Improving an Exhibit at Mosede Fort:
A Multimodal System to Enhance Learning in a Museum Experience

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Contents

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Abbreviations

WWI	**W**orld **W**ar **I**
SOTA	**S**tate **O**f **T**he **A**rt
PAP	**P**lastic **A**nimation **P**aper
UDP	**U**ser **D**atagram **P**rotocol

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Chapter 1

Introduction

"Human History includes a large number of battles and wars, whose results cannot be understood properly from the traditional teaching, where they are presented as occasional events that involve two sides (the good and the evil forces) and that apparently end fortuitously. Nothing is so simple in reality, and so the classical pedagogical approach neglects many facts about the reasons for the battles, alliances and supporters, why things went on the way they did, what were the winning or losing choices, what were the consequences in the short, medium and long terms, etc. As a result, our general awareness of History is rather partial and deficient, and students end up with little more that a collection of dates and a vague idea of who defeated who." [7, p. 4811]

It is seen today that museums begin to have an interest in including the visitors more when designing an exhibit [32, pp. 6-13], [36], [67, p. 41]. They furthermore look more into digital culture and are more open to using new technologies [32, pp. 6-13, 54]. It is therefore relevant to explore the museum field. As new technology immerses, it have been found that multimodal systems are easier to learn and use [56, pp. 1, 5], why it will be desired to create such a system for a museum, especially since visitors typically only spend a short amount of time on a single exhibit [34, p. 138]. Another motivation behind this thesis is based upon a personal interest in the museum field, and the desire to tell stories - to convey history through storytelling.

The idea behind the project came to light when working upon a previous project - also in the museum field - last year (2015), during an interview conducted at the Mosede Fort museum. At the interview there was talked about how they present information, which stories they want to tell and how - including their obstacles with especially a physical/digitally projected map of the area. It is therefore this map and how it can be improved, which is the main focus for this thesis.

Since the museum conveys information about World War I, it is desired to investigate how information concerning the predicaments of how Germans was believed to invade during the war at the Tune trench line can best be conveyed to the visitors. The goal is to achieve this bt using the already implemented map-installation at Mosede Fort by creating a multimodal system for it.

The map at the museum (the case) will first of all be presented. This leads to an investigation of how the goal can be achieved. Based upon the investigation will the ideal design for the case be presented, whereafter a proof-of-concept will be implemented and evaluated. The thesis ends with a discussion of the results and the project itself and a conclusion.

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Chapter 2

The Case

The focus for this project is based upon an interview conducted with the contact person at Mosede Fort: to find a way to further improve the map, such that the visitors are more included and information about the World War I (WWI) is conveyed. The map exhibit can be seen in its exhibition environment in Figure 2.1.

Figure 2.1: A photograph of the exhibition including the map at Mosede Fort. Figure retrieved [51]

An inspection of the map (see Figure 2.2) conducted together with the contact person (the interviewee) showed that the map does not include larger areas of importance, thus giving quite the challenge on how to convey information concerning those areas. It is therefore desired to find a possible solution for this problem.

The original idea behind the map had according to the interviewee been somewhat vague: the visitors should be able to ”explore the history through the map”. Furthermore, they had wanted to show the relevant images they had from WWI and the area by letting the visitors trigger something on the map, which should let the corresponding images show.

The physical map is 193 cm. wide, 392 cm. long, with a height of 29-30cm and it takes up a large area of the room it is exhibited in. However, when looking at its role and the idea behind the map, the execution does not seem completely successful. This can for example be seen by the two screens situated with the map, where the user can interact with the screen on the left, while the information (images from the time period) is shown on the right screen. This setup results in - according to the interviewee - that most visitors do not notice when information is

Figure 2.2: A photograph of the map at Mosede Fort

given on the screen to the right. This could be due to something as simple that most visitors are probably right handed, why they naturally use their right hand to interact with the left screen, thus blocking the view to the other screen. Furthermore, do the visitors already concentrate upon the screen to the left and the map itself, which displays new content/a light cone depending on their actions, why they are most likely not noticing the other screen showing information as well.

The goal of this thesis is to further develop upon the already installed map at Mosede Fort. It is desired to present the hypothetical question of how the fort would have reacted (what the response chain would have been) if the Danish coast had in fact been invaded by the Germans. These assumptions are based upon sources gotten from the museum and by using the book *Tunestillingen - Feltbefæstningen fra Roskilde fjord til Køge bugt* [5]. It is needed to research and find a solution to the following points:

1. Find a solution for the missing areas on the map.
2. Find a way to include the visitors more in the experience (of using the map) by creating a multimodal system.
3. Investigate how visitors can be motivated to learn (at museums).
4. Make the prototype interface intuitive to use/for the visitors to interact with.

Chapter 3

Investigation

As stated (see Chapter 1 and 2), this thesis focus upon a case at Mosede Fort. In order to obtain a solution for this case, multiple different topics need to be researched and presented. This chapter will therefore include a presentation of seven main topics, whereas the first topic is *Museums*. It is of interest to research museums because it is considered important to know what the essence of museums are, their goals as well as the different ways in which they communicate. There will also be a focus upon user experience at museums. The second topic is *Storytelling*, since it is known that storytelling will be a main element in the design of the case – based on wishes of the contact person at Mosede Fort. Since a *Multimodal* system is a possible solution to overcome the challenge of the missing parts of the map at Mosede Fort (see Chapter 2). The next section is therefore a presentation of what multimodal systems is. This is followed by *Adaptive and Personalized Systems*, which covers how a system can be made to fit individuals. The next topic is *Graphics*, which have a focus on animations. This topic is selected based on a meeting with the contact person, who have been talking about expanding the use of the map by including e.g. animations. The next investigated topic is *Audio*, since this could be a possible solution for the missing parts of the map, such that it might be possible to use sound to auditory give the visitors clues of what is happening upon the areas of the map, which are not possible to be displayed visually. The last topic is *Learning*, since a large part of museums is to teach the visitors. It is therefore investigated how it is possible to achieve an experience in which the visitors can learn by interacting with the map (system).

"Museums are a natural laboratory in which to examine the complex nature of constructing meaning, learning from and enjoying objects and environments through interaction" [68, p. 1].

3.1 Museums

In this section, the traditional museum and how we now see a change in it is presented. The concerns related to these changes - that the use of computers etc. might move the visitors' focus away from the presented artifacts - will also shortly be presented. Furthermore interactive exhibits will be investigated. For more elaborated information about this subject, the report *Presenting Historical Events Using Counterfactuals in a Museum Setting - An Interactive Experience* can be seen [4].

3.1.1 The Traditional Museum

The traditional museum concentrates upon the presented artifacts; these are the museum's main attraction and communication element, while signs and photographs are the secondary tool. Eilean Hooper-Greenhill, explain the traditional museum's communication through a communication model, where the museum is the deliverers of the information, while the visitors are the receivers of said information. She does, however, also stress that there are problems with this model, since it makes the receiver as one just getting a transfer of information from the museum, which is why she has elaborated upon the model by giving it a feedback loop. The loop makes it possible for the receiver (the visitor) to give feedback to the sender (museum); creating a circular process. This, however, is also why the message given by the museum might end up changed. [36, pp. 31-35, 38-39], [67, p. 24]

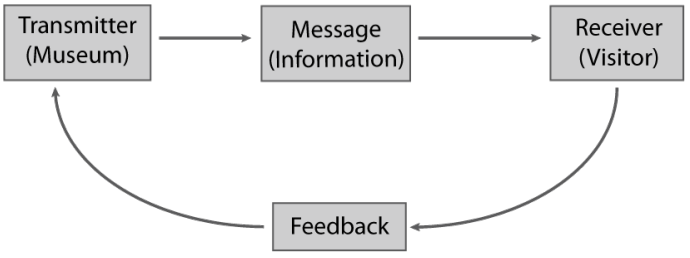

Figure 3.1: The traditional communication model as explained by Hooper-Greenhill with a feedback loop. Figure based upon [36, p. 34].

3.1.2 Museums Today

Today we see that a change is happening in the museum field: the museums get more inspired by the digital culture and have their visitors in focus when they create their exhibitions, instead of the artifacts as they used to, see also Section 3.1.1. [32, pp. 6-13], [36], [67, p. 24].

The museums now animate their collections in new ways by e.g. the use of technologies such as sounds, graphics and other visual media, or interactive features. Museums does, however, still find it difficult to engage the younger generation, due to their higher demands, although Kulturarvsstyrelsen (i.e. the Danish Agency for Cultural Heritage) believes that the use of computer games might be a way to get them engaged because of their confidence using technology. [32, p. 54]

Kulturarvsstyrelsen have made a list (in order) that they believe museums should focus upon in their communication of exhibitions:

1. "Contextualizing

2. Structured and thematic sharing of knowledge

3. Storytelling

4. Emotional Impact"

[4, p. 20], [32, p. 21]

Although museums are becoming more open to the use of technology in their exhibitions, there is also the concern that the technology will make the visitors focus more upon the used technology instead of the real world (hence the presented artifacts etc.). This was also found to be true when computers (such as desktop PCs) are used to present videos and images. This is especially if larger screens are used, as they can both distract the visitors and be obtrusive in the environment. [48, p. 4], [31, p. 232].

Interactive Exhibits

Interactive exhibits are defined as an exhibit[1], which lets the visitors be active (explore). This means that the visitors have to gather information due to their experiences with the exhibit and their inputs, in order to form their own conclusions. The visitors' inputs will change the outcome of the exhibit. An interactive exhibit is therefore when the exhibit responds to (gives feedback to) the visitors when they use it [2, p. 1]. [40, p. 5], [46]

Today is an increase in the number of museums, which use interactive and participatory exhibits, seen [46, p. 92]. One should, however, be aware that even though the term 'participatory' and 'interactive' have often been used together, it is not equivalent to a hands-on exhibit. Having an exhibit where the visitors can touch it, does not necessarily mean that the exhibit is also interactive. [46, p. 92]

Interactive exhibits often use a guide, in order to tell the visitors how the exhibit work. Such a guide can for example consist of small hints, or instructions. Interactive exhibits have the ability to engage the visitors for a longer time than static exhibits. Letting the visitors participate and interact with an exhibit or exhibition can also personalize the experience for each visitor. [2, pp. 1-2], [46, p. 93]

User Experience

User experience is a term allied with multiple understandings, while there are no specific theories that can "guide" the designers when designing an experience. [27, p. 261]. This section will therefore go through different angles and elements of user experience – with a focus on user experiences at museums.

No matter what is desired by the museum, the experience at the museum is individual because of the visitors' former encounters with museums and their 'perceptual skills' [16, p. 170]. This means that museums today should listen to what the public wants (their needs) and not just let the curators decide what they believe that the public should know [16, p. 170], [37]. Falk and Dierking made the Interactive Experience Model, which makes it clear that "people create their own experiences and meanings" [16, p. 178], [24, pp. 67-68]. It is the visitors themselves, who decides what they want to have a focus upon, why each visitor's experience differs from one another. The visitor's experience also depends upon his 'personal and social context.' [16, pp. 178-179], [24, pp. 67-68].

A given product should be designed with attention upon the kind of experience it should create for the user when he interacts with the product, thus making the design research a part of understanding the experience. [27, p. 261].

[1] In the rest of this report will the word 'exhibit' be used to cover only a single installation ('individual element') at a museum, while 'exhibition' will be used to cover a whole section at a museum that concerns a themed topic, such as *The White Busses*, or *The Ancient Department* at the National Museum of Denmark. [2, p. 17]

User-product Interaction Forlizzi and Battarbee have divided *experience* into three different types: *experience, an experience*, and *co-experience*. The division of the types of experience and their definitions can be seen in Table 3.1. *Experience* is the conscious stream that humans have; the 'self-talk'. It concerns our what we would like to achieve about "the people, products and environments that surround us at any given time" [27, p. 263]. *An experience* is what one have when e.g. interacting with a product; it has a start and an end - it is finite. An experience can change the behaviour of a person. A *co-experience* is what one experiences when the experience happens together with other people: the experience is either "created together, or shared with others" [27, p. 263]. [27, p. 263].

Types of Experience	Description	Example
Experience	Constant stream of "self-talk" that happens when we interact with products	• walking in a park • doing light housekeeping • using instant messaging systems
An Experience	Can be articulated or named: has a beginning and end: inspires behavioral and emotional change	• going on a roller coaster ride • watching a movie • discovering an online community of interest
Co-Experience	Creating meaning and emotion together through product use	• interacting with others with a museum exhibit • communicating on a friend's remodeled kitchen • playing a mobile message game with friends

Table 3.1: The table shows the definitions of the three types of experience by Forlizzi and Battarbee [27, p. 263]

The 'affordance of products' provides hints to help us with- and understand how to handle the activity. Affordance is for some related with 'product usability'. Affordance can, however, also be used as a term to cover how users based on 'cognition' as well as 'action' makes sense of the world. [27, p. 264].

User experience at Museums

How visitors understand and experience the different exhibits "through spatial and visual relations" depend a great deal on how the route and movement around a museum is designed "as a public space by shaping visitors physical and visual coawareness." [66, p. 327].

Obtaining a positive and appreciated experience for the visitors have become of importance for the museums (cultural heritage institutions) and is now considered a vital goal. [59, p. 562]. Technology becomes more and more a necessity for museums when it comes to securing a greater experience for their visitors. The research behind the usage of technologies in museum environments are, however, lacking in assessment of the user experience [59, p. 562].

Whether or not a museum is a place where educating and teaching the visitors are the most essential thing to gain is questioned: some find it to be so, but it is not all accepted at a universal level. Some argue that educating and teaching are so important that museums should focus on that, but these arguments are counteracted by others saying that this would lead to 'dumbing down' and making museums be "purely instrumental roles that are in any case the proper responsibility of institutions of education and learning" [49, p. 76], [35], [39]. All the same, it should be considered that the style in which learning is presented at the museum still influence the experience of the visit – no matter if the visitor is there for obtaining knowledge or there for enjoyment. [49, p. 76]

Different medias can be used for an exhibition. These medias include computer screens, display panels, interactive elements, etc. The use of media in exhibitions create a possible dilemma or wonder in the social aspect: how does these exhibitions work when it comes to cooperation between visitors, and is it even a possibility? [44, p. 154]. The paper *Interconnecting: museum visiting and exhibition design* states that when visiting a museum, it becomes a social event no matter what, since other visitors are there too, even though they are not accompanying said visitor, an aspect of socializing often overlooked [44, p. 156]. Using a computer is not always considered to be social, why a multi-touch interface is at least seen as being a more 'social' solution for the visitors. According to Falk and Dierking is the social aspect a very important one in the museum, especially when it comes to learning [40, p. 21].

3.2 Storytelling

This section focuses upon the use of storytelling in museums. First we will look upon the general use, why it is used, and how, whereafter the focus will change to be upon a state of the art project, wherein storytelling have been used for a museum.

Stories are a powerful tool to use. They provide a kind of seduction made up of three main factors: Structure, pacing, and mood [29, p. 422]. Stories do not fill in all the blanks, as this is up for the listener or reader to do himself. This means that stories can "open up a space into which the listener's own thoughts, feelings, and memories can flow and expand. They inspire an internal dialogue and thus ensure a real connection" [6, p. 29]

The world of museums are now seeing a shift of focus from the collection of artifacts, to using the artifacts for creating an interactive experience, see Section 3.1. This also means that the visitors now expect more from the museums: They want to learn, and they want to have an experience. This can for example be achieved through interactive storytelling and gaming; not only can this solve the problem of the traditional means, such as text, it also allow for visitors to learn at their own pace and to deliver a personalized experience for each visitor. [19, p. 104]

3.2.1 Storytelling in Museums

This section focuses upon the general use of storytelling in museums: why it is used and how it is used.

Bruner [13] describe two features, which are related to museums:

1. *Learning*. People "make sense of the world" [6, p. 28] by storytelling (narrative).
2. *Taking a moral stance*; "stories have a point of view" [6, p. 28]. A story helps people to put their beliefs in order through its narrative.

[6, pp. 28-29]

Danks et al. also say that storytelling is a big part of how humans learn; it helps organizing newly gained knowledge and experiences [19, p. 105], [45]. And similarly does Falk and

Dierking [26, p. 51], say that information is organized better, if one tell it as a story - and that this is even true across cultures. It is therefore believed by Egan [21, pp. 70-79], [22, pp. 25-31] that even very young children can learn about history as long as the information is given to them in a level that is appropriate for the age group. This means that e.g. children under seven years old should be presented to history in binary opposites (good and evil, love and hate - also known as the "mythic stage"). Older children, although still having a fascination for the binary opposites, will want the heroes in the stories to be more complex, like real people. [6, p. 29], [19, p. 105]

Today storytelling in museums is often used in public programs, especially where interpreters guide or reenact history, as these "appeal to different learning styles and levels of expertise." [6, p. 32]. This type of storytelling is more often remembered by visitors, although it is not as informal. It is therefore very much possible that for the case that this project revolves around (see Chapter 2), it should be considered to similarly use a sort of reenactment of the event. [6, p. 32]

Creating Narratives for Museums

When one wants to create a narrative for a museums, it is also needed to know, what the visitors desire. Visitors give these challenges when they visit an exhibition:

1. "They want to explore the space and see the artifacts
2. They want to have an entertaining experience
3. They want to learn something from the artifacts and the visit"

[19, p. 106]

When creating an interactive story for an application, there lies a challenge in the so-called "free scenes". Free scenes are in relation to museums, using - or play with - an interactive installation, and when doing unguided tours (on-site rallies), such that the user can explore the informational world by himself in his own pace. Free scenes can disturb the narrative's fluency, it's plot and the dramaturgy. It is therefore necessary to consider that the case that his thesis revolves around (see Chapter 2), should be possible to be used both by visitors exploring on their own, as well as guided tours. [29, p. 419]

There are two types of time constraints when working with an (interactive) narrative for museums: 1) external, and 2) internal time constraints. The external time constraints are when e.g. 60 minutes are planned for a school class' visit at the museum, since the next lesson start right after the visit. Internal constraints are when the time and pace of an application is affected by the user's behavior or needs, such as hunger or fatigue, or it can be by the story itself. For this thesis, it is therefore needed to keep in mind that e.g. school classes only have a limited time for their visit, while it should maybe be considered to let other visitor's having time constraints as well, to have the possibility to get a quicker version of the system for the map at Mosede Fort, e.g. by skipping some of the lesser important parts of the story or to not participate in some of the interactive parts of it. [29, p. 420]

3.2.2 SOTA - Storytelling

The *Interactive Storytelling Exhibition Project* was created by Danks et al. in 2007, in order to make BBC content (BBC Egypt) easier available as a free public service. It concerns a way to make assignments for visitors to complete, in order to progress in the story. Furthermore, they desired to immerse visitors in an exhibition, while finding new ways to create such an immersive

and interactive exhibition. The project will after being presented, also be addressed in relation to this project. [19, p. 106]

For their purpose, they used the BBC Egypt series, which they used seven episodes of content from. The episodes are possible to run in a web browser environment. The user has to give a unique identifier for the system to play the correct episode. This works for both a single user or a group. There are different levels in which the user engage with the stories: 1) a story giving content, 2) a story where the user is taking on the role as a newspaper Editor, and 3) the existing story in the exhibition *Ancient Egypt*. The stories are connected by having the user in the role of the newspaper Editor. The story takes place in the 1920's and mixed media, props and clothes from the BBC show, video and posters are used to immerse the user. In order to register and proceed in the story, the users get an 'International Press Identity Card'. The Press Card can be seen in Figure 3.2. [19, pp. 107-108]

Figure 3.2: The Press Card used for the Interactive Storytelling Exhibition Project. Figure retrieved from [19, p. 110].

The visitors are presented with a first clue before going on the mission. The story is made such that it requires for the visitor to finish different tasks, in order for them to continue the story; the prize for finishing a task is to get the next bit of the story. The challenges and assignments that the user encounters is completed away from the screen, why they only go back to the screen when they need to prove that they have fulfilled the assignment. [19, pp. 109-110]

As a last remark, they found that some of the visitors commented on how long the video episodes were without any breaks, why it is believed that one should use no longer than 1 minute and 30 seconds long un-interrupted video sequences for a standing audience. Furthermore, people can get uneasy when they are not told how long a video will last. It is therefore of importance for this project that all potential video sequences should not be longer than suggested by Danks et al. [19, p. 114]

The project by Danks et al. show that it is possible to mix both posters, various digital media and at the same time include the exhibition itself, without having the visitors only focus upon a screen all the time. The use of challenges can prove to be a possible way to engage the visitors in this project (see Chapter 2) as well, using the map as a basis for the visitors to answer or maybe even overcome various challenges. Furthermore should it, if using animations of a sort or similar, be a way of indicating the length of them - and perhaps of the whole experience itself - in order to not make the standing visitors feel uncomfortable or loose interest in the experience.

Each used video-sequence should likewise not exceed the suggestion by Dansk et al. of 1 minute and 30 seconds.

3.3 Multimodal

This section covers what the term *Multimodal* means, and what it is. The focus thereafter shift towards a state of the art project wherein multimodal methods have been used in relation to museums. After presenting the project, it will be found how it is related to this thesis and how it is possible to use the gained knowledge.

3.3.1 Multimodal Interface

In order to be a multimodal system, the system needs to contain the possibility to handle at least two user inputs; these inputs could for example be gestures, speech, etc. “in a coordinated manner with multimedia system output” [56, p. 1]. Multimodal systems focuses on using common human actions or language, while using a minimum of one ‘recognition-based technology’, such as speech, vision, etc. [56, pp. 1, 5].

It is anticipated that interfaces using multimodal systems will be ’easier to learn and use’ and that it will be a favorite in a variety of cases making applications. Using a multimodal system makes it possible to make advanced applications by expanding computing, and allowing the application to be used by a larger variety of ’everyday people’. It is estimated that multimodal applications are more ’robust and stable’ compared to a ’unimodal recognition system’ where only one recognition-based technology is used [56, pp. 1, 5]. It is different how groups of people interact with the computer, why a multimodal interface is a good tool to use. It is possible to include more different users when having a multimodal interface compared to a traditional one. The users are different due to e.g. previous knowledge and abilities, handicaps, etc. [56, p. 6].

Multimodal systems and interfaces are able to recognize as well as identify different aspects such as actions, and/or people they have encountered in one way or another before. The systems are able to provide the users with a ’voice’. ”They can also be playful and self-reflective interfaces that suggest new forms of human identity as we interact face to face with animated personas representing our own kind.” [56, p. 17]. [56, p. 17]

3.3.2 SOTA - Multimodal

Kitalong et al. made a mixed reality science museum installation called *Journey with Sea Creatures*, to which they used a technique they themselves call ‘retrospective narrative mapping’. The pilot project was a three-dimensional multimodal text that incorporated visuals, sound, motion, and interactive manipulation.” [41, p. 144]. They used observations and interviews, in order to understand the user experience of the installation. The narrative mapping was made based upon additional analysis, and resulted in the creation of the two personas: Ellie and Elizabeth (young teenagers; public school students on a field trip). [41, p. 142, 144]

The creation of the narrative mapping showed Kitalong et al. that you might benefit from not only focusing upon the usability and design of the screen itself, but that you should also look at the surroundings of said screen when evaluating multimodal texts [41, p. 146]. When working with a multimodal project, a screen might not play the main role. In cases where the screen is used for a multimodal project, the screen does, however, have a tendency to be the main focus for the visitors due to the well-known technology and the fact that it is not challenging to use. The result of this is often that the visitors overlook other technologies or parts used in the project. [41, p. 146]

The installation, Journey with Sea Creates, is an augmented virtuality installation that overlays the physical space with virtual content using a screen. It should bring a few of the fossils 'to life' using scientifically correct behaviours. The installation itself is made of a podium and styrofoam, which resembles a cave, and a curved screen for projection. The installation begin when the user presses the start button, whereafter Dr. T. R. Urtle is shown. He describes what will happen and how to use the controls. The Dino Dig exhibition in which the installation is situated in seem to be flooded after the instructions are given, and dinosaurs are swimming around in the exhibition (shown on the screen), see Figure 3.3. [41, pp. 147-149].

Figure 3.3: The Journey with Sea Creatures' interfaces when the exhibition appear to be flooded (AR). Figure retrieved from [41, p. 114].

After using the retrospective narrative mapping, Kitalong et al. discovered that had they used the narrative mapping already during the design phase, it would have been helpful: the "designers might have been led to consider traffic patterns and might thereby have chosen to route traffic through the side door to call attention to the JwSC kiosk [i.e. the Journey with Seacreatures installation]" [41, p. 155]. Furthermore, they discovered that other exhibitions competed with the attention of the visitors. [41, pp. 155, 159-160, 162]

This project shows that the placement and use of an exhibit or exhibits in an exhibition area might benefit from using narrative mapping while designing it. The narrative mapping can show if there is e.g. competing exhibitions or exhibits, if the visitors will even notice the new exhibit and can give an idea of how the exhibit will be used. Since the case at Mosede Fort concern an already implemented and situated exhibit, it is not an option place the map elsewhere. It is perhaps a possibility to used to create personas of the typical visitor at Mosede Fort, in order to gain an insight into how they will use the map. Furthermore, does the project show that it can be beneficial to create user requirements before the design start and that audio can be used to enhance the experience, and to attract the visitors [41, pp. 159-160].

3.4 Adaptive and Personalized Systems

According to Bowen et al. are the terms 'personalization' and 'customization' "sometimes used rather loosely". [10, p. 2]. It is therefore needed to clearly define these terms, including what an adaptive system is. This is therefore the focus of this section. After the terms have been defined and elaborated upon will a state of the art project concerning an adaptive and personalized system for guiding visitors around in a museum be presented (see Section 3.1.2).

Based on research by Granic et al. "[a]daptive systems attempt to personalize and enhance human-machine interaction, bridging the gap between human information needs and the ability of machines to meet them" [30, p. 292]. Adaptive interaction has been mentioned in the literature since the 1980's, and are therefore not a completely new thing. [30, p. 292].

Customization is when the user can change a given interface to fit with his 'individual requirements', while personalization is when the system is adapting to the user based upon information that he provides. The user provide this information either by giving it explicitly or the system can implicitly gather the needed information by observing how he behaves (his actions). This process is also known as user modeling: User modeling and adaptation "are two sides of the same coin. The amount and the nature of the information represented in the user model depend to a large extent on the kind of adaptation effect that the system has to deliver." [14, p. 3]. This also means that adaptive systems (called 'personalized' systems by Bowen et al.) rely a lot upon user models, in order for them to adapt (behave differently depending on the user in question) [30, pp. 292-293], [14, p. 3]. Bowen et al. argues that the term 'individualization' can be used to mean all types of customization and personalization, and so it will also be used for the rest of this paper. It should be noted, though, that a user's knowledge can change from session to session or even within the same session, as the user either learn something new (knowledge increases) or he forget (knowledge decreases). The system therefore needs to be aware of this change and adapt to it ("update the user model accordingly" [14, pp. 5-6]). [14, pp. 3, 5-6], [10, p. 2].

Personalization can be used as a communication strategy at museums that is based upon a collaboration between visitors and the museum. This means that personalization can help create a new communication paradigm different from the one used traditionally at museums (see Section 3.1), such that the communication strategies are changed in a way that uses 'interaction and exchange' to shape a more natural communication (see Section 3.1.2 and 3.2). The museum can therefore to talk with the visitors by being aware that each visitor is an individual; the communication becomes a dialogue. If the museum learns more about the visitor, it is possible for them to deliver a more suitable service. According to Granic et al. can an adaptive system - which is unlike a traditional 'one-size-fits-all'-system - better take the different users into account and can even give more usable user interaction in many domains, thus it can improve the user experience in several contexts. [10, p. 4], [30, pp. 291-292].

