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Aquaculture Simulator

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Aquaculture simulator

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Abstract

Salmon fish farming has evolved to become a multi-billion dollar industry for Norway, with a significant growth in the last 10 years. With the introduction of modern and advanced technical equipment and higher environmental demands, follows a need for further training of experienced fish farmers and aquaculture students. Spreading knowledge about aquaculture and get people interested in the industry is important in order to secure future growth.

This project will continue the development of an aquaculture simulator, supporting virtual reality with Oculus Rift. The simulator allows a user to visit a salmon fish-farm, dive into a fish cage to swim among the salmon, or check out the anchoring of the cages. The player will also have control over the feeding machine, being able to observe the change in behaviour of the fish once the machine is turned on and off.

The goal of the project is to seek out how a simulator can be used for educational purposes and enlightenment of the aquaculture industry. User-testing the simulator at several exhibitions, with an aquaculture class, experts from a fish farm company among others have resulted in great positive feedback and online publicity in different medias. Several companies have showed interest in the project, and want to support the future development.

Sammen drag

Lakseoppdrett har utviklet seg til å bli en milliardindustri for Norge, med en sterk vekst de 10 siste årene. Med introduksjonen av moderne og avansert teknologisk utstyr og et voksende miljøkrav, følger et behov for videre opplæring av erfarne fiskeoppdrettere og akvakultur-studenter. Å spre kunnskap om akvakultur, samt få folk interessert i industrien er en viktig oppgave for å sikre fremtidig vekst.

Dette prosjektet vil fortsette utviklingen av en havbrukssimulator, med støtte for virtuell virkelighet med Oculus Rift. Simulatoren lar brukeren besøke et lakseoppdrettsanlegg, dykke ned i fiskemerdene og svømme med laksen. Brukeren kan også utforske fortøyningen til merdene, og styre foringsmaskinen. Ved å skru foringen av og på, kan en observere hvordan laksen forandrer oppførsel.

Målet med dette prosjektet er å finne ut av hvordan en simulator kan bli brukt i undervisningen, og opplyse folk generelt om havbruksindustrien. Brukertestning av simulatoren på ulike messer, med en akvakultur klasse, eksperter fra et fiskeoppdretts-firma og andre tilfeldig spurte personer har resultert i veldig gode tilbakemeldinger og publisitet i flere nettaviser. Flere ulike firmaer har vist interesse i prosjektet og ønsker å bistå med fremtidig utvikling.

Preface

This document is a master thesis in Computer Science written at the Department of Computer and Information Science (IDI) at the Norwegian University of Science and Technology (NTNU). The duration of this project is from January to June 2015.

The project continues the work of an aquaculture simulator created in TDT4501, a Computer Science Specialization Project which took place from August to December 2014.

I would like to thank my supervisor Ekaterina Prasolova-Førland for support throughout the whole year. Meetings and discussions with her have contributed with useful information and professional input regarding the thesis. Prasolova-Førland's engagement and connections have given me opportunities to show the final product of this thesis at several events, resulting in a lot of publicity.

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Chapter 1

Introduction

This chapter will give a brief overview of the project. The first section describes some background information along with the motivation and reasons for why this project is important, while the second section will give a outline for the remainder of this report.

1.1 Background and motivation

Norwegian salmon have become widely popular around the whole world over the last decades. In 2004 Norway had a total salmon export value of 10 billion NOK, which has grown to almost 40 billion NOK in 2013 [12]. The fish farming industry is expected to grow significantly in the future. This highly emerging marked does not only give good income to the Norwegian people and their government, it is very important for continuing the growth of food production in order to follow the worlds population growth. Towards year 2050, the world need to increase it's food production by 69% [40]. Fish is today one of Norway's largest export sectors after oil and gas, and Norway is currently the 9th. largest fish producer in the world. The ocean offers vast areas of unused "land", to further grow this industry. During NTNU Ocean Week Norway's Minister of Education and Research Torbjørn Røe Isaksen stated the following: Aquaculture is important, and the government is planning to increase funding of aquaculture research the coming years. Norway's prime minister Erna Solberg also stated under the "Eat" conference in Stockholm[11] that the government want to increase focus on fish farming, as an environmental friendly food production. White paper (Stortingsmelding) number 7 from the Norwegian parliament (the Storting) states that the ocean is a prioritized field of study and utilization[32].

Knowledge and interest in fish farming among people is important in order

to secure a continuous growth, and the industry is actively looking for new ways to attract new people to take an education within aquaculture.

The fish farm industry also creates workplaces, and sufficient training and education of employees are needed in order to operate as profitable as possible. Maintaining the fish welfare and avoiding negative environmental impacts are important tasks for an employee, next to keeping up to date with the constant advancing technology that effectively changes the work day at the sea stations.

Måsøval Fiskeoppdrett, in cooperation with SINTEF, NTNU and Sør-Trøndelag fylkeskommune wants to develop an aquaculture simulator which will be placed at Blått kompetansesenter at Frøya. The simulator will address important needs in the regions fish farm industry and educational institutions by creating opportunities to convey knowledge about salmon farming to the public and training both students and existing employees. The simulator project is currently in a planning phase, where one of it's main goals is to develop a smaller and portable demonstration of the simulator.

This project is one of these demonstrations. It's goal is to develop a small serious game (defined by Zyda [23]), where the user will be able to visit a fish farm in different weather conditions, dive into the fish cages to swim with the salmon and see how they react when the feeding is turned on. The simulator will support Oculus Rift, a head-mounted display and game controllers to make the experience as real and exiting as possible. Another goal is to make the simulator portable, so it can be easily moved around to show Norwegian salmon farming to the public, as well as using it for educational purposes at schools.

1.2 Report Outline

The rest of this report is structured as follows:

Chapter 2 describes the project in detail, covering the requirements, research questions and research methods used.

Chapter 3 presents the background theory, as well as the software and hardware used in the development of the mini-simulator.

Chapter 4 will go through the implementation phase, describing how the 3D modeling was done and how the simulator was put together.

Chapter 5 presents the evaluation methods used, and the results obtained.

Chapter 7 will sum up the project in a conclusion and discuss future work.

Chapter 2

Project Specification

In this chapter the research questions will be presented, followed by a discussion of the project scope and requirements. The chapter ends with explaining the research methods used in the project.

2.1 Research questions

The research question for this project have been formalized in one main research question (MRQ) which have been further divided into three sub research questions (SRQ).

MRQ: How can a virtual reality aquaculture simulator be used for education, tourism and promotion of fish farming to the general public?

SRQ1: What are the requirements for such a simulator, and how can it be implemented?

SRQ2: How can such a simulator be used for professional training and education?

SRQ3: How can such a simulator be used for enlightenment of aquaculture to the general public?

2.2 Project scope and main requirements

In the 2014 fall, the first version of the Aquaculture mini-simulator was created, and it received great responses from both Måsøval Fiskeoppdrett and visitors at the Trondheim Tourist Office who tested it. It was originally a project prepared in cooperation between NTNU, Måsøval Fiskeoppdrett and Trondheim Turistkontor. After the successful start of the aquaculture simulator, it was decided to continue the work on the project to improve and add new features. Trondheim Turistkontor have not taken a big part during the second project period, but it is planned to place the final product there to show Trondheim's fish farming industry to visitors.

This project started in January with a meeting between my supervisor, several experts from Måsøval Fiskeoppdrett and me. The most important goals with this meeting was to review the first version of the simulator, and lay down the way ahead for future development. That included specifying what parts of the simulator which should be improved, and which requested features that should be prioritized to implement.

The discussion of the first version suggested two different ways to consider when choosing the future work with the simulator. It should either be concentrated towards an educational simulator to be used in training new fish farmers and students, or a simulator for demonstration purposes to a wide audience. At the meeting it was primarily decided that some fundamental features of the fish farm needed to be implemented, and that the focus should be concentrated towards an attraction for a wide audience. The educational part should however not be forgotten, and aquaculture students from Frøya VGS will still be included in the evaluation of the project.

Fundamental requirements for the project was discussed, and will mostly remain the same as in the first version of the simulator. As seen from table 2.1, the simulator should be runnable on a laptop. Since the simulator will be demonstrated and showed at several occasions during the spring, it is important that it is mobile and easy to move from place to place. It will mainly be targeted towards a wide audience, and should thereby be easy to use for children as well as grown ups, with and without aquaculture experience. That includes easy controllers for movement and navigation, as well as not too complex interfaces for the users.

Support for virtual reality and Oculus Rift is essential in this project. The immersive experience that lets the user actually feel like he/she are visiting a fish farm are not only important for the project owners, it is also something that makes this simulator unique.

The simulator should be available to download from an online source for private use. It makes it easier to spread the simulator, and let users all around the world try it out.

ID	Requirement
1	Runnable on a laptop
2	Easy to use for a wide audience
3	Support for Oculus Rift
4	Available to download online

Table 2.1: Fundamental requirements

The first version of the simulator presents a static world where the player are located at a fish cage. The player can walk around on the cage, and jump into it in order to swim among the fish. Several features was suggested for future work, and it has been carefully decided which ones that should be prioritized. Table 2.2 presents the chosen features.

ID	Requirement
1	Improved Fish cages
2	Anchoring system and sea life around the cages
3	Boat driving
4	Dynamic weather

Table 2.2: Feature requirements

The fish cages needed be more detailed, ideally a replica of a real cage system that is used today. The fish cages in the first version of the simulator was only based on amateur pictures and videos, and not any documented drawings or similar. It was not properly scaled, and lacked details like a sinker ring below water, a bird net to encapsulate the whole cage and the different parts of the cage was poorly detailed.

As there was nothing to see outside the fish cage in the first version, Måsøval Fiskeoppdrett wanted to add more sea life to reflect a real fish farm. They also had a request to implement an anchoring system, in order to show how the fish farm is put together, and held in place. More sea life outside the fish cages would also lower the feeling of a complete static environment.

Driving a boat is an essential task at a fish farm, whether it is back and forth to the main land or between the control station and the different fish cages. It was therefore decided to add boat driving to the requirement list, as it would also open up a lot of new opportunities when it comes to the use of the simulator.

The weather at Frøya is not always nice and sunny. One of the biggest challenges being a fish farmer is handling all kind of weather[17]. It was therefore requested to implement dynamic weather, including both good and bad weather, and waves in the ocean that could be noticed when driving the boat or standing on one of the cages.

Another meeting with an expert from Måsøval Fiskeoppdrett was held the following week in order to go through the anchoring system of a fish farm in detail. This was important in order to get a good overview of the anchoring, as well as learning what parts of it Måsøval though was most important to implement. This meeting also put me in contact with Aqualine, a producer of fish cages[4]. A meeting with Aqualine was arranged, where the goal was to get 3D models of their fish cages and anchoring system - to be used in the Simulator. A short demonstration of the first version of the aquaculture simulator was shown to Aqualine to get them interested, and show them what the 3D models would be used for.

Unity was chosen for further development of the simulator, mainly because it was used to develop the first version. The choice will be elaborated in chapter 3.

2.3 Research methods

Several research methods have been used in order to gain the knowledge required to continue the development of the simulator. That includes both background for the technological software used in the development, and knowledge about how a salmon fish farm is constructed and operate today. Expert evaluations, meetings, demonstrations and presentations have also been conducted throughout the project to obtain information and evaluate the final product.

2.3.1 Literature research

The literature research in this project has been focused on two different aspects: background theory for serious games and virtual reality, and background and introductions to the technology used to develop the simulator. That includes articles, tutorials and documents/references for the software and hardware used, as well as research to get good techniques for both 3D modelling and scripting.

An inspection report[33] from one of the fish farms owned by Måsøval Fiskeoppdrett, and product specifications[13][14] from Aqualine have also been important in order to get theoretical and visual knowledge of what the different components look like, how they are scaled compared to each other, and in general how a fish farm is constructed and held together.

2.3.2 Field Trip

During the fall of 2014, a field trip to Frøya took place in order to visit one of the fish farms owned by Måsøval Fiskeoppdrett. This trip gave valuable insight into the fish farming industry, and the information gained was heavily used in the construction of the fish cage used in the first version of the simulator. The

input obtained, including photos, videos and memories of the trip have also been diligently used during this project, especially to recreate the feeling of driving a boat around a fish farm, and to set up a proper system of fish cages, buoys, feeding pipes and a feeding station.

2.3.3 Expert evaluation, interviews, and demonstrations

As mentioned in chapter 2.2, meetings with Måsøval Fiskeoppdrett and Aqualine were held in order to get a good overview of fish farms, the anchoring system, and obtain 3D models. Such meetings/interviews have been very valuable to this project.

Throughout the project period, several demonstrations of the aquaculture simulator have been held at different events. Expert evaluations by an aquaculture class and experts from Måsøval Fiskeoppdrett have been important in the evaluation of the project, as well as feedback from people who tested it at the demonstrations.

Chapter 3

Background and Related work

This chapter will present related work and the background theory used for developing the aquaculture simulator. The different hardware and software used in the project to create 3D models, the virtual world, and how to control it will also be briefly described.

3.1 Related work

This project is interdisciplinary, covering aquaculture, games, serious games, virtual reality and learning/education. The following subsections will present some related work for the different topics.

3.1.1 Aquaculture Simulators

To my knowledge, there exists no similar aquaculture simulators with focus on virtual reality. That theory can be supported by the popularity the simulator gained and publicity it received from media once it was released - see chapter 7.2. The technology used in the simulator is also relatively new (Oculus Rift was released in 2012), and there are for the moment being limited software that supports development with such technology.

However, a project at NTNU in 2009, in cooperation with SINTEF worked on creating a 3D aquaculture demonstrator, where the user can place equipment and perform simple simulations and calculations. The system is created for Windows, and have limited player interactions. Based on screenshots and description from

their report[2], there is no gamification in this simulator, and the possibility of virtual reality with Oculus Rift did not exist at that time.

Something that could look like an aquaculture simulator, "Aquafarm" [3], was developed in the late 90's/early 2000. It describes itself as "a software for aquaculture facility design, management planning, enterprise development, research, and education". It is possible to download it from its homepage, and a short video of the simulator can also be found at the site. The simulator is mostly text based with some 2D graphic elements.

3.1.2 Aquaculture Industry

Aquaculture and fish farming research is a hot topic in Norway these days. With a long coastline, many unused possibilities for fish farms, increasing salmon prices internationally, and a global need for increased food production[40], aquaculture is described as Norway's next gold mine when the oil runs out. At NTNU Ocean week several projects related to fish farming was presented. None of them was directly connected to an aquaculture simulator, but such simulator could be of much help in their research. Hans Bjelland from SINTEF Fishery presented their research on exposed aquaculture operations [15], where the use of unused sea, further away from the general public and wild salmon are the key points. The unstable weather are the toughest challenge for this project, and they are working on a remote control and monitoring system - perfect for a simulator for training purposes.

Some of the biggest challenges in fish farming today is sea lice, escaping fish and pollution. All of these problems can be solved by using closed fish cages, even usage of exposed areas could be set aside. Ida Strand presented their work on closed flexible fish cages[16] in water. There are limited knowledge of how closed fish cages responds to sea loads, including the ocean currents, different weather conditions etc. They have also been looking at how much of the cage that should be filled with water. Results have shown that the cage might be more stable under strong currents if it is not completely filled.

Another project by SINTEF, presented by Marting Føre[21], are looking into optimizing aquaculture production and fish welfare. As fish cages get larger, it is hard to monitor the fish using conventional observation methods. Their solution is to use acoustic telemetry which is a wireless communication method underwater that works better than radio. By placing acoustic receivers around in the cages, and transmitter tags on a representative selection of the fish, one could monitor the fish behaviour. The data could be used to create mathematical models and equations to describe processes and fish behaviour.

Martin Søreide from Aqualine presented one of their new fish cage systems[22], the one that the fish cages in this aquaculture simulator is based on. These fish

cages are designed to withstand tougher sea, and be more mobile than existing systems. Aqualine have showed interest in the aquaculture simulator, and have been looking at it as a good opportunity to show off their new systems and equipment.

The aquaculture industry has the second most work related injuries in Norway [17]. It is partly blamed on long hours, shift work, and wet and harsh working environment. Today it is more focus and research of the welfare of the fish, than the welfare of the actual fish farm operators. The operators are forced to make safety critical decisions during operations, and is described as an heavy burden. It was raised a question to use an aquaculture simulator, like this one, for safety training.

3.1.3 Serious games

The aquaculture simulator will be developed as a serious game, defined by Zyda [23]. The purpose of a serious game is not pure entertainment, but use it as a tool to achieve the desired goal. Zyda describes how a military war game had woken interest among players to join the US army, and that the game was used for training. The players could learn war tactics, as well as basic weapon handling. In the same way, the aquaculture simulator could create interest among players for fish farming, and lead them to start studying aquaculture, or even start working at a fish farm. The simulator can also be used for training, learning new employees how to operate different equipment and conducting daily routines at a fish cage.

”Serious games represent an important opportunity for improving education, also in a life-long learning perspective, thanks to their ability to compel players and present realistic simulations.”[7]. Bellotti et al., (2011) describe virtual worlds as an important factor to convey knowledge. They propose an approach where games does not need a detailed story, but an open world with a high level challenge that encourages players to explore the virtual world and complete tasks. The tasks may be specified by the teacher and supports different learning styles. They may improve the player’s skills, or exploiting them to make learning easier. The aquaculture simulator will be developed as an open world game, where the player can freely explore the fish farm. In a learning situation it will be possible for a teacher to specify simple tasks that can be done by the learner.

Backlund and Hendrix [5] have conducted a literature survey of the effectiveness of serious games in order to determine whether it is worth the effort or not to develop and use educational games. Out of 40 studies they reviewed, 29 yielded a positive effect on learning by use of serious games. Seven studies had a neutral effect, and only two showed a negative effect. The remaining two was unclear. 12 of the reviewed studies had a mathematical topic, but more practical topics like

fire fighters, surgery and engineering was also included in their study. All of the latter ones had a positive result with use of serious games, which is good when considering developing a serious game for aquaculture. They concluded that the evidence of serious games being effective learning materials in their own, is quite strong.

3.1.4 Gamification

Gamification is a term that has arisen in the 21st Century. Bakker[6] defines it as "applying the mechanics of gaming to non-game activities to change people's behavior. When used in a business context, gamification is the process of integrating game dynamics (and new game mechanics) into a website, business service, online community, or marketing campaign in order to drive participation and engagement" (as cited in Herzig, 2012[26]). The main purpose of gamification is to engage, teach and entertain users of a product.

