AR EXPERIENCE DESIGN IN MUSEUMS:
DESIGNING FOR PEOPLE WITH CONSTRAINTS
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2014
BACHELOR THESIS
B.S. in Digital Culture

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1. Introduction

Digital media such as augmented reality and mixed reality are most often produced without considering a specific audience. However, there are different requirements and parameters to
consider during the design process. This is often not deeply considered. Augmented and mixed reality are relatively new technologies that became popular and commercially available as mobile technology advanced. Currently AR (augmented reality) is used in many apps: advertisement-apps, location-based-apps, informative-apps etc. For my specific research, I am interested in the use of AR in the field of museum studies and in relation with audiences who have particular needs. Some of those special criteria could be children's space recognition and the limited movement in the space of an elderly person or a person sitting on the wheelchair.

Considering more specifically the case of museums, those constraints have been addressed and solved at the level of the physical space and the building planning. Nevertheless, not all museums can afford to hire curators who take care of translating their digital or analog exhibitions’ experiences for a public who is not able to see or interact with them. In order to address these needs, digital tools can help in developing inclusive exhibitions and design specifically. Designing using personas as a developing tool can be a solution to create an AR exhibition for people with different kinds of constraints.

In this thesis, I will argue how combining a method from interaction design to the process of designing multimodal museum exhibitions can be effective to address issues of particular audience needs. Museums are increasingly developing and hosting digital exhibitions alongside traditional exhibitions of objects such as paintings, sculptures et cetera. The application of personas to the design process of museum exhibitions feels necessary as this tool is a design method which allows to further analyse the audience. Alan Cooper (1999), the theorist who introduced this concept, states that this method is different from the others in interaction design. Cooper claims that “users” is a too wide concept and that each person has their own interpretation of what a user or user type might want and need. For this reason he introduces personas, an archetype of a user with a given name, face and job, described in detail in terms of needs, goals and tasks. The specificity of the tool can in
this way address a more specific audience and it avoids preconceived unarticulated notions of what users such as “children”, “students”, “blind” actually need and want.

This thesis starts by presenting the literature on which the analysis is based. Then it introduces an overview of the exhibitions' submarine-hall at Karlskrona's Naval Museum, considering which obstacles or special spaces a person with constraints might need or find there. A longer section will be later dedicated to the tool of personas, mentioned above. After this study, there will be a section devoted to an in-depth analysis in which I will combine various case studies with personas, and present a scenario of how an/the exhibition could benefit from being designed with the interaction design's tool. To conclude, I will discuss the importance of applying interaction design principles and methods in museum exhibit design which are using in AR/MR.

2. Background theory

There are many researchers active in the fields of AR, museum studies and interaction design. Although scholars and designers may deal with similar digitally mediated experiences of cultural heritage and despite, in practice designers may work in museum environments, in research, these fields do not often intersect. The importance of this intersection for my paper is dictated by the specificity of the exhibition, which hosts an AR experience in addition to the on-site exhibition. In what follows, I will introduce the fields of museum studies focusing on Fiona Candlin's point of view on the importance of touch in the exhibitions as well as Dourish's concept of embodied interaction, a milestone in the interaction design field. Furthermore, I will provide a brief introduction to the field of AR and to the tool of personas.

In the field of museum studies, Fiona Candlin has analysed the importance of touch and of other senses for museum visitors, in particular for blind people as they visit an exhibition. As an important starting point, Candlin underlines the weakness of museums in defining their audiences. By all means, museums and similar institutions often classify blind people as one single group.
Candlin argues that “the museum and gallery system positions blind people as a unitary group. However diverse individual blind people might be, as museum visitors they are primarily defined in relation to a lack of sight” (2003, 100). This generalization of the audience creates a faulty basis on which the exhibitions/experiences are planned. As a result Candlin’s research reveals a divided feedback from the blind visitors: half of the visitors felt offended or deluded by the low level of the content and the child-like way in which they were treated (Candlin, 2003, JFS, interviews, 1st May 2002), while the other half appreciated the service, used to not having one at all. In addition to quality concerns, the low availability of touch tours or different ways of experiencing museums are a problem as well. Candlin states that the problem is partly created by the lack of adequate education of the institutions' employees (Candlin, 2003, 108). Candlin also reminds the reader how the interest in disabilities and specific exhibitions is a relatively new topic for museum curators. Often the museums' employees responsible for planning touch tours are young, without experience, and often not properly educated (Candlin 2003, 108) Having guided tours is nevertheless essential for blind people. As Candlin argues: “Understanding and appreciating art through touch requires a different level of concentration and focus to using touch in a daily context. Importantly, blind people need far more time to handle objects than non-blind people need to see them and at least initially there needs to be guidance on what is being touched and how to touch it. It is not enough to simply hand objects over to be felt, or worse, to pass a single object swiftly around the room” (Candlin 2003, 107).

In the field of interaction design, Paul Dourish’s *Where the Action Is* is a foundational text. Dourish provides a sophisticated understanding of embodied interaction in complex mediated environments. Dourish bases his theories on the philosophy of phenomenology, extending it by articulating a way of understanding interaction between humans and any digital mediated object: “Embodied interaction is the creation, manipulation, and sharing of meaning through engaged
interaction with artifacts” (Dourish 2001, 126). This means that meaning is created, shaped and shared in the moment in which the user gets engaged with artifacts.