3.4.1 SOTA - Adaptive and Personalized Systems

In 2008 created Zimmermann et al. a project called LISTEN. LISTEN was made in order to give visitors at museums a "personalized augmented environment, [...] which goes beyond the guiding purpose." [69, p. 389]. The aim of the project was to let the visitors experience an audio-based presentation of the museum that adapt to their interests, motions and so on. The system was installed at the Kunstmuseum Bonn in an exhibition of artworks by August Macke. [69, p. 389]

The LISTEN project uses motion-tracked wireless headphones and three-dimensional sounds for their interactive soundscapes in different environments. The system allows the users to create a more personal experience in their daily environment by the use of sound. The audio consists of both speech, music and sound effects, and the soundscapes are made to be both individualized and location-based. [69, p. 390].

The audio the visitors hear are dependent upon how the users move around in the space, and their direction of gaze. This means that when a visitor goes closer to an exhibit, he will hear the information associated with the exhibit and he will activate a "simulation of a moving sound source" [69, p. 392]. The system "manages an intelligent memory" [69, p. 394], meaning that the system remembers if an action is a repetition of an action performed earlier, and then offers

other sounds and audio sources. [69, p. 394]

The LISTEN project had also listed three adaptation goals:

1. *Increasing knowledge*. The visitors should get information related to their interests. Zimmermann et al. assumes that the visitors spend more time on an exhibit that they are interested in.

2. *Increasing the comprehension of semantic relations.* An understandable structure between the presented exhibits should be created for the visitors to understand.

3. *Considering the social context.* Visitors taking a similar route in a close time-span with others (similar spatial and temporal behaviour), should be given similar information by LISTEN, as they might be a family or other group, and hence they can afterwards discuss the visit.

[69, p. 400]

The LISTEN system can be seen as relevant for this thesis, since it could be desired to let visitors at Mosede Fort be able to personalize their experience, regardless which visitor scenario (groups and individuals) is in focus.

3.5 Graphics

This section will cover the use of graphics, having a focus on animation. Graphics in relation to learning will first be presented whereafter animation at museums, including state of the art projects within the field. will be investigated.

3.5.1 Graphics in an Learning Environment

Using graphics to create different expressions might be possible, such as making something that is beautiful, funny, etc. - something that catches the viewers' eyes and thereby their attention, keeping their focus as well as their motivation. "Graphics can make internal knowledge external, available to a community to consider and revise". [50, P. 1]. The use of graphics can in many circumstances make it possible to avoid using a lot of words to describe the same thing; this does especially count when referring to faces, maps, and in general in situations where it might be difficult to explain as well as imagine. Graphics have been around for a long time as a way to save information, such as history or simply for personal situations. Graphics are in some cases more effective if they are not too pretentious, however, only if the graphics still manage to deliver the essential and intended information. [50, p. 1].

Animation

The answer to the question whether or not to use animation instead of static graphics can be based on the research conducted by Morrison et al. Their research showed that animated graphics proved to be better in a learning situation than static graphics. Their evaluation suggest that this might be due to the gaps that are created when using static graphics, while animations make it possible to present more information and avoid having gaps between the different steps of information. When one does not gain much (learn) from an animation, this might be due to the difficulty of perceiving the it. [50, p. 1].

3.5.2 SOTA - Graphics

This section will present two state of the art-projects, where animation is used at a museum. The first project is focusing on an interactive system created for the Jing-Hand Grand Canal. The system involves multiple aspects, such as *virtual reality*, *games*, and *animation*. The second case is a guide system called Coach Mike, where the idea is to give the visitors feedback right after an interaction.

The Jing-Hang Grand Canal

The *Jing-Hang Grand Canal* is a canal located in China. The canal is considered a cultural-heritage site, but even though all generations know of it based on images and stories, it is not believed by Chen that the population gives the site the attention it deserves. The suggested solution was to make the experience more attractive by making it interactive, and making the experience more immersive [17, p. 84]. For the presentation of the canal, it was desired to make it as historical correct as possible. The system itself should display two aspects of information: a humanistic and a scientific. This was achieved by including *hands-on*, *minds-on*, and *learn by doing*-methods for presenting information. [17, pp. 84-85].

The system uses animation for the introduction. Based on an old painting of a Festival next to the canal, an additional animation was created. This animation is an image-based animation, based on an around 1.000 years old painting. Several areas in the painting were selected for the main locations of the story. The objects in the animation were created in 3D based on the 2D background and the style used for the animation was a mix of making it realistic, while still keeping the original style of the image. The original painting and the animated version can be seen in Figure 3.4. [17, p. 85-86]

Figure 3.4: To the right the original painting of the festival at the riverside, to the left the animated version. Figure retrieved from [17, pp. 87-88].

Using these techniques for an animation at an exhibit might be a possible way to create animations for this thesis as well, since it also include stories of an old heritage-site. At the same time, it shows how the site itself looks like. This approach could be used, since Mosede Fort is also a historical museum and the contact person has mentioned a wish of using animation as one of the ways to communicate the desired information.

Coach Mike

The main goal with this project was to teach the museum visitors programming in an appealing manner, and to test whether or not a virtual guide can gain the same results as if it had been a human guide in an museum exhibit. The *Coach Mike* project worked with a Robot Park.

The idea for the project was to follow some steps, such as making a simple interface, make it familiar regarding the controls, and to make sure that the visitors get feedback right after an action is executed, since this makes it possible for the visitors to see the changes based on their influence. [42, p. 156]

When creating Coach Mike, the staff at the Museum of Science were asked what sort of questions they were asked, what they experienced, and what their tasks were when working in the Cahner's Computer Place. Based on feedback from the visitors, staff, and the target group (children between the ages 7-12), it was decided to create Coach Mike as a 3D 'cartoon-styled body' with inspiration from newer animation movies, see Figure 3.5. [42, p. 157]

46 animations were created in order to make Coach Mike. These animations include everything from breathing, different gestures, reassuring gestures toward the visitors, such as thumbs up or clapping. When no interaction is occurring, he is "flexing his muscles, knocking on the glass, looking all around, and raising his arms to signal a touchdown (as in American football)". [42, p. 158].

Figure 3.5: This figure shows images of the 3D made Coach Mike. Figure retrieved from [42, p. 158]

The way Coach Mike use animation and interactive elements together could be used in this thesis, so forth interactive elements together with animations. An animation take takes place when no interaction is occurring could be included in this thesis to make the visitors curious about the exhibit. An animation could also be used as an introduction for the interactive elements, so the visitors know how to interact with the exhibit. The same goes for the reassuring part of Coach Mike, since this might motivate people to continue or simply support that what they are doing is correct.

3.6 Audio

The section will start by presenting general information about sound and its usage in learning and the usage of it at museums. It will thereafter cover some state of the art with a focus on how sound has been used in different ways at museums. Each project will be introduced and shortly explained. Each project will end with a discussion about how it is relevant for this thesis.

Audio can be used as a tool for learning. The vision might work faster than listening when it comes to learning from a biological point of view. It can, however, be argued that more is gained from listening, since it plays an important role for people to communicate. [38, p. 173]

Using a soundscape[2] to tell a story or use sound to keep the visitors immersed at the given museum. Multimodal systems (see Section3.3) are being created more and more by using other

[2] "A piece of music considered in terms of its component sounds" [57].

means than simple AR regarding vision, but are now also including sonic and haptic stimuli. [60, p. 167], [38, p. 173].

It is experienced that more museum exhibits are including sound, with the results of the visitors being more willing and positive to take part in an experience at a museum where interactive elements are used to present cultural knowledge. [15, p. 391].

Audio can be used as a trigger to remember specific episodes or events in ones life. When presenting an image while having some sort of audio in the back, the audio "hides away from our consciousness" [53, p. 4]. It is different when the sound becomes the main focus for the awareness: When listening to the audio it transports us to another place where the visual elements and their meanings are based on the sound. "The directness of sound can reveal things to us that are impossible to discover through other media" [53, p. 4]. [53, p. 4].

It depends on the kind of museum as well as the purpose of the exhibit which sort of audio should be used – a voice, music, or well-known sounds that the visitors would easily recognize. It is the selection of said sounds that could be beneficial when creating an environment using multimodal elements, as the multimodality makes it possible for the visitors to understand it in various ways. [15, p. 393].

3.6.1 SOTA – Audio

This section will cover different cases in which audio has been used at Mosede Fort museum. The information presented is based on a field study conducted by the authors behind this project. As mentioned in Chapter 2, this thesis will revolve around the Mosede Fort museum. While making an assessment of the case in focus, the additional exhibits at the museum were explored as well. During this field study, it became clear that the museum have a special focus regarding the usage of sound. Multiple of the exhibits are using sound as a means of communication or to create an atmosphere of the Fort during WWI. The focus for this section will be on three of the rooms at the museum.

The first room is the music room: a room full of instruments, see image to the right in Figure 3.6. Audio of the instruments playing begin upon entering, showing how the entertainment was at the fort. The music room shows one of the more joyful atmospheres at the fort. The second room is the shower room, where four shower cubicles are installed. The idea is for the visitors to enter the cubicles while listening to a conversation between soldiers talking a shower. The design of the exhibit is made so the sound is played from the showerheads (see to the left in Figure 3.6), making it appear as if there actually are people in the cubicles. The last room - called Arrest (translated from Danish: Arresten) - is empty besides a bench and four speakers, see the middle image in Figure 3.6. The idea is for the visitors to sit on the bench. To start with the room becomes dark and the only thing the visitors are experiencing is sound coming from the four speakers – one in each corner. Since the room is completely dark, the visitors are only experiencing the sound, which is a conversation between soldiers. This makes it appear as if the soldiers are actually in the room with the visitors.

One thing that should be taken into consideration is that since the museum already uses a lot of sound in their exhibits. It would therefore create a nice thread throughout the museum, if the solution for the case (the map) would do the same. It could also be relevant to use a soundscape to explain certain events in the story where it is not possible to present the information using graphics, e.g. for the areas on the map, which are missing for the full area/story to be presented. Creating a soundscape does not only provide the visitor with information, but also helps create the right atmosphere that might take the visitor back in time. It should therefore be considered when creating a soundscape that it can be used for more than just delivering information.

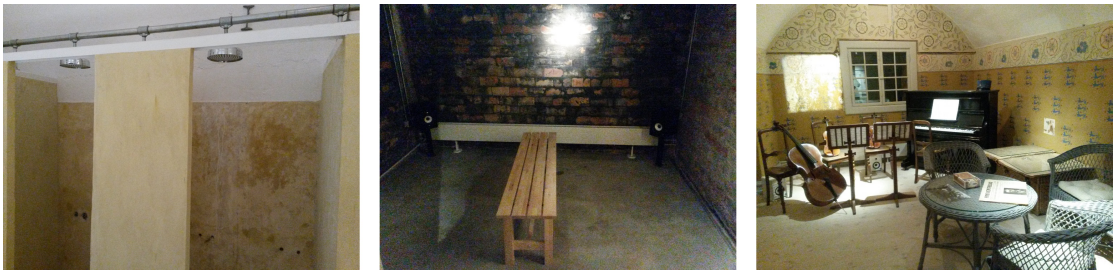

Figure 3.6: The figure includes three images each representing one of the rooms with audio in focus.

3.7 Learning

This section covers the topic *learning*. This includes an introduction to learning in general, although the focus is upon learning in museums - which kind of learning occurs at museums - and how one can design an optimal learning experience at museums.

Learning begins "with the individual. Learning involves others. Learning takes place somewhere" [25, p. 36]. These three statements makes in a very simplistic way the learning experience. It should be noted, though, that to divide learning into these three statements is an artificial division, as they all overlap and work together to facilitate learning. [61, pp. 10-11]

Millions visit museums around the world every year, and most of them learn something from those visits. These visits often happen in family groups (groups consisting of up to 5-6 people and who comes to the museum together [34, p. 146]), who only uses a short amount of time on the often complex activities at the museum. Contrary to school and work are these visits also usually voluntary. These voluntary visits to museums normally happens infrequently, even when we are talking about 'expert practitioners' they might only visit museums a couple of times each year. Earlier when assessing the visitors' learning outcome, the visitors would have to give answers corresponding to some predefined information, similar to that one could expect from learning in a classroom setting. Nowadays the museums have acknowledged that this is not the best way to figure out what people have learned. Usually, however, the visitors seem to get reinforced of already known ideas, and the visits to museums also seem to make a change in the visitors; they remember the visits usually with pleasure and the visits can influence the visitors' behaviours in the future as well. [23, pp. 259-260], [16, p.181], [34, pp. 135-136], [26, p. 150].

It has long been proposed that people tend to learn more when they are participating in 'meaningful physical activity'. Now, it is, however, also empathized that not only is hands-on activities needed, so are minds-on [20]. Museums are therefore also having more and more 'activity rooms' and parts of their exhibitions where the visitors can be problem solvers or do crafts; the visitors can take part in activities that is not just physical actions. [34, p. 144]

The time used on each exhibit element by the visitors are not long - in most cases it is merely seconds. The visitors rarely care to read labels or even investigate the majority of the exhibits elements. When interactive elements are involved most visitors do not seem to read the guidelines, but are instead trying it out without any knowledge of how to operate it. It has also been shown that children are most inclined to try the interactive elements compared to grownups, and that the visitors' focus decay after around 30 minutes. The time that the visitors use upon a single exhibition can be increased; the 'visitor time' can even be more than doubled (how many visitors that stop at the exhibition and for how long time they spend on it). "Perhaps least surprising is the finding that explanatory labels, as distinct from no labels at all, make an

enormous difference in visitors' attention." [34, p. 138]. [34, p. 138]

3.7.1 Characteristics of Learning

According to Falk and Dierking should it be expected that museum learning is contextually driven, that it is impacted by the "interaction between the personal, sociocultural, and physical contexts of the experience." [26, p. 152]. They therefore reasons that it is to be expected that learning:

1. ... should be scaled to each visitor's expectations and motivations
2. ... is very personal and therefore also affected by his prior knowledge and interests
3. ... depends upon the visitor's preferences of what to learn and his wish to control the learning
4. ... is influenced by the interactions and his cooperation with the other visitors; both outside and within his own group

[26, p. 152].

In Rennie and Johnston's paper *The nature of learning and its implications for research on learning from museums* from 2004 they argued further on the three characteristics proposed by Falk and Dierking. [26]: 1) learning is personal, 2) it is contextualized, and 3) learning takes time. It should be noted, though, that these characteristics does not exclude each other, but that it is together that they form learning. Rennie and Johnston reasons that museums will have to change people in one way or another, so forth that they have an influence upon their lives. [61, pp. 4-6], [26, p. 178]

According to Falk and Dierking are there eight major factors, which can go in and influence learning in museums [26, p. 178]. It is in the following sections that these factors will be elaborated upon. The factors can be seen in Table 3.2.

Learning is Personal

Not only is the given curriculum (what the museum want to convey) different from museum to museum, so is the visitors; which exhibit and to which extent they want to participate from the museum's curriculum is up to them. The visitors all bring their own plan to the museum of what he wants to learn - his own curriculum - why each visitor will also have an individual and subjective learning experience and outcome from the visit (each visitor has his own *motivation and expectation* for the visit, see also Table 3.2). Shortly, it can be said that the preferences and the motivation for learning simply differs from visitor to visitor [2, p. 27-28]. Not only does the museum visitors bring their own agendas to the museum, they also bring different previous museum expectations, levels of perceptual skills and even different expectations for the visit. This also means that a museum visit cannot be standardized; it is individual and very personal, see Section 3.4 for more about personalized systems. [61, p. 6], [16, p. 1701 178-179], [26, p. 179]

In order for a person to learn, he needs to be engaged, and it is not possible to learn without having a mental, a physical or a social activity. It is the person's past (prior knowledge) that helps the visitor to learn and create new meanings (the visitors *prior knowledge, interests and beliefs* have an impact upon the learning outcome from the visit, see also Table 3.2). Rennie and Johnston reasons that one cannot for sure see when learning has happened, but it is possible to observe it in the visitor's actions: both what he does and what he says. The visitors tries to even consciously or subconsciously to create a connection with the exhibition, the program or

Characteristic	Key factors of the characteristic
Personal context	1. Motivation and expectations 2. Prior knowledge, interests and beliefs 3. Choice and control
Sociocultural context	4. Within-group sociocultural mediation 5. Facilitated mediation by others
Physical context	6. Advance organizers and orientation 7. Design 8. Reinforcing events and experiences outside the museum

Table 3.2: The key eight factors, which can influence the learning in museums. Table created based on [26, p. 178]

the website; the visitors want to be able to 'see themselves' there. In order for them to do so, they need to know why the exhibition is even relevant for them. Museums offer the opportunity of 'choice' for the visitors (*choice and control*, see also Table 3.2); the visitors can choose themselves where they want to go and what they want to learn. The museum is a 'free-choice' environment, similarly to free scenes, see Section 3.2. [61, p. 6, 8], [26, p. 150, 182, 185]

Learning is Contextualized

Since learning experiences are based on only a specific location, time, and event, the experiences can be categorized as 'contextual'. The three contexts - 1) the personal, 2) the social, and 3) the physical (see Table 3.2) - work together in order to create the visitor's museum experience. The personal context is related to the visitor's background, such as his interests and prior knowledge. The social context is the other people present at the museum and how the visitor communicate with them. It also includes "the social and cultural features associated with the artifacts and exhibits" [61, p. 6]. The physical context is the environment of the museum, such as its architecture and the exhibitions themselves. In general, it is very important in regards to learning that the visitors feel comfortable at the museum. They should not feel intimidated by how intellectual the exhibit is or of the sheer number of exhibits. Likewise should the noise level be comfortable. [61, pp. 6-7], [16, p. 181]

In relation to the social aspects of learning, Falk and Dierking reasons, that even when one looks like you are learning alone, you are in fact not: "people are learning socially" [26, p. 189]. There have therefore been created exhibits to be used by small groups (*within-group sociocultural mediation*, see also Table 3.2). Borun et al. found seven characteristics that makes a family-friendly exhibit for learning in a collaboration:

1. *Multisided*: making it possible for multiple people, e.g. families, to gather around it.
2. *Multiuser*: where more than one user wants to interact without interrupting each others'

experience.

3. *Being accessible*: allowing both children and adults to use the system.
4. *Multi-outcome*: the outcome should be different enough for a discussion to occur within the given group.
5. *Multimodal*: in order to achieve a good result for families with different needs (learning styles as well as adjustments based on age, multimodal systems are a good way to go).
6. *Being readable*: it needs to be easy to understand when reading a text.
7. *Being relevant*: it needs to support and maybe add more to the visitors' prior knowledge and experiences.

[26, pp. 190-191], [8].

In order to convey information to the visitors, one can also use staff members to e.g. perform museum theater and create storytelling for the visitors to enjoy and learn from (*facilitated mediation by others*, see also Table 3.2). [26, pp. 191]

Learning Takes Time

Learning takes time, because learning is change and change does not happen immediately. It takes time for the visitors to gain new understandings based upon connecting their prior experiences and knowledge with the newly acquired information from the visit: the visitors need time to reflect, in order to create links between the old and the new. Although you can sometimes get an *Heureka!*-moment, this only happens if the pieces falling into place were not already a part what you knew. New learning is dependent upon the things you already know; new learning builds upon already known information, and new information will likewise build upon the newly learned things in the future. Learning is cumulative and it is iterative. This also means that what the visitors learn from a museum visit might actually not show itself until later. "if the visit is to have any long-term impact then time is required to allow learning to find relevance and be transferred from the context of the museum to other contexts in the visitor's life situations" [61, p. 8]. [61, pp. 7-8]

3.7.2 Learning at Museums

Museums offer a free-choice learning experience to its visitors. Both the visitors and the designers of the exhibitions at the museum anticipate that the visit will result in a learning outcome [26, p. 177]. By telling the visitors what they might learn from an exhibit has proved to increase the visitors' learning outcome from the exhibit. [34, pp. 138-139]

Studies have shown that people do not only learn from museums; they also carry this learning experience with them for months after a visit. One such a study was conducted at the National Zoo in Washington, which had a focus upon the zoo's *Think Tank* exhibition. In the study, the researchers contacted 150 of the zoo's visitors 13 months after they had been at the zoo. In essence was the 'evidence for learning' unchanged, despite it was more than a year ago they had visited the zoo, including that half of the contacted visitors said that the exhibition had impacted their behavior concerned to animals. Some of the visitors mentioned watching TV shows, or read books about the topic, or have conversations with their friends or family members about it. [23, pp. 264-270]

In order to make people learn when using a exhibit, should the visitors in the ideal world be motivated to continue based on their interest and a curiosity of discovering more as well. The motivation should be kept based on the "flow" state (i.e. a state that is achieved when the visitor

is completely engaged with both their body and mind in an activity). In order to achieve the flow state, the tasks given to the visitor should have a difficulty fitting the skill level of the given visitor, together with specific guidelines and a precise goal. Research suggest that visitors will most likely agree to partake in an activity if they feel that it is something that they are able to manage, and so they feel comfortable. [18], [33]. The comfort of the visitors is a very important aspect in regards for the visitors to learn. Comfort includes factors, such as physical comfort (e,g, having places to rest), and the psychological conditions (such as the discomfort one can get when not facing the open spaces at the museum) [55]. Similarly are the light in the museum, the noise etc. a large part of visitor comfort. [2, p. 23], [34, p. 137], [26, p. 152]

The cognitive overload for the visitors are a major obstacle in museums, according to Sue Allen. One way to perhaps limit it in especially hands-on museums, is to use what she calls 'immediate apprehendability', meaning something that the visitors will understand (its use, purpose and its properties) almost instantaneously (similar to affordance [28], [54], although more generalized to include labels and similar). Immediate apprehendability rely on the visitors' prior knowledge, although Allen claim that "it is possible to consider it as a property of the environment to the extent that the visitors share perceptual and conceptual schemata." [2, p. 21]. A way to get immediate apprehendability is by user-centered-design (also known as end-user and natural design), such that the objects used only call for specific types of use, such as knobs for turning and slots for inserting e.g. coins or similarly: the user will know what the objects are for without the need of further instructions or labels, at least as long as it is kept simple [54, pp. 9-10]. [2, pp. 20-21]

In 2004 Allen and Gutwill found five pitfalls when working with exhibits that have many interactive features: "(1) multiple options with equal salience can overwhelm visitors, (2) interactivity by multiple simultaneous users can lead to disruption, (3) interactivity, even by a single visitor, can disrupt the phenomenon being displayed, (4) interactive features can make a critical phenomenon difficult to find, and (5) secondary features can displace visitors' attention from the primary one" [2, p. 25], [3].

It is proposed that interactivity advocate increased engagement of the visitor, as well as his understanding and ability to remember the exhibits. [2, p. 24]. Sue Allen, however, found in her article *Designs for learning: Studying science museum exhibits that do more than entertain* that it should be with caution that one claims that interactivity is absolutely needed for learning, and that it should make the most memorable and appealing experience in museums, even though George E. Hein only four year earlier had claimed exactly that: that there should be interaction - the visitors should 'attend to something' - in order for learning to happen [34, p. 136]. It was also found by Allen that physical interactivity is not necessarily equal to effective learning. Having too many features might actually make the learning outcome and the visitors' engagement worse. [2, pp. 24-25, 30]

Family groups learn according to Borun and Dritsas [9] in a multimodal way, since the group members have various learning styles. It is therefore for this thesis believed that a multimodal system, which takes the different age differences, as well as their level of knowledge, in a family group into account to be the best solution. [2, p. 28]

In a study by Hall and Bannon where they studied children in the exhibition *Retracing the Past*, they found that one very important aspect about the exhibition was that they had reproduced and added replica artifacts for the visitors to handle. That there were physical objects like this made the children at the museum more engaged. Furthermore had the exhibition area been deemed to be comfortable and 'welcoming' by the children as well. They did, however, also find that sometimes the children, when encountering the technology present in the exhibition, focused too much on the technology itself and its 'magic', instead of the actual task that the part of the exhibit gave them. [31, pp. 234-237, 242]

3.7.3 Creating a Learning Experience

When wanting to create a learning experience, the designer can have specific learning outcomes (or objectives): statements that describe what the learner (in this case, the visitor) should get out of participating in the activity. Having such learning outcomes means that it is possible for the educator or museum to evaluate what have been learnt, indicating how successful the activity have proven to be in regards to learning. This, however, does according to others not necessarily state all the learning outcomes or the effect that the visit have had on the visitor, see Section 3.7. [11, p. 413]

Brown found in his study that "more sophisticated multimedia are not necessarily the same thing as 'innovative e-learning resources and services'." [11, p. 423], and that it might not be the media types that should be the main focus, but the form of them (narrative, interactive, communicative, adaptive and productive) instead. [11, pp. 423-425]

3.7.4 Last Remarks for Learning

We have learned that visitors do learn and perform meaning making in museums. The visitors gain an understanding of the presented subjects, especially when they can see, touch and manipulate them. It is, however, not always that the visitors gain the intended learning outcome, but even so, they have still learned from the exhibitions [26, p. 173]. The learning happening at the museum need to take offset in the visitors' prior knowledge, which they bring to the museum, since learning can only happen "when visitors can connect to what they already know, can make an association between what they bring to the exhibition and what is presented" [34, p. 152] - conclusions, which was also reached by Falk and Dierking [26, p. 151-153]. The visitors can not only recall a visit to a museum months after the visit itself, the exhibition also have the ability to change the visitors' behaviours and can have an impact upon them and their beliefs. [34, p. 152]

3.8 Conclusion of the Investigation

We have in this chapter investigated various topics, in order to be able to design a multimodal system, to work with the already implemented physical/digitally projected map at Mosede Fort (see Chapter 2). The historic event in question (WWI), however, presented some challenges that it is needed to find outside-of-the-box solutions for: 1) there are important areas on the physical map, which are missing, 2) there is no access to the source code for the system that Mosede Fort already have implemented. The investigation have shown that it will be possible to use audio, in order to indicate what is happening in the areas not visible on the map. Since there is no access to the source code already implemented at the museum, it has therefore been decided to create a proof-of-concept of a part of the system that will work independently from the already implemented digital-part of the map.

It was learned through the investigation that we now see a change in the field of museums: from the traditional museum where the museum is the deliverer of information (usually an artifact including a sign-explanation of it) and the visitor being the (passive) learner of the information, to having the visitor in focus when designing the exhibitions. This makes the visitors more involved in the museum experience than before.

An investigation of storytelling and how it is used at museums showed that it consist of structure, pacing and mood, and that it makes the reader fill in the blanks himself, such that it inspires for internal dialogue and connection. It can give the visitors a personalized experience and a chance to learn at their own pace. Furthermore are stories a way of letting people make sense of the world; it makes people learn better, as the information is structured and it helps

even young children to learn about history. It was also learned that the external and internal time constraints that visitors have is needed to be taken into consideration when designing an exhibit, why it is believed that for the case at Mosede Fort, it might be beneficial to make it possible for the visitors to e.g. skip non-essential parts of the story or similar, in order to accommodate the time constraints. Similarly should the system be adaptable, such that it has a special mode for school-classes, who often only have a limited time available for the museum visit.

In order to create a multimodal system, the term was defined to be a system, which uses more than one input modality. A state of the art-project showed that audio can be used to enhance the experience and attract the visitors, why this should be considered when designing the system. Researching adaptive system, it was learned that creating such system can unite human and technology as well as allowing individuals to create a more personal experience.

When investigating the use of both static graphics and animations at museums, it was found that it can be used to catch the viewer's eyes, their attention; focus and motivation, including making the use of many words or text unnecessary. It was discovered that animated graphics are usually better in a learning situation than static graphics are. Looking at state of the art projects, it was found that multiple different animation styles can be used to present old historical sites. It was also found that it might be useful to include an animation to attract the visitors, when no interaction have been occurring for a while. Likewise can an animation work as an introduction to how the visitors should use the interactive elements of the system, and reassuring animations might motivate people to continue since they know what they are doing is correct as shown the state of the art case Coach Mike.