The aquaculture simulator is a virtual world where the player can move freely around, and can be described as a game by itself. Gamification techniques can still be added, in order to engage and entertain users even more. That includes e.g. giving points or other rewards for completing tasks, high-score tables for competition, and sounds effects to visualize success or failure. A shark was added in the aquaculture simulator, in order to increase engagement and with pure entertainment purposes. That turned out to be rather effective, something that can be seen from the results in chapter 5.3.1.

3.1.5 Virtual reality and learning

The use of virtual reality in learning have become a popular topic over the last decade. It is a field of study that has changed significantly following the technology since the late 60's[41]. The technology have been expensive, and nowhere near today's possibilities when it comes to quality and an immersive experience. Oculus VR released their first head-mounted-display in 2012 [25], which have revolutionized the industry. Section 3.4.1 will describe Oculus Rift in more detail.

For many people, virtual reality have been associated with games, and Nintendo released a virtual reality gaming console called "VirtualBoy" in 1995. It did not become a success, and is considered to be one of the biggest video game console failures[1]. A picture of the Virtualboy can be seen in figure 3.1.



Figure 3.1: Nintendo's "VirtualBoy", Photo: PocketGamer[24]

Immersive virtual reality describes the experience a user will have when using the aquaculture simulator. The main goal of immersive virtual reality is to "place a person into a simulated environment that looks and feels to some degree like the real world"[18]. Military training is one of the first areas where immersive virtual reality was used and it has been rather successful. It has also been successfully applied into training of pilots using flight simulators.. Using virtual reality for such tasks offers more realism than it is possible to achieve in a classroom, and for a less cost than real-world training exercises [10].

Researchers have been looking into the educational use of virtual reality for several years, and besides military training, medical treatment have been a popular topic. Seymour et al. (2002)[29] conducted research in order to show that virtual reality training transfers technical skills to the operating room. Their experiment put 16 surgeon students into the task of removing the gallbladder from a liver. One group would be trained using virtual reality, while the other group would be trained after standard procedures. The experiment resulted in an overall better performance by those students who trained using virtual reality. They completed the surgery 29% faster than the other group. The students who trained using the standard procedures was five times more likely to injure the gallbladder or burn nontarget tissue during the surgery.

It is also possible to utilize immersive virtual reality for learning by using videos. Creating 3D videos for head mounted displays requires multiple cameras shooting in different angles. The cameras can be put in a classroom, so the student can sit at home and watch a course lecture by streaming the video or downloading it from an appropriate web site. Lartigue et al. (2014)[19] discuss such use of head mounted displays, and it is also suggested to put the cameras on the head of a worker in order to get a first person view of real life situations. In this way students can watch how a surgeon performs his tasks, or in this case: watch a fish farmer complete an inspection of a cage or similar.

CAVE systems can also be used for creating an immersive virtual reality experience. Univeristy College London has a virtual lab where a CAVE is built[9]. High resolution stereo pair images are projected on three walls and the floor in real time, and one user can stand in the middle wearing 3D glasses and a head tracking unit. The user will see an illusion of 3D objects appearing both within and beyond the walls of the CAVE, and by moving around the system will calculate new projections based on the head tracking unit. The first version of the aquaculture simulator was tested in the CAVE in January, see figure 3.2 for a photo from the event.



Figure 3.2: The Aquaculture simulator in the CAVE system at University College London, Photo: Ekaterina Prasolova-Førland

3.2 Construction of a Fish farm

In order to construct a fish farm in a 3D world, it is important to know how a fish farm is put together in real life. This theory is gained through meetings with Måsøval Fiskeoppdrett, field trips to a fish farm and an inspection report done by a ROV under the fish cages.

The fish farm that is created in this simulator consists of six fish cages. Each cage is connected to four mooring plates, forming a square around the cage. See figure 3.3 for an overview. Each connection between the cage and the mooring plate consists of two ropes, called a "hanefot" (rooster-foot). The actual connection of the rope to the mooring plate consists of some chain pieces and a shackle.

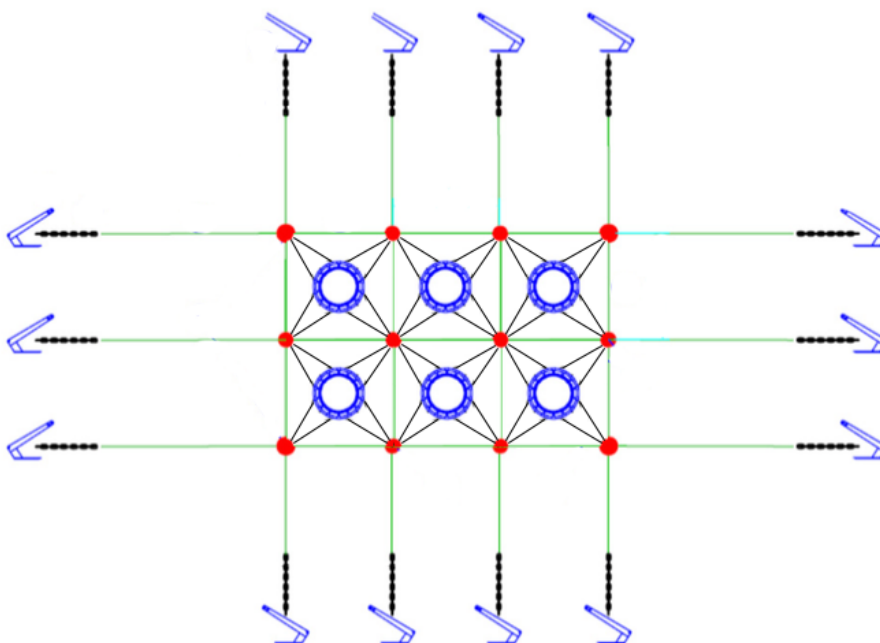


Figure 3.3: The overview of a fish farm with six fish cages. Each connected to four mooring plates with a total of eight ropes. The mooring plates are connected to each other, and to anchors/bolts at the bottom of the sea. Photo: Edited from Aqualine Systemfortøyning[14]

The mooring plates is below water level, each hanging in a buoy by chain.

These buoys are large and yellow, and can easily be spotted next to the fish cages above water. The mooring plates are also connected to each other by rope. In order to keep the fish farm in place, the mooring plates are also connected to anchors and bolts that are placed at the bottom of the sea.

Next to the fish cages are also a control station placed, a small "floating house" where they monitor the cages with several cameras. Six "feeding pipes" are connected to the station and their respective fish cage. The food is processed at this station, and transported to the fish cages through the pipes.

3.3 Software

This section will in short terms present the different software used in the development of the simulator.

3.3.1 Blender

Blender is an open source, free 3D modelling software that was initially released in the late 90's [8]. The software features powerful tools, and has been used to create some of the 3D models seen in the simulator. It has also been used to modify existing models, preparing them for use in Unity.

3.3.2 Solid works

Solid Works is a professional 3D modelling software, and is widely used in the industry to design 3D models and components [31]. Several of the models obtained in this project was created in Solid Works, and thereby only readable by Solid Works. This software was needed in order to extract the models and its components to a format that in the end could be imported to Blender and Unity.

3.3.3 freeCAD

Solid works was not able to export the 3D models to a format readable by Blender or Unity, so a second software was needed to make the transition. FreeCAD is a free 3D model viewer, that was used to open the exported files in a supported format.

3.3.4 Simplygon

Simplygon is a software that can automatically reduce the amount of vertices in a 3D model, in order to generate models with lower level of detail and improve rendering performance [30]. It is a popular and powerful tool that is widely used

among the biggest game producers in the world like Blizzard, Ubisoft, 2K Games and more[39]. Simplygon offers a free and a paid version, the free version had the necessary features for the aquaculture simulator. The company have also created a Unity plug-in that makes it easy to use combined with development in Unity.

3.3.5 Photoshop

Adobe Photoshop CS6 [27] is a popular photo-editing software, and was used to edit the texture images of the salmon.

3.3.6 Unity

Unity [36] is the chosen game engine for this project. It was used to create the mini version of the aquaculture simulator, and it would take a huge amount of time to switch to an other game engine. It has proven to work well, and has over the last years grown to become one of the most popular game engines with over 3.3 million registered developers [37]. Software created in Unity can be built to run natively on most hardware today, from desktop computers (OSX, Windows, Linux) to mobile devices (iOS, Android, Windows Phone), to game consoles (Playstation 4, Xbox One). It can also be built to run in most web browsers, meaning that the end user does not need to download the salmon farm simulator in order to run it.

Unity does also support virtual reality with Oculus Rift and a wide variety of game controllers. All 3D models that are imported to Unity, are put together in an environment, and scripts are written in order to make objects interact as wanted. Unity offers a load of powerful tools like a terrain editor, lights and image effects. The scripts can be written in either C#, JavaScript or Boo [38]. A more detailed description of the implementation in Unity will be described later in this chapter.

Version 4.6 of Unity is used, while version 5.0 was released in the middle of the project. For the moment being, version 5.0 did not have any necessary features or major improvements that would benefit the aquaculture simulator. Upgrading the project files would not be done just by pressing a button, so it was decided to continue using version 4.6.

The Unity Asset store is a marketplace for all kinds of stuff that can be used in Unity, including 3D models, textures, shaders, scripts, sound effects, etc. Any developer can create assets and put them for sale in the asset store. Other Unity developers can access the asset store inside Unity or in a web browser in order to buy and download assets for use in their own games and projects.

In this project, three assets have been used in order to improve the simulator by adding finished components instead of spending time creating them all over.

This includes a fish school asset that is used to simulate the salmon inside the cage, buoyancy scripts for water simulation and a rope generator.

3.4 Hardware

This section will present the hardware used for the final aquaculture simulator developed during the project.

3.4.1 Oculus Rift

Oculus rift is a head-mounted display that was initially released in 2012[25]. With two small screens, one for each eye, a 110°field-of-view (FOV) and the ability to use your head to look around, Oculus Rift will give a good virtual reality experience for the user. For the moment being (Spring 2015), two version of the headset have been released: Development kit 1 (DK1) and Development kit 2 (DK2), see figure 3.4. The DK1 has a resolution of 1280x800 pixels, while the DK2 runs at full HD, 1920x1080 pixels. The latency and motion blur by turning your head around has caused sickness for a lot of people, especially with DK1. That has been significantly improved in DK2, making it a far better experience for the users. The DK2 does also feature a detection camera which tracks the movement of the headset.

DK2 will be used for the development and evaluation of the aquaculture simulator.



Figure 3.4: Oculus rift: DK1 (left) and DK2 (right)

3.4.2 Game controller

A game controller will be used for movement and other actions in the aquaculture simulator. The simulator will still support keyboard and mouse, but a game

controller requires less space, and is ideal for showing and testing at stands and presentations.

Most game controllers today would do the job. Besides Sony's Playstation 4 controller, and Microsoft's Xbox controller, there exists a lot of cheaper options coming from smaller and much less known companies. A Playstation 4 controller was chosen in this project, mainly because that is what the developer had in hand. It is easily connected to a laptop (or any other machine) running the simulator with Bluetooth or a USB cable. The controller can be seen in figure 3.5



Figure 3.5: Playstation 4 controller

Chapter 4

Implementation

This chapter will describe the implementation phase, explaining the requirements in more detail and covering the 3D modelling, structuring and scripting.

4.1 Requirements

Table 2.2 in section 2.2 lists the requirements set for the development phase of this project. This section will explain the requirements in more detail.

4.1.1 Improved fish cages

It was requested by Måsøval to increase the level of detail in the fish cages, in order to increase the overall realism feeling when using the simulator. Increasing the realism will make the simulator feel even more immersive. In order to use the simulator as a serious game, it is also important to maximize the level of detail. If students are supposed to complete simple inspection routines on the cage, the cage must look as real as possible, and not contain unrealistic simplifications when it comes to the 3D models. To achieve as detailed fish cages as possible, the 3D models of the fish cages should be made by professionals. It could either be bought online, or supplied by a fish cage company like Aqualine, who have donated 3D models of their products to this project. The description of the creation and implementation of the cages can be seen in section 4.2.1 and 4.3.4.

4.1.2 Anchoring system and sea life around the cages

Adding an anchoring system became a requirement in order to expand the world the user could explore. It is also an important part of a fish farm which was not

present in the first version of the simulator. As described in chapter 3, Bellotti et al., (2011) suggested that virtual worlds are important to convey knowledge. By expanding the virtual world from the first version of the simulator, and adding an anchoring system, the simulator will be more suitable as a serious game. The anchoring system was implemented using the background theory learned by Måsøval Fiskeoppdrett as described in chapter 3.2. Appropriate 3D models were either obtained from Aqualine, or created in Blender.

Adding sea life around the cages would not only give a more realistic picture of a real fish farm, it would also decrease the user's impression of a static world. It was decided to add a shark, which does not add realism, but as a gamification feature to increase the enjoyment of using the simulator. Adding general sea life around the cages can be done using a fish school like the ones used inside the fish cages. The 3D model of a shark can be found online, or created in Blender.

4.1.3 Boat driving

Making it possible to drive the boat around is an important feature in order to let the user explore the rest of the fish farm, and navigate around in the virtual world. A boat is also an essential tool used when working as a fish farmer, as some of their daily tasks is to perform inspections at the different fish cages. Driving the boat around might also be a fun thing to do for the users, and will add a level of excitement. The boat driving itself could be added by creating a script to move the boat around. It could either be a simple movement script, or an advanced script with support for buoyancy so the boat will detect waves and move along with them. Downloading an advanced buoyancy script from the Unity Asset store would save a lot of time, and make the experience more immersive than a simple movement script.

4.1.4 Dynamic weather

The dynamic weather is also a requirement that will make the simulator more immersive, and make the virtual world less static. As a serious game, a dynamic weather adds realism to the simulator, and will make it possible for users to do tasks under different weather conditions. Dynamic weather must be controlled by a script, and will in this project consist of good and bad weather. Rain can be added using a particle generator that will be placed above the player's head, and waves can be increased or decreased by the buoyancy script.

4.2 3D modelling

The work with the 3D models have mainly been performed in Blender, with some usage of SolidWorks, freeCAD and Simplygon for converting between 3D formats and automatic generation of simplified versions of the models. Some models are reused from the earlier project "Aquaculture simulator", while others are remade. Aqualine [4] is a supplier of fish cages and belonging equipment, and have been supportive with 3D models of their products. This section will in detail describe the different 3D models used in the simulator.

4.2.1 Fish cage

The fish cage is one of the main attractions, and thereby one of the most important 3D models in the simulator. The cage has been completely remade by request of Måsøval Fiskeoppdrett. A full-sized fish cage model was received from Aqualine with a great level of detail. Without reducing the user experience, some minor simplifications have been made in order to improve performance.

Unfortunately the model came in a format that was not readable by Blender or Unity. It took a good amount of work to extract the different parts of the fish cage, and convert them into a supported 3D format. The main visual differences between the old and new fish cages lies in the details of the metal construction that holds the cage together, and the overall size and dimensions of the cage. There have also been added some new details, like ropes and a sinker ring that were not present in the earlier version. Following comes a description of the main components of the fish cage:

"Pipes" The black pipes that keep the cage floating was impossible to convert from Aqualines models without adding a great amount of unnecessary geometry-points, resulting in a unnecessary largely sized 3D model. The pipes were therefore remade in Blender with Bezier Circles, scaled to have the same dimensions as a real fish cage. The results from Blender can be seen in figure 4.1.

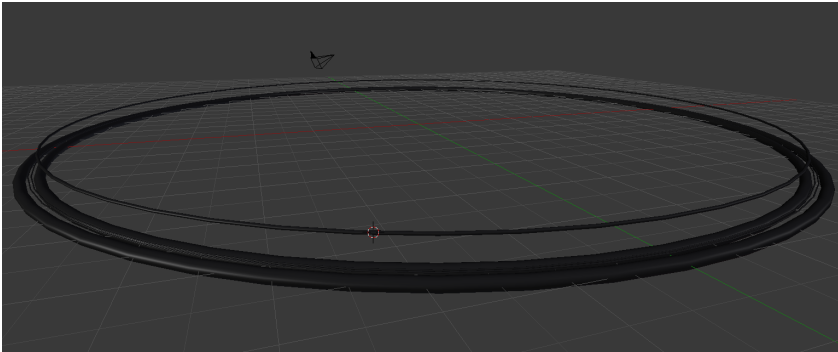


Figure 4.1: Fish cage pipes in Blender

”Metal stakes” Four different metal stakes are used, based on different features that supplies them. They are all extracted from models obtained from Aqualine and can be seen in figure 4.2. A few details like the chain and lock on two of the four models are added manually in blender. For a comparison to the old model see figure 4.3. A total of 60 metal pieces holds the cage together.

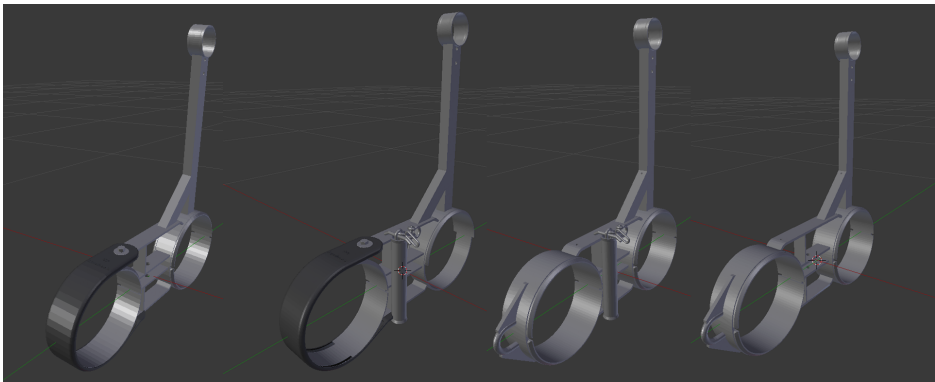


Figure 4.2: Four different metal stakes

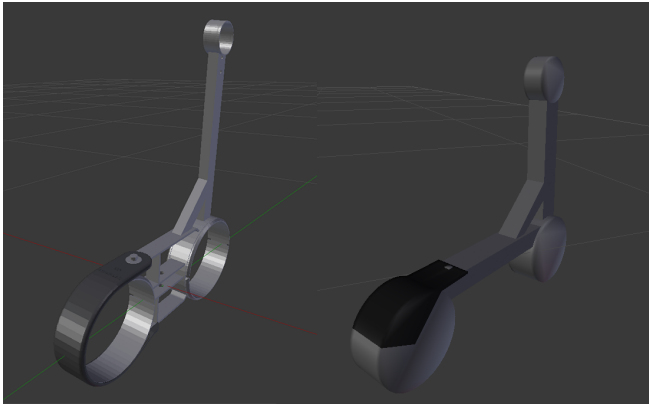


Figure 4.3: Comparison: new stake (left) and old stake (right)

”Floor” The floor around the cage was remade to fit the new design. It consists of simple plane meshes that has transparent lattice textures attached. Aqualine did also supply a 3D model of the floor, this model consists of 300 000 triangles. A 2D plane with two triangles yield almost the same user experience and a lot less computational power is needed to render. The floor construction from Blender can be seen in figure 4.4.

