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BACHELOR PROJECT

ADVANTAGES AND DISADVANTAGES OF CONVERTING AN ORDINARY COMPUTER GAME TO VR

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Abstract

This study investigates the complications met during a conversion of a traditional PC game into virtual reality (VR). This conversion is based on a game called Solitude, which was made in an earlier semester during the course, Game Design 2. The objective of the research is to examine the advantages and disadvantages of the suggested alternated game mechanics and explore the difference in immersion. The designed adaptations to the game were play tested to give an overview on what potentially works in practice. The tests were informal with ongoing conversations and the playtesters answered questionaries at the end. The tests provided feedback, which supported the improvements towards a more significant player experience, as well as showing that the level of immersion in the VR version transcends the traditional gaming platforms. The design process also showed the game mechanics' level of functionality depends heavily on the type of game being converted.

Keywords: Conversion, Virtual reality (VR), Immersion, Playtesting, Game mechanics

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Introduction

Gaming has been transformed by virtual reality (VR), an innovation that has altered several industries. It has become possible for game designers to create more immersive and engaging experiences thanks to the ability to immerse players in virtual worlds. A traditional PC game can be converted into a VR format, but this process is not without its difficulties. This study aims to look into these difficulties encountered when converting the ordinary third-person PC game Solitude into a VR experience.

This conversion will result in a whole new game, fitted for the VR experience, while still upholding the nature of the original game.

A comprehensive video comparing some of the biggest changes of both versions can be seen in Appendix 1. It is not meant for the reader to watch the whole video in one sitting, but instead watch specific comparisons when mentioned in this report. Timestamps will be shown in both the video and paper. A full playthrough of both the PC and VR version can be seen in Appendix 5 & 6.

Problem Statement

Virtual Reality (VR) has become increasingly more relevant as a medium in the world (Alsop, 2022).Especially in the gaming and entertainment business, VR has become a revolutionary platform where new game mechanics are being tested. Many manufactures of games are joining the wave and has transformed their bestselling computer games to also be available on the VR platform (Bethesda Softworks, 2017) (InnerSloth LLC, 2022). In order to convert an ordinary computer game to VR it was necessary for the manufactures to redesign already existing game mechanics.

This project is based on this conversion, to investigate which advantages and disadvantages could occur when converting an ordinary computer game into a VR based game. In connection with this, there will be a great focus on qualified playtests, with the aim of capturing and validating which experiences are achieved by the changes.

Background

This project is based on another paper from 2021, which was a part of a semester project for the course Game Design 2 (T560020101-1-F21). The original project involved development and user testing of the game Solitude, and also contains the original game file including the game assets. This project refers to the PC version of Solitude when relevant for the problem statement. The paper from Game Design 2 is attached in Appendix 4 and the original game is located in Appendix 7.

Description of the Original Game

As mentioned, this project is based on the original PC game 'Solitude', a 3D adventure game developed with a hero's journey narrative. The graphics, characters and overarching story of this VR project are therefore similar to the original game.

In Solitude the player inhabits the child character 'Arthur', who is playing in the garden with his little brother 'Max'. After accidentally kicking a ball over the hedge and into the neighbor's garden, Arthur convinces Max to go retrieve it. However, after some time Arthur realizes that Max is not coming back and therefore starts off on a journey to rescue his little brother. During Arthur's journey into the neighbor's backyard, he encounters an uncanny world of strange places and other-worldly beings, which only get more mystifying throughout his travels. He finds himself navigating a labyrinth of hedges, fighting his way through an overgrown garden filled with dangerous tree spirits, and finally encounters the evil neighbor 'Mr. Dargon' whom he must fight in order to save Max. This adventure is greatly exaggerated by Arthur's imagination.

The essence of the original game of Solitude was to convey different storytelling aspects into a fun 3D game experience. The game implements the 12 steps of the hero's journey (Campbell, 1990) as its overall structure, while also including some of the character archetypes, such as the hero and the mentor. Additionally, the game focuses on environmental storytelling and indirect navigational techniques to lead the player in the right direction. This also ties into the level design of the different areas that the player has to traverse. The graphics are made in a voxel-art style and different original soundtracks were created for each level to better convey the gameplay atmosphere.

Figure 1: Screenshots from Solitude PC

Related Work

It is not uncommon to take inspiration from other similar projects when developing a game. Since this project focuses on the conversion of a video game from PC to VR, it only seemed fitting to find related works. Additionally, it would be appropriate to look at other VR games to see which aspects they have implemented for the best player experience, while also getting an idea of which aspects to potentially avoid.

A great starting point is to look at Bethesda Game Studios, as they have converted their popular game 'The Elder Scrolls V: Skyrim', also referred to as 'Skyrim', to virtual reality (Bethesda Softworks, 2017). Skyrim is an open world role playing game set in a medieval environment, in which the player can discover different areas and fight mythical monsters. The VR version of Skyrim is almost a direct copy from the original game, with the only major difference being the fact that it requires a head mounted display to play. However, this one-to-one conversion did not receive very positive reviews from both critics (Stapleton, 2018) and the player base (Steam, 2023), as many thought it to be lazy and unimaginative.

Furthermore, the development team had to make some major sacrifices, such as reducing frame rates and worsening texture quality. The conversion also exaggerated many of Skyrim's historically infamous problems, such as bad character animations, as these problems now severely stood out. The combat system became harder and therefore much more aggravating and many players became prone to cybersickness. (Stapleton, 2018)

An example of a more successful conversion from PC to VR is the game 'SUPERHOT' (SUPERHOT Team, SUPERHOT, 2016) (SUPERHOT Team, SUPERHOT VR, 2019). The concept of the game is very unique, as time in the game only moves when the player does. The player has to defeat a variety of enemies throughout different levels, while using this time-stopping-mechanic to their advantage. While the game is simple in its premise, it also allowed the team to not only convert it to VR, but actually improve on the original concept. In the VR version the player now has to use their physical body movement to activate the time-stopping-mechanic and also to dodge enemy attacks, which greatly improves immersion while playing. The success of this conversion is primarily based on the fact that the development team emphasized the strengths of virtual reality, when it came to the game's core mechanics. This aspect is essential when converting a PC game to VR, as it is vital to consider which aspects of the gameplay have to be tailored to the new virtual experience, and which have to stay more or less the same.

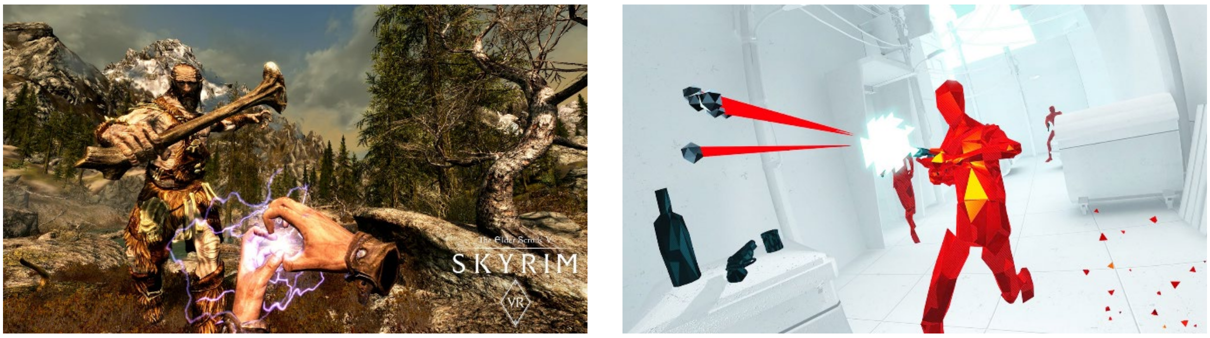

Figure 2: Screenshots of The Elder Scrolls V: Skyrim VR (The Elder Scrolls, 2023) and SUPERHOT VR (Steam, 2023)

Methodology

Use of AI-tools

The advancement of AI and especially ChatGPT has made it relevant for a disclaimer on the use of AI-tools in this project.

ChatGPT has been used as a work tool and it has been utilized in this project according to the official rules stated by the Faculty of Engineering at SDU. The AI has been used for minor tasks regarding software and correcting grammatical errors. It has not been used to generate any original text. However, it has been used for correcting recurring grammatical errors and incorrect sentence structure. Regarding technical use, ChatGPT has been utilized in early code frameworks and in creating some algorithms when needed.

The overall sentiment of the usage of ChatGPT in this project has been from a critical viewpoint. It has solely been a support in advancing on some of the critical paths throughout the project.

Development Process

Game development can be a very complex process in which effective planning and management are important factors for a successful result. Some often used methodologies for team organization include working iteratively, creating an overall overview and dividing various big work tasks into smaller parts. Additionally, it is important to develop with the end-users in mind, to customize and design the final product to their liking. This project makes use of these methodologies in order for the team to meet deadlines, stay organized and finally deliver a high-fidelity product.

Iterative Process

The Iterative process (Eby, 2019) is a development approach to continuously improve a product through different iterations. The steps included in the iterative process are:

1. Planning
2. Analysis
3. Implementation
4. Testing
5. Evaluation

These steps are repeated throughout each cycle, with the intention of building upon the previous iteration, thus developing the project incrementally. This makes it possible to flexibly change, adjust and tweak different features throughout the project. One of the main benefits of this procedure relies on the testing-phase, as this step gives the team valuable feedback for further improvements. Different iterations of the VR game have been developed and tested, in order for the team to evaluate potential refinements in later iterations, thus bringing the team closer to the desired result.

Gantt Chart

This project makes use of a Gantt chart to get a visual representation of the project schedule. Gantt charts divide individual tasks into specific time frames, for a better overview of when each task needs to be done. This makes it possible for the development team to allocate their resources more effectively and optimize their time management. The Gantt chart created for this project divides different overall tasks into 10 sprints, that stretch over a period of 17 weeks. Each sprint is allocated a specific time, in weeks, that indicates a loose deadline for the given tasks. This ensures that the team does not fall behind schedule and further facilitates the possibility of adjusting the plan if necessary.

