Tampere University of Applied Sciences

Creation of 3D Scoreboard in Virtual Reality

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Degree Programme in Business Information Systems
Game Production

TIIVISTELMÄ

Tampereen ammattikorkeakoulu
Tietojenkäsittelyn tutkinto-ohjelma
Game Production

KARILAINEN, VILLE:
3D-tulostaulun luominen virtuaalitodellisuudessa

Opinnäytetyö 29 sivua
Maaliskuu 2024

Laajennetun todellisuuden teknologia on kehittynyt ja saavuttanut suosiota sekä kuluttajien että yritysten keskuudessa. Suosittuja laajennetun todellisuuden kokemuksia ovat esimerkiksi virtuaalikierrokset museoihin tai tehtaisiin sekä koulutussimulaattorit uusille työntekijöille. Yksi tapa ylläpitää käyttäjän kiinnostusta harjoitusta toistettaessa on lisätä vuorovaikutteisuutta. Se voidaan toteuttaa lisäämällä kokemukseen tulostaulujärjestelmä, joka kannustaa käyttäjiä kilpailemaan sijoituksesta tulostaulukossa.

Opinnäytetyön tarkoituksena oli luoda virtuaalitodellisuustulostaulujärjestelmä Unityllä. Järjestelmää käytettiin ABB Oy:lle tehdyssä virtuaalitodellisuuskoulutussimulaattorissa, jossa tutustutaan yhteen heidän tuotteistaan, Relion 615 -releeseen. Koulutussimulaatiossa käyttäjät rakentavat tuotetta virtuaalitodellisuudessa samalla kun heitä ajoitetaan, ja viisi nopeinta käyttäjää näytetään tulostaululla.

Opinnäytetyössä keskityttiin virtuaalitodellisuustulostaulujärjestelmän luomiseen Unityssä ohjelmoijan näkökulmasta. Tähän sisältyy laajennetun todellisuuden terminologian läpikäynti, mikä tekee virtuaalitodellisuuteen kolmiulotteisen tulostaulun luomisesta ainutlaatuista ja mitä järjestelmiä prosessin aikana käytettiin. Opinnäytetyön tavoitteena on antaa lukijalle kuva siitä, mitä virtuaalitodellisuuden kehittämiseen kuuluu Unityssä.

Prosessin lopputuloksena luotiin toimiva tulostaulujärjestelmä, joka tallentaa viisi nopeinta aikaa ja näyttää ne järjestyksessä. Järjestelmään kuuluu näppäimistö, jolla käyttäjä kirjoittaa nimensä. Tulostaulujärjestelmää kehitettiin aktiivisella pelitestauksella. Testaus varmisti, että tulostaulujärjestelmä oli toimiva, ja paljasti myös, että siinä oli vielä parantamisen varaa.

Avainsanat: laajennettu todellisuus, tulostaulu, Unity, virtuaalitodellisuus

ABSTRACT

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Extended reality technology has recently improved and gained popularity for both the consumers and companies. Some popular extended reality experiences include virtual tours of museums or factories, as well as training simulators for new employees. A method to maintain the user engagement during the experience is by adding interactivity, which can make training simulators more fun for the user to practice multiple times. This can be achieved by adding a scoreboard system to the experience, giving users an incentive to have friendly competition to place themselves on top of the scoreboard.

The aim of this thesis was the creation of a virtual reality scoreboard system in Unity. This system was used for a virtual reality training simulator project done for ABB Group, helping people to become familiar with one of their products, the Relion 615 relay. In the training simulation the users will build the product in virtual reality while being timed, and the five fastest users will be displayed on the scoreboard.

This thesis focuses on creating a virtual reality scoreboard system in Unity from the point of view of a programmer. This includes going over extended reality terminology, what makes creating a virtual reality 3-dimensional scoreboard unique, and what systems were used during the process. The thesis aims to give the reader an image of what goes into Unity virtual reality development.

The end product is a functioning scoreboard system which records the five fastest times and displays them in order. This includes a keyboard which is used to take the user’s name. The scoreboard system was fully developed with the help of active playtesting. The playtesting ensured that the scoreboard system was functional, also revealing that some room was left for improvement.

Key words: extended reality, scoreboard, Unity, virtual reality

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ABBREVIATIONS AND TERMS

2D	Two-dimensional
3D	Three-dimensional
360-degree video	Video taken with a 360-degree camera
AR	Augmented reality
Canvas	An element applied to Unity GameObjects to display images or text
Feedback loop	System which takes the system's output and uses it as input
GameObject	Fundamental objects in Unity that represent characters, props and scenery
MR	Mixed reality
PlayerPrefs	A class that stores Player preferences between sessions
Scoreboard	Display panel showing scores or points in a game or competition
Stereoscopic vision	Perception of depth by showing the user two slightly offset images
UI	User interface
UX	User experience
VR	Virtual reality
XR	Extended reality

1 INTRODUCTION

In recent times extended reality technology has taken strides and slowly worked its way in to the use of both the consumers and companies alike. We've seen companies of all caliber make use of virtual reality to create unique experiences, be it a virtual tour of a museum or a factory, or perhaps a training simulator for new employees. It is important that the user is engaged in the experience in some way, and in the case of training simulators having some interactivity not only makes it more fun for the user to train but also gives them an incentive to practice multiple times. One way to create such interactivity is by adding a scoreboard system to the experience, giving users an incentive to have a friendly competition to place themselves on top of the scoreboard.

