Edutainment & Engagement at Exhibitions: A Case Study of Gamification in the Historic Hammaburg Model

Steffen Haesler, Karen Obernesser, Tino Raupp, Christoph Jahnke, Jonathan Stapf, Julia Bräker, Paul Lubos, Gerd Bruder, Frank Steinicke

Human-Computer Interaction, Department of Informatics, Universität Hamburg

Abstract

Gamification in the context of interactive exhibitions has enormous potential to attract visitors and improve their engagement, flow, and learning, in particular when other groups of visitors can share the experience. This paper describes a case study in which we use game-design elements for an interactive and collaborative exploration of a virtual exhibition. Using distinct user interfaces and input devices – a head-mounted display (HMD) and a multi-touch table – two players can explore the virtual 3D Model of the "Hammaburg", which is a medieval castle of the 9th century and the origin of the German city Hamburg. One player is using a multi-touch table from a bird's eye perspective, whereas the other player is using an immersive HMD in egocentric perspective, combined with a game controller to navigate through the virtual environment (VE). Both players can interactively explore the shared VE and play a mini game together. The mini game consists of collaborative tasks related to a medieval pottery scene. We performed a user study to evaluate the game concepts and user engagement. The results suggest that communication between the players – both verbal and nonverbal – is a challenging task, and seems especially difficult for the HMD player. Furthermore, this paper proposes an exploration of possibilities and challenges of this setup.

1 Introduction

The goal of many exhibitions is to not only attract visitors but to provide a rich memorable interactive experience and engagement with the exhibits. Gamification and edutainment are two similar approaches to address this challenge. Gamification denotes the application of game-design elements and principles in traditionally non-game contexts in order to improve user engagement, flow and learning (Deterding et al. 2011). In a similar way, educational

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entertainment, sometimes referred to as edutainment, includes content that is primarily educational, but has incidental entertainment value, or vice versa.

Recently, there are some studies on interactive exhibitions and their value to visitors using edutainment material. More and more research groups start investigating the effects of gamification and entertainment on learning educational material in museum contexts (Horn et al. 2014; Leong et. al., 2014; Moesgaard 2015, Göbel et al. 2006). The goal of these works is to determine what makes a museum exhibit engaging and educational. (Lingnau et al. 2012, Haesen et al. 2012).

In many scenarios, multi-touch setups such as in tabletop configurations are used due to their inherent ability to allow several users to interact from different sides (Correia et. al. 2010; Horn et al. 2014). HMDs are also already used for educational and training purposes to help people learn different activities or understand processes (Kozhevnikov et al. 2013, Ragan et al. 2010).

In contrast, the goal of our project was not only to provide a rich user engagement and interactive experience but also to make use of heterogeneous technology involving two or more people. This paper investigates a collaborative multiplayer virtual exhibition using immersive virtual reality (VR) as well as multi-touch technologies in a shared virtual environment (VE). VEs that allow multiple users to meet, work, learn, or play together are called collaborative virtual environments (CVEs). CVEs are used for different domains like education, industrial training, research, and community building (Langbehn et. al. 2016, Zhang & Furnas, 2002).

Focused on virtual exploration, we created an interactive, cooperative multi-interface game to evaluate a possible setting in a museum. Therefore, we want to explore the combination of these technologies and determine challenges as well as solutions.

The remainder of this paper is structured as follows. Section 2 introduces our setup. Section 3 describes a user study that we performed in order to evaluate the usefulness of the setup. Section 4 provides a general discussion. Section 5 concludes the paper and gives an overview of future work.

Figure 1: Illustration of the setup of the multi-user interactive exhibition. Player [1] is using the multi-touch table and player [2] is wearing a head-mounted display. Both players are present in the physical setup while experiencing the same shared virtual space from different viewpoints. (Note that the distance and angle of users is just for photographic reasons. Usually users cannot see the screen of the other player). The inset shows a user performing the virtual pottery task using touch input to form virtual clay.