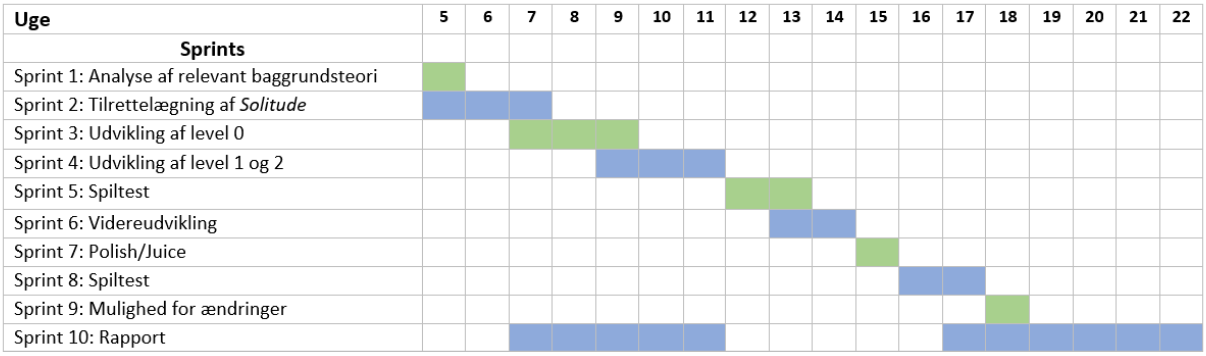

Figure 3: Table showing our sprints

Sprints

A sprint is defined as an iterative work cycle, during which different tasks have to be completed within a specific time frame (Brunskill, 2019). The sprints for this project were usually initiated during weekly meetings. At these meetings the team would start off by setting the agenda of the day, which included:

1. Discussing the current state of the project.
2. Talking about the next steps of the project.
3. Talking about any potential problems having occurred in between meetings.

The development team made use of the program, Trello, to flexibly allocate tasks between the members. Trello is a visual management tool to quickly and easily structure, allocate and visualize the different aspects of the development process. This tool makes it possible to get an easy overview of which tasks needed to be done and which tasks had already been completed. Furthermore, it effectively summarized the work process and made it possible to prioritize different assignments, depending on if they were essential or merely optional.

User Testing

Introduction to User Testing

User testing is a large part of this project and has been utilized in designing the playtests. The essence of the good VR experience is subjective to each individual test user. Designing something meant for a broad demographic is therefore strongly dependent on the response and feedback from the users. To mitigate errors and poor design choices in this project, user tests have been conducted throughout the project from early development to the final product. This chapter is not a review of the actual user tests, but an introduction to the design and methodology behind the playtests conducted in this project.

The approach to user testing and data gathering have been both planned and designed. The purpose of designing the premises for the user tests accordingly is to achieve a relevant and purposeful output for the data gathered.

Methodology for User Testing

It is important to note that the different methodologies have been utilized for some of their very specific strengths and not in their entireties. Therefore, different methodologies have been used for conducting user tests for this project. In addition, the data collection has been done using a survey with questions appropriate for the problem statement (See Appendix 2 & 3).

Test Driven Development

One of the primary methods used is the concept of Test-Driven-Development, also referred to as TDD (Gill, 2022). TDD uses an iterative approach for testing. It is mostly used for software, but the iterative aspects are perfect for the test-design for this project. The purpose of TDD is to prototype software and user test it early on in development. Used correctly, TDD helps with identifying bugs while it also increases the quality of the code. For TDD it is expected that the code is changed according to feedback after each unit-testing. For this project a unit test is defined by each testing session.

Regarding this project, TDD adds beneficial concepts and principles to the design of a coherent user test. TDD has been essential for the design of the user tests in this project. Relevant benefits of using TDD for this project are:

- Improves code quality.
- Fewer bugs.
- Overall enhanced quality.

In conclusion TDD has been chosen as a relevant methodology for designing the user tests in this project. The iterative process behind TDD is relevant for creating a coherent test design, resulting in a product of quality.

The Formality of Usability Testing

The formality of usability testing is dependent on the purpose of the test that is being conducted. The main purpose of user testing is creating an intuitive product that the user understands and relates to. The methodology behind usability testing is very vast and functions more like a framework for designing tests, rather than concrete rules. It is the test and the purpose of testing, that decides how the usability test is conducted. A test can be defined as being either formal or informal. The informal usability tests tend to be more informal and engages the respondent with the developer while testing. The output for an informal test is often qualitative while sacrificing efficiency. The formal test serves the same purpose of gathering data, but the approach is more strict. Here, the respondent will be as isolated as possible while avoiding engagement with the developer throughout the test. The output for formal testing is often quantitative. The terminology of usability testing in this project is gathered from Sogeti (Sogeti, 2023). The source covers all the terminology as well as guidelines on using different methods for testing.

For this project, the formality has per definition been informal. The developers have talked with the respondents and guided them through the prototype. The respondents have been observed, while also engaged in active dialogue with the developers throughout the test. The reasoning for choosing the informal approach to test is the fact that testing a game on both the computer and VR platform is time consuming. Coming in at 45 minutes per respondent, the informal testing would be limited by the few test numbers. In contrary, the informality of the 45-minute segments allowed for possibilities, such as interviewing the respondent while receiving active feedback. As a result, the informal approach was chosen to increase the quality of the playtesting.

Test Design

Based on the two prior mentioned methodologies, the design for the usability test contains the following attributes:

1. The test time per respondent is expected to be 45 minutes.
2. The formality of the test is informal, and the respondent and developer can engage in dialogue.
3. The respondent is interviewed based on the respondent's experiences.
4. The respondent must answer the digital survey after their test session.

While conducting the user tests, the emphasis has been on interviewing the respondent through dialogue. The purpose of this has been to measure the specific user experiences. E.g., first impressions and unique opinions on the difference in VR and PC experience. In addition, the tests have also been supported by general observations, with the purpose of observing the behavior of the respondents.

Types of Conversion

The rising popularity in VR has brought with it a variety of possibilities for gamers to experience different levels of immersivity, as well as challenge the usual console-based gaming style. When developers seek to bring their original PC games into the world of VR, an important decision needs to be made beforehand; should the game become a one-to-one replication of its original, or should it be more of an experience-based adaptation? This decision is essential, as it not only shapes the design process, but also determines how well the converted game will translate into the unique affordances of the VR platform.

A one-to-one conversion aims to be faithful to its original version, which entails not changing anything major in the game, therefore merely making it compatible to support the VR platform. This approach preserves the familiarity of the player gained in the original version, often capitalized from an existing fan base. By maintaining the consistency, the developers can take leverage in the mechanics and assets created for the original version, while making the transition for players more seamless.

This approach can lead to potentially streamlining the process of the conversion, which can be considered to be successful in some cases. However, it can plausibly bring forth a discussion on whether there has been taken full advantage of the platform's competences.

This is where a more experience-based conversion takes a different turn. It lets the developers focus on creating an adaptation, which takes full advantage of the virtual environment by, among others, utilizing the room-scale movement, stereo audio and gesture-based interactions. In other words, the game conversion gets tailored specifically for the VR platform, to give the players an enhanced gaming experience.

This project has been decided to focus on the experience of the player, to see which changes must be made to accommodate the limitations in VR, while not compromising the gameplay.

This choice allows for thorough testing and redesign of game mechanics to ensure an optimal VR experience. Furthermore, it aligns with the problem statement, enabling the identification of potential complications and offering recommendations for solutions during the process of converting a game to VR.

Challenges of Conversion

Hardware Limitations

The hardware limitations were one of the big challenges met doing the development of Solitude VR. For a VR game to be playable, it must uphold a constant number of frames per second (fps) of above the target device's refresh rate. In the case of the Oculus Quest 2, it is 90Hz (Damjan, 2022). The original Solitude was designed to run on a PC, which usually have a lot more processing power than a VR headset. This meant that throwing all of the old assets into a new project and expect the same results was not realistic.

To address this problem, a couple of optimizations were implemented to enhance the game's performance for VR. The initial step involved separating the various levels into distinct scenes within Unity. This approach effectively decreased the quantity of active GameObjects, resulting in a significant reduction in processing costs. Additionally, Unity's Occlusion Culling function was utilized to further diminish the number of GameObjects. This feature generates a map of all static objects present in the scene and hides any GameObject that remains out of the camera's view.

During the development of the first Solitude game, not a lot of thoughts were put into the 3D models of the game. With no knowledge of what vertices, polygons and faces were, the models quickly became big and detailed. This resulted in a lot of assets, which had over 30.000 faces. In comparison, the original Gnome character from World of Warcraft (Blizzard Entertainment, 2004) had only 956 polygons (Rowe, 2013). The main problem with our models was, that they were created in a voxel-making software called MagicaVoxel, which is not good at optimizing meshes.

To explain what the difference of a good and badly designed mesh is, is not easy. The statement that low-poly meshes is equal to a good model is not always true. It all depends on the medium you are making the model for. 3D models consists of *vertices*, which are dots connected by *edges.* These connections make up the *faces* of a model.

Some softwares makes use of *triangles*, other make use of *n-gons*, which is a n-sided polygon. The more vertices, the smoother the model. However, this also increases your face-count, which eventually uses more processing power for game engines like Unity. To have a detailed, but low-poly model is possible with the help of textures. Textures are good at hiding the edges of a model, making it look like a more detailed model. This is only scratching the surface of 3D meshes and good optimization, but it is what is needed to understand how to optimize them for VR.

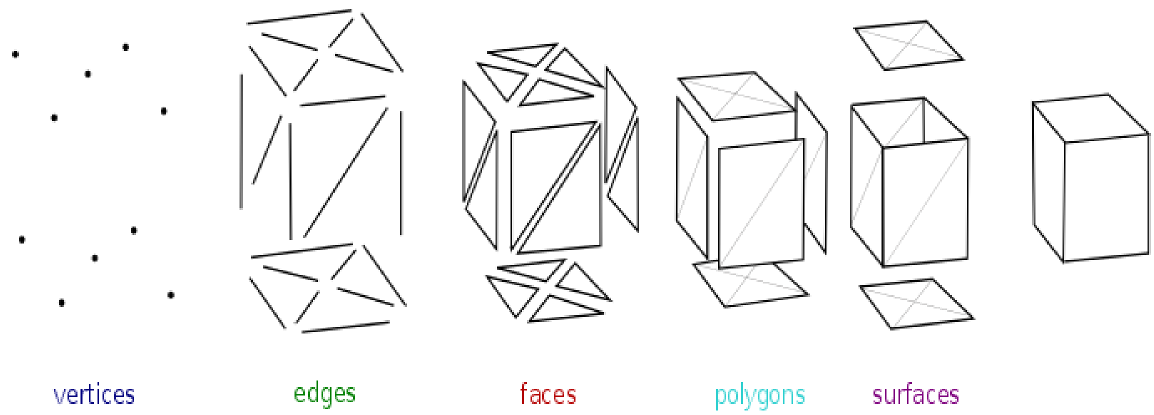

Figure 4: Visual representation of a polygon mesh structure (Wikipedia, 2023)

A prime example of a bad model is the hedge asset in Solitude. The model is made by having a grid of boxes in three different green hues. It was made by pushing the darkest green one block in and pushing the slightly lighter green half a block in, which ultimately gave the impression of shadows in the hedge. The problem with this was, that all the faces inside the hedge was still present. This led to each hedge having about 46.000 faces. This was a massive model compared to how many was places in each scene.