Audio should be used to convey information about the areas of the physical map at Mosede Fort, which are not represented there, why audio and its use at museums where investigated. It was found that audio - as well as visuals - can support learning and that it can play a large role when it comes to communication. It was shown that it is possible to create a soundscape, which can express a certain atmosphere or environment.

learning was investigated, having a focus on learning experiences at museums. Here it was discovered that learning in a large sense consist of three components: 1) learning is personal, 2) it is contextualized, and 3) learning takes time. Furthermore, it was discovered that learning is a social thing, since - even if you are going to the museum alone - there are still other people at the museum with you. This means that not only should the design of the map at Mosede Fort consider that people are individual, and each bring their own past experiences, expectations, motivations and learning style to the museum. The system should also be able to accommodate the use of more than a single user, or as a minimum make it possible for other visitors to see what is happening, while the system is in use. It was also found that when creating a learning experience, it is beneficial to explain to the learner (the visitor) what they should get out of the experience, and that interactivity in a learning environment can make the visitors stay longer at an exhibit, and that it can increase the engagement of the visitor, including his understanding and how well he can remember the exhibits.

3.8.1 Design Requirements

This section sums up what was learned in this chapter into design requirements for the case at Mosede Fort.

The prototype should...

1. ... be made for the analogue/digitally projected map already installed at the museum Mosede Fort

2. ... revolve around WWI and how the battery would have reacted if the Danish coast had been invaded by the Germans

3. ... take the missing areas of the map into account; audio should be used, in order to let the visitors know what is happening in these areas
4. ... take into account that the source-code etc. already implemented at Mosede Fort is not accessible by anyone else than the company who made the digital part of the map; the designed system should therefore be made as a smaller, proof-of-concept prototype
5. ... mix various media, such as audio, graphics etc: it should be a multimodal system
6. ... should be user-friendly and intuitive, e.g. should it be possible for the regular visitor to use the system on his own, without intervention of the museum staff
7. ... attract the visitors, e.g. through the use of audio
8. ... be able to be used multiple times by the same visitor, when visiting the museum again
9. ... take advantage of immediate apprehendability/affordances, in order to be intuitive
10. ... be possible to use it individually and in groups
11. ... take into account that some users do not have a lot of time available or do not wish to spend a lot of time on the system
12. ... tell the visitors what is going to happen, what they might learn before starting the system
13. ... make use of the same type of graphics that was used during WWI, such that e.g. the map layer used underneath will be similar to that of a map from WWI (based on a meeting with the contact person at Mosede Fort)
14. ... be made with the seven characteristics founds by Borun et al. that makes a family-friendly exhibit for learning in a collaboration in mind

Chapter 4

Design

This chapter concerns the ideal design, which are made based on the Investigation, see Chapter 3. The chapter is divided into the following topics: the target group for the system, architecture of the system, the appearance of the map, the told (hi)story, the graphics, the audio (soundscape), and challenges for the visitors, which also includes the interactions for the system. Three different personas will be describe how the authors visualize the system in use. One of the challenges have been chosen to be presented in depth and will represent the proof of concept.

The design will cover all the features that the multimodal system will add to the original map at Mosede Fort (see Section 2), such as more diverse interactive elements, a story will be played out presented with different methods, and it will be made in a way where it is possible for the visitors to be co-designers of their experience.

4.1 Target Group

The system is designed with the visitors of Mosede Fort Museum in mind. According to the contact person are the most typical visitors at the museum divided into: 1) the family: parents or grandparents with smaller children, and 2) young adults: usually school visits, primary school and high school. Furthermore, it is also believed that there is a third group: 3) the history-interested.

4.2 Architecture

This section will focus on the architecture of the system. The reasons behind what the system should be able to do, which things the visitor and the museum staff should be able to do etc.

The system provides the user with an overview of his performance of the challenges when all challenges have been overcome and the story is finished, before the system ends and it is ready for the next user(s). The system will revolve around WWI and how the battery would have reacted if the Danish coast had been invaded by the Germans (see Section 3.8.1). The visitors will learn about the subject through a story, which is given to them through animations, sounds and a voice over, and by accomplishing various challenges.

The architecture of the system (application flow) can be seen in Figure 4.1. As it can be seen, the user is involved in two processes: the start of the system and to solve some challenges. The start button will be activated when the system detects the visitor standing on a start-mark, which is projected down on the floor, making the visitor stand in the most optimal area for interacting with the system. The challenges are made for the visitors to learn by doing, as inspired by the state of the art project *The Jing-Hang Grand Canal*, see Section 3.5.2, and will be implemented using different techniques; some will be simple questions, while others will require the visitors to be more active. The challenges will together with small animations and sound files provide the visitors with additional knowledge. In order to let the user know what he will learn through the use of the application, he is given an introduction to the system, since it was learned in Section 3.7 that people tend to learn more and stay longer at an exhibit if this information is provided before start. It is the story itself and especially the challenges, which will facilitate the learning experience for the user, since stories make it easier for the user to make sense of the provided information (Section 3.2), and the challenges makes the user learn by doing (it should consist of both hands-on and minds-on challenges), see Section 3.7. In the end - before the whole system ends - the visitor(s) will get feedback on their performance. Everyday visitors will simply get feedback on their performance, where as for school classes it will be possible for the museum staff to print out the results (feedback), for the teacher as well as the students.

4.3 The Appearance of the Physical Map

The appearance of the physical map is grounded in the map already implemented at Mosede Fort, see Chapter 2. This means that the physical map itself will continue to look like it does already, albeit with some changes to the usage of it and the projected map will get a new appearance more suited for the time period in questions (this will be addressed further in Section 4.4.1. It is these changes, which will be explained and elaborated upon in this section. The design of the physical map and some of its attributes, including some of the parts of the map that are not presented physically at the museum can be seen in Figure 4.2.

As the map is now, it will have some areas, which is a part of the chosen story, but that are not shown on the physical map itself, why these areas will instead be represented by an audio ‘landscape’, so to speak (a soundscape), see Section 3.6 for more about the usage of audio

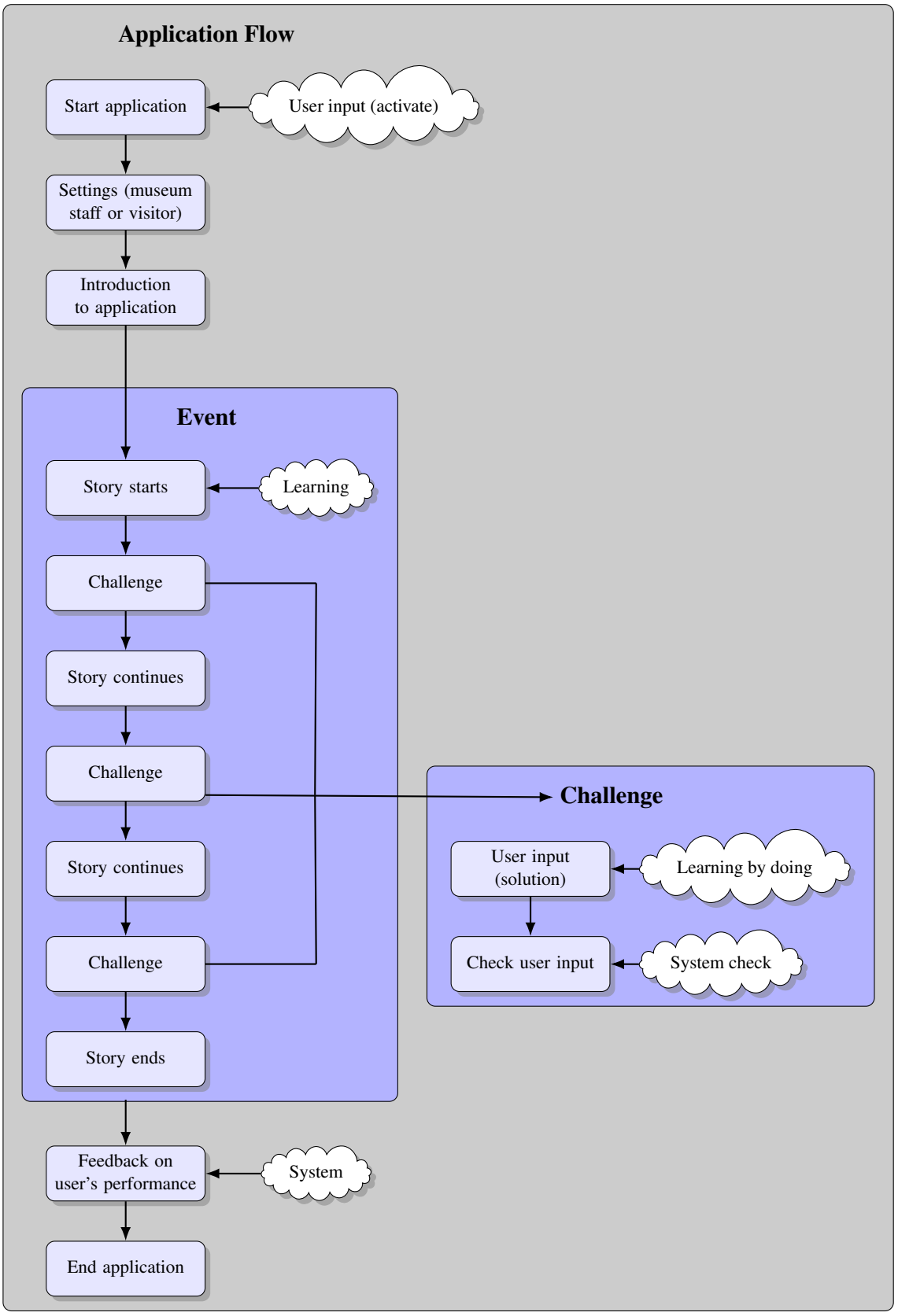

Figure 4.1: The architecture shows the flow of the system; mapping out the event

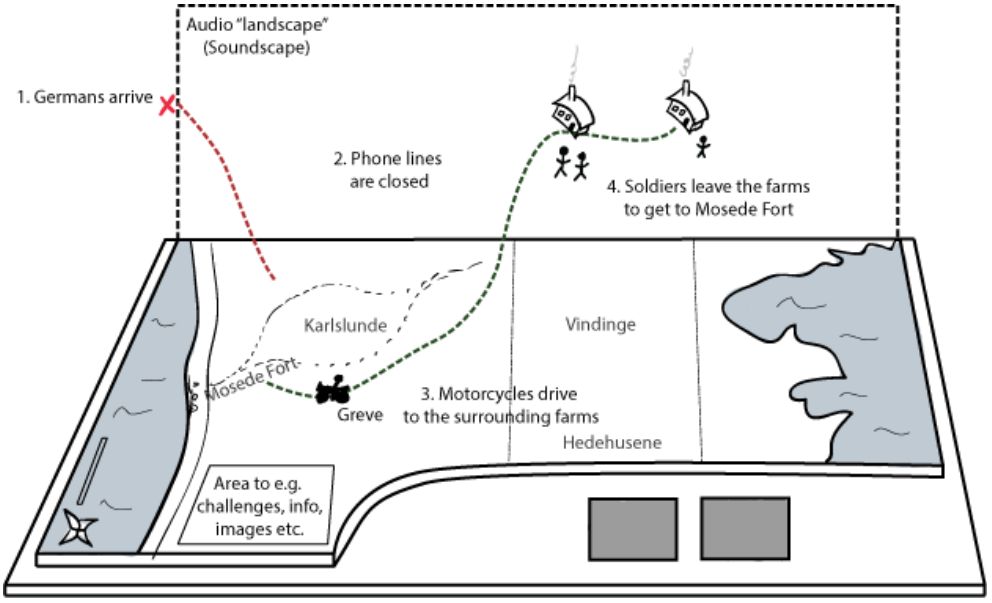

Figure 4.2: The overall design of the map, including the main events in the story.

at museums. The soundscape will give the visitors an indication of what is happening on the areas of the map that they cannot see, without being too obtrusive for other visitors (more about the audio and the type of it will be addressed in Section 4.5). Another solution, which was considered, was to make the physical map larger, but it is believed that it would be obtrusive for the other visitors. This would mean that visitors would not be able to walk the whole way around the map, or for all the visitors of the guided tours to stand around the map, while the tour guide explains and talk about what the map shows, as a trip to Mosede Fort showed that they do, see Section 3.7.1.

Since there are already two screens implemented with the map, it is not desired to use more screens. Because the already implemented screens are situated away from where the main events of the story takes place, it is desired to avoid the usage of screens altogether and instead use the projectors to project extra info, images, and challenges for the visitor to overcome directly on the map. Similar to the screens, it is desired to avoid the use of labels, since it has been discovered that most visitors do not seem to be interested in reading the labels at museums or simply do not take the time to read all the information. It should, however, be mentioned that some are still able get the gist of what the label concerns [34, p. 140].

Images and some of the challenges which will be addressed in Section 4.6 and for more in detail in Appendix A - will be shown and solved directly on the map in the area of where the story is happening (in the bottom left of the map), see Figure 4.2. This also means that in the implemented system, it will simply use the four projectors that are already used at the museum, but since it is not possible to access the source code for the already-implemented projected map - see Section 3.8 - another, single projector will be used for this system when evaluating the proof-of-concept.

4.4 The Story

This section covers the thoughts behind the designed story. The story is originally written in Danish due to the audience at the museum, but a translated version (to English) of the full story can be seen in Appendix B.

The story is based on sources gotten from Mosede Fort, conversations with the contact

person and the book *Tunestillingen - Feltbefæstningen fra Roskilde fjord til Køge bugt* [5]. The main goals of the story is to show the user's: 1) that the Tune trench line was created in order to protect the Danish coast from a possible invasion by the Germans, and 2) how the Danish military had planned their reaction plan, in case that the Germans had tried to invade Denmark through Køge harbour. It was furthermore desired to make the challenges an integral part of the story, such that they did not feel like they had been plastered on top of the story, and that the story would function just as well with the challenges as without them. The users should during the story primarily follow a single (Danish) soldier, called Thomsen.

4.4.1 Graphics

This section covers the design and appearance of the graphics to be used for the system.

Due to the time period, the map and what is used at the museum already - here referring mostly to Mosede Forts iPad applications - it is decided to mainly use 2D graphics. Especially for the animations used to tell the story should 2D graphics be used at all times, although for the challenges 3D graphics can be used as well, so forth that it fit well with the given challenge.

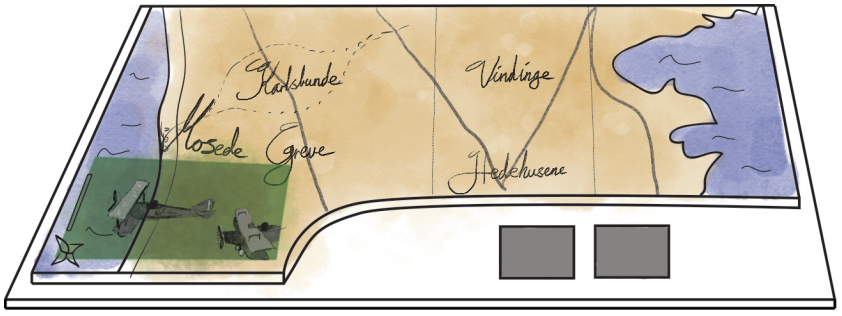

Figure 4.3: The design of the map, inspired by maps from WWI. Here it is shown how it is believed that an animation showing what is happening in one of the parts of the map, which is not else visible on the map normally (Germans airplanes scouting), should look like.

In order to give the system a 'historic feel' to it, it is decided, although to be coloured digitally on a computer, to use watercolours to colour the background of the map, and for the animations where it fit. Examples of how it is imagined that this should be coloured can be seen in Figure 4.3 and 4.4. This means that it is desired to have the backgrounds painted in a watercolour style, being fairly detailed, while the characters themselves should be considerably more simple in their colouring and style.

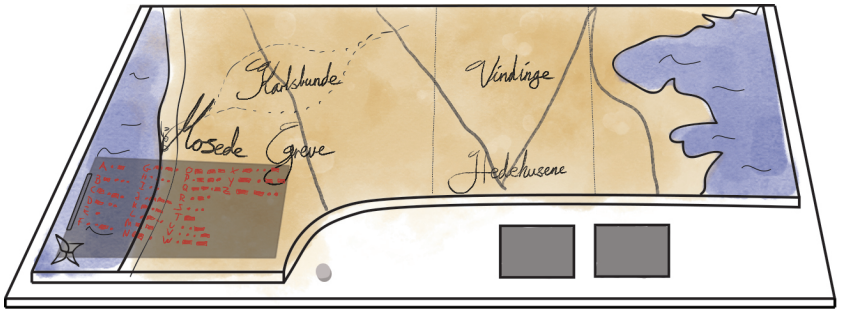

Figure 4.4: The design of the map, inspired by maps from WWI. Here it is shown how it is believed that one of the challenges, which will be presented in Section 4.6 and in Appendix A, could look like.

The animation themselves should be digital 2D animations, resembling traditional frame-by-frame animations (although they do not need to be made that way, as long as they resemble). The style of the animations are inspired by animated short films, including The Butterfly Dragon[1], Seedling[2], Red[3], and the state of the art project The Jing-Hang Grand Canal, described in Section 3.5.2.

In order to figure out how the soldier - Thomsen - should look like were various sketches of him made. These sketches can be seen in Figure 4.5. It was desired to have a simple drawn stroke and feel to it, similar to e.g. a Disney animated movie. The two authors of this thesis therefore drew each their own suggestions of how Thomsen could look like. In the end, it was decided to use a mixture of two of the suggested sketches. The reason for choosing the mixture was the authors' ability to be able to draw it multiple times, that the soldier looked like a young man, new to the life of a soldier, and that this therefore would fit with the visitors having to help Thomsen through the challenges. The chosen soldier and drawing style can be seen in Figure 4.6. Thomsen's body here referring to his uniform is based on the uniform exhibited at Mosede Fort.

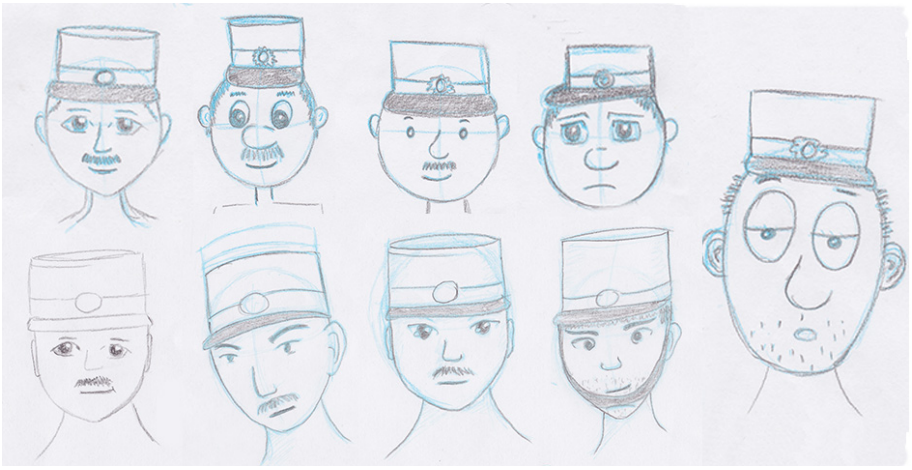

Figure 4.5: Sketches of the design process of the soldier that the user at Mosede Fort should follow through the animations and challenges.

4.5 Audio – The Soundscape

The idea is to present the parts of the story that takes place outside the physical map by using audio (see Section 4.3). A soundscape was in Section (3.6) referred to as "A piece of music considered in terms of its component sounds" [57]. In this thesis, the authors will refer to a soundscape with the following definition: an audio based environment using a combination of three types of audios and a voice-over to guide the visitors through the event and the challenges as well as present the historical information. The three types of audio being:

1. Dialogue (conversations between active roles of the story).
2. Sound effects (birds, footsteps, etc.).
3. Background music (to create a certain atmosphere).

[1]The Butterfly Dragon can be seen here: `https://www.youtube.com/watch?v=bAQ56_dfOfY`
[2]Seedling can we seen here: `https://vimeo.com/22912215`
[3]Red can be seen here: `https://vimeo.com/11584663`

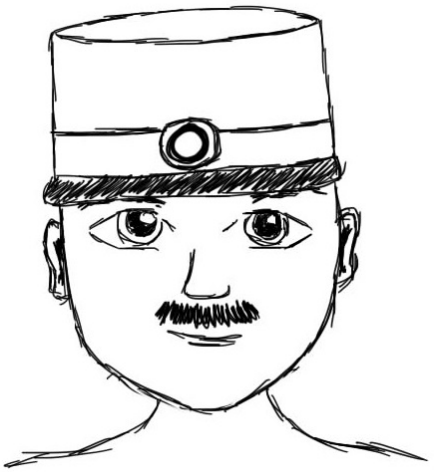

Figure 4.6: The final design of Soldier Thomsen's face

All three types will be used in order to create a soundscape for this exhibit. The different sounds will be created and combined with the purpose of achieving the desired atmosphere as well as to present the story in a simple, clear way, such that it is easy to understand what is going on.

4.6 Challenges

For the ideal design, six challenges have been made - see Table 4.1 for a short overview of them. To see a more detailed description of the challenges see Appendix A. Each of the challenges are designed with a learning prospect in mind and present different assignments conducted in the theoretical plan from Mosede Fort. These assignments (challenges) include, but are not limited to: building a fence of barbed wire and signaling the fort when Germans have been spotted. The different challenges are designed with a multimodal system in mind (see Section 3.3) and different techniques, such as movement, sound, the tactile experience of a button, and visuals (primarily feedback), have been used. The challenges are also designed such that it is possible for the visitors to affect the difficulty of them, see Table 4.2. This was decided partly due to the paper *Edutainment? No Thanks. I Prefer Playful Learning* - saying that when designing a learning experience, it is often made too easy by the designers and the educators, but instead the learning experience should be challenging, without it becoming too much for the user, since people tend to get more engaged when they are been giving challenges. As long as the challenges and activities are related to a person's interests and what they care about, the activities can be difficult and hard to overcome and the person will still enjoy them. [48, p. 3].

4.7 Interface

This section presents the interface (settings) that the regular visitors at the museum will see, and that the museum staff can access and change, in order to make it fit with more specific target groups as well (here especially school classes and to use it for tours). The settings are made based on knowledge gained in Section 3.7, where it is stated that learning is a personal process and therefore could require individual settings. See Section 3.4 for more about personalized (individualized), adaptive systems.

Challenges	Learning goals	Modalities	The Task	Time
Challenge 1: *Place soldiers*	That there was not enough room for all of the soldiers at the fort, so they had to stay at the farms. The farms was not allowed to reject the soldiers, even though they had to feed more people. It was therefore important to make sure that each farm did not have more soldiers stationed than the farmers could handle financially.	Audio, vision, tactile (map), gestures.	The visitors drag and drop soldiers to either the farms or the fort. The visitors then get feedback based on their performance.	Long
Challenge 2: *Barbed wire*	The visitors learn about how the fort was protected by barbed wire and that it was the soldiers' job to maintain and lay it out. The users furthermore practice their math skills.	Audio, visual, and gestures.	The visitors are presented with different lengths corresponding to the area that needs to be surrounded by barbed wire. They have to calculate the total length and type it in on the keyboard. The story will continue no matter the result, but the soldiers' responses will differ.	Short, Medium, and Long
Challenge 3: *Signal Attack*	The visitors are asked to help out signal the fort, thus teaching them the importance of keeping watch and the fact that clear and fast communication can make a huge difference. They are also taught about how morse code works and they have to work under pressure.	Audio and tactile.	The visitors use the button and a Morse code table to signal the fort. They need to signal the correct message which they are presented with and do it before the time runs out. In case the time runs out, the fort is taken by the Germans and the visitors can try again.	Medium and Long
Challenge 4: *How to collect soldiers*	The visitors should learn: 1) That the phone lines are down, 2) that they need to contact the soldiers stationed at the farms, 3) that they contact them by messengers on motorcycles	Tactile, touch, audio, vision, and gestures.	The visitors are asked a multiple choice question about how they should contact the soldiers situated at the farms. The possible answers are given through images that the user should press. If the user decides to skip the challenge the correct answer is given. If the visitor gives a wrong answer, the user can try to answer again.	Medium and Long
Challenge 5: *Route*	The visitors will learn 1) that they needed to contact the soldiers stationed on the farms, but calling them on the phone is not an option. 2) That a route needs to be planned for the messenger.	Gestures, tactile, visual, and audio.	The visitors "draw" the route that they find most fitting by using their fingers/hand on the map. The soldiers will not reach the farm, if the route is too long.	Short, Medium, and Long
Challenge 6: *Protection of Karlslunde*	The goal of this challenge is to test the user's knowledge about Mosede Fort - more specifically the topics already encountered in the story and the other challenges.	Tactile, visual, audio, and gestures.	When a German scout appears they get a question they need to answer before the German reaches the city. The questions are based on previous information they have received throughout the event.	Short, Medium, and Long

Table 4.1: The table shows an overview of the six different challenges, for mere detail about the challenges see Appendix A

Challenges	**Easy**	**Medium**	**Hard**
Challenge 1: *Place soldiers*	The margin of error of how many soldiers were stationed at the farms/the fort is larger than that of *Medium* and *Hard*.	The margin of error of how many soldiers were stationed at the farms/the fort itself is smaller than that of *Easy*.	The margin of error of how many soldiers were stationed at the farms/the fort is smaller than that of *Easy* and *Medium*.
Challenge 2: *Barbed wire*	Easy numbers (10, 15, 20, etc.).	Semi-difficult numbers (12, 23, 84, etc.).	Difficult numbers (12.3, 23.7, 45.4, etc.).
Challenge 3: *Signal Attack*	SOS – Germans.	SOS – The Germans are here.	SOS – The Germans are here + less time.
Challenge 4: *How to collect soldiers*	There will be experienced no change.	There will be experienced no change.	There will be experienced no change.
Challenge 5: *Route*	The margin of error of the length of the route is larger than of *Medium* and *Hard*.	The margin of error of the length of the route is smaller than that of *Easy*.	The margin of error of the length of the route is smaller than that of *Medium*.
Challenge 6: *Protection of Karlslunde*	The questions should be easier than those for the *Medium* and *Hard*. The questions should be a mix of questions regarding the facts and a few questions addressing their understanding of the hypothetical attack from the Germans. The time it takes for the Germans to reach Karlslunde should also be longer.	The questions are a bit trickier than those for *Easy*. The questions should be a mix of questions regarding the facts and of the user's understanding of the hypothetical attack. The time it takes for the Germans to reach Karlslunde should be somewhat quicker.	The questions are a bit trickier than those for *Medium*. The questions should be a mix of questions regarding the facts and of the user's understanding of the hypothetical attack. The time it takes for the Germans to reach Karlslunde should be quicker.

Table 4.2: The table shows how the challenges will change based on their difficulty

The interface is going to be projected down on the map itself, why the interface can be changed to accommodate the different users and by using e.g. tracking, it will be possible for the user to interact directly with the interface. The alternative to this would be to use one of the (touch-sensitive) screens already implemented at the map, see Chapter 2, or to implement physical buttons and sliders.