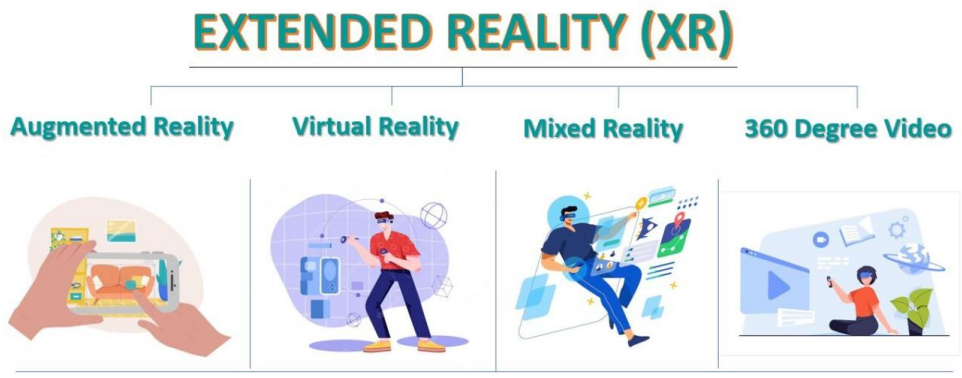
This thesis focuses on creating a virtual reality 3-dimensional scoreboard in Unity from the point of view of a programmer. This includes going over some extended reality related terminology, why you can't make a 3-dimensional virtual reality scoreboard the same way as a regular two-dimensional one, and what systems were used in order to put it all together. The purpose of the thesis is to provide context to the reader about what goes into making a virtual reality project like this in Unity.

The goal of this thesis is the creation of a scoreboard system for a virtual reality training simulator project done for ABB Group, helping people get familiar with one of their products, the Relion 615 relay. The user's will be timed during the building process, and the five fastest users will be displayed on the scoreboard.

2 EXTENDED REALITY

2.1 What is extended reality?

Extended reality, also known as XR, is defined as the spectrum of all virtual and augmented experiences, which merges the physical and virtual worlds to create engaging and immersive virtual environments allowing users to interact with computer generated elements in real-time. It utilizes a combination of technologies in order to enhance human perceptions of reality, blurring the boundaries between what is digital and what is real. Extended reality has a variety of uses, with its technology being useful in training simulations as well as online meetings for example. Extended reality is an umbrella term which includes virtual reality, augmented reality, mixed reality as well as 360-degree video (Picture 1), all which are different approaches to altering our perception of reality. (Willing 2023.) 360-degree video is a video format that captures 360-degree views of a scene, which allows the user to explore it from many angles. It's great for immersive experiences that place the user in the centre of action, like a virtual factory tour for new employees (Picture 2), or training workers in customer service skills in life-like simulation scenarios. (Sharma 2023, ABB)



PICTURE 1. Extended reality is an umbrella term (Sharma 2023).

PICTURE 2. Final assembly captured using 360-degree video (ABB Oy n.d).

2.2 What is augmented reality?

Augmented reality, also known as AR, is an interactive and reality-based display environment that enhances the user's perception of the real-world by using computer generated display, sound, text, effects etc. Augmented reality combines scenes from the real world and ones generated by computer in order to create a unified and enhanced image of the world (Picture 3). (Rouse 2017.) Augmented reality is most commonly experienced using smartphones, tablets or augmented reality glasses. These devices project virtual objects, text or images to the user, allowing them to simultaneously interact with both the virtual and physical world. (Willing 2023.)

PICTURE 3. Augmented reality captured in Pokémon Go.

2.3 What is virtual reality?

VR or virtual reality technology allows the user to act in an environment that is digital yet feel as if they are immersed in a physical environment. Virtual reality allows the user to experience an environment that feels as if it was the real world. To achieve a proper immersion the environment in virtual reality must appear life-sized from the perspective of the user, and the system running the simulation must track the user's actions so it can react and change the visuals on display. (Rouse 2023.)

Jonathan Steuer, a Ph.D. in communication theory and research, proposed that virtual reality has two vital components, depth of information and breadth of information. Depth of information refers to the data fed to the user by the virtual environment, achieved by the graphics quality and complexity of the environment, for example. Breadth of information refers to the number of senses being stimulated by the environment. Most commonly this will only include audio and

