Interweaving Physical Artifacts with Visualization on Digital Media in Museums

Kerstin Blumenstein
St. Pölten University of
Applied Sciences
3100 St. Pölten, Austria
kerstin.blumenstein@fhstp.ac.at

TU Wien, Austria
1040 Vienna, Austria

ISS'18 Companion, November 25–28, 2018, Tokyo, Japan.

ACM ISBN 978-1-4503-6010-4/18/11.
http://dx.doi.org/10.1145/3280295.3280297

Abstract
Museums and libraries store a huge number of data related to their exhibition objects. Often, these data cannot be presented in exhibitions because of limited space or limited time during guided tours. Interweaving these physical artifacts with data visualization on digital media can help to make these data visible and searchable for visitors independently. Concepts and best practices for such situated visualizations are still rare. Our approach is to utilize the visitor's own device to enhance the museum visit through interactive data visualization. Thus, the visitor gets the ability to interactively gain more information on topics of interest or can link different topics.

Author Keywords
Physical artifact; Mobile device; Multi device; BYOD; Museum; Information Visualization

Introduction & Related Work
In museums, exhibition objects are silent in general. The physical artifacts cannot provide e.g., additional information or recommendations by themselves. Often, artifacts are augmented by short textual descriptions or orally through a guide. However, museums and libraries know much more about the artifact than can be written in limited space or presented in a short time. Yet, the utilization of interactive data visualization in museums is relatively uncommon [16].

Our goal is to introduce the perspective of Information Visualization (InfoVis), i.e., the interactive visual exploration and communication of data. At the same time, digital information systems (e.g., access to web browser via smartphone) exist. Despite, systems are not intended to be used in museums and not connected to exhibition objects. Therefore, an interplay between physical artifacts and InfoVis on digital media seems to be a promising approach to enrich a visit to a museum.

The recently introduced term *situated visualization* describes a data representation that depends on the situation in which the user is located or on the object which is close to the user [26]. An everyday use case for situated visualization is mobile maps, e.g., showing traffic information depending on the users' position. Ongoing research in this area deals with ambient and peripheral displays (e.g., [21, 28]). For example, the activity wallpaper by Skog [22] shows acoustic change over time in a cafe. In addition, several researchers build upon video see-through technologies from augmented reality and discuss augmented visualization (e.g., [1, 5, 18]) by recognizing for example plants [25] or products [9] and visualizing additional information. Willet et al. [26] state there is a need for additional research in this field concerning how to design situated data representations. We want to build on this open research field and focus on interweaving existing physical artifacts in a museum with InfoVis on digital media to enrich the museum visit and to support learning through active participation [11].

On the other hand, the term data physicalization is used to describe computer-supported physical representations of data [13]. In that research, an artifact's geometry or material property itself encodes data. In our work, the artifact itself does not have to be a data representative. We focus on situated visualization [26].

In museums, visitors access digital media mainly via smartphones, tablets, and smartwatches as personal devices as well as touch displays used in semi-public spaces (museums). The current spread of mobile devices (smartphones as well as tablets) with affordable data rates has resulted in intensive use of location-based services such as maps, routing, event information, location-dependent advertising, or games. In private space, the usage of tablets or smartphones as an extension of TV experience (second screen) is growing. In public space, device ecosystems which combine several end devices with the users' own devices are subject of research (e.g., [8, 23, 27]). Thus, it is promising to integrate the visitor's own device into the museum's ecosystem.

However, multi-device applications for museums or similar cultural places are rare. With "I-m-Cave" [12], an interactive tabletop system is presented. The user can virtually explore the Mogao caves in Dunhuang, China. In [7], Dini et al. propose a multi-device, location-aware guide, including the possibility of enriching the visit through games. Ghiani et al. [10] present a location-aware guide with mobile devices which are equipped with RFID tags. Belinky et al. [2] describe a system for collaborative planning and re-planning of a visit for a small group of visitors using their devices and a situated display at the entrance.

