deeper than intellectual understanding [3, 4].

A museum storytelling approach may draw on the rich history of research into interactive storytelling for digital media, including games and films. Museums, however, raise significant new challenges for interactive storytelling research. The nature of visitor-exhibit interaction is such that digital media must gracefully complement the physical artifacts, which remain the primary focus, while at the same time take into account visitor's needs and preferences.

On the other hand, personalization can also be a valuable tool for the organization of the multi-dimensional museum content, as well as for its communication to an heterogeneous audience [5, 6, 7]. An increasing number of museums and cultural institutions around the world are using personalized applications. For example, there are adaptive applications for different target groups [8, 9], or conversely for visitors with similar interests [10]. In addition, a wide range of mobile and space sensitive devices have been recently developed [11, 12, 13, 14, 15, 16]. And evaluations at different stages have also been conducted. For example, in a study comparing different personalization approaches [17], users were very positive towards adaptation: it helped create an immersive environment that improved orientation, localization of objects, and comparison between them while reducing redundant information. In [18] a detailed survey of the field of personalized applications in cultural heritage is available.

Yet, introducing personalization and adaptation in an interactive digital storytelling system remains, to the best of our knowledge, an unresolved issue.

### 3. The CHESS project

CHESS<sup>2</sup> proposes to enrich the museum visit through personalized interactive storytelling experiences by personalizing and dynamically adapting information about cultural artifacts to each individual or group of visitors. CHESS targets two kinds of end-users:

1. Visitors: people experiencing CHESS interactive stories. They are invited to join in the available adventures when entering the museum or from home. When on-site, they participate through their mobile phone, receiving information from the system according to the story plot, their position, their personal profile, but also contributing information in response to the system's solicitations.
2. Authors: non computer-experts (e.g., content providers, curators, and museum staff) in charge of creating cultural interactive experiences for visitors. They use the CHESS authoring tool to create narrative structures that use existing digital multimedia content, support several devices and multiple visitor interactions.

To support this approach, a user-centered design philosophy is followed throughout the entire course of the project, both in the design and the evaluation phases. The main tenets include:

1. An iterative process of design – development – evaluation, which begins with a comprehensive analysis of the needs, wants, and limitations of the end-users. For every step of the project, a multi-tiered evaluation methodology has been set, in order to test the validity of the design, either in real world experiments or through the organization of user workshops.
2. A participatory design methodology, implemented with a small group of end-users (both museum curators and representative groups of visitors) who, either as partners in the consortium or through a user group, actively participate in the planning and design of the scenarios from the outset.
3. The development of both a personalized and an adaptive system, which delivers narrative experiences tailored to each visitor.

The CHESS consortium comprises seven organizations from four different countries, which provide all the necessary competencies throughout three complementary categories of partners: industrial, research-oriented and cultural. The different nature of the cultural partners (an archaeological museum and a science centre) provides an interesting test bed for the implementation of interactive digital storytelling in different contexts. Cité de l'Espace is a science centre displaying educational models with a high degree of interaction, and it expects that CHESS provides a coherent link between exhibits. The Acropolis Museum, on the other hand, displays originals aimed at contemplation, with a low degree of interaction, and expects from CHESS an explicit interpretation of objects.

---

<sup>2</sup> The CHESS Project, <http://www.chesseexperience.eu>



Figure 1. The Archaic Gallery

At the Acropolis Museum, the CHES project focuses on the Archaic Gallery (figure 1), which is located on the first floor. Here, visitors can wander amongst the architectural and sculptural remains of the period spanning from the 7<sup>th</sup> century B.C. to the Persian Wars (480/79 BC). The flexibility of its design, as well as the diversity of historical facts and approaches behind the objects, makes the Archaic Gallery the perfect context to develop the CHES project.

#### 4. Implementing adaptive personalized stories in CHES

##### 4.1 Defining profiles

Personas are detailed descriptions of imaginary people constructed out of well-understood, highly specified data about real people[19]. Personas are not actual people but are synthesized directly from observations of real people. As a design tool, personas are a powerful way to communicate behaviors, goals, and needs. In other words, when creating personas for CHES, we are creating a set of representative profiles, or archetypes, for the visitor base (and also for the authors) of each museum.