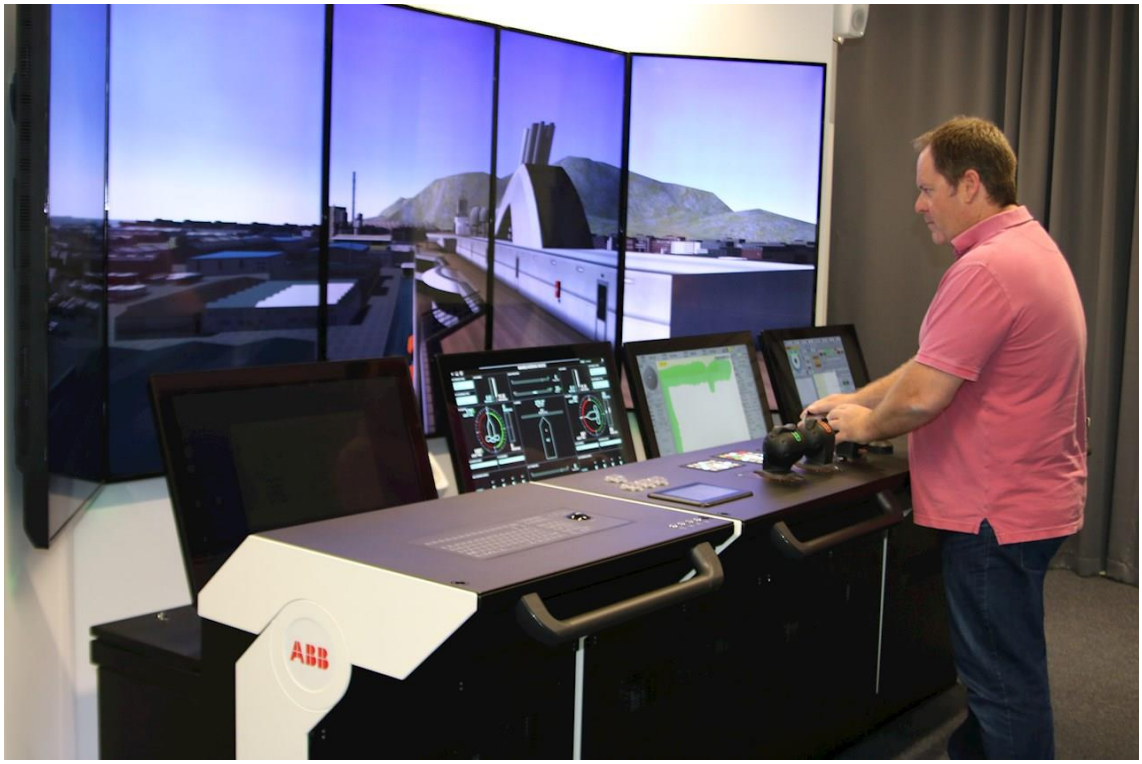
visual stimuli, immersion could be enhanced by stimulating all five senses. (Rouse 2023.) An example of virtual reality being used is the game SUPERHOT (Picture 4).

PICTURE 4. Example of virtual reality from the game SUPERHOT (SUPERHOT Team 2016)

2.4 What is mixed reality?

Mixed reality is a hybrid form of extended reality that combines features of virtual reality and augmented reality. Mixed reality allows users to engage with virtual objects while staying aware and interacting with their physical environment. The real-world environment and virtual objects interact and respond with one another. (Willing 2023) The effects and possibilities of mixed reality are on display in the game Demeo (Picture 5). ABB also uses mixed reality in cases like at the ABB Marine Academy (Picture 6).

PICTURE 5. Demeo is a tabletop game in mixed reality (Resolution Games 2022).



PICTURE 6. ABB Marine Academy in Helsinki uses mixed reality for education (ABB 2021).

3 SCOREBOARDS

3.1 History of the scoreboard and the high score

Scoreboards as a concept are nothing new, having been around for over 50 years. Scoreboards are a vital component in games, and one of the most famous examples of an arcade game featuring a scoreboard is Space Invaders originally released in Japan in 1978. Later on came Pacman, Donkey Kong, Frogger etc, all featuring a similar high score system and scoreboard. (Green 2017.)

ArcadeBlogger (2021) defines the purpose of the scoreboard (Picture 7) in their blog post Anatomy of Arcade High Score Tables:

> For designers of the pioneering arcade titles of the day, the high score table served a couple of purposes. Not only was it a thrill to see yourself as a player on top of the world (well, the mini universe of your local arcade at least) – which of course is what the entire industry was based on – but it also gave arcade goers a reason to return to any particular game, check the scoreboards, and attempt to reclaim (or further cement) their status as a high scorer.

PICTURE 7. Scoreboard of Defender (ArcadeBlogger).

3.2 Scoreboards in virtual reality

One of virtual reality's core objectives is immersing the user completely in the virtual environment. However, having poor virtual reality user experience design can break this immersion for the user. User experience design, also known as UX design, is the process of designing something that provides the user with a meaningful experience (Interaction Design Foundation n.d.). Virtual reality user experience design is creating meaningful interfaces and experiences to the user in virtual environments (Mammadli 2023).