The field of interaction design intersects one part of a larger field called HCI (Human-Computer Interaction). HCI is a field of research and production emerged in the early 1980s. As Carroll defines it, HCI was initially "a specialty area in computer science embracing cognitive science and human factors engineering" (Carroll, 2013). More recently, HCI has aggregated various semi-autonomous fields of research and practices in the field of human-centered informatics, one of which is interaction design. Interaction design, though, is moving away from the more traditional usability engineering, towards aesthetical and ethical qualities. The interaction designer and professor Jonas Löwgren elucidates the reasoning behind interaction design: "Whether something looks and feels good to use, and whether it makes you comfortable in terms of social accountability and moral standards, has a real impact not only on the overall user experience but also on measurable, instrumental outcomes. For an interaction designer, users are whole people with complex sensibilities and design processes need to be conducted accordingly."

Dourish situates himself into the interaction design field and relates to HCI as “what is being done and how it is being done” (Dourish 2001, 4).

Dourish also introduces other kinds of interaction that can be both found in museums and in the interaction design field. One of those interactions is the textual interaction which includes conversation or dialogue and is often associated to the most general idea of interaction. An other kind of interaction defined by Dourish is the symbolic interaction. The symbolic interaction allow users to bring intuitions and abilities to the interactive tasks, and for this reason it is particularly interesting when thinking about AR experiences.

Tangible interaction, defined by Dourish as tangible computing, is a class of interaction which also relates to HCI and various computer science fields. As defined by Eva Hornecker, assistant
professor at the University of Strathclyde, tangible interaction is a highly interdisciplinary area. She argues that tangible interaction “spans a variety of perspectives, such as HCI and Interaction Design, but specializes on interfaces or systems that are in some way physically embodied - be it in physical artefacts or in environments” (Hornecker, 2009). The topic became a research area rapidly after its introduction in the late 90s. It was the MIT lab led by Professor Hiroshi Ishii who introduced this concept, from whom Dourish borrows it.

As we will see the affordance of AR come really near the idea of tangible computing. The main idea behind tangible computing is to distribute computation across a variety of devices, it augments everyday world with computational power and it is, in Dourish’s words “how these sorts of approaches can be harnessed to create environments for computational activity in which we interact directly through physical artifacts rather than traditional graphical interfaces and interface devices such as mice” (2001, 16). Dourish also defines some general issues of the interaction with tangible computers. A second model is the sequential nature of interaction at the interface, which is transformed by tangible interaction. The author reminds the reader that: “in tangible design we use physical properties of the interface to suggest its use. Taking this approach, designers can create artifacts that lead users through the process of using them with each stage leading naturally to the next through the ways in which the physical configuration at each moment suggest the appropriate action to take” (Dourish 2001, 52).

Dourish's concept of embodied interaction and symbolic interaction are specifically relevant for this thesis considering the design process and the final experience of AR.

Dourish was writing in 2001; Augmented Reality was then known only in researchers' labs. Today, AR has become a consumer technology because of its demand of a certain embodied engagement that other mobile apps generally do not expect. Specifically, AR relies on the physical movement of the user to explore the digital and physical space you are shown by the app. The user is not just
experiencing media, but media gets linked to the place you are in so that it creates a dual action. Quite literally the user deals with two different spaces at once, which creates a different conceptualization of the space itself and also of the user's physicality.

The definition of AR by Azuma is the most clear and well-accepted in the field. Azuma argues that “Augmented Reality systems have the following three characteristics:
1) Combines real and virtual
2) Interactive in real time

This relatively new technology is adapted into many different fields: in computer science, for medical and educational purposes as well as commercial ones. The commercial use of AR and MR (Mixed Reality) is based on two different ways of creating AR: browser-based AR and purpose-built applications. The first method allows the designers to build their own AR experiences using browsers such as Argon and Layar, while the second method uses optic AR (the camera-view of the device) to augment a physical space resulting in apps such as WhatWasThere.

As the reader will see in the following case studies, AR can also be used as a tool to augment cultural heritage experiences for specific user categories. There are several studies of prototypes for AR, for example “Augmented-Reality Scratch: a Children’s Authoring Environment for Augmented-Reality Experiences” is an AR app made specifically for children by Iulian Radu and Blair MacIntyre. The program Scratch allows children to create AR experiences mixing real and virtual elements by simply using the drag-and-drop programming. Scratch aims to enhance the expansion of children's creativity by presenting AR in an appropriate way for the young audience. AR can also be adaptive to serve as an assistive technology in helping handicapped children in the process of learning. An example of this use can be found in the study by Chien-Yu et. al:
“Augmented Reality-Based Assistive Technology for Handicapped Children.” After a short introduction to the technology and an explanation of how it works, teachers in different subjects tried to use AR as an addition to the normal teaching system for children with disabilities. The teachers noticed that “children with special learning needs were able to make use of a high-tech teaching aid that created realistic interactions. The convenience provided by this technology made learning easier and more interesting for children with special needs” (2010, 63). Furthermore, the results show that this technology provides an alternative learning method which can hopefully reduce learning barriers and difficulties for children with learning disorders, sensory handicaps, communication disorders etc.

These case studies emphasize the affordance of augmented reality to serve as a bridge-technology to fill physical or psychological deficiencies.