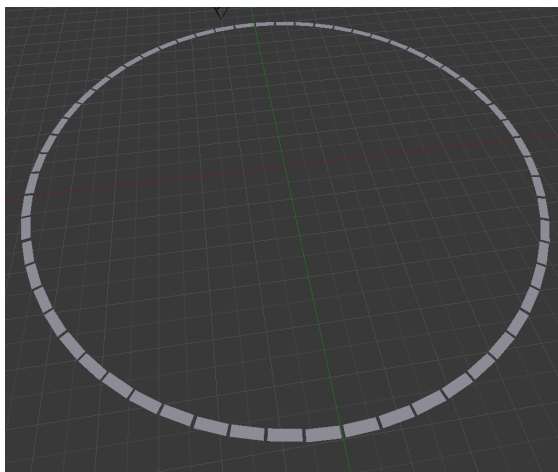


Figure 4.4: Floor construction in Blender

”Net” Aqualine did not have any models of the fish net, so the net from the previous model is reused, only with some small scaling modifications to make it fit the cage. As with the rest of the cage, the net is extracted as a separate model, and can be seen in figure 4.5.

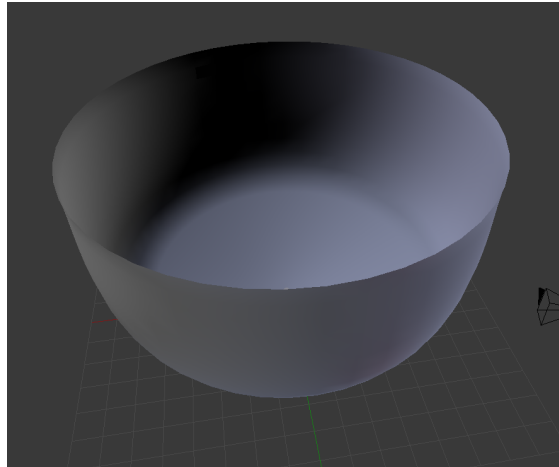


Figure 4.5: The fish cage net in Blender

”Sinker ring” A sinker ring was created and added to the model, as it was missing from the previous version. The ring itself was created by a Bezier Circle like the other pipes in the cage, and looks the same as one of the rings in figure 4.1. The ”bottom clamps” that the rope from the fish cage is attached to is supplied by Aqualine, and can be seen in figure 4.6.



Figure 4.6: A bottom clamp that will be attached to a sinker ring

”Chains and ropes” ”Ultimate ropes”, a third party script from the Unity Asset store [35] have been used in order to generate the ropes and chains seen in the fish cage. The script requires a texture for ropes, or a 3D model for a chain. By default the ropes have attached physics, but to improve the overall performance, a static copy of the generated rope was created and used instead. The rope endpoints with a metal loop was created in Blender, and have a texture applied. Figure 4.7 shows the endpoint from Blender, and with a texture applied in Unity.

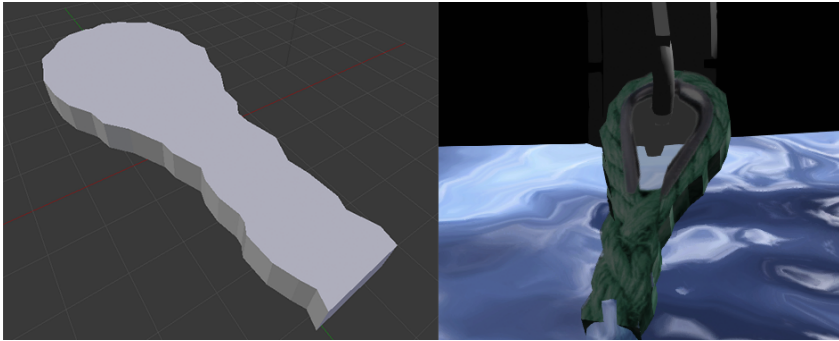


Figure 4.7: The rope endpoint from Blender (left) and with a texture applied in Unity (right)

Figure 4.8 shows the chain model used, and a shackle model which is used in the end of the chains.

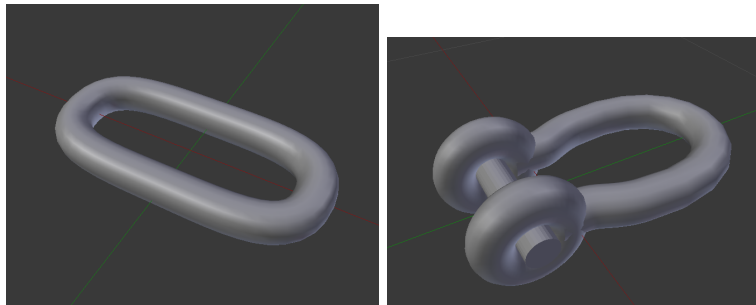


Figure 4.8: Chain model (left) and a shackle model (right) created in Blender

4.2.2 Mooring plate

The mooring plates was obtained from Aqualine, and imported to Blender. A few simplification of the model was conducted before it was made ready for Unity. The mooring plate can be seen in figure 4.9.

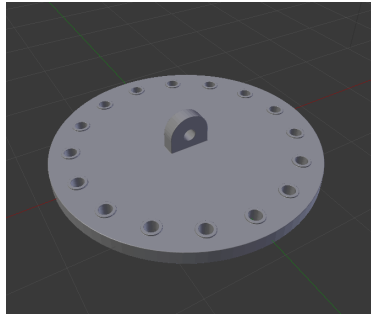


Figure 4.9: The mooring plate in Blender

4.2.3 Buoy

Buoys can be seen floating around the whole fish farm, keeping the mooring plates in place. With a picture and dimensions of a buoy from Aqualine, a simple look-alike model was created in Blender. Yellow and grey solid colors was then applied to the different parts of the buoy. The model from Blender can be seen in figure 4.10.

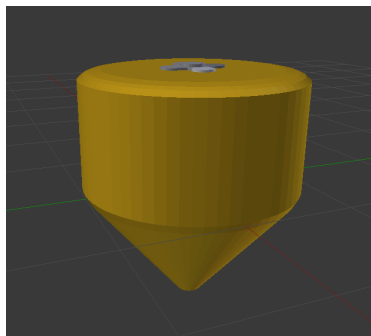


Figure 4.10: The buoy created in Blender with colors applied

4.2.4 Endpoint/Bolt

A bolt and two floating underwater-buoys was created in Blender, as components to a look-alike endpoint for the anchoring system. The results can be seen in figure 4.11. The final result after the models were put together will be described in the following Unity section.

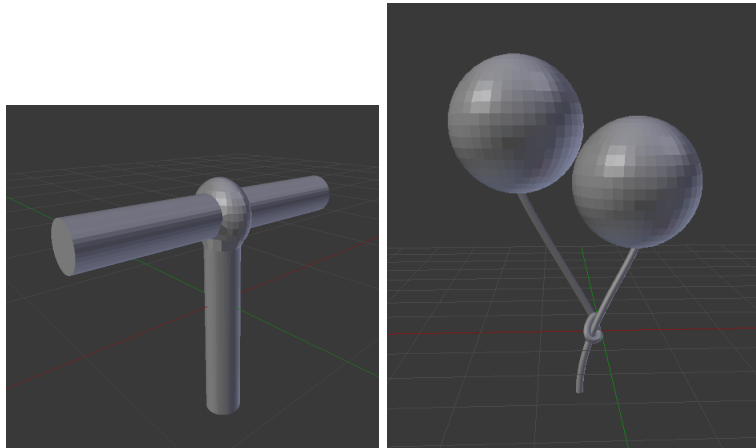


Figure 4.11: The bolt (left) and underwater-buoy (right) created in Blender

4.2.5 Shark

A 3D model of a shark was downloaded from TF3DM[34]. The model consist of the 3D model and textures. A huge shark swimming around a fish farm is not realistic here in Norway, but it was added because a lot of the testers have asked for it. It's a part of the gamification described in chapter 3.1.4, and contributes with fun and excitement while exploring underwater scene. The model can be seen in figure 4.12.

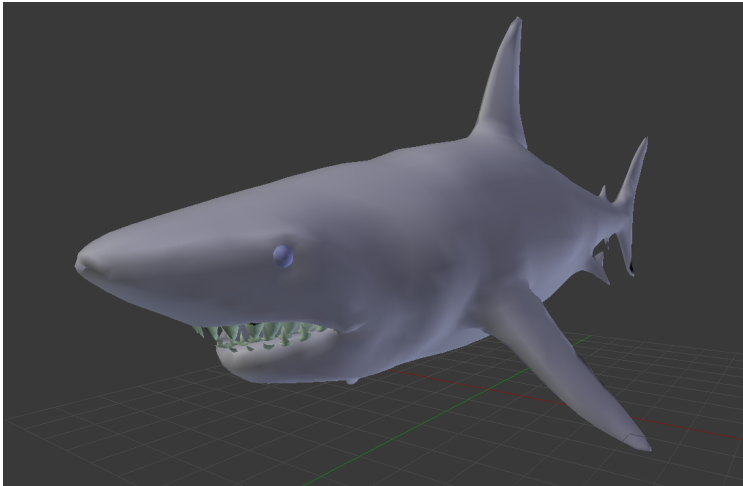


Figure 4.12: The shark model in Blender

4.3 Unity

The following subsections will describe in detail the process with Unity, including the modelling and scripting, what have been done, and what parts that are reused from the old version of the simulator.

Most of the components from the old simulator have been replaced or modified during this project, only a few components remain in it's original form. The reason is mainly a request of higher detailed models from Måsøval Fiskeoppdrett.

4.3.1 LOD - Level of detail

Each fish cage consists for about 1 million triangles to render. Adding several fish cages, along with the mooring plates, ropes, buoys and all other game elements have a serious impact on the performance. In order to get an overall better rendering performance, the principles of LOD is used. That means, the greater the distance from the camera to a game object, the less detailed 3D model is used. A third party application called "Simplygon" [30] is used to automatically simplify the existing models. Each game object in the aquaculture simulator has 3-4 levels of detail, each with 50% less triangles than the previous model. Unity has built in support for LOD objects, which comes in handy.

4.3.2 The terrain

The terrain has only received some small modifications. The bottom of the sea was completely flat, that is now changed into a more bumpy terrain as seen in figure 4.13. There is also some small improvements to the textures used at the bottom of the ocean.

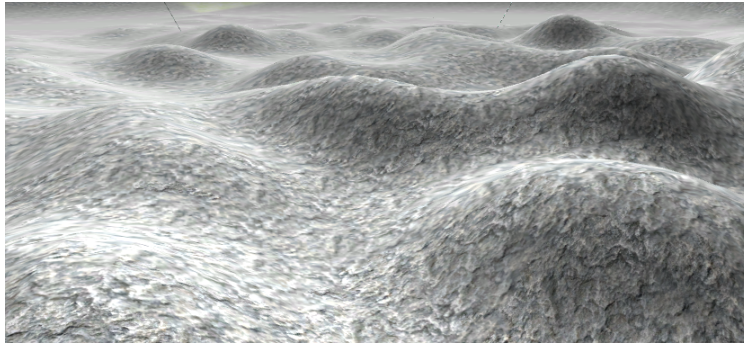


Figure 4.13: A view of the bumpy sea bottom

4.3.3 The sea

One of the main requirements of this project was being able to drive a boat around the fish farm, and simulate bad weather with high waves. The boat model will be reused from the last version of the simulator. The boat driving could easily be done by just moving the boat model around, but the experience would be very static and non-natural. Implementing waves on the current sea is not possible, as it is just a flat plane with a water shader attached. To accomplish both waves and a nice boat driving experience, implementing buoyancy is essential. The Unity Asset store does offer some different buoyancy motors, and in this simulator an asset called "Dynamic Water" [20] is implemented. It offer a nice ocean shader alongside with scripts that can make existing game objects float. It's water system can also simulate waves.

In order to make objects floating, one must decide what part of the object that should collide with the water, an anchor point, and weight of the object. The buoyancy script from the "Dynamic Water" asset will generate several cubes spread around the attached object that will handle the water collision. An invincible cube were added to the boat to make it float the preferred way. When the waves are turned on, the boat will feel light and follow the height of the ocean, while the fish cages will feel heavier and are much slower in their movement.

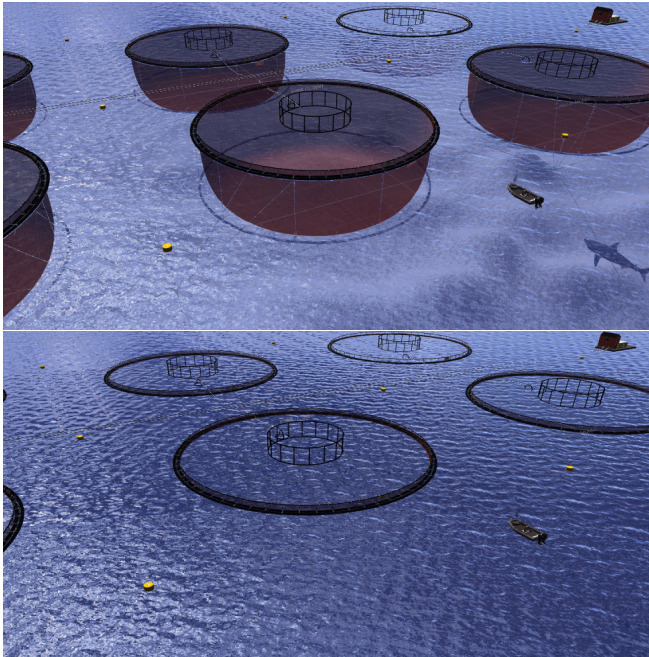


Figure 4.14: Water see-through fix by adding a black plane beneath the water plane

As in the previous version of the simulator, the new water shader is "see-through", making the whole fish cages and the bottom of the ocean visible from above water. Adding a solid black plane just underneath the water plane makes it look more realistic, see figure 4.14. The water plane is also just visible from one side. In the previous version of the simulator, the water plane was rotated 180 degrees once the player got under water. This solution will not work with the new water system, as the buoyancy script does not work on a water plane that is upside-down. All floating objects would just stop floating and disappear if this is done. Instead, another water plane is added upside-down just below the water level. This water plane is static, and does not support waves. That means if there is huge waves, the waves will not be visible under water. A user would in normal circumstances not notice that unless he/she is aware of it.

4.3.4 The fish cage

In the previous version of the simulator, the whole fish cage was one 3D model created in Blender. It was low detailed, and not correctly dimensioned. As described in the modelling phase, the different parts of the cage was made ready for Unity in Blender. The cage itself is put together in Unity, piece by piece. This makes it easier to modify the model, and utilize the use of LOD as much as possible. The closest metal pieces can be highly detailed, while the the ones at the other side of the cage remain low detailed. A bird net has been placed over the whole cage, a huge solid mesh with a transparent texture. The ropes that connects the fish net to the floating ring has also been added, generated with help of the Ultimate Ropes asset. Figure 4.15 shows a detailed picture of the new cage, with rope added at the top tube and metal stake.

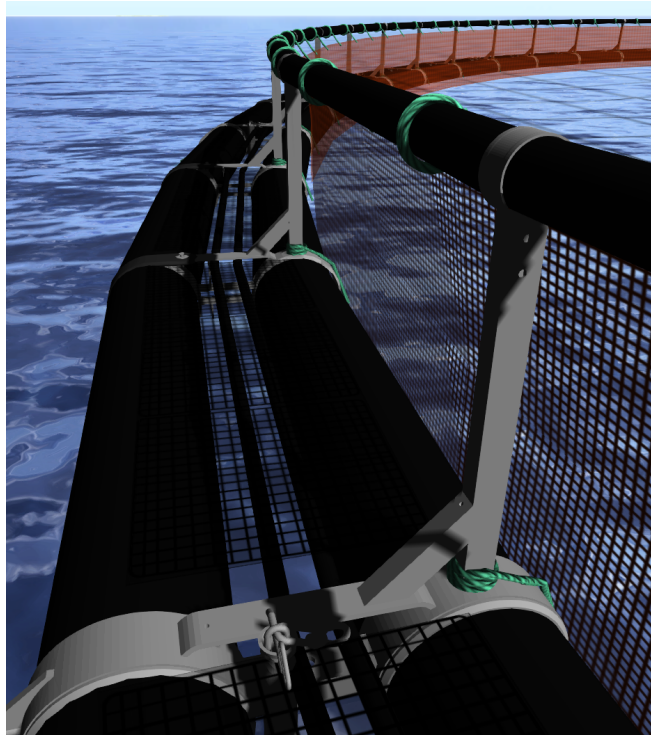


Figure 4.15: A detail picture of the fish cage

A sinker ring is an important part of the fish cage that was missing, and is added in this version. The tube is stretched around the whole cage, hanging in the fish net and floating tubes. Figure 4.16 shows the results, compared to a real picture taken by a ROV. Details like the "bottom clamps" and chain pieces was added manually afterwards, while the rope that connects it to the rest of the cage is generated with the Ultimate Ropes asset between two fixed points.