2 Interactive Shared Exhibition Setup

As illustrated in Figure 1, one of the players is wearing an HMD and can move freely through the VE with a Wii remote input device. The other player is standing in front of a multi-touch table where they can overlook the entire Hammaburg in bird's eye perspective. The Hammaburg is a medieval castle of the 9th century and the origin of the German city Hamburg from which the city has evolved over the centuries. The virtual avatar of the HMD user is visible to the player at the touchscreen and the movement is synchronized through the network. This setup allows a collaborative exploration, in which two users can explore a shared VE from different perspectives (Langbehn et al. 2016). By cooperating in the shared virtual space, both players can participate differently in an interactive mini game. For instance, in order to create a virtual clay pot (see inset in Fig. 1), they have to synchronize their actions: In order to heat the virtual oven, the HMD player has to carry chopped wood in the virtual world to the touch player, who takes the wood and uses it to heat the oven.

2.1 Hardware

Fundamental for the Hammaburg project was the selection of suitable displays and input devices to maximize usability and to provide a rich and joyful user experience.

2.1.1 Fully-Immersive HMD Setup

One of the players is immersed into the medieval Hammaburg with a first-person perspective using an HMD. Given a Nintendo Wii Remote (Wii-mote) with an attached Nunchuk, the player is free to walk and jump within the scene based on a view-directed steering metaphor using the orientation of the HMD. In the wood-chopping task, the HMD player can chop wood by raising and lowering the Wii-mote like an ax, making use of the controller's inertial measurement unit. Since the Wii-mote is connected wirelessly through a Bluetooth connection to the rendering workstation, the player has a high degree of freedom of movement. To read the sensor data from the Wii-mote we used the Unity Wii Remote API[1].

2.1.2 Semi-Immersive Multi-Touch Table

The second player used the iSpace (Lubos et al. 2014) a multi-sensor touch interface with a 55” screen. With touch gestures for panning, rotating and zooming, the user can navigate in the scene. By a long press gesture the user can create a “God’s Beam”, i.e., a landmark looking like a vertical beam of light as shown in Figure 1. The landmark is visible for the HMD player as well, to help him navigate. The touch player can therefore, give directions to the HMD player. In the cooperative pottery task, the perspective changes and the user can shape a pot with touch gestures with their fingers (see inset in Fig. 1). We implemented touch gestures on the multi-touch table using TouchScript for Unity[2].

2.2 Software Architecture

We used the Unity3D game engine version 5.3.3 on Windows 8 PCs. For the network architecture, we used the Unity3D high-level scripting API to control game states and invoke actions on client and server. The project was organized by a model-view-controller-based architecture, enhanced with network-managing classes (Reenskaug 1979). The HMD player's virtual avatar position, rotation, and movement, the “God’s Beam” landmark, handover objects like wood, and the game states are being synchronized. For network performance issues some objects are not being synchronized, e.g. the non-player characters (NPCs).

[1] Unity Wii Remote API Github: https://github.com/Flafla2/Unity-Wiimote/releases (last retrieved March 29th, 2016)

[2] Touchscript for Unity: http://touchscript.github.io/ (last retrieved March 29th, 2016)

3 Experiment

In this quantitative experiment, we evaluated the two-player concept in general and our interactive Hammaburg exhibition model in specific.

3.1 Participants

We recruited ten participants (7 male, 3 female) between the age of 20 and 58 (M = 25.5). All participants were students of the local department of informatics at our university. All participants had normal or corrected-to-normal vision. None of our participants reported a vision disorder. The total time per participant was 45 minutes. The total time wearing the HMD or using the iSpace multi-touch table was approximately 15 minutes each.

3.2 Materials

The study was conducted in a laboratory setting. We used two Windows 8 computers; one connected to the iSpace stereoscopic multi-touch table and the other connected to an Oculus Rift Development Kit 2 with a resolution of 960x1080 pixel per eye. They were located in the same room at an approximately two-meter distance but could not see the screen of the respectively other player. The multi-touch table player was standing at arm length in front of the multi-touch table, which was tilted at a 75-degree angle at 1.1-meter height. The HMD player was seated in a comfortable position in a swivel chair, with the Wii-mote in one hand and the Nunchuk in the other hand, depending on preference. The visual stimulus was the Hammaburg model, as shown in Figure 1.