Knowing the need for optimization, the model was recreated without the faces inside the hedge, reducing the faces to approximately 12,000. Recognizing the limited visibility of the top and back side of the hedge in the VR version of the game, modifications were implemented to make the hedge four voxels wide, cutting away most of the hedge in favor of better performance (See Figure 5). This final model was even further optimized, now only having about 4200 faces. (See Appendix 1, 0:00)

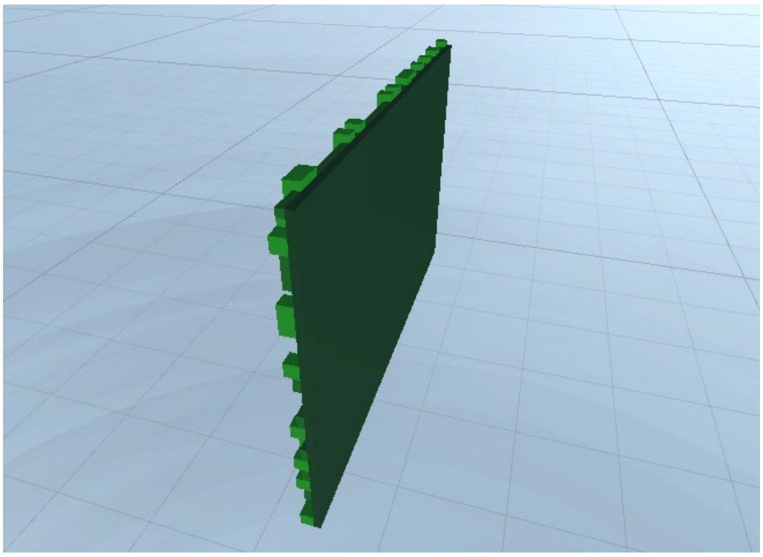

Figure 5: Image of the 4 voxel wide hedge from behind

However, even with these changes, the game did not run well on the VR headset. Due to time constraints, optimizing every asset from the PC version was not possible. This gave two options: remaking every asset to create the indents and voxel art style solely with textures, or converting the VR game to PCVR, allowing the game to run on a computer while connecting the VR headset using a USB connection. The decision was to prioritize the latter, as it would maintain the same game feel.

Some companies have also chosen to build their VR games as PCVR, especially for larger projects that require higher processing power. By doing so, they can take advantage of the power of a high-performance PC, while still delivering an amazing VR experience.

Proportions

The concept of proportions when converting a media from a monitor was originally not considered in the beginning of this project. However, it became very relevant when the first VR level was ready for pre-user testing. Upon entering the game for the first time, it became transparent that something was disproportionate. The world in the VR version seemed a lot larger than the world in the PC version.

From a theoretical viewpoint, proportions play an important role in how the player perceives their surroundings. From a designer's perspective, the proportions need to be considered when designing a level. According to Jesse Schell in The Art of Game Design; Inaccurate proportions for the player, can distort the player's experience of a game. Schell's theory concerns the proportion from a first- and third-person perspective on a monitor (Schell, 2008). However, the theory can also be relevant for this project's problem statement, since the conversion is from third- to first-person in VR.

Schell's focus is on how proportions change depending on the perspective. Here, Schell also mentions the term third-person distortion. E.g., a room with normal furniture displacement will be perceived as extremely crowded in third person. In addition, the human brain is excellent at sensing scale on a natural level. As a result, a disproportionate environment can seem off, as it does not get recognized by the natural brain patterns for proper proportions. A method to adjusting the digital world to the sense of proportion is to implement some patterns the brain recognizes. These methods from Schell are:

- Keep the eyesight of the player between the height: 152,4 cm – 213,36 cm.
- People and doorways are some of the strongest recognition factors and should be utilized.

These methods to disproportions became relevant just before testing the early prototype of Solitude.

When the first level for Solitude was designed, something seemed off. The method of creating the base of the level was to simply examine and reproduce the level one-to-one before implementing the VR changes. The walls were giant, the garden furniture was huge and the grill as tall as an adult. This was when the group realized that the main character is a young child. All the objects in the game are seen from the height of a child. The tall grass is actually tall. The grill is huge, and the doorways seems larger.

These proportions were not regarded as a problem. The player would be keeping the size of the player character, but some adjustments were made, for instance, the furniture being scaled down (See Figure 6).

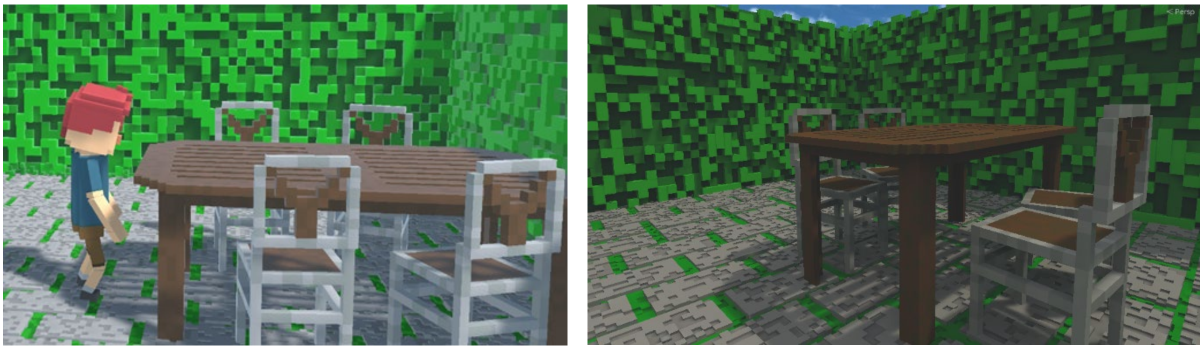

Figure 6: Comparison of Arthur standing next to the garden furniture.

In conclusion the choice to rescale some of the components in the VR-version was a compromise. The purpose of the decision was to make the proportions a little smaller to fit the senses of a first-person perspective. The result was a more natural feel to the environment, even though the player character is the size of a child.

Immersion & Hitboxes

An essential asset of any gaming experience lies in the ability of a game to immerse its players in its environment. For developers, creating that foundation is a crucial step, and when it comes to VR, there are a few key aspects to take into consideration.

The first and probably most obvious factor is to create a satisfying accommodation of sensory immersion. Endowment with high-quality gear which gets properly installed on the player, provides clearer feedback and can enhance the depth of the surrounding settings. Moreover, it leads to a greater captivation and engagement of the player, as well as facilitating a heightened level of potential Place Illusion (PI) (Slater, 2009). PI occurs in the limitation of immersion, when the player takes on the belief of them being present in the virtual world. The theory of presence is based on, among others, a visual and auditory fidelity, the interactions available and the user's level of engagement. To get the stronger sense of presence, it requires the VR experience to be immersive and realistic to the senses of the player.

Beyond PI is the concept of Plausibility Illusion (psi), which in contrast to PI being about how the world is perceived, is focusing on *what* is being perceived instead. Does the player adopt the illusion that what is happening around them in the virtual world is real? When put together the two types of illusions, supports the immersion and furthermore the overall positive experience of a game in VR.

In the VR version of Solitude, some factors were implemented with the intention of supporting the aforementioned theories and then potentially enhancing the players sense of immersion.

For the sensory experience, haptic feedback was applied whenever the player would either pick up or drop an item. This feedback is in the form of a tactile sensation which simulates the feeling of physically touching an object. Although the vibration in the controller is not continuous when holding an item, it initiates a sense of realism and helps trick the brain into believing that the held object is real. The visual and haptic aspect of the interaction plays a big role in the plausibility illusion of holding an item such as an apple or a sword.

Additionally, creating agency and implementing interactivity for the player to have the feeling of control and consequential actions, emerges the user in the heightened plausibility of the virtual reality.

The goal was to push the player to rely on their body movements rather than an excessive button usage, to create a more physical gameplay. Examples mentioned later in the paper would be features such as using physical movement to activate dialogues, access and navigate the inventory system, and how the combat setup was integrated. These actions required some sort of physical movement, rather than pushing buttons on the controller.

As it got more apparent through testing that people liked to manipulate items and explore, a broader interactive system in comparison to the PC version was created. For this it was made possible to pick up more items and bettered the colliders on objects, to give a more convincing illusion of it being real (See Appendix 1, 10:00). For that purpose, mesh colliders were used instead of box colliders, despite the latter being less heavy on the system. It was noted that the user being able to touch the item as realistically as possible, without there being space between the object and the hand, was versed to give a better experience for the player.

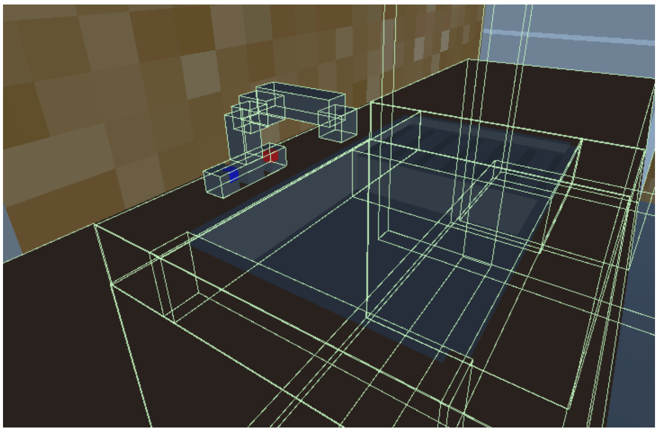

Figure 7: Screenshot of the improved hitboxes in Solitude VR

Movement

Second to deciding which conversion style to go with, another and possibly most important aspect to consider, is how the player moves and interacts with the environment. This is also where the VR conversion alters the furthest from its original, where a physical freedom is unlocked contrary to the prior digital limitations. However, movement in VR can be a bit of a sensitive experience, often prone to causing cybersickness.