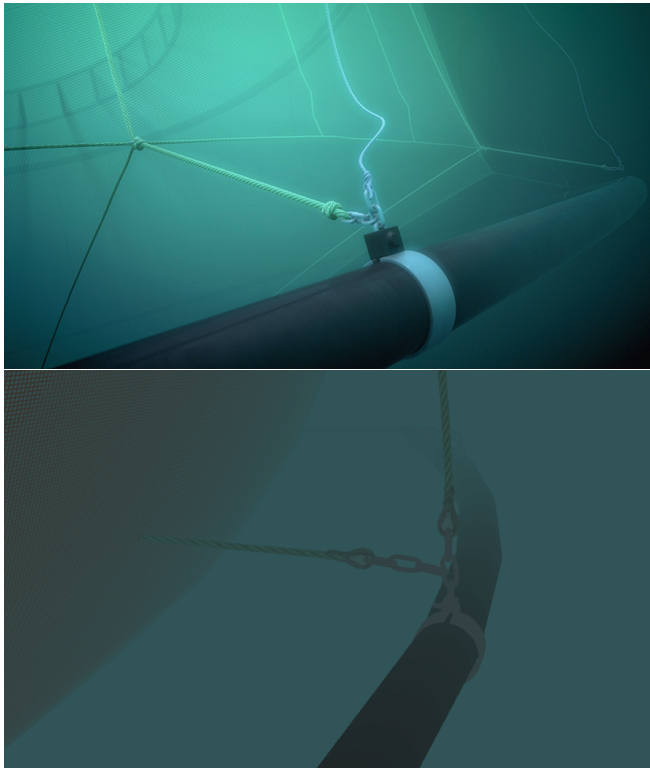


Figure 4.16: A comparison between a real sinker ring (Photo from Aqualine) and the one created in Unity

The fish net was properly rescaled to fit the new cage, and match up with the given details from Aqualine for width and depth. It uses the same texture from the old model. Eight attachment points was also added around the floating ring, where the anchoring of the cage is attached. Figure 4.19 in chapter 4.3.6 show how the attachment points are used.

4.3.5 Weather

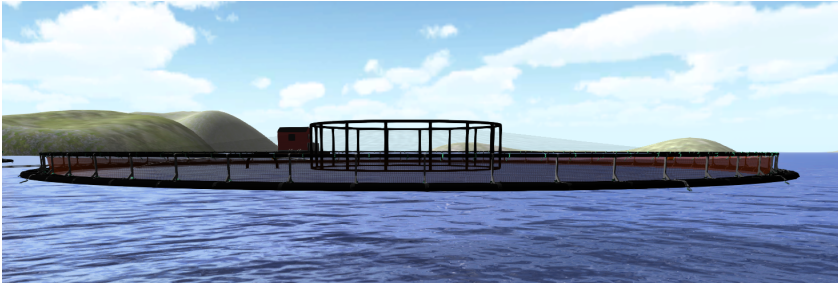


Figure 4.17: Good weather

Two different weather conditions have been implemented in the aquaculture simulator. Good and bad weather. When the weather is good (figure 4.17), the sky is blue, the sun is shining and the water is calm and one could barely spot the waves. When the weather is bad, the lights are dimmed down, the sky is cloudy, distant fog is visible, it's raining and the waves makes the whole scene and it's components move up and down (figure 4.18). Switching between the weather conditions is done by a button press as seen in table 4.1. The button press will trigger an action defined in the playerscript (see sub section 4.3.10) that will make all necessary changes to the environment. The rain is generated using a particle generator which is placed above the player, while the waves are controlled by the buoyancy script described in chapter 4.3.3.

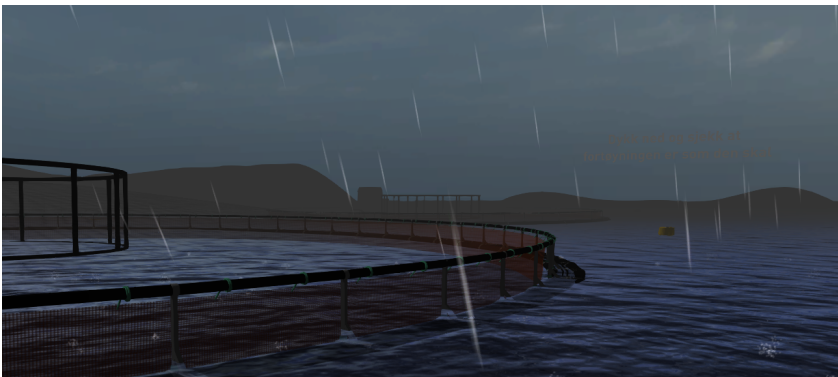


Figure 4.18: Bad weather

4.3.6 Anchoring system

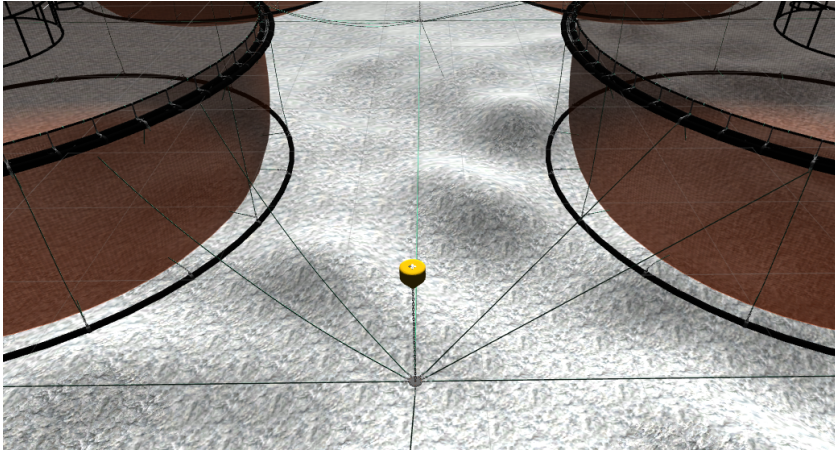


Figure 4.19: An overview of the anchoring system, showing how the cages and buoys are connected to the mooring plates. (Water removed)

The anchoring system was non-existent in the previous version of the aquaculture simulator, and one of the biggest changes in this version. Each fish cage will have four buoys around itself, and the buoys will be the only part of the anchoring system visible above water. Under each buoy, a mooring plate is placed, and a chain is generated using the Ultimate Rope asset to connect these two parts. A brief overview of how the cages and buoys are connected to the mooring plates can be seen in figure 4.19. At each mooring plate, up to 12 empty objects are placed as rope ends. These empty objects are used to connect each mooring plate together with ropes, and to fish cages and bolts at the bottom of the ocean. See figure 4.20 for the final mooring plate compared to a real picture taken by a ROV. The ropes connected to the main fish cage is affected by physics, meaning it will act as a rope, and move along with the cage, holding it in place during bad weather. The rest of the ropes anchoring system are static due to performance reasons.

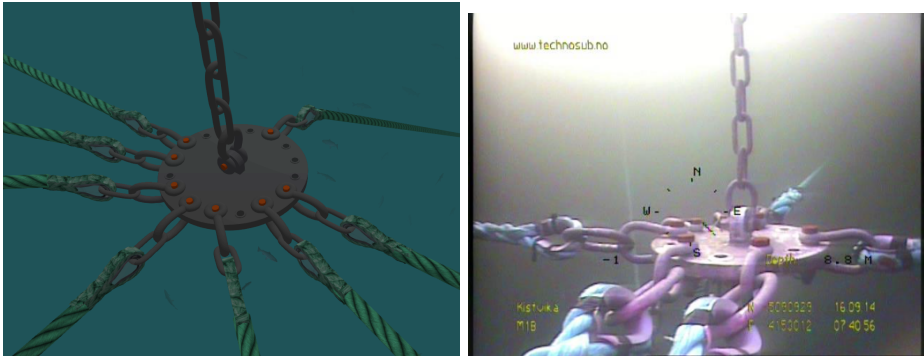


Figure 4.20: A mooring plate in Unity and a real picture taken by a ROV

The bolts are placed at the bottom of the sea. Between the bolts and mooring plates are chain and ropes generated using the Ultimate Rope asset. At the transition between the chain and rope are the underwater buoys attached. Figure 4.21 and 4.22 shows a comparison between the final result in Unity and real pictures of the bolt/endpoint.



Figure 4.21: Comparison of the transition between rope and chain with an underwater buoy

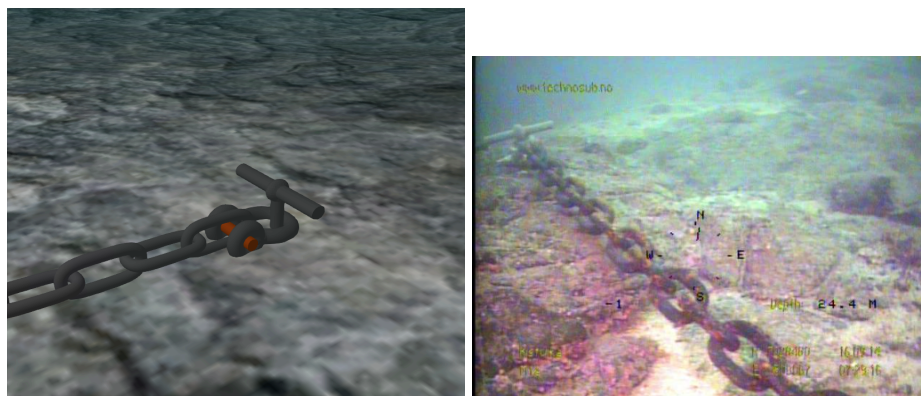


Figure 4.22: Comparison between the bolt created in Unity and a real one

4.3.7 Flying text

In order to give the user of the simulator some guidelines of what to do, a flying text mesh has been added above one fish cage and one buoy, telling the user to dive down and check it out. The text meshes can be seen in figure 4.23. Each text mesh will always rotate to face the camera of the player, so it will be readable from any angle. The text meshes are clearly visible through all kind of objects, something that would look weird once the player dives into the water. To prevent that problem, the text meshes are hidden once the player get below water level. While the user are driving the boat around, no objects will obscure the text, and hence it will not be a problem.



Figure 4.23: A text mesh telling the user to dive down and check out the anchoring system

4.3.8 Sea life outside the fish cages

An other requirement requested by Måsøval was to add some sea life outside the fish cages. A lot of fish tends to swim around due to food that falls through the cages. To cover this, a fish school was added (using the fish school asset) between the fish cage, and buoy with the text above described in chapter 4.3.7. The fish school contains different sized fish, with random movement speed and different waypoints, making it look like a partly crowded area. At the bottom of the fish school, just below the mooring plate, a shark is placed. It has a roaming area defined by two points, where it will swim back and forth. When the player inspects the mooring plate, he/she can get a glimpse of the shark deep below, see figure 4.24. While it has no deep roots in reality, the shark is added to add some excitement to the simulator, and have been requested by multiple testers throughout stands and demonstrations of the simulator. If the player gets too close to the shark, it will turn around and start following the player.



Figure 4.24: The shark that can be found swimming between the fish cages

4.3.9 Controller

Unity can easily recognize and use the input from a connected gamecontroller. A built in button mapping form need to be filled out for every button on the controller, as seen in figure 4.25. While writing scripts, these buttons could easily be referred to. The button mapping conducted in this project is specific to the Playstation 4 controller, but would work with most other similar controllers. In order to make the controllers as easy to use as possible, the button mapping done in the scripting phase will be based on button mappings from other first-person games. That way it will be easier to use for experienced gamers, and also easy to adapt for newcomers. A complete list of the button mapping can be seen in table 4.1

Button	Action
Left analog stick	Move player around
Right analog stick	Turn camera left and right
X	Jump
Circle	Enter and leave boat
Triangle	Turn on/off feeding machine
R3	Toggle good/bad weather
L2	Swim up while under water
Playstation button	Reset player position to boat

Table 4.1: Button mapping for a Playstation 4 controller

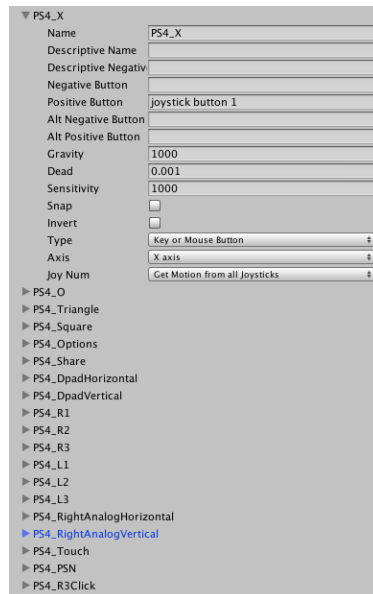


Figure 4.25: The button mapping form for a PS4 controller

4.3.10 Scripting

In order to have all game object interact with each other as required, some objects have their own scripts, while other objects are controlled from a main game script. All scripts that are created (not used from an asset) can be found in the appendix.

The player-object has one important script attached, the "PlayerScript". It is

written in JavaScript, and contains references to all important game objects in the simulator. That includes the fish schools, the boat, the water, the text-meshes, the lights, etc. Mainly all components that the player can interact with, or should change its behaviour based on the player position and actions. The PlayerScript does also control input from the gamecontroller/keyboard and can change the behaviour in other scripts like the salmon swim speed and roaming area when fed, and the water waves during bad weather. A small script generates particles once the feeding starts, as seen in figure 4.26. In order to improve performance, only one set of fish schools are created, and moved between the different fish cages based on where the player are.

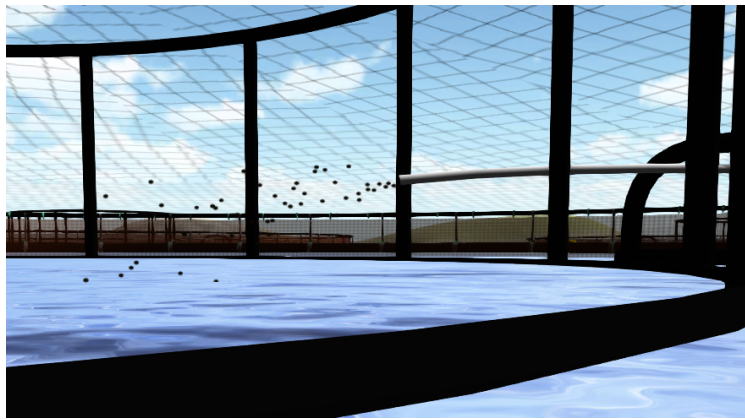


Figure 4.26: Food particles flying out of the feeding pipe once the feeding is turned on

The objects that also perform some kind of action without involvement by the player has their own scripts. That includes the fish schools, the water and objects that float on it, and the shark. The salmon swimming around in the fish cages are currently behaving based on randomly generated numbers. That means, they have a defined area to swim in, and a random point inside the area is generated as a waypoint for the salmon. The salmon will swim towards it, and once enough salmon have reached the point, a new waypoint is generated. The goal of the fish behaviour was to make it look realistic, while implementing a real fish behaviour will be discussed in future work, under chapter 7.3.

While driving the boat, a script generates water particles to simulate water splashing, as seen in figure 4.27

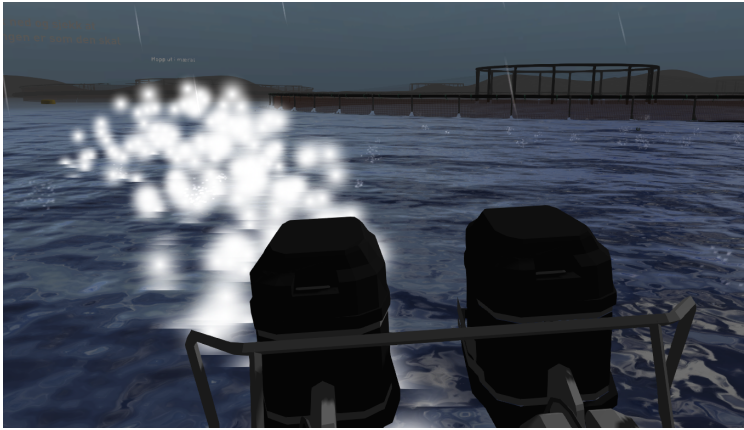


Figure 4.27: Water particles behind boat when driving

Chapter 5

Evaluation and results

This chapter will cover the evaluation of the project, the user-tests, how it was set up, who participated and present the results.

5.1 Evaluation plan

The evaluation of this project was divided into several phases. It was important to let people from the aquaculture industry, as well as the general public test the simulator. The aquaculture simulator was shown at different events throughout the spring of 2015, but most of the evaluation took part towards the end, after the new features had been implemented.

It was not possible to let the testers fill out a questionnaire at all events, both due to the age and time pressure. Spoken feedback during these user-tests and afterwards was just as valuable to the project as the written feedback from other user-tests.

The age of the user-testers varied from very small (kinder garden) to old (retired), and their aquaculture experience varied as well. Following is a list of the events where the aquaculture simulator was shown, and who the audience was.

”Ta Utdanning” - 9. February An education exhibition in Trondheim who was open for everyone, but mainly visited by high school students, to get a glimpse of different educational possibilities. The aquaculture simulator was shown at ”Sett sjøbeins” stand, and no questionnaire was filled out at this event due to time restrictions. ”Sett sjøbein” is a national project to get students interested in the aquaculture industry [28].

”Visjon 2013” - 2. March A conference at NTNU gathering professors, the NTNU principal, several ministers from the Norwegian Government, the business world and others to talk about how Norwegian innovation can contribute to the sustainability goals within health and education towards the year 2030. The aquaculture simulator was presented at a stand, and no questionnaire was filled out at this event either due to time restrictions.

”Open day at NTNU”, 29. April Another education exhibition taking place at NTNU for VG2 students (High school). The students was able to try out the final version of the aquaculture simulator, and at this event a questionnaire was given to the testing students.

”Vitensenteret” - 2. and 9. May The aquaculture simulator was shown to visitors at the Science Center in Trondheim during two weekends. The age of the visitors ranged from young to old, but consisted mainly of young children. Only a simple questionnaire was used at these events.

”NTNU Ocean Week” - 4.-7. May For the first time, NTNU invites the maritime and aquaculture industry to a conference at NTNU. Ekaterina Prasolova-Førland held a presentation about the Aquaculture simulator, and the participants was able to try it out during the dinner the first day, and in the coffee brakes the second day. Due to time pressure no questionnaire was given during these demonstrations.

”Laksefestival” - 11.-13. May A three day long ”salmon-festival” will be held at Frøya, in ”Nabeita oppvekstsenter”. Together with Måsøval Fiskeoppdrett, the aquaculture simulator will be showed at a stand. The audience at the festival is mainly children from the primary school, aged 6-13. These testers will not fill out a questionnaire, mainly due to their age, and the fact that many of them can’t read. During the time at Frøya, the simulator will also be showed to a kindergarten.

One of the more important evaluations will take place the last day at Frøya, letting aquaculture students at Frøya VGS, and experts from Måsøval Fiskeoppdrett test the simulator. The students will answer a more extensive questionnaire, while the visit will be rounded off with an in-depth interview with Måsøval.