For the Acropolis Museum we created five visitor personas (Table1):

Table 1. Visitor personas at the AM.

					
<b>Nikos Athanasiou</b> , 10 year-old: “The museum is boring”	<b>Georgia Athanasiou</b> , retired literature professor: “The museum makes me feel young”	<b>Jack Harris</b> , young athlete: “The museum would be much more interesting if the exhibits could tell me their stories”	<b>Natalie Schmidt</b> , IT executive: “The museum is an excellent way to relax between meetings”	<b>Dimitris Georgiadis</b> , teenager: “The museum would be cooler with technology”	<b>Takis Karathanasis</b> middle-aged shop owner: “The museum is really great but sometimes too much for me”

The definition of personas for CHES is a result of the synthesis of data from both primary sources (museum data collected via questionnaires, interviews with staff, and ethnographic observations) and secondary sources (visitor studies). This data has been pieced together to define a set of 26 demographic and behavioral variables, with values that are used to describe a) each persona's characteristics (demographic data, interests and attitudes); and b) the context of her visit (visiting duration, social interaction style, preferred way to obtain information and to use the system).

Profiling and subsequent personalization for first-time visitors begins with the CHES Visitor Survey (CVS), a configurable web application performed using a desktop or mobile web client. The goal of the quiz is to identify the user's characteristics, preferences, and visiting styles through a series of single-choice, multiple-choice and ranking questions. The system is generic and can be used to implement any quiz, provided it contains the constructs supported. It allows a variety of presentation formats (e.g., textual, visual, single/multiple column layout, etc.). It also supports a flexible model for mapping the answers to personalization variables, as part of an XML specification, thus reaching an initial user profile. This profile is then employed for providing personalized versions of the Horse story.

#### 4.2 Storytelling

Stories are commonly considered to have a narrative form, containing a set of smaller story pieces which are typically placed into a static order by the author, so as to communicate one or more messages to the end user/audience. Depending on the type of the story (and the author's will), the ordering of the smaller story pieces may be strict, allowing for no other orderings, or flexible, enabling the production of alternative orderings of the same story pieces, which all convey the same message(s).



Figure 2. The Monster Factory Game

The first distinguishing aspect of CHES with regard to traditional storytelling is that it is interactive. Interactivity within stories is accomplished at the following levels:

- User interface: visitors interact with the provided content through a predefined set of presentation utilities over the digital resources (zoom, play, pause, stop), and over the whole story structure via navigation menus.

- Multimedia productions: stories contain short-games (figure 2), aimed at enhancing content recall, and augmented reality activities, aimed at enhancing the exploration of exhibits.
- Story plot: user actions and attitudes affect the unfolding of the story plot, thus generating personalized, adaptive experiences.

Another distinguishing aspect in CHESS is that the story unfolds within a specific physical environment, which serves as the story setting. Moreover, through the arrangement of the exhibits, each museum direction mentally sketches an abstract plot, which will hopefully be understood and followed by museum visitors. Hence, when designing storytelling experiences for museums it is of great importance to carefully consider the setting, for three reasons: firstly, the story needs to be able to “serve” the exhibits (although it may contain story pieces that are not directly related to specific exhibits); secondly, the exhibition arrangement may provide story patterns; and finally, the location of objects may imply special requirements or constraints over the multimedia productions employed.

To be able to provide personalized versions of the story to different visitors, authors designed alternative story sub-flows in various points of the main story, based on a variety of visitor and contextual parameters and/or events. In this sense they actually defined a story “space” that includes several candidate stories. During the visitor’s experience, the system leverages the visitor profile, context and actions to appropriately traverse the authored story space and provide a story that is tailored to the visitor’s characteristics, attitudes and needs.

#### *4.3. Authoring flexible CHESS stories*

To define alternative flows within the story, authors needed to take into account the most important visitor attitudes and characteristics, which significantly differ between visitors, while also affecting their satisfaction with the overall storytelling experience.

The main candidates for personalization identified so far included the script and its script pieces, the staging of the script, and the short multimedia productions of the staged script pieces. All these entities represent fundamental aspects of the visitor’s experience and each one of them are tailored so as to better match the visitor’s attitudes and needs.