3.3 Methods

We used a within-subject design. There were two conditions tested in the experiment: The HMD condition, where the participant was using the HMD, and the multi-touch table condition, where the participant was using the iSpace. The starting condition was randomized for each participant to counteract possible habituation effects of the setting. In both conditions, participants had the possibility to first explore the Hammaburg and then play the virtual pottery mini game.

In all cases, participants interacted with a partner played by one of our research assistants using the other interface. We chose to use a research assistant as the other player to systematically control the process of the experiment and to ensure the same context (e.g., guiding the HMD player to specific landmarks using the “God’s Beam”) for every participant. The research assistant was trained before on how and what to communicate to the participant. Participants could hear the partner but could not see the screen of the other one. A questionnaire with different items regarding the model, the communication between the players and the feeling of connectedness to the other player were evaluated with Likert scales from one to five, where one represents a strong negative response and five a strong positive response.

Examples for items on the questionnaire are “How strongly did you feel connected to the other player?” and “How helpful did you find the “God’s Beam” as a guiding tool?”.

To collect subjective data, we used the think-aloud method to get an overall view on the user experience. We analyzed the results by looking at usual comments by the users. To evaluate the VR experience wearing the HMD we used the Simulator Sickness Questionnaire (SSQ) (Kennedy et al. 1993), which measures sickness symptoms in VEs and the Slater-Usoh-Steed Presence Questionnaire (SUS), measuring the sense of being present in the VE, in the HMD condition (Slater et al. 1994).

4 Results

In general, in the HMD condition the mean SSQ score, was 4.1 (SD=4.53) before the experiment and 9.7 (SD=7.42) after the experiment. This indicates a typical increase wearing an HMD like the Oculus Rift over the duration of the experiment. The mean SUS score, was 4.33 (SD = .95), which indicates a high sense of presence.

Throughout the experiment, we observed that the concept of two players using different user interfaces and displays was regarded as very interesting as reported by seven participants. Regarding our Hammaburg model as seen in Figure 3, participants found the model appealing. In the touch condition participants found the model even slightly more appealing (M=3.9, SD=1.0) than in the HMD condition (M=3.4, SD=0.7; see Fig. 3 “Model”). When participants were asked to rate the interaction with the partner during their exploration and during their mini game, participants in the HMD condition reported a lower interaction in the mini game (M=2.9, SD=0.9) than while exploring the Hammaburg (M=3.2, SD=0.8).

In the touch condition, results for the mini game and exploring the Hammaburg were similar, but in general slightly better than in the HMD condition (mini game: M=3.3, SD=0.9; Explore: M=3.3, SD=1.3; see Fig. 3 “Interaction Minigame” and “Interaction Explore”).

In the multi-touch table condition, participants reported a higher connection to the other player (M=3.0, SD=1.3) than in the HMD player condition (M=2.6, SD=1.6) (as seen in Fig. 3 “Connectedness”).

Some of the participants reported confusion on not knowing exactly what their partner was doing. Especially when wearing the HMD, participants reported they would have had a stronger connection if they could have seen what the person using the multi-touch table was doing.

Another appreciated aspect of the navigation in the same environment was the “God’s Beam”. Participants in the HMD condition (M=3.8, SD=0.6) and in the multi-touch table condition (M=3.8, SD=0.8) both reported that the “God’s Beam” was helpful to their navigation and communication (see Fig. 3 “God’s Beam”). Furthermore, eight participants stated that they could imagine using the multi-touch table with more than one player.