5.2 Evaluation setup

During the testing, the simulator will run on a laptop (Early 2011 Macbook Pro, 2.3GHz Intel i7 quad core, 8GB ram, AMD Radeon HD 6750M, OSX 10.9.5) connected to Oculus Rift development kit 2 (DK2) and a Playstation remote. It

will run in full HD resolution (1920x1080), but on the lowest graphic settings due to a mid/low-end graphic card. The picture will still be crisp, and the low graphic settings should not bring too much of a different experience to the users.

The testers will mainly be asked to move freely around in the simulator, exploring the fish farm. However, since there are several features that should be seen in a limited time, the testers will be guided to check out the different areas of the simulator. People having a hard time using the controller can sit down and enjoy a ride around the fish farm given by the presenter of the simulator.

The testers will initially spawn in a boat, and will be able to drive it around the fish farm. By driving next to a fish cage, the user can jump onto it, walk around it, and jump into it. If they jump into it, they will swim among salmon, and can turn the feeding machine on and off to see how the fish behavior changes. The testers will also be able to dive into the ocean outside the fish cages, to observe the anchoring system, and maybe spot the shark.

5.2.1 The test groups

The different testers have been briefly described in chapter 5.1, but will be generalized into 4 different test groups before the results are presented in chapter 5.3. The groups are categorized after their age, test situation, and aquaculture experience.

The youngsters are the testers from the Salmon Festival at Frøya, the kindergarten and the testers at the Science center in Trondheim. They represent the largest user-test base in this evaluation, and are mainly aged from 4-15 years old with a few exceptions. They have little or no aquaculture experience.

The event participants are the testers from the "Ta Utdanning" exhibition, "Visjon 2030", "Open day at NTNU", and the NTNU Ocean week. This group represents the widest general public, mainly aged 17+, with a good variation of aquaculture experience. The common denominator is busy events where the simulator is not the main attraction. With the exception of the "Open day at NTNU", there is only time for oral feedback.

The aquaculture class are a group of high school students at Frøya VGS, studying to work in the aquaculture industry, mainly fish farming. Some of the students did also test the last version of the simulator, while most of them are new testers. All students in this group have work experience from local fish-farming companies, and have in general more aquaculture knowledge than testers from the general public.

Experts from Måsøval Fiskeoppdrett are people with several years in the aquaculture industry, and hands on experience with most of the aspects of the simulator. They are also the ones who started this project, and have a strong say in it's future development. An interview will be held with the experts, discussing

the aquaculture simulator in it's current standing, and the future of it.

5.3 Results

This section will present the results gained both orally and through questionnaires for the different test groups described in chapter 5.2.1. Some graphs will be highlighted in the results, while all of them can be found in the appendix.

5.3.1 The youngsters

Never-ending queues and a high level of excitement among the children have been a common denominator at these stands. Most of the testers have played either PlayStation or Xbox, and had no problems using the controller even though they can't see it while wearing the Oculus Rift. The users at the Science Center in Trondheim were asked to rate the simulator and experience with Oculus Rift on a happiness scale from a happy face to a sad face. A total of 62 people answered the small questionnaire, and seen from figure 5.1, 58 testers rated it with with a big smile, while four testers rated it with a normal smile. Converting it into numbers from 1-5 where 5 is best results in an average score of 4.9. The testers were also asked if the Science Centre should have a permanent stand with Oculus Rift. 62 of 62 testers answered yes. Comments like "this was cool", "I loved this" and "where can I get this" were common during the testing.

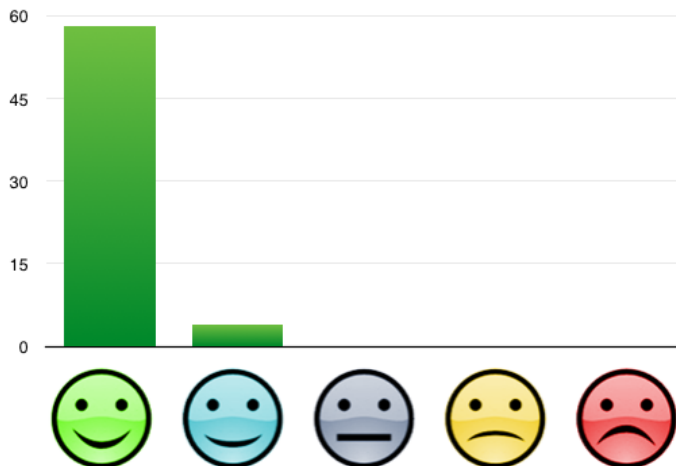


Figure 5.1: "Smiley evaluation" at the Science Center

At the "Salmon Festival" at Frøya, the shark quickly became a popular topic among the children. In order to let as many as possible try out the simulator, each user was limited to three minutes with the simulator. A total of about 150 people tried out the simulator during this festival. While standing in the queue waiting, they talked about what they were going to do once it was their turn, and whether they dared to seek out the shark or not. Several children stated "I am really looking forward to my turn", and as the timer got close to three minutes, a unison loud countdown was conducted. As everyone could spectate on the laptop screen what the current tester was doing, everyone was shouting their opinion of what the tester should do, or not do. After jumping into a fish cage, statements like "Wow, this is so cool!" was said while swimming around with the salmon, turning their head around to get a full look of it. They also liked the boat driving a lot, and some users wanted to explore the different islands around the fish farm once they had seen the salmon and shark. See figure 5.2 for a picture from the stand.



Figure 5.2: Salmon Festival at Frøya. Photo: Trond Anders Bøe

Most of those who dared to seek the shark startled once they saw it, some almost lost their balance. Some testers was screaming when the shark got too close, with a laughter from the other observers. Even though the shark was really scary for some, everyone left the aquaculture simulator with a broad smile around their face, talking about how cool it was. As the aquaculture simulator was showed at the festival (located at a school) for three days, several teachers

came by too see what the simulator was all about, since all of what their students talked about, was the aquaculture simulator and the scary shark. A local paper at Frøya did also pay a visit, writing two articles about the simulator, see chapter 7.2.

As with the other testers, most children in the kindergarten was really excited to try the simulator. Figure 5.3 shows a photo from the visit to the kindergarten. Some of the youngest children did not want try it, probably because the Oculus Rift headset was big, and a little scary for most of them. But those who tried it, loved it. As they were not able to use the Playstation remote themselves, they only had to wear the Oculus Rift and enjoy a ride around in the simulator. They were all asked whether they wanted to see the shark or not, as it might be frightening. Most of them wanted to have a look at it.



Figure 5.3: Kids at Rabben Kindergarten at Frøya testing the simulator. Photo: Rabben Kindergarten

Some of the testers was also a little curious about the background of the simulator, asking questions like "What do you study?", "Why have you created this?", and "Where can I buy Oculus Rift?".

5.3.2 The event participants

The "Ta Utdanning" exhibition and "Visjon 2030" took place quite early in the semester, and therefore mainly the old version of the aquaculture simulator with a few improvements was showed at these events. That said, the people who tested it was overall excited, and loved the use of virtual reality and Oculus Rift. From the "Ta Utdanning" exhibition stand, one visitor said "I am definitely going to study aquaculture" after trying the simulator. A photo from the "Sett sjøbein"

stand can be seen in figure 5.4. The crew was really excited about the simulator, and liked how it attracted people to their stand.



Figure 5.4: "Ta utdanning" exhibition with "Sett sjøbein". Photo: Sett sjøbein

Testers at "Visjon 2030" did also like the simulator, some was really surprised how good the 3D effect of Oculus Rift was compared to just looking at a computer screen. Both testers here and at NTNU Ocean week liked how such simulator could be used for education, and simulate events that could be weather dependent, or require a lot of resources. A photo from Visjon 2030 can be seen in figure 5.5.



Figure 5.5: Testing the aquaculture simulator at "Visjon 2030" at NTNU. Photo: Stein Mortensholm/NTNU

Being able to show how a fish farm was put together underwater was also something that appealed, as it is normally just divers and those who work with inspection of the anchoring system who sees that. A quote from the director of NTNU Ocean Science and Technology after trying the simulator: "Wow, this is great, this is really cool, this could be of good use when educating people in aquaculture". Figure 5.6 shows a photo from one of the demonstrations during the Ocean Week. Prasolova-Førland did also get good feedback after her presentation of virtual reality in aquaculture, one person said it was the most interesting presentation that day. Some inquiries about downloading the simulator have also been received after the Ocean Week at NTNU.



Figure 5.6: Demonstration at NTNU Ocean Week. Photo: Ekaterina Prasolova-Førland

As with the other stands and events, the high school students at "Open day at NTNU" enjoyed trying out the aquaculture simulator, see figure 5.7 for a photo from the event. Unfortunately, a small bug in the build caused some frame-rate drops in which yielded a not so good experience for all testers.



Figure 5.7: High school students trying the simulator at "Open Day at NTNU". Photo: Ekaterina Prasolova-Førland

Overall, 40 students answered the questionnaire after testing the simulator, 67% men, 33% women. 30% said they had knowledge about fish farming. Most people were neutral in the question whether they learned something about fish farming, or the anchoring system at a farm, see figure 5.8. 65% of the testers thought the shark was a bit or very scary, while 23% did not find it scary at all. The rest did not see the shark. 88% wanted the shark to remain in the simulator. The testers were also asked if they thought the fish looked and acted realistically, where the overall score was 4.0 out of 5.0. They thought the boat driving was OK, with some complaints about the lag that had a negative impact on their experience, see figure 5.9.

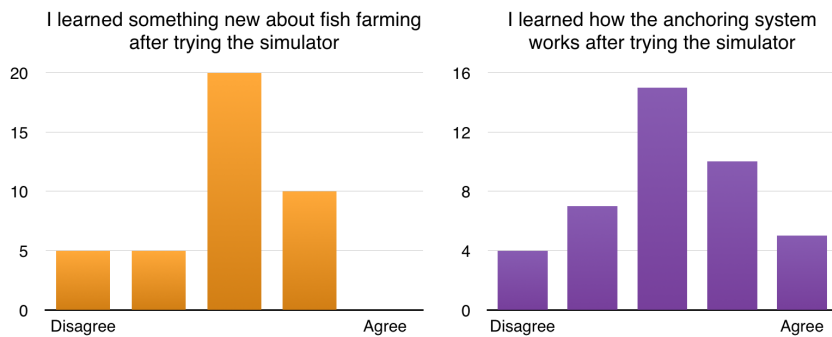


Figure 5.8: Did the high school students learn something? Rated from "Disagree" to "Agree"

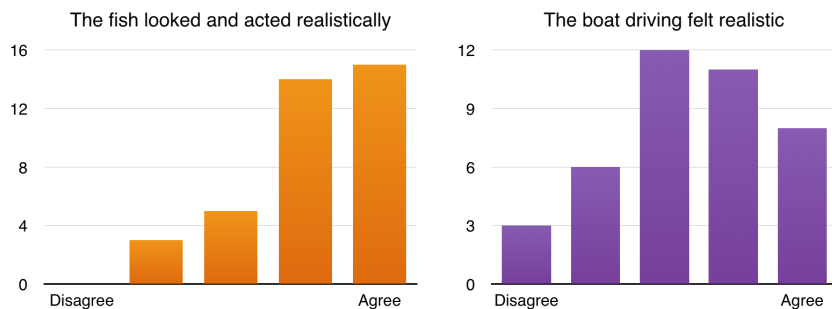


Figure 5.9: How realistic did the high school students think the fish and boat driving was?

A little mixed answers, but most people did not feel sick after driving the boat around in the storm, and the realistic score of the storm was 3.7 out of 5. Most testers found the controllers easy to use, with a score of 4.2 out of 5. 92% of the testers would like to use Oculus Rift/virtual reality in their education, see figure 5.10.

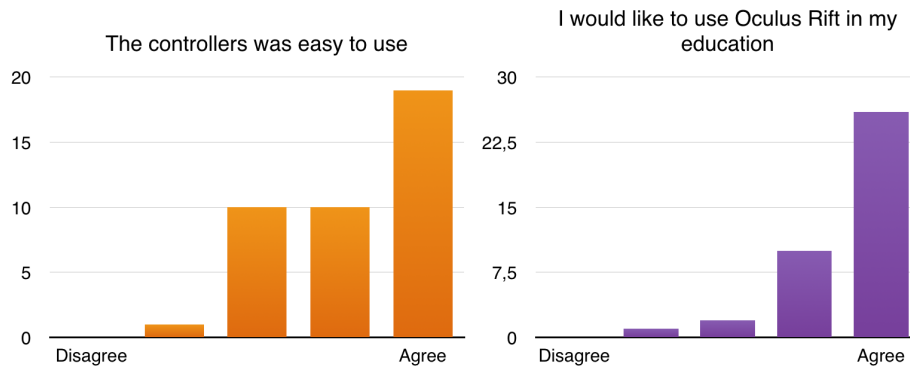


Figure 5.10: What did the high school students think of the controllers and use of Oculus Rift in their education? Rated from "Disagree" to "Agree"

Most of the written feedback was complaints about the frame rate, and one tester wanted a better AI for the salmon, to be more aware of the user.

5.3.3 The aquaculture class

17 students from the aquaculture class tried out the aquaculture simulator, 5 of them did also test the first version in 2014. The overall distribution was 70% men and 30% women. The excitement for the simulator among these students were high, and most of them were really interested in the project. 15 of the testers liked the simulator, while two voted neutral for that question. The students were asked to rate how realistic several parts of the simulator appeared as seen in figure 5.11 and 5.12.

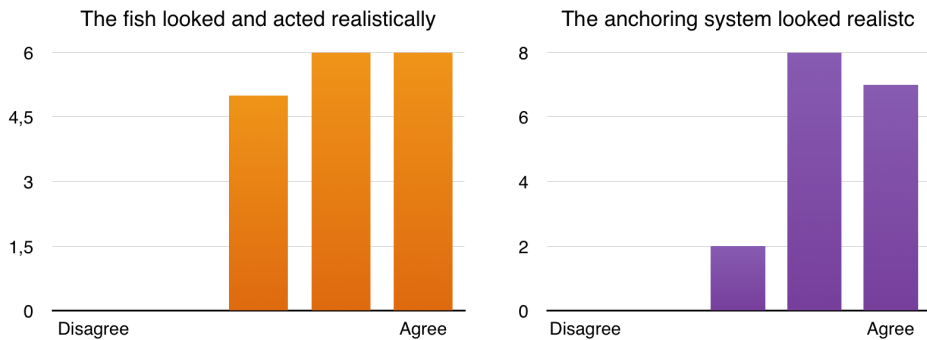


Figure 5.11: What did the aquaculture class think of the fish and anchoring system realism? Rated from "Disagree" to "Agree"

By converting the rating scale into numbers from "1"- "5", where "5" is best, the average "realistic score" can be seen in table 5.1. The anchoring system got a realistic score of 4.3, while the fish look and behaviour got a realistic score of 4.1, out of 5. 89% of the testers thought the boat driving was easy, but not so realistic, see figure 5.12. The boat driving got a realistic score of 3.6. The students thought the storm was cool, and gave it a realistic score of 3.7.

What part	Average score (1-5), 5 is best
Anchoring system	4.3
Fish behavior	4.1
Boat driving	3.6
Storm	3.7

Table 5.1: How realistic does these features of the aquaculture simulator feel? (Students)

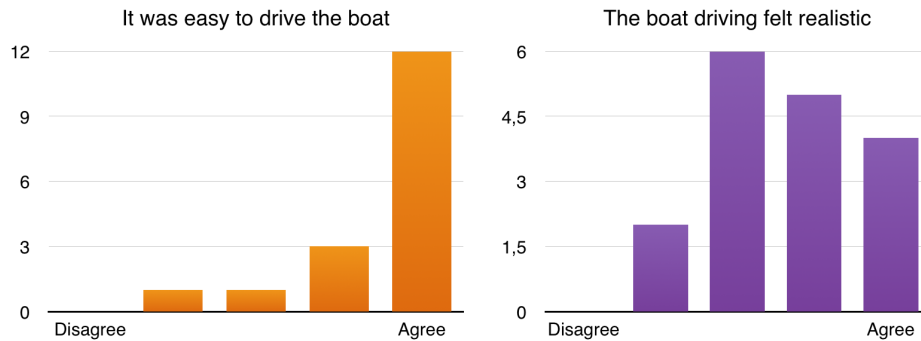


Figure 5.12: What did the aquaculture class think about the boat driving? Rated from "Disagree" to "Agree"

Only two of the testers felt dizzy with the use of Oculus rift after driving the boat in the storm. As with the other young testers, most people did not find any trouble using the controller and they enjoyed playing with the simulator. In questions regarding whether it could be used for safety training, create interest for aquaculture among children, increase general knowledge about fish farming to the general public and be used for international promotion of Norwegian salmon, the answers was very positive weighted, with most votes leaning towards "agree", see figure 5.13 and 5.14.

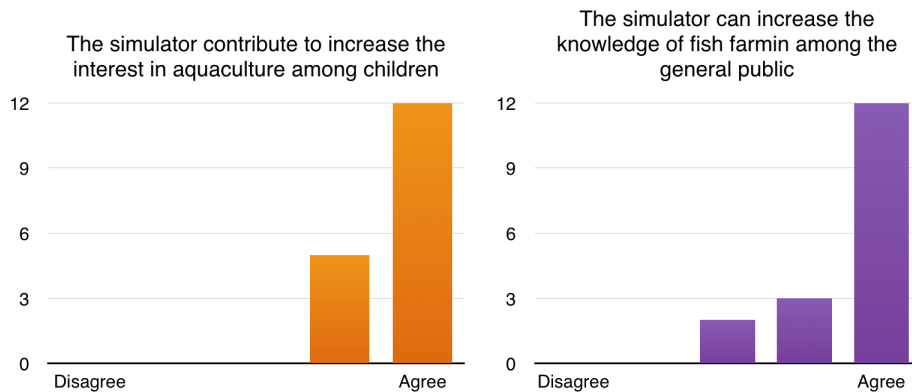


Figure 5.13: The aquaculture class's opinion about use of the aquaculture simulator to spread knowledge. Rated from "Disagree" to "Agree"

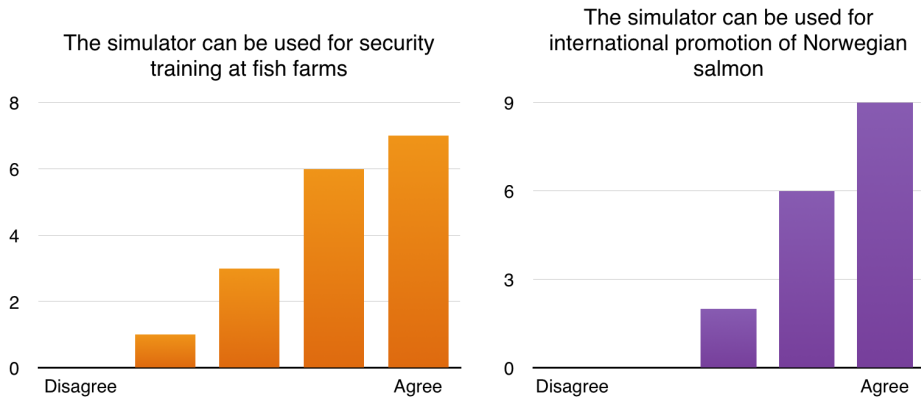


Figure 5.14: The aquaculture class's opinion about use of the aquaculture simulator for safety training and international promotion. Rated from "Disagree" to "Agree"

16 of 17 testers said they would like to use the aquaculture simulator in their class for educational purposes, and most of them thought it could be used for training of fish farmers, see figure 5.15. 16 of 17 testers also meant it should be presented to visitors at Frøya, while the last vote was neutral. 11 of the testers found the floating information text helpful, five neutral, and one who did not find it helpful.

