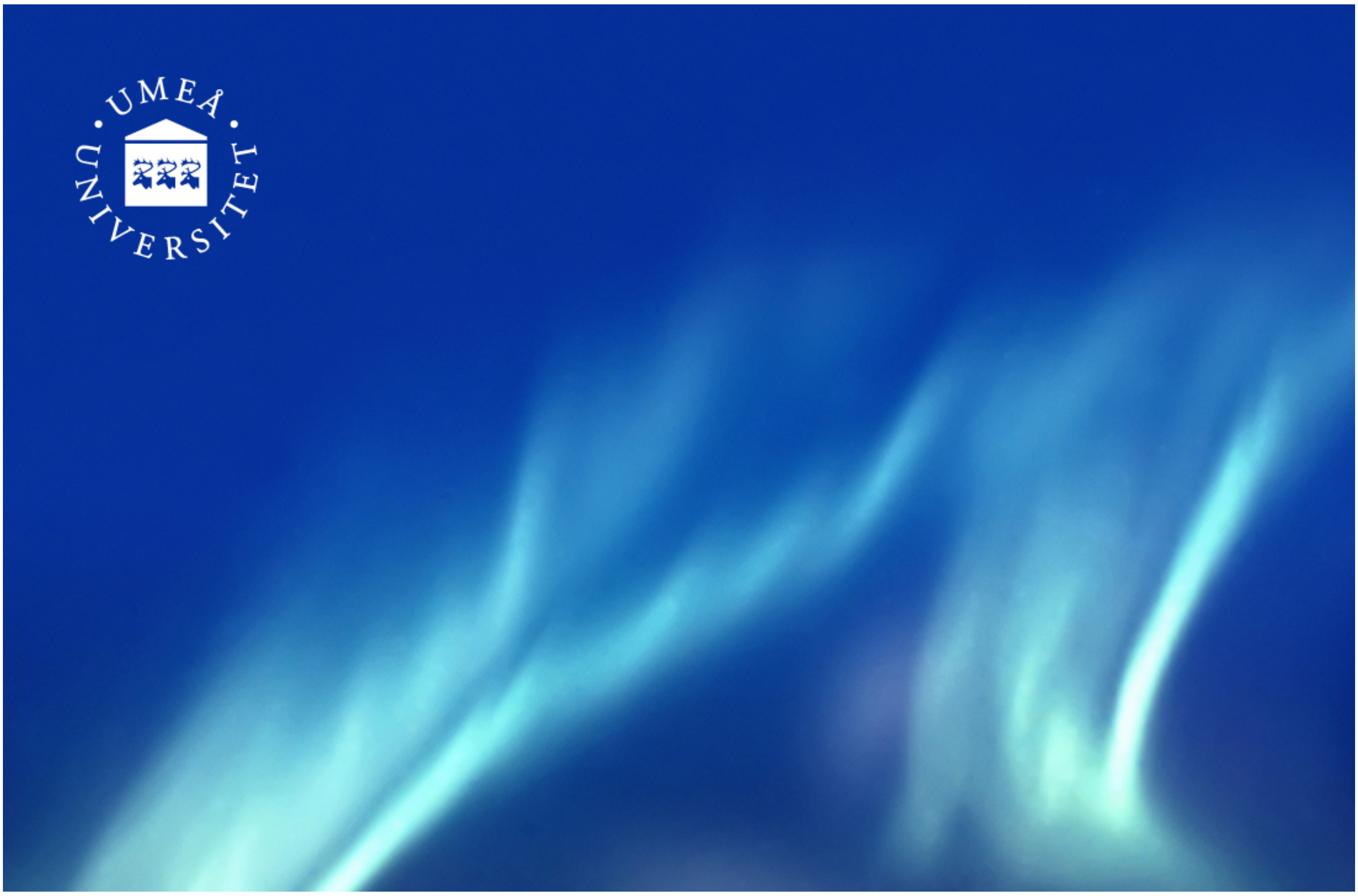

Master Thesis Report

Development and design in virtual reality: A user experience evaluation of creating 3D experiences while emerged in virtual reality

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Student
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1 Introduction

