InfoGrid: Acceptance and Usability of Augmented Reality for Mobiles in Real Museum Contexts

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Abstract

In this paper, we present the concept and prototype of the Augmented Reality (AR) app InfoGrid for mobile devices, which enables museum visitors to experience digital media as an overlay for physical exhibits. With InfoGrid, it is possible to view 3D objects, videos, and animations, or listen to audio recordings prepared by museum professionals. InfoGrid interfaces with our web-based framework, the Network Environment for Multimedia Objects (NEMO), which stores and handles all data in a cloud-based semantic database. In this contribution, we present the usability field evaluation of InfoGrid in a nature museum, using the System Usability Scale (SUS) questionnaire and additional observations.

1 Introduction

Museums curators spend a lot of effort to make their exhibitions as interesting as possible for their visitors and to raise interest for the key topics of their museum. Using Augmented Reality (AR) in museum context, curators have a new medium at their disposal to augment the exhibits with a digital information and presentation layer. AR technology in conjunction with public displays allows providing personalized and contextualized interactive information to the exhibition without the necessity for providing extra physical space. Visitors enjoy the original artwork or artifacts of the museum while receiving additional and personalized information of interest to them.

For more than 10 years, the Institute for Multimedia and Interactive Systems (IMIS) at the University of Luebeck runs the research and transfer project *Ambient Learning Spaces (ALS)* (T Winkler, Scharf, Hahn, & Herczeg, 2011), supported by the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG). In the project we developed digitally enriched body- and space-oriented learning environments for schools and museums. In these environments, users can interact with multiple interconnected display devices in physical space to learn cooperatively. In the context of ALS, body- and space-oriented human-computer interaction equipped with cross-device interaction (XDI) build a conceptual foundation. For this purpose, a family of learning applications, such as InfoGrid, have been developed as frontend applications for ALS. For museum curators we provide the web-based ALS-Portal to add and

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edit content for these ALS applications. We furthermore developed tools accessible through the ALS-Portal that enable museum curators to create and edit 3D objects (Bouck-Standen, Ohlei, Daibert, Winkler, & Herczeg, 2017). Providing these applications, our research focuses on self-directed learning with interactive media (Thomas Winkler, Bouck-standen, Ide, Ohlei, & Herczeg, 2016). With the support of our project partners, two schools and two museums, we study the use of these systems on-site in the field with real users, primarily children and youth. One of our museum project partners, where we deployed the smartphone app InfoGrid, is the municipal Museum of Nature and Environment (MNU) in Luebeck, Germany. Its exhibitions offer insights into the natural history of the country of Schleswig-Holstein and the rich flora and fauna of the Luebeck area.

2 Visitor Scenario for the Museum of Nature and Environment

Clara Miller arrives at the Museum of Nature and Environment (MNU) with her children Sarah and Jonas. Clara notices a poster titled "Story-telling Stones". Sarah and Jonas get curious and use the QR code on the poster to download and install InfoGrid onto their mobiles. After purchasing a ticket, they enter the museum and activate the app on their smartphones. Launching InfoGrid, the app announces the museum tour "Story-telling Stones" with a hint that they may retrieve AR content whenever they encounter a small sticker with a spade symbol in the corresponding exhibition area, a staging of a paleontological excavation site. Sarah and Jonas already know augmented reality from a street game they have been playing a few months ago.

For now, Clara puts her smartphone away while Sarah and Jonas are directly heading for the pieces of clay and petrified bones on the floor. Clara recognizes the symbol that was previously visible on the poster and also shown by InfoGrid. Using her smartphone, Clara starts the app and follows the instructions on the screen. Sarah and Jonas are already holding their smartphones in the direction where the camera captures the corresponding area around the spade symbol. Suddenly, Sarah can see a 3D skeleton of a primordial Baleen Whale, where in reality just a fossil jaw fragment is displayed in the exhibition. Sarah and Jonas are moving around the petrified bone with their smartphones, taking a look at the whale's skeleton in more detail from all sides. When Jonas taps the screen with his finger, the whale skeleton is blended by a 3D object of a reconstruction of the whale's body, which shows animated swimming motion. At the same time she hears an explanation about the anatomy, age, and other facts around an extinct species of a Baleen Whale through the smartphone speaker. When she holds her smartphone in the direction of an excavation sign, she can see a video on her smartphone, with an excavation team working in the pit of Gross Pampau. Overall, Clara, Sarah and Jonas look at various media in several locations in the exhibition area.

3 Related Work

AR applications have already been setup for many exhibitions. Sammerauer et al. (Sommerauer & Müller, 2018) show that visitors using augmented reality technology performed significantly better on knowledge acquisition and retention tests related to augmented exhibits than to non-augmented exhibits in the short term. AR applications running on smartphones and tablets can extend the possibilities of museums not just in digitizing data, but also in making artifacts interactive (Dirgantoro, Joseph, & Martinez, 2016). Although putting AR content into the exhibition is harder to achieve, it offers more advantages to museum visitors than compared to Web3D and VR exhibitions. The augmentation of the real-world environment can lead to an intuitive access to the museum information (Styliani, Fotis, Kostas, & Petros, 2009).