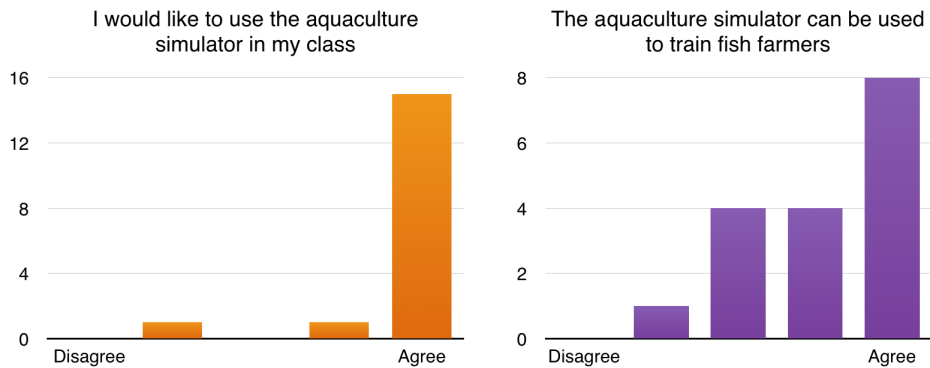


Figure 5.15: The aquaculture class's opinion about use of the aquaculture simulator for education and training. Rated from "Disagree" to "Agree"

The testers who also tested the first version of the aquaculture simulator in 2014 was impressed with the progress so far, and really liked the new features that had been implemented. For future improvements and new features, most people wanted the feeding station to be finished, being able to walk into the control room and control the feeding from there. Being able to do tasks like lice removal and inspection of the fish net was also high on their list of priorities. Safety training at the fish cages was also something that the testers was interested in, and a general improvement of graphics was mentioned by one. One of the students also thought that the shark should be removed.

5.3.4 The experts from Måsøval Fiskeoppdrett

Besides the video that was shown at NTNU Ocean Week, the Salmon Festival at Frøya was the first time the experts tried out the new version of the simulator. Last time was during the evaluation of the first version, which took place in November 2014. They were really impressed with the work at that point, and was eagerly looking forward to try out the new features that have been implemented.

During the Salmon Festival, they observed how the kids reacted and talked about the simulator. They were satisfied with how popular it became. After trying the simulator themselves, they were very impressed with the work, and saw a significant improvement since last time. A brief summary of their response to the interview can be seen below.

The simulator gives a snapshot of a situation at a fish farm today. The fish cages, the fish net and the anchoring system gives a good visual view both over and under water. In it's current stand, the simulator works as a disseminator of knowledge, and will be suitable for a broad general public to get more insight in the construction of a fish farm, compared to actually visiting a traditional fish farm.

In order to be able to use the simulator for training and education, the simulator needs to be updated with more details, and possibilities to simulate different scenarios. Feedback from lecturers at Frøya VGS says the simulator can be a useful tool if this is implemented.

The aquaculture simulator can be an important tool for recruiting people, and trigger the interest among the younger ones at education exhibitions and visits at schools. It has proven to create a lot of attention at the exhibitions where it has been placed so far, and will probably increase the number of visitors to their stands in the future, and thereby increase the possibility to promote aquaculture. In the same way, the simulator is useful in the industry context, for example at fish industry exhibitions. The simulator could be of good use to promote Måsøval Fiskeoppdrett by placing their logo at the fish cages. This will help to build their brand and increase both their and the industry's reputation.

Future features was also discussed, and Måsøval Fiskeoppdrett are interested in implementing more equipment that are daily seen and used at the fish cages. That includes a "dead-fish-net" at the bottom of the cages, hideouts for the wrasse, cameras and "blinkers". They want to be able to activate and deactivate different scenarios, like turn the shark on and off depending on the audience. A helicopter ride along the coast at Frøya, ending at their fish farm was also discussed, something that also was mentioned in the evaluation of the first version of the simulator. The experts did also want the feeding station to be created, making it possible to observe the salmon in the cages from computer screens inside the station. It was also discussed to add more floating text around in the simulator, to present relevant facts of what the user sees.

Chapter 6

Discussion

This chapter will discuss the results presented in chapter 5, along with limitations during the evaluation.

6.1 Discussion

The first version of the Aquaculture simulator received great responses during its evaluation, both from the experts from Måsøval Fiskeoppdrett and the students/general public who tested it. It defined the form of the simulator, and set high expectations for future development, especially for Måsøval Fiskeoppdrett.

Overall, the new features pleased the experts from Måsøval, they were satisfied with the results of the development that took place during the project period. They all agreed on that there have been some significant improvements since the first version, and were all eager to continue the development which will be discussed in chapter 7.3. The aquaculture simulator in its current stand gives a good visual view of a real fish farm, and is an excellent tool to use at exhibitions and similar to draw attention, and show the industry to a wide audience. It can also work well for promoting Måsøval Fiskeoppdrett by placing their logo around in the simulator.

The experts from Måsøval Fiskeoppdrett were not the only ones who were satisfied with the simulator. The feedback has been unanimously positive at all occasions where it has been presented. The only exception is the "Open day at NTNU" event, where some performance issues appeared. The testers who filled out a questionnaire rated the realism in the simulator high, but with room for improvements. Considering the number of developers (1) and current size of this project, the quality of graphics will always have room for improvements, when testers are automatically comparing it to high end modern games with up to

hundred of millions USD budgets. The students at "Open day at NTNU" were overall neutral in the question whether they learned something or not, the reason lies mainly in the limitations discussed in section 6.1.1. Limited testing time, and generally not a purpose to learn something about fish farming when trying the simulator played a big factor.

Showing the simulator at NTNU Ocean Week and Visjon 2030 gave a good insight in what people from the aquaculture industry and in general an older audience thought about the project. The responses were positive, and several people saw a lot of possibilities in the usage of an immersive virtual reality simulator for education. Not only for fish farming, but for other practical professions in general. It was also suggested to use it for showing specific products in a 3D environment, like fish cages in this simulator. An open world like the one in the aquaculture simulator has almost unlimited possibilities for future feature implementations, whether it should be for pure enjoyment or used for educational purposes as a serious game.

The answer to RQ1 is briefly answered in chapter 2.2 and 4.1, listing the main requirements for the simulator prepared in cooperation with Måsøval Fiskeoppdrett and my supervisor. It has been put to test during the evaluation phase, and have been rather successful. The final product is runnable on a laptop, and has support for Oculus Rift. Most testers found the controllers easy to use, especially those who have used a Playstation or Xbox controller before, which applies to most younger people. The simulator has been published, and is available for download from the internet, see chapter 7.2. The new features appealed, and looked realistic according to the testers. They experienced immersive virtual reality while driving the boat in different weather conditions, and diving down to inspect the anchoring system. The fact that some people got really scared when they saw or got close to the shark proves the "immersiveness" of the aquaculture simulator.

Most aquaculture students were very excited about the project, and they shown great interest in possibilities to use the simulator in their education. To focus the light on RQ2, some aquaculture teachers at Frøya VGS did also see good potential for educational use, and as the experts from Måsøval said: there are absolutely room for usage of an aquaculture simulator in training of new employees, and for educational use at Frøya VGS. The use of Oculus Rift gives a sense of reality which makes it possible to simulate different scenarios, and get a look at a cages system from new angles. The current simulator could not be directly used for those purposes at the moment, as more detailed tasks and more specific features needs to be implemented. A more realistic physics engine might also be considered, as well as making more objects follow the physic laws, instead of just being static. However, there are huge potential for developing the aquaculture simulator into a real serious game.

Virtual reality in general is not a new invention, but the technology which makes it accessible to a wide audience is. Oculus Rift attracts a lot of people, and several of the testers have played around in the aquaculture simulator mainly to try out the headset. This is not necessarily a bad thing for the simulator, as it have been more or less a "passive" introduction to the aquaculture industry. The simulator itself was however quite popular at events like NTNU Ocean Week, as it does not exits any similar aquaculture simulators. The kids at the "Salmon Festival" was really interested in the headset, but also in the simulator itself, as it simulates a fish farm in their hometown, and many of their parents works in the aquaculture industry. The use of new technology like Oculus Rift, and gamification objects like the shark, has proven to have a strong impact on the popularity of the simulator in a positive way. In terms of answering RQ3, these features are responsible for introducing several new people to the aquaculture industry, have been very beneficial for attracting people to stands at exhibitions, and are also the reason several newspapers, including the Norwegian Broadcasting Corporation (NRK), published articles covering the simulator (See chapter 7.2).

6.1.1 Limitations

There have been some limitations to the evaluations which have more or less affected the results. Almost constant queues for trying the aquaculture simulator at exhibitions have resulted in limited testing time for each user. Not everyone got to see everything, or get a guided tour around in the simulator. The aquaculture class got more time per person in the simulator compared to the other events, but there were some restrictions here as well in order to let everyone try it.

The hardware have also been a small limitation, preventing testers to get the best experience with Oculus Rift. The overall experience have been ok, but the simulator had some frame rate drops in certain situations, which could have been avoided if more powerful hardware was used for the demonstrations. The graphic settings was also set to "low", something that resulted in lower detailed 3D models being showed.

Chapter 7

Conclusion

In this chapter, the main contributions and future work of the project will be presented. A small section will describe the publicity this project achieved in national medias.

7.1 Contributions

The main contribution of this project is the aquaculture simulator itself, an open world immersive virtual reality simulator. I would dare to say that it is the only one of it's kind. For Måsøval Fiskeoppdrett it has become a great tool to show their company to visitors and customers, how they operate and where their salmon comes from. The simulator has also proven to be an effective tool at exhibitions as it attracts a lot of people. The aquaculture simulator in it's current stand is a solid base for a serious game that can be used for education. It have introduced advanced technology for teachers at Frøya VGS, opening their eyes for the use of virtual reality and serious games in their teaching. In all, the simulator has got a lot of attention during the evaluation phase, and given people with no aquaculture knowledge an introduction to the industry. Being in times where aquaculture is in the governments focus to increase food production, the simulator is a nice addition to promote aquaculture.

7.2 Publicity

The aquaculture simulator got some publicity in several online newspapers after the demonstrations at "NTNU Ocean Week" and the "Salmon Festival" at Frøya. A short demonstration movie of the simulator was created for "NTNU Ocean

Week”, and later on uploaded to YouTube. The video got over 2000 views during the first 10 days online. A small home site for the project was also created, where the aquaculture simulator can be downloaded for both OSX and Windows, to use on a normal computer screen or with Oculus Rift.

The first newspaper who wrote about the simulator was Hitra-Frøya, a local newspaper who visited the Salmon Festival, closely followed by an article in NTNU and SINTEF’s paper Gemini. Later on it was picked up by the Norwegian Broadcasting Corporation NRK, Forskning.no, two papers from the aquaculture industry: iLaks.no and intrafish.no, and another article in Hitra-Frøya. An even more local paper, frøya.no did also write a small article a few days after the salmon festival. An article was also posted at kyst.no, and in the greek paper ”ktiniatrikanea”. It may have been published other places as well without my knowledge. Table 7.1 shows the different medias with the corresponding URL’s.

Media	URL
YouTube	https://youtu.be/ho6A65PuUDM
Download	http://boeconsulting.no
Hitra-Frøya 1	http://www.hitra-froya.no/nyheter/article10948754.ece
Hitra-Frøya 2	http://www.hitra-froya.no/nyheter/article10938861.ece
Gemini	http://gemini.no/2015/05/hopp-i-havet-svom-med-laksen/
NRK	http://www.nrk.no/trondelag/simulator-lar-deg-svomme-med-laksen-1.12360658
Forskning.no	http://forskning.no/2015/05/hopp-i-havet-svom-med-laksen
iLaks.no	http://www.ilaks.no/hopp-i-havet-svom-med-laksen/
intrafish.no	http://www.intrafish.no/norsk/nyheter/article1411988.ece
kyst.no	http://www.kyst.no/nyhet/?article_id=113001
froya.no	http://www.froya.no/nyheter/svomte-med-laksen
Ktiniatrikanea.com	http://www.ktiniatrikanea.com/vinteoepchnidi-prosomiotis-ichthiokalliergias/

Table 7.1: Publicity of the Aquaculture Simulator

7.3 Future work

One could never say that the aquaculture simulator is finished, as it will always be new features to implement or improve. The current version presents a solid base that works well for it’s purposes, but has nearly limitless with possibilities for future features. Both students at Frøya VGS and the experts from Måsøval Fiskeoppdrett was asked what they wanted to see in a future version, and the most popular choices from the results chapter can be seen in table 7.2

Popularity	Feature
1	Walk inside the control station
2	Quests and other tasks like removal of dead fish, inspection of cage, etc
3	Security training
4	Helicopter ride around the fish farm

Table 7.2: Most requested new features

Måsøval Fiskeoppdrett does also wish to implement specific detailed features in order to make it usable for education. That includes a possibility to enable/disable small errors and similar to the cage system for the students to discover. Setting up scenarios where people are asked to do specific tasks that are done on a daily basis is also wanted. In a long term, Måsøval Fiskeoppdrett has a vision to present the simulator at "Blått kompetansesenter" at Frøya, where one could follow a salmon from it's birth to a dinner dish in a 30-40 min. long sequence.

SINTEF has been involved with the application for an aquaculture simulator at "Blått Kompetansesenter" at Frøya, but not in the development of the simulator created during this project. In the future, Sintef Fisheries Aquaculture is expected to participate in further development of the simulator and contribute with relevant data and scientific knowledge. As the fish movement in the current version is based on random generation, it has been talked about implementing more real simulated fish schools based on real data.

The future development of the simulator can be directed towards the educational part, or to the "demonstration" part where the goal is to show it to a wide audience. It is also possible to combine these two directions, whereas the final decision will be made in cooperation with Måsøval Fiskeoppdrett, NTNU and SINTEF. It has been suggested to continue the project over the next year throughout a new master thesis, and a "Customer-driven project". Måsøval Fiskeoppdrett have also been willing to hire a paid programmer in order to continue the development of the aquaculture simulator.

Aquaculture in general is a growing economy, and an important one considering the world's food demand. Popularization of aquaculture is necessary in order to attract young people into relevant studies, and get graduated students start working in the industry.