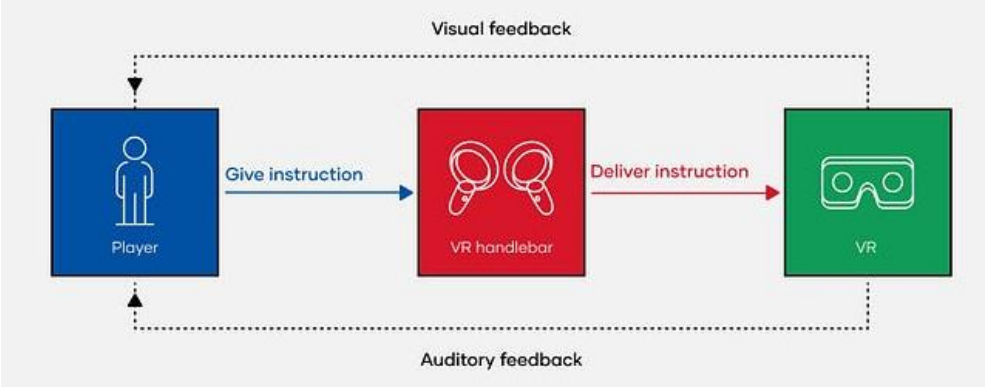
Virtual reality user experience is important as it goes beyond traditional 2D interfaces (Picture 8) and incorporates new elements like spatial design, user flow and immersive interactions for a seamless experience for the user. (Mammadli 2023.) Spatial design is vital for the user's spatial awareness in virtual reality. Interactions and interfaces must be made to suit a 3D virtual reality environment, which requires a profound understanding of spatial design principles. (Mammadli 2023.)

PICTURE 8. Leaderboard of Fruit Ninja VR (Fruit Ninja 2016)

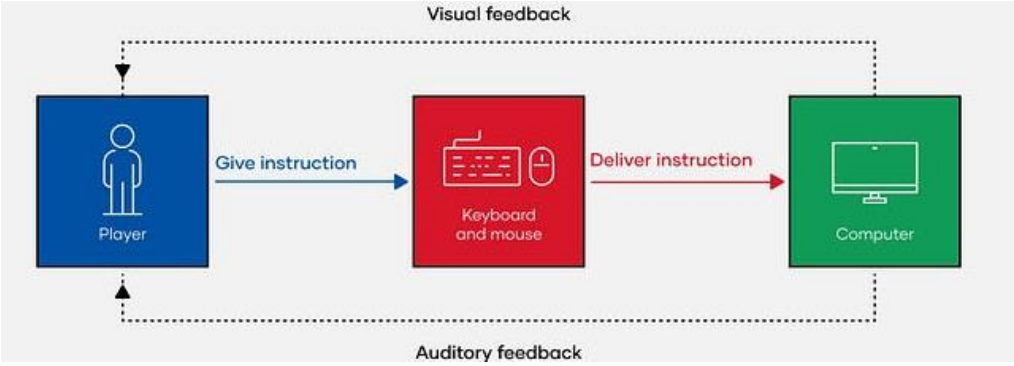
A scoreboard, like any user interface, has many differences in virtual reality compared to their 2-dimensional counterparts User interfaces are the points at which the users interact with a computer, website or application. The user's input may be taken with a keyboard, touch screen, trackpad etc. The goal is to make the user interface effective enough that the user's experience is as easy and intuitive as possible (Indeed Editorial Team 2022.). Even if user interfaces

or menus in virtual reality are 2-dimensional, you still need to consider the surrounding. In virtual reality you're not really designing screens, which traditional scoreboards and high score tables are, but instead you're creating an environment for the user. (Visartech Inc. 2019.)

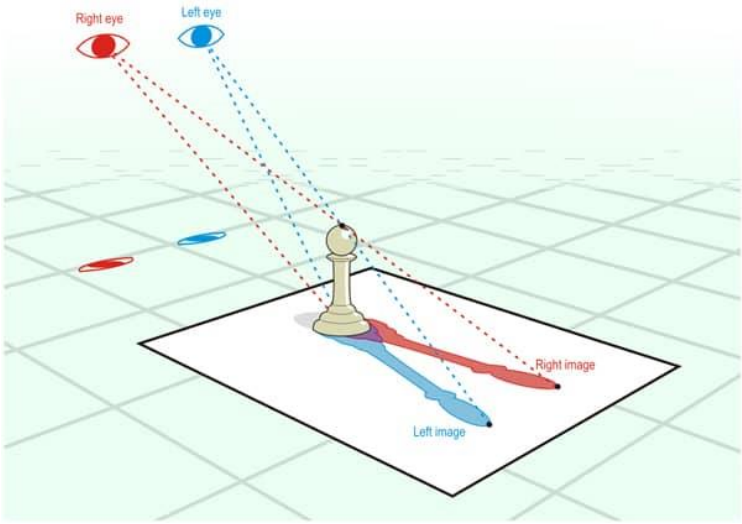
Comparing further between a virtual reality and a 2-dimensional view, it is important to take note of the difference in feedback loops between the systems. A feedback loop is a system which responds to the user's actions and creates either positive or negative consequences which reinforce certain actions (Montgomery Singman n.d). In other words, a feedback loop is a system which takes the system's output and uses it as input (Machinations n.d). Feedback loops in virtual reality (Picture 9) and on a normal 2-dimensional computer (Picture 10) have many similarities in function on paper, but there are many differentiating factors between the systems. Not only does a virtual reality setting not use a keyboard and mouse for input but instead buttons and joysticks, but the picture that is shown to the user isn't on a single screen the user can safely view from a distance, but instead on 2 smaller screens close to the user inside of the virtual reality headset (rct AI 2020). Images and scenes in virtual reality are made to be stereoscopic, meaning that instead of 1 image there are 2 images made for the user, one for each eye (Picture 11). These images are made to more closely resemble the view of a real human eye, with both being from a slightly different angle and perspective to create a sense of depth and 3-dimensionality (Picture 12). (Immersion VR.) Therefore, designing a scoreboard in virtual reality is nigh impossible to do the same way as in a 2-dimensional setting without many issues, such as motion sickness (Mammadli 2023).



