Can’t Touch This – The Design Case Study of a Museum Installation

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Abstract

Museum exhibits offer particular challenges for the design of interactive installations, as visitors usually cannot directly interact with artefacts. This paper presents a depth-sensor based system for interaction via pointing gestures that we developed for an interactive museum installation (IMI), permanently installed in a showcase of the grave of a Germanic princess. Users interact by walking up to and pointing at artefacts within the showcase. Our IMI determines which artefact is addressed and displays corresponding information on a screen. The IMI also provides a setup-mode for curators for configuration. We describe the system, preliminary deployment observations, and the considerations involved in negotiating design options. Our case study exemplifies how domain restrictions, predominantly curatorial concerns, can significantly constrain the space of viable design choices, lead to discarding many novel and interesting interaction designs, and increase implementation effort.

1 Introduction

Museums want to increase visitor engagement by allowing for more interaction. But frequently, direct interaction with exhibited artefacts is prohibited due to the artefacts’ immaterial or material value. In this paper, we describe an installation system for such situations, which enables visitors to interact by pointing, and which augments an existing showcase. For this thesis project, we collaborated with the local museum of pre- and early history of Thuringia in Weimar, to create novel interpretation facilities for the *Prinzessin von Haßleben* exhibit – the grave of a Germanic princess from the 4th century CE. A showcase features the burial site as it was found, with a very rich and diverse collection of burial objects distributed around the skeleton.

In the early phases of the project, we walked through the museum with a curator, identifying potential exhibits to work with. The Haßleben grave was of mutual interest. From our perspective, it provided a unique challenge and triggered design ideas. The museum selected it as a priority. It is one of its showpieces, but curators feel it does not receive enough attention from museum visitors. This is partially due to its location on the 3rd level, which is

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not reached by all visitors, and if, then towards the end of their visit, when they have grown tired and less attentive. This motivated developing an installation that entices people to engage with the showcase contents and increases awareness of its significance. It was important for interaction to be intuitive and immediately accessible (i.e. not requiring use of potentially encumbering input devices, training, or long instructions). Moreover, any interference with the structure and appearance of the grave was out of the question. In this paper, we describe the development outcome, initial deployment test findings, and some of the considerations involved in negotiating design options, which often meant letting go of interesting design ideas to accommodate curatorial concerns. Moreover, due to the specific setup we dealt with, various practical constraints had to be resolved that constrained our design space.

Our IMI system (figure 1) enables interaction at a distance via pointing. Pointing is the main (and sole) interaction mode not only for visitors, but also for setup and configuration. Users point at artefacts in the showcase and are shown information on a screen. The system provides guidance on how to interact and select items. It is easy to maintain and enables curators to set up a new exhibit, thus reducing reliance on technical staff or companies, important in this context, as limited museum budgets often hinder technical innovation (Maye et al 2014).

Figure 1: (left, middle): The IMI inside the showcase of the grave of a Germanic princess. Who stands on the foot-prints can select artefacts by pointing. (right): Output screen and tracking sensor are embedded in the back wall.

2 Background

A common goal for many museums is to enhance visitor engagement and to increase their appeal. New trends in visitor studies emphasize multisensory and emotional engagement as well as the sociality of museum experience (Falk & Dierking 2012). While considerable work has provided access to digital assets in museums and enables interaction with databases or virtual representations (e.g. kiosk systems, touchscreens) (Grammenos et al. 2012), more direct interaction with the artefacts on display is less common. A downside of kiosk systems, touchscreens and multimedia guides is that these create a parallel experience, disengaging visitors from the exhibit or isolating them from another (Petrelli et al. 2013). While desirable (Chatterjee 2008), direct interaction with historical artefacts is challenging and often impossible. Precious objects need to be kept safe and preserved, often secured behind glass.

In such situations, pointing is still feasible. Although a very different type of action, it at least enables visitors to directly reference the artefact (instead of e.g., reading a number from a label and typing it into a device). Pointing is a natural gesture when investigating objects or an environment, and discussing with companions. Interactive VR or AR environments and gesture recognition technologies (Argelaguet & Andujar 2013, Wigdor & Wixon 2011) can thus make a difference compared to conventional systems. While less precise than pointing devices, un-instrumented in-air pointing tends to be less intrusive and more convenient (Brown et al. 2014). New low-cost tracking solutions such as the Kinect and Leap Motion provide affordable technology that enables unencumbered interaction, thus increasing accessibility in ‘walk-up and use’ scenarios (Ren & O’Neill 2013).

