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University of
Applied Sciences

Digital creation of a cultural heritage

VR experience of Fjell Fortress 1945

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I confirm that the work is self-prepared and that references/source references to all sources used in the work are provided, cf. Regulation relating to academic studies and examinations at the Western Norway University of Applied Sciences (HVL), § 10.

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<p><i>Sammendrag:</i></p> <p>This report will explain our approach to creating the environment and landscape at Fjell Fortress 1945 as a VR-explorable game. The main goal was to recreate this historical area as realistic as possible in said time period. The secondary goal was to implement a storyline that would unfold there. The final version of this project will be further developed by Medielab at HVL.</p> <p>Finally, the report will discuss, evaluate and conclude based on the results.</p> <p>We would recommend quickly watching through this video to have a better understanding when reading the report.</p> <p>Link to video: https://youtu.be/WO-xO4UrAos</p>

Stikkord:

Digital recreation VR Gamification	Unity C#	Blender 3D models
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PREFACE

This thesis is written as part of the bachelor's in computing and information technology at Western Norway University of Applied Sciences (hereby referred to as 'HVL'). The project is a continuation of several previous bachelor theses. The project is a collaboration between Medielab at HVL and the museum of Fjell Fortress in Norway.

The purpose is to create and display Fjell Fortress in Virtual Reality so the users can experience the museum in a new and different light. The target audience is children in middle school, but we aim to make it an interesting experience for all ages. We were inspired to learn more about computer graphics and game design after taking a course in a previous semester.

We sincerely want to express our gratitude to our supervisor Harald Solheim for his guidance and valuable feedback. We would also like to thank the project owner Øyvind Fosse who has given us great ideas and information in this process.



Figure 1: Shows a part of the finished result in Unity seen from above the entrance of Fjell Fortress.

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1 INTRODUCTION

Since the digital age began in the 1970s, and later bloomed with computers, video games and social media, people have been quick at adapting to technological changes, especially the younger generations. Newspapers are read on a screen and radio shows are downloaded. And we can only wonder what the future might look like.

In the midst of the technological rush we live in, there is a museum, Fjell Fortress, which is working on a project in order to keep up with time. For those who are more interested in Fortnite than learning about World War II, there might be a pleasant surprise for them at the museum in the near future.

By utilising technology, we hope to develop a new way of telling a story, that might reach another audience and that really gets their attention in a way “normal” storytelling cannot do.

This chapter describes the goals and motivation of the project. It also tells about the context of the project and limitations. In the end the resources available are discussed and how the report is organized.

1.1 Motivation and goal

This section will try to provide a clear, concise statement of the project’s overall goal and its “subgoals”. It will also explain the motivation for choosing this project as well as what the main purpose and intended result are.

1.1.1 Medielab and Museum Vest overall goal

Medielab at HVL together with Museum Vest have since 2018 been working on a project to preserve and tell a piece of our cultural heritage. The two parties are trying to develop a digital copy of Fjell Fortress year 1945, and to provide the audience with an experience in VR. Utilising this technology they want to convey how life could have been at that time and to teach the user about the history surrounding the fortress. The bachelor groups [1] that have put in many hours of work with the support of Medielab [4] and Museum Vest [2] have provided us with a great foundation. We are therefore thankful to be part of some of the last parts of the project, where terrain, trees, light and characters all come together.

1.1.2 Our main goal

Our main goal is to create the landscape at Fjell Fortress and to make it as realistic as possible. The world created is going to be experienced in virtual reality. By utilizing this technology, we hope to make the users feel like they are transported back in time.

This bachelor group has its own goals which will contribute to finish the overall project goal mentioned in chapter 1.1.1. As this is a technical project, our main resources will be used on the technical development. However, there is another side to this project, which could be equally challenging, the history. The end product for the whole project is to be used by visitors at the Fjell Fortress museum. It is therefore important to create a product that is as historically correct as possible, to preserve the museum’s credibility. A lot has changed since

1945, especially the vegetation. Today there is grass, bushes and trees everywhere, a typical Norwegian coastline nature. Based on photos from that time (see figure 2 and 3), Fjell Fortress looked more like a construction site, with less vegetation and more rock. We are provided with books about Fjell Fortress and help from enthusiastic workers at the museum and our project leader Øyvind Fosse, to assist us to create a digital copy that resemble the fortress in 1945 as good as possible.



Figure 2: Road leading up to Fjell Fortress. Foto: Bundesarchiv.



Figure 3: Russian prisoners of war building constructions at Fjell Fortress. Foto: Bundesarchiv.

1.1.3 Secondary goal

When the landscape is finished and everything runs smoothly, we will work on the secondary goal of this project, which is gamification. The end product that the user will experience at the museum is a game. The game takes the user back in time to the end of World War II, where he/she is a reporter writing a case about the fortress. The game has a narrative, characters and dialogues which have been created by Medielab and the museum, ready to be used in the landscape we have created. Although the story is fiction, the goal is to give the user an impression of the circumstances surrounding Fjell Fortress.

1.1.4 Motivation

Our interest and motivation behind this project can be separated into two different categories. The first and most prevalent of these is the effect and possibilities the project can create. The second category revolves around our own self interest in both history and the graphical aspect around this project.

This project is creating new possibilities for presenting and preserving historical sites in a digital world. Our project is to specifically create Fjell Fortress year 1945 in a VR-environment where a user can walk around and interact with various people in this world. This is a relatively new way of exploring and experiencing different areas and buildings, therefore this concept can be transferred to multiple other scenarios such as churches, cities and much more. Using this type of technology for areas like this will make it more accessible for people that usually do not have the opportunity to visit the area themselves.

During our research phase we came across some partially similar projects. Most of these are in a much smaller scale and less precise. There are many available VR-solutions [18] that presents single scenarios or paintings like the Mona Lisa [17] at the Louvre in Paris. Other interesting projects with similarities to our own is the reconstruction of Oslo Harbor 1798 [19] and Bergen anno 1350 [20], but these are not based on realistic data such as heightmaps or scans, and do not support VR.

One of the most interesting projects we came across during our research was Assassins Creed: Odyssey. For those not familiar with the game series, the games unfold themselves in a partial reconstruction of entire cities and/or countrysides from a certain time period. By partial reconstruction we mean that they have recreated the areas to the best degree possible, but there are many unknowns that have been "filled in" to recreate the entirety of the different cities [27]. This applies to most of the games, but we have chosen to accentuate Assassins Creed: Odyssey because they have implemented an educational mode where you can explore a guided tour of the areas reconstructed, in this case ancient Greece.

Our own self interest stems from an interest in how to create worlds in technologies such as Unity and also the history hidden at places like Fjell Fortress. Creating a game around this landscape will hopefully make the experience more interesting as it opens up new ways of presenting information.

1.2 Context

As previously mentioned in section 1.1.1 our project is based on a previous bachelor project.

The previous students have already laid the foundation for our project with models of the terrain as well as some models of artillery and buildings.

1.3 Limitations

This chapter will explain some of the main limitations of the finished product in regards of recreating the world perfectly.

1.3.1 Digital recreation

We are using relatively good performance equipment developing the project. Even so, we will not be able to recreate an exact digital copy of the real world. To be able to simulate every particle in a given space and how they interact with each other demands a tremendous amount of computing power, which we do not possess at the time. There are smart graphical solutions however, which is able to create a realistic looking world without the need of a computer the size of a city. Many of these techniques are handled automatically by the game engine we are using. Some techniques will be explained later in the report.

1.3.2 Equipment

The finished product to be experienced by visitors at the museum must be able to run on the museums equipment. We are using the HTC Vive VR headset which is connected to a relatively good performance computer. The computer handles all the processing. To be sure that the museum can run the game smoothly, it needs equipment equally or better than what we are using.

1.3.3 Neglected areas

A large part of the underground military base has not been modeled, and will therefore not be a part of the finished game. Some important parts however, such as the triple-cannon and many of the bunkers, are modeled and available. In the end, it is a matter of time to see how many of the 3D models we can add to our scene, and which of these we decide to prioritize.

1.3.4 History

Another limitation that demands our attention is the lack of historical information. A lot has happened during 75 years. Buildings, trenches and other infrastructure have altered, and the forest has grown. As mentioned, it is important to be as accurate as possible to make it historically correct. Specific problems we are encountering are for example: The location of different buildings and what purpose they had? How much vegetation were alongside the roads? The appearance of the bridge used to transport materials to the cannon? All these and many more questions needs answers to best provide a realistic outcome (See figure 4 for an example). We have to make the best of the historical data we have, and create a world that reflects and respects Fjell Fortress 1945.

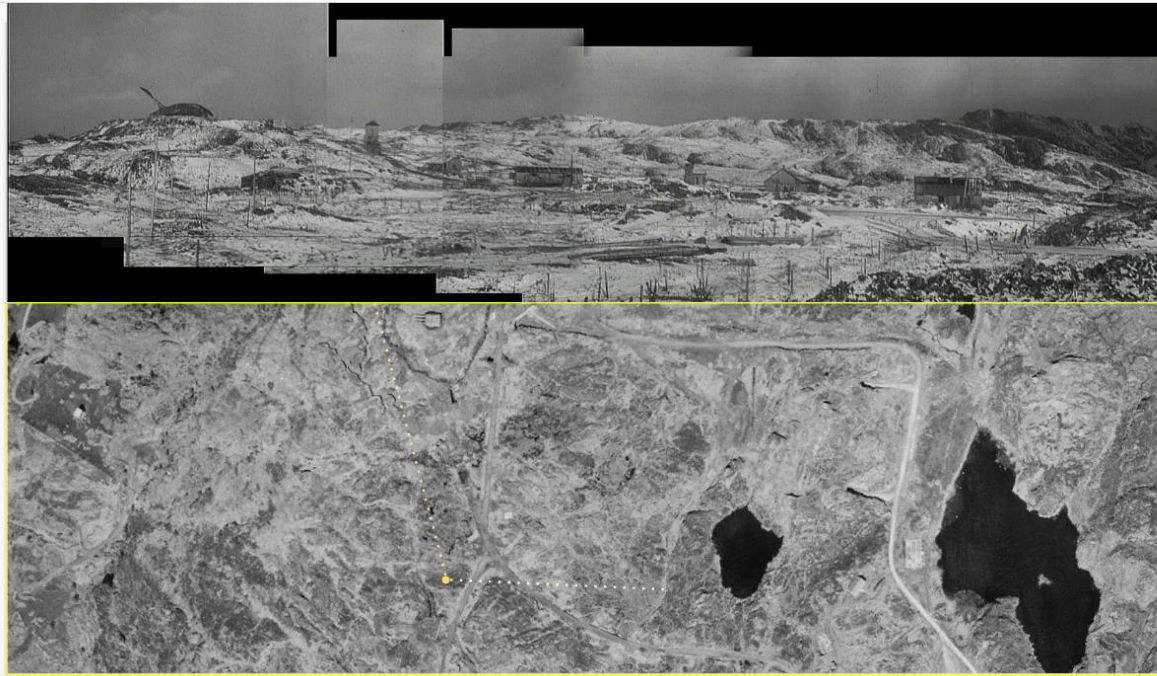


Figure 4: The top picture is a collage of frames from a movie taken in the 1940s that shows buildings seen from the yellow point marked in the picture below. None of the buildings are there today, only remnants of them remain. The movie was acquired from bundesarchiv and the picture was put together by Medielab.

1.3.5 Evaluation

To evaluate our work, it was initially intended that a 9-grade class were to try out the game and give us feedback. Because of Corona we had to rethink our strategy. Instead the game will be evaluated in two different ways, qualitative and quantitative. The qualitative evaluation consisted of our weekly meetings with the project owner Øyvind and museum director Vigleik. The quantitative evaluation was delivered by a larger group consisting of multiple members of Medielab, Museum Vest, and representatives from other departments at HVL. This group answered a questionnaire and partook in a Zoom meeting with further clarifications.

1.4 Resources

Software:

During setup of the program we used Blender to complete our terrain model. Visual Studio and Unity will be used as our main tools, both on an academic licence.

Hardware:

Custom built desktop computer running on Windows 10
Processor - Intel(R) Core(TM) i7-7700K CPU @ 4.20GHz
RAM - 32.0 GB
GPU - NVIDIA GeForce GTX 1080 Ti
HTC Vive VR headset, controllers and sensors.
Two monitors.

Data:

To build our world we are using 3D-models and terrain created by a previous bachelor group [1]. Medielab at HVL will also supply different 3D-models that will be used in the project.

Medielab will supply us with a storyline the player can follow in the game. They have also given us some books with information and pictures of Fjell Fortress so we will be able to accurately reconstruct the area in Unity.

Time:

The final project delivery is set to the second of June, therefore we have 12 weeks from project-kickoff(09/03-2020) until delivery.

Contacts:

Our project supervisor Harald Solheim has created a Microsoft Team called VR consisting of 10 members. The team consist of members that are writing their master thesis at HVL and another group that is also working on a Virtual Reality project for their bachelor thesis. In case we run into some problems regarding VR or HTC Vive we have several people we can contact for help.

Since this project is a collaboration between Medielab and Fjell Fortress we also have two contacts at Fjell Fortress, Sahra Torsvik and Vigeik Røkke Mathisen. They have lent us books and provided us with useful information about Fjell. They have also made themselves available for any questions that we may have.

This project is a continuation of previous bachelor projects. Considering they had the same project leader as us; Øyvind Fosse, he can contribute with a lot of information regarding the previous project but also in terms of the vision for this project.

1.5 Thesis outline

The first chapter gives an overview of the main goal and motivations for the project as well as a short description of the people with the strongest interest and influence in the project.

The second chapter provides more depth in terms of previous work, the project owners and their requirements and ideas. Furthermore, it will outline the project specification as well as explain some technical terms.

The third chapter gives the reader an overview over the possible choices and which is selected. Moreover, the chapter gives an overview regarding the different methods used along with how the risk is managed.

Chapter four presents how the results were achieved as well as focus on the different steps we took along the way.

In the fifth chapter we evaluate the result and the different methods we used. With a critical eye we will review the decision we took and how things could have been done differently.

2 PROJECT DESCRIPTION

This chapter will give a general description of the project. The first section will give a short introduction to the project owners, Medielab and Museum Vest and the history behind this collaboration. Mainly focusing on the previous work of the bachelor group [1], who built the terrain that we will expand on and use as the foundation. The next section will outline the initial project specifications and initial solution. Finally the last section will introduce the reader to some technical terms used, and a brief explanation of them.

2.1 Project background

This section provides background information about the project owners Medielab and Museum Vest followed by a section which describes the previous work done by another bachelor group at HVL [1].

2.1.1 Project owner

Medielab at HVL is, as mentioned above, the project owner. The whole project is built on a collaboration between Medielab and Museum Vest. We therefore include a brief background of both parties.

2.1.1.1 Medielab

Medielab is the university's competence unit responsible for developing and supporting new ways to utilize digital media in research, teaching, education and dissemination [4].

The unit consist of 13 employees with multiple different backgrounds. The members of the the staff are programmers, some are educators with expertise in media production and such, while others have a long and broad media background.

This year they are celebrating their 25th anniversary and making a lot of changes. Medielab before 2020 aka. "The Centre for New Media", have until this year had some income requirements, but by the end of 2020 they will be 100% financed by HVL. Medielab will still have a great deal of externally funded business.

It has been a long-standing collaboration between Museum Vest and Medielab. Over the past 15 years they have collaborated with several of the museums' departments regarding ideas and development of new digital dissemination solutions. Our project is a continuation of one of these collaborations which started in 2018.

During these years of collaboration, both HVL and Museum Vest have acquired a great deal of experience that they have shared with the museum community in Norway. There has also been interest from abroad and together they have attended networking meetings as well as given lectures on their experiences and results.

It is important to point out that the collaboration has gradually become important for HVL as the collaboration in recent years has generated student involvement in the form of a bachelor and/or master's projects.

2.1.1.2 Museum West and Fjell Fortress

Fjell Fortress is part of the foundation Museum West, which was established after a national museum reform in 2005. The reform merged several former independent museums along the west coast into the foundation. The objective was to strengthen the museums by linking them together. Each Museum still maintained the operational responsibility and budget for their respective museum, while functions such as accounting and marketing were organized as joint services.

Within Museum West, the various museums each have their own special fields. They can be divided into the following three categories:

- Fisheries and aquaculture, fish processing and fish trade.
- Coastal culture with a special focus on an energy perspective.
- War and occupation, defence and human rights [2].

Fjell Fortress is a preserved German fortress from World War II. It was built between 1942-1945 as part of the Atlantic Wall [3]. It belongs to the latter category and they want to present the history of the fortress to the public. Many ruins today, are outdoors, so resetting them to their original state gives a gain in dissemination ability.