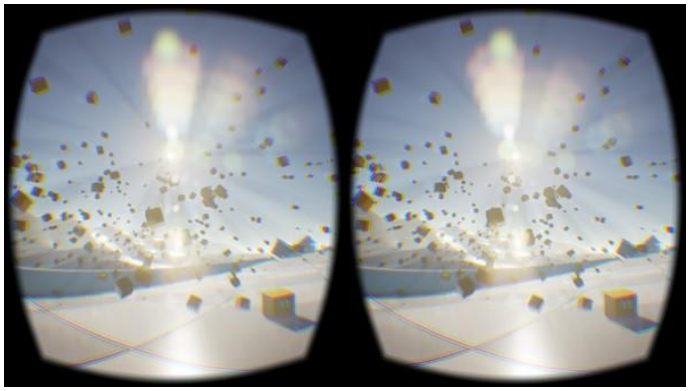
PICTURE 9. Feedback loop in virtual reality (rct AI 2020).



PICTURE 10. Feedback loop example on pc (rct AI 2020).



PICTURE 11. The two lenses of virtual reality glasses create a sense of depth (Immersion VR n.d.)



PICTURE 12. Stereoscopic virtual reality creates 2 images (Immersion VR n.d.)

4 THE PROJECT

4.1 Background about the project

The project started in early spring 2023 as a client project from ABB through Tampere University of Applied Sciences. The purpose was to make a virtual reality training simulation for assembling a Relion 615 relay for client to showcase and use it to onboard new factory employees. Later the client wished the training simulation to be gamified to make it a more enjoyable experience for the user. We came up with the idea to create a time-based scoring system to enhance the user experience and increase replay value. This solution was created in the hopes of making a friendly competition among users, where the best scoring users would get their name saved to the scoreboard as a reward while others could get more training on assembling the relay to try getting on the scoreboard. It is worth mentioning that the original idea was to have a score system based on multiple factors such as efficiency and precision, however it was scoped down for this thesis.

The client wished that Varjo XR-3 was used as the virtual reality headset hardware to achieve accuracy, realism and high resolution for the simulation. The Varjo XR-3 isn't aimed at the consumer market but rather at industries that require the highest level of performance and visual fidelity for tasks such as simulations (Knoxlabs n.d). The Varjo XR-3 glasses (Picture 13) are a high-end mixed reality headset created by Varjo and launched 1.12.2020. With features such as a horizontal 115° field of view, a 90 Hz refresh rate, the worlds most advanced hand tracking as well as eye tracking at 200 Hz powering foveated rendering, the Varjo XR3 are the most advanced mixed reality headset on the market. User's will also require a Varjo subscription as well as a powerful enough computer to make use of the glasses. Users will also need to sign in to the Varjo Base software to use the glasses. (Varjo n.d.)

PICTURE 13. Varjo XR-3 delivers the most immersive mixed reality experience ever constructed (Varjo N.d).

For the project itself we chose the use of Unity as the main engine. Unity was chosen for a few different reasons, most importantly the fact that it was the engine I was personally the most familiar with. I had never worked on a virtual reality project before, so using Unity was a way to get some sense of familiarity to start with. As for the use of Unity we needed some plugins that were discovered more on-the-fly, and these will be further explained in the following chapters.

4.2 Systems that were used on the project

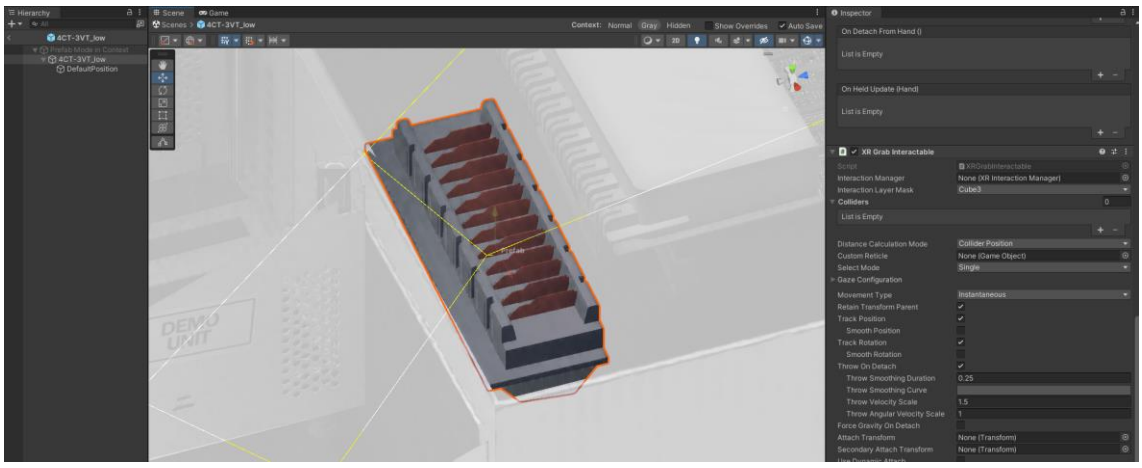
4.2.1 Unity

Unity is a game engine developed by Unity Technologies and released initially on June 8, 2005. Unity is built on a combination of C++ and C#, with it using C# for its main programming language. (Brodkin 2013.) It is a real time development platform which supports the creation of 2D, 3D, Virtual Reality and Augmented Reality content and games and has roughly 1.3 million monthly users as of March 2023. Unity also has a large asset store where users can go find tools, extensions and packages for your project, and Unity itself makes it easy for users to create their own tools if need be. (Dealessandri 2020.)

