

Ubiquitous Computing for Knowledge Transfer and Exhibition Design

An interdisciplinary design research project

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Abstract

We discuss how exhibits and exhibition spaces can be augmented by interactive media to inform and emotionally involve visitors without the need for supplemental interaction devices with additional information layers. From the perspectives of scenography, museology and design the potential of ubiquitous computing for exhibition design and knowledge transfer is considered and the development process is elaborated. Partners from disciplines of design and technology carry out three case studies together with three renowned Swiss museums.

1 Introduction

Museums nowadays fulfill an extended mission not only collect, categorize, preserve and present, but also to offer education and entertainment and to follow economical principles to attract visitors. To satisfy this mission they have introduced interactive technologies such as multimedia terminals and audio guides that have become a standard to deliver contextual information. However, graphical user interfaces and the presentation of a separate information layer that is detached from the primary artifacts have the potential to distract visitors [Flec02] [Stil02] from the actual exhibits. The use of these technologies can isolate visitors from a group experience [Goul00] in the museum.

Interface concepts from AR and VR have become popular for use in museums. VR is a technology that immerses the user in a digitally constructed, synthetic world, isolating her from the physical surroundings. AR fundamentally follows the same paradigm by extending the physical world through a superimposed, contextualized layer of digital, audiovisual information, displayed on a mobile device or even a head worn display (HMD). By their technological approach, VR and AR present highly focused information that they place, often together with a mobile device, *between* a visitor and their surroundings or other people.

Ubicomp embeds a networked computational infrastructure into the environment and with interface concepts of ambient display and calm computing [Weis93] represents a marked departure from conventional interaction paradigms. The application of ubicomp for museum exhibitions and information presentation aims to overcome problems of distraction, isolation and obscuring the exhibits by interweaving mediated information with the artifacts and the visitor behavior. The goal is to enable visitors to experience the original places and museum artifacts, to have a shared experience with others and to enrich that experience by selectively introducing information through narrative elements and storytelling. Projected videos and images, spatially arranged localized sound sources and animated physical objects as tangible interfaces are triggered by the visitor's behavior and the interaction with her surroundings. They are embedded as responsive, location sensitive, non-linear elements into the exhibition. The physical exhibition space itself becomes the interface to inform and emotionally involve exhibition visitors. Our goal is to instrument the museum environment to allow artifacts and exhibition spaces to tell an engaging and informative story that captures a visitor's imagination. The presented project examines the application potential of ubicomp and tangible interaction for knowledge transfer, exhibition design and museum operations. We aim to identify suitable contents, concepts and media approaches and to develop modular tools that are necessary for exhibition-making with ubicomp interaction and technology. We therefore develop systems that detect user behavior and accordingly process and present contextual information. Beyond the technical implementation we are concerned with the design approach, interaction concepts, use of media, narrative and comprehension, and are motivated by questions of scenography and museology: How can physical exhibits be mediated and dramaturgically staged without the implementation of visible user interfaces and decoupled, separate information layers? What kind of information and formats are adequate for which interaction concepts and design approaches and how do visitors and operators accept and comprehend the approach?

2 Related Work

2.1 Designing for Museums and Knowledge Transfer

The problem of conventional interaction to present highly focused information and thereby potentially distract from the museum experience and the presented artifacts has been identified before. Fleck et al. [Flec02] have developed a ubiquitous system that allows visitors to capture and replay their experience, while Hall and Bannon [Hall06] have proposed the design of a ubicomp system in a museum to specifically support children's learning. More recently there has been renewed interest in the use of ubicomp and tangible interaction as an alternative modality to support storytelling and learning in museums. Chu et al. [Chu15] explore the value of tangible tabletop interaction, others extend the idea of embedded interaction to replicas of artifacts in a museum [Mars16][Kwan16].

An aspect of ubicomp interaction that is particularly relevant is the ability of the visitor to naturally control the degree of focus on ambient interaction and display. This concept has been originally explored for large scale ambient displays [Voge04] and was more recently discussed [Pohl13] as focused and casual interaction.

Storytelling is an important concept for the *innerface of the interface* [Ryan02][Umas97], for disseminating information in interactive settings and as a concept for understanding experience [Forl00]. It has been successfully applied to the design of learning and knowledge transfer for tangible interaction [Har16], and ubicomp [Clif13].