2.1.2 Previous work

This project is a continuation of a previous bachelor projects [1], as mentioned in section 1.1.1 above. There were two groups from surveying and one group from computing who collaborated on mapping Fjell Fortress. The survey bachelor teams used two different methods to map the area around Fjell Fortress. To map the outside terrain and structures around the fortress they used photogrammetry by taking detailed photographs from a drone. While laser scanning was used to map the interior of the fortress. Afterwards they sent all the datasets from the survey to the data group. Either in the form of point clouds and / or meshes.

Subsequently the data bachelor group processed the data and created meshes from the point clouds. In addition, they also used some publicly available terrain data from Kartverket [6].

2.2 Project specification

In this section we will briefly describe Medielab at HVL and Museum Vest's vision regarding new methods of conveying history and user experiences. Furthermore we will present the initial requirements for the project and the initial idea pitched as a solution based on these requirements.

2.2.1 Initial requirements specification

To use Unity to texture and populate the terrain with 3D models (trees, buildings, grass etc).

To support VR in the created scene in Unity.

To implement a storyline the end user can follow and complete within the created world where we can represent the different areas of interest.

To deliver a functional VR-experience of Fjell Fortress that accurately represents the terrain and buildings present at the end of WW2. The end user should also be able to follow a storyline created within this world.

2.2.2 Initial solution idea

Using the data provided by Medielab from the previous project [1] we will create a realistic reconstruction of Fjell Fortress during the end of World War II. The terrain model in the previous project is very large (3.2GB), therefore we will explore the possibility to extract the terrain from Unity and simplify the model. It is possible to use different scripts to export/import a terrain in Unity (TerrainObjExporter.cs [8] and Object2Terrain.cs [7]) which uses .obj files as input/output.

We know that in the final version the player will be somewhat contained within certain areas of the terrain (roads and buildings), this allows us to modify the amount of vertices in a specific area to the necessary accuracy needed. In figure 5 we see the two parts of the terrain used in the previous project, they overlap each other and form the full terrain. This results in a large area of the terrain having twice the amount of data needed to create the actual terrain, while also making the two terrains clip into each other creating some distinct lines and differences where they do not perfectly match, see figure 6.

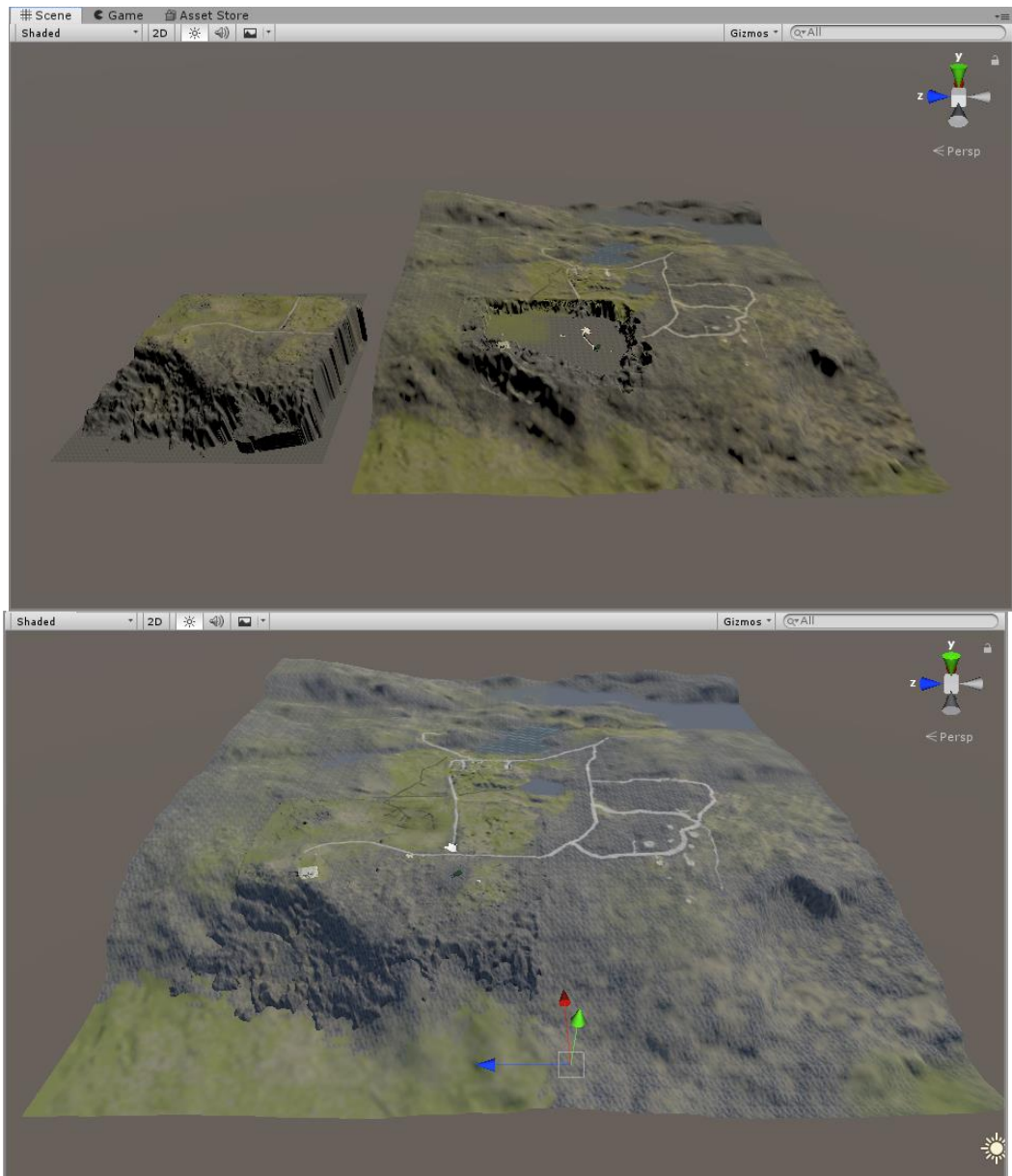


Figure 5: The two terrains used in the former project in their original position.

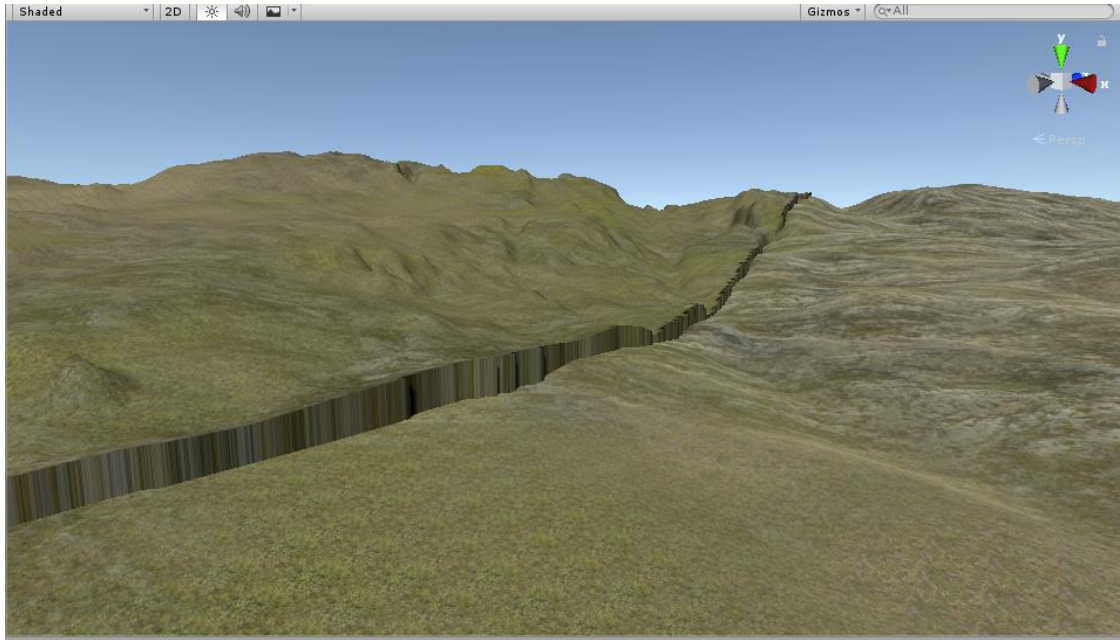


Figure 6: Clearly showing the edge between the two terrains.

2.2.2.1 Process of creating the new terrain

By using TerrainObjExporter.cs [8] to export the two separate parts of the terrain to a .obj file we can import to a 3D-modelling software called Blender. In Blender we can connect the two meshes properly and do some modifications to the terrain as needed.

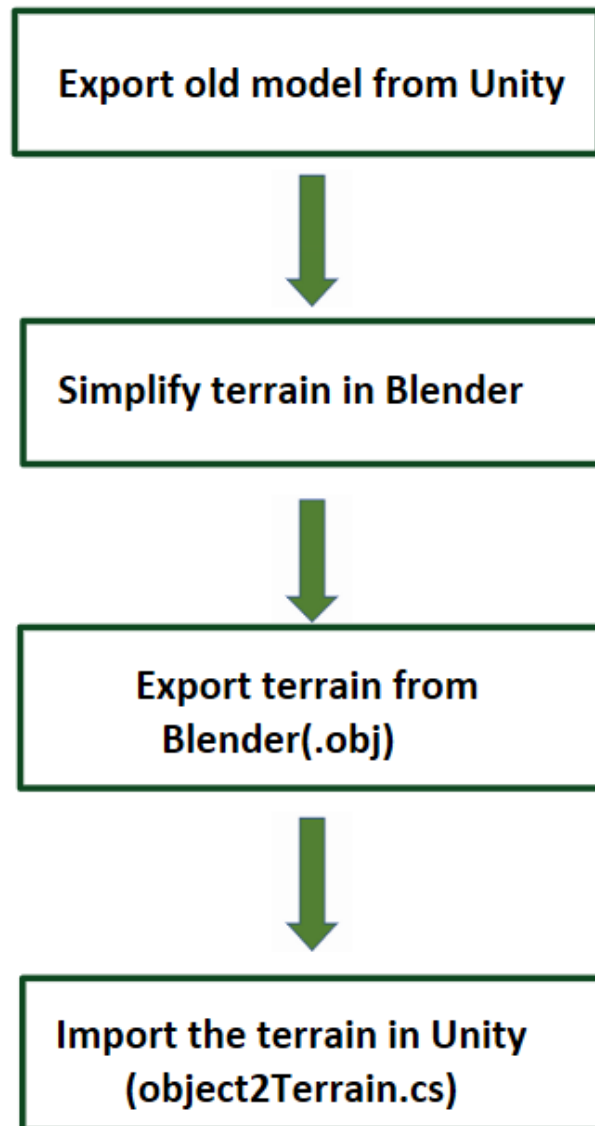


Figure 7: Step by step process for object to terrain.

Another alternative approach to the terrain would be to use the actual 3D model from Blender directly as a terrain without importing it with object2Terrain.cs [7]. Unity's terrain objects are based on heightmaps. Using the 3D model we could avoid being bound by the limitations of this technology.

2.2.2.2 Texturing and populating scene

After we have made our changes to the terrain we will use Unity to texture and fill the terrain with models (trees, grass, buildings etc.).

2.2.2.3 VR-functionality

When the terrain is finished, we will create the functionality needed in the scene for VR. Unity has multiple different assets to make this task very simple.

2.2.2.4 Gamification

Finally when the VR-functionality and populating our scene is finished we can start creating the storyline the user would follow during a playthrough. This storyline will take a player through the scene with some interaction with NPCs (Non-Player character).

2.3 Literature background

Vertices/faces:

A vertex or vertices (plural) is a point in 2D or 3D space. It can contain different attributes like position and color. By connecting two vertices an *edge* (a straight line) is created which in turn can be part of a *face* (Mesh element that defines a piece of surface. It consists of three or more edges) [5].

Terrain:

The terrain object is the main object that represents the ground in our scene. It is the object that almost everything else is built upon. In terrain creation there is mostly two choices, using a 3D model directly as a terrain or using a heightmap to create the terrain. Unity terrain objects are created with a heightmap as its base for vertex elevations.

Heightmap:

A grayscale image where pixels in the image represents elevation. A heightmap can therefore only represent one specific height in any x, y coordinate (See figure 8 for an example). If the terrain being created has no overlapping elements (in for example a cave) a heightmap is recommended to use.

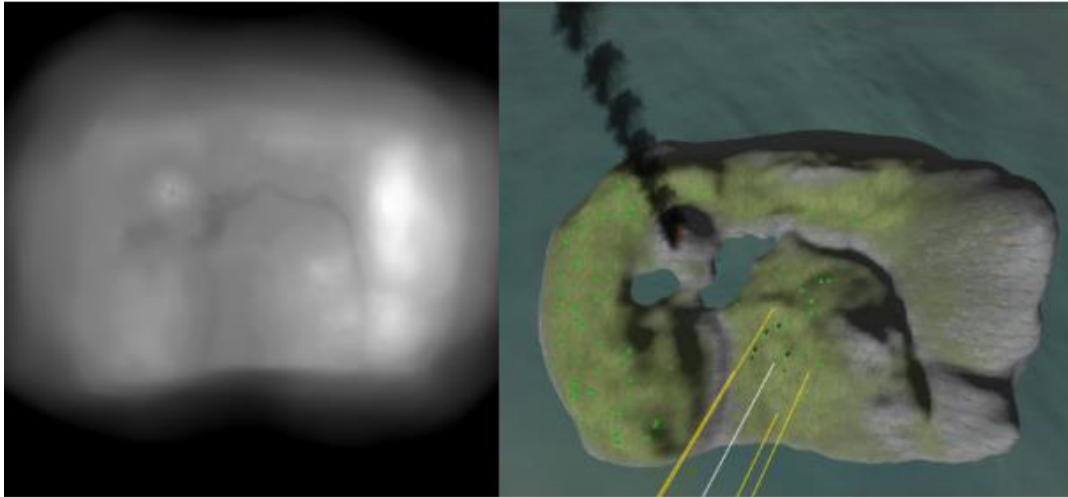


Figure 8: Heightmap of a terrain with a picture of the resulting terrain it generates.

Mesh:

The structural build of polygons that creates a 3D model. A 3D mesh uses references to points in X, Y and Z coordinates to define a shape.

Texture:

A texture is a standard bitmap image that is applied over the mesh surface [10]. Textures can be real life pictures or can be generated /created on a computer. It is used to color the scene and objects.

Occlusion culling:

Occlusion culling is a tool within Unity that will disable the rendering of objects in a scene that is blocked by other objects in the current camera view. This will reduce the rendering time of the visible scene since it removes the unnecessary objects.

3 PROJECT DESIGN

This chapter will present the possible approaches, the specifications, the tools, the development method and evaluation method for our project.

3.1 Possible approaches

The method of which we approach our assignment is fairly limited because of the nature of the task. Our assignment in its current state requires us to finish specific tasks before we can perform any other tasks. This means that our approach is mostly altered based on what technology we decide to use.

3.1.1 Primary method

In section 2.2.1 and 2.2.2 we briefly explained the main method of choice towards our goal. For this project we will use technologies that were recommended to us by developers at Medielab. The different technologies are widely used and well documented. We were already somewhat familiar with Blender and the scripting language in Unity, C#. This lets us quickly start working with modifying the terrain and therefore be able to begin reconstructing the surface with objects and textures.

As explained earlier (2.2.2) the first step was to extract the terrains from Unity and import them to Blender. In Blender we connected the two terrains and modified them as needed. After completing the terrain we reimported it to Unity and we started texturing and placing objects on the scene.

Finishing the first step swiftly was paramount to the standard of our final version. The faster we started testing with different textures and models in the terrain we would be able to create a more realistic finish. This also allowed us to create the VR-functionality that was needed to move around the scene and therefore also make sure the textures work within a VR environment.

When the steps mentioned above was at a reasonable level we started implementing the game aspect of the project, this involved coding all the storylines.

Finally when everything else was completed we went back to texturing and modelling in the scene to make sure everything is at the degree of realism we want to achieve.

3.1.2 Alternative approaches

In the scenario where any of our selected tools is suboptimal or not usable for the task we require it for, we might have to move to other software.

Using our terrain as a 3D-model instead of the heightmap based terrain object in Unity is also a possibility since our terrain contains caves.

The different tools we are using are top of the line software to create a 3D environment. Replacing any of our selected tools would only be realistic if either Unity or Blender is incapable to perform a task we need.

3.1.3 Discussion of alternative approaches.

The reason we have chosen the specific tools we are using is because they were recommended to us by Medielab as previously explained in 3.1.1. We are also familiar with Blender and the functions it provides. On the other hand Unity is a tool we have little to no experience with, but the scripting is performed using C# which we can use to a high level. See 3.3 for more.