4.2.2 XR Interaction toolkit

The Unity XR Interaction Toolkit is a high-level, component-based system designed for the creation of Virtual Reality and Augmented Reality games and experiences. It grants the user a framework that makes 3D and UI interactions available from Unity input events. (Unity Technologies 2018.) The toolkit is available for Unity 2019.3 and later versions and can be downloaded from the Package Manager. The XR Interaction Toolkit includes many different components that can be attached onto GameObjects to give them different interactive features. Typically these features would need to be scripted or downloaded from external libraries, but thanks to the toolkit extended reality development is easier and faster than ever. (Buckley 2023.)

The XR Interaction Toolkit was used in the project for a multitude of different interactions in addition to the Unity SteamVR extension. Primarily the toolkit was the main system used for grabbing and interacting with all of the grabbable GameObjects in the project with the use of the XR Grab Interactable script (Picture 13).



PICTURE 13. Each grabbable object has the XR Grab Interactable script attached to them.

The XR Interaction Toolkit also has another very important interactor for the project, that being the XR Poke Interactor. In all its simplicity the XR Poke Interactor is an interactor which uses poking for interaction (Unity Technologies 2023). In the project poke interactors were used on the players pointer fingers

(Picture 14), allowing the player to use the keyboard by poking the buttons with their fingers. The poke interactor is added to the players hand and then moved into the pointer finger through code. The script is from Fist Full of Shrimp's YouTube channel (Picture 15).

PICTURE 14. The XR Poke Interactable is attached at the end of the pointer finger.

SetPokeToFingerAttachPoint.cs

C: > Users > Wille > Documents > VRProject > Assets > Scripts > SetPokeToFingerAttachPoint.cs

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.XR.Interaction.Toolkit;

public class SetPokeToFingerAttachPoint : MonoBehaviour
{

    public Transform PokeAttachPoint;

    private XRPokeInteractor _xrPokeInteractor;

    void Start()
    {
        _xrPokeInteractor = transform.parent.parent.GetComponentInChildren<XRPokeInteractor>();
        SetPokeAttachPoint();
    }

    // Update is called once per frame
    void SetPokeAttachPoint()
    {
        if (PokeAttachPoint == null)
        {
            Debug.Log("Poke attachpoint is null");
            return;
        }
        if (_xrPokeInteractor == null)
        {
            Debug.Log("XR poke interactor is null");
            return;
        }
        _xrPokeInteractor.attachTransform = PokeAttachPoint;
    }
}

```

PICTURE 15. Code used for setting the position of the XR Poke Interactor (Fist Full of Shrimp 2023).

4.2.3 SteamVR

SteamVR is a virtual reality platform developed by Valve for Steam. It was originally announced in 1.3.2015 and offers a 360-degree full room virtual reality experience. SteamVR also released a plugin for Unity developers a few months later in 30.4.2015. The SteamVR Unity Plugin is a tool developed by Valve that allows developers to interface SteamVR with Unity. The plugin supports a wide array of VR headsets and controllers, making it a versatile tool for VR development. It also includes an Interaction System example to help developers get started with VR interactions, some of which were used in the project, like the player prefab. (Valve n.d.)

5 SCOREBOARD IMPLEMENTATION

I had done a scoring system in a previous project, but an actual scoreboard system was something I hadn't quite done before. I had done a simple scoring system in a game before for a previous project, so saving and loading a score wasn't entirely new to me. A scoreboard system however, was new to me, as I had no previous experience with sorting user scores and implementing it for a virtual reality application. I had a rough idea what went into making one, tracking the player's score, which in this case was time, saving the best times and filtering the scoreboard accordingly.

What went into the design was quite simple, and the design was created in collaboration with the customer. The user will start a run by pressing the button and starting the timer, and once the user is done with building the relay press the button again to stop the timer. If the user placed in the top 5, their time will be displayed on the scoreboard and saved into local memory using PlayerPrefs. PlayerPrefs is a simple way to save and load data locally between game sessions, so the next time the project is played the previous top 5 times will be loaded from PlayerPrefs on to display. Taking the user's name was something I had no previous experience with, but luckily there was a lot of information available on the subjects. §The code in this project never got too advanced which was my intention to begin with.

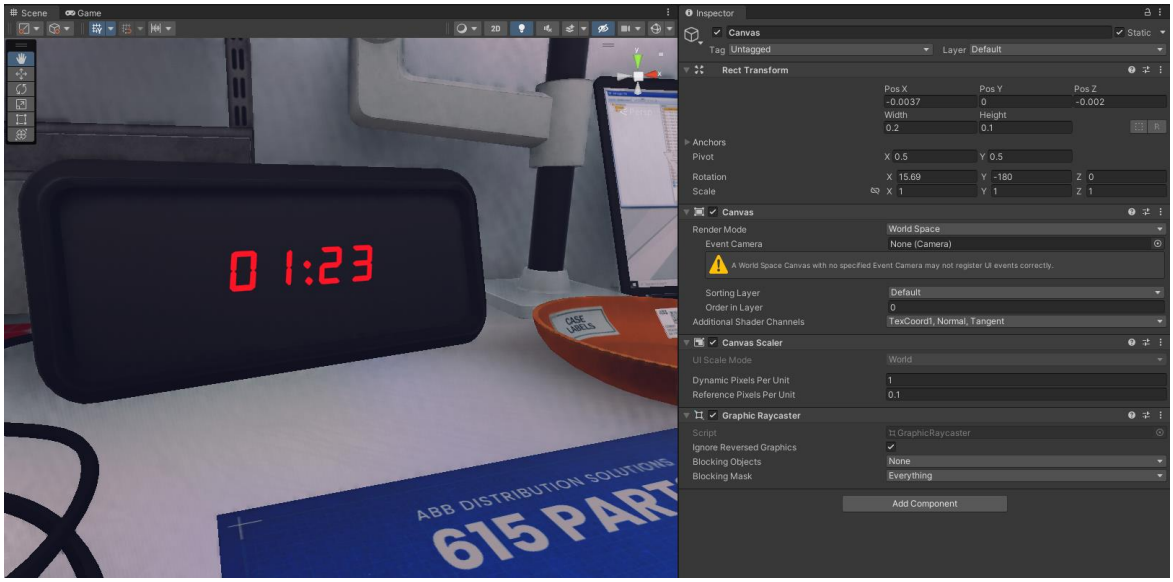
5.1 Scoreboard for non-top 5 user

The scoreboard for a non-top 5 user is similar to the top 5 user for the most part expect for taking the user's input for the scoreboard. The user starts their time by pressing the button on the table, activating the code for the timer (Picture 17). Using the update method, the code checks if the timer's button has been pressed with the timerActive boolean and then increases the time accordingly by one for each second. The current time will be displayed as text on the actual timer, and it is formatted using the time.ToString() method.

