

Navigation in Virtual Reality Space

Concepts of Navigation Methods

**IP5 Project of**

**Bär Dominic**

**Groux Marcel**

**FHNW**

**University of Applied Sciences**

**Degree Course: Computer Science / iCompetence**

**Supervising Lecturers: Arizona Stefan, Marcin Simon**

**Windisch, 12. January 2017**

Summary (Both)

Project Summary

Preface (Both)

Vorwort

Index

1 Introduction (Dominic) 5

1.1 What has been achieved? 5

1.2 Why has it been done? 5

1.3 How has it been achieved? 5

1.4 Readers Guide: How is the rest of the document constructed? 5

2 Initial Position (Dominic) 6

2.1 Introduction 6

2.2 Application domain 6

2.3 Overall scenario 6

2.3.1 Target audience 6

2.4 Project Goals 6

2.4.1 Navigation Methods 6

2.5 Project Scope 7

2.6 Limitations and Assumptions 7

3 Research (Dominic) 8

3.1 Introduction 8

3.2 Problem 8

3.3 Researched Navigation Methods 8

3.3.1 Walking 8

3.3.2 Teleporting 10

3.3.3 Other Methods 11

3.3.4 Researched Parameters (MARCEL) 12

3.4 Technical Research 12

3.4.1 Game Engines 12

3.4.2 VR Headsets 13

4 Implementation (Marcel) 15

4.1 Introduction (Dominic) 15

4.2 Walking in Place 15

4.2.1 Concept & Idea 15

4.2.2 Implementation 15

4.2.3 Parameters 15

4.3 Scaled Walking 16

4.3.1 Concept & Idea 16

4.3.2 Implementation 16

4.3.3 Parameters 16

4.4 Walking by Leaning 16

4.4.1 Concept & Ideas 16

4.4.2 Implementation 17

4.4.3 Parameters 17

4.5 Jumping 17

4.5.1 Concept & Idea 17

4.5.2 Implementation 18

4.5.3 Parameters 18

4.6 Combining the navigation methods 18

5 Testing (BOTH) 19

5.1 Introduction (Dominic) 19

5.2 Test 19

5.3 Expected results 19

5.4 Test Results 19

5.5 Problems during testing 19

6 Conclusion (BOTH) 20

6.1 Introduction 20

6.2 Insights 20

6.3 Suggestions 20

7 Further Steps (Marcel) 21

7.1 Introduction (Dominic) 21

7.2 Marketplace UE4 / Unity3D 21

7.3 Graphical Navigation Menu / UI 21

7.4 Composition of Navigation methods 21

8 Reflection (Both) 22

8.1 Introduction 22

8.2 Lessons Learned 22

8.2.1 Dominic Bär 22

8.2.2 Marcel Groux 22

8.3 Time Management 22

8.4 Collaboration 22

8.4.1 Team Internal Collaboration 22

8.4.2 Collaboration with Coaches / Clients 22

9 Index of Literature (Both) 23

L1. Literature 23

L2. Internet 23

L3. Existing Projects (Marcel) 23

10 Index of Figures 24

A. Attachment (Dominic) 25

A1. Project Agreement 25

A2. Test Survey 25

A3. Attachment 3 25

A4. Clarification of Honest 25

1. Introduction (Dominic)

This chapter contains an overview of the project. It describes what has been accomplished with the project and which topics are covered.

## What has been achieved?

Was wurde mit dem Projekt erreicht.

* Im Rahmen des Projektes wurden Prototypen zu Navigationsmethoden im VR Space erstellt
* Kurze Beschreibung der Prototypen

## Why has it been done?

Aus welchem Grund wurden die Prototypen erstellt?

## How has it been achieved?

Neue Technologie 🡪 Explorativer Ansatz (Ausprobieren, Entwickeln, Ausprobieren, etc)

Game Engine Unreal

## Readers Guide: How is the rest of the document constructed?

Zwei Teile

1. Theoretisches:
   1. Fragestellug
   2. Research
   3. Navigation Methods
2. Praktisches
   1. Implementation Prototypes
   2. Tests
   3. Results
3. Initial Position (Dominic)

## Introduction

In this chapter the initial position of the project will be introduced. The Application domain will be described and an overall scenario will be shown. Furthermore, the project goals and scope will be stated.