The terrains in Unity is a specific type of object that gives the user a lot of extra abilities to texture and modify the terrain itself, however this requires the use of a heightmap. Using a 3D-model instead would be preferable considering the amount of caves and tunnels existing in our world, but losing the functions bound to the terrainobjects would require us to spend more time during texturing of the 3D-model. Unity also provides different workarounds to the downsides of the heightmaps [11]-[12]-[13].

3.2 Specification

In order to achieve our goals, the project can be broken down into these phases concerning the main goal and the secondary goal.

3.2.1 Main goal - Creating the scene

This will give a description of how we got the terrain, and how we made it render realistically.

3.2.1.1 Extracting a usable model from previous work:

The Unity project created by the previous bachelor group [1] consisted of two terrains and some 3D models all mixed together, along with other game objects and scripts to enable use of VR. In order to have a project with a good overview of all the Unity components and to ensure that software and plugins are up to date, we decided to extract the terrains, do some work on them, and then implement a single terrain into a new empty Unity project. The terrains were combined and adjusted in Blender.

3.2.1.2 Figuring out which assets to use in our scene:

The historical data available of Fjell Fortress gives us an idea of the look of the environment. There are many different packages that can be downloaded from the Unity asset store that contains important objects like trees and rocks, as well as textures, which we will use to “paint” the terrain. Our challenge is to figure out which assets best represents Fjell in 1945.



Figure 9: Showing road, vehicles and vegetation (1942). Foto: Bundesarchiv.

3.2.1.3 Building the terrain

After selecting all the different textures and objects, it was time to put them to use. Unity's terrain object has many useful tools in order to create beautiful landscapes, and these were the steps taken in order to do so:

- **Terrain layer.** The terrain layer defines the surface qualities of the terrain, such as the texture, and is normally the first thing to start with when designing a terrain. What this actually does is to paint a repetitive 2D picture onto the terrain. The picture could be anything, like grass, rock, snow or sand. Moving close to the terrain, it is hard to notice the repetition of the pictures.
- **Terrain details.** These are 2D pictures also called sprites. Unlike the layers, these are standing perpendicular onto the terrain. Typical examples of terrain details are bushes, grass and flowers and even trees when placed in a distance of the player. 2D details are less computationally heavy for the computer, and can be put together in large numbers with different rotation to make it look natural.
- **Adding Objects/models.** A object/model is a 3D object like a tree or a rock. They consist of a number of vertices making up the geometric shape. This is called the mesh. When adding a material to a mesh, we end up with a 3D-object we can use in the scene. The 3D-objects contains more data than the 2D pictures. Unity has built in functions to handle the rendering of these objects in a smart way, which will limit the computation needed of the PC. This technique will be mentioned later in the report.
- **Adding large models.** There were a number of constructions central for Fjell Fortress' history. The most know is of course the enormous triple-cannon, but there

were also a medical centre, many bunkers and other buildings as well. Thanks to the efficiency of the Germans, many of the buildings were standardized, and the same bunkers found at Fjell can be found throughout Europe. Many of the bunkers have been modeled, and can be downloaded and used for free.

- **Post processing effects.** When all the bits and pieces are put together, all that is left to do is to add the post processing effects. This is really important because it sets the mood of the scene. What it does is that it applies full-screen filters and effects to the image buffer before the image is displayed on the screen [9].

3.2.2 Secondary goal - Gamification

To create a good game, there are many pieces that need to work together, like: the look of the game, user interface, story, actions, music/sounds, characters, and player choices to mention a few. This chapter will give an overview of how we intend to make a good game of the world we have created.

3.2.2.1 VR

By using the SteamVR SDK created by Valve we were able to quickly install and import all necessary components in order to walk around in the world created using the VR headset and controller. The initial feeling of the player movement was good, and there were not any discomfort.

3.2.2.2 Story

The game starts with a short movie intro made by Øyvind and Vigleik, which tells a little bit about the main character and why he is at the Fortress. After the movie, the player is able to control the main character with the controllers who is a journalist that has been given an assignment to write a story about what is going on at Fjell Fortress. Now, the player can start exploring the world, and talk to the characters in the game.

3.2.2.3 Character dialogues and animations

The non player characters (NPC) dialogs are text boxes which pop up over the NPC's heads when the player gets close to them and presses the talk button. The conversations are dynamic, which means that depending on which question the player asks, the NPC answers based on the player's choice. As the NPC is talking, they are also doing animations based on what they talk about. The state machine in Unity's Animation Controller are controlling the animations based on a script. This will be explained in detail in chapter 4.6.4. Making the player choose what to talk about may be a smart move in order for the player to get more invested in the story.

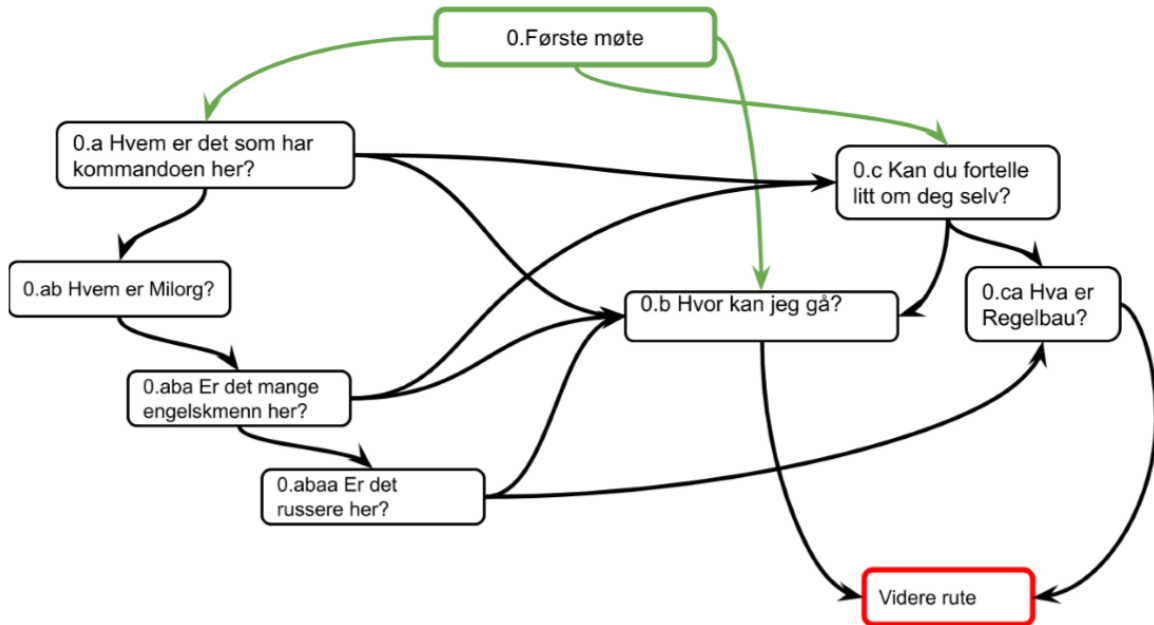


Figure 10: Illustrates how one of the dialogues could be arranged.

3.2.2.4 Game design

There are many details and game design choices implemented in a game that a player may not take into consideration or think twice about. Some of these ‘designs’ make the game more interesting and lively or are simply there to keep the player on the right track. These are some of the game designs we are adding:

Gate: The gate at the start of the game opens when the player gets close and closes when the player has walked through.

Restricted areas: We do not want the player to be able to roam around the entire Fortress. Some places have fences and barbed wire to keep the player from walking in some areas. Where we want to restrict movement and there are no evidence of fences or barbed wire (from photos), we simply place invisible box colliders in the terrain that the player cannot pass.

Sounds: The river and wind makes sound that the player can hear if inside the source sound radius.

3.3 Tools

To complete our task the group must be able to understand and use multiple different technologies. Medielab recommended multiple of the technologies we used.

Unity

Unity is the main program we will use in this project; it is a very powerful game engine that can perform the tasks we need. We must be able to use the preset functions in Unity and also script some ourselves using C#. Downloading some extra assets in Unity allows us to

create the basic VR-functionality we need. We selected this tool because we had previous experience with the scripting language C#.

SteamVR

SteamVR [16] is an API used for VR-development which allows for different VR-headsets to be compatible with a game without multiple codebases. This can be imported to Unity and be used to create the VR-functionality regardless of the headset being used.

Blender

Blender is a 3D modelling software that we will use to create and adjust 3D models for our scenes. To fully utilize this software, it requires us to be familiar with most of the tools it offers and how to use them to their full potential. We had previous experience using this program to create and modify 3D models and therefore it was logical to use this tool.

Substance Painter

Substance Painter is a tool that is used to texture and color 3D models. Tools like Blender is also capable of performing this task, but Substance Painter is more powerful to create proper textures that seems realistic. This tool was suggested and recommended by a developer at Medielab [4].

Gimp

Gimp is a free image editing tool, this will be used to create and modify some of the textures we will use on the terrain and models.

3.4 Project development method

This chapter explains how the project is divided into different phases and what kind of work methods we use to reach the goals. Then it is explained how the different risks in regards of reaching the goals are handled.

3.4.1 Development method

Since this is a large and complex project, it is important to have structured work methods and timed goals. In order not to get overwhelmed by to-do's, we are dividing the workload into smaller packages, or sprints. Each week we have different to-do's which we are working on to achieve a larger milestone at the end of the week. Each sprint might be a part of a larger sprint. For example, we have two main goals in the main project phase, which is designing the scene and to make the game. Each of these goals are sums of smaller sprints.

During these sprints we also had a weekly meeting with the project owners where they could give valuable feedback and clarify any issues or questions we had.

It can be easy to spend too much time on designing the scene. There is always something to make better. Therefore, even after the designing part is over, we have decided to set aside time once a week to increase the quality of our world.

3.4.2 Project Plan

The project is divided into five different phases. Each of the phases with its own agenda of tasks and issues to be solved.

The first phase in the project is the startup phase. As the name implies, it involves starting up a new project and all the preparation this entails.

The second phase is the exploration phase where we will explore the different approaches for creating our final product. In this phase we will explore the possibility to extract the previous terrain and simplify it. And to do basic VR testing and explore Unity's functions.

The third phase is finding a way to create a realistic scene by creating, modifying and acquire the necessary models. By adding different features to the models, we can get the desired information-dissemination that we want.

The fourth phase is gamification where we will implement the different aspects of the storyline given to us. In this phase we will also explore more in depth the possibilities when using VR in the model. How to control the user's behaviour so that we provide them the best experience we can when they explore the world, while we also explore what constraints must be implemented and how we should implement them.

The fifth phase is the last phase of the project. We will complete the end report and deliver the result to our product owner with the necessary documentation. We were also going to present our project to some of our peers, but due to corona, it will be a Zoom meeting instead. We will also create a poster that will go into a digital yearbook along with the other bachelor theses.

3.4.3 Risk management

This section gives an overview of the main risks discovered in the project work, and how they are addressed.

3.4.3.1 Not enough time to complete the project

Many of the tasks are new to the group members, such as creating a world in Unity, or making a game. It was hard to predict the exact amount of time the different parts of the project would take, but a strict plan with clear milestones was made in order to ensure progress.

3.4.3.2 Encounter unforeseen problems

As mentioned, the project members lack experience on some of the central tasks. It is logical to expect some unforeseen challenges along the way. It is impossible to estimate how much time such challenges could take. To prevent this becoming a threat, we added a time buffer to both of the main tasks; the terrain creation and the gamification.

3.4.3.3 Nausea in VR

Some people experience nausea when using VR, because they "think" they are moving when their body is actually still. There are many factors which could cause nausea using VR:

- The type of equipment. Better equipment could help with the general feel of using VR.
- The program/game the user is playing. If it is a fast paced racing game it is more likely to cause discomfort than a game where the user stands still picking flowers.
- The individual reaction of VR. Some people get motion sickness playing VR, and some do not, which is the same reason some people get motion sickness when traveling by boat, and some people do not.

The only factor we can do something about, is how the game is designed. Even if the game design is good with regards to nausea, there probably is someone who will experience nausea, and will sadly not be able to play the game.

3.4.3.4 Not enough computational power to run the game smoothly

The end result must be able to run smoothly on the equipment available to the museum. To ensure this, we used various graphical techniques to relieve the workload for both the CPU and GPU. Unity has many built in functions to help us with this. We will always perform tests on the game to check if we have made the scene too complicated to be rendered smoothly. Also, there will be an evaluation of the finished game by external people, which will give us feedback on this topic.

3.4.4 Development testing

During the project period, we have worked closely with our project owners. Each week we have at least one meeting. Since the middle of March, an experienced game developer from Medielab together with the museum director of Fjell Fortress, Vignleik Røkke Mathisen has joined in one these weekly meetings. In these meetings we have discussed the progress, showed the latest changes, adjusted the plan accordingly and made corrections when necessary. We have also continuously tested the functionality of elements in the game itself by running the game and confirming correct behaviour.

3.5 Evaluation method

The evaluation will determine if the project has been successful. There are many things to consider to determine if the goals have been reached, especially since the project has two goals. For the evaluation of the project we have decided to use both qualitative and quantitative evaluation methods.

3.5.1 Qualitative evaluation

The basis of our qualitative evaluation is based on the response during our weekly meetings with Vignleik and Medielab. Both Vignleik and Medielab's response is valuable in its own way. Vignleik's knowledge about the history surrounding the Fortress is unchallenged, and will provide detailed information about everything from the color on buildings to which jackets the guards used. Øyvind has supervised the previous bachelor groups, and knows the project in and out. Also, he can give advice on technical issues and help us create a rational plan fitting to the workload.

3.5.2 Quantitative evaluation

The initial plan to evaluate our work was to test the finished product on groups of people, like middle school students and/or students from other studies at HVL, and ask questions about their experience. Due to the Corona-situation, there was not an opportunity to meet with other people to that extent. Instead, we will create and show a video of the finished gameplay. The viewers of the video will be asked to answer a questionnaire, that will help us evaluate if the goals have been reached. More details about the questionnaire in chapter 5.2.2.

4 DESIGN AND CREATION

This chapter presents the different steps we have worked through to reach our goal. It will go into some details since it is part of the final project solution.

4.1 Initial planning

The initial plan was based around the description given to us by the project owner which was a brief description of the desired outcome of our work. This description and multiple meetings with our project owner specified the scope and outcome of our task. Since we had some extra time before we started on the project, we created the time schedule we have based our work around.

4.1.1 Meetings

Our first meetings with the project owner took place in december 2019. At this point we were presented what resources were available from the previous project [1]. In February of 2020 we started more frequent meetings where we discussed more in detail what tools was preferred for the task and the experiences Medielab had gathered from their previous work. Due to the current pandemic we have been using zoom to carry out these meetings. See 3.3.

These meetings continued regularly for the rest of the project period where we discussed our progress. The state of Fjell Fortress during and after World War II is a somewhat unknown field. The museum is constantly working to figure out what buildings, roads and other constructions existed during the time, and their function at the fortress. This information was relayed to us through the meetings with Medielab. We had at least one meeting per week with the project owner since we were dependent of the feedback/input we were receiving.

During this time we also went on a field trip to Fjell Fortress so we could see and experience the area for ourselves to have a better understanding of what we were creating.

4.1.2 Practical setup

Since our project is dependent on a computer able to perform heavy computing, the school supplied us with a computer and a VR-headset, see 1.4 Resources. During the startup of the project we created a Google Drive folder to collaborate and store our reports and the different resources we had available such as 3D-models, pictures/videos and other valuable assets. Since the school closed down for student activity due to the current pandemic we were allowed to move our hardware to one of our apartments.

4.2 Terrain Modification

As we previously explained in 2.2.2 Initial solution idea we had to recreate the terrain based on what assets we had available from the previous project [1]. The terrain model that we received from Medielab at the start of the project was a combination of two different 3D-models. These models were overlapping each other to create the entire terrain. This resulted

in large areas of the terrain to be rendered without ever being required for the scene. Therefore, we decided to combine the two models to avoid this issue, this task proved to be harder than expected due to the compiler in Unity, and this will be further explained in the following paragraph.

4.2.1 Extraction from Unity

To extract the two 3D-models from Unity we used a script [8] designed to create a .obj file of the targeted terrain. This script is added to the editor in Unity and will create a button to extract the terrain, however, this script will be compiled after the scene in Unity, in other words, if there is a compile error in your scene you will not get the option to extract a terrain. The Unity project we received was unable to run the script due to such errors, therefore, we spent some time debugging the old project [1] to extract the terrains.

4.2.2 Modification

The two extracted terrains, now in .obj format, can be imported to Blender which is a 3D-modelling software. In Blender, we connected the two 3D-models by removing areas that were covered by the other terrain, see figure 11, and then connecting the two models. Finally we exported this model using a built-in exporter in Blender to .obj.