Virtual Reality technology (Sideris & Roussou 2002) has a long history in cultural heritage. Sparacino (2004) argued for instrumenting spaces so they are aware of visitors approaching, pointing and other gestures, and presented an exhibition where visitors could explore 3D models. With VR, visitors can explore virtual reconstructions of historic sites, investigate artefacts by scaling, moving and rotating them, puzzle broken pieces together etc. (Pietroni & Adami 2014, Schieck & Moutinho 2012). Gestural interaction encourages visitors to learn and explore playfully (Pietroni & Adami 2014) and Augmented Reality can integrate digital information into views of the real environment (Damala & Stojanovic 2012). Ridel et al. (2014) exemplify the potential of pointing applications with a ‘revealing flashlight’, where visitors point at a historical artefact to reveal details or original colouring (using spatial augmented reality / 3D projection mapping). Another inspiring example is an installation allowing visitors to explore projected X-Ray views of a Constable painting by pointing (vom Lehn et al. 2007). Our project is based on the VR interaction mechanism of 3D pointing, but does not utilize 3D graphics.

2.1 Context: The Museum and the Haßleben Exhibit

The museum of pre- and early history of Thuringia is a mid-sized museum run by the state’s archaeological agency. Despite its considerable size, it has only few staff, a director (and main curator), who is an archaeologist, a technician, a public relations person, a museum educator running workshops with schools, and floor and ticket sales staff. The museum features only little technology in museum installations and there was limited experience (this is common for small and mid-scale museums (Maye et al. 2014)), but curators were very interested to explore the new possibilities and improve visitor engagement.

The Haßleben grave was uncovered in 1910 on excavating a Germanic gentry cemetery. The princess was buried with an ornate, high quality set of objects, including a choker, golden fibulas, a ring, a collier of roman glass beads, roman coins, pottery plates and vessels, and the skeleton of a small dog. The grave indicates thriving trade and shows how the Germanic tribes began to adopt roman traditions. The site has been painstakingly reconstructed with all finds inside a sealed glass showcase to show how such a grave was set up.

Figure 2: View of the burial site from an adult height viewpoint.

An initial study at the start of our project aimed to find out how visitors currently attend to the Haßleben exhibit. Over 5 full days, we informally observed visitors and interviewed them after they exited the room, to see whether they had noticed the showcase and what they remembered. Overall 19 groups of visitors were observed and we could interview 14 of these (visitor numbers on this level are low). Many groups just looked for 10 seconds, and just about a third (six) spent 1-2 minutes; thus on average, groups spent less than a minute. Most visitors engaged closer by inspecting details, but only five groups looked at the text panel located left of the showcase. With the 14 interviewed groups, memory of the contents was sketchy. Only two groups remembered the fibula and hair-pin artefacts, and only two knew the grave contained an ornate wooden jewellery box of which only the fixings had remained (figure 4). Our observations confirmed curators’ impression that visitors do not realize the grave’s significance, and supported their wish to attract more attention to the showcase and encourage visitors to learn about the artefacts. Moreover, visitor groups were frequently seen to be pointing at the showcase and its contents when talking about these. This motivated us to pursue a pointing-based interaction design for the IMI.

3 The IMI (Interactive Museum Installation) System

We first describe the interaction process and then the technology. When one or more visitors are detected in front of the showcase, the screen on the wall at the back of the showcase changes from ‘hide’ mode (a photo resembling the back wall) to an invitation screen which instructs users to stand on the footprints in front of the showcase and to point at objects within (figure 3, left). The footprints constitute the dedicated input position (figure 1). Once a person is on this spot, the screen shifts to a birds-eye view map of the grave, with selectable artefacts highlighted. These have hot spots of varying size, enabling selection of objects. The screen also provides feedback by showing the current identified pointing target as a red spot. This assists users in selecting their target in case of an offset between detected and intended 3D vector of pointing (using one eye or the other can change perspective, eye dominance having an effect).