Activating the System

In order for the visitor to activate the system, he will have to place himself on the start-mark which will be on the floor. Until the visitor has placed himself on the start-mark, the system will remain in sleep-mode. In sleep-mode the visitors will be able to interact with the map, as it is currently implemented at Mosede Fort, however, once in a while it will make a notice of itself, by saying a short line like: ”psst! - try to stand on the start-mark” or ”You wanna learn more about a predicament of an attack on the coast? - If yes, try and stand on start”. If no sound is desired, it is possible also just to have the start-mark or the map to light up, in order to put focus

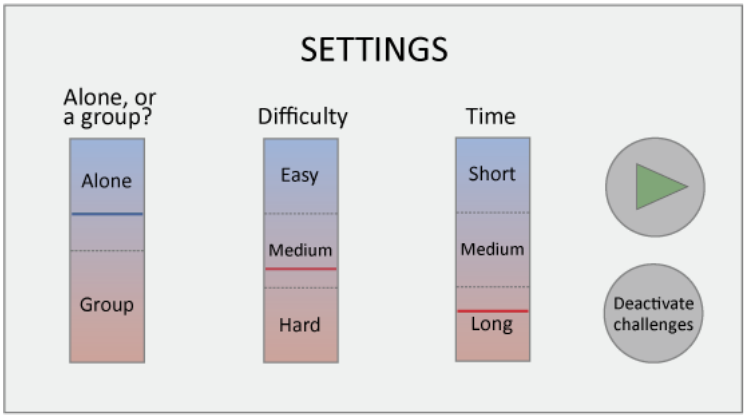

Figure 4.7: The interface, which is going to be presented to the regular visitor at the museum.

on it. This is inspired by the Coach Mike project presented in Section 3.5.2.

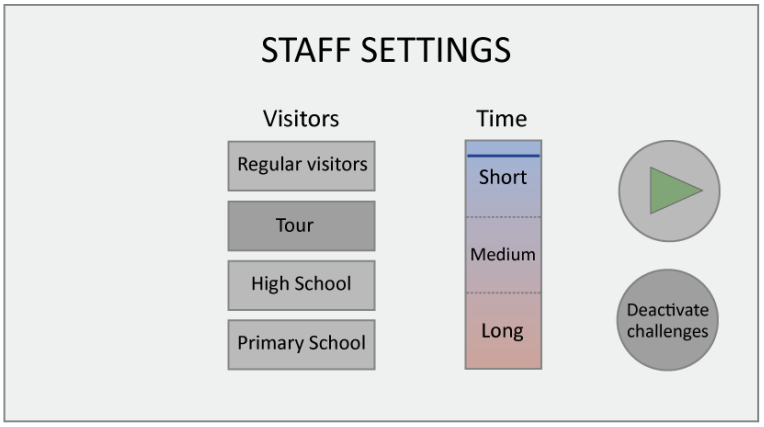

Figure 4.8: The interface (settings), which are going to be presented to the museum staff. The *time*-section and the buttons *Deactive challenges* are not available for the staff when 'Regular visitor' is chosen.

Settings for the Regular Visitor

The regular visitor will before starting the actual experience (after having gotten an introduction to the system. This will be addressed further in Section 4.7.1) be presented with settings, which are projected down on the map. The settings presented to the user can be seen in Figure 4.7.

The regular visitor should be able to tell the system whether or not he is using the map alone or in a group, if he wants to deactivate the challenges or not, how difficult the challenges should be (this setting will disappear, so forth the user deactivates the challenges), and how long time he has available. He should be able to start the actual experience. It was decided to use sliders for the majority of the settings, as these should be easy to understand for most visitors; they do not suggest other uses than to move the bar either up or down. It is therefore easy to comprehend, see also Section 3.1.2 and 3.7.2. This is the same with the two buttons: the text on the button to deactivate the challenges does not make much ground for misinterpretations, and

the *Start*-button is inspired by the start-buttons on CD players, remote controls etc. such that it should be easily comprehensible for the users.

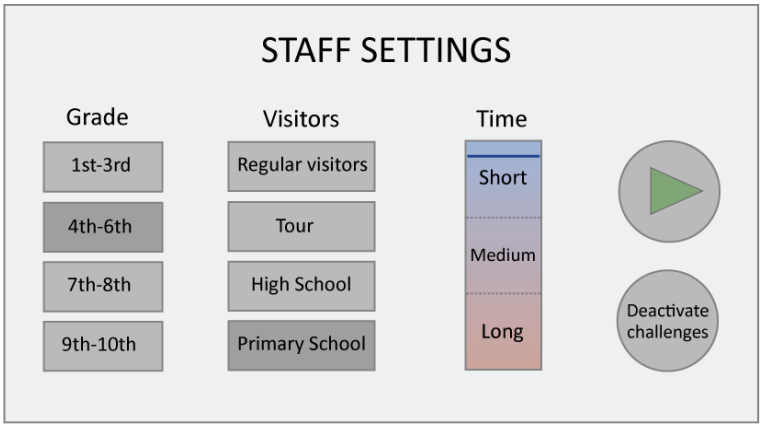

Figure 4.9: The interface (settings) for the museum staff, when they have chosen that the map should accommodate a primary school class; it is possible for the museum professional to specialize the challenges and story for the pupils even more (based on which grade the class is)

Settings for the Museum Staff

The museum staff should be able to access a special menu only meant for them. They can access this e.g. through a login-code or by drawing a specific pattern, such as when using some smartphones. The settings that the museum staff should be able to change can be seen in Figure 4.8 and 4.9.

The museum staff should be able to first of all change which type of visitors that the system should currently be specialised for. The groups of visitors are divided into the following: Regular visitors, tours, high school classes, and primary school classes. When choosing a visitor group other than the regular visitors (since they can adjust this themselves), a bar for adjusting the amount of time available and the button *Deactivate challenges* should be shown.

When choosing the visitor group *Primary school* a new topic should appear, see Figure 4.9. This topic with its four buttons makes it possible for the museums staff to accommodate the system even more to the school class' grade; there is after all quite a difference between a first grade and a 10th grade. Buttons have been chosen for simplicity.

4.7.1 Personas

This section will cover how it is imagined that the system (the experience) will be for a single user, a school class, and a family of four. The three personas focus upon how the experience of the system changes based on the social surroundings and the adjustment of the different available interface settings.

Individual Visitor

The visitor, Carl (male and 35 years old), have an interest in history and the Tune trench line in particular because he had a relative that were a soldier in the area. He enters the room, investigates the map, and places himself on the *Start*-mark on the floor. The system therefore goes from ”sleep-mode” to being active. A voice over appears explaining to Carl that he is going to experience a predicament of how it was believed that a German attack would have

happened and that he will have to solve some challenges along the way, unless he chooses to deactivate them. A menu is projected down on the map with settings which he can adjust using sliders. Carl adjust the slider using hand gestures (see Figure 4.7). When Carl have selected his desired settings (medium difficulty and medium amount of time), he waits for a second while considering selecting the *Deactivate challenges* button, so he does not get interruptions or further interactive elements throughout the story (making the experience quicker to go through). After considering his options, Carl selects to go with the challenges and therefore holds his hand over the green button to start. He hears the voice-guide again. This time the voice-over prepares him for the upcoming event.

The story starts and Carl quickly realizes that in cases where the physical map does not present the area referred to in the story, a soundscape is used instead of an animation. Throughout the story, Carl comes across different challenges that he needs to solve, in order to continue. After solving two of the challenges Carl starts to feel very confident, however, at the third challenge he runs into problems and needs to try it multiple times, before he in the end decides to give up and skip the challenge. Before the story continues the system informs Carl with the correct solution.

He quickly go through the rest of the story and the remaining challenges and the story ends. After the story ends, the voice over reappears and gives Carl some last remarks as well as feedback on his performance, before the system returns to ”sleep-mode”.

School Class

The class is from a primary school, 6th grade, and consists of 20 pupils. Due to the larger number of pupils, and the limited amount of time they got at Mosede Fort, it was decided to divide the class into four smaller groups of five students each. We will in this persona follow one of these groups consisting of the pupils: Jacob, Emma, Emil, Birk and Alberte.

When arriving at the museum, the class is divided into the four groups. Two of the groups are going to use the iPad-game (Dilemma) that Mosede Fort offers for schools, while one of the groups are supposed to look around at the museum and gather information for an essay they are going to write about the visit in the following week. The group in focus is going to use the map.

When Jacob, Emma, Emil, Birk and Alberte follows the museum professional to the room, it is with little attention and focus upon the task ahead. As soon as they enter the room, the museum professional ask them to stand still around the map for a few seconds, while she places herself on the start-mark on the floor and uses one of the screens at the map to access some settings that can only be accessed by museum staff (see Section 4.7). She quickly change the settings to fit with a 6th grade primary school, having only a limited amount of time available. She select the short version of the experience, meaning three challenges remains activated in the system. Before pressing the Start-button, she asks the five pupils to be still and listen. She explains shortly what the idea behind the map is and that the group is supposed to overcome the various challenges together, as a team, but everything else will be explained as they start the experience.

The museum professional ’presses’ on the Start-button and a voice over occurs presenting the story and how the Danish military believed that the Germans might try to invade Denmark through Køge bugt. The pupils wait for the system to start the actual story, intrigued. The first challenge is encountered after the introduction, including the first few animations and story-bits. The pupils quickly decide for Birk to be in charge of the main controls of the system, while they are trying to overcome the first challenge. After two tries, they succeed and the story continues until the next challenge. The system continues like this until they have fulfilled the last challenge. During the challenges, the five pupils talked together, in order to find solutions for the presented problems and worked together to overcome the challenges.

Before the system ends, the pupils are given a score of how well they overcame the challenges, and a list of how they had answered the various challenges. The system saves their score, including the following scores from the rest of the class, such that the museum professional can then go in and access them, in order for the scores to make ground for a discussion when all four groups have tried the map. The system automatically deletes the saved scores, when a new target group is chosen by the museum professional.

The museum professional check the time, they still have a few minutes to spare, so she sends the group out to find the next group to get their turn at the map.

After all four groups have finished both the iPad-application and the system of the map, the class gathers in the room with the large map-installation again, in order to discuss both experiences, their choices and why they chose as they did with the museum professional and their two teachers. The group, who performed best in the challenges, are being presented, and they are asked to explain what why they did as they did during the challenges.

A Family of Four

The Hansen family arrives at Mosede Fort a Saturday afternoon. The family consist of dad Bjarne, 38 years old, mom Hanna (37), their daughter Simone (12), and their 8 year old son Noah.

Hanna and Bjarne have often talked about visiting the museum, since it is only a 15 minute drive from where they live. They therefore agreed earlier that today was the day. The family walks a bit around in the museum before they end up in the room with the map. When entering the room, it does not take long for Simone to spot the start mark on the floor and rushes over there. The system is activated and the rest of the family joins her, to see what is happening.

Bjarne looks at the settings. First he selects that they are a group, chooses the medium difficulty, and together with Hanna, they decide to take the medium length of time, since they also want to go through the rest of the museum before the children become too drained of energy. They decide that Simone should be in charge of using the system, since she has most experience with technology and games. Simone 'presses' start and story begin. At the first challenge, they succeed the second time, failing the first try. The story continues and the family goes through the other four challenges, some of them take more time than others. The family have fun and enjoys spending time together and working as a team, especially Hanna and Bjarne are happy that their two children are not fighting, but instead working together.

They reach the last challenge and discovers that in order to solve it, they have to remember all the previous information they had gotten from the story and the challenges, since that is the only way to succeed. The family discusses a bit when answering one of the questions, since they remember the information differently, but in the end they decide to go for Noah's answer and they realizes that he remembers the most - they get the rest of the questions correct, thanks to Noah's help and finishes the challenge. The voice over appears again and finishes the story, for then to explain the family how well they performed.

The system ends and goes into sleep mode again. The family continues their exploration of the museum. It does, however, not take long before Simone returns to the map and tries it again on her own. The time comes for the family to go home and on the way, they talk about their experiences and discusses the map and the knowledge they gained from it.

4.8 Proof of Concept: Challenge 5

This section will go through the proof-of-concept (Challenge 5) in a more detailed manner than presented in Table 4.1. As learned in Section 3.2 it is suggested that a video episode should not take too long and the idea is therefore to keep the different aspects of the challenge short and

with breaks following the suggestion by Danks et. al. [19, p. 114]. The first thing, which will be introduced in this section, is the interface, followed by the system feedback. The design of the animation and the soundscape will thereafter be presented in detail, including a storyboard and a soundscape layout.

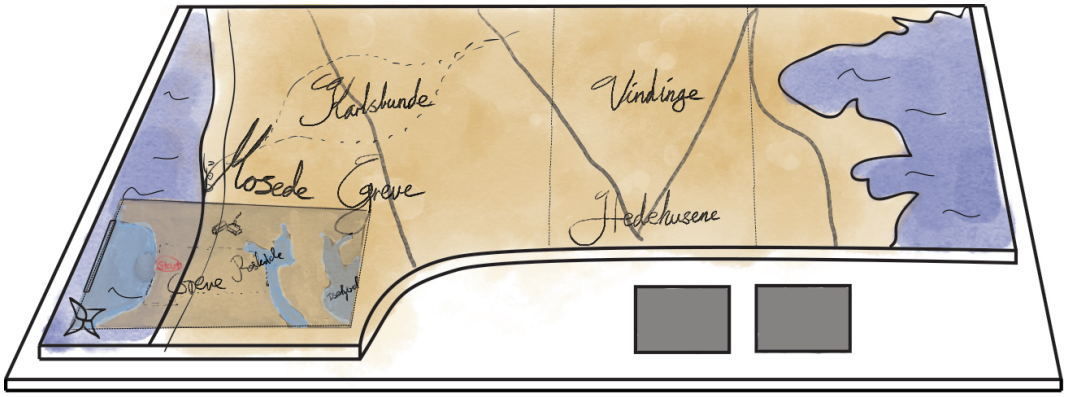

Figure 4.10: An illustration of how the design of the interface for Challenge 5 should look like.

4.8.1 Interface

The interface for *Challenge 5: Route* consist of a projected mini-map in the lower left corner of the original and larger map, see Figure 4.10. The projected mini-map will be the area in which the interactions will occur between the visitors and the system. It was decided to have the mini-map in order to avoid using screens and keep the whole interaction focused on the physical map, see also Section 3.8.1. The mini-map is used for the visitors to be able to draw the route - without having to be tall enough to reach all parts of the larger, physical map. The feedback will be projected on the larger map. The information includes an animation with corresponding sounds. The system will then have to detect the user's hand, in order for the user to draw the route. This should similarly happen in the beginning of the whole system (when the visitor adjust the settings). The route will be displayed on the larger map when the visitor starts drawing the the route (see Figure 4.11, so that everyone around the map, can see what is happening even though they are not in charge of the mini-map. The system has two possible outcomes:

1. The visitor complete the task and an animation showing the soldier complete the route is shown. The user can thereafter continue the story.
2. The visitor fails the task (the route is either too long or so short that the soldier (Thomsen) would have to go through bushes and other impassable terrain. The visitor then gets the option to either try again or skip the task (continue the story)

All information is given using audio (a voice over) and the only way for the visitor to respond and select is by using his hand movements (gesture tracking).

4.8.2 System Feedback

It is said by Rogers that "products should be designed to provide adequate feedback to the users to ensure they know what to do next in their tasks." [62, p. 38]. It was therefore decided to look more into how the system could provide the user with feedback.

It was chosen that the system should give as immediate feedback upon the user's actions as possible (real-time feedback [62, p. 166]), in order to let the user know that his action(s) have had an impact upon the system. The feedback includes auditory (also verbal) and visual

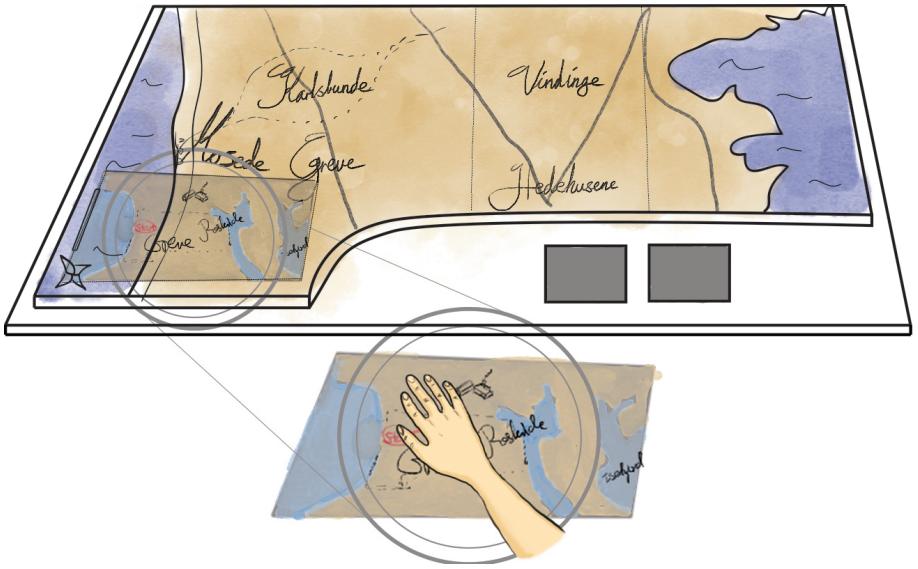

Figure 4.11: An illustration of how the user will draw the route on the map

feedback. The auditory feedback consists of: a sound when the system detects the user's hand, and a voice over explaining what the user should do and how well he completed/did not complete the given challenge. The visual feedback consist of an avatar in the form of a messenger, which shows the user's hand's position according to the tracking (mainly for finding flaws in the tracking), and that the line (the route) should be drawn continuously, such that the user always know how his route for the messenger looks like.

4.8.3 Storyboard for Challenge 5 – the Route

The storyboard for the animation is quite simple and can be divided in three parts: 1) the Sergeant giving Thomsen an order, 2) Thomsen riding the motorcycle, and 3) Thomsen arriving at the farms, see Figure 4.12. For the animation, only the first two parts will be made, since part three will be presented using only sounds. In theory this would not be necessary, since it could be a possibility to select a farm that is represented on the physical map, but as explained in Chapter 2, will a non represented farm be used for the museum's sake a.

The Animation The first part of the animation will contain two characters, the soldier Thomsen and his Sergeant in command. The scene will start out with the Sergeant addressing Thomsen and giving him the order of retrieving the soldiers situated at the surrounding farms, as a messenger. Thomsen agrees and the system continues with the challenge. When the user have finished the challenge, the second animation will play, following the visitor's route. The second animation only shows Thomsen, and there is no dialogue.

The main focus for this animation is Thomsen's motorcycle ride – hopefully giving the visitors an idea of how important a role this was during a possible attack on the Danish coast line during WWI.

The Sergeant is used in the first animation (see Figure 4.12). The design of the Sergeant is based on one of the drawings made originally as an option for Thomsen, however, with changes inspired by a picture of C. F. Holm, found at the webpage Tunestillingens venner [65] and [5]. The idea is to make him look like he has more experience and more authority than Thomsen, for the final design see Figure 4.13.

In Figure 4.14 can a sketch of Thomsen on a motorcycle can be seen to the left. Thomsen should be surrounded by another background than the projected map, see image to the right in

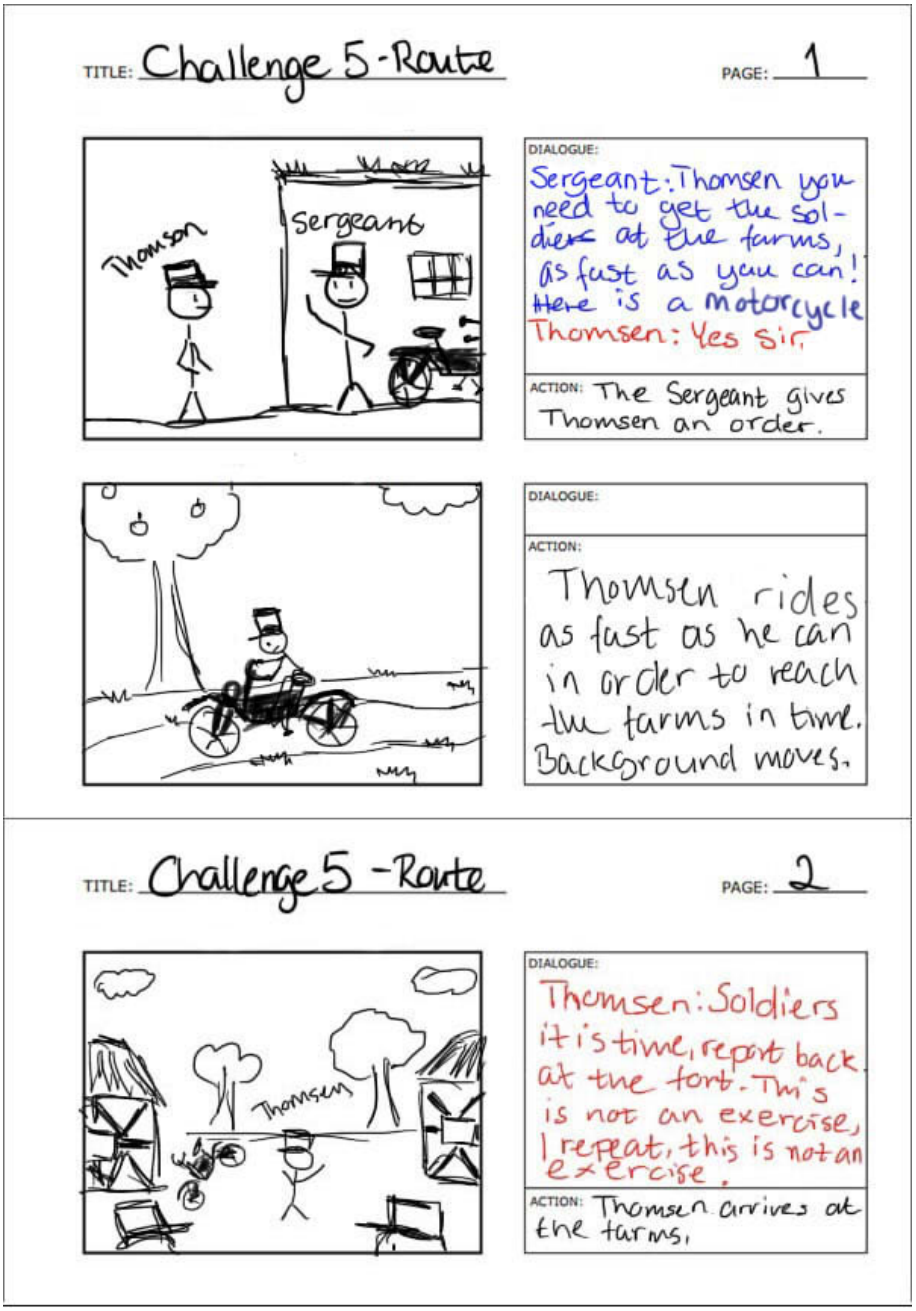

Figure 4.12: The storyboard to be used for the animation - Challenge 5: *Route*, page 2 of the storyboard will only be represented using sounds

Figure 4.13: The final design of the Sergeant

Figure 4.14. The background should only surround Thomsen riding the motorcycle (as seen in Figure 4.3 and 4.4). The motorcycle animation should work in a loop, since the route that the user draw might be longer than the drawn animation. This type of loop is inspired by the old Zoetrope[4] animations.

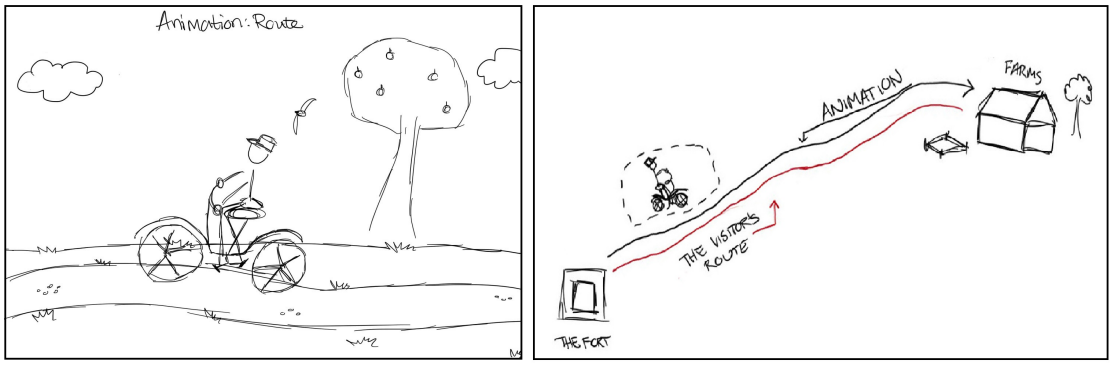

Figure 4.14: A close-up sketch of the soldier biking-animation for Challenge 5: *Route* to the left. A sketch showing the full animation of the soldier biking for Challenge 5: *Route* to the right

The Soundscape The sound layout will be divided in two, first the voice over used as the guide will be presented. The voice over has different feedback responses, so the visitor will therefore most likely not be experiencing all of the different outcomes. The second will be the script for the voices to be used in the two animations (Thomsen and Sergeant). In the end will the different sound effects, which should be used, be displayed in Table 4.3.

Voice Over for the challenge

Voice Over 1: "We now know that in order to collect the soldiers on the surrounding farms, a motorcycle messenger should be dispatched. Thomsen has been selected as a meseenger, but on his way to the farms, he drops the map with the route and There is not enough time to drive back to get a new map. At the same time, he is not that familiar with the area - which is why he

[4] A Zoetrope is: "A 19th-century optical toy consisting of a cylinder with a series of pictures on the inner surface that, when viewed through slits with the cylinder rotating, give an impression of continuous motion. Also called thaumatrope." [58]

now needs your help.

Voice Over 2: “To help Thomsen, draw the route you think is best with your hand, so he can reach the farms and alarm the soldiers. Be careful: if the route takes too long, the soldiers will not be able to reach the fort before it is too late and if it is too short it can also go wrong - remember to stick to the roads.”

Voice Over 2.1: “In order to draw the route for Thomsen, your hand needs to first be registered by the system. In order to register your hand, you need to wave with it until you hear this sound [sound], which indicate that you hand is registered. In order to draw, keep your hand close to the map and hold it over the small points that you think Thomsen should drive through”.

Voice Over for the feedback

Voice Over 3: “Good job. Thomsen managed to reach the farms in time and the soldiers, the fort. It is all going according to the plan.”

Voice Over 4: “Ohh no, Thomsen did not reach the farms in time and the soldiers could therefore not help the other soldiers with protecting the fort and the surrounding area. Germans have succeeded talking over a larger areas and the defenses of the fort is weakened. Try again.”

Voice Over 4.1: “Ohh no, Thomsen did not make it, he thought he would take a shortcut, but realized that there was no road. He therefore had to go through a field area. The soldiers could because of this not reach the fort in time to help out the other soldiers. Germans have succeeded talking over a larger areas and the defenses of the fort is weakened”.

Voice Over 5: “That is the spirit, let’s try again.”

Voice Over 6: “Your route is not done. Please finish the route by drawing it all the way to the illustrated farm.”

Voice Over 7: “You are now done with the experience. In the full system you would have continued with the story about how it was predicted that the Germans would try to invade Denmark. Thank you for testing”.

Part 1: Animation and Audio

Sergeant: Thomsen! Come quickly. The Germans have been spotted and we need to retrieve the soldiers situated at the farms, before it is too late. Do you know how to ride a motorcycle?

Thomsen: Yes, sir.

Sergeant: Good, I need you to take this motorcycle, and the map with your route to the farms and that you bike as fast as you can to warn the soldiers at the farms.

Thomsen: Yes sir, I will do my absolute best, sir.

Part 2: Audio only

Thomsen: Almost there.

Thomsen: Soldiers! It is time, report back at the fort. This is not an exercise, I repeat, this is not an exercise! (When arriving at the farms)

Beside the dialogue will multiple sound effects also be used, such as seagulls and the sound of the ocean (indicating the whereabouts of the event). Multiple footsteps from other soldiers (showing the severity of the event: an indication of atmosphere) will also be included. In addition to these sounds, a more generic sound will be used as well: wind. The audio used for this challenge can be seen in Table 4.3. To see some more sound examples for the general and whole story, see Table B in Appendix B. In the Section 4.5, background music is also included as the definition of a soundscape, however, for this challenge, it is decided not to use background music. This is decided, based on two things: 1) Using background music does not seem to fit the challenge due to the serious theme and Thomsens role. 2) Since the last part of this challenge

only include a soundscape, the background music might interrupt or overpower the additional and more important sound categories.