Cybersickness is an experience quite similar to getting motion sick, albeit for different reasons. It simply comes down to your brain sending you conflicting signals concerning the environmental movements in contrast to your own. When getting motion sick, your body feels the impact of the environment in motion, but your eyes does not register movement. On the other side, when you are in VR your eyes see movement, but your brain tells you that you yourself are not the one in motion (Lawson, 2023).

The original Solitude game included a lot of player movement in the 3D space with jumping, crouching and fighting enemies. This needed to be converted into the VR version while minimizing cybersickness to the best ability, without compromising the gameplay. Specifically for the latter purpose, it was decided to implement continuous movement using the analogue-stick on the left controller, to walk or run around. Knowing that this could possibly cause a lot of players to become sick, some measures were taken to minimize the changes of it happening.

The Heads-up-display (HUD) in the original game which shows the player stats as well as objectives, fulfilled the fixed frame reference technique when implemented in the VR version. By having a fixed frame or object following your view, it helps with reducing the occurrence of getting sick when being subjected to moving around. Following this technique is the prohibition of acceleration as well as forced movement, as this can cause instant sickness and make your head feel heavy. (Qualcomm Technologies, Inc, 2023)

Having carefully considered these factors, the taken accommodations aimed to provide an enjoyable gameplay experience, while also ensuring the users comfort to the best ability.

Jump

A new challenge presented itself in level 2, where players needed to navigate across pitfalls, by jumping on a form of branch platforms (See Appendix 1, 1:43). This posed a problem as the physical room-scaling limited the available space, so that real-life jumping over a distance could be potentially dangerous and complicated. To address this, three primary ideas were conceived and carefully considered for adapting the level.

The first concept attempted to create a realistic jumping experience, by making the player use the available room space, which entailed physically jumping from one end of the guardian border to another. Henceforth, having to jump from platform to platform would require adjusting the in-game space, so the player can move back to the guardian border, making it possible to jump again. However, this was perceived to be the most unlikely to work due to a lack of intuitive play and furthermore overcomplicates an originally simple mechanic. During further considerations it was even doubted whether the idea could even work in practice. However, the impact it could potentially have on the player if they could jump in real life seemed intriguing and so the idea was taken for further adaptation.

The second idea was to create a simplistic point to point teleportation system, only activating in the area in which it is needed. This solution is an easy fix to the problem but makes the whole mechanic pointless and removes the meaning behind the obstacle being there in the first place.

The last idea was a mixture between the two other concepts and created a challenge while remaining intuitive and introduced an in-life movement. The player had to point to a platform and then physically jump straight up in the air to active the teleportation mechanic.

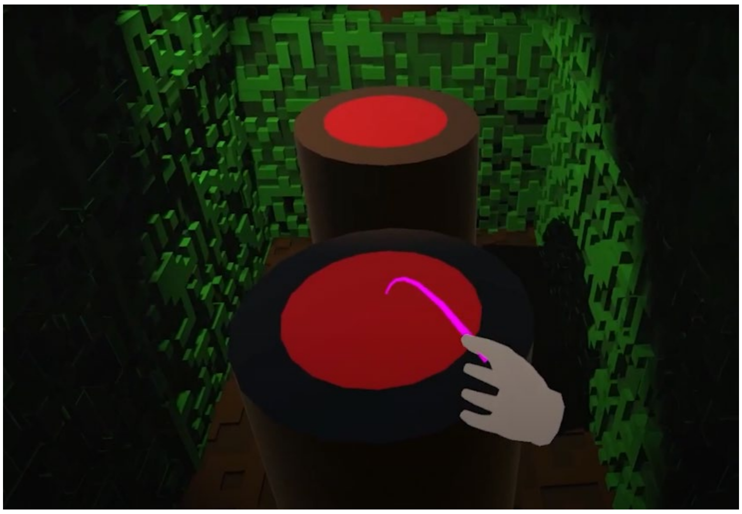

Figure 8: Screenshot of the jump mechanic

While it was the third concept which got chosen, the implementation didn't go smoothly. It resulted in the jumping mechanic only working with a button activation for the teleportation. (See Appendix 1, 2:00)

The design process of the adaptation further led to the implementation of a climbing mechanic to see if it could work as a replacement for jumping.

Despite the wonky way of getting over the last edge and onto solid ground again, the climbing mechanic turned out to provide a fun alternative way to get from point A to B. This method has been placed in level 3, where the player can find walls with climbing stones needed to be traversed to reach the big chest with the sword. (See Appendix 1, 2:34)

Figure 9: Screenshot of the climb mechanic

Not having been able to test the jumping mechanic to its full potential, gives a lacking result on how well it could have been. However, the climbing, with a bit more polish, has shown to be a good candidate for easy conversion of jumping.

Navigation

An essential aspect of designing a video game is to make sure that the player does not get lost, while traversing the different levels. This is especially the case for games where exploration of the game world is a factor. However, this important aspect is often overlooked during development and is only noticed once the development team starts play-testing. As explained in the article 'Visually Directing the Player' by Joshua Nuernberger:

"… what's the obvious direction for me is not the obvious direction for the player." (Nuernberger, 2009, p. 1)

In other words, it may feel intuitive for the designer on where to go, but this is often not the case for the player. This factor is also very important when developing a VR game, where the player's vision may be severely decreased, due to the visual limitations of an HMD.

The original Solitude relies on various aspects to visually guide the player. Nuernberger explains 'Visual Direction' as the use of visual elements in the game to give the player direction and reinforce their gameplay goals (Nuernberger, 2009, p. 1). The PC version of Solitude implements some of these navigational elements to guide the player in the right direction, such as *lighting cues* (Nuernberger, 2009, p. 2) which entails shining light at specific elements to indicate a potential point of interest, and *contextual trails* (Nuernberger, 2009, p. 5) which are different elements in the world that indicate where to go.

However, something that was not taken into account was the fact that traversing the game in VR from a first-person perspective is very different compared to navigating the game from a third-person perspective on PC. Initially, it was thought that players would have the same ability to navigate in VR as on PC, as many of the same navigational techniques were translated from the original game to the VR version.

In order for the player to enter the game in virtual reality they have to wear a HMD The forced first-person perspective from the HMD, has the added drawback of potentially decreasing the player's orientational awareness, meaning that they might find it harder to estimate their in-game location compared to on PC.

Therefore, it is essential to make these visually navigational techniques even more profound when navigating a VR space, as they otherwise might get unnoticed by the player.

A major change made in the VR version is made in level 3, where the staircase is replaced by a climbable wall (See Figure 10). The problem with navigation became very clear after numerous playtests, where the majority of players found it difficult to find the right path towards the climbing wall. It often became necessary to manually tell the players where to go in order for them to not get stuck in a needless exploration of the area. This is of course not their fault, as it is the developer's responsibility to prevent this from happening (Nuernberger, 2009, p. 1). The main reason for this problem stems from the fact that the climbing wall in the VR version simply blends too much into the environment, without any real indicator of its existence. This is an example of where the decreased environmental awareness makes it especially hard to force the player to focus on a specific point of interest. The PC version had a comparatively more indicative way to make sure the player knows where to go, as the staircase in that version stood more out from the rest of the scenery.

Figure 10: Image of the first climbable wall in Level 3

Combat

The original Solitude game allowed the player to engage in combat with different enemies through a simple combat system. The player could make Arthur swing his weapon at different enemies by pressing the attack button, thereby damaging, and potentially killing the enemy. Conversely, the enemy would be able to attack Arthur back, with the intent of reducing Arthur's health to zero and knocking him out. To avoid this, the player would be able to jump, and roll around to dodge attacks (See Appendix 1, 4:30).

Figure 11: Screenshot of combat in Solitude PC

However, converting this combat system to VR was not a straightforward process. The first challenge was the fact that the player no longer controlled the avatar of Arthur from a third-person perspective, but instead embodied the actual avatar from a first-person perspective. This meant that actions, such as swinging the sword and dodging enemy attacks, would have to be executed directly via the player's physical movements. Furthermore, the player would no longer be able to use the roll mechanic because of physical limitations of the VR headset, i.e., it would not be possible to roll around from a first-person perspective because of the following issues:

1. It is impractical to make the player roll physically in order to initiate the roll mechanic in game.

2. It would feel less immersive to make the player roll in the game by e.g. pressing a button.
3. Making a rolling movement in VR drastically increases the chance of cyber sickness.

Another aspect was the use of stamina. In the original game, stamina was consumed every time the player performed an attack action. If stamina reached zero, the player would not be able to perform any more attacks, thereby making the player rely on strategic thinking rather than button smashing.

Combat in VR is nothing new. Many aforementioned games such as Skyrim (Bethesda Softworks, 2017) and Boneworks (Stress Level Zero, 2019) have designed combat systems that give substance to their respective gameplay-styles. The most intuitive and effective approach for this conversion was therefore to make the player do the physical actions themselves, by holding the weapons and swinging them around. This has the added benefit of greatly increasing immersion, as the player feels like they are the ones doing the attacking, instead of making an avatar do it for them. However, this created a potential problem, which was the fact that the player would be able to simply swing their weapon mindlessly around at the enemy. This would make combat too easy, as the player would be able to swing much faster than in the original game. To solve this, some designated weak points would spawn randomly on different locations on the enemy. Hitting these would make them take damage, thus making the player more mindful about where to swing the sword. Additionally, the damage dealt to the enemy would be calculated based on how fast the player swings the weapon at these weak points. This incentivizes the player to swing their weapon, instead of just poking the enemy.

As for an alternative to the roll mechanic, a potential idea that has not yet been implemented into the game is the use of a shield to block incoming attacks. It would make sense in the VR setting but would also require some additional tweaking to avoid the player simply hiding behind the shield the entire time. Instead, the player is now more mobile, as they can move in all directions while still maintaining focus on the enemy and making it easier to dodge incoming attacks.