After several seconds dwell time on a hot spot, it is selected. A description is displayed on the screen alongside a series of detail images of the artefact (figure 4). Based on screen size (15,6”) and viewing distance (2,8m), text was limited to 300 characters in 70pt font. Once the slide show is through, the overview map is shown again. Users can interrupt and select another artefact (without map feedback). At any time, they can swap places or leave.

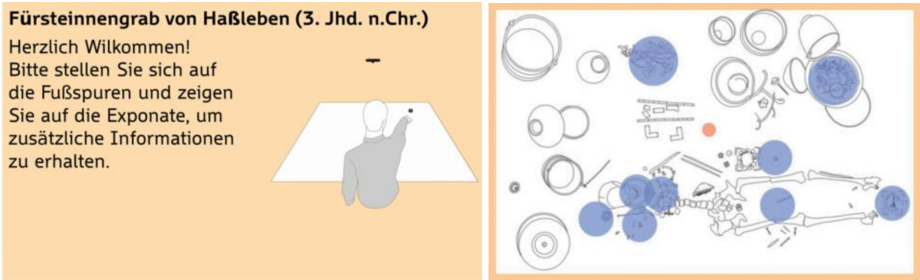

Figure 3: Introduction screen and overview map with small red dot as pointing feedback and blue artefact hot spots.

3.1 Technological Setup and Issues

We early-on decided to use a depth-sensor, specifically the ASUS Xtion Pro, which due to its small size is easier to insert and conceal in the showcase than the original Kinect. The FUBI framework (Kistler et al. 2011) (which incorporates the OpenNI SDK) is used for skeleton tracking to determine the 3D pointing vector. A 15,6” LED screen was selected which only emanates negligible heat – important for preserving artefacts. It is placed on book-ends attached to the back wall. Both screen and depth-sensor are connected via USB3.0 through a hole drilled into the back wall of the showcase to the main computer housed behind that wall (in a hidden crawling space accessible from the gallery space). Automatic booting at 8.30am and shutdown at 4.45pm reduce maintenance effort of our IMI.

The software was iteratively developed in the lab, once we could verify that the ASUS sensor works through the glass of the showcase. A mock-up of the showcase floor plate was set up on a table with the ASUS sensor on a tripod, and rigorous experimental tests were run to iteratively develop and test the ISI system and its 3D pointing vector algorithm. Furthermore, an open-door demo day was utilized for a stress test of the final software.

Inspired by recent efforts to lower costs and thresholds for museum innovation by empowering museum professionals to design, build, and maintain interactive exhibits (Petrelli et al. 2013, Kubitza et al. 2015), our IMI also has an authoring mode. Curators can set up a new installation, all with non-contact configuration. They first point at the corners of the showcase to define the reference plane, and then at the objects on this plane. A guided procedure has the user point repeatedly and from different positions, enabling the system to triangulate positions. Then, they can attach text and images via a file select desktop menu. At any time, points of interest (PoIs) and related contents can be deleted, added or changed. One can also edit the radius of a PoI’s hot-spot (bigger for a bigger object) and assign weights, which serve to attract the cursor in case of nearby and overlapping hot-spots.

Different from most Kinect-based projects in the literature that interact with screens and wall displays (e.g. Brown et al. 2014, Pietroni & Adami 2014, Schieck & Moutinho 2012), angular error is an issue for pointing along a horizontal plane, and increases with rising distance of the target. Small postural variations have increasing effect on accuracy with distance. Fortunately, tests revealed that user size had little influence, as long as users were > 1,50m. For shorter users, the angle is too flat. Based on the current implementation, a minimal hot spot radius of 100mm was chosen as threshold for set-up, and achievable pointing accuracy in authoring mode determines the hot spot size. A complex issue was dealing with eye-hand visibility mismatch (Mine 1995, Argelaguet et al. 2008), that is whether the user imagines the ‘pointing’ vector as going from elbow to finger or as ‘aiming’ from eye to finger. We thus calculate both pointing and aiming vector, resulting in a larger combined target area. While people seem to have a preference for either pointing or aiming, the IMI cannot exploit this, since there is no opportunity and time to personalize the system for a given visitors. In general, studies found large individual differences in how people point - there is thus no ideal general algorithm (Brown et al. 2014).