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2 Objective

The objective of this thesis is to evaluate the use of VR as a tool for designing and developing 3D experiences.
It will also investigate if a userfriendly design of this tool can be used asto bridge the gap between developers and the rest of the core team. By creating a tool that can be used without the knowlage of 3D development, other team members can make direct changes to the 3D experience to show the team their vision and ideas. There would be no need for developers to interpret their vision based on words or drawings. use subimport subsections/filename to add subsections

3 Methodology

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3.1 Interviews

Designing and developing applications in VR is

3.1.1 Expert Interviews

As the VR industry are still to develop a general pipeline for VR projects, expert interviews were conducted. The main focus were to get a broad view of how pipelines and design processes are carried out in VR projects. It also serves as an oppertunity to investigate if the internal processes at North Kingdom[add footnote] were missing some fundimental steps or parts.

3.1.2 Internal Interviews

In order to understand the specific VR pipeline [add footnote] and workflow in projects at North Kingdom, expert interviews were conducted. These interviews contributed to the selection of parts within the pipeline that will be the foundation of the VR tool.

3.2 Theoretical Framework

In order to support the design and implementation in VR, a theoretical framework was conducted on a variety of fields within the VR spectrum.

3.3 Iterative prototyping

Prototyping is a paradigm that is embodied in the "plan to throw one away" philosophy of system development [4]. In order to test the concepts from problems that were discovered in the interview phase, interface designs were designed and developed by utilizing iterative prototyping within the design process. Iterative prototyping keeps refining a design by creating partially workingh prototypes and user-testing them at a fast pace to get early and regular observation of the system and interface behavior. One of the main benefits with rapid prototyping is that the approach reveals misunderstandings between designers and developers and the users. These missunderstandings can originate from differences in backgrounds and/or experience [Prototyping as a tool in the specifications of user requirements]

3.4 Testing of the refined prototype

some stuff

4 Theoretical Framework

4.1 User-Centered Design

4.1.1 UCD within Virtual Reality

According to Stanney et al. it is crucial to consider the human factors when designing successful applications in virtual reality environments. This is even more important when the end user has little to no technical knowlegde about the processes going on within the designed system or application. [@articlestanney1998human, title=Human factors issues in virtual environments: A review of the literature, author=Stanney, Kay M and Mourant, Ronald R and Kennedy, Robert S, journal=Presence: Teleoperators and Virtual Environments, volume=7, number=4, pages=327–351, year=1998, publisher=MIT Press].

4.2 Interactions in VR

[INTRO MISSING]

4.2.1 Interaction Technique issues

[INTRO MISSING] [New Directions in 3D User Interfaces] presents four ways that the majority of interaction techniques exhibit generality:

- Application- and domain-generality: The technique was not designed with any particular application or application domain in mind, but rather was designed to work with any application.
- Task-generality: The technique was designed to work in any task situation, rather than being designed to target a specific type of task. For example, the design of the ray-casting technique does not take into account the size of the objects to be selected and becomes very difficult to use with very small objects (Poupyrev et al. 1997).
- Device-generality: The technique was designed without consideration for the particular input and display devices that would be used with the technique. Often techniques are implemented and evaluated using particular devices, but the characteristics of those devices are not considered as part of the design process. For example, the HOMER technique (Bowman and Hodges 1997) is assumed to work with any six-degree-of-freedom input device and any display device, but all of the evaluations of this technique have used a wand-like input device and a head-mounted display (HMD).
- User-generality: The technique was not designed with any particular group of users or user characteristics in mind, but rather was designed to work for a "typical" user.

4.2.2 Occlusion problem

A problem with interactions in VR that has a very small significance on screen-based UI is occlusion. Since the user interacts and moves in a VE in 3D and with 3D objects, the possiblity of objects blocking each other. To solve this the user can move arounid in the virtual space and hopefully getting an angle that occludes the object, or use a selection tool that can be bent around the first object or pass through it. [Large Scale Cut Plane:] offers a different solution, where the user can "slice the environment and hide it in order to get access to the desired object. This method were preferable from the standard method which is to move and find a better angle.