Part	Location	Atmosphere	Generic
Part 1: Getting the order	Seagulls, ocean (waves).	Fast footsteps and yelling from other soldiers.	Wind,.
Part 2: The motorbike ride	Wind, change of ground material (gravel, grass, etc.)		Wind, motorcycle.
Part 3: Arriving at the farms	Cows, chickens, birds, etc.	Fast footsteps - getting louder and louder, since the other soldiers are getting closer.	Light wind, motorcycle driving and stand still.

Table 4.3: The table shows which sounds should be used in the proof of concept (Challenge 5)

4.8.4 Setup of the System

How the system will be set up can be seen in Figure 4.15. The system will consist of various elements, which are (hardware):

1. A projector to project the map and the elements of the proof-of-concept upon a surface.
2. A surface that the projector will project upon. In the ideal world, this surface would be the surface of the map, implemented at Mosede Fort museum, but since the map is currently being used and that it is not possible to implement the system in the system that is already there, the surface will either be a table, a whiteboard, a wall or an actual projector screen.
3. A computer to run the system upon.
4. Speakers for the soundscape, dialogue and voice over of the system to be played.
5. A device for tracking of the user's hand, e.g. a Microsoft Kinect.

As it can be seen in Figure 4.15 the user will stand in front of the map while using the system, thus making the tracking device (the Kinect) and computer 'hidden' technologies. It is desired to keep the Kinect and the computer as hidden technologies, in order for the user to focus solemnly upon what is happening on the map and what is given to him of information through audio.

4.8.5 Requirements for the Implementation of Challenge 5 - the Route

The visitor will need to be able to draw a route between the fort and one of the farms for the soldier - Thomsen - to follow, see the rest of Section (4.8. To do so, it is decided to use hand gestures while trying to avoid using any additional objects, e.g. gloves or a "pen", etc. Using hand gestures also makes the interaction between the system and the visitor more simple and hopefully also intuitive to use. Hand gestures makes it possible for groups to change between the person in "charge", without having to reequip a person, why it is also believed to be less time consuming for the visitors to use the system.

The goal of the implementation is therefore that:

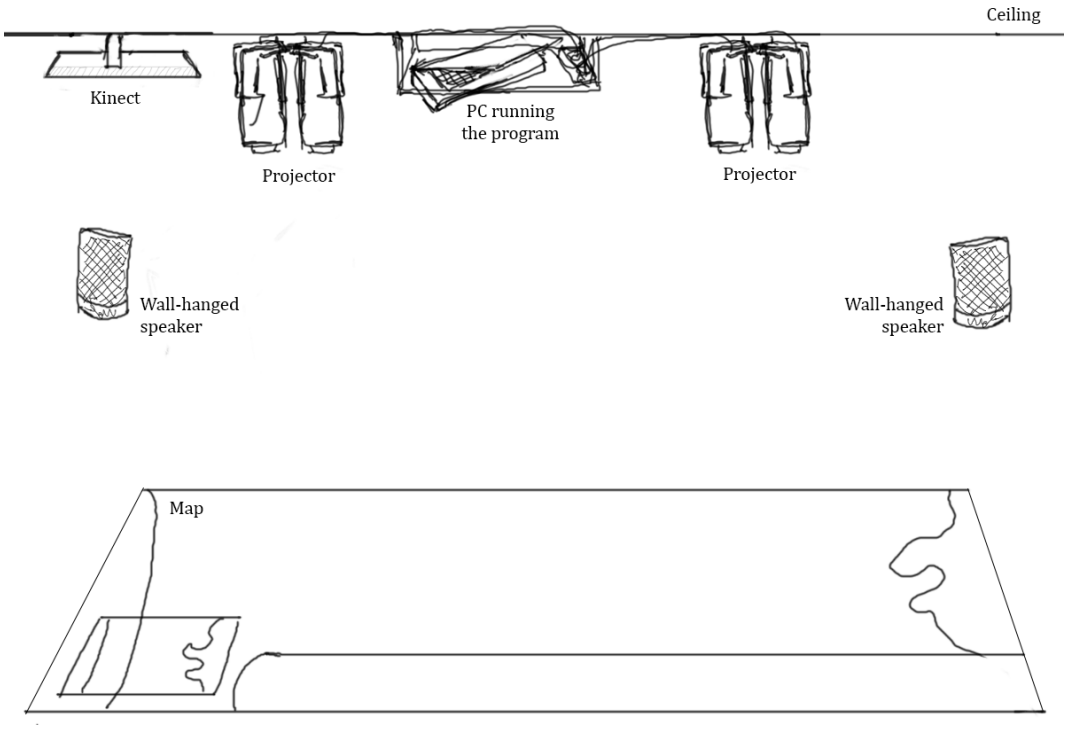

Figure 4.15: The ideal setup of the system.

1. ... it should not require for the user to be equipped with any objects, in order to be tracked.
2. ... users should be able to communicate with the system using only their hand and hand gestures.
3. ... it should be implemented such that no screens are used, since the visitor's main focus should be on the physical map at the museum.
4. ... it should be implemented fitting *medium* in difficulty.

Chapter 5

Implementation

This chapter concerns the implementation of the system presented in Chapter 4. This includes an overall introduction to what the system comprise of, which types of software will be used for the different tasks and how the system was implemented, including which changes was needed to be made, due to discovered limitations in the used programs, time restrains and what was found to be better suited solutions for the system during the implementation of it.

For this thesis project, the full design is not implemented, but instead a proof of concept is made by implementing one of the challenges presented in Section 4.6: Challenge 5 - Route, which was also presented in depth in Section 4.8.

5.1 Implementation Structure

In order to get an overview of what needs to be implemented, an implementation structure was created. The structure can be seen in Figure 5.1. The implementation structure shows what happens in Challenge 5 - Route, see also Section 4.8, and which parts need to be implemented for the challenge to work as intended. The implementation structure was made based upon a few changes from the design - these changes are further addressed in Section 5.5.2.

The first thing that happens is the animation in which Thomsen gets the order (see Section 4.8.3). It is not until the introduction to what the user is going to do and how the system works that the visitor will be able to interact with the system, and can draw the route for the soldier to follow. When the user has drawn the route, there are three scenarios which can happen: 1) the route is correctly drawn, 2) the route is too long, or 3) the route is unrealistically short. It should be mentioned that in each of the three scenarios, the user must complete the route. If the visitor does not complete the route is an additional sound file is played, which tells the visitor to complete it. Feedback is given in the form of a sound file for all of the three scenarios f. If the route has been correctly drawn, the system will automatically continue to another sound file that tells what would have happened now if it had been the full system and it thanks the visitor for his participation in the test. For the other two scenarios, however, the visitor can choose between trying the challenge again or to skip the challenge, see also Section 4.8. If the visitor skips the challenge, he is also given the sound file, which tells him what would have happened next in the full system and that thanks him for having participated - similar to if he had completed the challenge. If the visitor decides to try again he returns to the challenge of drawing the route again.

5.2 Graphics

This section covers the implementation of the used graphics in the proof of concept. This means that it is described how the small and large versions of the map was created, including how the two animations, described in Section 4.4.1 was made.

5.2.1 The Map

The illustrated map was created using Adobe Illustrator CS6, in order to be able to take advantage of vector graphics [1]. The map was based on a pdf-version of the projected map currently used at Mosede Fort that was provided by the museum and on the interactive map from Tunestillingens Venner (i.e. the Friends of the Tune Trench Line) [64].

In order to create the map was the pdf version of the map imported into Adobe Illustrator and all lines (distinction between sea and land, cities and roads) drawn. All the city-names was likewise handdrawn using a Wacom Intuous Pro Medium Pen & Touch inside the program. The style used for the lines and the city-names was made with the inbuilt watercolours. This style was also used to colour the rest of the map (sea and land). The created map can be seen in Figure 5.2.

In order to create the (small) map, which covers more of the area were the already drawn map used, and print screens of the interactive map from Tunestillingens Venner [64] were taken, placed in a patchwork, so they added up to form the area. This was in order to see where the cities and the distinction between the sea and land were. The rest of the map was coloured in a similar way. Since this map was going to be shown in a smaller version, all roads were disregarded.

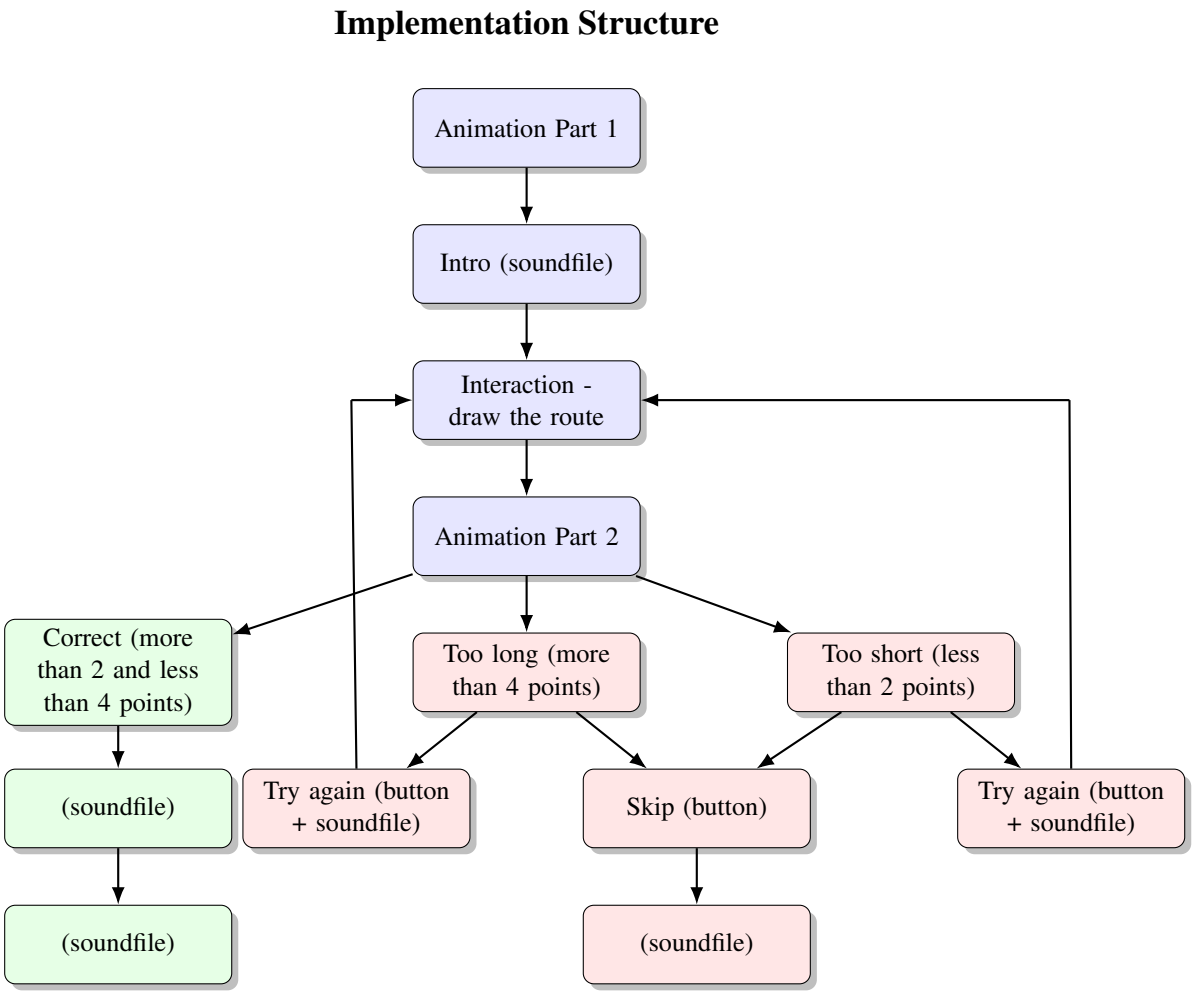

Figure 5.1: An overview of the implementaion structure

Figure 5.2: The redesigned (large) map to be used in the system

5.2.2 Animations

This section covers how the two animations for Challenge 5 was made.

The animations was created using the program called *Plastic Animation Paper*, also known as PAP[1]. This program was mostly chosen due to its simplicity, it does nothing else than what it claims: it makes it possible for one to create traditionally drawn, digital 2D animations, although with a few benefits of using a digital medium, such as using cutouts, which were widely used in the creation of the animations.

GIMP[2] was used to colour each frame, since this is not possible to do in PAP. GIMP is a free and open-source image manipulation program. The animations were coloured to resemble watercolours, where it was seemed fit (see Section 4.4.1). Other areas were kept completely simple and was therefore not coloured, in order to create contrast and to give the user's eyes a place to rest as well. The watercolour effect was created by using a normal paintbrush and pale colours. The opacity was changed differently depending on if it was for shadows or colouring. The blur/sharpen tool and especially the smudge tool was applied after the frame had been coloured. Example frames of the coloured animations can be seen in Figure 5.3.

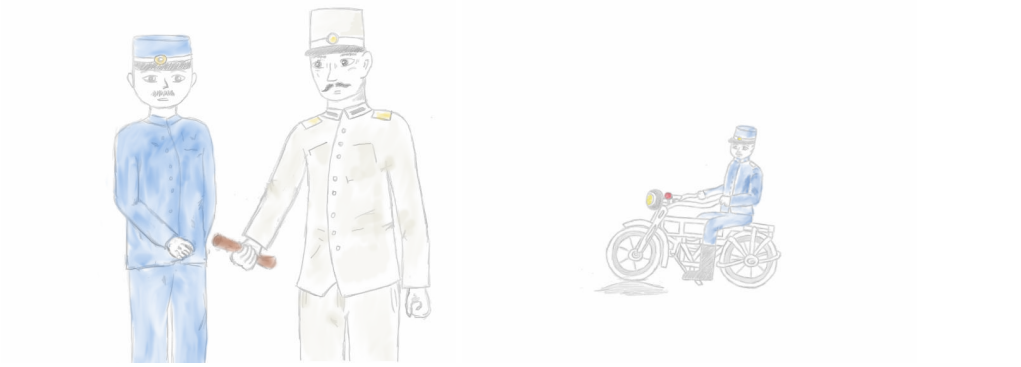

Figure 5.3: Example frames of the two animations for Challenge 5 - Route. To the left: Thomsen and the Sergeant. To the right: Thomsen taking the motorcycle out to the farms.

Since neither PAP nor GIMP have a function to create movie formats, Adobe Premiere Pro CS6[3] was used to put the frames of each animation together in an image sequence. The frame rate was put down to 12 frames per second instead of the standard framerate. In order to make the animations longer were some of the frames copied and in the first animation (with the Sergeant, see Section 4.8.3) were a few of the frames' speed made even slower. This also made the two soldiers' movements seem more natural.

5.3 Audio

This section concerns the implemented audio for the system (Challenge 5).

The audio for soundscapes were found on the homepage called *freesound*[4]. All sounds used from freesound have a creative commons license, meaning that the sounds are free to use. To see list of the used sounds see Table 4.3 in Section 4.8.

[1]PAP can be downloaded from: `http://animationpaper.com/old-pap-free-download/`

[2]GIMP can be downloaded from: `https://www.gimp.org/downloads/`

[3]This version (CS6) of Adobe Premiere is no longer available through Adobes homepage. Instead can their newest version - Adobe Premiere CC - be found: `http://www.adobe.com/dk/products/premiere.html`

[4]Freesound homepage: `http://freesound.org/`

The software Audacity[5] was used to put the sounds together into a soundscape, and to record all voice overs and the dialogue. Audacity is a free, open-souce and cross platform program, which can be used to edit and record sounds. It has a lot of features, including noise removal and amplify, which were used for all recorded sounds.

The used recorded audio and soundscape was exported as .wav-files and used directly in Unity3D, which is used for creating Challenge 5 - Route itself.

5.4 Kinect

This section concerns the use of Kinect in the implemented system. This includes why a Kinect was chosen to track the user's hand and how it was implemented to the system by the use Processing.

The Microsoft Kinect was selected, in order to track the user's hand. The Kinect was selected based on the following points:

- It is possible to detect the hand and its gestures without needing any gloves, or special object(s) attached.
- It is possible to use the installation regardless of different light settings due to the infra-red camera - the museum has a great deal of artificial light that might change from time to time, a new lightbulb or a change in the larger exhibition.
- It is possible to work with it on a regular PC.
- It provides the option to work with different software and platforms. It is already known at this point that the Processing and Unity3D will be used which is possible with the Kinect.

It is possible to get both image and depth data by using the Kinect, since it uses an inner RGB camera and an infrared depth sensor [52, 570].

To be able to work with a Kinect upon a (Windows) computer, it was needed to first of all download and install the Kinect SDK 1.8 from Microsoft[6]. The Kinect Developer Toolkit[7] and OpenNi[8] was also downloaded.

5.4.1 Processing: Tracking with the Kinect and UDP-connection

It was decided to use Processing[9] 2.2.1, as this can work with Kinect through the library *SimpleOpenNi*, which can be downloaded through the Processing interface, and includes example projects. It was one of these example projects (called 'HandsTracking'), which was altered and used to be able to track the user's hand and to send the gathered data to Unity through a UDP (User Datagram Protocal) connection. In order to create the UDP connection the library *UDP* was downloaded and installed through the Processing interface. The example project called 'udp' was copied, altered and added to the altered HandsTracking project. The full Processing project file can be found in the additional uploaded material, and is called *HandsTrackingKinectUDP*.

[5] Audacity homepage: `http://www.audacityteam.org/`

[6] The SDK was downloaded from Microsoft's homepage: `https://www.microsoft.com/en-us/download/details.aspx?id=40278`

[7] The Kinect Developer Toolkit was downloaded from: `http://go.microsoft.com/fwlink/?LinkID=323589`

[8] OpenNi downloaded from: `http://openni.ru/openni-sdk/`

[9] Processing can be downloaded from: `https://processing.org/`

Inside Processing were the libraries first imported, and the used variables are defined. Inside the setup()-function is the UDP connection for Unity on port 6000 created. Furthermore is the size of the Processing window (which shows the depth image coming from the Microsoft Kinect) set, and it is defined that the user's hand should be tracked through the gesture called 'WAVE'. This means that the user has to wave his hand, in order for the system to recognize it. This part of the code can be seen in Code 5.1.

```
1  void setup()
2  {
3    // create a new datagram connection on port 6000
4    // and wait for incomming message
5    udp = new UDP(this, 6000);
6    udp.listen( true );
7    message = new PVector(0,0);
8    lastPos = new PVector(0,0,0);
9    size(640,480);
10   context = new SimpleOpenNI(this);
11   if(context.isInit() == false)
12   {
13      println("Can't init SimpleOpenNI, maybe the camera is not
        ↪ connected!");
14      exit();
15      return;
16   }
17
18   // enable depthMap generation
19   context.enableDepth();
20
21   // enable hands + gesture generation
22   context.enableHand();
23   context.startGesture(SimpleOpenNI.GESTURE_WAVE);
24  }
```

Code 5.1: The setup-function from the code in Processing, used for this project (Kinect hand recognizion and UDP).

In the function draw() is the image from the Kinect drawn on the Processing window together with the array (line) for the tracked hand. In the function onNewHand is the hand's position and ID found and added to the list called handPathList, while its position alone is added to the array list, called *vecList*. This is purely for drawing a line of where the hand has been tracked by the Kinect.

It is in the function onTrackedHand that the most important things happen. Here, the current position of the hand is send to Unity via the UDP connection so forth that the position of the hand is not equal to the previous position of the hand. This is simply to avoid that unnecessary messages are sent to Unity; this is also why the delay(100) is added after the UDP-message has been sent. The code from the function onTrackedHand can be seen in Code 5.2

```
1  void onTrackedHand(SimpleOpenNI curContext,int handId,PVector pos)
2  {
3    ArrayList<PVector> vecList = handPathList.get(handId);
4    // Add the hand position if vecList is not equal to null:
5    if(vecList != null)
6    {
7      vecList.add(0,pos);
8
```

```
9     // If the size of vecList is larger than or equal to the defined
          ↪ handVecListSize:
10    if(vecList.size() >= handVecListSize)
11      // remove the last point
12      vecList.remove(vecList.size()-1);
13  }
14     // If the current position is not equal to the last position:
15     if (pos != lastPos){
16       String message = pos.x + ";" + pos.y + ";" + pos.z;
17       String ip       = "localhost";  // the remote IP address.
             ↪ Localhost = ip = 127.0.0.1
18       int port        = 6100;     // the destination port
19       // formats the message for Pd:
20       message = message+";\n";
21       print(message);
22       // send the message (the message is the current position of
             ↪ the hand)
23       udp.send( message, ip, port );
24         delay(100);
25     }
26     lastPos = pos;
27 }
```

Code 5.2: The onTrackedHand-function from the code in Processing, used for this project (Kinect hand recognizion and UDP).

5.5 Unity3D

Unity3D[10] (also known as Unity) was used for the rest of the implementation of the system. Unity3D is a game engine, where one can create both 2D and 3D games and applications. It is possible to add code in both JavaScript and C# - for this thesis project is C# used. Unity is available as a Personal (free) and as a Professional edition, for this project is the Personal edition of Unity 5.3.4f (64-bit) used. The Unity project can be found as GITHUB project, by following this link: `https://github.com/KBregnhoved/MED10`.

5.5.1 Scene 1: The Introduction

Before the user is going to draw the path (try to complete Challenge 5) is an introduction in the form of a short animation be shown, see Section 4.8 and 5.2.2. It was decided to have a single scene inside Unity to play this introductory animation (the animation with the Sergeant, see Section 4.8.3), and then change to the next scene as soon as the animation have played through.

In order to play the animation, it was added to the project's assets and put upon a plane, which had been created inside Unity, as a movie-texture. Behind the plane with the movie-texture were the large map added as a 2D sprite. The whole scene is controlled by a single script, which makes sure that the animation plays when the scene has been loaded in and that the next scene (scene 2, called *Draw*) will be loaded afterwards. In Code 5.3 can the used script be seen.

```
1 using UnityEngine;
2 using System.Collections;
3 using UnityEngine.SceneManagement;
4
```

[10] Unity3D can be downloaded from the homepage: `https://unity3d.com/`

```
5  public class StartScript : MonoBehaviour {
6          private AudioSource voiceFile;
7          bool videoHasPlayed = false;
8          private MovieTexture movie;
9          private Renderer r;
10
11         void Awake () {
12                 // Get audio
13                 voiceFile= GetComponent<AudioSource> ();
14
15                 // Get movie texture
16                 r = GetComponent<Renderer>();
17                 movie = (MovieTexture)r.material.mainTexture;
18
19                 // Makes sure that the movie does not loop
20                 movie.loop = false;
21
22                 // Plays the sound and movie on awake
23                 if (!Application.isLoadingLevel){
24                         voiceFile.clip = movie.audioClip;
25                         movie.Play();
26                         voiceFile.Play();
27                         videoHasPlayed = true;
28                 }
29         }
30
31         void Update(){
32                 // Loads in the next scene:
33                 if (!movie.isPlaying && videoHasPlayed){
34                         SceneManager.LoadScene("Draw");
35                 }
36         }
37 }
```

Code 5.3: The script in Scene 1, which makes sure that the animation is being played and the next scene loaded afterwards

5.5.2 Scene 2: Drawing the Path

It was desired to let the user make a free path using hand gestures, see Section 4.8. During the implementation of said path, it was discovered that the path, due to natural fluctuations in the tracking of the hand, did not turn out as desired. This could be due to the UDP-connection from Processing (see Section 5.4) maybe sometime skipped or received a hand-coordinate at a later time. The path would turn out to be a mess and nowhere near a straight line. It was therefore decided that the line should not be drawn in 'free-hand', but instead it would always go through specified points (dots), thus the line should only be drawn when the user have held his hand above one of these points. This type of drawing is not much different from 'connect-the-dots'-painting books/exercises, except that here the points are not numbered and the user can draw freely between the points and the user are not meant to go (draw) through all points, see Figure 5.4. In order for the user to therefore start drawing, he should keep his hand above the *Start*-area. The drawing of the path stops as soon as he reaches the farm with his hand.

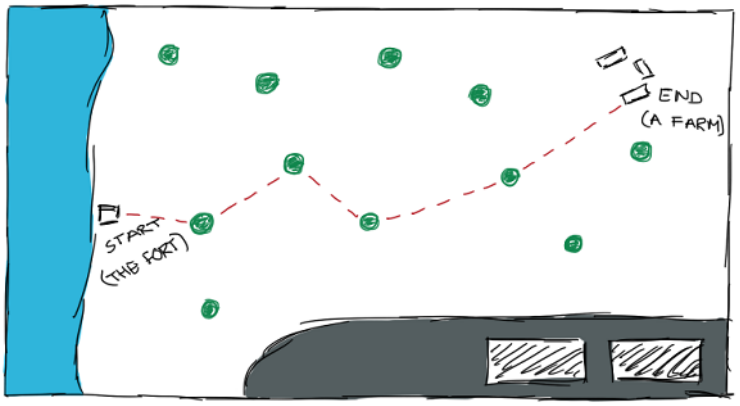

Figure 5.4: An illustration of how the point-system will look like on the map

5.5.3 UDP-connection

At all a UDP-connection receive was needed, in order to get the hand position coordinates that is send from Processing (see Section 5.4). The connection was achieved by getting the UDP receive code from the Unity Forum[11]), adding the suggestions from the other users in the forum as well (disabling the thread and client in the function *onDisable()*, because else Unity crashed after being run), and altering it to fit with the correct port-

When Unity receives the data from Processing in a string, it is split into three parts (one for each coordinate; x, y, and z), and the coordinates are converted into a Vector3 and later into a Vector3 list. In order to be able to make the string into a Vector3 (float), it first needs to make the system aware that a '-' is a minus sign (var fmt = new NumberFormatInfo(); fmt.NegativeSign = "-";), whereafter the string is converted into a double, which is cast as a float (secondTempHandPos.x = (float)double.Parse(tempHandPos[0], fmt);), see Code 5.4.

```
1  try
2  {
3          // Received Bytes
4          IPEndPoint anyIP = new IPEndPoint(IPAddress.Any, 0);
5          byte[] data = client.Receive(ref anyIP);
6
7          // Bytes encode the UTF8 encoding in the text format.
8          string text = Encoding.UTF8.GetString(data);
9
10         // latest UDPpacket
11         lastReceivedUDPPacket=text;
12
13         //Splitting the received UDP into an array, to be put into a
               ↪ Vector3 afterwards
14         tempHandPos = lastReceivedUDPPacket.Split(';');
15
16         //Adding the last received UDP-packet to a Vector3
17         var fmt = new NumberFormatInfo();
18         fmt.NegativeSign = "-";
19         secondTempHandPos.x = (float)double.Parse(tempHandPos[0], fmt
               ↪ );
20         secondTempHandPos.y = (float)double.Parse(tempHandPos[1], fmt
```

[11] http://forum.unity3d.com/threads/simple-udp-implementation-send-read-via-mono-c.15900/

```
            ↪ );
21          secondTempHandPos.z = (float)double.Parse(tempHandPos[2], fmt
            ↪ );
22          zVal = secondTempHandPos.z; // Storing the z-value of the
            ↪ received package
23
24          // Adds the Vector3, which contains the latest received UDP
            ↪ package, into a Vector3 List:
25          handPos.Add(new Vector3(secondTempHandPos.x,
            ↪ secondTempHandPos.y, 0));
26
27  }
```

Code 5.4: The main code of the script, UDPReceive. It shows how the data from the UDP-connection with Processing is gathered, split up and put into a Vector3 list

5.5.4 Creating the Path

The user has to wave his hand, in order for the system to detect it. A sound is played inside Unity when the hand is first detected. This is achieved through an if-sentence, which checks if the last position of the hand is not zero and if the last position of the hand is not the same as the current position of it. Furthermore does it only play the sound for detection of the hand, in case that it have not been played before already, see Code
ref.