Figure 4: An artefact (jewelry box) with corresponding information on screen.

3.2 IMI Design: Domain-based Design Considerations

Besides of costs, usability, and maintenance, a range of issues had to be considered for hardware selection and setup, but also for the overall system design resulting from conservation, safety, and curatorial reasons. Discussions of design ideas with curators involved a complex negotiation of the design space around conflicts of interest between technological options, conservation, archaeological curation, and visitor / interaction experience. Final decisions lay with museum curators as problem (and artefact) owners.

We already mentioned a few requirements for museum installations in general. These need to be easy to use, need little training or instruction, and not require encumbering devices that could create a threshold for use. Given the museum’s limited technical experience, maintenance needs to be simple (therefore, automatic restart and shutdown each day). From a conservation standpoint, the integrity of artefacts had to be ensured and protected from damage and decay. This meant that devices inside the showcase should not emanate more than negligible heat or air flow, nor create any other hazard, constraining choices for display technology. For similar reasons, maintenance should not require opening up the showcase and treading upon the grave. This also affected the development process - given the logistics of installing devices, it was not possible to test prototypes in-situ. Moreover, curators wanted any instrumentation and augmentation to be as discrete as possible, so as not to distract from, disturb, obstruct or alter the view of the burial site, presenting it exactly as excavated.

Early ideas of an interactive table with replicas next to the showcase encountered the problem that it would need to be extremely low to not occlude view of the grave (which is fairly low) and would prevent people from stepping right up to the glass. Much consideration had to be taken of where to place the screen so it would not occlude the grave’s contents, change the view or distract, while still being easily visible. It thus could not be placed at the front of the showcase. Putting it *behind* the burial setup was the only option that did not occlude the view for anyone (from small children to tall adults). But curators also did not want us to place the screen right at the back wall on the ground, as this would alter the view. The steps of the back wall provided an opportunity to safely mount the screen higher up, at approximate eye height, where its frame would also blend in more easily in a low-lit area.

Various ideas for alternative displays and more direct pointing feedback had to be discarded. While technically interesting, an idea for actuated LED spotlights that follow users’ pointing (similar to Ridel et al.’s (2014) revealing flashlight) and brighten upon the artefacts was rejected, being prone to mechanical wear and failure of the mechanism, and difficult to maintain (requiring climbing inside the grave). Furthermore, the curators felt that a moving spotlight would be too distracting. They also argued against static spotlights that only go on when people point at the artefacts, as they felt this would still add too much visual noise, and preferred the showcase to be calm. We also discussed projecting onto the back wall. This would have had the benefits of providing a large surface, disappearing when not in use, and allowing for more atmospheric imagery. But installing a projector inside the showcase was out of the question. We further toyed with the idea of projecting against a matte overlay on the glass showcase, but this would have obstructed the view from some angles (to get the best view of some artefacts, one has to walk around the showcase). The Haßleben setup, with an enclosed glass casing, further meant that it was best to locate all technology in one corner, to avoid wiring long cables around the showcase or (not allowed) through the glass walls. This prevented us from mounting the motion-sensor to the ceiling. In addition, the FUBI framework is optimal for frontal detection – although in hindsight, some of our software effort could have been simplified with top-down tracking.

Overall, there was a combination of issues, including the concrete setup of the showcase, the nature of the exhibit (not isolated objects, but a site), and strict requirements from a cultural heritage preservation standpoint that restricted the design space. In addition, curators were not used to thinking about visitor interaction and prioritized archaeological truth as what they wanted visitors to experience. Thus, there was a learning process on both sides for curators and research team, which we knew we couldn’t rush.