Focusing on the script and its contents, different visitors may have different preferences on a variety of features, such as the plot, the subject (society and politics, war, etc.) or even the type of information provided (e.g. mythological or historical). With regard to the plot, different versions are created to match different personas. For instance, the "Horse" storyboard has two plot versions: one aimed at Nikos engaging him in a quest for the horse's relatives and friends, who are stuck in time; and one for Natalie, where the horse acts as a guide.

With regard to the subject, the horse story is built around a specific theme, namely “Animals and monsters”, and covers several, diverse, secondary subjects, such as society, politics, wars, mythology, sports, etc. Probably, the majority of visitors are not interested in all of these subjects, so different parts of the script are omitted for different visitors, under the condition that such a removal does not influence the script

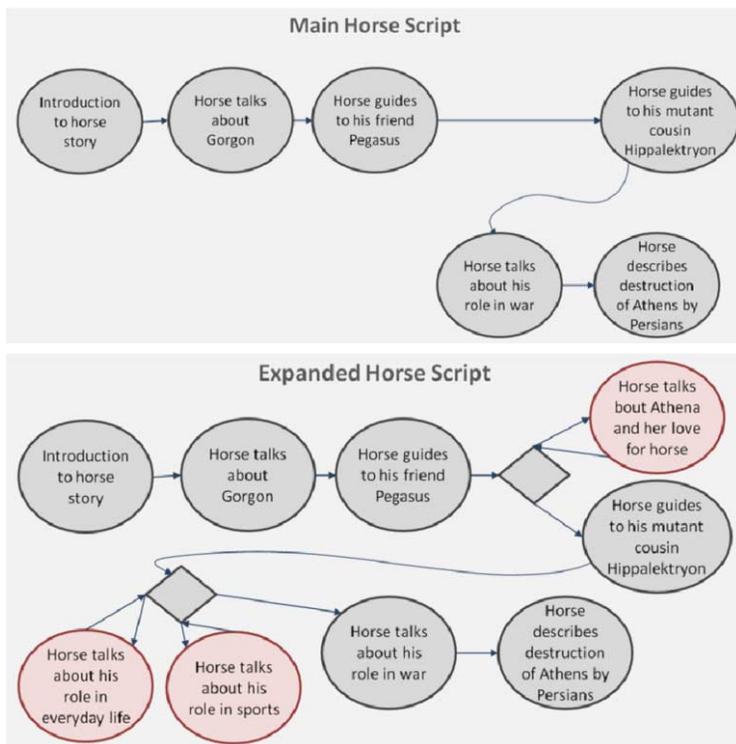


Figure 3. Development of the "Horse" storyboard with optional sub-flows.

plot. This is a very challenging issue, since at first glance there would seem to be some incompatibility between the hypertext structure and the storytelling structure (comprising a beginning, a climax, and a conclusion).

User characteristics and attitudes may also affect the staging of a script. Consider for instance a script piece talking about a mythical creature, for which two exhibits are available in the museum: a statue and a plate in a showcase. In this case the author may choose to define different staging for kids and adults, promoting the exploration of less popular exhibits for adults while considering preservation of enthusiasm as well as visibility issues for kids. Finally, the same holds for multimedia productions, which are designed depending on visitors' particular features and interests.

While a single story was available for the latest evaluation at the Acropolis Museum, new stories are on the way, addressing the needs and expectations of additional personas. When the new stories are entered into the CHESSE system, an additional story selection step will take place at the beginning of the visit, to suggest the story that best matches the visitor's attitudes. Instead of merely using the initial profile on that front, personas profiles will be also leveraged to further address the "cold start" problem. Each visitor will be matched to one (or maybe more) of the aforementioned pre-defined personas and the CHESSE system will promote the stories that are more suitable for the corresponding personas. An overview of the described approach implemented in CHESSE may be found in [20].

#### 4.4 Adaptive storytelling

During the visit, the authored story space is traversed by the CHESSTelling Component to provide an adaptive, personalized storyline. Whenever more than one choices are available in the story space, the CHESSTelling System needs to decide what to do next. Such points in the story space are referred to as decision points and they are indicated with diamonds in fig. 3. So when a decision point is met, the CHESSTelling System uses the visitor profile to estimate the visitor's interest in each one of the candidate story sub-flows.