In order to link AR design to the concerns of museums, I am using the personas tool to analyse the audience’s needs. To get a complete understanding of what this tool is and how it is used, I referred to A. Cooper’s *The Inmates are Running the Asylum: Why High-Tech Products Drive Us Crazy and How to Restore the Sanity* (1999) and to Åsa Blomquist and Mattias Arvola’s “Personas in Action: Ethnography in an Interaction Design Team.” These two texts offer a full introduction to personas and scenarios. A further literature background of personas and scenarios can be found in this thesis' section “The Tool of Personas”.

Usually personas are created after having done interviews with possible users of the designed object. In my study I have not done this research. This process would have been complicated by not getting in contact with users with constraints who experienced AR. To implement the missing interviews-research, I am basing the development of personas on a series of case studies where AR experiences have been designed for different audience, as for example handicapped children, blind or deaf people. It was important for me to exclude the more commonly
analysed public of adults and families from the design processes of the AR experiences. Nevertheless, this research is still quite generic as Fiona Candlin observes. Blind people cannot be treated as only one category because they might be children, they might be professors etc. The specificity of personas comes into help exactly to solve this argument by Candlin, and it reduces the general categorization of users into one specific person we design for.

3. Exhibition Description

As a part of my thesis project I have worked on an AR project connected to the Naval Museum's 2014 opening of a new submarine-hall 1. In this section, I will go through the exhibition hosted in the submarine-hall as it will also be the set for the scenarios presented in the section “Designing AR Experiences for Petra, Jonathan and Ulrika”. The process of designing an AR exhibition for people with constraints with the tool of personas is put in relation to the exhibition Neptun. In connection to my thesis project, I have access to the work materials used during the planning/designing and creation of the submarine-hall's exhibition. My access to the working material of the exhibition will make it easier and clearer to fully describe and offer an idea of how the exhibition has been thought of and created. The exhibition highlights the first submarine built in Sweden side by side with Neptun, a submarine from the more recent Cold War. Both of the submachines were renovated, transported to Karlskrona and placed nearby the museum, onshore. The building housing the two submarines and their relevant exhibition has been specially built around the two submarines. The building is custom built for the submarines and the exhibition. For my purposes, it is interesting to analyse and think of the needs or constraints which people may have in the space or while experiencing the exhibition.

1 See the thesis project report for more details.
Obviously, there are many details in the exhibitions I will not get into. I will offer a general experience of the building space and of the exhibition hosted.

The submarines hall is hosting the two submarines *Hajen* and *Neptun* in their entire physicality.

The building is divided into two floors: a ground floor and a first floor which is opened in the middle and runs as a balcony all around the exhibition hall.
The entrance to the submarine-hall is connected with the already existing building of the Naval Museum through a corridor. This corridor leads to a staircase that allows the visitors’ access to the upper floor of the exhibition's hall. At the end of the staircase, one of the best views over the two submarines is presented to the visitors. For people with limited physical abilities, there is an elevator with glass doors nearby the staircase, which arrives at that same place and offers the same view on the submarines.

The exhibition planned on the upper floor is a timeline of the submarines’ history in Sweden. Starting form the year 1904, when the first submarine was built, the timeline has twenty-five stations where the submarines' history is told. Those stations are also presenting models recreating the submarines from different years. From the first model nearby the staircase, the visitors go around the submarines-hall to the last technologies of submarines. This exhibition creates a natural flow for the visitors through the floor until they get to a "resting" point: a wide staircase. Those stairs are strategically placed in front of the submarines. Furthermore, this spot offers a great view over both submarines, and it connects the higher floor with the lower. Following again the timeline, the visitors arrive at the entrance of the Neptun, the submarine from the Cold War. This part of the exhibition has to be booked beforehand, as it comprises a guided tour into the submarine. To get into the submarine, big doors have been created by cutting through the submarine's surface. The visitors access the submarine via a ramp. After this guided tour, the visitors can follow once again the timeline of the history of submarines to get to the starting point. Here visitors are free to go
downstairs to explore the floor, or to follow the timeline again and go to the wide staircase to then access to the lower floor.

While on the first floor, the timeline leads the visitors along the hall. On the ground floor the visitors are instead free to discover the space, without a planned path to follow. The exhibitions are organized as themed spots like “Life on board”, “Rescue and air”, “Attack and threats” etc. In addition on this floor it is possible to enter Neptun for free. This floor offers only a smaller place to explore and provides no guided tour. The visitors are left alone to discover the space and the themed exhibition.

4. The tool of Personas

Personas are representations of real people used throughout the design process. Cooper defines them as "(...) hypothetical archetypes of actual users. Although they are imaginary, they are defined with significant rigor and precision" (124). Personas are for example used as a help to guide decisions about product features, navigation, interactions, and even visual design. Often, personas are created after a series of ethnographic interviews with real people. The personas' details would then be abstracted into 1-2 pages including behavior patterns, goals, skills, attitudes, environment, personal details etc. to be as specific as possible and to make the persona as real as possible. The more descriptive and narrative the details of the persona are, the more effective the tool will be. The people using the persona tools should get familiar with the persona and know his/her skills, attitudes, environment, goals as well as what she/he would or wouldn't do. To solve a design problem, usually more than one persona is used. With extensive projects, primary and secondary personas might be used. More than one primary persona is created when the needs of each single persona cannot be solved in the same way. Secondary personas are personas with more specific needs. The fulfillment of the secondary persona's needs might not negatively interfere with the first personas' one. The secondary personas' needs might instead be an addition, or a small change in the
Petra

Age: 31

Job: consultant for companies: specialized in advising how to create a fair environment for disable

Slogan: “Even if I am blind, I have a degree in Management-Consulting, I am a normal person.”

