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Extending museum exhibits by embedded media content for an embodied interaction experience

Investigation topic

Nowadays, museums not only collect, categorize, preserve and present; a museum must also educate and entertain, all the while following market principles to attract visitors. To satisfy this mission, they started to introduce interactive technologies in the 1990s, such as multimedia terminals and audio guides, which have since become standard for delivering contextual information. More recently there has been a shift towards the creation of personalized sensorial experiences by applying user tracking and adaptive user modeling based on location-sensitive and context-aware sensor systems with mobile information retrieval devices. However, the technological gadgets and complex graphical user interfaces (GUIs) generate a separate information layer and detach visitors from the physical exhibits. The attention is drawn to the screen and the interactive technology becomes a competing element with the environment and the exhibited collection [Stille 2003, Goulding 2000, Wakkary 2007]. Furthermore, the vast majority of visitors comes in groups and the social setting gets interrupted by the digital information extension [Petrelli 2016]. Exhibitions generate encounters of the visitor's lifeworld with the exhibits' objectworld [Wood 2016]. Objects contain information about material and physical characteristics, functionalities, actions and events, cultural and historical context and associated people during their entire lifespan. These aspects can be extended by the allocated media extensions that are subtly staged within the exhibition space. First studies about museum visitor behavior were carried out at the end of the 19th and during the 20th Century [Robinson 1928, Melton 1972]. More recently, a significant body of ethnographic research about visitor experience of single persons and groups has contributed studies about technologically extended and interactive installations. Publications about visitor motivation, circulation and orientation, engagement, learning processes, as well as cognitive and affective relationship to the exhibits are of interest for our research approach [Bitgood 2006, Vom Lehn 2007, Dudley 2010, Falk 2011]. Most relevant are studies of the Human Computer Interaction (HCI) researcher community in the fields of Ubiquitous Computing (ubiComp), Tangible User Interfaces and Augmented Reality (AR), investigating hybrid exhibition spaces and the bridging of the material and physical with the technologically mediated and virtual [Hornecker 2006, Wakkary 2007, Benford 2009, Petrelli 2016].

Approach

At the Institute of Experimental Design and Media Cultures (IXDM) we have conducted several design research projects applying AR for cultural applications but got increasingly frustrated with disturbing GUIs and physical interfaces such as mobile phones and Head Mounted Displays. We therefore started to experiment with Ubiquitous Computing, the Internet of Things and physical computing technologies that became increasingly accessible for the design community during the last twelve years because of shrinking size and price of sensors, actuators and controllers. In the presented research project, we therefore examine the extension of museum exhibits by physically embedded media technologies for an embodied interaction experience. We intend to overcome problems of distraction, isolation and stifled learning processes with artificial GUIs by interweaving mediated information directly into the context of the exhibits and by triggering events according to visitor behavior.

Our research approach was interdisciplinary and praxis-based including the observation of concept, content and design development and technological implementation processes before the final

evaluations. The team was composed of two research partners, three commercial/engineering partners and three museums, closely working together on three tracks: technology, design and museology. The engineering partners developed and implemented a scalable distributed hardware node system and a Linux-based content management system. It is able to detect user behavior and accordingly process and display contextual information. The content design team worked on three case studies following a scenario-driven prototyping approach. They first elaborated criteria catalogues, suitable content and scenarios to define the requirement profiles for the distributed technological environment. Subsequently, they carried out usability studies in the *Critical Media Lab* of the IXDM and finally set up and evaluated three case studies with test persons. The three museums involved, the *Swiss Open-Air Museum Ballenberg,* the *Roman City of Augusta Raurica and* the *Museum der Kulturen Basel*, all have in common that they exhibit objects or rooms that function as staged knowledge containers and can therefore be extended by means of ubiComp technologies.



Figure 1. *Roman City of Augusta Raurica*, case study: *"The Roman trade center Schmidmatt"*.
Figure 2. *Open-Air Museum Ballenberg*, case study: *"The farmhouse Uesslingen".*
Figure 3. *Museum der Kulturen Basel*, case study: "*Meditation box*".