4.2.3 Human body limitations

[INTRO MISSING] Fatigue is one of the biggest problems with VR [A survey of 3D object selection techniques for virtual environments]. (Add more content about fatigue) Selection techniques are more severe on arm and wrist strain/pain while navigation can induce simulation sickness.(expand)
Physical reach is also a big problem when interacting in a virtual environment. It limits the interactionspace to the length of the user's body (most often arms).
The field of view of the user (just by moving their eyes) is about 94 degrees in a cone shape (circular vision). Past 77 degrees is considered peripheral vision and is not focusable without turning. The user can rotate their head 30 degrees without any constraint, and max out at 55 degrees. Looking up is 20 degrees as comfortable and 60 as max. Looking down is comfortable to about 12 degrees with a max of 40 degrees. (Create image to display this). By combining all of this we get three directional zones for content, as explained by (Alger 2015):

- Comfortable content zone: 0 - 77°
- Peripheral zone 77° - 102°
- Curiosity zone 102° - 158°

There are also 3 depth zones, which represents how the object is percieved. Those are:

- No content zone: 0 - 50 cm. Alger explains that this is because objects that appear closer than that will cause the user's eyes to cross.
- Primary depth perception zone: 50cm - 20m. Within these distances the user can perceive objects with depth.
- Beyond the horizon: 20m - MAX. Objects at this distance loses their depth perspective.

By combining three zones that represents where different kinds of content should appear (*** CREATE FIGURE FOR Comfort-perfifial-curiosity zones ***)

4.2.4 Physical Space

The journey to a virtual environment using a portable headset does not include a vast infinite empty physical space to move around in. This causes problems when users are imerged as they cannot see the physical objects in the real world which can cause injuries.

4.3 Interaction Tools in VR

There is a lot of parameters in the virtual world to take into account when deciding on a selection tool and technique. Some of the tools and techniques that exists for VE will be explained.

4.3.1 Raycast techniques

Multiple studies have concluded that in an environment with a sparse selection of objects with a volume that is not too small, using a raycast is most really fast and reliable. [insert raycast (pointer) references here] When some of these parameters change however, the raycast tool with a "laser-pointer" technique experiences more issues. In an environment that contains alot of objects in a small space, the error rate rises. This factor is multiplied when movement is added to the object (typical for games).
Accordning to [Dense and Dynamic 3D Selection for Game-Based Virtual Environments] there are better ways to perform object selection in a more complex and dynamic environment by tweaking this concept. By using techniques that are designed for dynamic and cluttered environment the speed and error rate can be reduced. Two of these techniques

are ‘zoom’ and ‘expand’. On first selection the surrounding area of the selected object is enhanced to simplify the selection.
A big problem with pointing is trembling of the hand and twitches that occour when user tries to select an option. This has been given the name “Heisenberg effect” and is the cause of new interaction issues:

- user dissatisfaction due to increased error rates,
- discomfort due to the duration of corrective movements, which in the absence of physical support require an additional physical effort, and
- unconfidence on which object will be selected after triggering the confirmation

[Improving 3D Selection in VEs through Expanding Targets and Forced Disocclusion]

4.4 Interface Design

Interfaces in a virtual environment comes with a new set of challenges when compared to a traditional interface designed for a screen. If these challenges are neglected the virtual experience for the user might be troublesome.
When designing an interface it’s important to evaluate the speed of selection. Fitts’ law is a fundemental and proven way to evaluate pointing to real-world objects by measuring the distant to the object and its size. [Fitts, P.M., 1954. The information capacity of the human motor system in controlling the amplitude of movement. Journal of Experimental Psychology 47, 381–391.]
This is however based on a real-world scenario which does not translate into a virtual environment were the user need a tool to interact with objects. Despite these differences, Fitts´ law can be applied to pointing in a virtual environment using following formula [Evaluation of mouse, rate-controlled isometric joystick, step keys, and text keys for text selection on a CRT]

$$ID = log(2) * (2 * D/W) \tag{1}$$

where ID is the index of difficulty, D is the distance from startingpoint to the middle of the correct target. W is the width of the target (caluculated on the axis where the pointer will travel).

4.4.1 Interface Design in VR

5 Results

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6 Discussion

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