Figure 12: Screenshot of combat in Solitude VR

Stamina consumption is also a feature that has yet to be implemented into the combat system. A feasible idea for future development is to make the player use stamina each time they swing the sword. At zero stamina the player would then be unable to damage or shield against enemies.

Football Segment

In the first level of Solitude PC, which also works as the tutorial, the player is in control of Arthur, who must dribble a football to Max to then shoot it accidentally over the hedge into the neighbor's garden. This part of the tutorial was originally developed for the PC version of the game, where the player had direct control over the character's movements, including visuals of their legs and feet. However, in the conversion to VR, replicating the action of dribbling a football became a challenge due to the player's lack of direct control over their feet.

To address this issue, a decision was made to replace the football with a baseball and bat. In the VR version of the game, the player must now hit a ball that Max throws at them, instead of dribbling a football. This solution allows for the story to unfold like in the original game, as well as adding a minigame that foreshadows the combat mechanic. (See Appendix 1, 8:59)

Figure 13: Screenshot of the football and baseball segments

Overall, this segment serves as a good example of the design challenges that shows when converting a PC game to a VR game. It highlights the importance of carefully considering the limitations of the VR platform, and being creative in finding solutions that maintain the core gameplay while adapting it to the new medium.

Interaction

An essential part of the original Solitude game is its interaction system. This system is responsible for letting the player interact with the different game elements, such as picking up items, talking to non-player characters and teleporting to new levels. To do this, the player simply has to stay within the specified interaction radius of the interactable object and press the 'E' button on the keyboard. The overall structure of this interactable system is designed to be as flexible as possible, i.e., the player would be able to interact with a variety of different objects in different specific ways.

However, several changes had to be accounted for when attempting to convert the PC game to VR. These changes primarily dealt with the fact that simply pressing a physical button on the controller to interact with objects in a virtual world would break immersion and reduce the potential for player interaction.

One example of this lack of immersion occurred when interacting with items. In the original game, items in the world could be added to the players inventory by interacting with them. These items could then be used by clicking on them in the inventory interface, such as eating an apple or equipping a wooden sword. (See Appendix 1, 5:56)

During development of the VR game, it became clear that this approach would be unintuitive and boring for the player. The solution was to make the player able to grab and hold the different items in their virtual hands and then use them in a way that would make sense in the real world. For instance, to eat an apple the player simply has to take the physical apple up to their head to consume it (See Appendix 1, 11:59). Additionally, instead of having to equip a weapon indirectly via the inventory, the player would simply have to hold the weapon in their virtual hands to be able to use it in combat.

As for general interactions, such as starting conversations with NPC's or objects, a new yet similar solution from the original game was developed. Instead of pressing the 'E' button on the keyboard when near an interactable object, the player now has to press a virtual icon with their virtual hands (See Appendix 1, 1:28). This solution adds

Figure 14: Image of the interaction symbol

another way the player can more directly interact with the world around them, and thereby make them feel more immersed.

Dialogue

The dialogue system in Solitude allowed players to interact with characters and objects using the "E" button on the keyboard, which would open a 2D textbox, displaying the face of the person speaking. Additionally, Arthur would also talk to himself when interacting with objects like the back door and the garden tree.

However, when attempting to convert this dialogue system to VR, several challenges were met. One of the primary problems were that having a 2D textbox as an UI element could break immersion for the player. In VR, players expect a more interactive and realistic environment. Therefore, it was necessary to create a more immersive dialogue system that would better fit the VR experience. Additionally, UIs don't tend to work as well in VR, as you are not watching a 2D screen like when you are playing on PC.

Figure 15: Screenshots of the dialogue box in each version of Solitude

To address this issue, a decision was made to create a 3D dialogue system that was tangible and dynamic. The 2D textbox as an UI element was removed and replaced with a 3D model floating above the head of the character being interacted with (See Appendix 1, 1:19). This change added an extra layer of immersion to the game, allowing the player to better see the character as they speak. The floating textbox was also given colliders that the player can touch, and in addition it also rotates to face the player.

Another aspect of the original game was Arthur's self-talk when interacting with objects like a locked door. This could break immersion in VR since it felt like the character was speaking without the player actually speaking.

To fix this, the dialogue system was modified to remove Arthur's self-talk. Instead, descriptive text was used to convey what Arthur was thinking or saying, while eliminating the appearance of his face when interacting with objects. This solution preserved the original game feel, while creating a more immersive VR experience, maintaining the player's sense of being the big brother.

In conclusion, the challenges of converting the dialogue system to VR were overcome by creating a 3D dialogue system and removing Arthur's self-dialogue. This solution contributed to the creation of a more immersive world in Solitude VR.

Inventory

There is currently no consensus in the videogame industry, as to what defines a good inventory system. The interest of creating a well-functioning inventory system is shared both among new VR-games and games converted to VR. As a result, finding information to what defines a good inventory system in VR is not so straightforward. An article by blogger Yacine Salmi (Salmi, 2021) takes an interesting approach to the concept of VR inventory systems. Salmi is a game developer on a team trying to create a good inventory system for their own VR-game. To do so, the developers looked into current inventory system, as well as user-based opinions on what defines a well-made system. The conclusions on the user preferences are:

> *"The focus on "streamlining reality". Inventories should be intuitive and easy to use, a more streamlined implementation of an existing metaphor."* (Salmi, 2021)

"Inventories should support the game world you are creating. You can still get creative, but it essentially boils down to: use a system that fits with the overall aesthetic of the world you are creating." (Salmi, 2021)

In addition, the article also mentions some of the currently most used inventory systems for VR games. Two of the mentioned concepts could potentially be the foundation for an inventory system for Solitude. The first of these being a wrist-based inventory system, where the user has access to the inventory trough a UI implemented on the wrist of the virtual hand in the game. An example of a wrist-based system being Space Pirate Trainer (I-Illusions, 2016). The second relevant concept is an on-body system where you access a grid-based system through an inventory component. Due to the narrative of the backpack in the original game of Solitude; the backpack concept was the most appropriate. A good example of an on-body inventory system is the system from The Walking Dead: Saints & Sinners (Skydance Interactive & Skydance Productions, LLC, 2020).

The original inventory system was a simple UI-popup which could be navigated using the mouse. The UI-inventory contained all the pick-ups the player would have gathered during their playthrough (See Appendix 1, 5:56). Accessing, and utilizing the

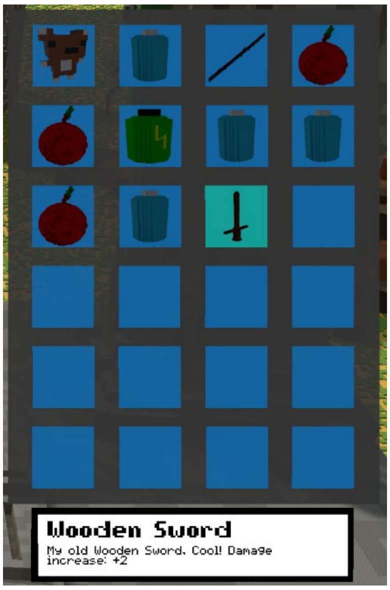

Figure 16: Screenshot of the inventory system in Solitude PC

pick-ups was done using a simple click. All this could be done when the player had picked up the backpack in the first level.

However, converting the game from PC to VR challenged the structural design of the inventory, resulting in a necessary redesign for the VR platform.

The initial issue was the fact that the inventory should no longer be accessed through the 2D interface. Accessing the inventory through the 2D interface in a first-person view in Solitude would be unintuitive and therefore also unpractical. The inventory system would therefore need to be re-designed, so it would be external from the player.

The design for the new inventory system is as follows: The player will still be required to fetch the backpack before moving on to the next level. However, the backpack can be both detached and anchored to the player's back. While anchored, the backpack is non-visible and out of the player's view. When detached, the backpack will fall to the ground and stay static. While the backpack is stationed, an interaction symbol is shown above. By pressing the symbol, a grid-based UI appears with the collected items. The player can interact with it and pick up items from the grid. (See Figure 17 & Appendix 1, 6:15) The player can then choose to pick up the backpack and re-anchor

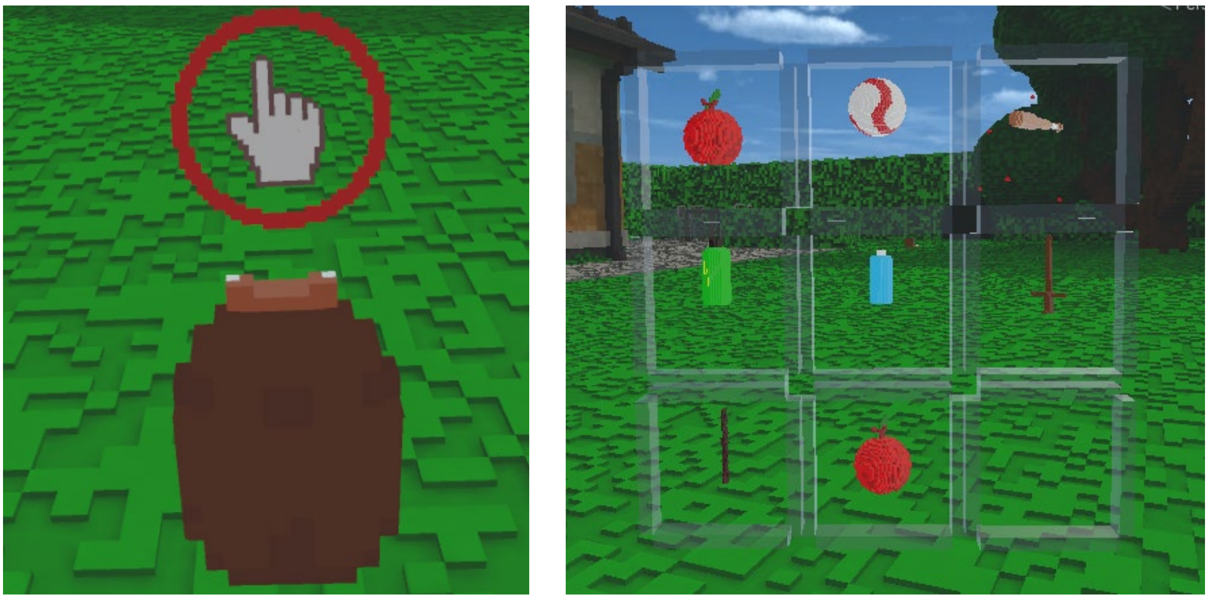

Figure 17: Screenshots of the inventory system in Solitude VR

it or open the inventory. The player can also add collected items and consumables to their inventory, simply by moving the item to their back. The backpack cannot be affected by any other sources than the player.