The three case studies were thematically distinct and offered specific exhibition situations:

- Case study 1: *Roman City of Augusta Raurica: "The Roman trade center Schmidmatt*". The primary imparting concept was "oral history", and documentary film served as a related model: An archaeologist present during the excavations acted as a virtual guide, giving visitors information about the excavation and research methods, findings, hypotheses and reconstructions.



Figure 4. Prototypical catwalk system for test visitors.
Figure 5. Test visitor with video projection and illuminated replica.
Figure 6. Projection mapping onto a hypocaust floor and wall allows "x-ray view" to understand the construction.

- Case study 2: *Open-Air Museum Ballenberg:* "Farmhouse from Uesslingen". The main design investigation was "narratives" about the former inhabitants and the main theme "alcohol": Its use for cooking, medical application, religious rituals and abuse.



Figure 7. Sensors and nodes are hidden in the furniture.
Figure 8. Kitchen with video projection onto book and scenic sounds.
Figure 9. Bedroom with responsive video projected stains and illuminated medical utensils.

- Case study 3: *Museum der Kulturen Basel:* "Meditation box". The main design investigation was "visitor participation" with biofeedback technologies.



Figure 10. Usability study setup at *IXDM's Critical Media Lab*.
Figure 11. Visitor evaluation setup: Sofa (containing main technology items), touch-sensitive handle (3D printed lotus pedestal) and biofeedback chest belt visitors can wear.
Figure 12. Mandala behind semi-transparent textile with projected video animation explaining its functions.

Technological development

This project entailed the development of a prototype for a commercial hardware and software toolkit for exhibition designers and museums. Our technology partners elaborated a distributed system that can be composed and scaled according to the specific requirements of an exhibition. The system consists of two main parts:

- A centralized database with an online content management system (CMS) to setup and control the main software, node scripts, media content and hardware configuration. After the technical installation it also allows the museums to edit, update, monitor and maintain their exhibitions.
- Different types of hardware nodes that can be extended by specific types of sensors and actuators. Each node, sensor and actuator has its own separate ID; they are all networked together and are therefore individually accessible via the CMS. A node can run on a Raspberry Pi, for example, an FPGA based on Cyclone V or any desktop computer and can thus be adapted to the required performance.

The modular architecture allows for technological adaption or extension according to specific needs. First modules were developed for the project and then implemented according to the case study scenarios.

Evaluation methods

Through a participatory design process, we developed a scenario for each case study, suitable for walkthrough with several test persons. Comparable and complementary case study scenarios allowed us to identify risks and opportunities for exhibition design and knowledge transfer and define the tasks and challenges for technical implementation. For the visitor evaluation, we selected end-users, experts and in-house museum personnel. The test persons were of various genders and ages (including families with children), had varying levels of technical understanding and little or no knowledge about the project. For each case study we asked about 12 persons or groups of persons to

explore the setting as long as they wanted (normally 10–15 minutes). They agreed to be observed and video recorded during the walkthrough and to participate in a semi-structured interview afterwards. We also asked the supervisory staff about their observations and mingled with regular visitors to gain insight into their primary reactions, comments and general behavior. The evaluation was followed by a heuristic qualitative content analysis of the recorded audio and video files and the notes we took during the interviews. Shortly after each evaluation we presented and discussed the results in team workshops.

Findings and Conclusions

The field work lead to many detailed insights about interweaving interactive mediated information directly into the context of physical exhibits. The findings are relevant for museums, design researchers and practitioners, the HCI community and technology developers. We organized the results along five main investigation topics:

1. Discovery-based information retrieval

Unexpected ambient events generate surprise and strong experiences but also contain the risk of information loss if visitors do not trigger or understand the media aids. The concept of unfolding the big picture by gathering distributed, hidden information fragments requires visitor attentiveness. Teasing, timing and the choice of location are therefore crucial to generate flowing trajectories.

2. Embodied interaction

The ambient events are surprising but visitors are not always aware of their interactions. The unconscious mode of interaction lacks of an obvious interaction feedback. But the fact that visitors do not have to interact with technical devices or learn how to operate graphical user interfaces means that no user groups are excluded from the experience and information retrieval.