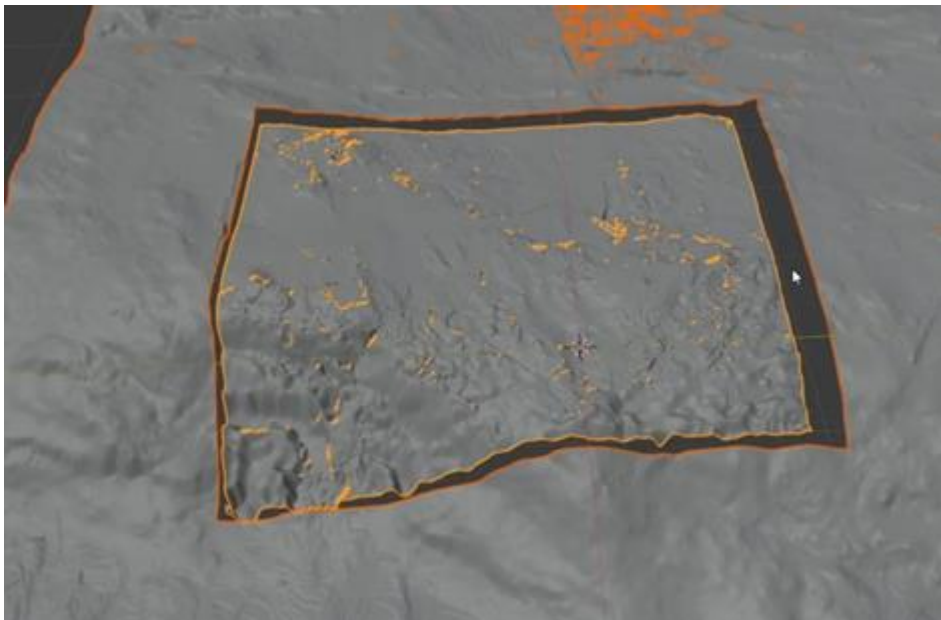


Figure 11: Shows the cuts made in the terrain before we connected the seams.

This created some unrealistic seams that was later fixed in Unity with the terrain tools it provides.

4.2.3 Importing back to Unity

To import the modified terrain back into Unity we used another script [7] that creates Unity terrain objects from .obj files. This script allows us to select the resolution of the heightmap

created for the terrain, we therefore tested some different variations of resolution to minimize the amount of data without losing the overall look of the terrain.

4.3 Remodelling to WWII state

This section will explain how we remodelled the scene back to its World War II state.

4.3.1 Assets and models

Most of the assets used in this project are free assets, however for certain aspects the free assets did not have enough detail to make it look real. Often the best assets costs money since they are made by professionals. The assets purchased for this projects are as follows:

Meadow Environment - Dynamic Nature

This package comes with a lot of high quality assets such as rocks, foliage and trees. The cliff models used several places in the scene is included in this package. The different models also comes with LOD's [22].

R.A.M

The package specialize on creating advanced rivers, lakes and tools for connecting them. It can also be used when creating roads and connecting them as well. We used it for all the lakes, rivers and main roads in the scene [23].

WWII Ultimate Pack

This asset added a lot of realism to our project. We could not find a free assets with good models from World War II, so this package was purchased. It consists of 147 3D objects from WWII, for example the different cars and the gate at the entrance to Fjell Fortress [24].

4.3.2 Buildings and characters

Buildings and characters present in the scene where mostly designed by a game designer from Medielab. He designed these based on pictures, inputs from the Museum as well as visiting the site himself. During these visits he took pictures of the buildings he was to reconstruct. The characters were made based on images of people and uniforms used during WWII.

4.4 Tool Evaluations

This section will evaluate the performance and usability of the tools (see 3.3) we have used in the project.

4.4.1 Primary tools

The Primary tools used in the project consists of what we expected to use for all elements of the project. These tools are Unity, Blender and SteamVR.

We have had little to no issues with these tools except for limitations in the hardware we had available to us. Some of the tasks we had to perform were very computationally heavy and therefore took a while longer to be executed, in example the modifications of the terrain.

4.4.2 Extra tools

In the cases where we realized that our primary tools were less capable or incapable of performing a task properly we had to find new and more specialized tool for that exact problem. These specialized tools include Gimp and Substance Painter (see 3.3).

These tools were used to create and apply realistic textures to different 3D models and the terrain in Unity.

Gimp was mainly used to create the road texture in our scene. We had large issues finding any proper textures of a gravel road and therefore created one using this program. To do this we took a bird's eye view picture of a single roadtrack (figure 12) and then modified it with Gimp and created a tileable roadtexture (figure 13). A tileable image is a image that will seamlessly connect to itself when put side by side (figure 14).

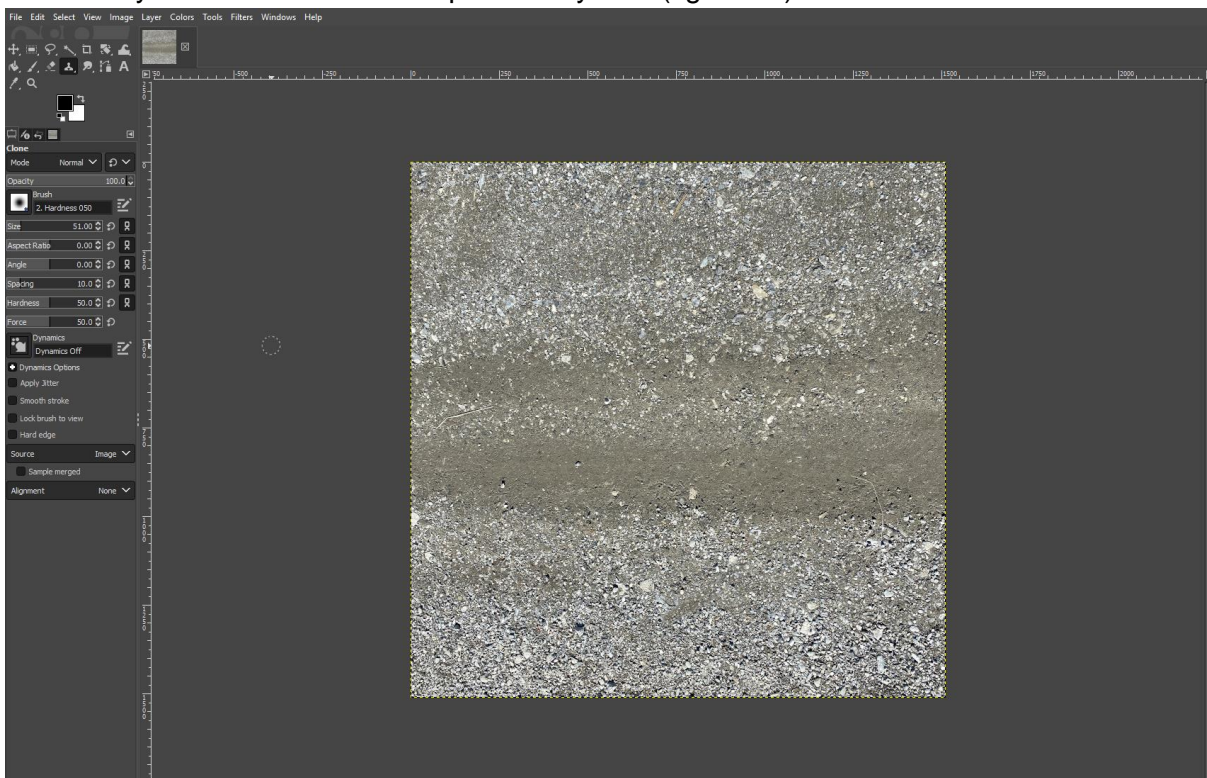


Figure 12: The initial image used to create the roadtexture.

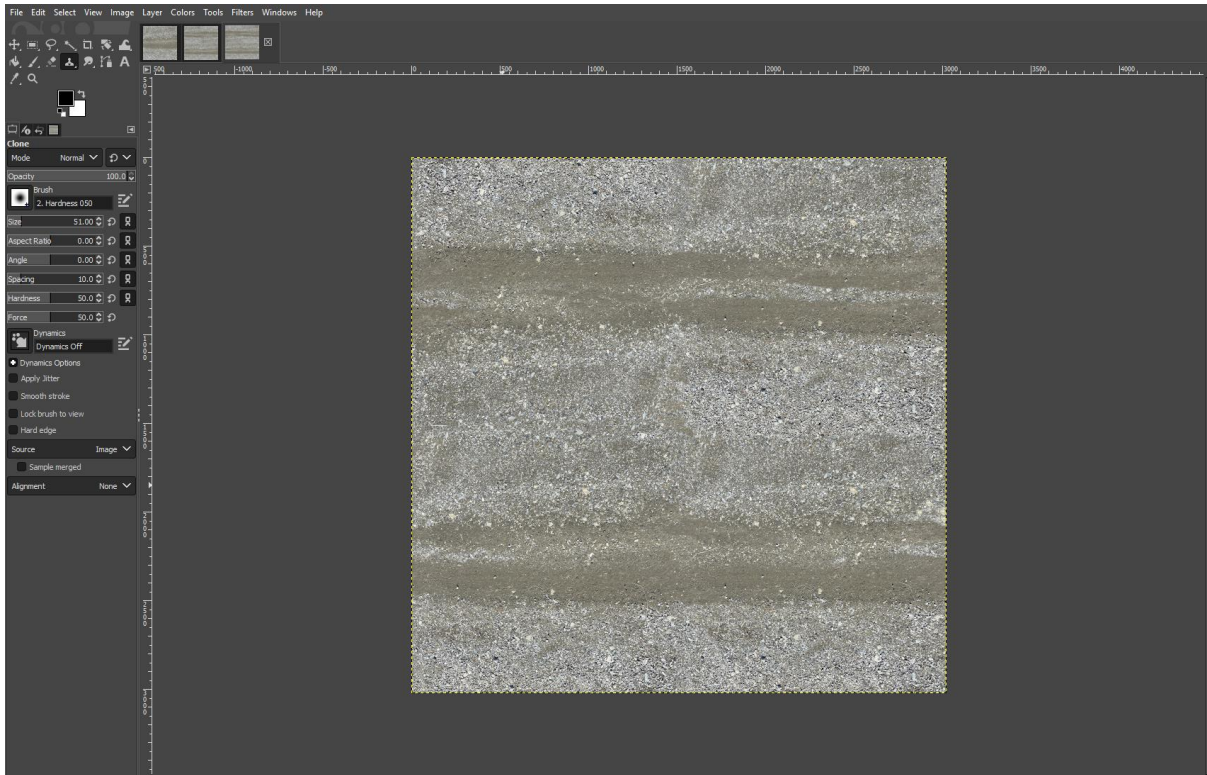


Figure 13: The tileable roadtexture after image manipulation in Gimp.



Figure 14 : The finalized roadtexture in the Unity scene. As you can see there is no visible seam where the texture is tiled.

4.5 Performance in Unity

Our project requires a lot of computational resources due to its size. It is therefore important to look at how we can improve the performance. Unity has many different features to improve the performance during runtime of the game. We will focus on some of them in the coming chapter.

There are primarily two systems on the computer that is affected by the graphical part of the game, namely the CPU and the GPU [15]. One of the first steps was to implement occlusion culling to improve the performance. 'Occlusion culling is a process which prevents Unity from performing rendering calculations for GameObjects that are completely hidden from view (occluded) by other Game Objects' [14]. It is used to reduce the amount geometry draw-calls. When the game starts, Unity will render all the objects in the scene by default. It does not matter whether our player can see all those objects or not. The camera performs frustum culling by design, but since it does not check for visibility, that is whether the objects can be seen from the players point of view or not, we implemented occlusion culling. Occlusion culling is supported in Unity and is easy to enable. There is no use to render all the objects and use unnecessary CPU and GPU power. We need to bake the scene when we add new objects or makes changes to existing ones. See figure 15 to have a look at the baking processes. Figure 16 shows the occlusion culling of the scene when the player is facing two different angles.

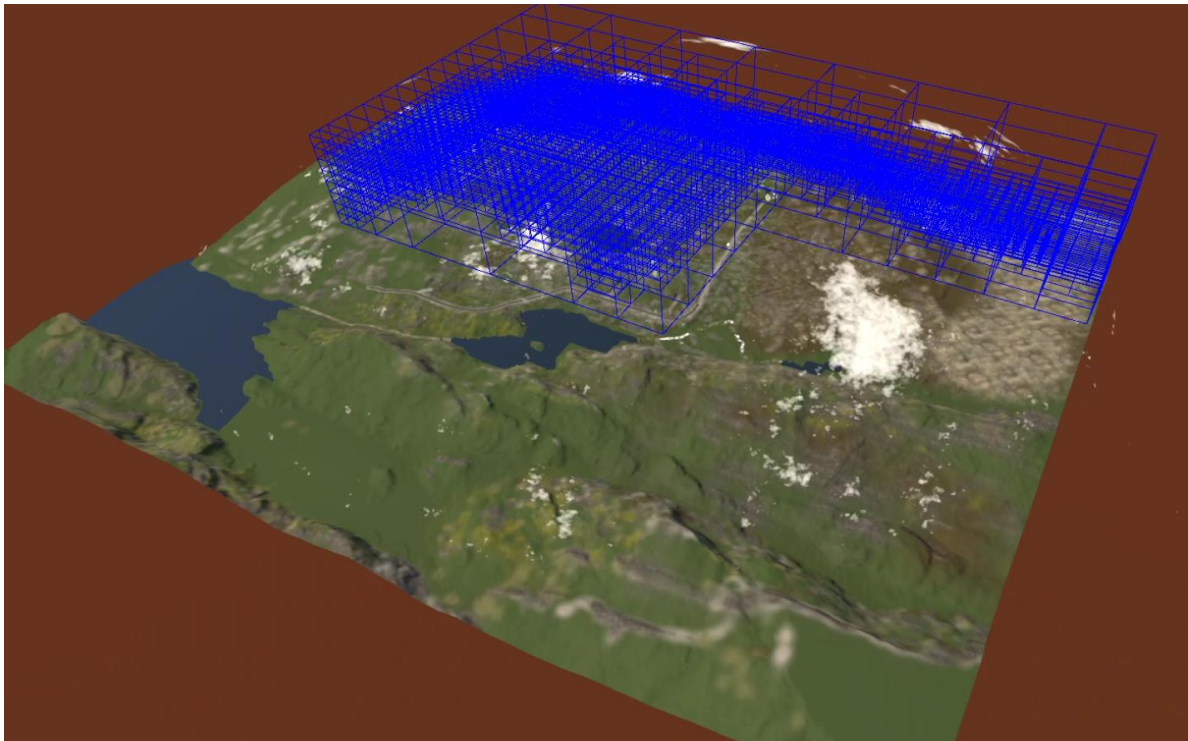


Figure 15: Shows the baking of the terrain.