Back story

Petra is working as a responsible for disabled visitors for the museum of Stockholm.

Petra has a degree in Management-Consulting and loves to be updated on the topic by reading academic papers and relevant magazines. Her main hobby is art and history. Petra is a regular visitor of museums: she has already visited many different exhibitions in different parts of the world. She loves to visit museums on her own as well as with a close group of friends who share the same passion.

Petra is blind from birth. However, she does not consider her disability as an obstacle to visiting museums and exhibitions and follow her passion. She knows how to move in such spaces and she also expects big museums to be prepared to accommodate, in an adequate way, blind or disabled visitors.

Motivations
Petra is really interested in history and wants to get a lot of information as well as a deep experience out of her visit.

**Frustrations**

Petra knows that many museums are not prepared for blind visitors, and are often only offering poor quality audio-guides. She also knows that some people are treating blind people as people with cognitive problems.

**The ideal experience**

Petra's ideal experience is one which gives her something to treasure, some knowledge and feelings to walk home with. She also loves to visit museums that are prepared to offer an inclusive experience for blind people and let them explore and feel the space that they can't see, using other senses.

**Jonathan**

Age: 69

Job: retired official from the Swedish army

Slogan: “I love to do things with my nephews during the summer holidays ”

**Back story**

Jonathan is a retired official from the army.

During one of his mission he had an accident which left him in a wheelchair.

He loves gardening and being in his villa with his wife. The happiest time of the year is the summer, when his nephews come to visit him and his wife for one month. He loves spending time with the 4 and 6-year-old and also make something educational.
Motivations

Jonathan was really engaged in his work and he is still really interested in military machines. He is looking forward to get to know the marine part of the army which is presented together with the submarines exhibition at Karlskrona's Naval Museum.

He is really close to his nephews and likes to take them to some educational-experiences.

Frustrations

Jonathan would like to get the same experience of his nephews even if he is physically disabled. He wants to be able to talk about it once at home and explain it better to the young nephews. He also would like to not be physically too far away from his nephews during the exhibition visit.

The ideal experience

Jonathan's ideal experience is being able to be with his nephews during all the exhibition and have easy access to the spaces and the information.

Ulrika

Age: 43

Job: employee at Karlskrona kommun

Slogan: “I enjoy doing things with my colleagues outside the working time”

Back story

Ulrika is a mother of two children who are already living away from home. To fill her now free afternoons and weekends, she really enjoys doing things with her female colleagues from work. They often go for walks and they are always present at the jazz concerts in the centre. When Ulrika and her colleagues decided to go to the opening of the new exhibition at
the Naval Museum, she did not realize that she is in fact claustrophobic. She realized it in the moment she entered the submarine.

Motivations
Ulrika and her colleagues are looking forward for a new activity together at the opening of the Naval Museum.

Frustrations
Once inside the submarine, Ulrika feels claustrophobic and must go outside immediately. She paid the ticket to the guided tour on the upper floor of the submarine and she would like to get the same experience as her friends/colleagues to be able to discuss it later on. She is embarrassed of discovering that she is claustrophobic but on the other hand she doesn't want to be left out of the group and looks for all the opportunities of getting a bit of the exhibition.

The ideal experience
The ideal experience for Ulrika is to be able to visit the submarine without entering it and being able in this way to share the same experience as her friends/colleagues.

5. Designing AR Experiences for Petra, Jonathan and Ulrika

The tools and theories presented previously, are fundamental to give a foundation to the following analysis. This analysis will show how the use of personas to design AR experiences can create inclusive exhibitions addressed to people with different kinds of constraints. The following analysis will be organised in case studies, where each case corresponds to one of the personas created for this process. The theoretical concepts and links will be further analysed after having presented the cases.

Petra is coming to the submarine-hall one month after the opening. She is avoiding the opening because she knows that being blind would be a problem around a crowd of people. Hence, she would not be able to take the time she wants to feel and experience every single detail of the
exhibition. Petra together with a group of friends have been waiting for the opening for a really long time. As always, they have been reading and sharing all the informative material they found to understand the background history of the exhibition. When Petra gets to the museum she likes to have enough time to both follow the audio-guide and to touch what is exposed. Her friends always go to museums with her, and they are really good in implementing the information given by the audio-guide to the ones Petra cannot see. Nevertheless, Petra likes to have her freedom in discovering the spaces and she does not always follow closely her friends throughout the visit. This often leaves her in the hand of the audio-guides as an informative source. Once in place, Petra does not like to have to follow the binding path offered by the audio-guides. Often she finds herself interfering the flow of the other exhibition visitors by standing near the stations of the timeline to be able to listen to the audio-guide. Petra's problem could be solved by creating an informative GPS-based AR experience. This would allow her to benefit of a more sophisticated tool than audio-guides in terms of freedom, but also in terms of content. The freedom of AR experiences is based in the portability of the devices that mobile AR in smartphones or tablets offer. Petra could in this way decide to take her time to listen to the timeline AR experience, while comfortably sitting on the wide stairs in the submarine-hall or while touching the objects that are being described. She would not interfere the exhibition's flow, but she could get the information she likes without the constriction of a child-like, mandatory path to follow. Petra would of course miss the visual part of AR shown on her device, but she could still benefit from the more detailed descriptions and customisation of the sound possible in AR. This AR experience could also be exclusively designed for visitors like Petra as such virtual exhibitions do not take up any physical space. Petra would be really satisfied have the possibility of an extensive experience through media. She would appreciate the commitment of the museum to make the exhibition more accessible. She would also feel she has
been treated in an adult-like way, thanks to the use of new technology, and by allowing her to move freely in the space.