3.3 Insights from Post-Deployment Tests

After installation of the IMI system, 58 participants were recruited for a deployment test. 22 were normal visitors we could recruit in the museum. To get more data, we solicited another 36 participants via our own networks (University students and staff). Participants were between 6 and 61 years old (Ø 31,5). After individually using the IMI for as long as they wanted (while a researcher observed and took notes), participants were interviewed and completed the System Usability Scale (SUS) questionnaire. Finally, they listed all artefacts they could remember. After spending (self-directed) between 2 to 6 minutes with the installation, participants could all remember about half of the artefacts in the showcase, in particular those featured in the IMI. The IMI scored well on the SUS questionnaire, with an overall averaged score of 77,5. Most questions had above 70 (in the literature considered ‘good’). The lowest score was 68 (‘ok’, for ‘I thought the system was easy to use’) and the highest 90 (‘excellent’) for ‘I did not need to learn a lot of things before I could get going’).

Despite the positive SUS rating, we observed a range of issues that hampered fluid interactions and interfered with participant’s desire to focus on the artefacts. Some participants stated they would want to see the visual feedback closer to the exhibit plane or within view, making it easier to glance back and forth between the information on-screen and artefacts. This confirmed that our original plan to place the screen at the back wall of the grave, close to the ground, would have been advantageous from a user interaction point of view. We further observed many participants relying predominantly on the screen to hit a target, rather than looking down at the grave. This creates split attention, which can be cognitively demanding. Our early idea of moving spotlights would have eliminated the need to check the screen, but had been deemed to be too distracting. Here, the curators’ ideal of ‘unaltered appearance’ creates an inherent conflict with usability, and, almost ironically, may distract attention from the exhibit. This exemplifies a trade-off between usability and curatorial concerns, exacerbated because the exhibit is to present the grave exactly as it was found.

Due to the low visitor numbers, it was considered impractical to run an observational study. Instead we analysed log-file data from 31 days. This recorded 410 sessions. A session starts when the system detects a person in front of the showcase. 206 were ‘empty’ sessions, i.e. visitors were detected, but did not select objects by pointing. Thus, almost half the (detected) people passing through the room interacted with the IMI. The average length of stay for IMI users was 1:34 minutes, whereas in our initial observation pre-deployment people on average spent less than a minute (and only a third over a minute). This provides an indication that engagement with the showcase has increased. We acknowledge that some visitors might evade detection by the depth sensor (e.g. walking along the other side of the room), skewing our data. Overall, 391 artefacts were selected in 204 sessions, 1.5 on average per session. The majority (63.2%) of transitions between selections were between artefacts located further apart in the showcase. This indicates that our system helped to direct visitors' attention across the entire exhibit. As no further data on empty sessions was logged, we unfortunately cannot tell how long visitors who did not interact with the IMI (point) investigated the showcase visually.

4 Conclusion

Our IMI system provides a suitable option for curators to enhance displays in ways compatible with hard domain constraints: Specifically, our system does not require altering the display’s contents or compromising the displayed artefacts’ state of preservation. Apart from the tracking sensor and screen, no other devices are necessary - visitors interact by simply pointing to receive information on the artefacts. Our trials confirm that the system works intuitively for a wide range of visitors and appears to increase the number of visitors that engage with the exhibit. In particular the IMI’s overview map highlights objects that are easily overlooked due to their small size.

A technical challenge has been to adapt depth-sensor-based motion sensing technology to determine pointing targets on a horizontal plane, to account for angular error, eye-hand visibility mismatch, and pointing inaccuracy. Limitations of accuracy are partially due to the requirements for ‘walk up and use’ interaction, which does not allow for user calibration or preferences.

Some of the key insights in this project relate to the host of domain requirements and constraints, some intrinsic to the exhibit and some emerging from curators’ mind frame, where archaeological truth had highest priority, which prohibited more experimental approach and presentation. Repeatedly, this multifarious set of constraints foreclosed alternative, technically more innovative approaches (e.g. actuated spotlights, deemed too distracting by curators and too maintenance intensive). This also resulted in conflicts with system usability, as when curators’ wish for an unaltered view of the burial site required moving the screen out of line-of-sight, resulted in split attention. Ironically, this prevents visitors from focusing on the exhibits, another desired outcome for curators. Our case study highlights the difficulties in doing justice to multiple valid concerns in museum exhibit design, and the learning process that we as researchers and curators alike have ahead of us in negotiating between visitor-focused interaction design, interesting technology ideas, and curatorial ideals.

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