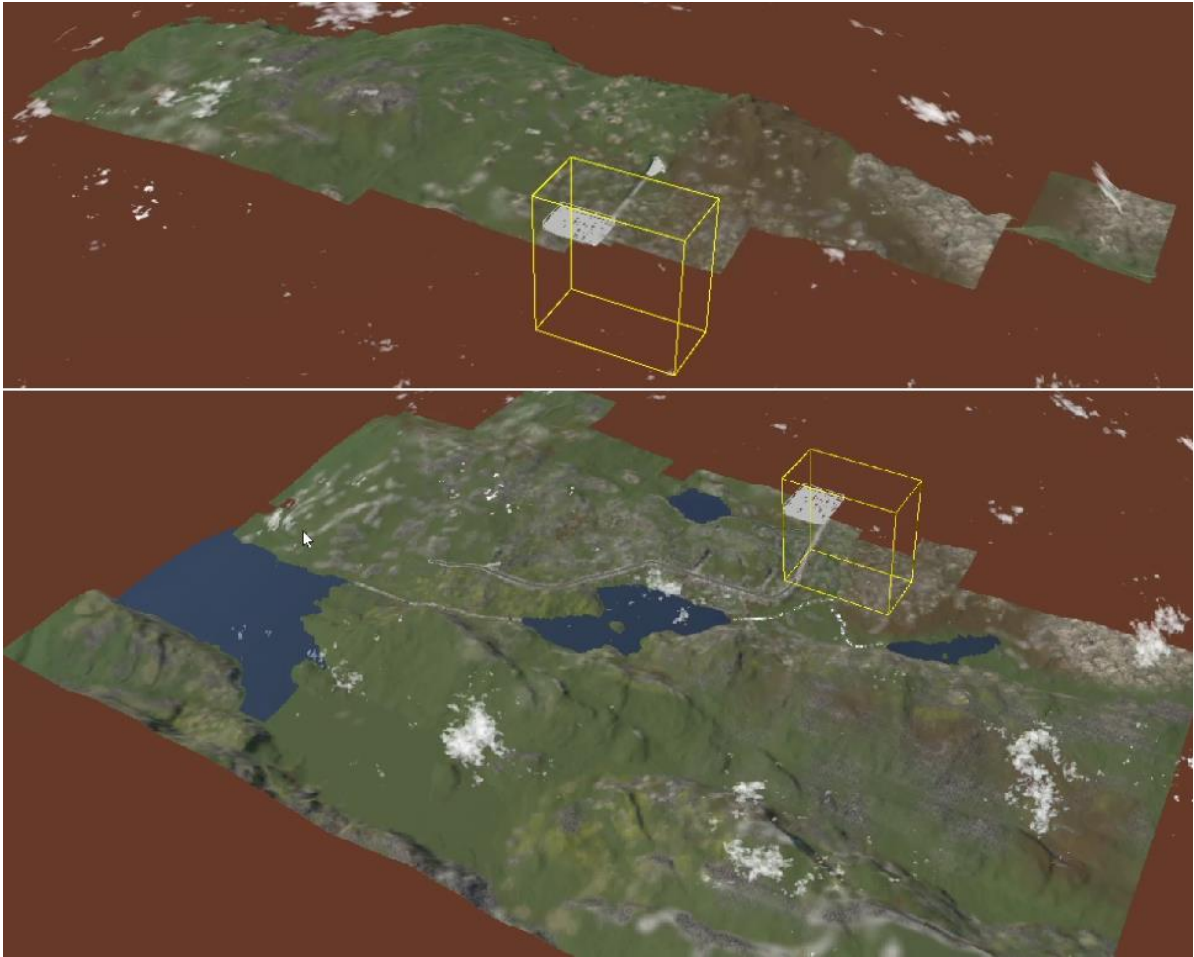


Figure 16: Occlusion culling of the scene when the player is facing different directions.

The rendering statistics window in Unity displays the games real-time rendering statistics and gives us a lot of useful information such as tris (number of vertices and triangles drawn) and batches (number of times the processor is “talking” to the GPU). Figure 17 and 18 shows an example.



Figure 17: Shows the statistics window in Unity when running the game.

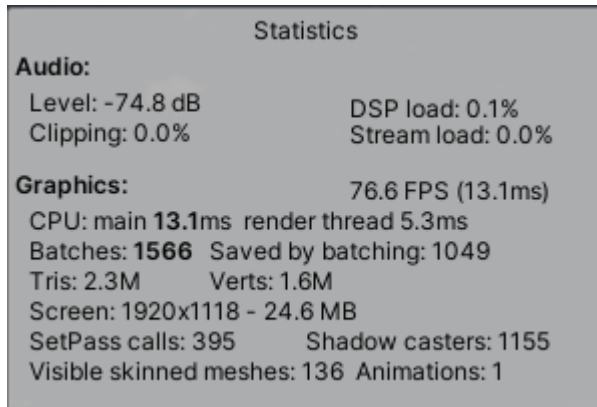


Figure 18: Shows the statistics window that gives insights to the performance in Unity.

Unity comes with a built-in profiler and quality settings that we can use to change the quality of our game. By default the quality is set to ultra quality for every new project, which is the best setting. That also means that it takes up a lot of the performance and therefore is maybe not the best quality setting for us.

4.6 Gamification

Everything explained in the report so far has been related to the creation of the digital copy of Fjell Fortress 1945. Now, the time has come to explain how we are going to use the world we have created in the game. This chapter will explain some of the core concepts in our game such as, character movement, the dialogue system and animations on characters.

4.6.1 VR implementation

The SteamVR SDK is an official library created by Valve that enables developers to interact with all the major VR headsets through Unity. In our case we are using the HTC Vive VR headset. We have installed the SteamVR plugin in Unity which handles mainly three things; loading 3D models for VR controllers, handling input from those controllers, and estimating what your hand looks like while using the controller [22].

4.6.2 The main character

The main character, which is the player, is controlled in first person. We have added a Character Controller component which basically is a capsule shaped collider. The radius and

height are adjusted to shape our main character.

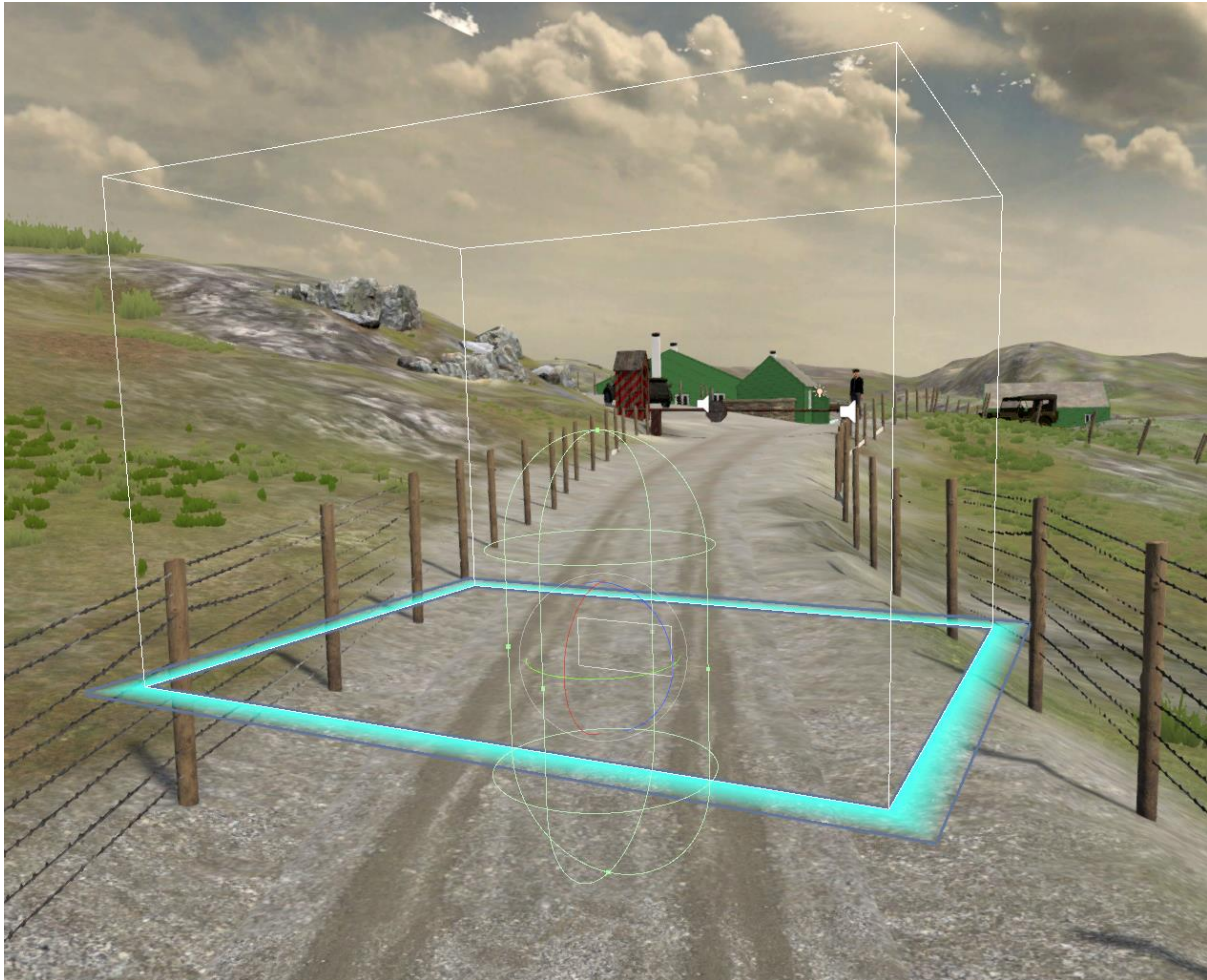


Figure 19: The green oval shape in the center of the square is the capsule collider.

There are no built in physics in the component other than the collider, which means our character will collide with objects such as walls and the ground [21].

In order to be able to move the character we have created a movement script. This script is responsible of all the movement concerning the character, which also includes downward movement to keep the player on the ground. The way the player is able to move is to press the trackpad (large round button) on the controller, either forward or backwards, which will move the character in the direction the player is facing.

The camera, which will be the players “eyes”, is called the “Camera rig”. This is a component imported from the SteamVR library that lets us use the VR headset. Any movement applied to the VR headset will be applied to the Camera rig (translation and rotation), which is the players eyes.

4.6.3 The story

Before the actual story takes place, the user will be placed at a small intro scene where he/she will get a short introduction on how to use the VR equipment. By pressing a button on a canvas with the controller a short introduction video to the game will appear at the canvas in front of the player. Just like the movies. The video is a slideshow where a story is told

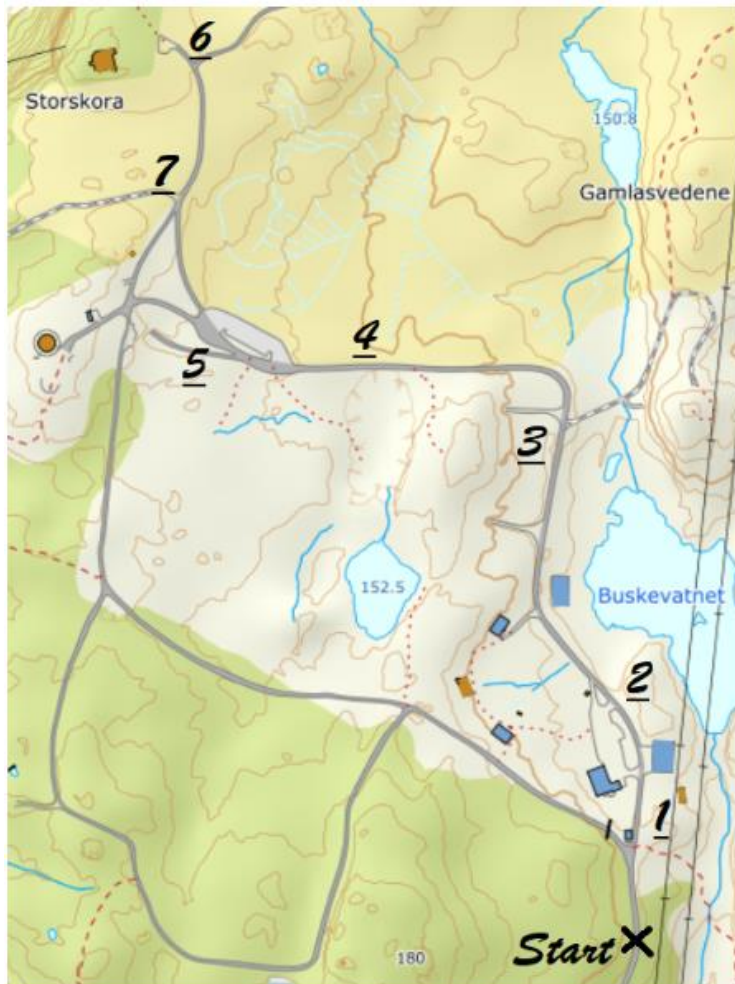
along with pictures about how life were at the time. The video is put together by Øyvind and Vagleik and voiced by Bård Gram Økland.



Figure 20: A screenshot of the game that shows the intro video playing at a canvas before the actual game starts.

When the video is finished, the player is transported to Fjell. The player is a journalist by the name "Arne Båtstrand ". He has traveled to Fjell to write a story about what is going on at the fortress. It will be the players job to step into the journalists shoes and to investigate further.

The story will start at the entrance of Fjell Fortress, where the player will meet Ed Nordberg, chief of operations. From this point on the player will follow the road to the triple cannon, and talk to many people along the way. This story was written by Vagleik from Museum Vest. The picture (figure 21) below illustrates how the course of events takes place and where the player is supposed to talk to the NPC's.



- 1: Ed Nordberg.
- 2: Hans Oppkvitne
- 3: Nazarenko
- 4: Lill Tveito
- 5: Lewis Adams
- 6: August Jugler
7. Laurits. The end

Figure 21: The player route.

4.6.4 Dialogues

In order to make the interaction with the characters in the game feel authentic, they have dynamic dialogs. The dialogue system is text based and not vocal. In order to get all the dialogues vocally, we would have to find voice actors and get recording equipment. This would take a lot of time. Therefore we choose to go with text boxes which are easy to set up and easy to make changes to. Depending on which question you ask the NPC, you will get an answer based on your question. A suitable solution to this type of dialogue is a node based system, where the dialogue is steered in the direction of the players questions.

Instead of using weeks on creating a node-dialogue system with a user interface and everything, we imported a finishes asset called VIDE, which is exactly what we need: A node based dialogue system. It allows us to create an infinite amount of nodes, which takes you to another node based on which choice is made. A node holds either a NPC comment or player choices.

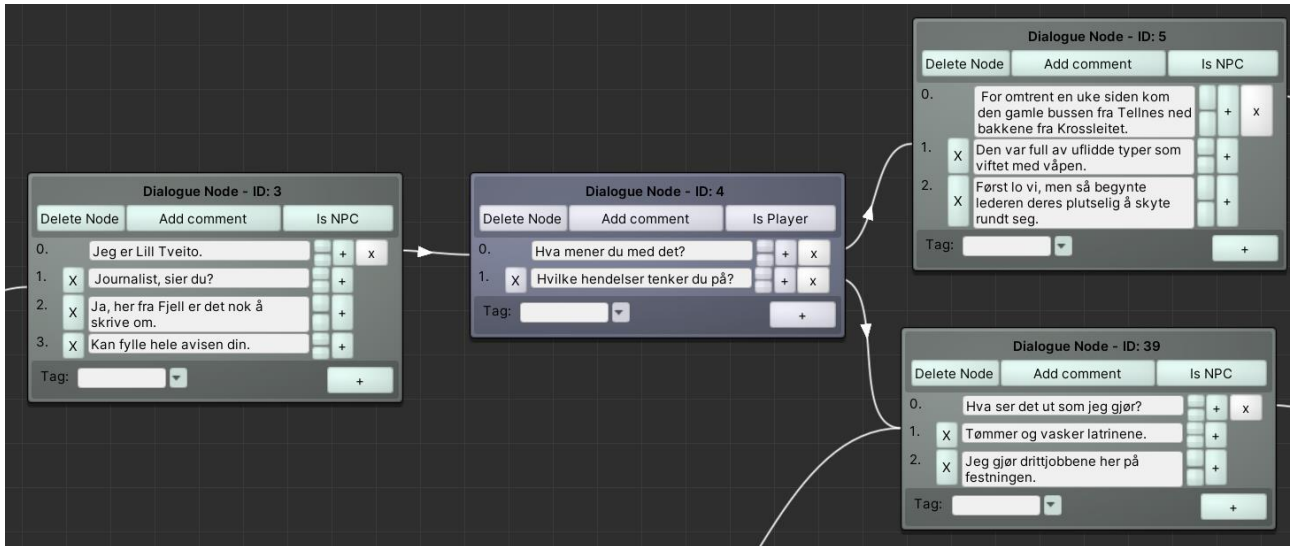


Figure 22: The figure is a screenshot from the VIDE editor and shows a section of a dialog. The box in the middle is a player choice node, while the three others are NPC nodes.

Every node has buttons on them to add or delete comments or change the node type to “Is NPC” (grey) or “Is Player” (blue). The key feature of the system is the connections between the nodes. The player node has a connections for each question leading the conversation to the correct NPC node. Long conversations can get intricate. By using nodes like this we are able to reuse the same nodes and keep a good overview of the whole conversation. The picture below shows a conversation with Lewis Adams, an english officer. The conversations starts from the left, where it develops and ends in the top right corner. It is the players choice how much information he/she wants to get out of Lewis. When the conversation is finished, it can be started again if the player wants to get even more information.

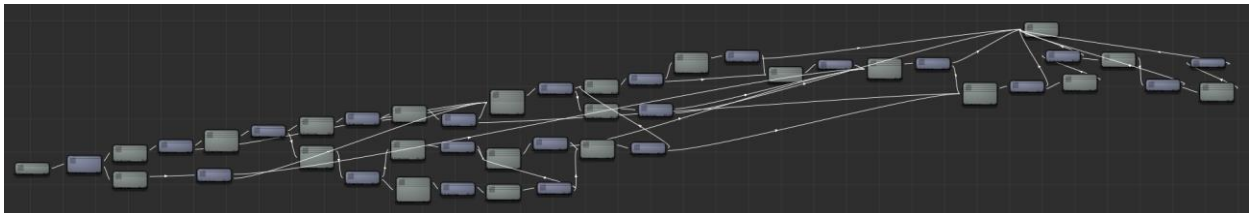


Figure 23: Shows how large some of the node systems can be when linked together.