Now that the hand's position is received from Processing, it should also be used by the system. A new script, called *followPath*, was therefore created. It was decided that the hand coordinates should be used as long as a button, called skip (translated from Danish "Spring over"), which enables the user to stop the challenge and continue the system was not pressed. This is checked by an if-sentence checking a boolean (so forth that the boolean is not true, then the rest of the code runs). The button - skip - is currently also invoked so forth that the challenge has been achieved.

When the system has made sure that the boolean skip is not true, it checks if the path is finished (if the user has both reached the start-area and the farm using hand gestures, or if the user has reached the start-area and then moved the hand too far away from the map). The system will then put the motorcycle animation of the soldier, Thomsen, on the path that the user has drawn, start the animation and move the animation along the route. In the ideal design, it was desired to have the animation shown a bit above the path see (Figure 4.14 in Section 4.8), but in this implementation, the animation is put directly on the path instead. This part of the code can be seen in Code 5.5.

```
1   if (!skip){
2           // When the path is finished and has been drawn, we will make
            ↪  the bike animation follow the line's position:
3           if (pathFinished) {
4           // if the bike animation is not out of the map collider then
5                   if (currentPosition < 0.1) {
6                   if (!movie.isPlaying){
7                                   voiceFile.clip = movie.audioClip;
8                                   movie.Play();
9                           }
10                          currentPosition += percentSec * Time.
                               ↪ deltaTime;
```

```
11                          iTween.PutOnPath(this.gameObject,
                                ↪ pathLargeMap.ToArray(), currentPosition
                                ↪ );
12                  } else if (currentPosition > 1.0) {
13                          currentPosition = 1.1f;
14                          movie.Stop();
15                          voiceFile.Stop();
16                  } else {
17                  if (!movie.isPlaying){
18                          voiceFile.clip = movie.audioClip;
19                          movie.Play();
20                  }
21                          currentPosition += percentSec * Time.
                                ↪ deltaTime;
22                          iTween.PutOnPath(this.gameObject,
                                ↪ pathLargeMap.ToArray(), currentPosition
                                ↪ );
23                  }
```

Code 5.5: Snippet of code from the script *followPath*. Here it can be seen how the system checks if the button *skip* (translated from Danish ”Spring over”) has been invoked and if the path is finished, before it makes the motorcycle animation of the solider move along the path that the user has drawn from Start to End (the farm).

The system checks via a collider placed on the large map that has been made to cover the visible area for the user, if the motorcycle animation is reaching the point in the path, where it is no longer visible for the user, see Code 5.5. This is checked via an if-sentence containing a boolean. Inside the if-sentence, another if-sentence checks if the soundscape has started or not and if so, it plays the soundscape. The soundscape is a continuation of the motorcycle animation, although purely in sound (see also Section 4.8.3). If, on the other hand, the soundscape is not playing anymore, it invokes the button ’skip’.

The hand’s position and the path itself is ensured to only be worked with as long as the path is not finished being drawn, that the motorcycle animation is not being moved along the path and as long as the hand is not too far away from the map, including that at least two UDP-messages has been received. See Code 5.6. This if-sentence covers the rest of the presented code from this script, unless stated otherwise.

```
1  // Path finished and path done both ensures that we will only add the
       ↪  hand position to currentPosOfHand when the path is not
       ↪ finished
2  // and that we will not start the animation until the path is done.
3  // As long as path is not finished and done and that the hand is X
       ↪ amount close to the Kinect, this happens:
4  else if (!pathFinished && !pathDone && udpRec.zVal < zValMax &&
       ↪ udpRec.handPos.Count>1){
5          length = udpRec.handPos.Count;
6          currentPosOfHand = new Vector3(udpRec.handPos[length-1].x,
               ↪ udpRec.handPos[length-1].y, 0f);
```

Code 5.6: Shows the if-sentence that covers the majority of the code. The rest of the code is run so forth that the path is not finished being drawn, that the motorcycle animation is not being moved along the path and as long as the hand is not too far away from the map, including that at least two UDP-messages has been received.

The mean of the last 20 received UDP-messages is calculated and the position of the avatar assigned to be that mean., in order to get a fairly stable avatar shown for the hand

The next if-sentence checks if if the user's position of the hand is inside the last (End-)collider, as this means that the user has made a path to the farm. The end-points position is so forth this is true added to two Vector3 lists, which are used to create the drawn paths: one list for the small map, and one for the large map. In order to add the position for the large map, it is needed to both scale the position vector of the End-point and to translate it. The scaling and the translation was first calculated by taking the size of each map and then dividing the width of the large map with the small map, and the same with the height of the map. The numbers achieved (6.5 for the height and 5.9091 for the width) was then used as a starting point for the scaling vector. The translation numbers were found by taking one of the points on the small map, scaling it, noting down the new numbers and then moving it until the appropriate place onto the large map. The numbers noted down was thereafter subtracted from the correct position (y and x-wise, the z-value is disregarded), and the resulting number was used as the translate vector. The vector did, however, need to be somewhat changed until it fitted more properly than the initial numbers had. Furthermore in the if-sentence all other sounds is stopped and the boolean pathDone is set to be true. The snippet of code can be seen in Code 5.7.

In order to give the user feedback for finishing the route, the amount of points that is added to the list of one of the paths is checked, and depending on how large an amount of points is in the list, the user gets corresponding feedback.

```
1 if (end.bounds.Contains(currentPosOfHand) && wereInsideStart){
2 // Add end coordinates to path
3 path.Add(end.transform.position);
4 pathLargeMap.Add(new Vector3(end.transform.position.x*
    ↪ largeMapMultiplyX+largeMapAddX, end.transform.position.y*
    ↪ largeMapMultiplyY+largeMapAddY, 200f));
5 pathDone = true;
6 print("Farm reached");
7 stopAllSounds.StopAllAudio();
```

Code 5.7: The system checks if the user's position of the hand is inside the last (End-)collider, as this means that the user has made a path to the farm, the end-points position is added to two Vector3 lists: one list for the small map, and one for the large map. Furthermore is all other sounds stopped and the boolean pathDone is set to be true.

Adding the positions of the points in the scene that the user hits with his hand's position (including the Start-point) of the hand is achieved in a similar way. Although, in order for the system to make sure that the user does not hit the same point twice and to get the colliders of all the points in the scene, it is needed to work in a for-loop. The for-loop goes through all the points in the scene, which have already been put into a GameObject array automatically in the Start()-function. This means that it is possible to easily add or delete these points, as long as you remember to add the Tag "Path" to any new points. The user can only draw through the points when he has first reached *Start*. The snippet of code can be seen in Code 5.8

```
1 //When we have reached Start, then we can begin to add things to the
    ↪ path:
2 else if (wereInsideStart){
3         for (int i = 0; i<pathPoints.Length; i++){
4                 currentPathPoint = pathPoints[i].GetComponent<
                    ↪ SphereCollider>();
5                 if (currentPathPoint.bounds.Contains(currentPosOfHand
                    ↪ ) && !haveBeenAtPathPoint[i]){
6                         path.Add(currentPathPoint.transform.position)
                            ↪ ;
7                         pathLargeMap.Add(new Vector3(currentPathPoint
                            ↪ .transform.position.x*largeMapMultiplyX
```

```
                                    ↪ +largeMapAddX, currentPathPoint.
                                    ↪ transform.position.y*largeMapMultiplyY+
                                    ↪ largeMapAddY, 200f));
8                                haveBeenAtPathPoint[i] = true;
9                                numberOfPathPoints++;
10                           }
11                   }
12           }
```

Code 5.8: Snippet of code from the script *followPath*. Here it can be seen how a for loop checks if the user's hand's position collides with any of the points' colliders.

The path itself is drawn each time a new connection between points is made, see Code 5.9. In order to be able to draw the path and to move the motorcycle animation along it, the plugin iTween[12] is used. There are two paths drawn: one path on the large map and a path on the small map. When the user has also reached the End-point, the avatar following the user's hand's position is changed and the boolean pathFinished is set to be true.

```
1  // When we have made the path (when pathDone=true), it should draw
       ↪ the path
2  void OnDrawGizmos () {
3          if (path.Count>1 && pathLargeMap.Count>1){
4              // Draws the path in the small map:
5                  iTween.DrawPath(path.ToArray(), Color.red);
6                  // Draws the path in the large map:
7                  iTween.DrawPath(pathLargeMap.ToArray(), Color.red);
8                  //When the path is done is pathFinished set to true
                       ↪ and the avatar's position is set to be at a
                       ↪ place that is not visible for the user
9                  if (pathDone){
10                         pathFinished = true;
11                         follower.position = new Vector3(0f, 0f, 30f);
12                         }
13         }
14 }
```

Code 5.9: Snippet of code from the script *followPath*. Here the paths are drawn whenever a new connection between points is made. When the user has also reached the End-point, is the avatar following the user's hand's position changed and the boolean pathFinished is set to be true.

[12] iTween can be downloaded from here: `http://itween.pixelplacement.com/`

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Chapter 6

Evaluations

This chapter presents the evaluation of the proof of concept and the designed system, which were designed and implemented (see Chapter 4 and 5). This means that this section covers what will be evaluated, why it will be tested, how it will be evaluated and the results from the evaluation.

In order to get an overview of how well the implemented part of the system is working, is a technical evaluation of it being made, concerning the detection and tracking of a user's hand and the provided feedback. It is desired to mainly evaluate the participants' desire to continue using the system, so forth they had been able to use the full system. Furthermore is the system brought to the museum to see how visitors behave with the proof of concept compared to how they behave when using the map already installed at the museum. It is also desired to show the implemented part of the system to the staff at Mosede Fort to get their feedback upon it. The last evaluation is a theoretical evaluation, which focuses on learning; does the fully designed system deliver a learning experience? This evaluation is based on two theoretical aspects.

6.1 Desire to Continue

In Section 3.7, were multiple aspects of learning - as well as ways of testing whether or not learning has been achieved or improved - presented. The research showed that the most optimal way to test learning would be to follow the participant, before, during, and after they have been presented with new information. This method means that it is most beneficial to have a longer period of time to conduct the test, at least a few weeks, but preferably a few months and up to a full year or more. Since this project is a progress with a time restraint, learning will in this case not be the main focus for the evaluation. The evaluation will instead focus on the user's desire to continue, to see if the users are even interested in using the system, because learning cannot be achieved if people do not want to continue using it. The idea is therefore to evaluate the implemented challenge to see if it can engage the visitors and to find out if they would like to have more challenges – learn more of the presented story. Schonau-Fog suggest based on his findings that the result of feeling engaged is often based on wanting to continue (continuation desire). Furthermore is the desire to continue also a key element of play. It is through the enjoyment of performing/the experience, which creates the desire to continue playing. The last thing the player want to do is stop so - in order to avoid that from happening - he bends the rules, change the circumstances and guidelines. After completing the event, there is a desire to start it all over. It is also reasoned by Schonau-Fog that as long as an engaged player has not fulfilled the objective, he "can have the desire to continue" [63, p. 6]. It should, however, be mentioned that it was found that the desire to continue is not evident when a game's controls are not easily accessible or are badly designed [63, p. 8]. [63, p. 2], [12, p. 18]

6.2 Evaluation 1: Technical

This evaluation was a technical evaluation of the system, in order to check 1) if the detection of the user's hand by the Microsoft Kinect is quick and the tracking reliable, and 2) that all feedback provided and buttons work correctly. To see more about how this evaluation was performed, see Section 6.2.1.

6.2.1 Explanation of Evaluation 1

The technical evaluation will focus upon two things:

1. The tracking of the user's hand with the Kinect; both how well the system is to first detect (track) the hand, and then how often the user's hand is lost to the system when drawing a simple route on the map through four specified of the points (stability of the tracking).

2. The overall implemented part of the system, especially feedback: is something missing, does everything work as intended? The focus here will mainly be upon what should be changed, in order to improve the implemented system.

It is desired to evaluate this in order to be able to clearly state what is needed to be changed or further developed for improving the system.

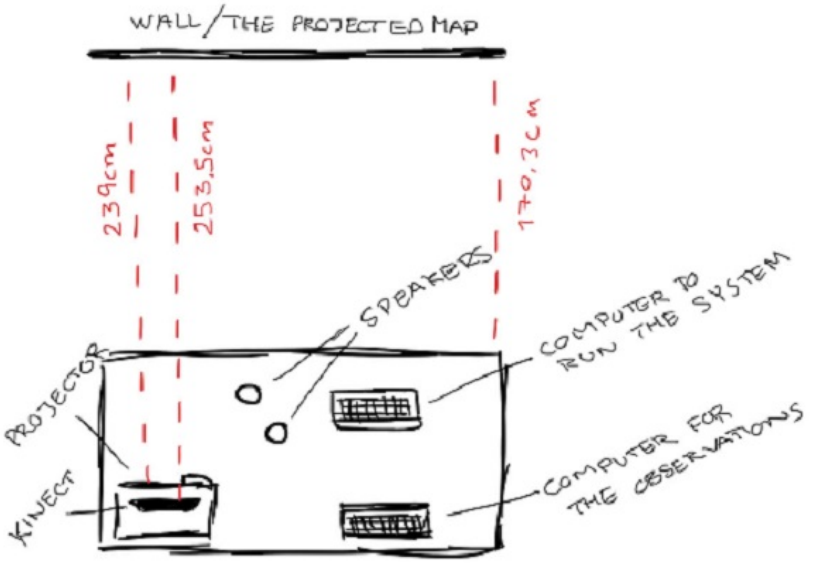

Figure 6.1: An illustration of the test setup for the technical evaluation and the second evaluation

In order to evaluate this, it is needed to first and foremost use the same computer, projector, and test conductor to test the detection and tracking of the hand. The Kinects should be tested in different light conditions with and without the projector several times, in order to be able to get an average of its performance: how long time it takes to get the hand detected and how often the system loses the tracking of the hand while drawing a specified route. The system feedback should be evaluated by going through the immplemented part of the system multiple times, in order to see if all feedback is given appropriately. Furthermore should the ”skip” and ”try again”-buttons be tested to see if they work as they should.

6.2.2 Results for Evaluation 1

The Microsoft Kinect The reliability of the Microsoft Kinect was evaluated, both in regards to detecting the hand and to the continuous tracking of it. It was tested on the same PC, with the same Kinect and the same conductor to stand in as the user (detection and tracking of her hand). For each condition were the hand detection tested 10 times. The different condition and how long time it took for the system to detect the conductor's hand can be seen in Table 6.1.

In order to see how fast the system would detect a waving hand, the time were taken for different conditions. During the first three conditions were the same room (and background) used, including the same type of lighting. In these three conditions were the only changing parameters that of how many programs related to the system were running on the computer. The first condition were evaluated with only Processing running, the second condition with Processing and Unity running, while the third condition were running with Processing and an executable file, instead of Unity3D. Due to the discovery of the conductor standing slightly at another distance and angle to the Kinect than in the previous test condition were Test1 with Processing and Unity running discarded, and a new test (Test 11) had to be performed instead. The means for the three conditions were very close to each other as it can be seen in Table 6.1.

	Time before hand is detected				Disconnection of hand	Missed points
	- Unity (Cond. 1)	+ Unity (Cond. 2)	exe file (Cond. 3)	Projector (Cond. 4)		
Test 1	2.2	20.4	1.1	1.7	0	0
Test 2	1.2	4.0	1.3	1.4	0	1
Test 3	1.3	3.3	7.5	1.3	0	1
Test 4	1.4	1.3	3.2	1.6	0	0
Test 5	2.7	1.7	3.6	1.1	0	0
Test 6	1.3	1.5	2.6	1.5	0	0
Test 7	1.8	1.1	1.9	1.4	0	0
Test 8	1.8	2.5	1.3	1.4	0	0
Test 9	3.8	2.7	1.3	1.4	0	0
Test 10	1.9	1.3	2.0	1.7	0	0
Test 11		2.7				
Mean	1.94	2.21	2.58	1.45	0	0.2

Table 6.1: Shows the technical evaluation of the Microsoft Kinect. The Kinect was tested in four conditions. All times are in seconds. The condition '+ Unity', Test 1 was discarded. It was furthermore tested how many times that the tracking of the hand was lost and how many points, which forms the path, was missed when drawing a specified path.

The last condition - condition 4 - were performed in another room than the other conditions. The test setup for this condition can be seen in Figure 6.1 and 6.2 had the lowest mean on only 1.45 seconds. This condition also had to take place in another room and had a projector included (it was also running with both Processing and in Unity), since the system would not detect the hand at all in the previously used room. It is believed this was because the room was too bright with sun coming in through the windows and a Kinect only work in specific light settings [47]. In order for the Kinect to work properly with the projector, it was therefore needed to use a smaller room, where the window blinds could be closed and all other lights be turned off.

Feedback and Buttons The full system was examined multiple times, in order to check if all possible feedback (described in Section 4.8) were given correctly and to see if the two buttons

behaved as they should. Furthermore were any other inconsistencies or flaws detected noted down.

The rest of the technical evaluation was tested using Processing, Unity and the projector. Partly because this had the fastest detection times for detecting the hand, partly because the executable Unity-file meant that the small map got a worse resolution and it was even more difficult to see what was happening in the map and to create the path on it than when running the project directly in Unity.

Figure 6.2: A photo of the setup of the projector and kinect used for Cond. 4

During the technical evaluation it was discovered that the soundscape for the second animation (motorcycle-animation) was too loud compared to the given feedback through voice over, why the soundscape was removed for further evaluation of the feedback. It was found that the conductor had a bit trouble at first to get the system detect the hand. Even though the 'try again'-button worked, it was discovered that the placement of the collision areas did not fit completely with the placement of the shown buttons, why this was changed to be correct for all further evaluation. The 'skip'-button was tested and it worked as intended.

The evaluation further showed that these things did not work as intended or should be changed/added in the future:

1. There should be a sound for not only when the hand is detected the first time (as it is now), but the sound should also be played when the tracking of the hand has been lost and is detected again.

2. When the button 'try again' is being 'pressed', the sound for the hand being tracked is played immediately after. The system should ideally not play this sound then, since the hand had already been detected earlier and was already being tracked.

3. When the path made is too long or too short, it was found that even though the correct feedback is given, the user is also getting told that he is done with the system, as he would have been told, if he had ended the test by hitting the 'skip'-button or the route path had been the correct length. Instead should the user be told that he can either try the challenge again or skip it.

4. The sound file with Thomsen riding the motorcycle to the farm (i.e. the soundscape which takes over when the animation reaches the end of the large map) did not play through the full file. This, however, was changed already for Evaluation 2, such that it did in fact play the full audio file for the participants to hear.

5. The second animation (the motorcycle animation) continues playing even though the user does not solve the challenge satisfactory. This should be changed, such that the animation does not start playing at all.

6. It was not made very clear in the introduction to the system that the user does not need to go through all of the points to create the route. This might need to be said more explicit than it is currently.

7. In the next iteration of the implementation, it should be made such that all the points for the path follows the actual (main) roads on the map, such that the user has to go create a path, which follows the roads, for the Thomsen to bike on. It should not be possible for the soldier to bike through the wilderness.

6.3 Evaluation 2: Technical - from a Secondary Perspective

In the second evaluation, it is desired to get a qualitative insight into what people think is working with the system, and what should be changed. The evaluation is inspired by an expert-based test of the type cognitive walkthrough [43, pp. 256-258]. It is therefore desired to get participants with a technical background, as it is believed that they have an insight into technology, how feedback should be provided, and who can maybe come with other suggestions to how the system can be improved both such that is works better and more intuitively for the user, but also on the technical level.

With this test, it is desired to know whether or not tracking with a Kinect is the best choice, if the introduction and guidelines from the voice over provided with the system are understandable, but foremost if the participants even have a desire to continue using the system, so forth they could have tried the other challenges as well.

The participants will be sampled using convenience sampling [62, p. 249] (non-probabilistic sampling [43, p. 107]), to some extent. The criteria for sampling the participants are that they are students at Aalborg University-CPH, who have the time, who wants to test and who have a technical background or are currently studying one of the more technical educations there.

In order to get the desired knowledge a questionnaire is used for the participants to answer. A questionnaire is used since many of the questions, which are desired an answer to, are simple questions (closed-ended questions, including a few questions using a Likert scale [43, p. 112]) and do not require a lot of elaboration. Furthermore is the participant going to be asked to tell the test conductors if he have any other questions, thoughts or things he would like to discuss, in case that the questionnaire or the test conductors have missed an aspect which the participant believes to be of importance. The participant is going to be observed by a test conductor. The test conductor will have some specific things to look after, such as if the participant have trouble getting his hand detected, and if he does not complete the challenge in the first try, does he then want to try again or just skip it? The questionnaire and observation check-list in question can be seen in the additional uploaded material under the names *Questionnaire for Evaluation 2* and *Check sheet for observations for Evaluation 2*.

The Evaluation Step by Step The participant will be greeted, and the test explained to him, including what the system is about and what would have happened up until now in the system, the guidelines used for the intro can be seen in Appendix C. After the conducted pilot test were other points added as well; that the participant can always try the challenge again (reset it) or he can skip it, if he does not want to try it anymore.

Thereafter will the participant try the system on his own, while being observed by one of the test conductors, and with the possibility for him to ask the other test conductor, if he has any

questions or immediate feedback about the system. The other test conductor can also jump in, in case the participant e.g. have problems with getting his hand detected by the system or have not understood the instructions given by the voice over properly - in case an intervention happens, this should be noted down by the observer.

When the participant has either completed the challenge or used the ”skip”-button, he is asked to answer the provided questionnaire and to tell if he has any other comments, if he has something he would like to discuss with the test conductors or if he has any questions related to the test or the system in general. Here, the test conductors can also ask the participant further questions, in case they have observed him do something which they did not understand, similarly to a very loose, unstructured interview [43, pp. 189-191]. This is simply to ensure that the observed data is correctly understood.

6.3.1 Pilot Test

The pilot test was conducted as described in Section 6.3. A single participant functioned as the pilot test, as further evaluation with the changes made based on the pilot test proved to be sufficient. It is this pilot test and the following changes needed, which will be described in this section.

Observations The observations were performed by having one of the two test conductors sit and observe the participant (male, Medialogy Master student) while he used the system. The test conductor had a checklist for what to look for and which questions to answer in an online questionnaire made using Google Drive, in order to easily have all notes assembled. Having the online survey as a check-list proved to work very well, as it gave a quick overview of what the conductor should pay attention to and it also prompted the conductor, in case a question still had been forgotten when the survey was being submitted. It was still, however, discovered that some important things were missing in said survey:

1. It was not possible to state that the participant had completed the challenge in the first try and therefore did not use the ‘skip’- nor the ‘try again’-button

2. It was not possible to write any other unforeseen, but nonetheless important observations in an ‘Other comments’-commentary box.

These two things were changed and added to the survey.

Questionnaire There were no changes made to the questionnaire for the participant, although he did ask what was meant with the question “Elaborate on previous question - why/why not?” which came after asking the participant whether he completed the challenge or not. The question was quickly explained and it was decided that it would be easier simply to explain the participants what was meant with the question, since it would need a more elaborate written explanation, in order to make sure that the participant would understand it completely.

Discussion - Other Comments After the test, the participant also had some other comments regarding the test. Most of these comments regarded the tracking of the hand and suggestions for how else, it could have been made, such as using a touch sensitive screen or tablet. He also suggested that it could be made using models or similar that had to be placed on the map.

Another comment from the participant was that he had not been aware of the possibility of using the ‘skip’- or ‘try again’-button. Unfortunately was the resolution on the available projector not great, and due to the text on the buttons being very small, it was not very visible. It was therefore decided to also mention the buttons in the introduction that each participant would

get before trying the system. Furthermore, since he had not himself been at Mosede Fort, he did not know the map in question and images of it was needed to be shown for him to understand how the new system should be implemented together with the already installed map. It was therefore decided to show the participants a single still image of the already installed map at the museum when introducing the system.

6.3.2 Results for Evaluation 2

The evaluation had a focus upon getting participants from a technical background, such that it would be possible to get an insight into how other experienced students within the field think of the system from two perspectives: 1) the general idea, and 2) the technical approach of the system. The evaluation will be conducted using observations and questionnaires.

All participants was either currently taking their Master in Medialogy or had finished their Bachelor in Medialogy within the last two years. The evaluation consisted of a total of eight participants, whereas one of these were a pilot test. Out of the eight participants were two of them females. The participants used for this evaluation were only based on their technical qualifications and it was therefore not necessary to select them based on their age, gender, or alike. The full observation notes and the answers to the questionnaire by the participants can be seen in the additional uploaded material under the names *Questionnaire for Evaluation 2 (Responses)* and *Check sheet for observations for Evaluation 2 (Responses)*.

Observations The seven participants who took part in the final evaluation were observed by the same test conductor, in order to avoid as much bias as possible.

The participants did in general seem interested. The test conductor would rate how interested the participants seemed (or did not seem) on a Likert-scale going from 1 (not interested) to 5 (very interested) and the average rating was upon 4.29. The participants did, however, also seem slightly bored with an average rating of 2.14 on a similar Likert-scale going from 1 (very bored) to 5 (not bored).

Furthermore, it was noted that the participants did on average move somewhat around, but not a lot. All seven participants moved the most when trying to get their hand detected by the system - which proved to be a difficulty for the majority of the participants. Two participants started making shadows (such as bunnies) with their hand and the projector, when they had tried getting the system to detect their hand for a while.

None of the participants used the 'skip'-button during the completion of the challenge, although a single participant used it after having tried the challenge, but not completed it satisfactory for the system. This was noted to be because she had had so many troubles getting the hand detected by the system and that the tracked hand was lost multiple times; if the detecting and tracking of her hand had been better, she said, she would have wanted to try completing the challenge again. Two of the participants completed the challenge satisfactory in their first try, while the last four tried again until they managed to get through the challenge.

The other comments from the observations have been gathered into groups, in order to more easily see where change is needed. One of the participants is still learning Danish (the system is all in Danish) and one of the test conductors therefore gave the introduction while speaking Danish slowly, and made sure that she understood it. In one of the evaluations, the last animation with the motorcycle moved slower on the path than in the other evaluations, which should be investigated further in the future. Two of the participants decided to use the 'try again'-button before having finished the path; the button worked as intended and the participants could restart drawing their route. There were problems with some of the participants not understanding the full idea of the points that the route should go through. Two of the participants thought that they had to go through all of the points, similar to a connect-the-dots drawing, why it was told in later

evaluations that the participant *only* had to go through the points that he thought would make up the best route. One of the other participants believed that the points were other farms, such that he had to get to as many of them as possible, but not all of them. It should therefore be made more clear in the voice over what is meant with the points and how the user should create a path with them. The main obstacle encountered in this evaluation was how much difficulty most of the participants had to get their hand registered by the system. Out of the seven participants was it mentioned for five participants to be an actual problem and for it to take too long time. It was also noted that the instruction for the participants to wave their hand to get it detected by the system was not sufficient, since the participants wave their hand differently, and not always in a way that the system can detect it. It should be noted that even after some of the participants had been shown by a test conductor how to wave with their hand to get the system to detect it, most of them still had trouble with it. Furthermore did three of the participants experience that the system lost their tracked hand.