But this raises the complication: What if the player walks away from the backpack and forgets where it is located? This complication was solved by making the backpack respawn from the players back. I.e., the player can always access the backpack from their back, as it will respawn no matter its current location. In addition, this method also simplifies the overall usage of the backpack, so the player does not have to worry about it.

HUD / UI

One of the more problematic design conversions turned out to be the HUD and UI system. As mentioned before the HUD's purpose is not just to show the player stats, but double as the fixed frame to help prevent cybersickness. However, implementing the HUD to fit the size and place preferences of the players, turned out to be more challenging than what was originally believed and, in the end, might not have been completely successful. Various contradicting feedback was given in forms of the objective text in the HUD being, either too small and unreadable, or then too big and clumsily disturbing the player's vision. It had been discussed on various occasions to make the objective text accessible on a wrist band, however it seemed to not fit into the design dimensions of the game, almost changing it into a sci-fi feel.

Figure 18: Screenshot of the HUD in VR

Changes in the player stat was visualized on the edges of the eyesight in the form of sweat drops when losing stamina and a red flash when losing health (See Figure 19). This was implemented to make the player more immersed and attentive to change in stats, as well as feel the impact of the consequential actions.

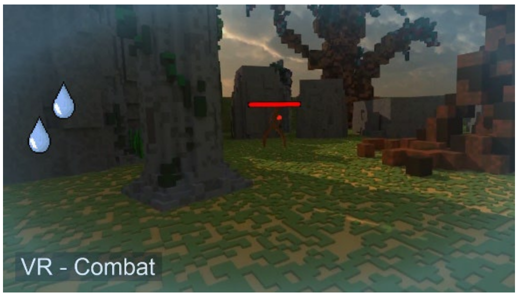

Figure 19: Images of the stamina and HP indicator flashing.

Although a balanced implementation of the HUD and UI visualizations of stat changes proved to be challenging, the efforts were made to adapt the engagement of the player and immersion with the virtual world.

Playtesting

Results of the 1st Playtest

Based on the responses received in the first field study, valuable initial feedback on the PC and VR versions of Solitude was gathered. It is important to note that this study was meant to guide the design choices in the right direction and not to definitively conclude on the pros and cons of each version. Additionally, this study only tested the first level, the tutorial, and a more in-depth study will be conducted in the next batch of tests with a bigger part of the game.

This study was split into three groups of tests, including 7-10th semester students, students taking the Game Design 2 course, and a class at HTX Svendborg. A questionnaire was given to each participant after them having tried out both the PC and VR version. A total of 34 responses were received, which provided the information shown in this segment. The questionnaire and other feedback can be seen in Appendix 2.

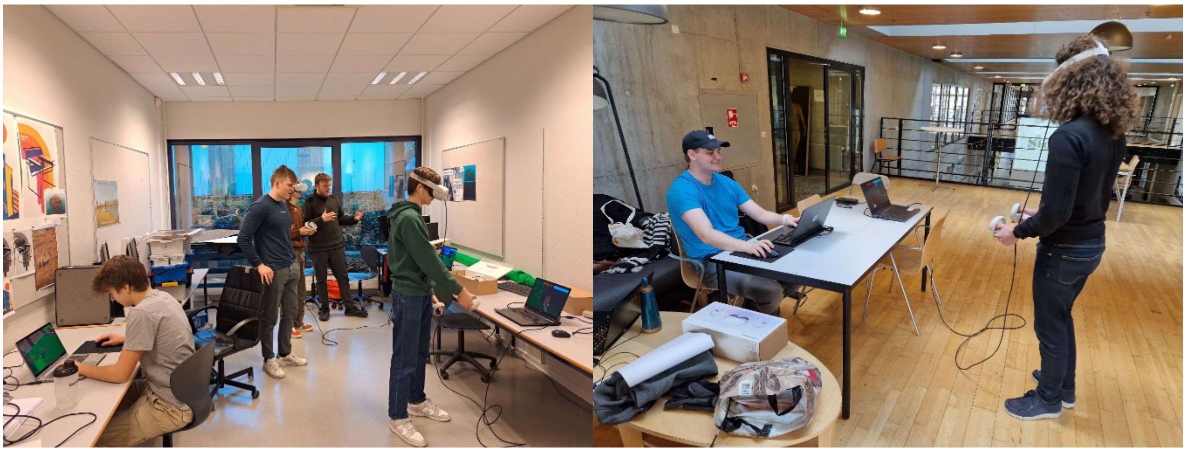

Figure 20: Pictures from the first playtests

Overall, the VR version of Solitude was recommended more frequently, with testers mentioning its immersive experience and fun interactions. However, the PC version received positive feedback for its easier visual navigation, precise controls, and clear instructions.

In terms of specific feedback, testers appreciated the standard controls in the PC version, which have been developed over many years, compared to the VR version, which is still figuring out its standards. Testers also found it easier to interact with objects in the PC version and to see the text bubbles.

On the other hand, testers enjoyed the immersive open world feel of the VR version (See Appendix 1 0:00), as well as its intuitive controls for those who haven't played many games on PC beforehand. They also appreciated the increased number of interactive elements in the VR version, such as being able to open the backdoor and to throw a baseball (See Appendix 1, 7:05 & 10:00). They mentioned that the game takes on another progress angle when converted to VR, making them focus much more on exploration, trying to push, grab and throw objects around the world.

It is worth noting that one of the PCs used to run the PC version of Solitude was not very strong, which impacted the game's performance. Additionally, there was a tendency for older individuals to experience more cybersickness or discomfort while playing the VR version, compared to younger individuals. These problems could lead to a bias when answering the questionnaire.

Figure 21: Image of the backdoor with the new and improved interaction symbol

To fix some of the issues that were identified in the first field study, adjustments were made to the VR version of Solitude. Specifically, it was realized that many participants had trouble interacting with objects in the VR version, which was due to the old way of interacting. To fix this, a new 3D model was made to indicate interaction, which was a model of the standard Windows pointy hand with a red circle around it, making it more noticeable than the previous 2D icon of four pointing arrows. This new model disappeared when pressed, which prevented testers from pressing it again. Additionally, a small text at the bottom corner of the text box was added, stating "Press (A) to continue.". (See Figure 21 & Appendix 1, 1:28)

In summary, the first field study provided valuable feedback that will guide the design choices moving forward. The next step will be to conduct a more in-depth field study with a larger part of the game to test even more features.

Results of the 2nd Playtest

The second batch of tests also provided valuable feedback to the many new mechanics added to the VR version. This second field study's purpose was to gather the final information on the advantages and disadvantages of converting an ordinary PC game to VR. The first three levels were made ready for the tests, with many new features and improvements from the previous test. Because of the estimated length it would take to complete the first three levels in each version, a decision was made to focus on a smaller group with interviews during and after the playtests. Additionally, another questionnaire was made for testers to add further comments. This segment will state the results of these tests. The questionnaire and other feedback can be seen in Appendix 3.

This batch of tests was split into two. Firstly, tests were conducted on students taking the Learning Technology 2 course, followed by revisiting the Game Design 2 course. With each group, valuable feedback was obtained on the new game mechanics, along with some great responses on the questionnaire. Each test took around 45 minutes to perform, with a total of 15 tests.

Figure 22: Picture from the second playtest

As with the previous test, the VR version received complements on immersing the player into the game. With the newly added levels, this was further enhanced as they adventured into the hedge and further into the neighbor's backyard. The maze in level 2 was way more mysterious and because of the first-person view, many found it to be more maze-like than the PC version. In level 3, they adventure into the neighbor's backyard with huge pillars, rocks, and overgrown trees. Many mentioned the cool experience of being a small kid in a big world, and how everything looked amazingly huge. (See Appendix 1, 0:22 & 0:49)

With level 2 and 3 added, people were also able to test the two new versions of the jump mechanic (See Appendix 1, 1:43 & 2:34). The climbing mechanic received lots of positive feedback, with testers saying that this was a clever change of game mechanic, making the game more immersive and fun. On the other hand, according to the tests, the jumping mechanic felt way better in the PC version. Many reported that they felt the jumping in VR broke their immersion. With the new jumping and climbing mechanic, many players felt that the jumping aspect of the game became too easy and therefore wanted another challenge instead.

Some people also preferred the PC version due to not feeling any cybersickness while playing. Testers also mentioned that the visual navigation was better in the PC version, with a better overview of the area.

Many were split on some elements of the conversion. The fighting mechanic had a lot of split opinions (See Appendix 1, 4:30). Some liked the click-and-hit style of the PC version, while others preferred the more interactive version in VR. Another point of interest was the HUD elements, such as stamina and hearts. Some preferred the VR version, and other liked the standard PC HUD.

Overall, about 2/3 preferred the VR version compared to the PC version, mentioning how interaction and immersion added a whole new element to the game.

As it was the last test, there was no incentive for addressing some of the issues with the new mechanics in the subsequent builds. However, having these responses was important for gaining an understanding of the various advantages and disadvantages. The interview-styled field study gave much more in-depth information about both the versions, with comments on precise segments on the game.

Discussion

Discussing the Playtests

The following segment will discuss playtests in the project. The segment will be split into three subsegments: one tied to each of the two batches of playtests and the last one tied to an overall discussion of all the tests.

First Playtest

Developers now what to do. Testers do not.

The first batch of playtests was intended to provide guidance for the conversion, and this objective was achieved. One of the initial realizations was that during development, every team member knew precisely what tasks to perform and when to execute them. However, this was not always the case during testing. Due to excessive familiarity with the game, the implementation of any player guides or hints were overlooked. Although some hints were present in the original game, they somehow got lost during the conversion.

This issue became evident in the initial playtests. Almost every tester encountered difficulties in understanding how to interact with characters and objects. There was no clear indication of what actions to take. The interaction method simply involved pushing the arrows with one's index finger to initiate a conversation, followed by pressing the 'A' button on the controller to continue the dialogue. Many testers struggled to figure this out as there was no indication provided.

Furthermore, testers were unsure of what to do within the game. The objective text was also lost during the conversion from PC, requiring guidance to be provided to the testers while they played the game.