As practical as this seems, we still had to get the dialogue to show on the player screen and create a way for the player to interact with the different choices. In order to do so canvases were created to hold the NPC text and the players choices as buttons.



Figure 24: Shows one of the characters, Lewis Adams talking with a dialogue box.

Each NPC has its own VIDE-dialogue attached to itself. In order to start a conversation with a NPC, two criteria must be fulfilled. The player must be within a set range of an NPC and the player must press the main button on the controller. To let the player know what to do, a small information box that says 'press button to talk' pops up automatically when getting close to a NPC. A script controls this logic.

Now the player can talk to the NPC's, and by pressing the button on the controller the dialogue advances. However, when the choices pop up on the screen, there is no way to select a button. The VIDE-system was designed for PC with a keyboard, where choices were selected with the arrow keys and enter. Therefore, we imported SteamVR's laser pointer. This is attached to one of the controllers such that a laser shoots out of it. This is only a visual effect though. In order to click the buttons with the laser we made a LaserClicker script. In the LaserClicker script, we created a raycaster which would identify the object it collided with. In order to collide with the buttons, we added box colliders on them. The laser would identify the object it collided with and perform the on-click function when the player pressed the button, and the dialogue would continue.

The logic working in the background letting us advance through the conversation and lets us use the information in the nodes (the NPC and player phrases), is controlled by a script which is a part of the VIDE asset.

By choosing this dialogue system we have made it very easy for the people who are going to work on this project later on to expand or change the dialogues. If they want to change a sentence or create a different option for the player it can all be done by a few clicks.

4.6.5 Animations

The VIDE asset also provides an 'Action node', where you can choose a gameobject and a method in that gameobject's script in order to perform an action (in example, animations). The picture below is an example of how this is implemented. We start to the left where the

player press the second button in the player choice node where we are lead to action node 43. The method 'sadStart' is invoked and runs from the gameobject Lill. Lill says her three lines in node 37 and we advance to action node 44 where 'sadStop' is called.

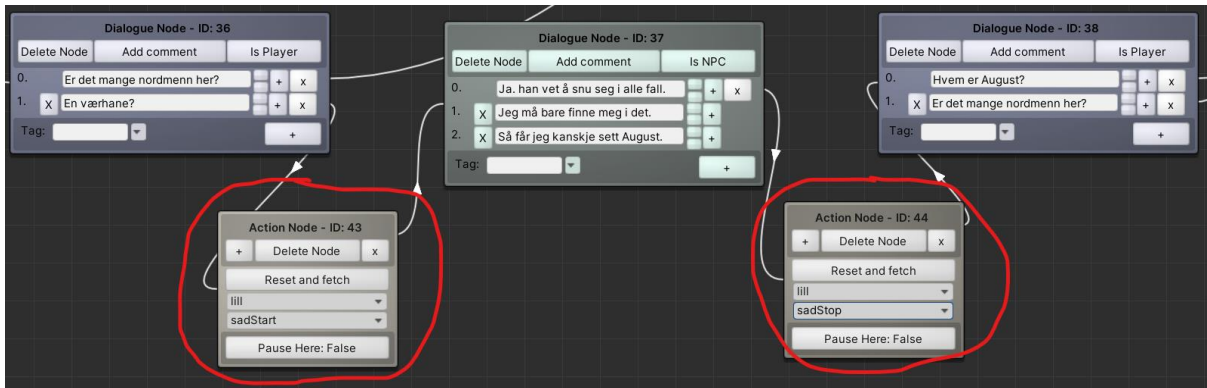


Figure 25: Action nodes in red circles.

In order to control animations on characters we are using Unity's Animation Controller. It is basically a state machine where each state has an animation attached to it that controls the characters animation.

The methods sadStart and sadStop that are run in the above example are found in Lill's animation script. These few lines of code simply tells Lill's animator controller (called anim in the script) that the boolean parameter 'Sad' should be true or false.

```

public void sadStart()
{
    anim.SetBool("Sad", true);
}

0 references
public void sadStop()
{
    anim.SetBool("Sad", false);
}

```

Figure 26: Simple script to control animations.

By changing these values we are changing the state of the animation controller. Our animation controllers on all our characters are fairly simple where it is only one possible way to get to another state. The picture below shows an example of such a state machine.

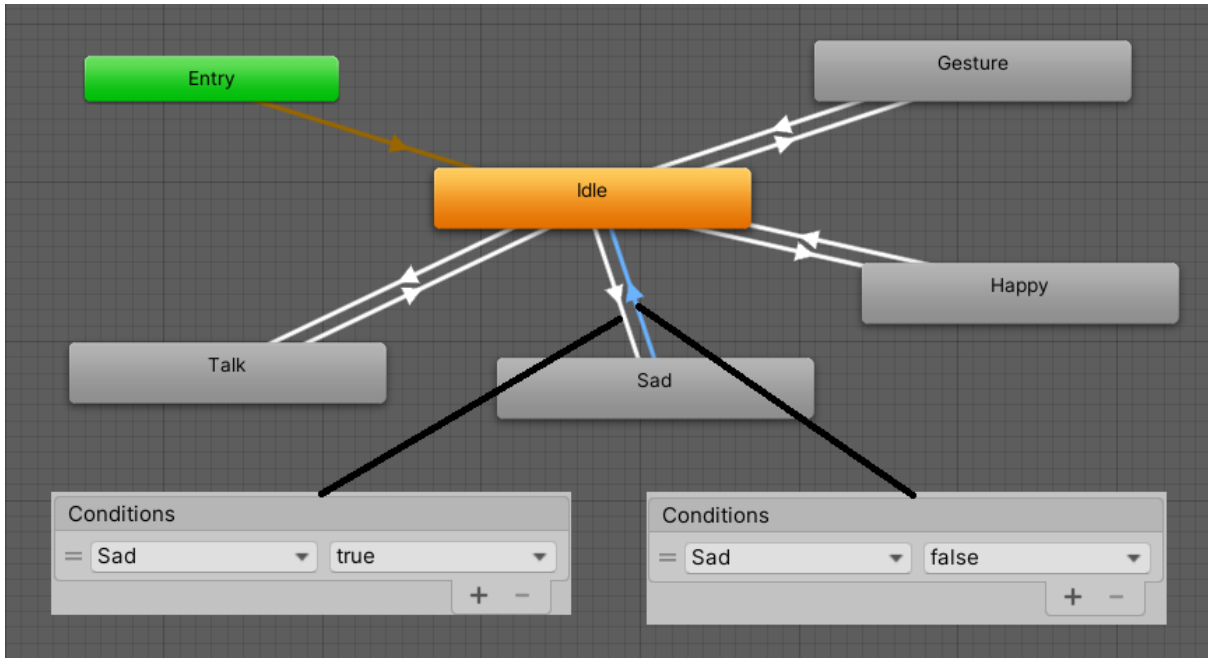


Figure 27: Animation Controller (state machine) with conditions on 'Sad' state.

In order to transition to the state 'Sad' we must fulfill the requirements attached to the connection between 'Idle' and 'Sad'. This is where the boolean parameter 'Sad' come in play. When the parameter 'Sad' is true we transition to the state 'Sad' and back to 'Idle' when the parameter 'Sad' is false.

As mentioned above, the states have animations attached to themselves. These animations are downloaded from Mixamo [29]. By uploading our characters to mixamo we are able to download many different animations which are perfectly fitted to the characters skeleton.



Figure 28: Some animations of Lill, one of the characters in the game. The characters are made by Medielab.

4.6.6 Sound

Correct use of music and sounds in games is important for the general “feel” of a game [25]. Unity makes it easy to implement audio. We attached a component called “Audio Listener” to the player object. This will give the player the ability to listen to sounds in the scene. We can divide the sounds in the game into three main categories. Ambient sound, object sound and action sound.

The ambient sound is the sound that happens in the background, like wind passing through trees or birds singing in the distance. These sounds are played everywhere in scene at the same volume. In this game we have two gameobjects responsible of playing ambient sounds. These are set to “play on awake” and “loop”, which means that when we start the game, these sounds starts to play, and when they finish they start again. It is also possible to stop the ambient sound when the player for example enters a house or a tunnel.

The object sounds are sounds put at a specific location, such as a radio, rivers, cars, electric cables and so on. When the player gets closer to these locations, the sounds gets louder as well. Unity has three choices when it comes to the sound ‘rolloff’, which determines how the sounds change when approaching the objects. These are logarithmic, linear and custom [26]. Most of the object sounds in this game have the logarithmic rolloff. This causes the sounds to be very loud when standing close to them, and decrease quickly when moving away. A challenge occurred when we wanted to have multiple audio sources along an object, in this case a river. It is possible to place many audio sources along the river, which will work fine, but it is not very efficient and we have to be make sure that the sounds are not overlapping if the player is inside more than one sound radius. If there were more time we could develop a system where the river sound where attached to a gameobject that moved along a linear line inside the river, always moving to the position that is closest to the player.



Figure 29: Displays the sound objects along one of the rivers.

Lastly we have the action sounds that occurs every time an action happens. Such actions in the game are footsteps, knocking over barrels and the main gate opening and closing. These sounds are activated through various scripts. For example the footsteps. These are activated when the player moves. The sound of the footsteps is determined by which surface material the player is located above. The game has two different sound types; gravel and grass. These categories have 9 and 5 different sound clips respectively which is picked randomly for each footstep.

4.6.7 Scenes and scene transitions

A scene in Unity is like a level of a game. When entering a new area in a game there is sometimes a loading screen in order to load all the data in the upcoming level. It is beneficial to make scenes in order to have a good overview of your project and to differentiate the “states” of your game. For example when creating one of the tunnels at Fjell Fortress, it is natural to create a new scene, only responsible of the world inside the tunnel. Why not just add the tunnel in the existing scene? Mainly there are two reasons for this. First, we do not want to add too much data to one scene, because it might slow the performance. Secondly, it is better to start from scratch when creating a new environment than to deactivate a lot of the settings from the same scene that has global effects, such as ambient sound and wind settings on objects, which we do not want in a tunnel.

This game has three scenes. A intro scene with the video, the main scene with the ‘VR walk’, and an ending scene where we thank the player for playing the game. When the player exits a scene the screen fades to black and when entering a scene it fades back to normal again. In order to make the fading transitions, a black canvas was placed right in front of the player camera. When the player does the action that triggers the scene change, an animation on the black canvas starts to run. Depending on exiting or entering the scene, the screen fades out or in by changing the alpha value on the canvas. The alpha value ranges from 0 to 1, and decides how transparent a picture is. If the animation ‘fade out’ is triggered, a function ‘changeScene(int)’ is triggered at the end of the animation taking the player to the correct scene. All scenes have an integer it can be referenced by, and it is therefore easy to change to different scenes in a script by giving the integer as a parameter to the scene we want to transition to.

5 EVALUATION

This chapter will explain the evaluation methods and results.

5.1 Evaluation method

Since this project aim to recreate a national site as realistic as possible the evaluation relies heavily on Museum Vest and the museum director Vigleik due to their knowledge and experience of the historical ground.

Our primary method to evaluate the result was through continuous feedback from Medielab and Vigleik. This allowed us to constantly evaluate the progress and result of various aspects of our project.

For the evaluation of the project we have decided to use both qualitative and quantitative evaluation methods.

The qualitative evaluation relies on the response and feedback from both Medielab and Museum Vest/Fjell Fortress. This together with our own perception will be used to evaluate the end result. Medielab will provide feedback on both the game systems and the experience while Museum Vest will mostly focus on the history and the dissemination ability. This evaluation has been continuous during the weekly meetings in the project period.

The quantitative evaluation was initially planned as a user experience test with the target audience. A ninth grade class was supposed to supply mass feedback on the experience as a user. Due to the current situation with coronavirus this was not possible to execute. Therefore we needed new subjects that could perform this test safely. Therefore Medielab set up a presentation where we did a walkthrough of the experience over Zoom and got feedback from an audience, mostly consisting of museum representatives and participants from Medielab.

5.2 Evaluation results

This section provides the results of our different evaluations.

5.2.1 Qualitative results

The basis of our qualitative evaluation is based on the response during our weekly meetings with Vigleik and Medielab. These meetings has been used to verify locations of buildings, objects, and textures for the entirety of the scene. Vigleik from Museum Vest is one of the most knowledgeable resources to confirm the authenticity and realism of the scene.

With the help and guidance of Museum Vest and Medielab the final version now looks and feels like a reconstruction of Fjell Fortress during the specified time period.

5.2.2 Quantitative results

As mentioned we did not have the opportunity for user testing. Our solution was to make a video of one of us playing the game and interacting with the characters in VR and uploading

it to youtube. Afterwards we mailed the video and a questionnaire consisting of 12 questions to nearly 30 people and asked them to watch it and reply to the questions. Among the recipients were people from Museum Vest, Medielab and people from Land Administration and Surveying at HVL.

This will not be representative of a participants experience in VR, but it will showcase the game as best as we can.

A few days later we arranged a Zoom meeting with Øyvind and Vigeik and the aforementioned recipients of the mail, where we explained the concept of our project as well as how we had proceeded to solve it. In the meeting we walked around in VR and streamed the video so they could ask questions during the runthrough or wanted to explore a specific place.

Questionnaire results

The results from the survey showed that 90% of those who answered, were familiar with Fjell Fortress (See figure 30). The survey also showed that the participants came from different backgrounds, which gave them different insights and experience for assessing the project.

13 svar

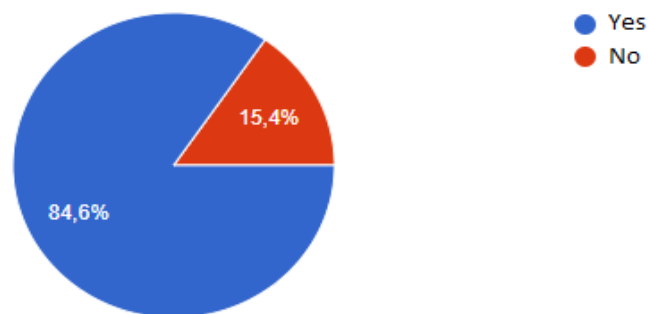


Figure 30: Shows the result of the question “Have you visited Fjell Fortress before?”. This gave us an overview of how many participants were familiar with Fjell.

13 svar

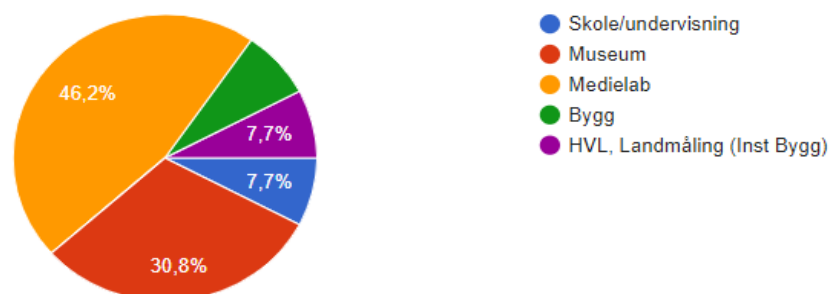


Figure 31: The pie graph shows which category the participants that answered the survey belongs to, in relative size of each other.

It also seems that the participants who have been to Fjell Fortress (answered yes to the first question) recognize the place to a high degree given the answers to the question “*To what extent do you feel that we have succeeded in creating Fjell Fortress?*”(See figure 32).

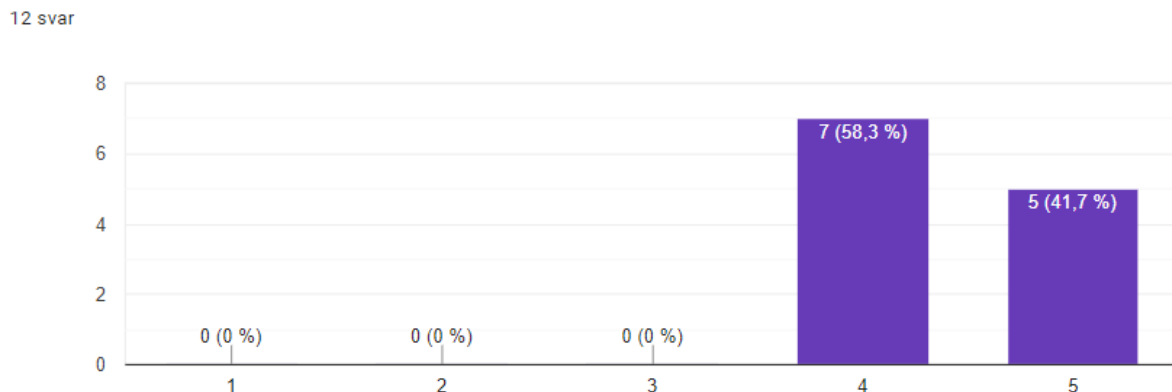


Figure 32 : Displaying the answers to the question “To what extent do you feel that we have succeeded in creating Fjell Fortress”

The question “*To what extent do you feel we are back in 1945?*” was one of the questions with the highest rating. On a scale from 1-5 all answered either 4 or 5 (see figure 33 below).