The initial visitor profile is further refined during the CHESSTelling experience by continuously monitoring user actions and interpreting them to implicit feedback. In particular, two main types of implicit feedback are currently considered. By pressing a "Next" button the visitor can skip to the next piece of the story, thus indicating a high certainty negative feedback for the skipped piece. On the contrary, when a story piece is completed without any visitor intervention, this is considered as low-certainty positive feedback for the specific part. Such positive and negative feedback is encompassed in the visitor's current profile at run-time and interest estimation in decision points is conducted using the updated visitor profile.

Users and storytelling entities are modeled over the same vocabulary of attributes, enabling the use of a wide range of metrics and techniques to compute their similarity [21], which can be either directly employed as a ranking metric for obtaining personalized rankings or leveraged in item-based collaborative filtering algorithms.

Having a set of evaluated alternatives, the Storytelling System has now two options, defining two alternative storytelling strategies. The first is to show all or the most promising (top-k) alternatives to the visitor through menus and let the visitor decide what to do. Menus are computed dynamically for decision points, based on the upcoming sub-flows defined in each case. The second is to automatically select the best ones for the particular user, without letting the visitor know about the other options.

For the purposes of the evaluation study, we have adopted a hybrid strategy with a higher priority to the former. So when a decision point is reached, the appropriate menu is instantiated and presented to the visitor, except for the ones where the author has explicitly disallowed menu display. When the same menu is reached for a second time, the visited branch gets demoted in the menu list of choices.

## 5. Evaluation

An evaluation of the CHESSTelling system with visitors and museum staff was held at the Acropolis Museum in December 2012. For the needs of the evaluation one story, personalized for two different personas, was produced. From the technical point of view, a full integration of the CHESSTelling system was in place, while the necessary infrastructure so that the mobile devices could seamlessly connect to the CHESSTelling server was installed at the museum.

The issues investigated with regard to personalization were the following: 1) Are the variables considered for personalization significant? 2) Which factors are relevant for adaptation during the visit?

### *5.1 Method*

A group of users was invited to test the CHES prototype experience at the Acropolis Museum on Monday, December 17, 2012. The evaluation took place on a day that the Museum is closed to the general public.

Each visitor was “shadowed” by two members of the CHES team, the observer and the recorder, while moving about the museum, and then interviewed. In particular, the two CHES researchers observed each visitor’s behaviour in the natural context of the activity, one taking notes and the other video recording the experience. After the end of the experience, two semi-structured interviews, one addressing general experience issues and the other focused on personalization issues, took place at the Museum’s temporary exhibitions room. Each individual session lasted approximately one and a half hour.

### *5.2 Participants*

Fifteen visitors completed the evaluation, scheduled in two-hour slots each. Of the fifteen participants, six were male and nine were female. The ages ranged from 10 to 55 (three 10 year olds, one 14 year old, one 20 year old, and ten from 30 to 55 years of age). The recruitment was mainly based on demographic information (such as gender, age or profession). All individuals contacted responded positively to our invitation.

### *5.3 Procedure*

Before the beginning of the observation session, each visitor was introduced to the study and asked to complete the consent form. Then, a small group comprised of the visitor, the researcher-observer, and the recorder holding a video camera, headed towards the museum’s foyer. There the visitor was handed the iPad with the CVS, the short quiz designed to bootstrap personalization.

After completing the CVS (which, on average, took less than 4 minutes), each user was accompanied by his/her observer and recorder to the Archaic Gallery. Then the visitor completed, guided by the Horse, a visit through the Archaic Gallery while listening to the story, exploring the exhibits, and looking at the complementary visual resources on the screen.

### *5.4 Results*

With regard to the first research question, the findings of the evaluation can be organized into three categories, related to the experience, the environment, and the user.

The experience characteristics that determine satisfaction are, amongst others, subject (animals and monsters, etc.), technology (multimedia vs. audio-guide), and size of the experience (long vs. short stories).

