Embedded media for embodied interaction experiences in cultural heritage

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Investigation topic

Since the 1990s museums increasingly apply multimedia terminals and audio guides to offer additional and more personalized information to their visitors. But the implemented technological devices and 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]. Exhibitions generate encounters of the visitor's lifeworld with the exhibits' objectworld [Wood 2016] and the majority of visitors comes in groups which is why the social setting should not be interrupted [Petrelli 2016].

More recent studies about visitor circulation and orientation, engagement, learning processes, as well as cognitive and affective relationship to the exhibits are of special 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, Tangible User Interfaces and Augmented Reality, 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

Exhibits contain information about material and physical characteristics, functionalities, events, cultural and historical context and associated people during their entire lifespan. We intended to extended these aspects and to engage visitors by responsive media extensions. We aimed to solve problems of distraction, isolation and learning processes through embodied interaction and embedded information, staged in physical context of the exhibits. Our research approach was praxis-based, participatory and interdisciplinary. The engineering partners developed and implemented hardware nodes and a database with a content management system (CMS). The distributed system was able to detect user behavior and accordingly process and display contextual information. The content design team followed a scenario-driven prototyping approach. They first elaborated criteria catalogues and interactive scenarios, defined technical requirements, carried out usability studies and finally evaluated three case studies at the partner museums. The comparable and complementary case studies allowed to identify risks and opportunities:

Case study 1: *Roman City of Augusta Raurica: "The Roman trade center Schmidmatt*". The primary concept was: oral history with a virtual guide and documentary film style.



Figure 1. Prototypical catwalk system.
Figure 2. Test visitor with video projection and illuminated replica.
Figure 3. Projection mapping onto a hypocaust allows "x-ray view" to explain the construction.

Case study 2: *Open-Air Museum Ballenberg: "Farmhouse Uesslingen"*. The main design approach was: narratives about former inhabitants. The main theme: "mis/use of alcohol".



Figure 4. Technology hidden in furniture.
Figure 5. Kitchen with video projection onto book and scenic sounds.
Figure 6. Bedroom with 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 7. Usability study setup at IXDM's Critical Media Lab.
Figure 8. Visitor evaluation setup with sofa, touch-sensitive handle and wearable biofeedback chest belt.
Figure 9. 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 engineering partners elaborated a Linux-based distributed system that can be composed and scaled according to the specific requirements of an exhibition. The networked system consists of a centralized database with an online CMS to setup and maintain node scripts, media content and hardware configuration. It also includes different types of hardware nodes with assigned IDs that can be extended by different types of sensors and actuators.

Evaluation methods
For the visitor evaluation, we invited end-users, experts and in-house museum personnel of varying gender and age. For each case study we asked about 12 persons or groups of persons to explore the setting. We observed, took notes, video recorded and conducted semi-structured interviews. Subsequently, we made a heuristic qualitative content analysis of the collected material.

Findings
The field work led to 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 and design principles.
1. Contextually extended exhibits:
An investigation topic was the correlation between the exhibit and the media extension. Technical devices were hidden and mediated content was only temporally blended in to preserve the exhibits authenticity and aura.
2. Discovery-based dramaturgy:
Unexpected ambient events generated strong surprising experiences but contained the risk of information loss if visitors do not trigger the offered content. Teasing, timing and the choice of location are crucial design aspects.
3. Embodied interaction:
The unconscious mode of interaction was not ideal for user guidance. But the fact that visitors do not have to interact with technical devices and GUIs allows experience and information retrieval for all user groups.
4. Situational, non-hierarchical, non-linear knowledge transfer:
We did not structure the distributed information hierarchically. However, the better the basic topics are introduced on a meta level, the more freedom emerges for memorable knowledge transfer.
5. Distributed embedded technology:
We investigated the applicability of the distributed system and different types of media and technologies on cultural heritage sites.

Conclusions
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. If areas for embodied interaction were indicated, sensor activity triggered feedback and audiovisual display devices presented hierarchically structured information, the developed system could be implemented as an overall exhibition concept. But in our opinion under these conditions embodied interaction would make no sense and GUIs and even simple buttons would be more appropriate for visitor interaction.

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