3. Non-linear contextual information accumulation

When deploying this project's approach as a central exhibition concept, information needs to be structured hierarchically. Text boards or info screens are still a good solution for introducing visitors to the ways they can navigate the exhibition. The better the basic topics and situations are initially introduced, the more freedom emerges for selective and memorable knowledge staged in close context to the exhibits.

4. Contextually extended physical exhibits

A crucial investigation topic was the correlation between the exhibit and the media extension. We therefore declined concepts that would overshadow the exhibition and would use it merely as a stage for storytelling with well-established characters or as an extensive media show. The museums requested that media content fades in only shortly when someone approaches a hotspot and that there are no technical interfaces or screens for projections that challenge the authenticity of the exhibits. We also discussed to what extend the physical exhibit should be staged to bridge the gap to the media extension.

5. Invisibly embedded technology

The problem of integrating sensors, actuators and controllers into cultural heritage collections was a further investigation topic. We used no visible displays to leave the exhibition space as pure as possible and investigated the applicability of different types of media technologies.

Final conclusion

Our museum partners agreed that our approach should not be implemented as a central concept and dense setting for an exhibition. If ubiComp is applied for discovery-based embodied interaction displaying contextual information without hierarchical structures, the approach should only be applied as a discreet additional information layer or just as a tool to be used when it makes sense to

explain something contextually or involve visitors emotionally. However, the developed sensor-actor-network and the database with a CMS for setup and maintenance also allows ubiComp implementations that are suitable for an overall concept of interactive information presentation: Areas for embodied interaction could be indicated, sensor activity could trigger distinguishable feedback, audiovisual displays could be integrated as aesthetic electronic devices to present hierarchically structured information and to help visitors to orientate and to retrieve all offered information. But in our opinion under these conditions embodied interaction would make no sense and devices with GUIs or even simple buttons would be more appropriate for visitor interaction.

References

Steve Benford et al. 2009. From Interaction to Trajectories: Designing Coherent Journeys Through User Experiences. Proc. CHI '09, ACM Press. 709–718.

Stephen Bitgood. 2006. An Analysis of Visitor Circulation: Movement Patterns and the General Value Principle. Curator the museum journal, Volume 49, Issue 4,463–475.

John Falk. 2011. Contextualizing Falk's Identity-Related Visitor Motivational Model. Visitors Studies. 14, 2, 141-157.

Sandra Dudley. 2010. Museum materialities: Objects, sense and feeling. In Dudley, S. (ed.) Museum Materialities: Objects, Engagements, Interpretations. Routledge, UK, 1-18.

Christina Goulding. 2000. The museum environment and the visitor experience. European Journal of marketing 34, no. 3/4, pp. 261-278.

Eva Hornecker and Jacob Buur. 2006. Getting a Grip on Tangible Interaction: A Framework on Physical Space and Social Interaction. CHI, Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. 437-446.

Dirk vom Lehn, Jon Hindmarsh, Paul Luff, Christian Heath. 2007. Engaging Constable: Revealing art with new technology. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '07), 1485-1494.

Arthur W. Melton. 1972. Visitor behavior in museums: Some early research in environmental design. In Human Factors. 14(5): 393-403.

Edward S. Robinson. 1928. The behavior of the museum visitor. Publications of the American Association of Museums, New Series, Nr. 5. Washington D.C.

Daniela Petrelli, Nick Dulake, Mark T. Marshall, Anna Pisetti, Elena Not. 2016. Voices from the War: Design as a Means of Understanding the Experience of Visiting Heritage. Proceedings Human-Computer Interaction, San Jose, CA, USA.

Alexander Stille. 2003. The future of the past. Macmillan. Pan Books Limited.

Ron Wakkary and Marek Hatala. 2007. Situated play in a tangible interface and adaptive audio museum guide. Published online: 4 November 2006. Springer-Verlag London Limited.

Elizabeth Wood and Kiersten F Latham. 2016. The Objects of Experience: Transforming Visitor-Object Encounters in Museums. Routledge, New York, USA.