1. Subject: our results indicate that two types of participants may be identified: i) those expressing interest on a few, specific subjects, and showing total indifference for the rest; and ii) those expressing interest in almost every subject covered in the horse storyboard. So it seems that in order to effectively address the needs of both types of participants, the storyboard should maintain a focused central theme, which however would be enhanced with a great number of optional subparts covering several diverse secondary subjects.
2. Technology: participants who were not familiar with AR or feel uncomfortable with technology in general would rather not get involved in such a production and they'd prefer more traditional, "audio-guide" alternatives instead. So it seems that in order to encourage visitors to explore all the possibilities offered by the experience, more information about what is next or use instructions should be integrated in seamless transitions from the story path to the different activities.
3. Size of the experience: two extreme types of participants have been observed. On the one hand, some participants kept their experience as short as possible, omitting almost all optional subparts, especially as the story progressed towards the end. They were concerned about the provision of "skipping" functionalities by the storytelling system and their main objective was to avoid getting bored. On the other hand, other participants wanted to join almost every optional subpart and their main objective was to explore the authored space, without missing something important. These participants commented that there were some points during their experience where they would like to ask for additional information on the historical or mythological background or on related exhibits that were close by.

Concerning the environment, our findings indicate that visitors liked to move around in the gallery and did not like staying at the same spot for a long time, especially when they were not required to interact with the system or with the exhibits. It was in fact systematically observed that low-level physical engagement generally hindered visitors' satisfaction, who felt confused about what behavior was expected from them, and looked at the screen expecting a request for interaction or wandered around trying to find an exhibit related to the narration. The seamless integration between the story and the environment through the interactive device and was one of the main drawbacks of the experience. It requires a whole different approach not only from the point of view of the contents, but especially of the communication paradigm, that should better integrate the story and the exhibits through the device.

Concerning the user, we identified three main roles, namely spectator, participant and contributor. A spectator has no personal involvement, (s)he simply follows the production (e.g. traditional audio-visual narrations). A participant is assigned with some task that (s)he needs to accomplish in the current production, as it is usually the case with games, quizzes and AR applications. Finally, a contributor needs to actively participate by providing content (such as text, drawing, photograph, opinion, etc.). We observed that while many participants expressed a high interest in productions

requiring their involvement, some stated that they'd absolutely dislike to be assigned tasks requiring specific actions from their part. Such a dislike is justified with various reasons, such as fear of failing, preference on dramatic tension offered by narratives, general preference on spectator role and so on.

The second research question had to do with the relevant factors for adaptation during the visit. Menus, the main adaptive element at this stage of the project, were in general well received because according to visitors, they allowed having control over their experience and did not interrupt the story flow. On the other hand, and contrary to the usage analysis results in traditional web search environments [22, 23], the order of menu choices did not influence selections.

However, there was a different approach to them depending on the goal of the visit. Some participants had come to learn about the museum's contents. They were interested in many side-stories and preferred to make their own choices through menus (rather than having the system deciding for them) due to their worry of missing out on something interesting. They paid great attention to menu descriptions because they wanted to make well-informed decisions and they wished additional information at some points. On the other hand, some participants had come to have an engaging experience. Consequently, their main concern was not to lose interest during their visit: they were very reluctant to choose side-stories and they did not pay attention to menu descriptions. Moreover, the re-ordering of menu choices confused them.

This indicates that any project integrating technology in a museum setting should take into account the visit's goal as a paramount factor since it influences visitors' attitudes, decisions, behaviours, and appreciation of the whole cultural experience.,

## **6. Future work**

Drawing on the analysis of the large corpus of feedback collected during this evaluation study, and on authors' and visitors' needs, we will continue to formulate our approach. The results will be our starting point for the expansion of the existing stories with additional alternative subparts. We are already investigating the extension of the authored story space with independent pieces (related to close exhibits or to similar themes) that will be dynamically injected upon user request, moving towards emerging storytelling approaches while respecting the story flow as paramount.

With regard to dynamic menus, since the order was deemed irrelevant or even confusing by visitors, the system will now visually highlight the recommended choice. The system will also include a "Hurry" button so that the visitor controls the duration of his/her experience. In this respect, a timeline indicating the path already seen and the remaining story will also be included.

Additionally, user interface issues need to be resolved to protect the fine balance between the visitors' shifting focus from the physical to the digital space. The interface should also ensure that the visitor's movement in space does not break his/her immersion in the experience. In this sense, we are already introducing more multimedia

productions for non-staged script units, proposing more direct or interactive observation of exhibits, enriching the narrator with audio clues, and integrating it all within a new interface of communication.