The exhibition designer of Neptun's experience had to insert a specific barrier which will be an issue for a visitor like Petra. Plexiglass has been used to protect all the buttons and parts of the submarine that visitors could possibly touch. According to the exhibition designers, this choice was necessary in order to prevent theft of or damage to any of parts. Petra understands their concerns, the plexiglass will prevent her from using the sense -touch- that she relies on in order to apprehend her environment. Once more, an AR implementation would help Petra to have additional descriptive material which could even offer a reproduction of the sound made by the buttons when being pushed etc. or by directing her toward these parts of the submarine which are free from the plexiglass and can actually be touched.

When developing an AR experience for Petra, as described above, Candlin’s detailed study of blind museum visitors and the conclusions that she draws from their experience can help the design process. As Candlin shows, many museums tend to treat blind visitor as mentally retarded. Instead, blind museum visitors are often people like Petra with a brilliant brain, who are truly and deeply interested in the field.

Jonathan planned the visit to the Naval Museum for the 30th of June. His two nephews are arriving for the usual one-month visit during the previous weekend. Jonathan thought that going on Monday the 30th would be a good idea to avoid the weekend crowd. Also, the weather will be nice then and he and his nephews will make a picnic after the visit at the submarine-hall. On the day of the visit, Jonathan will be alone with the two kids, his wife will be busy with her yoga classes and will join them only for the picnic. For this reason it is important for Jonathan to always be near the two children during the exhibition to keep an eye on them, but also to explain them the written information they cannot read themselves. Being in a wheelchair is a constraint in regard to
movement, but Jonathan is used to it and can move freely. Though, one of his concerns is that it will not be possible for him to access every part of the submarine together with his nephews. The 4- and 6-year old are not able to read such complicated information given in the exhibition so they would need the supervision of Jonathan. One of the traditions Jonathan and the children have, is to recall the visit in the evening and to recall strange or unclear information they saw during the visit, therefore Jonathan himself has to get the information in order to answer them later on.

Once in the submarine-hall, Jonathan realises that there are only two elevators that he can use for moving between the two floors: one nearby the entrance, and the other one in the opposite side of the hall. The problem is that there is no possibility for Jonathan to follow the children downstairs when they use the wide stairs positioned in front of the two submarines. This is a minor problem, but it will constrain him from the full freedom of following his nephews. His main concern, though, is that the corridor on the upper floor is not wide enough, and it will not be possible to stand too long by a timeline spot without interfering with the flow of the visitors. The best solution for Jonathan and his nephews would be to be able to access that information in a place where the children could sit nearby Jonathan. This problem could be solved by creating an AR experience which would mimic the exhibition, but would offer the freedom of accessibility. As discussed in the case of Petra, such AR experiences can be made mobile and the user does not have to be in the exact point of the exhibition panel to get information. The same AR experience would help Jonathan to also experience the Neptun's exhibition. Jonathan with his wheelchair, is able to enter only part of the submarine with ease. Being able to enter into the submarine itself allows him to have an eye on his nephews, but his sight is not good enough to be able to catch all the details in the submarine by only entering one meter into it due to the submarine's narrow spaces. Having an AR experience which reproduce the submarine's exhibition would help his issues and concerns regarding the surveillance of his nephews and his own mobility or lack thereof. Through panoramas
he would be able to experience for example the periscope-room that is difficult to enter with a wheelchair. In particular, Jonathan could experience the view from the periscope that is located in such a way in which it would be really hard for him to actually look through it. He could also get informed and experience the exhibition's sounds thanks to the addition of a narration into the experience. He would be able to see all the details thanks to a slideshow inserted into the AR experience, without having to strain to see from afar. By using an AR experience Jonathan could answer the questions of his nephews, share a similar experience and still be able to not be too far from them.

Ulrika will experience a constriction when entering the submarine too. Ulrika and her colleagues decided to go to the opening of the submarines exhibition. They are all really looking forward to one more afternoon together to spend in the museum and then to get a coffee at the museum's cafeteria. Ulrika is not really fond of sports and she is afraid of heights. She really appreciates the fact that the submarine Neptun can be entered from the side, and it is not needed to climb into it from the tower like the mariners actually did.