2.2 Design and Evaluation

The design and evaluation of ubicomp environments has been recognized as a research problem and as a significant hurdle for implementing successful applications. Participatory design approaches [Brat12] have proven to be helpful for identifying users' needs and expectations, and for transferring important domain knowledge. Usability testing has long been applied to interaction in museum settings [Bell02]. Scenario development and corresponding scenario-based usability techniques are particularly suitable for agile development processes [Oben08] and are able to produce information at early stages of development. For ubicomp there is a significant difference between controlled lab settings, where basic usability questions can be resolved, and the evaluation and study *in the wild* on location, that is necessary to uncover more complex issues such as social interaction and learning [Horn12].

2.3 Own Research

Within our research group we work at the intersections of design, media arts and technology. Over the last twelve years we experimented with technological platforms like AR and ubicomp in research and media art projects to investigate the perception of alternative spaces, developing design principles and examining the application potential of location sensitive information technologies. We developed the AR projects *living-room1* and *2* [Hers08] from an interior design point of view and the outdoor project series *lifeClipper* with for cultural heritage visualization, architecture and artistic game design [Torp13]. *Mediating the Future in Exhibitions* was a tangible info space with a ubiquitous computing approach for the *Museum of Communication Bern* [Tob13]. We are currently investigating affective qualities of ubicomp and the bodily perception of physically augmented spaces in a project called *Designed Immediacy* [Torp14].

3 Methods and Research Objectives

3.1 Development of Content and Design

For the project we follow a scenario-driven prototyping approach. At the beginning of the project we conducted inquiries with the museums and exhibition design partners to gather working strategies, attitudes, design principles, commercial conditions and expectations. The results are documented in a criteria catalog and as *requirement profiles* (3.1.1). Based on those findings, through a participatory design process, we developed *scenarios* (3.1.2) for the case studies, suitable for cognitive walkthrough and testing. Simplified lab setups were developed from these scenarios to run initial scenario-based *usability studies* (3.1.3) in the lab.

In the next stage of the ongoing project we will develop complete setups supporting the scenarios for on-site *visitor evaluation* (3.1.4) at the museums and for *final inquiries* (3.1.5) gathering the partners' experience over an extended period.

3.1.1 Criteria catalog

To carve out requirement profiles for the three museums, their philosophy and the specific cases, we created a criteria catalog. With the catalog it was possible to identify the differences and similarities between the three museums and their cases and to use this knowledge for the

scenarios and the evaluation. We defined categories such as: framing conditions, spatial situation, treatment of exhibit, implementation of media and technology, strategy of knowledge transfer, exhibition development processes, visitor's view and target groups.

3.1.2 Scenarios for case studies

The three involved museums have in common that they all exhibit objects and rooms that function as staged knowledge containers and can therefore be extended by means of ubiquitous computing. The selected case studies serve as epistemic installations with specific exhibition requirements and concepts as well as technological solutions.

The *Museum der Kulturen Basel* has the biggest international ethnographic collection of all Swiss museums and offers the case *Meditation Box* which is part of the exhibition *StrohGold - kulturelle Transformationen sichtbar gemacht*. The setting includes biofeedback sensing technologies to make meditation perceivable.

The *Swiss Open-Air Museum Ballenberg* with its 660'000m² area and more than 100 historic buildings proposed to prepare the furnished farmhouse *Uesslingen* (1568/1605). By telling the story of its former inhabitant, additional information should come alive and be emotionally engaging.

The nationally renowned *Roman City of Augusta Raurica* offered the ruins of the commerce building *Schmidmatt* to install a location-sensitive ID-system (RFID) that allows visitors to choose two different perspectives – a fictive historic owner and a modern archaeologist – to learn more about daily life in a colonial city during the Roman empire around 230 A.D.



Fig 1: Case study Meditation Box, Museum der Kulturen Basel. Fig 2: Case study Farmhouse Üsslingen, Freilichtmuseum Ballenberg. Fig 3: Case study Commerce building Schmidmatt, Römerstadt Augusta Raurica.