Many museums include vertical touch displays or multi-touch tables in their exhibitions (e.g., Natural History Museum Vienna, Zoom Children's Museum Vienna), but they are rarely used as part of a device ecology. Other museums offer the opportunity to download audio or additional information to their own smartphone (e.g., mumok museum Vienna, Haus des Meeres - Aqua Terra Zoo Vienna). How-

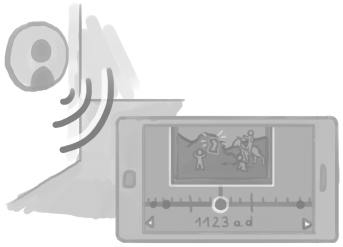

Figure 1: Early sketch of visualization on mobile devices which is filtered (and shows details) based on the visitor's current position and interactions. Since the exhibition area is structured chronologically, the visualization could build on a timeline. Depending on the position or object it can provide the opportunity to experience additional information and / or stories.

ever, often such information is the same as in the exhibit and are not location aware. Visitors have to select exhibits on their mobile devices themselves. In our vision, the mobile device of the visitor is utilized as a device for personal adaption of the information (e.g., through automated filtering of data depending on the artifact which is viewed or through different story lines). Instead, the physical artifact is seen as a shared object which is used by everyone. In addition, a back channel could be implemented to access and integrate user generated data (e.g., which data are selected, which exhibits are liked the most) in the exhibition.

Next, I outline the research objectives and the method used for the whole thesis. I will conclude with the stage of research and the planned next steps.

Research Objectives

The goal of this research is to study visualization methods for interweaving physical artifacts on digital media in museum's setting integrating the visitor's own device. This leads to the following main research question:

- How can visualization methods be used for interweaving physical artifacts with digital media in museums?

To achieve this goal the following sub research questions will be answered:

- Which types of interweaving physical objects with digital media are feasible in museums?
- Which types of visualization as well as types of interaction can best be used for the chosen scenarios?
- If the physical artifact itself is a visualization - how can the artifact be dynamically extended through a back channel?
- How can multi-device ecologies enrich such settings?
- What are best-practice guidelines for interweaving physical artifacts with digital media in museums?

To reach the overall goal, the whole design space for interweaving physical artifacts with digital media will be worked out. Building on that overview, concrete scenarios and concepts have to be developed as functional prototypes and evaluated. Finally, guidelines for designing and developing interweaving physical artifacts with InfoVis in museums will complete the thesis.

Method

> *"Visual representations of objects are often misinterpreted, either because they do not match our perceptual system, or they were intended to be misinterpreted."* [24]

Therefore, visualizations have to be developed and tested in the context of specific tasks, users, and application domains [19]. To use visual methods effectively one has to plan professionally (e.g., with user and task analysis) and evaluate empirically (e.g., with usability testing) [14, 17].

At the beginning, a desk research will be conducted, which includes extensive literature and web research. Topics like multi-device ecologies, research in semi-public spaces, relevant interaction and visualization methods will be researched, analyzed, and evaluated to get a detailed state-of-the-art analysis. Evaluation is based on structured criteria.

To implement functional prototypes, the study at hand uses the nested model [19], the goal-oriented design process [6] as well as experimental prototyping with user-centered design [20]. It will be an iterative process.

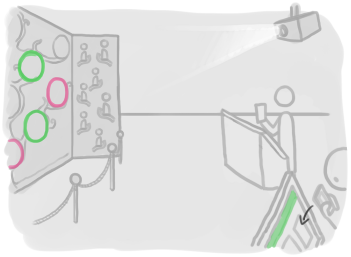

Figure 2: Early sketch of installation at a historic genealogical tree exhibit. Visitors can interact with a visualization on touch displays. The visualization shows data which are not presented by the family tree. Depending on the selected objects of the visitors a projection on the genealogical tree will highlight the object or shows not presented relations.

Concepts for visualization and interaction design will be evaluated based on mock-ups with qualitative user tests. Mock-ups will be improved by the results of user tests and implemented as functional prototypes. To improve these prototypes, usability tests will be conducted. Used methods will be audio-visual observation and semi-structured interviews [15].

To decide which concrete scenarios (at least two) will be developed, the whole design space will be considered as part of research.

Stage of Research & Next Steps

Currently, I am working on the concretization of the concepts in cooperation with the museum of the monastery Klosterneuburg, Austria (as an example see Figure 1 and 2).