Once in the museum, Ulrika and her friends go quickly through the timeline exhibition, because the highlight of their visit is the guided tour they booked of the second floor of the Neptun submarine. Really excited and after twenty minutes spent queuing, Ulrika and her friends are allowed to enter the submarine. As they enter the first room, the tour guide starts explaining that many people were actually living there during the missions. The tour guide asks the visitors to imagine how tight the space would be considering that the artificial door opening that they entered would actually not have existed and they would be several meters under the sea. At this point Ulrika starts realizing that she does not feel well, and that she feels really claustrophobic. She must get out as soon as possible from the submarine to get some fresh air. She reassures her friends that she can do that on her own to not let them miss the visit. Ulrika feels of course really disappointed by her reaction, as
her expectations and curiosity were really high. On the other hand, she really does not wish to enter the submarine again. To solve Ulrika's problem, an AR mimicking the submarine's exhibition could be created. Ulrika could take all the time she needs to get past the trauma and sit down on the wide staircase to wait for her friends. At the same time, thanks to the AR submarine tour, she would be able to have an idea of what the rest of the submarine looks like thanks to panoramas, slide-shows and informative and environmental audio. Being detached from the tight inside space itself, the AR experience would allow Ulrika to get informed without the claustrophobic sense of being trapped into the submarine. Ulrika could also wait for her colleagues to be ready with the tour and share the AR experience with them in order to get a confirmation that the experiences are similar, but also to feel included in the group. This would give Ulrika a point of view on the exhibition and an experience to talk about, once she and her colleagues have their coffee and recall the visit.

As these theorisations of possible AR experiences show, the tool of personas is really powerful in the process of design. A strong characteristic is that the personas become real people with actual needs. The process of personification would not have the same efficiency without some key points used while developing personas. A first essential concept is the use of photographs to give a face, an aspect to the persona that reinforces his/her realism and brings him/her to life. Furthermore, the process of empathy is fundamental for the design process. The persona description allows the designers to really get to know the persona, and feel emphatic towards his/her particular needs and frustrations. My experience showed me that after having created personas, I developed an insight into their personalities, and I fully understood what Petra would do, what Jonathan loves and what Ulrika thinks about other people and situations. To create a persona with his/her specificity means to get to know him/her completely and get to a level of empathy similar to the one developed when reading a novel toward the characters. To be empathetic towards the personas is absolutely fundamental, as this allows the designer to understand the persona at an emotional level, and to
anticipate his/her needs. After having shown how personas work so that we now understand their function in the design process, we can now link back to Paul Dourish’s idea of embodied interaction. Dourish defines embodied interaction as: “the creation, manipulation, and sharing of meaning through engaged interaction with artifacts” (2001, 126). Embodied interaction in the particular case of this thesis means that, although the AR exhibitions implementations we designed for our personas are a virtual response, there will be an embodied consequence to their use. The visitor of Neptun exhibition will in first place have an embodied interaction with the physical space and the physical exhibition. An added layer of embodied interaction will then be given by the AR experiences. The AR experiences will also serve as a primary embodied interaction for people like Petra who cannot see the physical exhibition. The AR experiences do this by filling those gaps created by her constraints. Similarly to Dourish, Barba and McIntyre offer an interesting connection between AR and interaction design too. Dourish, Barba and McIntyre move away from HCI and more traditional computer science research concerns to discuss human aspects of design. Barba and McIntyre shift towards interaction design in order to understand how AR and MR mediate human experience. They focus on looking at different kinds of spaces that surround the user. For the purposes of this essay, their articulation of a fifth kind of space, which they call the panoramic space, is particularly interesting. Their model of space is based on the one proposed by Montello, which includes four categories of space: geographic space, environmental space, vista and figural space. Barba and McIntyre add to these, a fifth space: the panoramic. This fifth space is fundamental when thinking about AR, as it includes “spaces which are not visible in their entirety from any orientation” (Barba and McIntyre, 2011, 121). To be able to view the AR experience the user need to engage physically by moving the device and his/her body. Yet the space shown on the device at a given time is always a segment of the space visible in the whole AR experience. For this reason a fifth space was necessary to be created for AR and MR experiences. The accessibility
6. Conclusion

This thesis presented research into a possible way to design AR experiences in the field of museum studies in relation to audiences with peculiar needs. After introducing some theorists from museum studies and interaction design which were concern with this topic, I proposed the use of the tool of personas as a solution to design those AR experiences. I suggested that the use of this interaction design tool in the field of museum studies can serve as a more efficient way of analysing the audience. I then described the tool, emphasising how Cooper's process could avoid misunderstandings between the parts involved in the design process. After this short introduction, I presented a description of the exhibition Neptun at Karlskrona's Naval Museum, focusing on the obstacles and peculiarity of the space giving problems to people with constraints. Afterwards, I introduced in depth the personas used for my analysis: Petra, Jonathan and Ulrika. I presented the scenarios they experienced at the exhibition and developed a possible solution to their frustrations by using AR. Finally, I reminded the reader about
the importance of the embodiment experienced by the personas and suggested some further researches and developments which could be done on the topic.

7. Works Cited


Alan Cooper. The Inmates are Running the Asylum: Why High-Tech Products Drive Us Crazy
and How to Restore the Sanity. SAMS publishing 1999. Print.