The scenarios allow to identify opportunities for exhibition design and knowledge transfer and to compare different design approaches and interactions. They give insight into topics such as:

- Verification of interaction concepts and information accessibility
- Verification of design, dramaturgy and comprehensibility

- Quality of media and technical implementation
- Suitability of sensors and actuators
- Applicability for different types of media and formats
- Applicability for types of information (depth of information)
- Staging and augmentation of physical museum exhibits
- Attractiveness and experiential value

As a detailed example we extract the script for one of the four rooms that will be deployed at the *Swiss Open-Air Museum Ballenberg*: The history of the farmhouse *Uesslingen* is well documented including construction stages since 1568 and individual information about the inhabitants. The different rooms of the building dramatize the use and abuse of alcohol during different periods of time: 1784, 1813, 1850 and 1893. An info board at the entrance of the building, visual teaser hotspots and interaction devices indicate the interactive information layer for those who want to fully experience the installation.

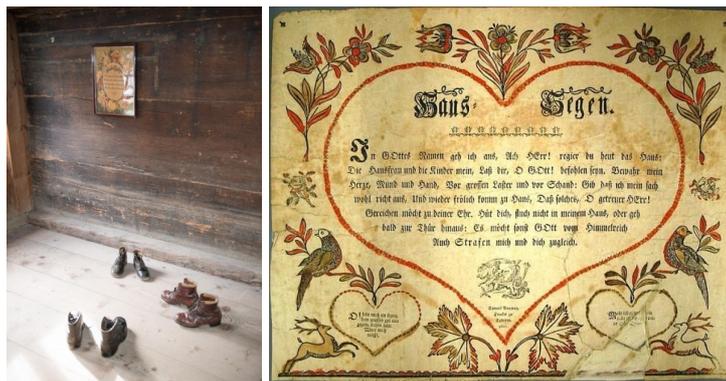


Fig 4: First sketch of living room scene of case study Uesslingen.

Fig 5: Possible picture of house blessing.

- *Location*: living room, *Time*: 1850, *Main theme*: alcohol and religion
- *Story*: The catholic Ferdinand Wyler and the protestant Gottfried Debrunner have had a brawl at the tavern. They arranged to meet with the catholic and protestant priests to reconcile in the living room of Debrunner. The discussion slowly moves away from the problem of the two farmers to the basic understanding and the use of alcohol in religion. The dialogs are in contemporary Standard German with regional helvetisms.
- *Staging*: *Situation*: The scene is located in front of the house-blessing picture at the wall between oven, windows and table. *Props*: characteristic shoes of the characters on the floor, in circle formation, house blessing at the wall, wine bottle and glasses on the table. *Audio*: Dispute (directional speaker). *Video animation*: The house blessing (monitor

with historic frame) displays an animation: texts, symbols or emblems of the catholic and protestant church (stills and video sequences, synchronized with audio dispute).

- *Interaction:*

If the visitor gets close to the house blessing, in the circle of shoes (distance sensor), the audiovisual animation of the house blessing starts. If the visitor leaves the range within seven seconds the animation blends back to the still image.

If the visitor stays in the range for more than seven seconds, the dispute goes on.

If the visitor touches or gets close to the wine bottle (capacitive sensor) the dispute goes on but the animation becomes more intense revealing more confronting content.

3.1.3 Lab-based usability studies

The evaluation of the three case studies take place as simulated museum settings at the *Critical Media Lab*. We observe and video record the behavior of participants and conduct semi-structured interviews. The lab-based usability studies are a pared down, simplified version of the planned on-site visitor evaluation and serve as a first investigation of aspects such as: spatial orientation, position and succession, interaction access, media implementation, information processing and comprehensibility.

We set up the hardware of the usability studies based on RaspberryPi, Arduino and common sensors and actuators. The prototype system helps to define requirement lists of features and parameters that need to be refined during the setup of a ubicomp exhibition, informing the development of the ubicomp museum toolbox.

3.1.4 On-site visitor evaluation

We will carry out visitor evaluations with invited participants (museum experts, museum personnel, single visitors and groups, families) under standardized conditions at the museums. Based on the findings and technical developments of the usability studies we will stage the scenarios at the museums. The usability studies will be extended with some relevant features: end user evaluation (visitor in the museum's context), multi-user (exchange and conflict of interest), comprehensibility and dramaturgy in the museum's context and feasibility of technical integration on site.

3.1.5 Final inquiry

Towards the end of the project we will make a final survey to investigate the partners experiences with ubicomp in exhibition settings. They will help to further improve the technical prototype and to estimate the necessary efforts to commercially develop a ubicomp toolkit for exhibition making.