4 InfoGrid and NEMO

Inside the museum's exhibition area the exhibit "Story-telling Stones" was prepared with seven image markers which could be scanned by InfoGrid. The app uses image recognition through the camera of the visitors' mobile devices to detect the exhibits. Next to the image markers, small labels with spade icons were attached to indicate that augmented content can be accessed at these specific locations. Once started, the app recognizes the markers and displays movies or 3D objects (see Figure 1), which have been prepared with the support of the curator of the museum.

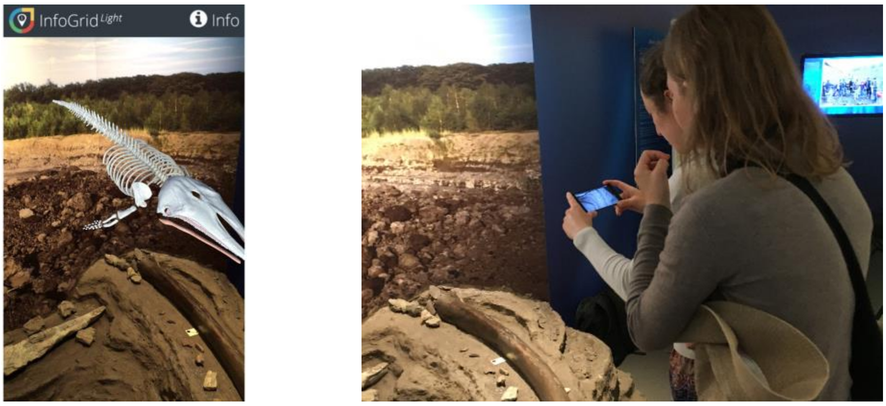

Fig. 1. Left: Screenshots of the AR view of InfoGrid showing a 3D object of whale bones displayed in relation to physical bones inside the exhibition. Right: Museum visitors scanning a bone of a whale with InfoGrid.

Once the exhibit is recognized, InfoGrid displays the corresponding personalized and individualized media files provided by our technological backend, the *Network Environment for Multimedia Objects (NEMO)*. NEMO is a the cloud-based framework and computing platform for all ALS applications (Bouck-Standen, 2016). It stores all media in a context specific semantic model, which supports the use by ALS applications. NEMO enables mobile and stationary devices to exchange media through a web-based API. The curators can use NEMO to create and interrelate media, which will be ubiquitously presented to the visitors as augmentations of the physical exhibition on different digital devices, like digital tabs (smartphones), pads (phablets, tablets) or boards (large stationary multi-touch screens) as denoted by Mark Weiser (Weiser, 1991). Depending on the personal profile of the visitors, certain media will be selected for presentation. This creates an interactive personalized access to the digital information layer of the exhibition for the visitors.

5 Evaluation

InfoGrid was evaluated in a usability study based on the System Usability Scale (SUS) (Brooke, 1996) and additional visitor observations among a heterogeneous group of people.

Study Design: The evaluation took place on the night of Museums in Luebeck in August 2017 when many visitors were expected. The app had been announced in advance in the program manifesto for the night. Two employees were in charge of the evaluation, answering visitor's questions and handing out the questionnaire. Along with the questionnaire, visitors were asked for permission to take photos of them while using the app (see Figure 1). To download the app access to a public Wi-Fi network was provided inside the Museum.

Study Participants: Several hundred visitors visited the MNU during that night. Around 70 of these visitors used the app, either with their own mobile phone or with a demo device. 31 visitors agreed to fill out the questionnaire and became part of the study. The average age of the participants was 34.67 ± 17.39 years. 22 out of 31 visitors came from Luebeck. The rest of the visitors came from other parts of Germany.

Instruments: For the evaluation, the used instruments were the app itself, a questionnaire, anonymous statistics of the app usage and observations.

Study Procedure: When visitors came to the exhibition area, they first connected to the Wi-Fi network provided and downloaded the app. Then they used the app inside the exhibition area. When they finished using the app they were asked to fill out the SUS questionnaire. The SUS values range from 1 (lowest) to 5 (highest) for every odd question id, and from 1 (highest) to 5 (lowest) for every even question id.

Results: The download statistics show that 23 visitors downloaded the Android and 14 visitors the iOS version of the app. Around 35 visitors used the demo device. The results of the SUS test are shown in Table 1. The usability score of the SUS test was 86.04 (of 100; N=31) which is interpreted as an excellent usability (Bangor, Kortum, & Miller, 2009). The installation of the app on the visitors' devices worked fine in all but two cases.

Discussion: The download statistics show that it is reasonable to offer an Android as well as an iOS version of InfoGrid. But still some users might not be able to use the app on their own mobile device, because (a) it is an unsupported smartphone (b) the battery level is depleted (c) the storage space of the mobile is full or (d) they left their mobile device at home.