Augmenting the Neptun: AR experiences for Karlskrona’s Naval Museum

In connection to the written component of my thesis “AR Experience Design in Museums: Designing for People with Constraints”, I have been working on an Augmented Reality-based project. The project was created thanks to a cooperation between Blekinge Tekniska Högskolan (BTH) and Karlskrona’s Naval Museum, and it consists of an AR/digital re-creation of the submarine exhibition which opened on the 6th June 2014 at the museum. The project resulted into a fully working prototype developed and designed by Jolanta Kolosinska and I, with a strong support and collaboration of the teachers from BTH Maria Engberg and Lissa Holloway-Attaway, and Jay David Bolter from the Augmented Reality Lab of the Georgia Institute of Technology. The exhibition we were concerned for the AR project is the one inside the Neptun: one of the two submarines hosted into the newly opened submarine-hall at the Naval Museum. The submarine-hall
has been custom built around the two sub-machines and offers, together with the submarines, different exhibitions that allow the visitors to get to know the story of the machines. The highlight of the submarine-hall is the visit on-board the submarine Neptun, a Cold War’s submarine hosting all its original machinery and equipment. However, people with constraints such as blindness, claustrophobia or sitting on a wheelchair, might not be able to access the submarine and the chance of getting an experience of it is limited. The AR project aims to fill this need by offering an experience of the inside of the submarine also to those who are not able to access it through the implementation of panoramas, audio and pictures.

Augmented Reality (AR), is a technology enhancing the view of reality with digital information being interactive in real time and registered in three dimensions. The application of this technology to the submarine exhibition offers Karlskrona’s Naval Museum a unique experience because of the modernity of the technology but also because it is an accessible experience for those who may not have the possibility to visit Neptun.

This paper offers an overview of the project’s process of development. It begins by summarizing the pre-production stages. The paper empahsises afterwards the connection between the written-theoretical component of my thesis and this project. It later presents the components of the project in all their details, and it shortly ends by presenting the feedback on the AR experience received from the museum visitors and curators.

1. Pre-production Stage

The contract between BTH and the Naval Museum was born in the fall 2013. This first contract stated that the experience developers should present a fully working prototype which might or might not be implemented into the submarines’ exhibition depending on the curators judgment.

In the pre-production part of the project a lot of time has been spent discussing with the

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Naval Museum’s responsibles. Those discussions were mainly focused on understanding which experiences the museum’s curators wanted but also to explain what AR is and how it can implement such an exhibition as the one planned in the subamarines-hall. Being AR more and more a consumer technology, it is also used as a tool to augment cultural heritage experiences. The museum’s responsibles were really interested in the possibility of AR to digitally recreate a physical space through panoramas. This way of experiencing media not only links the physical place to the digital one, but it literally creates an interaction with two different spaces at once. The additional feature of relying on physicality to explore the digital space shown by the AR experience creates a 360° experience. This allows the museum to be a “museum outside walls”, as visitors can experience the AR project even outside the museum and from their homes. This is a really important feature as Karlskrona’s Naval Museum aims to be Europe’s best museum in few years’ time.

The project-planning brainstorming concluded with the inclusion of four different experiences into the AR project. The experiences were the following ones:

1. “The accessibility panoramas”: panoramas-app which would allow people who cannot go into the submarine to experience its exhibition anyway. This part would include few panoramas linked to each other, mimicking the exhibition. Audio, including a narrative and sounds would also enrich the experience. This first part of the AR project is the one which the Naval Museum was asking for, while the following ones are a possible extension we though of.

2. “Getting into the submarine panoramas”: together with the Naval Museum's photographer Erling Klintefors we thought about re-creating the moment in which the marines got into the submarine from its real entrance. This would be created by linking many panoramas and adding a slide-show.

3. “Hajen's blended historical panorama”: the first submarine of Sweden, Hajen, is also part of the exhibition, but it is not possible to enter it as Neptun. This AR experience was thought to give the visitors an idea and feeling of how the Hajen looked like inside. The first idea was to use
some visual information and maybe get into the submarine to take a panorama.

4. “Teaser for the exhibition”: a teaser created using pictures by Erling Klintefors. This would show
the visitors how the submarines arrived to Karlskrona, their restoration and the creation of the
submarine-hall building. The experience would include photographs presented in a slide-show
and could be looked at both from home or in the museum, using maybe Aurasma.

Those experiences were inspired by already existing AR projects. Specifically, the accessibility
panoramas, would function in the same way of this a narrative-panorama experience “Projet” by Far
& Near (Maria Engberg and Jay David Bolter)\(^3\). The order and the media would of course be
different and fitting with the existing exhibition, but the functioning and the effect would be the
same. The *Hajen*’s blended historical panorama was also inspired by an already existing panorama
experience created at the Georgia Institute of Technology called “Sweet Auburn Avenue”\(^4\). This
experience features a panorama of a neighborhood in Georgia, where an historical image of a no-
longer existing building has been added on to the panorama. The building would shade forth and
back when clicking on the device.

2. The Importance of my Thesis “AR Experience Design in Museums: Designing for People with
Constraints” for Designing this AR Project

My written thesis with title “AR Experience Design in Museums: Designing for People with
Constraints” is clearly connected to this project. The aim of the research paper is to design an AR
experience for museum visitors with different kinds of constraints. The thesis proposes AR as a
bridge-technology to do so. The introduction of the tool of personas and interaction design into the
process of design of AR is really important as well. In fact, this method was really helpful when
thinking about the practical project we created for the Naval Museum. I often found myself thinking
of how the personas I developed in my thesis would interact and judge the various AR experiences.
The research made in the process of writing my thesis enriched my understanding of embodiment
and allowed me to create a high level of empathy towards the future visitors of the submarine-hall.