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Appendices

A: Scripts

PlayerScript.js

```
#pragma strict

// Public vars

// Player spesific
var playerRotationSpeed:float = 2.0f;
var swimUpSpeed : float = 5.0f;
var swimDownSpeed : float = 4.0f;
var maxSwimDepth : float = -27.0f;
var bloodsplatter : GameObject;
var shark : GameObject;

// Fish

var minSpeedFeeding:float = 6;
var maxSpeedFeeding:float = 9;
var minSpeedNotFeeding:float = 1;
var maxSpeedNotFeeding:float = 3;
var fishMaxSize:float = 0.7;
var fishMinSize:float = 0.4;

var fish1 : GameObject;
var fish2 : GameObject;
var fish3 : GameObject;
var fish4 : GameObject;
var fish5 : GameObject;

var theFishSchool:GameObject;
```

```
var fishSchoolLocation1:Vector3 = new Vector3(0,-13,46);
var fishSchoolLocation2:Vector3 = new Vector3(-130, -13, 46);
var fishSchoolLocation3:Vector3 = new Vector3(130, -13, 46);
var fishSchoolLocation4:Vector3 = new Vector3(-130, -13, 176);
var fishSchoolLocation5:Vector3 = new Vector3(0, -13, 176);
var fishSchoolLocation6:Vector3 = new Vector3(130, -13, 176);
var fishSchoolFarAwayLocation:Vector3 = new Vector3(500, 1000, -1000);

// Boat
var boat:GameObject;
var driveBoatDistance:float = 4;

// Weather
var rain:ParticleEmitter;
var badWeather:boolean = false;
var goodWeatherSkybox:Material;
var badWeatherSkybox:Material;

// Lights
var light1 : Light;
var light2 : Light;

// Colors
var underwaterColor : Color;
var normalColor : Color;
var badWeatherLightColor : Color;
var badWeatherWaterColor : Color;
var fogColor : Color;
var fogColorBW : Color;

// Text
var fiskemerdTekst = "Hopp ut i m\ae ra!";
var fiskeMerdTextObject:GameObject;
var boyeTekst = "Dykk ned og sjekk at \n fort\o yningen er som den skal";
var boyeTextObject:GameObject;

var infoText:GameObject;
var boatText:GameObject;

// Sounds
var underwaterSound : AudioSource;
var waterSplash : AudioSource;
var ambientOceanSound : AudioSource;
var rainAudio : AudioSource;
```

```
// Misc
var foodParticlesOverWater : ParticleSystem;
var foodParticles : ParticleSystem;
var fogDensity : float;
var waterLevel : float;
var cameraOffset : float = 0.9f;
var dynamicWater : GameObject;

// Fish stuff
private var fishSchoolLocation:Vector3;
private var fishScript1 : SchoolController;
private var fishScript2 : SchoolController;
private var fishScript3 : SchoolController;
private var fishScript4 : SchoolController;
private var fishScript5 : SchoolController;
private var fishScript6 : SchoolController;
private var fishScripts = [fishScript1, fishScript2, fishScript3,
    fishScript4, fishScript5, fishScript6];
private var fish = [fish1, fish2, fish3, fish4, fish5];
private var feeding:boolean;

// Boat stuff
private var closeToBoat:boolean;
private var driving:boolean = false;
private var boatController:BoatController;

// Weather stuff
private var isRaining:boolean = false;

// Misc stuff
private var motor:CharacterMotor;

//Underwater
private var haveSeenInfoText:boolean = false;
private var isUnderwater : boolean;
private var isSwimming : boolean;
private var hasPlayedSplashSound : boolean;

function Start () {

    bloodsplatter.renderer.enabled = false;
```

```
//dynamicWater.GetComponent(LostPolygon.DynamicWaterSystem.DynamicWaterSolverAdvanced)
fishSchoolLocation = fishSchoolFarAwayLocation;
theFishSchool.transform.position = fishSchoolLocation;

fishScripts[0] = fish1.GetComponent(SchoolController);
fishScripts[1] = fish2.GetComponent(SchoolController);
fishScripts[2] = fish3.GetComponent(SchoolController);
fishScripts[3] = fish4.GetComponent(SchoolController);
fishScripts[4] = fish5.GetComponent(SchoolController);

for (var i = 0; i < 5; i++) {
    fishScripts[i]._minScale = fishMinSize;
    fishScripts[i]._maxScale = fishMaxSize;
}

feeding = false;
foodParticles.Stop();
foodParticlesOverWater.Stop();

boatController = boat.GetComponent(BoatController);
motor = GetComponent(CharacterMotor);

boatController.canMove = true;
motor.canControl = false;
//displayText = "Press [E] to exit boat";
driving = true;

boatText.GetComponent(TextMesh).text = "Press 'O' to exit the
    boat\nUse the left stick to drive";
fiskeMerdTextObject.GetComponent(TextMesh).text = fiskeMerdTekst;
boyeTextObject.GetComponent(TextMesh).text = boyeTekst;

hasPlayedSplashSound = false;
isSwimming = false;
isUnderwater = false;

if (badWeather) SetBadWeather();
}

function Update () {

    // LOGIC UPDATE

    UpdateFishSchoolLocation();
```

```
// Enter boat
if(Vector3.Distance(transform.position, boat.transform.position) <
    driveBoatDistance) {
    closeToBoat = true;
    if (!driving) {
        boatText.GetComponent(TextMesh).text = "Press '0' to enter the
        boat";
    }
} else {
    closeToBoat = false;
    driving = false;
    boatController.canMove = false;
    motor.canControl = true;
    boatText.GetComponent(TextMesh).text = "";
}

if (transform.position.y < 0) {
    fiskeMerdTextObject.GetComponent(TextMesh).text = "";
    boyeTextObject.GetComponent(TextMesh).text = "";
} else {
    fiskeMerdTextObject.GetComponent(TextMesh).text = fiskemerdTekst;
    boyeTextObject.GetComponent(TextMesh).text = boyeTekst;
    fiskeMerdTextObject.transform.LookAt(transform.position);
    boyeTextObject.transform.LookAt(transform.position);
}

// From Unerwater

if (transform.position.y > 1 && isSwimming) {
    SetNormal();
}

if ((transform.position.y < waterLevel-cameraOffset) != isUnderwater)
{
    isUnderwater = transform.position.y <
        waterLevel-cameraOffset;
    if (isUnderwater) SetUnderwater ();
    if (!isUnderwater) { SetNormal (); haveSeenInfoText =
        false; }
}

if (!isUnderwater && waterSplash.transform.position.y < waterLevel &&
    !hasPlayedSplashSound) {
```

```
    waterSplash.Play();
    hasPlayedSplashSound = true;
}

if (transform.position.y < 0 && !haveSeenInfoText) {
    infoText.GetComponent(TextMesh).text = "Hold L2 for \aa sv\o mme
        oppover. \n Bruk venstre spake for \aa sv\o mme rundt";
    haveSeenInfoText = true;
}

var sharkDist = Vector3.Distance(shark.transform.position,
    transform.position);
if (sharkDist < 10) {
    bloodsplatter.renderer.enabled = true;
} else {
    bloodsplatter.renderer.enabled = false;
}

// BUTTON INPUT

if ((Input.GetKeyDown("y") || Input.GetButtonDown("PS4_R3")) &&
    transform.position.y > 0) {
    if (badWeather) {
        SetGoodWeather();
    } else {
        SetBadWeather();
    }
}

if (Input.GetKeyDown("r") || Input.GetButtonDown("PS4_PSN")) {
    var boatPos:Vector3 = boat.transform.position;
    transform.position = boatPos + new Vector3(0,2,0) - 0.9 *
        boat.transform.forward;
}

if (Input.GetKeyDown("l")) {
    boat.transform.position = new Vector3(22,2,-22);
}

if (Input.GetKeyDown("j")) {
    var vec:Vector3 = transform.position;
    vec.y = 200;
    transform.position = vec;
}
```

```
if (Input.GetKeyDown("f") || Input.GetButtonDown("PS4_Triangle")) {
    if (!feeding) {
        Debug.Log("turn on feeding");
        for (var i = 0; i < 5; i++) {
            fishScripts[i]._minSpeed = minSpeedFeeding;
            fishScripts[i]._maxSpeed = maxSpeedFeeding;
            fishScripts[i]._feeding = true;
            foodParticles.Play();
            foodParticlesOverWater.Play();
        }
    } else {
        Debug.Log("turn off feeding");
        for (i = 0; i < 5; i++) {
            fishScripts[i]._minSpeed = minSpeedNotFeeding;
            fishScripts[i]._maxSpeed = maxSpeedNotFeeding;
            fishScripts[i]._feeding = false;
            foodParticles.Stop();
            foodParticlesOverWater.Stop();
        }
    }
    feeding = !feeding;
}

if ((Input.GetKeyDown(KeyCode.E) || Input.GetButtonDown("PS4_Square")
    || Input.GetButtonDown("PS4_0") || Input.GetKeyDown(KeyCode.0)) &&
    closeToBoat ) {
    if (!driving) {
        var boatPos2:Vector3 = boat.transform.position;
        transform.position = boatPos2 + new Vector3(0,2,0) - 0.9 *
            boat.transform.forward;
        boatController.canMove = true;
        motor.canControl = false;
        boatText.GetComponent(TextMesh).text = "Press '0' to exit the
            boat\nUse the left stick to drive";

        //displayText = "Press [E] to exit boat";
    } else {
        boatController.canMove = false;
        motor.canControl = true;
        boatText.GetComponent(TextMesh).text = "Press '0' to enter the
            boat";
        //displayText = "Press [E] to enter boat";
    }
    driving = !driving;
}
```

```
}

if((Input.GetKey(KeyCode.T) || Input.GetButton("PS4_L2") ||
    Input.GetButton("PS4_R2") || Input.GetMouseButton(0))) {
    //constantForce.relativeForce = Vector3(0,200, 0);
    infoText.GetComponent(TextMesh).text = "";

    if (!isUnderwater && transform.position.y < 1 ) {
        if (!isSwimming) {
            transform.Translate(0.0f, 0.3, 0.0f);
            SetSwimming();
        }
    }

    if (isUnderwater && transform.position.y < waterLevel-cameraOffset)
    {
        transform.Translate(0.0f, swimUpSpeed * Time.deltaTime, 0.0f);
    }
} else if(isUnderwater && transform.position.y
    -swimDownSpeed*Time.deltaTime > maxSwimDepth &&
    Input.GetKey(KeyCode.G)) {
    transform.Translate(0.0f, -swimDownSpeed * Time.deltaTime,
        0.0f);
} else {
    //constantForce.relativeForce = Vector3(0, 0, 0);
}

// Weather
rain.transform.position.x = transform.position.x;
rain.transform.position.z = transform.position.z;
}

function UpdateFishSchoolLocation () {

    var pos = transform.position;
    if (pos.y < 0) {

        var dist1 = Vector3.Distance(pos, fishSchoolLocation1);
        var dist2 = Vector3.Distance(pos, fishSchoolLocation2);
        var dist3 = Vector3.Distance(pos, fishSchoolLocation3);
        var dist4 = Vector3.Distance(pos, fishSchoolLocation4);
        var dist5 = Vector3.Distance(pos, fishSchoolLocation5);
        var dist6 = Vector3.Distance(pos, fishSchoolLocation6);

        fishSchoolLocation = fishSchoolLocation1;
    }
}
```



```
var currentDistance = dist1;

if (dist2 < currentDistance) {fishSchoolLocation =
    fishSchoolLocation2; currentDistance = dist2;}
if (dist3 < currentDistance) {fishSchoolLocation =
    fishSchoolLocation3; currentDistance = dist3;}
if (dist4 < currentDistance) {fishSchoolLocation =
    fishSchoolLocation4; currentDistance = dist4;}
if (dist5 < currentDistance) {fishSchoolLocation =
    fishSchoolLocation5; currentDistance = dist5;}
if (dist6 < currentDistance) {fishSchoolLocation =
    fishSchoolLocation6; currentDistance = dist6;}

if (currentDistance > 70) fishSchoolLocation =
    fishSchoolFarAwayLocation;

    theFishSchool.transform.position = fishSchoolLocation;
} else {
    if (fishSchoolLocation != fishSchoolFarAwayLocation) {
        fishSchoolLocation = fishSchoolFarAwayLocation;
        theFishSchool.transform.position = fishSchoolLocation;
    }
}
}

function OnGUI () {
    if(closeToBoat) {
        //GUI.Label(new Rect(400, 400, 200, 20), displayText);
    }
    //var text = "FPS: " + (1.0f / Time.smoothDeltaTime);
    //GUI.Label(new Rect(50, 50, 100, 100), text);
}

function SetGoodWeather () {
    rain.emit = false;
    badWeather = false;
    RenderSettings.skybox = goodWeatherSkybox;
    var rend = dynamicWater.GetComponent.<Renderer>();
    rend.material.shader = Shader.Find ("Custom/Water Reflective Bumped
        (Fog)");
    rend.material.SetColor ("_ReflectColor", normalColor);

    light1.intensity = 1.0f;
    light1.color = normalColor;
```

```
    light2.color = normalColor;
    rainAudio.Stop();
    RenderSettings.fogColor = fogColor;
    RenderSettings.fogDensity = 0.001f;
}

function SetBadWeather () {
    rain.emit = true;
    badWeather = true;
    RenderSettings.skybox = badWeatherSkybox;
    var rend = dynamicWater.GetComponent.<Renderer>();
    rend.material.shader = Shader.Find ("Custom/Water Reflective Bumped
    (Fog)");
    rend.material.SetColor ("_ReflectColor", badWeatherWaterColor);

    light1.intensity = 0.7f;
    light1.color = badWeatherLightColor;
    light2.color = badWeatherLightColor;

    rainAudio.Play();

    RenderSettings.fogColor = fogColorBW;
    RenderSettings.fogDensity = 0.01f;
}

function SetNormal () {
    if (badWeather) {
        SetBadWeather();
    } else {
        light1.intensity = 1.0;
        light2.intensity = 0.4;
        light1.color = normalColor;
        light2.color = normalColor;
        RenderSettings.fogColor = normalColor;
        RenderSettings.fogDensity = 0.001f;
    }

    motor.movement.gravity = 20;
    motor.movement.maxFallSpeed = 20;
    motor.movement.maxForwardSpeed = 6;
    motor.movement.maxSidewaysSpeed = 6;
    underwaterSound.Stop();

    hasPlayedSplashSound = false;
    ambientOceanSound.Play();
}
```

```
        isSwimming = false;
    }

function SetSwimming () {
    if (badWeather) {
        SetBadWeather();
    } else {
        light1.intensity = 1.0;
        light2.intensity = 0.4;
        light1.color = normalColor;
        light2.color = normalColor;
    }

    motor.movement.gravity = 0.05;
    motor.movement.maxFallSpeed = 0.05;
    motor.movement.maxForwardSpeed = 4;
    motor.movement.maxSidewaysSpeed = 4;
    underwaterSound.Stop();
    hasPlayedSplashSound = false;
    ambientOceanSound.Play();
    RenderSettings.fogColor = normalColor;
    RenderSettings.fogDensity = 0.001f;
    isSwimming = true;
}

function SetUnderwater () {
    rain.emit = false;
    rainAudio.Stop();
    Debug.Log("UNDERWATER");
    RenderSettings.fogColor = underwaterColor;
    RenderSettings.fogDensity = fogDensity;
    motor.movement.gravity = 2;
    motor.movement.maxFallSpeed = 2;
    motor.movement.maxForwardSpeed = 4;
    motor.movement.maxSidewaysSpeed = 4;
    underwaterSound.Play();
    light1.intensity = 0.1;
    light1.color = underwaterColor;
    light2.intensity = 0.1;
    light2.color = underwaterColor;
    hasPlayedSplashSound = true;
    ambientOceanSound.Stop();
}
```

BoatController.js

```
public var MovementSpeed:float = 25f;
public var RotationSpeed:float = 5f;
public var canMove:boolean = false;
public var waterParticles:ParticleSystem;
public var motorSound : AudioSource;

function Update () {

    if (canMove) {
        waterParticles.Play();
        if (!motorSound.isPlaying){
            motorSound.Play();
        }
        var dir:Vector3 = Vector3.zero;

        #if UNITY_IPHONE || UNITY_ANDROID || UNITY_BLACKBERRY || UNITY_WP8
            #if UNITY_3_5 && UNITY_ANDROID
                dir.x = Mathf.Clamp(-Input.acceleration.y * 2f, -1f, 1f);
                dir.z = 1f;
            #else
                dir.x = Mathf.Clamp(Input.acceleration.x * 2f, -1f, 1f);
                dir.z = 1f;
            #endif
        #else
            dir.x = Input.GetAxisRaw("Horizontal");
            dir.z = Input.GetAxisRaw("Vertical");
        #endif

        // Move backwards at half speed
        var speed:float = dir.z > 0f ? dir.z : dir.z * 0.5f;

        // Apply movement
        var force:Vector3 = new Vector3(transform.forward.x, 0f,
            transform.forward.z) * speed * MovementSpeed;
        rigidbody.AddForce(force * Time.deltaTime,
            ForceMode.VelocityChange);

        // Apply rotation
        rigidbody.AddTorque(0f, dir.x * RotationSpeed * Time.deltaTime,
            0f, ForceMode.VelocityChange);
    }
}
```

```
    } else {
        waterParticles.Stop();
        if (motorSound.isPlaying){
            motorSound.Stop();
        }
    }
}
```

SharkSwim.js

```
#pragma strict

var xSpeed:float = 0.0f;
var ySpeed:float = 0.0f;
var zSpeed:float = 2.0f;
var rotationSpeed:float = 180;
var speed:float = 1.0f;
var playerEatDistance = 20.0f;

private var actualSpeed:float;
var player:GameObject;

private var direction:Vector3;
var strength:float = 0.5;

var targetPos1: Vector3 = new Vector3(71, -33, 30);
var targetPos2: Vector3 = new Vector3(71, -33, -24);
private var targetPos:Vector3;

function Start () {
    actualSpeed = speed;
    targetPos = targetPos1;
}

function Update () {
    var targetRotation;
    if (Vector3.Distance(transform.position, player.transform.position)
        < playerEatDistance && transform.position.y < -8) {
        actualSpeed = 4;
        var playerPos = player.transform.position;
        playerPos.y += 2;
        targetRotation = Quaternion.LookRotation (playerPos -
            transform.position);
    }
}
```

```
    } else {
        actualSpeed = speed;
        if(Vector3.Distance(transform.position, targetPos) < 5) {
            if (targetPos == targetPos1) {
                targetPos = targetPos2;
            } else {
                targetPos = targetPos1;
            }
        }
        targetRotation = Quaternion.LookRotation (targetPos -
            transform.position);
    }

    var str = Mathf.Min (strength * Time.deltaTime, 1);
    transform.rotation = Quaternion.Lerp (transform.rotation,
        targetRotation, str);
    transform.Translate(new Vector3(0, 0, actualSpeed)*Time.deltaTime);
}
```

PS4_ FPS_ Look

This script is originally created by Unity for their standard movement controller, but edited in this project in order to be able to use a PS4 controller.

```
using UnityEngine;
using System.Collections;

/// MouseLook rotates the transform based on the mouse delta.
/// Minimum and Maximum values can be used to constrain the possible
/// rotation

/// To make an FPS style character:
/// - Create a capsule.
/// - Add the MouseLook script to the capsule.
/// -> Set the mouse look to use LookX. (You want to only turn
/// character but not tilt it)
/// - Add FPSInputController script to the capsule
/// -> A CharacterMotor and a CharacterController component will be
/// automatically added.

/// - Create a camera. Make the camera a child of the capsule. Reset it's
/// transform.
/// - Add a MouseLook script to the camera.
/// -> Set the mouse look to use LookY. (You want the camera to tilt up
```

```
    and down like a head. The character already turns.)
[AddComponentMenu("Camera-Control/Mouse Look")]
public class PS4_FPS_Look : MonoBehaviour {

    public enum RotationAxes { MouseXAndY = 0, MouseX = 1, MouseY = 2 }
    public RotationAxes axes = RotationAxes.MouseXAndY;
    public float sensitivityX = 15F;
    public float sensitivityY = 15F;

    public float minimumX = -360F;
    public float maximumX = 360F;

    public float minimumY = -60F;
    public float maximumY = 60F;

    float rotationY = 0F;

    void Update ()
    {
        if (axes == RotationAxes.MouseXAndY)
        {
            float rotationX = transform.localEulerAngles.y +
                Input.GetAxis("Mouse X") * sensitivityX;

            rotationY += Input.GetAxis("Mouse Y") * sensitivityY;
            rotationY = Mathf.Clamp (rotationY, minimumY, maximumY);
            transform.localEulerAngles = new Vector3(-rotationY, rotationX,
                0);
        }
        else if (axes == RotationAxes.MouseX)
        {
            transform.Rotate(0, Input.GetAxis("PS4_RightAnalogHorizontal") *
                sensitivityX, 0);
            transform.Rotate(0, Input.GetAxis("Mouse X") * sensitivityX, 0);
        }
        else
        {
            rotationY += Input.GetAxis("PS4_RightAnalogVertical") *
                sensitivityY;
            rotationY = Mathf.Clamp (rotationY, minimumY, maximumY);

            transform.localEulerAngles = new Vector3(rotationY,
                transform.localEulerAngles.y, 0);
        }
    }
}
```

```
void Start ()
{
    // Make the rigid body not change rotation
    if (GetComponent<Rigidbody>())
        GetComponent<Rigidbody>().freezeRotation = true;
}
}
```

B: Interview

The interview with the experts from Måsøval contained these questions/discussion topics, with a following written feedback:

Hva syntes dere om simulatoren?