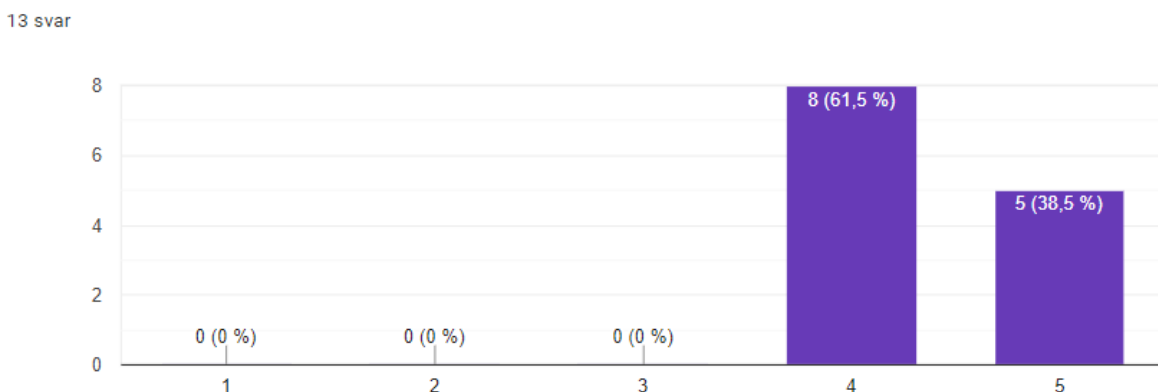


Figure 33: Displaying the answers to the question “To what extent do you feel we are back in 1945?”

They were least satisfied with the sound experience, based on the questions and feedback of the survey (See figure 34). Although some were more positive than others considering the feedback we received on other questions such as “*Was it something that stood out negatively? Something that could have been done better?*”. Some of the comments were:

“It was a nice sound of walking, but often at a little high volume. Some grinding, it got a little tiring at length. And stagnant water does not make sounds.”

“Audio additions to text on the characters. Was a little tired with that gravel sound as it was dominant.”

Answers and questions has been translated to english, see appendix 10.3 for originals.

Given that the implementation of sound was one of the last part added to the scene as well as not been our main focus, we agree that it needs more work.

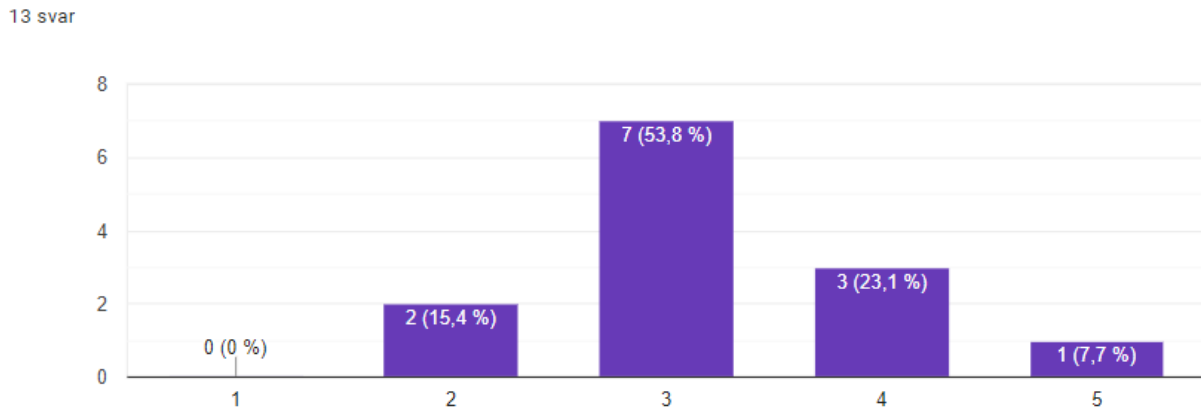


Figure 34: Displaying the answers to the question “How was the sound usage?”.

We already knew in advance that the gamification section was not the best since it is not finished and therefore the part where the participants would probably be most critical. This is reflected in the responses we received regarding the gamification part (See figure 35 and 36 for questions and answers regarding gamification).

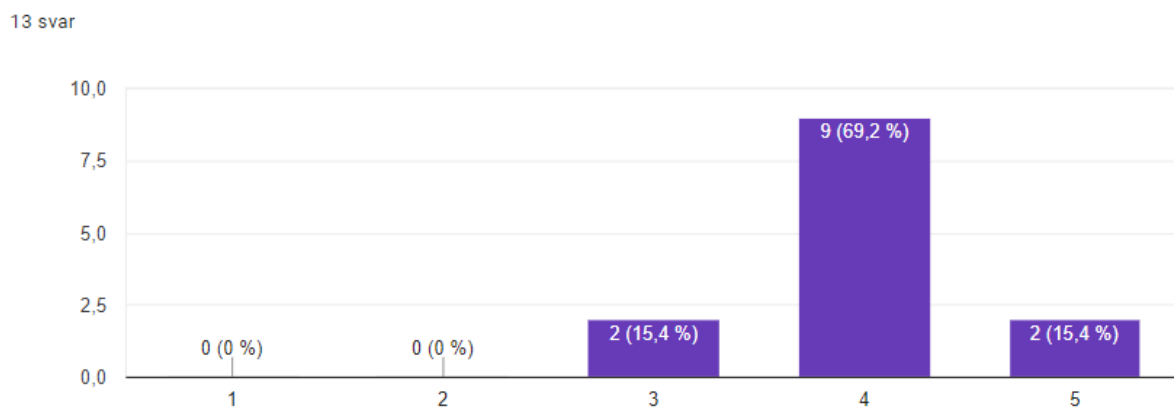


Figure 35: Displaying the answers to the question “To what extent do you think we have managed to create a story surrounding the fortress?”.

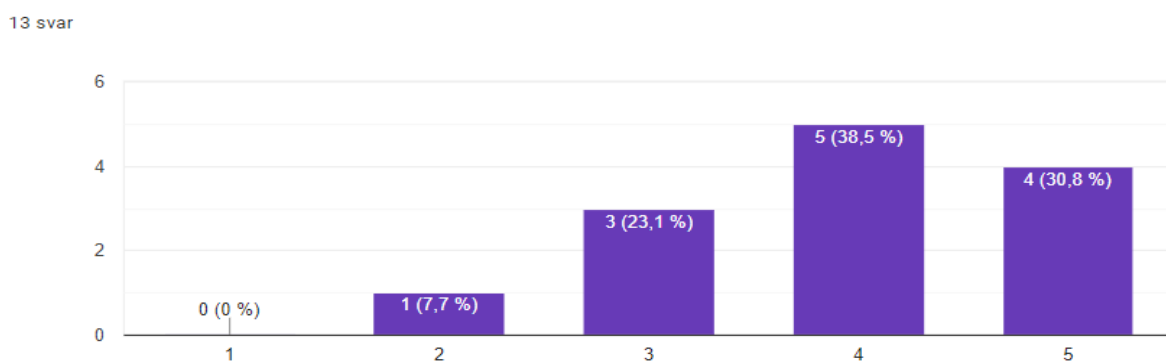


Figure 36: Displaying the answers to the question “To what extent did you feel that the characters and their presence made the experience better?”.

As we can see from the two graphs displayed above the feedback is still relatively good, but there are several participants who feel we can do a better job with the characters and the story surrounding them. Although several of them saw potential for improvement regarding gamification, the majority seemed to want to test the game themselves (See figure 37 displayed below).

13 svar

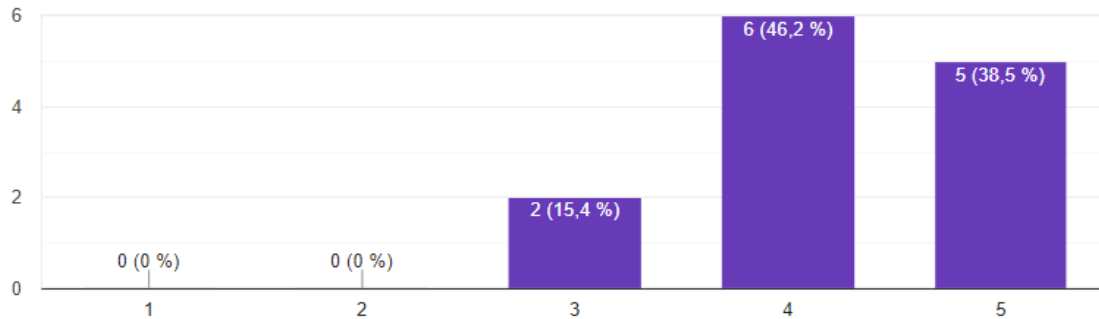


Figure 37: Displaying the answers to the question “To what extent would you like to play the game yourself?”.

Zoom meeting results

The Zoom meeting resulted in many new and different takes on what the final scene could and should look like. The different professions and experiences of the participants became clear from what they decided to focus on.

Most of the participants made it clear that the soundsetting during the playthrough was somewhat overridden by the dominant sounds from walking, however, the participants using a proper headset could pick up the ambient noises in the scene such as birds and wind.

The rest of the discussion mostly revolved around the storyline, the characters and their dialogues, this is one of the parts that can be improved the most. This coincides with our own impression, as well as the result from the questionnaire.

Finally we discussed the topography and texturing of the terrain and the participants considered it to be an accurate and realistic digital recreation of the area.

6 RESULTS AND DISCUSSION

This chapter will explain in depth some of the key elements of the game, and how they could have been improved if we wrote better code and utilized the Unity prefabs better. Also, we will discuss how the results were affected by planning, limitations and workflow.

6.1 Dialogue system

The way the dialogue system is set up is not generic. For each time a new character is to be implemented, we need to create a few scripts, copy code from another NPC and paste it in the new script attached to the new NPC. Also, a few gameobjects, has to be created, such as a dialogue gameobject, a near NPC gameobject and a VIDE manager gameobject. These objects are also copied from other NPC's and tweaked a little bit and added to the new NPC.

This is of course not efficient. In the beginning of the project the characters and the dialogue system were not very complex. For each passing week, we added new functionality and improvements to the character and the dialogues. Some examples of these functionalities are animations, freeze player when talking and add push to talk button. All these new changes were easy to add to our few characters and the existing script, which started to become quite large. When we received all the characters and their dialogues, we had to implement all the functionality to each one of them, which were exhausting and repetitive work. These were also missing some key components (See 6.4.1). As a result of this way of working, there are many dependencies that the developer must know or learn in order to create new characters and dialogue systems attached to them.

6.2 Scripts

If starting this project from the beginning today we would make changes in the way we develop and write code. In regards of writing code, we would divide the large scripts into smaller scripts, making it clearer which tasks each of them had. We would also make general methods that could work for any new NPC we brought into the game. The state of the NPC-scripts as of now, we have to copy and paste segments of code and change the names of the variables to fit the new character.

6.3 Prefabs

Unity has a system where you can make prefabs of gameobjects. Prefabs are basically a copy of a gameobject, which can be anything, that can be used multiple times. In our case, we should have made prefabs of everything that we were going to use frequently, such as dialogue canvases and characters. All we had to do then were to drag the chosen prefab into the scene with all its components (scrips, audio, colliders, etc.).

6.4 Clearer plan

The main focus and goals of the project were clear, but some details developed along the way. Some of these details could save us a lot of time if we had the knowledge we have

today about how the game was going to be played. There are especially two aspects of the game that had a negative impact on the game development that could be avoided if we had a clearer plan to begin with.

6.4.1 The manuscripts

The manuscripts were not finished when we started working on the project. We were given a large portion in the middle of the project phase, but it was not quite finished yet. Vigleik and Øyvind were still discussing some aspects of the storyline. Due to this, not every part of the story and the dialogues exist in the game. There were simply not enough time to implement all the changes from the finished manuscript. As a result, the finished game has a lifeless ending, were we made short and necessary dialogues in order to wrap things up. If starting again today, we would be more aware of our timeframe, and maybe ask Vigleik and Øyvind to create an alternative storyline that is shorter.

6.4.2 'The walk'

Knowing exactly where the player was going to walk in the game, from start to finish, could save us a lot of work. Many hours have been spent on making areas look great which is not ever going to be seen by the player. To be clear, we had a rough idea of the path, but we didn't know how little effect some tiny grass sprites in the distance had on the player camera. If doing the project again, we would focus more on the player path.

6.5 Limitations

Limiting ourselves to only focusing on the route the storyline takes us through made us able to create this area to the best of our ability. This would not have been possible if we tried to recreate the entire area at this level of detail.

6.6 Workflow

By evaluating our progress every week during the meetings with Medielab and Museum Vest we were able to quickly and efficiently modify the scene so that it could accurately represent Fjell Fortress. Having Øyvind and Vigleik were important in order to get quick answers to anything we were wondering about, such as objects positions, size, color and more. This allowed us to work faster towards our goals for the period.

7 CONCLUSIONS

This chapter will present the conclusion of the project. It will go through all the goals we had, if we reached them and how we did it. Finally a reflection on how this project and its results can be useful for any other group or company.

7.1 Goals

We had two goals for this project, the main goal was to realistically recreate the historical area that a person could explore in VR. The secondary goal was the gamification of this area. See 3.2 for more information on this.

7.1.1 Main goal

The recreation of the terrain and the environment at Fjell Fortress 1945 was a long process that we worked on for the entirety of the project. After the evaluation meeting with multiple members from Medielab and Museum Vest we can conclude that the final version of the project is a realistic representation of the area during this period. This is also the groups stand on the final version.

From the qualitative evaluation and the survey we can see that most of the participants agree with this conclusion, see some of the comments below to the question:

“Was there anything that stood out positively?”

“The environment works well. You can recognize the area.”

“The realism in the modelling and structure”

“Good reconstruction of the environment with the terrain, buildings, fences etc. very good!”

Answers and questions have been translated to english, see appendix 10.3 for originals.

7.1.2 Secondary goal

The gamification we have created in this scene is very bare-bones, the dialogue is currently a simple nodebased question-answer system that is missing some of the key elements that will be present in a game. The system is very isolated between different NPCs and their dialogues. Therefore the system will not adapt the dialogues or behaviours of any NPCs based on previously obtained information or actions. As a consequence of this, the experience feels mechanical and not dynamic.

As we can see from both the evaluation (See 5.5.2) and the questionnaire they support this conclusion. Multiple of the constructive critiques were specifically aimed at the dialogues, characters, sounds and the story. All of which is part of the gamification in our project.

This part of the project could in our own opinion become its own project to fulfill its main purpose of reliably present a storyline. Creating the logic for such a system is way out of the scope of this project due to the time limitations we had.

7.2 Relevance for others

This project is about recreating the real world in a VR environment, this can be relevant in many different scenarios.

The fact that museums are lagging behind when it comes to technological developments came to light during the corona situation which were discussed in an article from nrk [28]. It was stated in the article that the museums in Norway are far from a digital revolution.

First of all there are many museums in the same situation as Fjell Fortress, preserving a larger area of historical significance, but they have little to no means of presenting it to the public either due to inaccessibility or missing some of their main historical features. An example of this could be Telavåg harbor during World War II or Herdla airport which was suggested by a representative of Museum Vest during the Zoom meeting.

8 FURTHER WORK

This chapter will explain the different elements that can be improved or added to the project.

8.1 Possible improvements

There are lots of improvements that can be made to the different systems and models in our scene due to limited time of the project.

8.1.1 3D Models and texturing

The scene can be improved in many ways with more proper 3D models and texturing, since we mainly focused on finishing the area where the player would walk. As a result of this other areas on the terrain is somewhat unfinished when it comes to 3D models and textures. Some of these areas have placeholder 3D models that gives the impression that there is something there. There is also more possibilities with the current models in the scene in term of exploring them as well, as of now it is not possible to enter them.

8.1.2 Gamification

The gamification part has many different possible ways to be improved. First of all the coding behind the dialogue system is not generic, this results in much code being duplicated without much reusability. Second is the story and the way it is told, with more time and work the story can be more dynamic so that your choices in the dialogues and route would change the outcome of your playthrough or what type of information you could get from the different NPCs.

8.2 Possible additions

This project is scalable by nature, this means that there is always more elements that could be implemented to improve the overall impression of the game.

Currently the scene consists more or less of only the 3D models and characters required to finish the storyline. Adding animals such as dogs, horses and birds would make the scene more lifelike. The fact that there is also few non-vital NPCs like guards and workers makes the area feel a bit empty.