Missing Tutorial Elements for the VR Version

Some initial findings from the first tests revealed that not many people were familiar with the controls of VR. Many had trouble figuring out how to hold the controllers properly. Meanwhile, this problem was not as prominent in the PC version. In conjunction with the demographic mainly consisting of technologically adept individuals, it led to the belief that the keymap standards for VR controls were not as widely known as their PC counterpart.

Players who had experience with PC games knew, without any instructions, that they would move the character with the WASD keys and sprint with the Shift key. However, this was not the case for the VR testers. In VR, players had trouble finding the different buttons for movement, grabbing, and sprinting. These observations made it obvious that the game needed an explanatory tutorial of the key bindings.

Second Playtest

Interview-styled Approach

The second playtest had a much higher focus on obtaining results regarding the advantages and disadvantages of the conversion. This led to a shift in the way data was gathered, adopting a more interview-styled approach. With this approach, better data was obtained regarding specific mechanics by questioning the testers during gameplay. Two approaches were considered: the interview-styled approach and a numerical approach that solely focused on numbers.

The numerical approach would have allowed for a more detailed statistical analysis of the data collected during the playtests. While it may seem logical to determine the statistical pros and cons of converting a VR game using this approach, it was not viable due to the limited timeframe of the project and the inadequate sample sizes of the tests. Consequently, the data would not have been representative.

Therefore, through the subjective and interview-oriented data gathering, patterns of thought among the testers were identified. This approach also provided a deeper understanding of the testers' actual feelings and experiences during the playthroughs. It was evident that this approach was the most optimal.

Time

One aspect not considered when testing the game on both platforms was the time it took. Testing all three levels on PC, then VR, and finally conducting an interview for one person would take approximately 45-60 minutes in total. This process proved to be very time-consuming. With only two VR headsets and four computers, testing was limited to four testers at a time.

The manageable time of the first playtest led to initially overlooking the need for a change in approach. However, this could have been avoided by modifying the test scenes to focus solely on the mechanics that required testing. Nevertheless, implementing such a change would compromise the overall game and story experience. Further elaboration on this matter can be found in the Perspectives segment.

Overall Discussion of Results

PC vs VR

Through research, data on player preferences between the two versions of Solitude was gathered. Upon reviewing the questionnaires (see Appendix 2 & 3), it can be concluded that approximately 66% of participants preferred the VR version of Solitude. Around 20% expressed a preference for the PC version, while the remaining 14% favored both equally. This distribution came as a surprise, as there was an expectation of a more balanced split between PC and VR preferences.

When discussing this with the testers, they highlighted the immersive nature and overall game experience offered by the VR version. Despite encountering some issues related to navigation and interaction, the sheer experience of witnessing the world through their own eyes outweighed the negatives. Testers shifted their focus from mere level completion to exploration and experimentation, resulting in a slight shift in the game's overall progression angle and creating a more open world feel.

Player Preference on Game Mechanics

In their responses, almost all the testers agreed upon certain game mechanics in the VR version. One notable change was the conversion of the football minigame to a baseball minigame, which testers felt was better integrated into the storyline and foreshadowed the combat system later in the game. Additionally, replacing jumping with climbable walls in level 3 was seen as an adequate addition and a feature well-suited for the VR experience.

Opinions were divided when it came to mechanics such as fighting and movement. Some testers found it more immersive and enjoyable to engage in combat with the enemies using their own physical movements, while others experienced feelings of nausea and preferred the click-and-hit style on the PC.

Similar to the fighting mechanic, the movement of the character also caused mixed responses. Some players appreciated the immersive aspect of being able to move and rotate in the real world, with the character following suit. However, others experienced cybersickness and therefore preferred the PC version.

Considering these player preferences, it can be concluded that remaking a segment of the game to better align with the VR experience had a positive effect on testers, utilizing the strengths of the medium. The baseball and climbing segments, which were clear favorites among the changed mechanics, should be noted for future projects. Furthermore, preventing cybersickness in the VR version should receive more attention, as it was a significant factor in some players' aversion of certain mechanics.

Bias

Demographic Bias

During playtests, a narrow demographic of people was tested. The testers mainly consisted of technology-oriented individuals, with only 10% having no prior experience with VR. A limited demographic introduces potential bias.

Testing the project on individuals within the same field of study has both benefits and drawbacks. By doing so, a more nuanced answer can be obtained, as they know what gameplay aspects could be wrong in the game and how it could be fixed. It is important to note that there would not be much information to gather if the game was tested on people who do not play video games. The target demographic consists of people who have previously played VR games. In the context of this project, it makes more sense for them to review and provide feedback.

The Jump Mechanic

Although the jump mechanic received negative feedback, it is worth noting that during testing, the mechanic was not fully functional. The intended operation of the jump mechanic involved standing on a red circle, pointing towards another red circle, and then physically jumping to initiate the jump in the game. However, this approach did not work during the playtests, and instead, players were instructed to simply aim and press a button to perform the jump. The result of this change felt immersion breaking and might have had a negative impact on the overall feel of the jump mechanic.

Returning Players

It is worth mentioning that during the second batch of tests, some testers had already experienced the game in the first batch. This could have potentially introduced bias in their responses, as they were already familiar with the main mechanics and may have had a preference towards the VR version due to their prior participation.

Discussing the Advantages and Disadvantages

The following section will discuss the discovered advantages and disadvantages based on the results. The segment will be split into three main groups of interest, influenced by the challenges during conversion.

In-game Locomotion

There are a lot of different ways one can move about in a virtual world and it ultimately comes down to what wants to be achieved in the game- play and feel. As mentioned before, continuous movement was viewed to be the best option to fit in with the genre and style of the original game, as it contains the advantage of upholding the same degree of locomotion.

However, that choice also has some disadvantages to it, as it heightens the possibility of cybersickness. This leads to some players not being able to play the game or potentially decrease the playtime for the ones that can manage it to a certain level. This particular complication is also a reason why most of the popular and successful VR games are with a stand-still gameplay, as it eliminates this specific problem and makes it more accessible for a broader demographic. Despite this issue being solvable with the support of a walking platform it would be far from being accessible to the average person.

That being said, the continuous movement does not break the immersion as other movement systems could potentially do to a gameplay similar to Solitude's adventurous 3D world concept. Unless the game has been specifically designed to support a system like teleportation, it could disrupt the immersive aspect of the gameplay.

One vital aspect for the movement also comes down to the player actually knowing where to move to. It was not until after some playtests that the issue with navigation in VR came into consideration. This unfortunately made it difficult for the team to implement useful directional navigation techniques in time for the final product. One solution to the navigation problem could be to implement some more of the previously mentioned aspects of visual direction to navigate the player towards e.g., the climbing wall in level 3. There could have been added some lighting cues in the form of spotlights or some contextual trails by making the climbing rocks on the wall more distinguishable from the rest of the environment. This could have made a big difference for the player's sense of navigating in the unknown world and in knowing where the next goal is. Additionally, it would be appropriate to add some more visual aspects to guide the player more clearly towards destinations in the first place, such as making a defined path towards the intended area. While this is not considered an advantage nor a disadvantage, our results show that it is still important to adapt the use of visual navigation to the specific perspective used in the game.

The combat system was also dependent on how the player was able to move, where the continuous movement makes it possible to dodge fast out of the way when in a fight. Virtual reality opens up for an available physical room-scale, so that the player can physically wield a sword in a fight.

The introduction to a physical confrontation with enemies was seen as an enjoyable advantage to the gameplay, as the players' feedback indicated that they were feeling more immersed and engaged in the combat. It brought forth a higher level of impression concerning the consequential actions of facing the enemies. The player would feel embodied with the character and more in tune with the expected feelings occurring during a fight, as they are experiencing the scale and consequences with their own eyes.

The implementation of the combat system is not a straightforward concept and is again tied with the goals set for the game design. In a PC game the strength of the player is often determined by level or skill, while in VR it has to be accommodated to an in-life movement. This game balance can be more difficult to get right and can be seen as a disadvantage. In order for the player to not be able to just overpower the enemies with small light movements, strength was added in the velocity of the strike. If the same principles from the original game are implemented, then a player might feel satisfied and powerful when striking an enemy with applied forces, which does not necessarily match the players actual physical strength. However, if the opposite occurs then it potentially leads to the player being frustrated that their character is weaker than themselves and can on that note break immersion. This is a potential issue for a VR conversion in comparison to a VR game, specifically making it a goal to challenge the player physically in combat scenarios.

Additionally, when it came to the results of the jumping mechanic, the implementation only gave way for a teleportation system activated by a button, which otherwise was designed to introduce an in-life jump activation instead. During testing this simple jump mechanic then seemed too easy and pointless. Not having been able to test the original design idea, makes the following discussion solely based on the developers own point of view. Implementing the in-life jump gives a physicality and challenge to the obstacles needed to be traversed with this ability. However, this could potentially also provide a more dangerous game experience, as it is vital that the players can keep their balance and are aware of their surrounding space.

To try a different alternative to jumping, the climbing mechanic was designed for level 3. This showed through the tests to be a fun adaptation, with the only disadvantage being the reaction of the player when falling as it creates a rush to the stomach and awakens cybersickness. The climbing mechanic turned out to be an overall positive experience, which utilizes the strengths of VR with the usage of hand movements.

Lastly the design which alters the furthest from the original game, is the baseball adaptation of the football segment, as this is where the physical locomotive movement cannot be registered without the right equipment. This can be a disadvantage when converting a similar scenario, if not being able to find a suitable alternative which still embodies the same concept. However, for this case specifically the adaptability of the football segment from the original game turned out to be fairly straightforward, with the solution being met with positive feedback. As the adaptation supports the VR limitations of hand movements, with the baseball bat and baseballs, it gives more opportunities for natural interaction. Moreover, some players had the idea of saving the baseball bat in their backpack and using it to dual wield weapons later on in the game, as well as the baseballs for projectile attacks.

The impact of the locomotive adaptation during the conversion of the overall game, led to quite the positive experiences expressed from the players, where some disadvantages could be potentially fixed with further testing and tweaking of the game.