In addition, there is ongoing work on the state-of-the-art analysis concerning data visualization in multi-device settings, situated action models, and interactive applications in exhibitions (focusing on integrating the own device). I already finished a systematic survey of literature published in the main venues for InfoVis and HCI concerning InfoVis on mobile devices and their evaluation. The survey is published in [4].

In the context of the research project MEETeUX[1], we analyzed 39 exhibits mainly in Austria for getting an overview of existing interactive exhibits. Methodically, we used literature research for 25 exhibits as well as observations in 14 museums. We categorized the exhibits concerning used devices, target groups, and several content related tags (e.g., is the visitor's own device used (*BYOD*), is there a *personalization* possibility (like marking exhibition pieces as favorite), is *augmented reality* or *virtual reality* used)[2].

Afterwards, we defined personas, requirements and the basic system functions. Building on the requirements and the defined functions, we developed a technical concept for a multi-device ecology [3].

During the next months, we will prototypically implement the mentioned concepts and conduct early evaluations. In addition, I will start describing the whole design space of interweaving physical artifacts with visualization on digital media. I plan to finish my thesis with the end of 2019.

Open Questions and Issues for Discussion

There are several options how I could benefit from participating at the ISS Doctoral Symposium. Firstly, I would like to discuss the design space of interweaving physical artifacts with visualization on digital media. In addition, I would appreciate feedback for visualization as well as interaction concepts. The extensive evaluation phase is planned with the beginning of March 2019, so the feedback in November would fit perfectly to improve the concepts. Focusing on the evaluation phase, experiences within field tests in museums would improve my work. On the other hand, I could also benefit from a discussion about the technical perspective concerning experiences with software as well as hardware which work or not.

Acknowledgements

I would like to thank my supervisor Wolfgang Aigner for his support and encouragement as well as Grischa Schmiedl and Markus Seidl for pushing me in doing my doctoral studies and offering critical feedback, Magdalena Boucher for

[1] http://meeteux.fhstp.ac.at

[2] The categorization of the researched exhibits can be found at http://meeteux.fhstp.ac.at/assets/matrix/.

creating amazing sketches as well as Christina Stoiber and Markus Wagner for giving constructive feedback to my manuscript.

This work is supported by the Austrian Federal Ministry of Science, Research and Economy under the FFG COIN program (MEETeUX project, no. 856308) as well as the Internet Foundation Austria (IPA) with a PhD scholarship (no. 1587).

REFERENCES

1. Benjamin Bach, Ronell Sicat, Hanspeter Pfister, and Aaron Quigley. 2017. Drawing into the AR-CANVAS: Designing embedded visualizations for augmented reality. In *Workshop on Immersive Analytics, IEEE Vis*.
2. Inna Belinky, Joel Lanir, and Tsvi Kuflik. 2012. Using Handheld Devices and Situated Displays for Collaborative Planning of a Museum Visit. In *Proc. of PerDis*. ACM, 19:1–19:6.
3. Kerstin Blumenstein, Martin Kaltenbrunner, Markus Seidl, Laura Breban, Niklas Thür, and Wolfgang Aigner. 2017. Bringing Your Own Device into Multi-device Ecologies - A Technical Concept. In *Proc. of ISS*. ACM.
4. Kerstin Blumenstein, Christina Niederer, Markus Wagner, Grischa Schmiedl, Alexander Rind, and Wolfgang Aigner. 2016. Evaluating Information Visualization on Mobile Devices. In *Proc. of the Sixth Workshop on Beyond Time and Errors on Novel Evaluation Methods for Visualization*. ACM, 125–132.
5. Wolfgang Büschel, Annett Mitschick, and Raimund Dachselt. 2018. Here and Now: Reality-Based Information Retrieval: Perspective Paper. In *Proc. of CHIIR*. ACM, 171–180.
6. Alan Cooper, Robert Reimann, and Dave Cronin. 2007. *About face 3: the essentials of interaction design* (3 ed.). Wiley Pub., Indianapolis, IN.
7. Riccardo Dini, Fabio Paternò, and Carmen Santoro. 2007. An Environment to Support Multi-user Interaction and Cooperation for Improving Museum Visits Through Games. In *Proc. of MobileHCI*. ACM, 515–521.
8. Tanja Döring, Alireza Sahami Shirazi, and Albrecht Schmidt. 2010. Exploring Gesture-based Interaction Techniques in Multi-display Environments with Mobile Phones and a Multi-touch Table. In *Proc. of AVI*. ACM, 419–419.
9. Neven A. M. ElSayed, Bruce H. Thomas, Ross T. Smith, Kim Marriott, and Julia Piantadosi. 2015. Using augmented reality to support situated analytics. In *Proc. of VR*. 175–176.
10. Giuseppe Ghiani, Fabio Paternò, Carmen Santoro, and Lucio Davide Spano. 2009. A Location-Aware Guide Based on Active RFIDs in Multi-Device Environments. In *Computer-Aided Design of User Interfaces VI*. Springer, London, 59–70.
11. George E. Hein. 1998. *Learning in the museum*. Routledge, London ; New York.
12. Da-Yuan Huang, Shen-Chi Chen, Li-Erh Chang, Po-Shiun Chen, Yen-Ting Yeh, and Yi-Ping Hung. 2014. I-m-Cave. In *Proc. of ICME*. IEEE, 1–6.
13. Yvonne Jansen, Pierre Dragicevic, Petra Isenberg, Jason Alexander, Abhijit Karnik, Johan Kildal, Sriram Subramanian, and Kasper Hornbæk. 2015. Opportunities and Challenges for Data Physicalization. In *Proc. of SIGCHI*. ACM, 3227–3236.