The dialogues is also without sounds, having voice actors instead of the current dialogue text boxes would make the immersion better.

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10 APPENDIX

10.1 Risk list

Description	Risk of occurrence	Severity of consequence	Mitigation	Response
Not enough time to complete project	Low	Severe	Well structured plan	Some parts of project must be scrapped
Encounter unforeseen problems	Medium	Medium	Have time buffer for unknown issues	Get help, or work around problem
People getting nauseous "walking" in VR	Low	Low	Create a smooth game	Take break if feeling nauseous
Not enough computer power to run game smoothly	Low	Medium	Make terrain less detailed. Use smart graphic solutions	Remove different parts from the game. Lower resolution
People getting sick in the project group	Low	Medium	Be safe and wash hands	Work from home

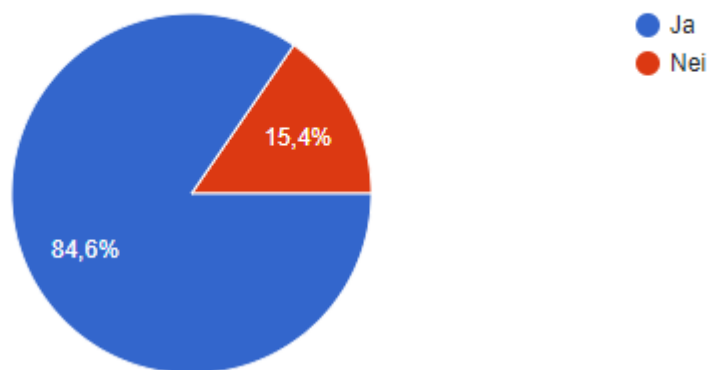
10.3 Survey questionnaire

The survey was conducted online after the the participants watched a video of one of us playing the game and interacting with the characters in VR.

(1= to a very small degree, 5=to a very large degree)

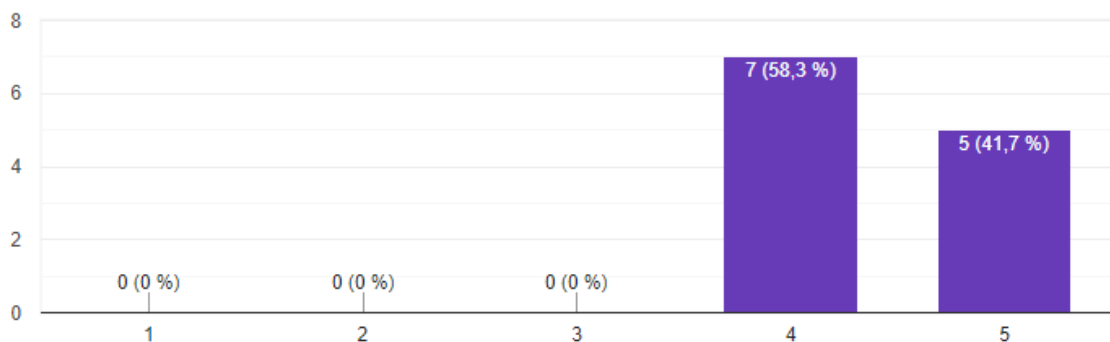
Har du vært på Fjell Festning før?

13 svar



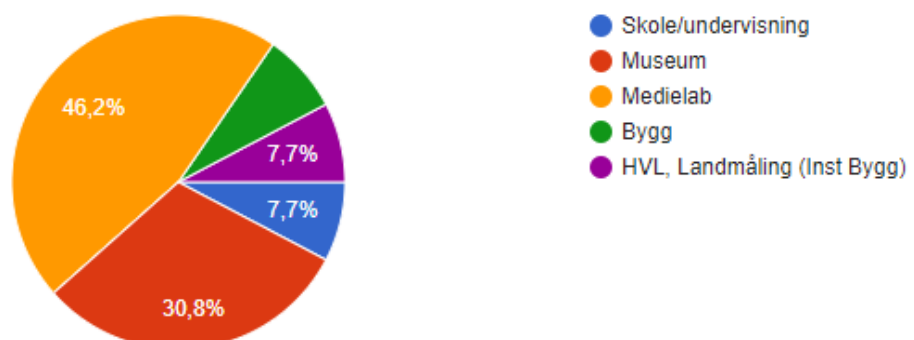
Hvis ja, hvilken grad føler du vi har klart å gjenskape Fjell Festning?

12 svar



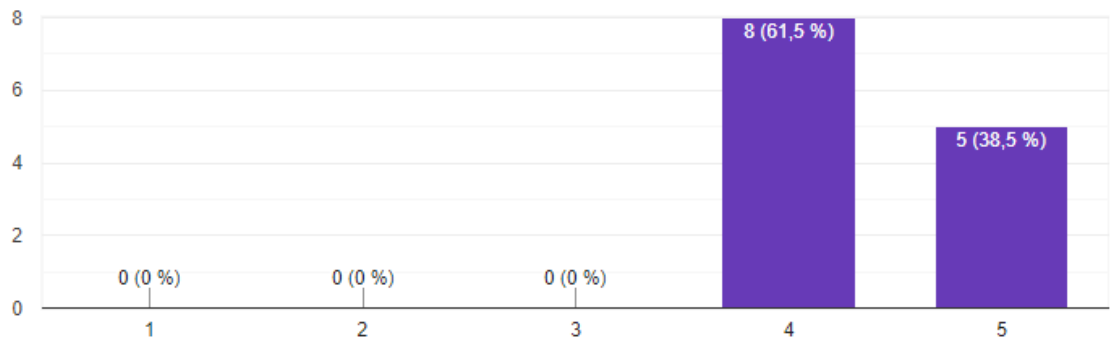
Hvilken bakgrunn har du?

13 svar



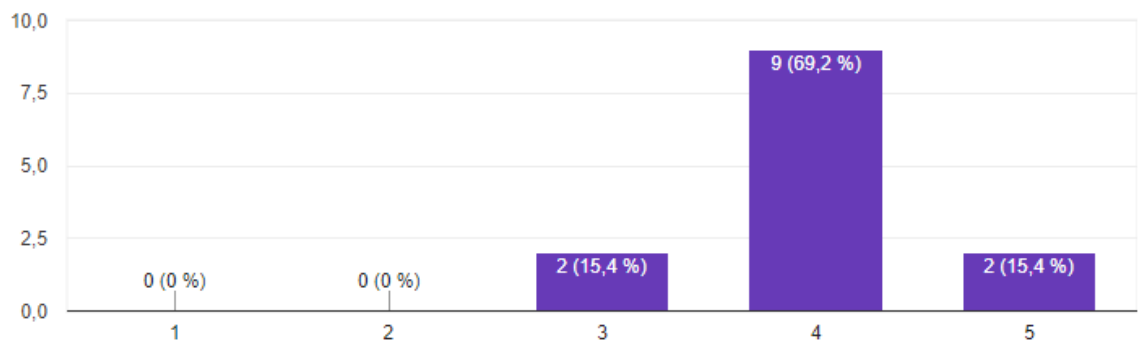
I hvilken grad føler du at vi er tilbake i 1945?

13 svar



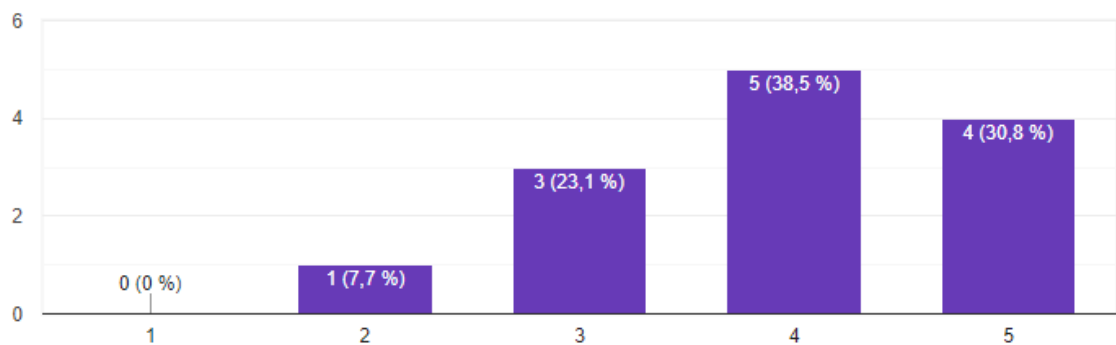
I hvilken grad har vi klart å få frem en historie rundt Festningen?

13 svar



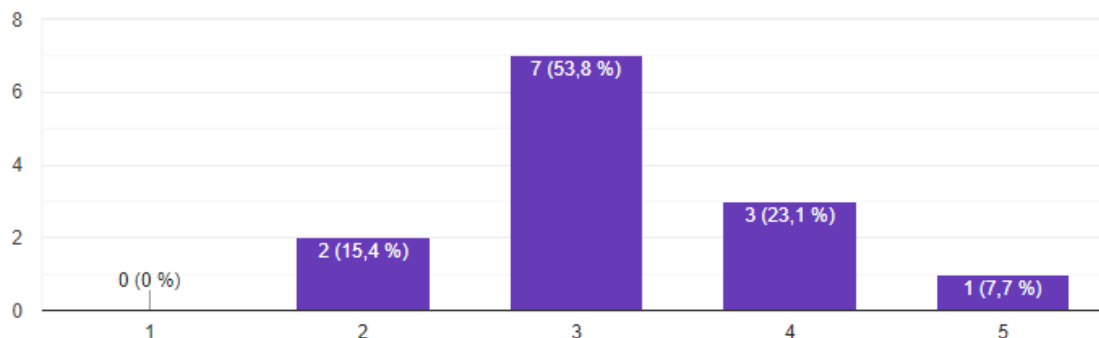
I hvilken grad opplevde du at karakterene og deres tilstedeværelse gjorde opplevelsen bedre?

13 svar



Hvordan var lydbruken?

13 svar



Var det noe som skilte seg ut positivt?

1. Veldig flotte scener. Realistiske personer både i kle og samtale. Gode samtaler, spennende å kunne velge hva man svarer selv. Likte spesielt sjåførere som skulle kjøre journalisten hjem, med bevegelser og prat.
2. Jeg syns dere har jobbet ut omgivelsene på en god måte, selv om det oppleves litt nakent her og der. Kanskje husene er litt for "striglet"/pene?
3. Landskapet er veldig bra. Himmelen.
4. Landskapet
5. Terrenget. Bygninger og topografi ser veldig realistisk ut
6. Interessante detaljer fra historien
7. Verkar solid teknologisk sett, og god gjenskaping av området på Fjell. Liker også utsjånaden og animasjon på karakterar.
8. Landskapet fungerer bra. Man kjenner seg igjen.
9. Realismen i modellering og struktur
10. Flott gjengivelse av området med landskapet, bygninger, gjerder m.m.Kjempebra!
11. Fin grafikk, bra gjennomført!

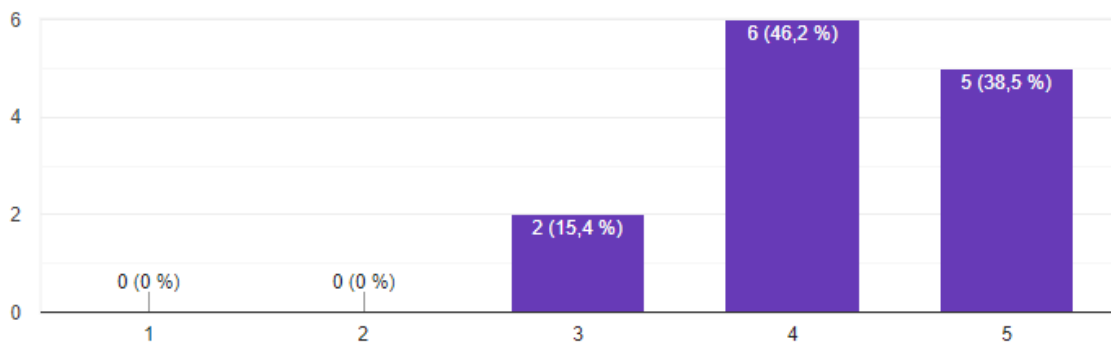
Var det noe som skilte seg ut negativt? Evt. kunne blitt gjort bedre?

1. Det var fin lyd av gange, men gjerne litt høyt volum. En del skurring, det ble litt slitsomt i lengden. Og stille vann lager ikke lyd :)
2. Filmpresentasjonen innledningsvis virker noe skviset sammen i høyden?
3. Det bør jobbes litt mer med layout/typografi i dialogboksene (og ellers der hvor det dukker opp tekstbokser)
4. Det er for få personar å møte.
5. Fysikk - en veldig lett tønne som flyr av gårde i starten, et bilhjul som svever i lufta. Inne i tunnelen virker det som man skaller i taket, det er høyt under taket der i virkeligheten. Lyd - det er lagt havlyd med bølgesus over tjernet. Fjellvann har en annen lyd enn hav. Skrittlyden kan godt endre seg over forskjellig underlag, grus, gress, stein.
6. LYDtillegg til tekst på figurene. Var litt slitsomt med den gruslyden når den var dominerende
7. Eit par av karakterane er ikkje animerte, men dette er de sikkert klar over.
8. Karakterene er statiske. Litt mer vegetasjon. Ser unaturlig ut utenfor veien.

9. Personene burde ikke bli stående når de sier de må komme seg avgårde. Hvis mulig ville jeg hørt svarene i stedet for tekster på skjermen
10. 1.Litt rart at journalisten mot slutten går utenom vege- var han ikke redd for miner? Men om en faktisk spiller, kan en vel styre ham selv? 2.Russerfangen- var han der sommeren 1945, eller var han allerede sendt til en oppsamlingsleir for russiske krigsfanger? 3. I landskapet dukker plutselig nye store steiner og enkelte trær opp. Det ser litt rart ut. Blir litt "hakkete". 4. Kunne samtalen med personene vært løst på annen måte? Litt forvirrende med tre spørsmål i dialogboksen.5. Blir også svært nysgjerrig på om en dame fra Fjell hadde et forhold til en tysk soldat på festningen- og om en brakke virkelig ble sprengt. Kjenner for lite til detaljene i historien her.
11. Lyden når man gikk, det var litt plagsomt

I hvilken grad kunne dere tenkt dere å spille spillet selv?

13 svar



Var det noe dere savnet?

1. Skulle gjerne sett kartet, dersom det ble vist gikk jeg glipp av det. Ble mye gåing, ser for meg at jeg ville hatt problemer med å finne frem. (Jeg har ikke erfaring med spill selv.)
2. Jeg savner å høre stemmen til de jeg møter underveis. Det nevnes et kart. Kan man se og navigere via dette? Har dere en hjelp-funksjon?
3. Litt meir bakgrunnslyd, musikk, hundebjeff?, fuglar
4. Har man kamera som kan ta bilder underveis?
5. LYD på figurene
6. Mogleg eg tek feil, men det verkar som det ikkje er mogleg å OPPNÅ noko med å snakke med karakterane. Saknar meir "gamification", dvs gåter ein skal løyse, informasjon ein skal finne e.a.
7. Lyd på dialogene
8. Å komme opp til kanonen :) og noe random bevegelse i områdene. Fugler, biler i det fjerne osv.
9. Hadde vært flott om personene vi treffer, pratet til oss. Forsto at det var vanskelig å få til.

Har du andre kommentarer?

1. Veldig bra! Stemningen er utrolig bra og realistisk med disse kulissene. Kjempebra jobbet! :)
2. I dialogen: Er det mulig å tydeliggjøre hvem det er som prater? Nå går det litt i surr for meg om det er jeg som spiller eller den jeg møter som prater. Det å gi karakterene en stemme i form av en lydfil ville også ha hjulpet på her, se kommentar over.
3. Elles veldig bra
4. Eg kunne godt tenkt meg å prøve spillet, det er sikkert ein heilt annan opplevelse enn å sjå det på youtube. Det er kanskje viktig å seie at eg aldri spiller, og aldri har prøvd vr-spill, det er dermed vanskelig for meg å vurdere. Men ut frå det eg ser, kunne eg i alle fall tenkt meg å prøve! Trur dette kan vere ein god måte å formidle historie, kanskje særleg til unge som ellers ikkje oppsøker museum? Håpar dåke også får vurdering frå ungdommar som driv med spill til vanlig:-) Mvh Sølvi
5. Godt utgangspunkt for vidare arbeid, veldig pluss at dere laget den grusvei-teksturen
6. Eg kjenner vel å merke ikkje oppgåva, og har vurdert det som "publikum".
7. Det skal bli spennende å få oppleve spillet. Viktig at det ikke blir for "skolete "
8. Synes at dere har gjort en god jobb- spesielt med selve festningsområdet. Kjente meg godt igjen!!