However, the personalization and adaption system need to take further account of the visiting roles that users may prefer and their relationship with technologies. In this sense, more information about what is next or use instructions should be integrated in seamless transitions from the story path to the different activities. The adaption required for these visitor roles also interacts with the flexibility needed to support the various preferences in content consumption. These user preferences have a considerable impact on the process of authoring new and existing stories.

Therefore, we need to improve the user modeling and profiling basis with more visitor research that helps determine which are the relevant personalization variables. To start with, we will refine the proposed user model with additional demographic and contextual attributes, such as the visit goal, which can be potentially employed to identify and discriminate between different types of visits or visitors, providing important indications about the sets of their attitudes.

## **7. Conclusions**

The main challenge for museums in the 21st century is to provide immersive experiences that make cultural heritage relevant for an heterogeneous audience. Personalized, adaptive storytelling is a very promising solution, which nevertheless entails its own challenges. Mainly, how to engage visitors in a story by maintaining story-coherency and preserving an uninterrupted feeling of a story flow, while also adjusting the story to better match visitor characteristics and needs.

Our main contributions to this field starts with the development of a storytelling model where stories are represented in a modular fashion as graphs, in three different levels of abstraction. Each graph uniformly represents numerous alternative story versions which are instantiated based on visitor and contextual attributes, hence tailoring visitor needs while also preserving story coherency.

We also propose a user model which captures visitor attitudes towards a variety of storytelling aspects. While many research efforts focus on defining fine-grained user models for traditional web or social environments [24, 25, 26], significantly less attention is paid to targeted application areas. Storytelling in museum environments is a new, fascinating research area [27, 28] and we believe that user modeling needs to be further explored under this novel setting.

Finally, we conducted a formative evaluation of the adopted personalization and adaptation approach to investigate the influence of the proposed attitudes to visitors' satisfaction. The preliminary results verify the significance of most of the considered attitudes, while also indicating important dependencies between them.

## References

- [1] L. Pujol, M. Roussou, S. Poulou, O. Balet, M. Vayanou, Y. Ioannidis: Personalizing interactive digital storytelling in archaeological museums: the CHESS project. In Proceedings of 40th Annual Conference of Computer Applications and Quantitative Methods in Archaeology (CAA), to appear. Amsterdam University Press, Southampton, UK (2012).
- [2] E. Johnsson: Telling tales. A guide to developing effective storytelling programmes for museums. Renaissance London. C. Adler. London, London Museums Hub, (2006)
- [3] L. Bedford: Storytelling: the real work of museums. *Curator* 44(1): 27-34 (2001).
- [4] J. Springer, S. Kajder, et al.: Digital storytelling at the National Gallery of Art. *Museums & the Web*. D. Bearman and J. Trant. Arlington, VA, Archives & Museums Informatics (2004).
- [5] A. Gaeta, M. Gaeta, P. Ritrovato: A grid based software architecture for delivery of adaptive and personalised learning experiences. *Personal and Ubiquitous Computing*. 13, 207-217 (2007).
- [6] C. H. Muntean, G.-M. Muntean: Open corpus architecture for personalised ubiquitous e-learning. *Personal and Ubiquitous Computing*. 13, 197-205 (2007).
- [7] R. Wakkary, M. Hatala: Situated play in a tangible interface and adaptive audio museum guide. *Personal and Ubiquitous Computing*. 11, 171-191 (2006).
- [8] K. Walczak, R. Wojciechowski, W. Cellary: Dynamic interactive VR network services for education. Proceedings of the ACM symposium on Virtual reality software and technology - VRST '06. pp. 277-286. ACM Press, New York, NY, USA (2006).
- [9] L. Terrenghi, A. Zimmermann: Tailored audio augmented environments for museums. Proceedings of the 9th international conference on Intelligent user interfaces - IUI '04. pp. 334-336. ACM Press, New York, NY, USA (2004).
- [10] Y. Sumi, K. Mase: Supporting the awareness of shared interests and experiences in communities. *International Journal of Human-Computer Studies*. 56, 127-146 (2002).
- [11] T. Hall, L. Bannon: Designing ubiquitous computing to enhance children's interaction in museums. Proceedings of the 2005 conference on Interaction design and children - IDC '05. pp. 62-69. ACM Press, New York, New York, USA (2005).
- [12] G. Jacucci, A. Spagnolli, A. Chalambalakis, A. Morrison, L. Liikkanen, S. Roveda, M. Bertoni: Bodily Explorations in Space: Social Experience of a Multimodal Art Installation. INTERACT '09. Proc. of 12th IFIP TC 13 International Conference on Human-Computer Interaction: Part II. pp. 62-75. Springer-Verlag Berlin Heidelberg (2009).
- [13] G. Leinhardt, K. Crowley, K. Knutson: *Learning Conversations in Museums*. Routledge (2002).
- [14] R. Oppermann, M. Specht: A Context-Sensitive Nomadic Exhibition Guide. *Handheld and Ubiquitous Computing, Lecture Notes in Computer Science*. pp. 127-142 (2000).
- [15] D. Petrelli, A. De Angeli, G. Convertino: A User-Centered Approach to User Modeling. In: Kay, J. (ed.) UM'99 Proceedings of the 7th International conference on User modeling. pp. 255-264. Springer-Verlag New York, Inc., Secaucus, NJ, USA (1999).
- [16] D. Raptis, N. Tselios, N. Avouris: Context-based design of mobile applications for museums. Proceedings of the 7th international conference on Human computer interaction with mobile devices & services - MobileHCI '05. pp. 153-160. ACM Press (2005).
- [17] S. Filippini Fantoni: "Personalization through IT in Museums. Does it really work? The case of the marble museum website". In ICHIM03: Cultural institutions and digital technology. Paris, Ecole du Louvre (2003).
- [18] L. Ardissono, D. Petrelli: UMUI Special Issue on Cultural Heritage Exploration Preface. *User Modeling and User-Adapted Interaction*. 18, 383-387 (2008).
- [19] J. Pruitt, T. Adlin: *The Persona Lifecycle: Keeping People in Mind Throughout Product Design* (p. 744). Morgan Kaufmann Publishers (2006).