Interactive Systems

Another important aspect that is relevant when converting a game from PC to VR is the interactive systems. The interactive systems are in this project defined as what the player is expected to interact with within a game. Examples of in game interactive systems can be general interactions, dialogue, and inventory management etc. An interaction system does not only allow for the player to navigate mechanics, but it also engages them directly in these mechanics through interaction. It is therefore important to consider the interactive systems and their functionality when converting them to the VR platform.

How players engage in interactive systems has also been a part of the observations during playtesting. One of these observations include the fact that many of the players encountered issues with otherwise simple general interactions. An example of a general interaction in Solitude is the door leading into the house. When comparing general interactions from PC with VR a clear difference can be observed. The players want to touch things in the game, and they tend to try and interact using their virtual hands. In the example with the door the players' first respond was to open it like a normal door in real life. The PC format's general interactions in Solitude are range based and activated by a button push when the player is within range. The same method could be applied in the VR format and the simple solution would be to just convert it using the same range and button method as from PC. However, VR immersivity is affected by the virtual hands as they are important assets for the player to feel immersed in the game.

Another example where the players can utilize their virtual hands for interaction is the inventory system. Converting an inventory system from PC to VR is both advantageous and disadvantageous at the same time. The disadvantageous aspect is that it can be difficult to create an optimal inventory system as the players are focused on the world around them and what they currently have in their hands. It is therefore important to consider that the interaction with the inventory does not break this immersivity. Breaking the immersion when interacting with the inventory will become a disadvantage and lessen the player experience. Contrary, a good interaction system that utilizes the VR format can be advantageous as it enhances the player experience while not breaking immersion.

Therefore, consider the following for general interaction when converting a game from PC to VR: utilize the use of virtual hands as players tend to try and make general interactions with them. Based on the playtests, the interaction does not necessarily have to be either simple or overcomplicated, but rather a compromise on the intention of the original general interaction, so it fits the players expectations for the VR platform. Doing so is an advantage and it will enhance the player's experience in the VR version.

It is however not all interactive systems that have the same effect and are supported using the virtual hands. Observations from the playtesting showed that the early dialogue-system was unintuitive for most players. The players did not find it intuitive to touch an area near the NPC (non-player character) to activate their dialogue. In the PC version of Solitude, the players would use the previously mentioned system of range and button click, which is a rather normal method of activating dialogue in PC games. Therefore, players expect most dialogue activation to be simple and implied in the gameplay. This complicates the conversion of dialogue systems when converting from PC to VR. However, after some design changes to the interaction symbol and guidance through the dialogue box, testers found the dialogue system more intuitive.

In the end creating new interaction systems when converting from PC to VR can be extremely advantageous, as it allows for the player to actively interact in VR. It is important to consider that the players adapt to the usage of virtual hands and want to explore and interact with them. However, it is not all interaction systems that are advantageous and interacting with other NPCs, can through dialogue be difficult to design on an immersive level.

Immersive Considerations

One of the more significant advantages with VR is the ability to enable full immersivity at a level which is less likely to be reproducible on PC, as it transcends traditional gaming experiences. Therefore, it is no surprise that almost everyone who tested the two versions unanimously agreed that the VR version felt significantly more immersive than the PC version. The effect that this feeling can have on a player should not be underestimated and is therefore one of the main positive factors to consider when contemplating a PC to VR conversion.

The topic of immersion in a virtual environment is closely connected to the limitations of the hardware and the optimization of the software. Different design choices were made during development to try and increase performance while playing. However, a lot of it came down to the limited power of the Meta Quest 2. Although it was prioritized to optimize the graphics for better performance, it still is not possible to play the game optimally without the help of more powerful computer hardware. This fact is not surprising in hindsight. The original PC version was relatively badly optimized to start with, and the few initial optimizations made at the beginning of the conversion to VR were not good enough for a substantial improvement in performance. This reduced performance can cause latency and make the player feel uncomfortable and sick. It can therefore be argued that it is of vital importance to consider if a game on PC would actually be able to run on a less powerful device i.e. a VR headset. If this is not the case, some major changes need to be made before even considering converting to VR. It is of course possible that more powerful VR devices might be developed in the future that have the ability to measure up to the processing power of a computer. But until this is the case, the hardware limitations should be accounted for before the conversion to VR even begins. It could therefore be said that a big drawback of converting to VR is the limited hardware capabilities, which greatly reduces the potential for optimal development.

Bad hardware performance is not the only factor that can decrease immersion while playing. The environmental setting of the game also has to be appropriate in the context of the game's atmosphere. For instance, choosing the right proportions for the environment was much more important than previously anticipated. Although it in theory might seem like a relatively insignificant factor to adjust, in practice it makes all the difference. Especially in the case of this particular game where the player has to embody the avatar of a child. It was quickly discovered that the size of assets in the game were much more important to adjust accordingly in a VR setting than in a PC setting, as even the smallest size differences were much more noticeable when in VR. In addition to this, it can also be argued that the hitboxes of objects in the VR world have to be much more detailed in order for Place Illusion (PI) to occur. The nuances in the way a player can interact with their hands in a virtual world is much more profound than its PC counterpart. For instance, the player will instantly notice if they cannot touch something in VR because of improper hitboxes, which has the potential drawback of bringing the player out of their immersive game experience. In comparison, a PC player will often not notice the same small hitbox inconsistencies since they are not able to touch the objects in the same nuanced way. These factors are arguably significant disadvantages if not properly implemented. However, if done correctly these aspects might just be able to give the final touch to the VR experience. It can therefore be said that it definitely would be appropriate to have proper proportionality and hitbox indicators in mind when converting to VR.

Other factors that were considered to be obstacles during conversion were the UI and the HUD. A standard PC monitor is generally considered to have more screen space than a VR headset interface can provide. For this reason, some alternative methods have to be considered when trying to fit these UI elements into VR. The general consensus during testing the VR version was that the UI elements were either too big and distracting or too small and unreadable. Although the HUD has the added benefit of giving the player a fixed frame of reference, thereby avoiding cybersickness, it quickly became a major debate on how to properly add all relevant information on screen without making it feel clumsy. Alternatives, such as adding UI elements to the player's wrist, would remove the clutter of UI elements from the player's field of view, but suffers from a lack of thematic relevance. In other words, it would not make sense in the context of the world that has been created. However, it is difficult to assess the impact of these alternative UI systems since they were never properly tested. Something to consider when converting from PC to VR is therefore how to properly implement the UI system from the previous version into the new one. The major drawback coincides with the fact that UI is not easily translated between PC and VR. It is therefore important to come up with alternative ways of implementing these UI elements so as to not ruin the game experience for the player.

Conclusion

The vocal point of this project has been to investigate the advantages and disadvantages that could occur when converting an ordinary computer game to virtual reality. The converted game of this project is based on a previous project, the narrative-oriented 3D game Solitude, made in 2021. The results and conclusions are based on data gathering from relevant playtesting. The playtests have been designed using relevant theory from usability testing, with a primary focus on gathering qualitative feedback supported by questionnaires and informal interviews. It is also important to note that these conclusions take baseline in this specific project, and results may differ for other conversions.

Converting a computer game to virtual reality is not always as simple as reusing old assets and systems. Many factors must be carefully considered when redeveloping.

Major adjustments are required for rather simple mechanics such as movement and jumping. With the intent to replicate as much of the original game as possible, limitations were met. It can be concluded that balancing immersive gameplay with the prevention of cybersickness can be a difficult task. Although continuous movement gives the player the necessary degree of freedom to match the gameplay, it was also, in some cases, the cause of nausea. Since jumping in virtual reality is impractical, alternatives like the climb mechanic were introduced. Our results show that conversions that utilizes the strength of VR, instead of trying to fix existing game mechanics, had much higher rate of satisfaction.

Converting interactive systems can also prove to be a challenge. General interactions can be converted from a button click on PC to an interactive element in the virtual scene. It can be advantageous to make use of the virtual hands in VR as it is intuitive to investigate and interact with in-game elements.

It was found that one of the biggest benefits of converting to VR is the achievable immersivity level. By using a head-mounted display, players are able to perceive the world through a lifelike embodiment of the main character. This immersion is further enhanced by recreating the original world to better support interactive actions. Furthermore, it became evident that translating the UI to VR also required higher focus on the intuitiveness.

Many design choices were made to increase the performance of the game, though full optimization was not achieved due to time and hardware limitations. This caused the game to be run as PCVR, requiring a constant connection to a PC.

In conclusion, playtesting has been used to examine the advantages and disadvantages when converting an ordinary computer game into virtual reality. Advantages such as free movement, deepened immersion and a broad interactive system gives the foundation for a satisfying conversion, where occurring disadvantages like cybersickness, physical and hardware-based limitations are fixable in the design creation.

Perspectives

Despite having reached the goals set from the problem statement, a few things could have been done in a different way to create a potentially more successful path.

Although the usage of Trello and a Gantt diagram has been taken fairly advantage of, further structured, and set deadlines for subtasks could have been beneficial. During the semester the project has stumbled upon times where it was not clarified what should be done when and how it would influence the user tests. Which resulted in the progress sometimes being a bit messy and uncoordinated between the teammates. Having a better time management and overview of what subtasks needed to be made before another, could potentially have paved the way for a smoother creation process. Based on this the quality and relevance during playtesting could have been more solidified and have born more sureness in the tested iterations.

An idea surfaced nearing the end of the project, which included a different test method that might have given better results and taken less time. Instead of always testing the entire storyline in the VR version, it might have worked better if there had been made a version in which the focus could have been solely on testing the game mechanics. In addition to saving time, it would have given way for more testers to try it and helped point out the issues that needed fixing. This would have given a more solid support of the problem statement by having clearer recommendations for the adaptation of the original game version into VR.

It was not made entirely sure what could additionally be benefitted from the questionnaires despite how well the game worked and what needed changing. There was made an attempt to try and see what kind of people were tested on, with questions concerning what games they normally play and whether they have technological experience. The results of the questionaries could have been taken more advantage of beyond trying to eliminate a bias between the testers who usually play and the ones that do not. As it is, it might be a bit uncertain to the potential the questions could have held.

Furthermore, having clearly planned conversations with the players after testing the game would have been beneficial to extract exact information on the mechanical game aspects. This could have possibly led to quicker implementations of polish to smoothen the mechanics and the overall game experience.

Although the project has still led to a satisfactory result, certain aspects that could have potentially created a better outcome or a smoother working process, instead provide an improved knowledge to apply in future projects to come.

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