```
// Update is called once per frame
void Update()
{
    if(timerActive == true)
    {
        clockSound.SetActive(true);
    }
    else if (timerActive == false)
    {
        clockSound.SetActive(false);
    }
    //yourTimeText = currentTime
    //Debug.Log(currentTime);
    if(timerActive == true)
    {
        currentTime = currentTime + Time.deltaTime;
    }
    TimeSpan time = TimeSpan.FromSeconds(currentTime);
    //displays time with minutes, seconds and millisecond accuracy
    currentTimeText.text = time.ToString(@"mm\:ss\:ff");
```

PICTURE 17. Code used for the timer.

The timer displays the user's current time with text on a canvas element (Picture 18). The Canvas is a Unity UI component applied to objects in order to display images or text. In this case a text object was applied to the canvas to show the user's time. The same was used for the scoreboard to make it visible in the Unity scene.



PICTURE 18. A canvas element was added to the timer to show the user's current time.

After successfully assembling the 615 relay, the user is intended to stop the timer by pressing the button on the table (Picture 19). The timer cannot be stopped unless the 615 relay has been fully assembled. Afterwards the score-board will check the user's time and display the users inside the top 5 and their corresponding times on a canvas on the scoreboard (Picture 20), this gives the user a chance to compare the time they got to the ones within the top 5, which gives them a reason to do even better next time.

PICTURE 19. The timer and the button which is pressed to start and end a run.

PICTURE 20. Scoreboard for a non-top 5 user.

5.2 Scoreboard for top 5 user

After completing their run and stopping the timer, any user who has a time that is better than the worst time currently on the list has their time added to the scoreboard. How good the time is will be checked one position at a time. If the time's worse than the first one for example, the time will be compared to the next one until all times have been compared. This process is done until the user's time is better than the time it's being compared to or until there are no more times to compare, in which case the user missed the top 5.

Writing the name on the scoreboard happens using a keyboard and the XR poke interactor. The keyboard in question is Microsoft's MRTK-Keyboard, and using it made life a whole lot easier considering it is a premade and fully functional keyboard (Picture 21). I found the keyboard, and worked on writing with it, thanks to Valem Tutorials' YouTube channel (Valem Tutorials 2023).

PICTURE 21. Scoreboard for a top 5 user.

The keyboard functions similar to a real-life keyboard, with each key of the keyboard having a button which can be pressed by poking it with the XR poke interactors at the tips of the user's fingers. Once the user has written their name, it will appear on the scoreboard. The keyboard can only be activated if the user is within the top 5.

When the user's time is added into the scoreboard all times that are worse than the user's will be moved down by one spot (Picture 22). If there are no other times on the board the user's time will automatically be number 1, and if the user's time is the fifth-best one the time it's replacing will be deleted. The first if-clause is for checking if the user made the top 5. The second if-clause checks if the user's time is better than the #1 time on the list and moves all the other times down one spot accordingly. If the user's time wasn't better than the #1 time, it will then be compared to the #2, #3 and so forth.