Hva er bra/hva kan bli bedre?

Kan simulatoren brukes til opplæring av ansatte?

Kan simulatoren brukes i undervisningen på VGS?

Kan simulatoren brukes til promotering av fiskeoppdrett?

Kan simulatoren brukes til promotering av Måsøval?

Kan simulatoren brukes til å vekke interesse for fiskeoppdrett blant unge?

Andre bruksområder for simulatoren?

Hva burde prioriteres av fremtidig funksjonalitet?

”Simulatoren viser i sin nåværende form et god øyeblikksbilde av situasjonen i et oppdrettsanlegg. Merder, not og fortøyning gir et reelt visuelt bilde både over og under vann. Slik den fremstår i dag fungerer den først å fremst som kunnskapsformidler. Den vil i så måte være egnet for et utenforstående publikum som vil få et helt annet innblikk i hvordan et anlegg er bygd opp, enn ved et tradisjonelt fysisk anleggsbesøk.

Ved videre utvikling må trinnene være å komplette anlegget med mere utstyr som daglig er å finne i anlegget (dødfiskhov, kamera, leppefiskskjul, blinkere etc.) Bruk av fakta ark i simulatoren kan øke kunnskapsformidlingen. Type fakta ark i visningen kan kunne variere ut i fra hvilket publikum det skal treffe. Videre gjøre det mulig å gå inn i kontrollrom for foring på flåte å observere fisk i kamera, styringsverktøy etc.

Når det gjelder opplæring i VGS og av ansatte vil det kreve at simulatoren oppdateres med hensyn på detaljer. I tillegg må det da på en enkel måte være mulig å simulere scenarier i de ulike delene av anlegget. Det er gitt tilbakemelding fra faglærere ved Frøya VGS at simulatoren kan være et nyttig verktøy om dette er på plass.

Simulatoren kan bli et viktig verktøy i rekruttering arbeid for å trigge interesse blant unge ved utdanningsmesser og besøk i grunnskolen. Simulatoren har vist seg å være et stort trekkplaster på unge i situasjonene vi har benyttet den. Simulatoren vil derfor øke antall besøk ved en evt. stand på messer og dermed muligheten for å presentere næringen.

Simulatoren ser vi også for oss kan brukes i bransjesammenheng som salgsmesse etc. I likhet med interesse ved utdanningsmesser vil simulatoren fatte stor interesse i en slik sammenheng.

Simulatoren kan bidra til promoteringen av Måsøval gjennom merking av anlegg og flåte i spillet. Videre vil det være nyttig for Måsøval at det klart

fremkommer av spillet at dette er et produkt som er utviklet som et samarbeid mellom Anders, NTNU og Anders.

Simulatoren og dens bruksområde vil helt klart ha en merkevarebyggende effekt for Måsøval, amt bidra til god omdømmebygging både for Måsøval og næringen.

Når det gjelder fremtidig funksjonalitet mådet prioriteres fremtidig brukervennlighet for MFO. Gjerne med forskjellige funksjoner/scenarioer som kan legges til. Helikoptertur for åse kysten og Frøya? Fin promotering av både kysten vår, Frøya og MFO! :)”

C: Questionnaires

Open day at NTNU

Forslag til annen ny funksjonalitet i simulatoren?

Kjøre katamaran

forbedre teksturer, bedre animasjoner på fisken, en måte å holde seg i ro under vann. vise groe, og beveglese i kjetting og fortøyning.

Kunna se og oppdage eventuelle realistiske hull i nota.

Förlåte

Andre kommentarer til havbrukssimulatoren?

haien syns jeg skal bort, ikke realistisk. få mer innblikk i arbeidssituasjoner, (avlusing, dødfisk, løfting av bøyer til koblingskive og fortøyninger.)

veldig godt på vei :D noe problemer med clipping og annet småfeil. vanskelig å si på 3 min.

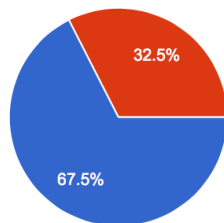
Burde vært enklere å kjøre båt. Skulle vært mulig å gå rundt mærdén, sjekke fortøyningene osv.

Litt bedre kvalitet på f.eks fortøyninger, var ting som forsvant litt.

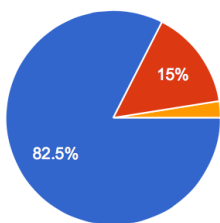
den var god

Det var mye bra oppdateringer, med tanke på sist gang du var her

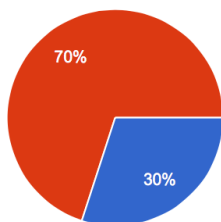
Kjønn



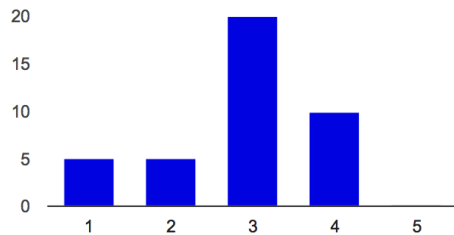
Mann	27	67.5%
Kvinne	13	32.5%

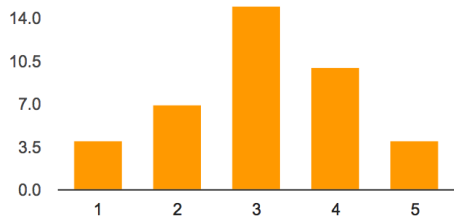
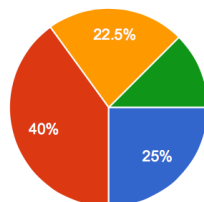
Alder

0-20	33	82.5%
20-30	6	15%
30+	1	2.5%

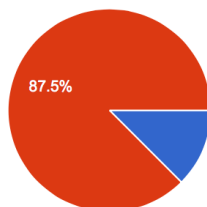
Jeg kan en del om fiskeoppdrett

Ja	12	30%
Nei	28	70%

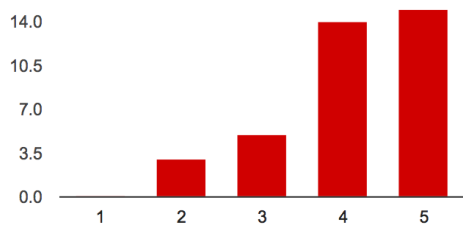
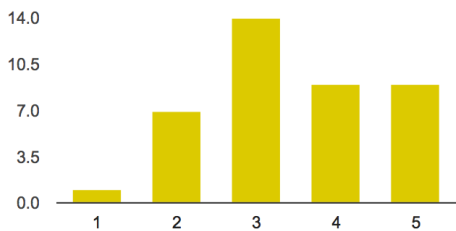
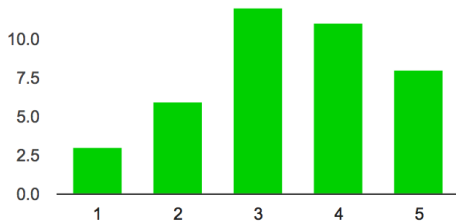
Jeg lærte noe nytt som fiskeoppdrett etter å ha prøvd havbrukssimulatoren

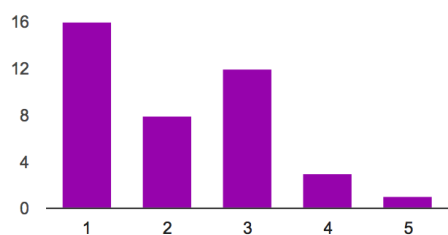
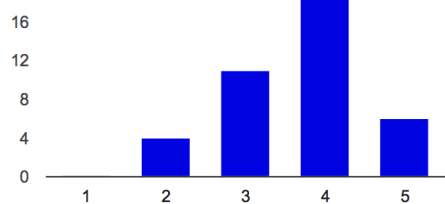
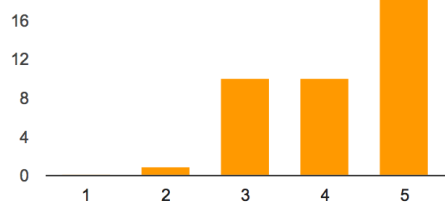
Jeg lærte hvordan ankringssystemet til et fiskeoppdrettsanlegg fungerer etter å ha prøvd havbrukssimulatoren**Haien var skremmende**

Ja	10	25%
Litt	16	40%
Nei	9	22.5%
Så ikke haien	5	12.5%

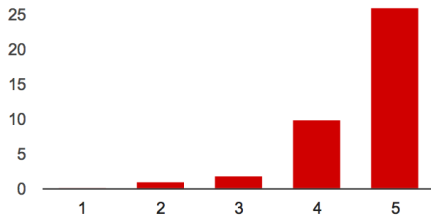
Hva syntes du om en hai i havbrukssimulatoren?

Den burde ikke være der	5	12.5%
Den kan være der	35	87.5%

Fisken så/oppførte seg realistisk**Båtkjøringen var enkel****Båtkjøringen følte "realistisk"**

Jeg ble litt kvalm/sjøsyk av å kjøre båten i stormen**Simuleringen av dårlig vær virket realistisk****Kontrollene generelt i simulatoren var enkle**

Jeg kunne tenkt meg å bruke virtuell virkelighet (Oculus Rift) i undervisningen



Forslag til ny funksjonalitet i simulatoren?

Kanskje mer fps for en bedre opplevelse.

Bedre fps for mer realisme

Annen maskin. Trenger bedre framrate.

Andre kommentarer til havbrukssimulatoren?

Styringen av båten var litt for fintfølende. Det lagget litt under simuleringen

Utralistisk pga. Frameraten.

fiske A.I-en trenger en oppgradering. kanskje få den til å reagere mer på tilværelsen til brukeren. Fiks framedroppen maybe.

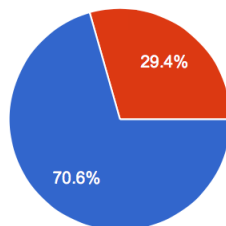
Styringen til båten var veldig sensitiv. Dårlig framerate, men blir vel bedre med en bedre pc.

Litt sensitiv kontroller

Skummelt men nice :)

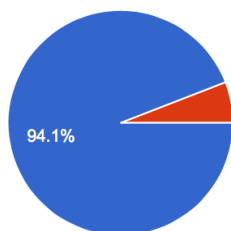
Aquaculture class

Kjønn



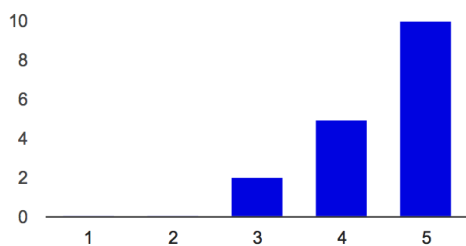
Mann	12	70.6%
Kvinne	5	29.4%

Alder

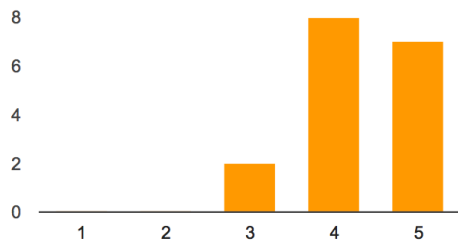


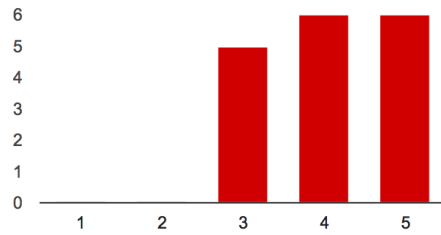
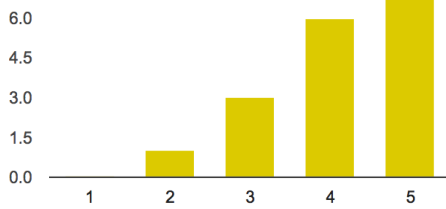
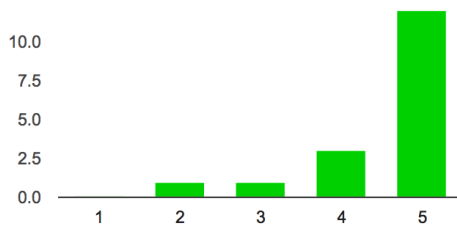
0-20	16	94.1%
20-30	1	5.9%
30+	0	0%

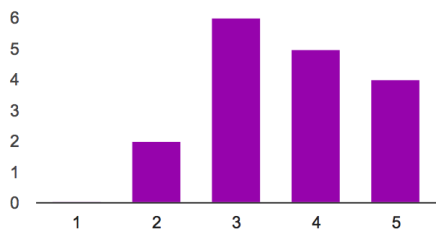
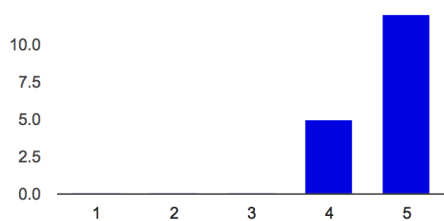
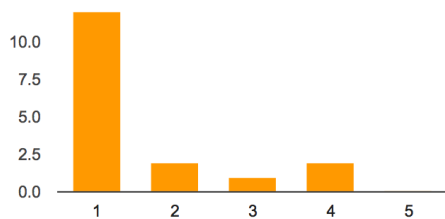
Jeg likte havbrukssimulatoren

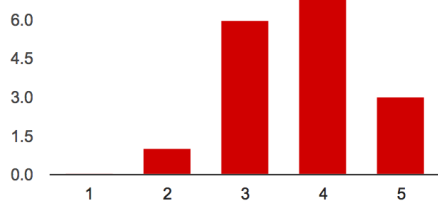
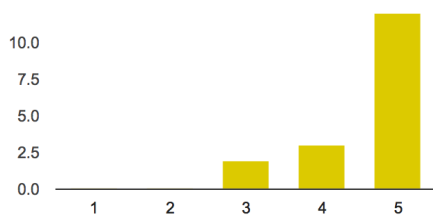
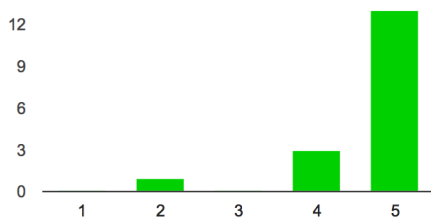


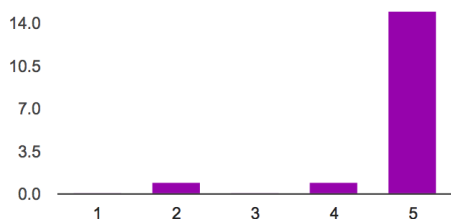
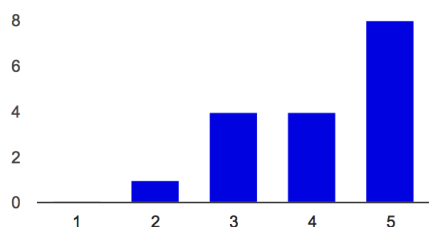
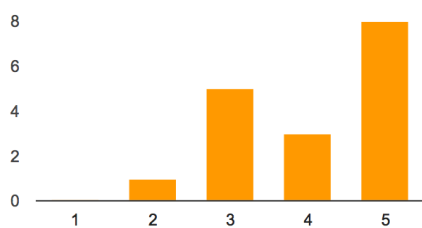
Ankringsystemet så realistisk ut



Fisken så/oppførte seg realistisk**Habrukssimulatoren kan brukes til sikkerhetstrening i oppdrettsnæring****Båtkjøringen var enkel**

Båtkjøringen føltes "realistisk"**Havbrukssimulatoren kan bidra til å vekke interesse for havbruk blant barn og unge****Jeg ble litt kvalm/sjøsyk av å kjøre båten i stormen**

Simuleringen av dårlig vær virket realistisk**Habrukssimulatoren kan bidra til å øke forståelse for oppdrettsnæring blant folk flest****Kontrollene generelt i simulatoren var enkle**

Jeg kunne tenkt meg å bruke havbrukssimulatoren i undervisningen**Havbrukssimulatoren kan brukes til opplæring av fiskeoppdrettere****Informasjonsteksten i båten, over merden og over bøya var hjelpsom****For opplæring, hva slags oppgaver kan/bør legges inn i havbrukssimulatoren?**

Lusetelling

Flåte, slik at vi kan prøve å føre på flåten.

arbeidssituasjoner..

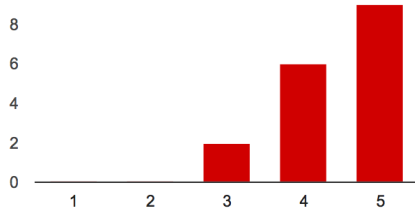
hva man skal se etter å hva man skal gjøre på et oppdrettsanlegg

FLÅTE FOR

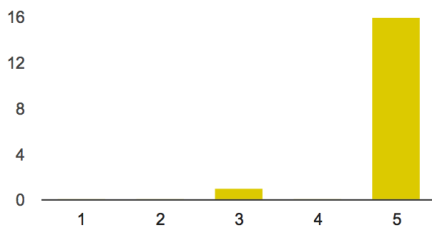
båtkjøring, kranbruk, simuleringer av f.eks. avlusing, levering, osv.

Animasjoner om hvordan festene i merden blir festet.

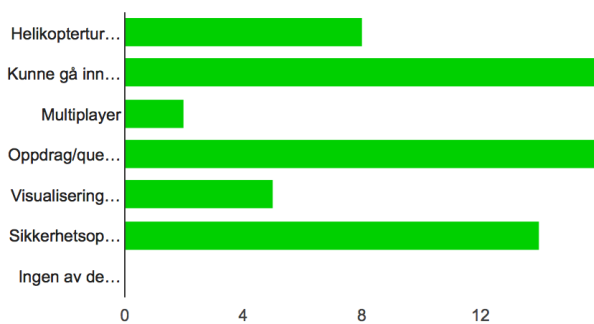
Havbrukssimulatoren kan brukes til promotering av norsk laks internasjonalt



Havbrukssimulatoren bør stilles ut for besøkende/turister på Frøya



Hvilke av disse punktene burde det fokuseres på videre?



Forslag til annen ny funksjonalitet i simulatoren?

Kjøre katamaran

forbedre teksturer, bedre animasjoner på fisken, en måte å holde seg i ro under vann. vise groe, og beveglese i kjetting og fortøyning.

Kunna se og oppdage eventuelle realistiske hull i nota.

Førflåte