14. Heidi Lam, Enrico Bertini, Petra Isenberg, Catherine Plaisant, and Sheelagh Carpendale. 2012. Empirical Studies in Information Visualization. *TVCG* 18, 9 (2012), 1520–1536.
15. Jonathan Lazar, Jinjuan Heidi Feng, and Harry Hochheiser. 2010. *Research Methods in Human-Computer Interaction* (1 edition ed.). Wiley, Chichester, West Sussex, U.K.
16. Yu-Chang Li, Alan Wee-Chung Liew, and Wen-Poh Su. 2012. The digital museum. In *ICIDT*, Vol. 3. 646–649.
17. Silvia Miksch and Wolfgang Aigner. 2014. A matter of time. *C&G* 38 (2014), 286–290.
18. Paul Milgram, Haruo Takemura, Akira Utsumi, and Fumio Kishino. 1995. Augmented reality: a class of displays on the reality-virtuality continuum. In *Telemanipulator and Telepresence Technologies*, Vol. 2351. International Society for Optics and Photonics, 282–293.
19. Tamara Munzner. 2009. A Nested Model for Visualization Design and Validation. *TVCG* 15, 6 (2009), 921–928.
20. Donald A. Norman and Stephen W. Draper (Eds.). 1986. *User centered system design: new perspectives on human-computer interaction*. CRC Press.
21. Zachary Pousman and John Stasko. 2006. A Taxonomy of Ambient Information Systems. In *Proc. of AVI*. ACM, 67–74.
22. Tobias Skog. 2004. Activity Wallpaper. In *Proc. of DIS*. ACM, 325–328.
23. Martin Spindler. 2012. Spatially Aware Tangible Display Interaction in a Tabletop Environment. In *Proc. of ITS*. ACM, 277–282.
24. Matthew Ward, Georges G. Grinstein, and Daniel Keim. 2010. *Interactive data visualization*. A K Peters, Natick, Mass.
25. Sean Michael White. 2009. *Interaction and Presentation Techniques for Situated Visualization*. Technical Report CUCS-046-09. Columbia University.
26. Wesley Willett, Yvonne Jansen, and Pierre Dragicevic. 2017. Embedded Data Representations. *TVCG* 23, 1 (2017), 461–470.
27. Christian Winkler, Markus Löchtefeld, David Dobbelstein, Antonio Krüger, and Enrico Rukzio. 2014. SurfacePhone. In *Proc. of SIGCHI*. ACM, 3513–3522.
28. Craig Wisneski, Hiroshi Ishii, Andrew Dahley, Matt Gorbet, Scott Brave, Brygg Ullmer, and Paul Yarin. 1998. Ambient Displays: Turning Architectural Space into an Interface between People and Digital Information. In *Cooperative Buildings: Integrating Information, Organization, and Architecture (LNCS)*. Springer, Berlin, Heidelberg, 22–32.