```
if (currentTime > PlayerPrefs.GetFloat("Highscore time 5" , 0) && PlayerPrefs.GetFloat("Highscore time 5" , 0) != 0)
{
    Debug.Log("Time was outside the top 5");
    return;
}

if (currentTime < PlayerPrefs.GetFloat("Highscore time" , 0) || PlayerPrefs.GetFloat("Highscore time" , 0) == 0 )
{

    TimeSpan timeScore = TimeSpan.FromSeconds(currentTime);

    PlayerPrefs.SetFloat("Highscore time 5", PlayerPrefs.GetFloat("Highscore time 4" , 0));
    PlayerPrefs.SetFloat("Highscore time 4", PlayerPrefs.GetFloat("Highscore time 3" , 0));
    PlayerPrefs.SetFloat("Highscore time 3", PlayerPrefs.GetFloat("Highscore time 2" , 0));
    PlayerPrefs.SetFloat("Highscore time 2", PlayerPrefs.GetFloat("Highscore time" , 0));
    PlayerPrefs.SetFloat("Highscore time", currentTime);
    inputfieldButton.SetActive(true);

    highScoreText.text = PlayerPrefs.GetFloat("Highscore time" , 0).ToString();

    highScoreText2.text = PlayerPrefs.GetFloat("Highscore time 2" , 0).ToString();

    highScoreText3.text = PlayerPrefs.GetFloat("Highscore time 3" , 0).ToString();

    highScoreText4.text = PlayerPrefs.GetFloat("Highscore time 4" , 0).ToString();

    highScoreText5.text = PlayerPrefs.GetFloat("Highscore time 5" , 0).ToString();
    TimeSpan time1 = TimeSpan.FromSeconds(PlayerPrefs.GetFloat("Highscore time" , 0));
    TimeSpan time2 = TimeSpan.FromSeconds(PlayerPrefs.GetFloat("Highscore time 2" , 0));
    TimeSpan time3 = TimeSpan.FromSeconds(PlayerPrefs.GetFloat("Highscore time 3" , 0));
    TimeSpan time4 = TimeSpan.FromSeconds(PlayerPrefs.GetFloat("Highscore time 4" , 0));
    TimeSpan time5 = TimeSpan.FromSeconds(PlayerPrefs.GetFloat("Highscore time 5" , 0));
    highScoreText.text = timeScore.ToString(@"mm\:ss\:ff");
    highScoreText2.text = time2.ToString(@"mm\:ss\:ff");
    highScoreText3.text = time3.ToString(@"mm\:ss\:ff");
    highScoreText4.text = time4.ToString(@"mm\:ss\:ff");
    highScoreText5.text = time5.ToString(@"mm\:ss\:ff");




    PlayerPrefs.SetString("Highscore name 5", PlayerPrefs.GetString("Highscore name 4" ,"null4"));
    PlayerPrefs.SetString("Highscore name 4", PlayerPrefs.GetString("Highscore name 3" , "null3"));
    PlayerPrefs.SetString("Highscore name 3", PlayerPrefs.GetString("Highscore name 2" , "null2"));
    PlayerPrefs.SetString("Highscore name 2", PlayerPrefs.GetString("Highscore name" , "null1"));


    //PlayerPrefs.SetString("Highscore name", inputFieldText.text);
    playerisNumber1 = true;

}
else if (currentTime < PlayerPrefs.GetFloat("Highscore time 2" , 0) || PlayerPrefs.GetFloat("Highscore time 2" , 0) == 0)
{
```

PICTURE 22. Code for the scoreboard system.

6 DISCUSSION

In this thesis we have gone through what is required to make a virtual reality project like this in Unity, therefore fulfilling the purpose of the thesis. The goal was reached by the creation of a scoreboard system for a virtual reality training simulator project done for ABB Group, helping people get familiar with one of their products, the Relion 615 relay. The scoreboard system works as intended, giving the user that extra incentive as was planned.

The project was tested in one of its earlier states with some of ABB Group's employees in Tampere during the summer of 2023. During the playtest employees had a chance to test the current build and give us feedback on how the general interaction was working and feeling. The score system only measured build time, without saving it or displaying it on the scoreboard. The keyboard was also missing at the time. Another thing I wouldn't mind changing would be making the building process as well as scoring system slightly more intricate. As it currently stands the pieces snap together quite effortlessly, perhaps a bit too effortlessly. This was done to limit the precision needed, lowering the skill level needed for people to use the project. I didn't want people's lack of virtual reality experience to be a huge hindrance. Regardless, I think with more time the building process could have been a bit more life-like without compromising the user experience.

One issue I have with the project in hindsight is the lack of instructions given to the user about fundamentals like using the controller. Many of the people who tested the project during the summer were not all that familiar with the controls, which is why I was there to help them, but I could have added more instructions. The project was playtested all the way through the development, with playtest sessions being held each week and taking notes after each session on what needs fixing. The playtesting was done to ensure that the scoreboard system as well as taking the user's input worked as intended. The playtesting was a vital part of the development cycle, and it was done with various people at various stages of development to ensure the functionality of all the features of the scoreboard.

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