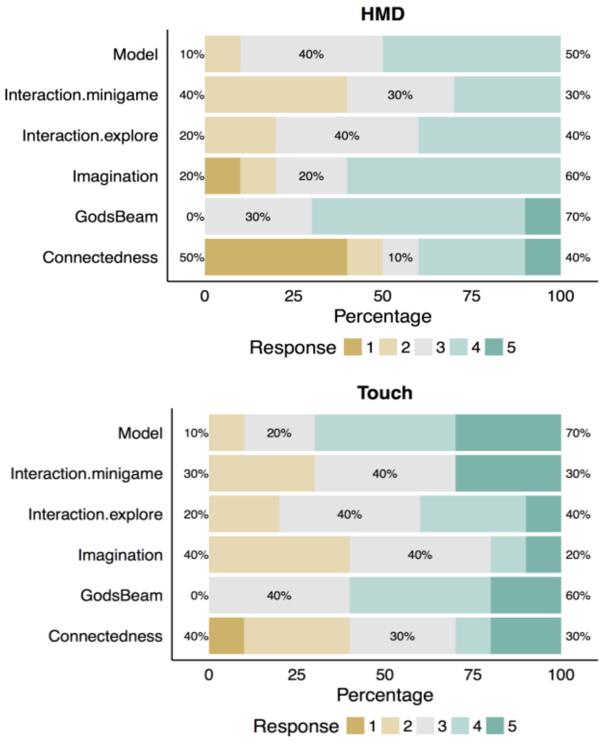

Figure 3: Results from the experiments comparing participants' responses on a Likert scale from one to five between the multi-touch table and HMD condition. One indicates a very low rating and five represents a very high rating regarding each question. The first one ("Model") compares the intuitiveness of the two-player game concept. The second ("Interaction Minigame") and third ("Interaction Explore") deal with the interaction with the partner while exploring or playing the mini game. "Imagination" compares if participants could imagine the medieval life in the Hammaburg better after the trial. "God's Beam" asses how helpful the God's Beam was for the given player. The last one, "Connectedness" compares the feeling of connection to the respectively other player.

4.1 Qualitative Data

For the majority of the participants, the interactive Hammaburg exhibition was visually attractive and generally appealing. The touch gestures used on the multi-touch table were familiar and easy to use. In the HMD condition, participants liked the choice of the Wii-mote as a controller. By experience, most of the participants tried to use the Wii-mote to pick up and carry the wood although it had no function in this task. They would have liked to see the other player's actions as well as get generally more feedback on what they were doing together.

5 Discussion

Generally, the game concept was regarded as intuitive, but not as intuitive as expected. Participants often reported confusion on the collaborative aspects of the project. We concluded that the project requires more information about purpose and functionality being conveyed to users before starting the experience in the Hammaburg. In addition, communication needed to be more supported (e.g., with a screen of the other user's perspective or an introduction explaining the roles to be played by both users). This is especially true for the HMD player, who was restricted in vision, which seems to have a great impact in feeling connected to the other player. We also noticed that participants wanted to use the interfaces more interactively, e.g., touching buildings and NPCs or trying to change the environment. Prominent in that matter was that most touch players tried to interact with the HMD players by touching the synchronized moving avatar. We concluded that this was another attempt to communicate with the partner, which is interesting for future revisions of this prototype.

6 Conclusion and Further Work

Further research could investigate how communication can be improved, particularly for the HMD player. A stronger connection to the other player could also be explored by adding more interactive elements like the "God's Beam". All NPCs and other moving objects could be synchronized between player sessions, to have more obvious landmarks supplementary to „God's Beam". Furthermore, menu navigation and tutorial sequences could be investigated, which could improve the intuitiveness of the setting. Another aspect that we just briefly evaluated is the educational benefit of such an immersive VE.

There could also be further investigation of the control methods. Alternatives for the Wiimote and Nunchuk, such as Oculus Touch or the HTC Vive controllers, omnidirectional treadmills or leaning interfaces could be explored.

In conclusion, the two-player concept seems to resonate well with users providing an elaborate and exciting experience with an interactive exhibition, although our qualitative evaluation revealed different areas for improvements and future research on collaborative interaction in shared virtual spaces.

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