- [20] M. Vayanou, M. Karvounis, M.Kyriakidi, A.Katifori, N.Manola, M.Roussou,Y. Ioannidis: Towards Personalized Storytelling for Museum Visits. In Proc. 6th Intl Workshop on Personalized Access, Profile Management, and Context Awareness in Databases - PersDB (2012).
- [21] E. Spertus, M. Sahami, O. Buyukkokten: Evaluating similarity measures: a large-scale study in the orkut social network. Proc. of ACM SIGKDD international conference on Knowledge discovery in data mining (2005).
- [22] T. Joachims, L.Granka, P. Bing, H.Heleneon, G. Geri:Accurately interpreting clickthrough data as implicit feedback. SIGIR,pp. 154-161 (2005)
- [23] T. Joachims, F. Radlinski: Search Engines that Learn from Implicit Feedback. IEEE Computer, Vol. 40, No. 8 (2007)
- [24] B. Steichen, H. Ashman, V. Wade: A comparative survey of Personalised Information Retrieval and Adaptive Hypermedia techniques. Information Processing & Management, Volume 48, Issue 4, 698-724 (2012)
- [25] M. R. Ghorab, D. Zhou, A. O'Connor, V. Wade: Personalised Information Retrieval: survey and classification. User Modeling and User-Adapted Interaction, 1-63, Springer Netherlands (2012).
- [26] S. Yang, B. Long, A.Smola, N. Sadagopan, Z.Zheng, H. Zha: Like like alike: Joint friendship and interest propagation in social networks. In: Proceedings of the 20th International Conference on World Wide Web, pp. 537-546. ACM (2011)
- [27] A. Glassner: Interactive Storytelling: Techniques for 21st Century Fiction. A. K. Peters, ISBN 1568812213 (2004)
- [28] T. Kuflik, O. Stock, M.Zancanaro, A.Gorfinkel, S. Jbara, S. Kats, J.Sheidin, N. Kashtan: A visitor's guide in an active museum: Presentations, communications, and reflection. Journal on Computing and Cultural Heritage (JOCCH), v.3 n.3, p.1-25 (2011)