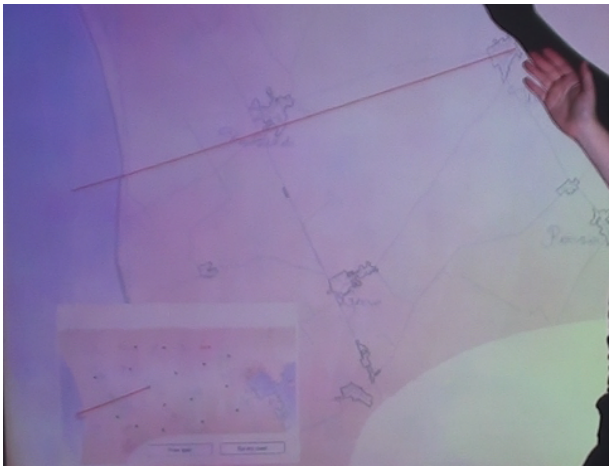

Figure 6.3: A photo of the route being drawn using hand gestures

Questionnaire ***The General Ideal***: Six out of the seven participants completed challenge 5, however, when asking if they would like to try more challenges - had they all been implemented - all seven participants answered 'Yes'. This indicate that even the participant, who did not complete the challenge, was not discouraged to continue. Three points were mentioned when the participants were asked why they would like to continue:

1. The system is a good way to gain historical information.
2. Having an interest in seeing what other ways of interaction with the system there is.
3. Having an interest in exploring the narrative more

The participants were then asked if the system in general made them want to continue. The results can be seen in Figure 6.4. As it can be seen from the figure would one participant not like to continue with the system, due to the difficulty with the tracking - an opinion, which might change if the tracking was improved, to see how the drawing was done using hand gestures see Figure 6.3. Another participant said 'I don't know', because of the tracking being exhausting, but at the same time liking the idea. This again indicates that improvements are needed. The remaining participants said that they did want to continue, reasoning that the system is fun, that they are curious, that they want to see more of the system (which for one is a new experience) and that they have an interest in discovering what Thomsen will need to go through next and

how he will be needing the participant's help. This positive feedback mean that even though improvements are needed, the idea in itself is a step in the right direction.

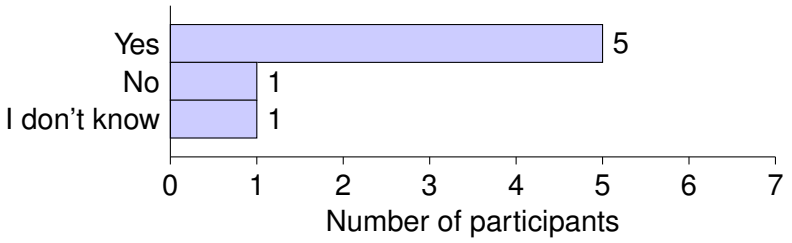

Figure 6.4: Shows the number of participants that would have liked to continue.

The Technical Aspect: In order to get a more technical evaluation, the feature with the hand gestures, the animations, and the soundscape were rated by the participants on a Likert-scale ranging from one to five; five being the best. The results can be seen in Table 6.2, where the mean has been calculated for each of the three categories. As the table shows, both the animations and the soundscape received an above average score (above 3), indicating that they are not bad, but that there is still certainly room for improvements. The feature with the hand gestures, however, only managed to gain a below average score. This means that more improvements need to be considered, or a whole new technique for it should perhaps be used.

Feature: hand gesture	Animation	Soundscape
2.9	3.7	3.6

Table 6.2: The average evaluation score for the feature hand gesture, the animations, and the soundscape

The participants were asked if they had any suggestions for improvements. As already mentioned, the hand tracking is the main issue with the system, so all additional comments regarding this will not be included again. tnstead had one participant an idea for an alternative way to draw the route. The participant suggested a tactile approach to achieve what he believes to produce a better feedback; such as using fiducials and make the participants move an object or character around, and in that way create the path. Another suggested to give the visitors a pen for the tracking so it also felt more like drawing.

Additional Comments: In the end of the given questionnaire were the participants given the chance to give some last remarks. Two of the participants believed that the system could with improvements become a fun museum exhibition. Another participant thought that it is a nice concept, which could help teach history. Both comments support the original idea. One of the participants also pointed out that the sensation of the experience might change: when the map is experienced horizontally (on the physical map), instead of vertically (on the wall), as they experienced it during the evaluation. The same participant also pointed out that having the map/system horizontally might be less exhausting for the participants' arms.

6.4 Evaluation 3: Mosede Fort

The third evaluation will take place at the museum. This is in order to get the museum's visitors' (the actual target group, see Section 4.1) reaction to the system and to see if they have any more desire to continue with the system than they have with the map already implemented at the museum.

This evaluation will therefore consist of two parts: 1) to observe the visitors using the already implemented map at Mosede Fort, and 2) to observe the visitors using the new system (Challenge 5). The visitors' desire to continue can either be concluded based upon how long time visitors use on the systems (quantitative, measurable data) or by asking them why they wanted to continue for such a long time/did not want to continue for that long (qualitative data).

6.4.1 Results for Evaluation 3

When arriving at Mosede Fort on the agreed day, no visitors were currently at the fort and the original map did not work. The third evaluation therefore only contain feedback from the contact person. At first the contact person were given a short introduction to the implemented part of the system (proof of concept). One of the authors then demonstrated how the prototype worked. Afterwards a conversation about it took place, where the contact person gave his thoughts and feedback. This section will cover the given feedback.

The first thing discussed was the route itself and the way the visitors would have to plan it now. The contact person suggested that instead of just having to finish a route, the goal could be to collect soldiers stationed at the farms in the right order, so those closes to the Germans will be alarmed first.

The contact person's main concern was time. The time that it would take to finish the system and whether or not the visitors would put the amount of time required into it. Another concern regarding time was the time that other visitors would have to wait, in order to get to use the map if other visitors' were using it upon arriving at the exhibit. The authors estimate that the entire ideal design of the system will probably take between 10-20 minutes with challenges (this depends on how quickly the visitor(s) complete each challenge) and around five minutes without. The proof of concept was implemented using the *Medium*-difficulty, since the challenge is encountered not dependent on the time-setting, it was not considered. A suggestion was to make a process bar show the visitors how long time there would be until the system have finished and new visitors can use it. It was also discussed whether the system should finish when a visitor fails, thus avoiding the system to take too long time.

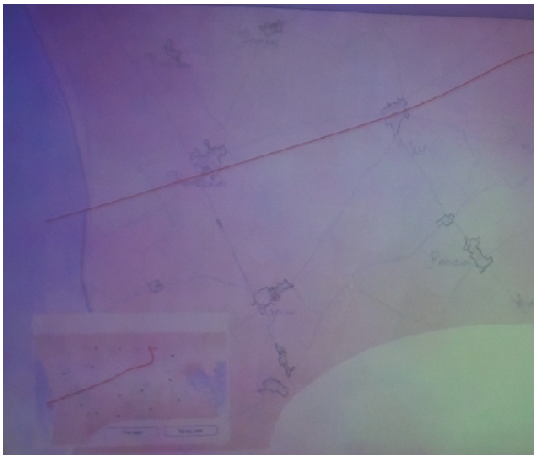

Figure 6.5: A photo of the mini-map together with the larger map

The contact person liked the mini-map and the way that it allows visitors to interact with areas that are not included on the large map, the mini-map together with the larger map can be seen in Figure 6.5. He did have concerns about the settings being intuitive enough, but at the same time also suggested to add a mode that makes it possible for groups to choose between teamwork and competition. This could maybe motivate people to be faster and to finish the

system. He often indicated that time could be used as a motivation factor in general.

Regarding the missing areas of the map, he liked the solution of using a soundscape, but also mentioned that he would like to have some visual feedback, when the soldier is actually reaching the farm. Here it was suggested by the interviewer that old photographs of the farms – similar to those they already use in the installed map (see Section 2) - could be used as well. The last thing asked was if he thought that this system and usage of the map would be a better solution than the original or not, and he said that it would.

6.5 Evaluation 4: Theoretical

Based on multiple sources presented in Section 3.7, it became clear that testing learning would not be an option (see also Section 6.1). It was therefore decided to make a theoretical evaluation, in order to see if the ideal design (see Chapter 4) of the system would theoretically be able to make people learn. A closer look upon the seven characteristics of learning and if these characteristics have been met will be evaluated in this section. Afterwards will the focus shift to whether or not pitfalls of interaction (presented in Section 3.7.2) have been avoided.

6.5.1 The Seven Characteristics of Learning

The theoretical evaluation will focus on the seven characteristics for making a family friendly exhibit for learning in a collaboration which were presented in 3.7.1, [26, pp. 190-191], [8]. The evaluation for each of the seven points can be seen in Table 6.3. The table shows that the ideal design lives up to four out of the seven characteristics, while the remaining three only delivers partly. These three characteristics are 1) *multiuser*, 2) *multi-outcome*, and 3) *being readable*. It can be discussed whether or not it is even desired to live up to the first of the three characteristics, which are only partly met, since the idea from the beginning was to create a system that allowed visitors to work together. Having multiple users therefore allows for having more than one individual to interact with the system at the same time, thus maybe disrupting the experience or rush each other. At the same time will it also be difficult to implement, since there is only one map to tell the story, as this would mean that the visitors would have to keep the same pace as well as have the same settings for everyone using the map. For the second characteristic *multi-outcome*, it can be argued that the system does include different outcomes, but only depending on how the visitors manages the given challenge, since the outcomes (feedback) from the current challenge will not affect the following challenges. The system can, however, as explained in the table, create different social outcomes, such as discussions. The third characteristic is *being readable*. Since this system focuses mostly on delivering information via visual elements (primarily in the form of animations), audio, and interactive elements, it cannot for sure be classified as readable. It is, however, still hoped that the system will be easy to understand.

6.5.2 The Pitfalls of Interaction Features

This section focuses on the five pitfalls found by Allen and Gutwill presented in Section 3.7, [2, p. 25], [3]. This evaluation will assess whether or not the ideal design has avoided the pitfalls, in order to prevent decreasing the visitors' learning outcome. Based on the evaluation made in Table 6.4, it can be assumed that four out of the five pitfalls have been avoided. The last pitfall is only marked as *avoided to some extend*, wince it can be argued: on one hand are the interactive elements designed such that they do not occur when receiving information, and therefore do not disrupt the phenomenon in that specific moment. On the other hand, however, can it be argued that the phenomenon being displayed might be disrupted since the information is broken into parts which breaks with interactive elements. It should, however, be mentioned that if the

Characteristics	**Evaluation (is the characteristic met?)**	**Why/Why Not**
Multisided	Yes	Not much can be done for this aspect, since the map is already installed at Mosede Fort. The installed, physical map is, however, already large and it allows multiple people (visitors) to gather around it; the characteristic is therefore met.
Multiuser	Depends	The system is designed for multiple users if they are in a group or otherwise do not mind working together as strangers. Some of the challenges require all visitors to be active, while other challenges simply require them to work together and make joint decisions, while having one person to control the system.
Being Accessible	Yes	The settings should invite not only children but also adults to dive in and try the system.
Multi-outcome	Not known	It is hoped that discussions will occur within the group due to the given challenges, but it can simply not be known if it will do so.
Multimodal	Yes	The whole system is designed with the concept of being multimodal in mind. This is especially seen in the user settings as well as in the design and implementation of the challenges.
Being Readable	Alternative	The reason this is marked as alternative, is due to the fact that minimum text is used and instead as an alternative, soundfiles convey the information. Based on the additional evaluations conducted, it is clear that improvements on the already implemented soundfiles are needed, however, the goal is of course to deliver an easy apprehendable product.
Being Relevant	Yes	The visitors will learn a new aspect of WW1 at the area around the Tune trench line. Since going to the museums, the visitors will most likely already know something about this topic beforehand, but the system will add more to their knowledge about WW1.

Table 6.3: An overview of the theoretical evaluation regarding learning. The seven characteristics was first presented in Section 3.7.1 by Borun et al. [26, pp. 190-191], [8].

visitor does not want these disruptions, they can simply select the version without challenges. However, this pitfall will remain as not avoided completely for now.

6.5.3 Conclusion of Evaluation 4

Based on the two evaluations it can be stated that the system still have room for improvements in order to achieve a perfect theoretical learning environment and tool to be used at a museum. It should, however, also be mentioned that even though these points can in fact be used as guidelines, not all of them is wanted to be fulfilled. The next step for evaluating the learning element for the system, would be to test it on participants, following some of the additional theory presented in Section 3.7.

Pitfalls	**Evaluation**	**Arguments**
Multiple options with equal salience can overwhelm visitors	Avoided	Since the system will present the information in a linear order (not presenting everything at once with an equal salience), it is belived that the visitors should not feel overwhelmed by the system.
Interactivity by multiple simultaneous users can lead to disruption	Avoided	It will not be possible for multiple visitors to use the map at once without them working as a team; the system will therefore *not* be used by multiple, individually working users at the same time. They will thereby proceed in the challenges and the story at the same speed.
Interactivity, even by a single visitor, can disrupt the phenomenon being displayed	Avoided to some extend	The system is designed in such a manner that everything happens in steps, meaning that when information is conveyed, no interactive elements are occurring that the same time. A way, however, interaction might disrupt is by making these forced breaks.
Interactive features can make a critical phenomenon difficult to find	Avoided	The interactive elements (the challenges) are kept very simple. At the same time does the visitor have the option to continue with the story without completing the interactive elements and will therefore always be able to find the critical phenomenon.
Secondary features can displace visitors' attention from the primary one	Avoided	Since the story is being told separately from the interactive elements and therefore not occurring at the same time, this should not be a problem. The exhibition room that the map is a part of, only contains static elements and is therefore less likely to take the visitors attention away from the map.

Table 6.4: An overview of the theoretical evaluation regarding possible pitfalls to avoid when working with interactive elements. The possible pitfalls was found by Allen and Gutwill, and is first presented in 3.7, [2, p. 25], [3].

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Chapter 7

Discussion

Selected topics and points will be discussed in this section. The design requirements based on the theory from the investigation are first of all discussed, in order to see if said requirements were in fact met in the ideal design and in the implemented proof of concept (Challenge 5 - Route). This is followed by a discussion of the findings from the evaluations of the proof of concept. The theoretical evaluation regarding learning of the fully designed system will in the end be discussed.

7.1 Requirements

The points made based on the investigation included 14 design requirements, see Section 3.8.1. Out of these requirements are 9 considered to be achieved in the ideal concept. Three of the requirements, which were not completely met will be discussed now, while the remaining two (requirements 11 and 14) will be discussed later in this chapter. Two of the three requirements are similar to each other and will therefore be discussed together (requirements 6 and 9). They both focus on the system being intuitive or not. The ideal design was created with the intentions of making it as user-friendly and adaptable as possible for children as well as adults. The second evaluation of the proof of concept did, however, showed that this was not entirely the case, since a lot of guidance from the test conductors were still needed for the participants to complete the challenge. This could perhaps be solved having a better tracking system or with more in dept guidance in the form of a voice-over, see Section 4.8. The fact that more guidance were needed for implemented part of the system does, however, not necessarily mean that it will be needed for the entire ideal design as well. The third of the requirements, which were not met, (requirement 8) revolves around whether or not the visitors would like to use the system multiple times. This cannot be known for sure, since this requires testing over a longer period of time (a chance for the visitors to visit the museum again). Even with testing, this is a requirement that will always depend on the individual.

The first three presented design requirements in Section 3.8.1 states that the system should be made for the map already installed at Mosede Fort, that it should revolve around WWI and the predicament of how a German attack should be encountered, and that audio should be used to represent the missing areas of the map. These requirements were met and it was possible to create a solution for the museum, which includes the missing areas of the map by the use of audio. It was furthermore also possible to present more specific information by the use of various media (creating a multimodal system), without having to interfere with any source code etc. that was already used at the museum (design requirements 4 and 5). Requirement 7 was not implemented as a part of the proof of concept, but instead it is believed that it is met in the ideal design (the ”sleep-mode,” see Section (4.7). The system is designed to be used for groups

and individuals, allowing the visitors to select this themselves before starting the system, why requirement 10 is met. It was learned in the investigation that it is a good idea to inform the visitors about what is going to happen - requirement 12. This requirement was met since voice overs were used to help and inform the visitors about the story as well as to the challenges. A requirement (design requirement 13) stated that the graphics should fit the time period. This was achieved by not using any bright colours and by using a watercolour technique and style.

It can be discussed whether or not the desire to continue is relevant enough to learning, but if the visitors do not want to continue with the system after having tried one challenge (the proof of concept); there is a very small chance that they will want to continue with the full system either. If the visitors do not even want to continue using the system, they will not learn as much about the subject. Since learning was not tested on human participants, it cannot be said with certainty that the system provides a learning experience.

7.2 Evaluations

One of the main concerns when making the technical evaluation was the stability of the tracking with the Kinect. The tracking was tested ten times in four different conditions. The evaluation showed that the tracking was stable and that the time it took for the system to detect a hand was minimal. Something else, however, was experienced in the second evaluation, which was conducted on people with a technical background: the tracking by the Kinect behaved completely differently. Instead, the tracking suddenly seemed to be unstable and much more unreliable. This could be due to the participants not understanding the guidelines properly (everyone waved differently, in order to get their hand detected), and that they were not trained using the system. A solution to this could either be to have an animation showing the user how to wave their hand for the system to detect it, to find another solution with the Kinect where it is not needed to wave, in order to get a hand detected, or to go away from using the Kinect completely. The idea of using e.g. a glove or a brightly coloured object, such as a pencil or similar, could perhaps be investigated further in the future, in order to see if it would provide a more stable detection. The second evaluation thereby showed that for now the tracking technique used for the system is not sufficient.

The idea was to work towards a system that does not require a museum professional to guide them, and that should be intuitive system, however, when the system was evaluated, the participants needed to get more guidance than was presented in the system. This was mostly in regards to the detection of their hands, but others also needed more information, in order to understand how the route should be drawn. This indicates that the guidance needs to be made more clear, in order to meet the design requirement of the system being intuitive (design requirement 9). The second evaluation also showed that all but one participant wanted to continue. They gave reasons such as wanting to see what else the system had to offer. This indicates that all but one participants had the desire to continue, which was the main goal to figure out in the evaluation. The participants did, however, also comment on the tracking being unstable, so they suggested that another solution for this would need to be found and implemented in the future.

Observations were made as well in the second evaluation. It should, however, be mentioned that this type of observations (seeing how interested and bored a participant seem like in the eyes of the test conductor) is biased, as 1) the test conductor can only make a qualified guess based on what the participant say, behave and his facial expressions, and 2) the test conductor is biased herself, as she - even if it is subconsciously - could be influenced by how much she has invested in the system and thus want it to perform well in an evaluation. A solution to this could be to make the participants to evaluate these questions themselves (self-evaluation), or to measure e.g. their physiological responses while using the system.

The third evaluation was supposed to be conducted at Mosede Fort - not only on the ideal target group, but also to get feedback from the contact person and perhaps other interested employees. This proved not to be possible: Only the contact person was tested, since no other employees met were available and no visitors were present at the museum at the time of the visit. The idea was also to observe the difference between the interaction of the original map and the system for this thesis, however, it turned out that the original map was out of order at the time - and had been for a month and a half. The plans were therefore changed and the third evaluation only focused on getting feedback from the contact person. Time is also presented as one of the requirements (design requirement 11). It was considered that time would play an important role for the visitors. The design was made such that the visitors have the possibility to choose what length they want for the system to be. Based on the feedback from Mosede Fort, it can be said that time is definitely something that should be considered even more in the future. Taking the average time that it takes visitors to complete the system would make it possible to clearly state how long time the system lasts on average to the visitors, and they will thereby have a clear idea of what they are agreeing to before starting the system. At the evaluation, one of the suggestions was to end the system when the visitor was not able to complete the challenge correctly and thereby teach the visitor the lesson of the importance of failing when executing the plan for the predicted invasion. This, however, means that the visitor will not be presented to the whole story, but this might not be a big issue; perhaps the lesson is more important than finishing the whole system – and it might even make the visitor want to try it again. Both ways, however, should in theory work, so this would simply come down to preference and considerations of time.

For the theoretical evaluation (see Section 6.5), it can be discussed whether or not a theory-based comparison can in fact show something concrete. In this case, the answer is most likely no, since learning itself is a very individual aspect. The theoretical evaluation can, however, indicate if the system is a step in the right direction. Since not all of the characteristics were met, it is likely that improvements or new considerations are needed. Since one of the pitfalls regarding learning were not completely avoided, it can indicate that some areas of the system should in fact be changed. The obvious solution for the doubt regarding the evaluation's validity could be to test the system over a longer period of time on the target group (see Section 4.1) and with different scenarios (groups and individuals).

The only part left of this evaluation was whether or not the contact person believed if the system would improve the original map or not. It would have been preferred to let the visitors evaluate the original map as well as the implemented system, but since this was as the time not possible, were the question asked to the contact person, who said that he would prefer the improved system over the original map. This answer could, however, be biased, as he might simply wanted to agree with the interviewers, but based on previous conversations with him and the additional feedback, this does not seem to be the case or at least not the only reason.

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Chapter 8

Conclusion

A case was found at Mosede Fort museum: one of the exhibits in the form of a large physical map needed improvements. It was therefore desired to create a solution that could fulfill the wishes of the museum as well as support a more theoretical aspect, in this case learning. Research about museums showed that they today are moving more away from the traditional way of communication and toward a more visitor oriented museum experience. They are also becoming more open towards new technology and the usage of it is seen more and more. Storytelling showed to be a good technique to teach information to the visitors, while at the same time allowing them to learn at their own pace. It can also be used to create a more personal experience. The state of the art case for storytelling gave inspiration in the way missions was used to motivate people to learn information and get the next video sequence. It was decided to work with a multimodal system that would include at least one kind of tracking and interaction, animations, and audio. Learning played a large role for the theoretical aspect and focus; through research it was learned that learning is personal, contextualized, and that it takes time. Adaptive and personalized systems were therefore researched, in order to allow the visitors to make and adapt the system for their individual needs and desires. Based on the theory and knowledge gathered, the ideal design was made to solve the obstacles met at Mosede Fort. The full system, however, was not implemented, instead were a smaller part of the system implemented as a proof of concept.

Four evaluations were made: three that focused on the proof of concept and the desire to continue, and one that focused upon the theoretical aspect and learning in the designed system. The participants' desire to continue were evaluated, since it was shown that testing learning is very time consuming and it would preferably be needed to extent the research further than the time period for this thesis. Furthermore was it relevant to evaluate the participants' desire to continue, since they will never experience the full system if they do not have this desire and will therefore not learn the entire amount of information. The two of the evaluations focused on the technical elements of the system and it quickly became clear that the tracking system was not sufficient and it can therefore be concluded that another solution should be found for this. The third evaluation was based on feedback from Mosede Fort, where it was learned that the idea was interesting, but that the amount of time it would take to finish the system was of concern. Time was in the investigation presented to be a factor to be considered, however, during the evaluation, it was found that time perhaps should have played a larger role in the design of the system. The fourth evaluation was purely theoretical and focused on the ideal design in relation to learning. The evaluation indicated that the system is a step in the right direction, however, this is something that should be tested if further investigations and development is made. Two learning theories were compared to the ideal design and implemented proof of concept in the fourth evaluation. It showed that four out of seven characteristics were met, while the remaining three is needed for future improvements or can simply be disregarded.

It can therefore be concluded that the implemented proof of concept need improvements and alterations: the used tracking is not stable and sufficient enough for it to work independently at a museum. Furthermore should the time that it will take the visitor to go through the designed system be reconsidered. This is further addressed in Section 8.1.

8.1 Future Perspectives

Throughout Chapter 5 and 6, it became clear that some elements should be improved or added to the system; these elements will be presented in this section. For the future, it is desired to implement the full system and test the learning outcome on the ideal target group. There will in this section only be focused on three out of the four evaluations, since future perspectives of the theoretical evaluation have already been discussed in Section 6.5.

A point system for drawing the route (similar to connect-the-dots) was implemented. In the future should the points be added, such that the points' location fit with the actual roads on the map. It should also be considered to make the failing of creating a route (a path) more advanced, as it was suggested by the contact person at Mosede Fort (see Section 6.4). The idea would be for the visitor to plan the route more practically and gather as many soldiers in time.

The other evaluations showed that a new tracking technique should be found or the very least should the current tracking be made more stable, since the Kinect did not manage to deliver a stable tracking and a fast enough detection. Other solutions should instead be found and evaluated in the future. Another point to be further investigated is whether or not the system is too time consuming for the visitors to finish at the museum (see Section 6.4). A solution for this could be - as the contact person in Evaluation 3 suggested - to end the system if the visitor does not complete a challenge satisfactory. A final remark based on the evaluations is that more visual feedback, such as animations and photographs, should be included in the implemented part of the system - and possibly for the other designed challenges as well.

8.1.1 Generalization of the System to Other Museums

Currently is the system designed to fit the museum Mosede Fort - and more specifically one of their exhibits (presented in Chapter 2). There is, however, no reason why a similar system should not be possible to implement at other museums. The only requirement is that the museum should have a blank surface, such as a table or even a wall that allows for multiple visitors to gather around it. The given story could be changed to fit with another area and time period and the challenges can be altered to fit the new story. This might require some work, depending on how much would need to be altered in the story, the shown map and in the challenges. The setting system (allowing the visitors to choose their own experience) and the options available for school classes can simply be reused.

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Appendix A

Challenges for the system

This section gives an in-depth description of the challenges, which have been designed for the system (map at Mosede Fort). These challenges are suggestions of what could be implemented in the future at the fort. The challenges are presented in the order in which they should be encountered by the user. Each of the presented challenges has a focus upon the desired learning goals; what is desired to teach the users, what the challenge is and how it can be altered to fit the various target groups (adults, school classes/children and groups). Furthermore is it reasoned which modalities are in use for each challenge.

A.1 Challenge 1: Soldiers

It should be noted that this challenge is heavily inspired by the recent Ipad-application that the museum have acquired, called 'Krigens Valg' (The Choices of War), and that the authors of this thesis tested before it was released at the museum.

This challenge concerns that the fort did not have enough room for all of the needed soldiers to be stationed at the fort itself, as it was learned from the visits to Mosede Fort. Instead, they had to have some of the soldiers staying at the nearby farms. The designed challenge can be seen in Figure A.1.

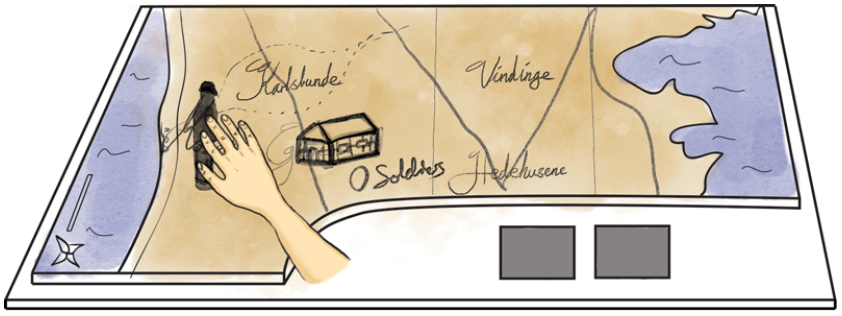

Figure A.1: The designed Challenge 1: Soldiers

A.1.1 Learning goals

It is desired that the visitors learn that there was not enough room for all of the soldiers at the fort, so they had to stay at the farms. The farms was not allowed to reject the soldiers, even though they had to feed more people. The farms did, however, get compensation for their troubles, but often this was not enough to cover all expenses [5, pp. 202-204]. It was therefore important

to make sure that each farm did not have more soldiers stationed than the farmers could handle financially.