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3 \[\text{artnotart.org/farnear/projet/projet.html}\]
4 \[\text{http://artnotart.org/jdbolter/good/herndon/fade.html} \text{ and http://www.auburn.gatech.edu}\]
3. Project Components

With the development of the project, we had to exclude one of the experiences: the “getting into the submarine”. It would have required a lot of security precautions as the only possible way to shoot the panoramas would be to climb up to the tower and hang over the submarine from the roof-top.

In order to present a fully working prototype, we mainly focused on the “accessibility panoramas” experience. This AR panoramic experience allows the visitors to experience two different parts of the submarine *Neptun*: the first is placed in the ground-floor and it represents the dining room. The second is located on the upper-floor of the submarine, in the command room which even hosts the periscope. The exact location of the two panoramas can be seen in the image below, which represents *Neptun’s* plan and in red the panoramas’ central point location.
The panoramas can be accessed by scanning a QR-code, or by typing in the link into a browser. This panoramic experience can be viewed into two different ways: using the AR browser Argon or through the web-browser based library three.js.

The first, fully represents our idea of panoramic and immersive experience. It is an embodied experience which reckon on the physical movement of the visitor in order to explore the intern of the submarine. The visitor needs to rotate and move the viewing device to be fully surrounded by the panoramic experience. A story-telling audio provided by Karlskrona’s Naval Museum has been added to the panoramic experience, making it a multisensorial-immersive experience. More details about the engagement of the visitor with the AR experience are presented in my written thesis.

This first part of the project can be experience by downloading for free the AR browser Argon, developed by the Augmented Reality Lab at Georgia Institute of Technology. At the moment Argon is available only for iOS devices. An Android version, though, is planned to be launched in the summer/fall 2014. The panoramic experience is designed using HTML5, CSS3 and JavaScript.

The second way of accessing the project is through a web browser. The adaption of this experience, based on the open source JavaScript library three.js, was necessary as it allows non-iOS devices as well as PCs to access the AR project. This second experience is presented as a self-rotating panorama which can be moved and explored using the cursor (on PC) or finger movements (on touch-screen devices). This experience embeds the audio provided by Karlskrona’s Naval Museum too, which adds a layer of immersion to the project.

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5 “AR Experience Design in Museums: Designing for People...”
experience allows the visitors to experience the two panoramas as one experience. In fact, it is possible to access the command room panorama by simply clicking the button “continue” which appears once the first panoramic experience is finished. On Argon the two panoramas need to be experience separately.

For the panoramas shooting, we got help from the Naval Museum’s photographer Erling Klitefors.

The second part of the project is an AR experience for the Hajen, hosted in the submarine-hall together with Neptun. Even tough Hajen is the first ever sub-machine built in Sweden, the submarine is not highlighted in the submarine-hall. Not many information are provided on Hajen and the visitors are not allowed to get on-board. The AR experience aims to allow the visitor to experience the intern of the submarine. This can be possible by overlaying the real view over the submarine with a digital layer representing its original skeleton and machinery.

The images below, show a mock-up of how the blended panorama of the Hajen could look like.

The third part of the project includes a teaser for the submarines’ exhibition. It is created as an interactive HTML5 website created from a CMS template on Squarespace platform. The website presents full-screen photographs taken by the Naval Museum’s photographer Erling Klintefors. The pictures are organised into three sections which can be selected on a minimal menu: the Neptun’s transportation to Stumholmen island, the submarine’s restoration and the creation of the submarine-hall. The images represent the unique travel of the two submarines and they do not need an
explanatory text. Those images are not part of any of the exhibitions hosted into the submarine-hall. They are presented as a teaser to both attract and make visitors curious about the submarines, but also to offer an extensive experience to those visitors who are queuing to access the submarine-hall (only 200 people can access the submarine-hall simultaneously).

4. Feedback at the opening of the submarines-hall

On the 6th June we were on place at the submarine-hall opening during which we presented our AR project to the visitors. We presented both the Argon and the three.js versions of the AR experiences. The visitors were curious about the AR technology that most of them had not got in contact with before. We also had a poster which shortly introduced the project and the technology and offered the possibility of scanning QR-codes to get to the experiences. Anyway the visitors were interested to personally get information about the project. We got really positive responses with some visitors underlining the importance and necessity of such a project. The feedback came from different kind of audience, from families with children, to students, to disabled and elderly visitors.
We got a really positive feedback also on the Hajen experience which was not completely
developed as the museums’ responsibles were not fully supporting the idea. This might be an
important further development of the project.
The museum will now consider the audience responses before adapting the AR project into their
exhibition and website.

5. Conclusion

This paper presented an overview on the development of the AR project ”Augmenting the
Neptun: AR experiences for Karlskrona’s Naval Museum”. It started by presenting the pre-
production process, with meetings with the museum’s curators and the development of the project’s
ideas. Afterwards, it emphasised the strong connection between my written part of the thesis and the
project itself. It later focused on all the different components of the project and explained them in
detail. It finally concluded by reporting the positive feedback we got from the audience when we
presented the AR project.

This project together with the written thesis, created a 360° understanding of how to design
an exhibition such as the *Neptun’s*. Getting positive responses from both the visitors and the curators was the key to confirm the viability of the project.