4 Results

4.1 Criteria Catalog

The criteria catalog helped us to identify topics and strategies that are of major importance for all museums and criteria that are specific for each museum. Gathered information as described in the following examples helped us to define three comparable scenarios.

All three museums mentioned that a ubicomp exhibition should be stable, updatable and adaptable for other cases to come. Interaction should be self-explanatory and not mandatory: the exhibition should also work without additional interactive information. They expect to attract new visitor target groups, like children and technophiles and to improve the appearance of modernity. Since museums have a much bigger collection than they can actually exhibit, they are interested in referencing treasures from their archives.

We recognized differences concerning the treatment and significance of the exhibits: They can on the one hand be theme receivers and on the other hand theme contributors as knowledge containers. Knowledge can be presented scientifically or be shifted to the here and now as a user experience and basis for discussion. To be able to investigate the impact of media and technology we implement different technological approaches like biofeedback sensing and RFID.

4.2 Scenario Implementation Process

Specifications gained from the criteria catalog and several visits of the locations helped the interdisciplinary team to develop the final version of the scenario script. For the concrete implementation we subdivided the script into four tracks: theme and dramaturgy, props and spatial interventions, media production and interaction programming. Up to this point the script referred to a fully functioning exhibition. For the evaluations we had to reduce the complexity

from an exhibition concept to a standardized visitor evaluation in a usability study in a prototypical lab setting.

4.3 Lab-Based Usability Studies

In February 2016, we conducted a usability study of the case *Meditation Box* of the *Museum der Kulturen Basel* with four expert subjects with backgrounds in design research and interaction design. The verification of interaction concepts and information accessibility showed that participants accessed all interaction points, mostly in the same order, but sometimes interpreted their interactive input wrongly. If they could not trigger the event to retrieve hidden information it was due to the timing of the system responses or the sequence of system states. Only half of the visitors read the introduction displayed at the entrance. They expected more guidance in the room itself, which somehow is in contradiction to the interface-less ubicomp approach and might be due to the current expectation of museum visitors. The verification of comprehensibility of media design and story telling showed that the participants understood both displayed contents: the classic didactics as much as the experiential animation. The length of the displayed information was assessed positive. As expected, the projection on a semi-transparent textile in front of the exhibit was criticized for occluding, which might be improved by an optimized light design in the final setting. The experiential animation was set up to be very simplistic, which was criticized by the participants. They expected more interactive features and a sound track to experience the process of meditation.

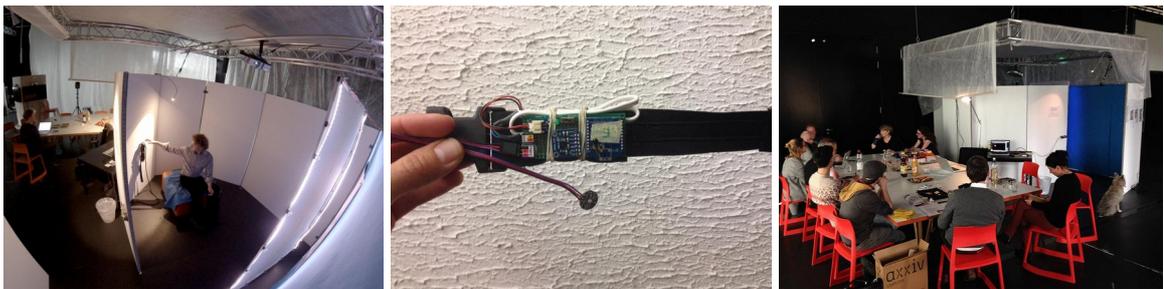


Fig 6: Usability Study Meditation Room, observation video: participant taking the chest belt.

Fig 7: Wireless biofeedback sensor set, chest belt prototype

Fig 8. Simulation of the Meditation Box at the IXDM, usability study workshop

5 Discussion and Outlook

Our design and evaluation process with requirements profiles, scenario development and initial lab-based usability testing produced a wealth of structured information that is useful to build museum installations with ubicomp interaction. The first usability study produced results concerning the implemented case study, but to gain valid insights for ubicomp exhibitions in general we need a comparison of all three case studies. The visitor evaluation on site will finally allow more detailed conclusions about the applicability of different technologies, media and depth of information, the augmentation potential of physical museum exhibits and the attractiveness and comprehensibility of exhibitions staged with the ubicomp approach.

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