A.1.2 The challenge

The challenge should be given primarily through a voice over, saying: "There are not enough room for the soldiers at the fort, despite that it was built in order to keep the Germans from attacking the area. It is therefore needed to have them stationed on the nearby farms. Your task is to assign the amount of soldiers that should stay at the farms instead of at the fort itself. But choose wisely; if you do not keep enough soldiers at the fort, you can risk that a potential attack from the Germans would succeed - and not only that - you would also anger the farmers, who will have too many mouths to feed. If you on the other hand have too many soldiers at the fort there will not be enough room and resources for all of them and you can risk illnesses spreading in the close quarters, not to mention soldiers deserting from their posts."

"In order to choose, drag the amount of soldiers that you would like to be situated at the farms by using your fingers. Drag the soldiers from the fort to the shown farm house(s) on the map. When you are content with your choices, click on the Continue-button."

A.1.3 Possible Feedback

The possible feedback are likewise primarily given through a voice over. It solemnly concerns whether or not the user(s) have dragged too many, too few or a correct amount of soldiers to the farms.

1. "There are too many soldiers stationed at the fort itself. Diseases are spreading rapidly, and the soldiers, who are still in good enough health, desert the fort. If the Germans evade the coast, there will not be enough soldiers to stop the invasion"

2. "Great job! The amount of soldiers at the farms are just enough for the farmers to feed them without taking too much toll on their supplies and there are still enough soldiers at the fort itself to be able to encounter the possible threat from the Germans."

3. "There are too many soldiers stationed at the farms. The farmers are not happy about the many mouths to feed and a riot is on its verge of rising against the Danish military. If the Germans evade the coast, there will not be enough soldiers at the fort, and the soldiers stationed at the farms will not be able to come in time in large enough numbers to stop the Germans from invading!"

When the user continues the story is this voice over also given: "In reality were X amount of soldiers present at the fort during the WWI, (whereas the last X amount of soldiers were distributed around on the farms.)"

A.1.4 Different target groups

In order to accommodate the different target groups (individual adults, children/school classes, and groups), it is needed to make a few changes to the challenge.

Easy The margin of error of how many soldiers were stationed at the farms/the fort is larger than that of *Medium/Hard*.

Medium/Hard The margin of error of how many soldiers were stationed at the farms/the fort itself is considerably smaller than that of *Easy*.

Group Each group member (up to 5) is given a farm that they should drag the soldier's to. The group members therefore have to cooperate, in order to get to the desired amount of soldiers stationed at the farms. The group members are distinguished by colour, similar to e.g. a board game.

A.1.5 Aesthetics

No added boxes, visible, physical buttons etc. Only interaction through gestures/where one stands. The interaction should be intuitive. For the user's to keep track of the amount of soldiers at the fort and farms should counter be used.

Modalities, user Audio, vision, tactile (map), movements

Modalities, system Gestures (e.g. Kinect), pressing (e.g. physical buttons, or image-based tracking).

A.2 Challenge 2: Barbed wire

This challenge is about the barbed wire that the military put out, in order to slow down the Germans, in case they should try to invade Denmark. This challenge concerns mainly how it was calculated how much of the wire was needed. The designed challenge can be seen in Figure A.2

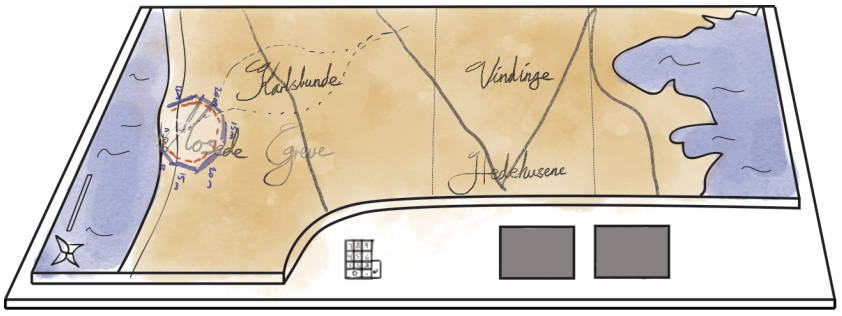

Figure A.2: The designed Challenge 2: Barbed wire

A.2.1 Learning goals

Here the users learn about how the fort was protected by barbed wire and that it was the soldiers' job to maintain and lay it out. The users also practice their math skills

A.2.2 The challenge

he challenge should primarily consist of a voice over: "The fort needs protection. It is therefore needed to install barbed wire, but the soldiers in charge are confused and under stress, so you need to help them. First you need to figure out how much wire is needed. We know the area and have already measured it, but what is it in total?"

"It is possible to see the different lengths on the map. You need to add them together so the men know how much barbed wire to use and collect."

A.2.3 Possible Feedback

1. If the barbed wire fits, the wire it built without complains
2. If some barbed wire is missing the soldiers get in trouble for not completing the task and ends up with the worst duties at the fort and the soldiers get in a bad mood.
3. If there are too much wire left the soldiers simply complain that there is too much and that they now how to bring it back to the fort where the other soldiers might laugh at them for needing to do the extra work.

When the user continues the story there should be a small animation of the barbed wire being built.

A.2.4 Different target groups

In order to accommodate the different target groups (individual adults, children/school classes, and groups), it is needed to make a few changes to it.

Easy Easy numbers (10, 15, 20, etc.)

Medium/Hard Difficult numbers (12, 23, 45.4, etc.)

Group Each in charge of smaller calculations, which in the end needs to add up to fit the total value (first person: 5 + 5 + 7 = 17, second person: 3 + 9 + 8 = 20, third person: 7 + 2 + 13 + 5 = 27, total: 64, ect.)

A.2.5 Aesthetics

Using the map as the main focus with the designed route for the wire as well as the length values of each side. The interface for the user should consist of a small number-keyboard: it needs to be simple (only contain the numbers, a delete option, and enter)

The design should contain the following:

1. The map with outlined barbed wire plans
2. The different lengths' values
3. A small "keyboard" with numbers (might use sensors or object recognition – such that they have to add the object on the number they want to write)

Modalities, user Audio, visual: a small animation projected on the map, interactive element (use an object to indicate which number you want to select)

Modalities, system Object recognition (tracking).

A.3 Challenge 3: Warning

This challenge is about warning the fort when the German soldiers are (hypothetically) being spotted outside Køge Bugt. The designed challenge can be seen in Figure 4.4 in Section 4.4.1.

A.3.1 Learning goals

The users are asked to help out signal the Fort, thus teaching them the importance of keeping watch and the fact that a clear and fast communication can make a huge difference (saving lives). They are also taught about morse code.

A.3.2 The challenge

The challenge should be given in a voice over: “The soldier in watch has spottet a German ship! He now needs to warn the fort. He finds his equipment for signaling and is about to signal the fort using morse code, but realizes that he cannot remember the code for it. He knows the sentence he has to communicate, but not the actual code. Help Thomsen to translate the message into morse code before it is too late. To do this, use the presented chart and press the button for the code, before the time runs out.”

A.3.3 Possible feedback

1. If the user manages to solve the code: the light from the projector will blink fitting the light pattern as an indication that the fort received the warning.

2. If the time runs out or the user did not manage to make the code correctly, the user will be told that the fort was taken – “so try again” (or the user can skip it, if he so desires)

A.3.4 Different target groups

In order to accommodate the different target groups (individual adults, children/school classes, and groups), it is needed to make a few changes to it. The soldier’s sentence to send to the fort changes as the following:

Easy SOS – Germans

Medium/Hard SOS – The Germans are here. The time available for the participant to send the code in is less in *Hard* than it is in *Easy* and *Medium*.

Group SOS – Germans (multiple people needs to send the signal at the same time)

A.3.5 Aesthetics

A small table of the different letters in morse code should be presented. The table should be, easy to read, and should be projected on the map itself.

The design should contain the following:

1. The message that should be sent to the fort.

2. A morse code conversion table.

3. Buttons (up to five buttons, which should be displayed around the area of the left side of the map).

Modalities, user Audio, visual feedback (blinking light), buttons.

Modalities, system Sensors (e.g. physical buttons).

A.4 Challenge 4: Contacting the soldiers

This challenge concerns how the soldiers stationed at the farms should be contacted by the fort, since the phone lines are down. The designed challenge can be seen in Figure A.3.

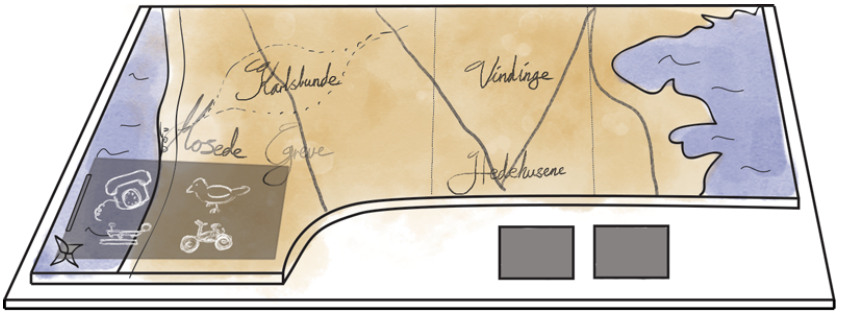

Figure A.3: The designed Challenge 4: Contacting the soldiers

A.4.1 Learning goals

The user should learn: 1) That the phone lines are down. 2) That they still need to contact the soldiers stationed at the farms somehow. 3) That they would have contacted them by messengers on motorcycles

A.4.2 The challenge

The challenge should be given by a voice over saying: "We need to contact the soldiers stationed at the farms. How can we contact them? Choose one of the shown methods by pressing on the icon: phones, carrier pigeons, morse code, or messengers."

A.4.3 Possible Feedback

When the user chooses:

1. Phones: "The Germans have cut the phone lines, so it is not possible to call anyone."

2. Carrier pigeons: "The pigeons might be spotted by the Germans and shot down, or shot by hunters, in either case will the message not get to the soldiers, and the message might be found by the Germans who will then know about our plans."

3. Morse code: "The Germans could be listening on the line, even when using a code, it might be possible for the Germans to crack it. We cannot risk it."

4. Messengers: "Messengers can come around somewhat unseen by the Germans and still reach the farms in time for the soldiers stationed there to get to their posts."

When the user continues the story is this voice over also given: "It was planned by the Danish military to use messengers to contact the soldiers stationed at the farms. It was calculated that it would take around X hours for the messengers to come around to the farms and for the soldiers to get to their designated posts."

A.4.4 Different target groups

Since this challenge is already somewhat simple, there is no distinction made between the different target groups.

A.4.5 Aesthetics

No visible buttons; using projections instead.

Modalities, user Tactile, touch. Audio (voice over), and vision (the projected 'buttons')

Modalities, system Tracking of fingers or hidden buttons in the map.

A.5 Challenge 5: Route

This challenge is about the route that the messengers assembling the soldiers stationed at the farms should take. The challenge is to make the quickest route possible for the messenger to take to a given farm. There are two solutions for this, since not all of the farms can currently be seen on the physical map: 1) to make a 'pseudo'-map inside the map (as a sort of projected screen), or 2) to make it on the full map, and then not have the factual correct placements of the farms presented, since the most important learning outcome from the challenge is not the geography of the farms' placement, but instead that messengers had to drive out to contact the soldiers. The designed challenge can be seen in Figure 4.11 in Section 4.8.1.

A.5.1 Learning goals

The users should learn: 1) That it would be needed to contact the soldiers stationed on the farms, but it would not be possible to simply call them because the phone lines were down. They therefore had to have messengers bike there. 2) That the route that the messengers were to take could influence the German invasion. If the route was too long and tedious, the soldiers might not have made it to their posts in time.

A.5.2 The challenge

The challenge consist of a voice over saying:

Voice Over 1: "We now know that in order to collect the soldiers on the surrounding farms, a motorcycle messenger should be dispatched. Thomsen has been selected as a meseenger, but on his way to the farms, he drops the map with the route and There is not enough time to drive back to get a new map. At the same time, he is not that familiar with the area - which is why he now needs your help.

Voice Over 2: "To help Thomsen, draw the route you think is best with your hand, so he can reach the farms and alarm the soldiers. Be careful: if the route takes too long, the soldiers will not be able to reach the fort before it is too late and if it is too short it can also go wrong - remember to stick to the roads."

Voice Over 2.1: "In order to draw the route for Thomsen, your hand needs to first be registered by the system. In order to register your hand, you need to wave with it until you hear this sound [sound], which indicate that you hand is registered. In order to draw, keep your hand close to the map and hold it over the small points that you think Thomsen should drive through".

A.5.3 Possible Feedback

The feedback consist of an animation and a voice over saying: Voice Over 3: "Good job. Thomsen managed to reach the farms in time and the soldiers, the fort. It is all going according to the plan."

Voice Over 4: “Ohh no, Thomsen did not reach the farms in time and the soldiers could therefore not help the other soldiers with protecting the fort and the surrounding area. Germans have succeeded talking over a larger areas and the defenses of the fort is weakened. Try again.”

Voice Over 4.1: “Ohh no, Thomsen did not make it, he thought he would take a shortcut, but realized that there was no road. He therefore had to go through a field area. The soldiers could because of this not reach the fort in time to help out the other soldiers. Germans have succeeded talking over a larger areas and the defenses of the fort is weakened”.

Voice Over 5: “That is the spirit, let’s try again.”

Voice Over 6: “Your route is not done. Please finish the route by drawing it all the way to the illustrated farm.”

Voice Over 7: “You are now done with the experience. In the full system you would have continued with the story about how it was predicted that the Germans would try to invade Denmark. Thank you for testing”.

When the user has drawn a route should an animation showing the messenger taking the route that the user have drawn on the map.

A.5.4 Different target groups

In order to accommodate the different target groups (individual adults, children/school classes, and groups), it is needed to make a few changes to it. In order to do so are there three different possibilities:

Easy The margin of error of the length of the route is larger than that of *Medium/Hard*.

Medium/Hard The margin of error of the length of the route is smaller than that of *Easy*.

Group Each group member (up to five) is given a farm and a messenger that he will have to find the most suitable route for. Each group member is distinguished by a chosen colour, similar to e.g. a board game.

A.5.5 Aesthetics

There should be no added buttons, only projections should be used. The line that symbolises the route should be easily distinguishable from the road-lines.

Modalities, user Gestures (movement), tactile, visual, audio

Modalities, system Tracking of the user’s fingers.

A.6 Challenge 6: Protection of Karlslunde

This challenge is the last challenge that the users are given. The challenge is different from the other presented challenges, as it is more similar to a pop-quiz, and the various questions are therefore not all represented here. The designed challenge can be seen in Figure A.4.

A.6.1 Learning goals

The learning goal of this challenge is to test the user’s knowledge about the topics already encountered in the story and in the other challenges.

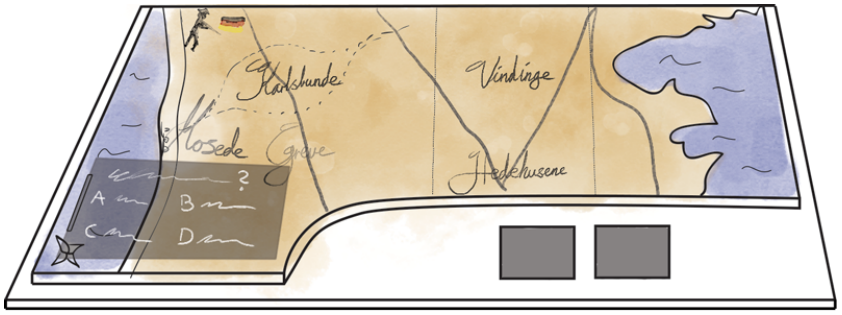

Figure A.4: The designed Challenge 6: Protection of Karlslunde

A.6.2 The challenge

The challenge is a sort of pop-quiz used to test the user's knowledge of the possible attack. The challenge begin with a short introduction to it, explaining the following: The pop-quiz begins as soon as a German soldier is seen moving closer to Karlslunde. The question is thereafter being presented with the user to choose between four given answers. The user need to answer the question before the German soldier reaches Karlslunde. If the user take the wrong answer, is the German immediately coming X amount of steps closer to the city. If the German soldier reaches Karlslunde, the city falls and the Germans will succeed in invading Denmark. The user can then choose to start the challenge again or to skip it. The museum professionals should in the ideal implementation also be able to add their own questions and answers to this pop-quiz, in order to make the experience more dynamic.

A.6.3 Possible Feedback

The possible feedback is already described in *The challenge*.

A.6.4 Different target groups

In order to accommodate the different target groups (individual adults, children/school classes, and groups), it is needed to make a few changes to it.

Easy The questions should be easier than those for the *Medium/Hard*. The questions should be a mix of questions regarding the facts and a few questions addressing their understanding of the hypothetical attack from the Germans. The time it takes for the Germans to reach Karlslunde should also be longer.

Medium/Hard The questions are a bit trickier than those for *Easy*. The questions should be a mix of questions regarding the facts and of the user's understanding of the hypothetical attack. The time it takes for the Germans to reach Karlslunde should be somewhat quicker.

Group There are three possibilities for a group setting: 1) That each group member is asked a question in turn, 2) that each group member has to answer the given questions, such that it is not only a pop-quiz, but also a competition; the group member who answers the question correctly first, wins a point. In the end will the group member with most points be the winner of the challenge, or 3) that the group members should collaborate to answer each question, so they only have one person i charge, who answers each question, but the questions are open for discussion before they answer it.

The amount of questions depends on how long time, the visitor wanted the experience to last, see Section 4.7.

A.6.5 Aesthetics

The questions and answers should be projected down on the map, so that there is not used any more screens. In order to answer a question is e.g. buttons or a press on the projected possible answers used. The Germans should also be projected down on the map itself and be moving towards Karlslunde while the user(s) finds an answer to the question.

Modalities, user tactile, visual, audio.

Modalities, system physical buttons or tracking of fingers

Appendix B

The Story

See Table B, in order to see the full story for the system (map) at Mosede Fort.

Table B.1: The table shows the full story, including challenges, the desired graphics and audio to be used. It also includes which visitors should see which parts of the story.

Begin of Table					
Timestamp	**Voice Over / Acting**	**Graphics**	**Audio**	**Challenge**	**Who should see it?** Time (short/medium/long) / Type of user etc.
Intro	It is assumed that Germany intend to seize Zealand. As the conditions are now, is Køge one of the points where an attack would be most advantageous, since the landing at Køge also gives chances to overtake the Tune trench line. [Pause] You now have the opportunity to help Mosede Fort avoid this of happening. You will within the experience be asked to help. You take on the role as the soldier Thomsen, who have to figure out what it takes to avoid a possible attack from the Germans in succeeding. Let us begin.	The old-fashioned drawn map appears during the voice over.			Everyone
Settings	Before you can start the story, you can choose to change the setting that is now appearing in front of you, in order to make you experience more personal. In order to change the settings, you simply press directly on the map with your fingers.	A screen with settings appear in the projected area.			When 'Regular Visitor' is chosen by the museum staff.

Continuation of Table B					
Timestamp	**Voice Over / Acting**	**Graphics**	**Audio**	**Challenge**	**Who should see it?** Time (short/medium/long) / Type of user etc.
Intro 2	To the Commander. Gradually as Mosede Coastal artillery section is getting closer to its completion, is the plausibility of the enemy landing here getting smaller, while the plausibility of this happening at the nearest coastal stretch South of Mosede coastal artillery section's impact area instead is getting larger. This observation have made me make an investigation of how the conditions could be assumed to be for an army corps, which go ashore at Køge with the intention to overtake the Tune trench line. [Pause] Even though the patrol boat discovers the German transport fleet outside of Køge Sønakke and gives the signal for danger, will the landing in the harbour of Køge not be possible to avoid.	The map is made darker/brighter or similar, in order to indicate that the experience is starting. E.g. highlighting the areas on the map, which the voice over talk about (Mosede coastal artillery section, the Tune trench line)			Everyone
Intro 3	There are not enough room for the soldiers at the Tune trench line, despite that it was built in order to keep the Germans from attacking the area. It is therefore needed to have them stationed on the nearby farms.			Challenge 1: Soldiers	Everyone
Intro 4	The Fort needs protection. It is therefore needed to install barbed wire, but the soldiers in charge are confused and under stress			Challenge 2: Barbed Wire	Everyone

Continuation of Table B					
Timestamp	**Voice Over / Acting**	**Graphics**	**Audio**	**Challenge**	**Who should see it?** Time (short/medium/long) / Type of user etc.
0h -30m	Before the Germans is believed to invade the bay of Køge, they will send fighter squadrons, of five machines each, with the stretch Køge-Copenhagen as a target. They pass Køge at 1h.	A sort of screen in the projected area appears, where one can shortly see an animation/video of the German fighters.	Airplanes (fighters) in the air / plane motors		Long
0h 0m	[Acting, Danish (yelling):] The Germans are coming! [Voice over:] Thomsen has spottet a German ship! He now needs to warn the Fort, and finds his equipment for signaling and is about to signal the Fort using morse code, but realizes that he cannot remember the code for it. He knows the sentence he has to communicate, but not the actual code.	A sort of screen in the projected area appears, where one can see a short animation of one of the Danish soldiers, who sees the German ships.	Footsteps (running), heavy breathing from running. Someone who fumbles with the equipments (morse code/phones)	Challenge 3: Warning	Everyone
0h 0m	The avantgarde launches their boats. This means that the German battle fleet's assignment is now double: partly to secure the transportation fleet and itself from attacks from the Danish torpedoboats and submarines, partly to shoot the facilities in Mosede coastal artillery section and the Karlslunde section.		Sea, boats/battle ships/submarines		Medium, and Long
0h 0m	The Germans sends two more fighter squadrons having the stretch Køge-Copenhagen as their target.	A sort of screen appears in the projected area, where one can see a short video/animation of the German fighters.	Airplanes in the air / fighter engines		Long (e.g. none)

Continuation of Table B					
Timestamp	**Voice Over / Acting**	**Graphics**	**Audio**	**Challenge**	**Who should see it?** Time (short/medium/long) / Type of user etc.
0h 50m	[Acting, German:] PEOPLE! Listen up! The Danish forces in Køge have been overrun, which means that the landing of Groset probably will be able to take place unobstructed! [Pause] [Yell/command:] B's - march here and start the landing				Long, maybe. Medium
0h 35m	The Germans moves forward and occupy the theaterbuilding, the railroad station, telegraphstation and the telephonestation in Køge.	Shows e.g. a close-up animation/pictures of the buildings/the Germans movements	Footsteps, soldiers, e.g. fighting		Long
1h 00m	The Germans send a reconnaissance squadron on five machines with the stretch Køge - Borup - Svogerslev - Roskilde - Glostrup as a target	E.g. close-up animation shown on the projected area, showing the squadron, similar to the fighters.	Airplanes		Medium/Long or maybe none
1h 20m	The Danes closes the barbed wire fences. [THomsen, Danish:] AUCH! Dammit! [Actor, Danish:] Scchhhh…!	You can see the barbed wire fences on the map get on place and being closed.	Squeaking of the fences or similar		Everyone

Continuation of Table B					
Timestamp	**Voice Over / Acting**	**Graphics**	**Audio**	**Challenge**	**Who should see it?** Time (short/medium/long) / Type of user etc.
1h 20m	The Germans tries to destroy the barbed wire shutters.	You see either on the large map or on a 'screen' in the projected area that the Germans tries to destroy the barbed wire shutters.			Medium/Long
1h 30m	[On the phone or similar, acting, Dane to commandor:] The submarines and the fighters have arrived.	You see two German armored cars, which reaches the barbed wire barring at Karlslunde and that they fire against the coastal artillery section's batteries and Karlslunde city from their fleet (on the large map)	Airplanes, submarines, armed cars, battle ships, opening of fire		E.g. only Medium/-Long
1h 0m - 1h 30m	10 of the German fighters passes Køge on their way to Copenhagen	E.g. a screen in the projected area, where a video/animation of German fighters are shown	Fighters		Long. Maybe none
1h 55m	Danish squads arrives to Bulveled Bakke, Højelse and Lellingegaard [not a part of the physical map]	E.g. animation/images from the places is shown on the projected area.	Soldiers, footsteps		Long. Maybe none

Continuation of Table B					
Timestamp	**Voice Over / Acting**	**Graphics**	**Audio**	**Challenge**	**Who should see it?** Time (short/medium/long) / Type of user etc.
2h 0m	[Acting, Danish:] The batteries are ready!	You can see Karlslunde lighten up on the map, and e.g. some close-up of the batteries being ready (shown on the map/projected area at the city)	Mechanical sounds		Everyone
2th 10m	[Acting, German:] Now we're here, boys.	You can e.g. see a closeup animation/images on the projected area of the Germans arriving at Ølby with 1 battery.	Soldiers, footsteps, mechanical sounds, squeeking wheels.		Everyone
2h 15m	The Danish squads is assembling at Karlslunde, Tune and Roskilde Hvile.	You can see the Danish squads assemble at Karlslune, Tune and Roskilde Hvile on the map	Soldiers, footsteps		Everyone
2h 30m	Karlslunde section is being occupied	You can e.g. see the occupation of the Karlslunde section in close up as an animation on the projected area	Soldiers, noise, yelling.		Everyone

Continuation of Table B					
Timestamp	**Voice Over / Acting**	**Graphics**	**Audio**	**Challenge**	**Who should see it?** Time (short/medium/long) / Type of user etc.
2h 30m	The 10 German reconnaissance machines passes South from above Køge.	In closeup on the projected area one can see the 10 German reconnaissance machines passes South from above Køge in video/animation	Airplanes		Long
2h 35m	The Danish squads are assembling at Tune	You can see the Danish squads are assembling at Tune on the map.	Soldiers, footsteps		Long. Maybe none
2h 40m	[Acting, Danish:] Now we're at ørsted, Boys		Soldiers		Long. Maybe none
3h 20m	Germans get the railroads at Urup, Hvalso, Merløse, Svenstrup, Haslev, Karise, Haarlev, Gadstrup and Kirke Syv disconnected. They destroy the telephonecentrals. They also cut the telephone- and telegraphcords. [For the challenge:] We need to contact the soldiers stationed at the farms.	You can see either in a closeup animation of the Germans or that it light up on the places on the map where the railroads and cords are situated.	Soldiers, railroads (trains), that something is cut/destroyed.	Challenge 4: Contacting the soldiers	Everyone
	The phone lines are down, yet it is still needed to contact the soldiers stationed at the farms.			Challenge 5: Route	Everyone
5h 0m	The Danes are assembling their troops towards ørsted.				Medium/Long

Continuation of Table B					
Timestamp	**Voice Over / Acting**	**Graphics**	**Audio**	**Challenge**	**Who should see it?** Time (short/medium/long) / Type of user etc.
5h 0m	The Germans arrive at Køge with 20 battalions.	You can see a closeup animation of Køge/the Germans with 20 battalions on the projected area.	Soldiers.		Everyone
5h 0m	The Germans reaches the regiment's front skirmish in height with Karlstrup.	You can e.g. see the Germans reach the regiment's front skirmish in a close-up animation on the projected area.			Everyone
5h 40m	The Danes are assembling at ørsted	E.g. a close-up animation on the projected area of the Danes assembling at ørsted.			Long. Maybe none
Closure	The Germans are trying to occupy Karlslunde, and it is needed to protect it.			Challenge: Protection of Karlslunde	Everyone
Closure 2		Shows a score of how well one performed in the various challenges			Only for the ones, who have chosen to get the challenges.
End of Table					

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Appendix C

Intro for Evaluation 2

1. Show image of the original map at Mosede Fort and explain the concept.
2. Explain that we want evaluations from them, first what they think of the idea and then secondly a more technical evaluation.
3. An introduction to the story and more importantly what they in the full system would have learned so far, before reaching the challenge they are going to test.
4. They will be informed that there is a 'skip'- and a 'try again'-button, as learned was necessary in the pilot test 6.3.1.
5. If the participant have troubles getting the hand detected: demonstrate how he should wave.
6. If asked; let the participants know that they do not need to go through all points on the map to get to the farm.

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