The excellent SUS value in all areas shows equally good values. The statement number 6 has the highest standard deviation. While filling out the form some visitors asked what was meant with the term "inconsistency" (in German "Inkonsistenz"). We assume that the difficulties in understanding the term played a role in the high SD.

ID	Statements	Total Sample N; M (SD)
1	I think that I would like to use this system frequently.	31; 4.52 (0.57)
2	I found the system unnecessarily complex.	31; 1.39 (0.50)
3	I thought the system was easy to use.	31; 4.58 (0.50)
4	I think that I would need the support of a technical person to be able to use this system.	31; 1.74 (0.93)
5	I found the various functions in this system were well integrated.	31; 4.16 (0.90)
6	I thought there was too much inconsistency in this system.	31; 1.97 (1.35)
7	I would imagine that most people would learn to use this system very quickly.	31; 4.68 (0.48)
8	I found the system very cumbersome to use.	31; 1.52 (0.63)
9	I felt very confident using the system.	31; 4.48 (0.77)
10	I needed to learn a lot of things before I could get going with this system.	31; 1.39 (0.62)

Abbreviations: N, number of participants, M, mean; SD, standard deviation; SUS, System Usability Scale

Table 1: Mean ± standard deviation of the SUS (statements originally provided in German.). The SUS values range from 1(lowest) to 5(highest) for every odd question id and from 1(highest) to 5(lowest) for every even question id.

Inside the exhibition area there were seven image markers ready to be scanned with the mobile device. To indicate image markers, small spade icon labels were attached to it. The observation has shown that with the camera of their mobile devices, multiple visitors scanned the spade icon label instead of the image marker. It was also observed that the visitors enjoyed interaction with the interactive 3D objects more than watching the videos.

6 Conclusions and Future Development

In this contribution, we illustrate the prototype setup of InfoGrid in the Museum of Nature and Environment Night of Museums in August 2017. The evaluation shows that the app runs well on the visitor's devices and has a high usability, according to the SUS score. Museum curators and professionals can use InfoGrid in their exhibition to digitally augment exhibits. In our future work, we will study how museum curators and professionals can create media and augmentations without professional help. Next to the mobile application InfoGrid we also developed an application called *InteractiveWall (IW)* running on large public displays in schools and museums. We plan to interconnect InfoGrid and the IW to evaluate the possibility for further personalization of the presented information. In this context, the interconnection between multiple distributed instances of NEMO, e.g. connecting museums and schools, will be subject to evaluation, as well as the effects of personalization of augmented content in Ambient Learning Spaces.

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References

Bangor, A., Kortum, P., & Miller, J. (2009). Determining What Individual SUS Scores Mean: Adding an Adjective Rating Scale. *J. Usability Studies*, *4*(3), 114–123. Retrieved from

Bouck-Standen, D. (2016). *Erstellung einer API zur Anbindung des Network Environment for Multimedia Objects an die Ambient Learning Spaces*. University of Luebeck. https://doi.org/10.13140/RG.2.2.12155.00804

Bouck-Standen, D., Ohlei, A., Daibert, V., Winkler, T., & Herczeg, M. (2017). NEMO Converter 3D : Reconstruction of 3D Objects from Photo and Video Footage for Ambient Learning Spaces. In J. L. Mauri & B. Gersbeck-Schierholz (Eds.), *AMBIENT 2017; The Seventh International Conference on Ambient Computing, Applications, Services and Technologies* (pp. 6–12). Barcelona, Spain: IARIA.

Brooke, J. (1996). *SUS - A quick and dirty usability scale*. *Usability evaluation in industry* (Vol. 189). CRC Press. https://doi.org/10.1002/hbm.20701

Dirgantoro, B. P., Joseph, J., & Martinez, L. (2016). Extending Information On Museum Artefacts Through Augmented Reality : Indonesian National Museum Case, *01*(01), 7–13.

Sommerauer, P., & Müller, O. (2018). Augmented Reality in Informal Learning Environments : Investigating Short - term and Long - term Effects. *Proceedings of the 51st Hawaii International Conference on System Sciences (HICSS)*, *9*, 1423–1430.

Styliani, S., Fotis, L., Kostas, K., & Petros, P. (2009). Virtual museums, a survey and some issues for consideration. *Journal of Cultural Heritage*, *10*(4), 520–528.

Weiser, M. (1991). The Computer for the Twenty-First Century. In *Scientific American* (pp. 94–104).

Winkler, T., Bouck-standen, D., Ide, M., Ohlei, A., & Herczeg, M. (2016). InteractiveWall 3.1 - Formal and Non - Formal Learning at School with Web - 3.0 - based Technology in Front of Large Multi-touch Screens. In *Outstanding Paper Award*. Washington: AACE EdMedia.

Winkler, T., Scharf, F., Hahn, C., & Herczeg, M. (2011). Ambient learning spaces. *Education in a Technological World: Communicating Current and Emerging Research and Technological Efforts*, 56–67.