## Application domain

Anwendungsdomäne

## Overall scenario

Big Picture

Um was geht es im Projekt? Navigationsmethoden in vr

Was ist das schlussendliche Ziel? Erstellung von prototypen zur analyse der Methoden

### Target audience

Zielpublikum

-> Entwickler von VR Applikationen / Games

## Project Goals

The goal of this project is the generation of a concept about the navigation in the Virtual Reality space. The concept is based on a scientific research and should address the questions of the suitability for different navigation methods and the corresponding parameters (e.g. camera angle/area, scaling in space, …) within specific scenarios, which are to be determined.

Finally, the concept contains a thorough scientific analysis of VR navigation and its parameters, elaborated in a scientific approach and reflecting the current state of research of the Virtual Reality Community as far as possible.

The navigation methods, elaborated in the concept, should be implemented as a template for different scenarios and be tested thoroughly. Such that it can be shown which navigation methods are suited best for different scenarios. Thereby it is to bear in mind that the navigation that we are reviewing should be possible to use in a home-user-environment.

* Project Agreement

### Navigation Methods

The elaborated Navigation methods:

* Various variants of walking
  + Walking
  + Walking in Place
  + Scaled Walking
  + Dynamic Walking
  + Walking by leaning)
* Jumping
* Project Agreement

## Project Scope

Aufgabenstellung

Schwerpunkte der Arbeit

* Project Agreement

## Limitations and Assumptions

Welche Einschränkungen mussten wir machen?

* Einschränkung der NavMet (Zeitlich niemals alle möglich)

Welche Annahmen mussten wir treffen?

1. Research (Dominic)

## Introduction

In this Chapter we discuss the problem of our project and show results of our research in the field of the application domain

## Problem

The community provides a variety of implementation and methods for the navigation in the Virtual Reality space. Many of those however couldn’t be tested and analyzed scientifically. Furthermore, the already existing scientifically elaborated concepts are not necessarily suited for the new VR Hardware and the User- Space available for the VR-setup, like the HTC Vive or the Oculus Rift, and the usage in a productive application with users that have varying know-how and experience in Virtual Reality.

* Project Agreement

## Researched Navigation Methods

Auflistung der Navigationsmethoden (siehe seperates Dokument für NavMethod / Parameters)

Unterteilt in Walking und Teleporting

Specify physical translocation and / or movement?

Change tables vertically YES

|  |  |
| --- | --- |
| Description | The user walks inside a given space |
| Physical Translocation | Yes |
| Physical Movement | Yes |
| Parameters | * Location * Speed * Acceleration * Deceleration * Camera Direction |
| Problems | * Wall Collision |

### Walking

#### Walking

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Description | Physical Translocation | Physical Movement | Parameters | Problems |
| The User walks inside a given space | Yes | Yes | * Location * Speed * Acceleration * Deceleration * Camera Direction | * Wall Collision |

#### Walking in Place (WIP)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Description | Physical Translocation | Physical Movement | Parameters | Problems |
| The user walks in place | No | Yes | * Speed * Acceleration * Deceleration * Camera Direction | * Wall Collision * When does it start to walk? * Motion sickness |

#### Scaled Walking

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Description | Physical Translocation | Physical Movement | Parameters | Problems |
| The user walks inside the given space. The physical translation in the VR-Space is scaled up. | Yes | Yes | * Location * Speed * Acceleration * Deceleration * Camera Direction * Scaling | * Wall Collision * Motion sickness * Scale-rate |

#### Dynamic Walking

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Description | Physical Translocation | Physical Movement | Parameters | Problems |
| The user walks like in scaled Walking. The intention of the user is detected. | Yes | Yes | * Location * Speed * Acceleration * Deceleration * Camera Direction * Scaling | * Wall Collision * Motion sickness * Scale-rate |

#### Auto Walking

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Description | Physical Translocation | Physical Movement | Parameters | Problems |
| The user looks down at his feet and starts to walk. | No | No | * Speed * Acceleration * Deceleration * Scaling | * Wall Collision * When does it start to walk? * When does it stop to walk? * Motion sickness * Scale-rate |

#### Walking by Leaning

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Description | Physical Translocation | Physical Movement | Parameters | Problems |
| The user leans towards the direction he wants to walk. | No | Yes | * Location * Location (Head) * Speed * Acceleration * Deceleration * Camera Direction * Scaling | * Wall Collision * Detection of leaning * Motion sickness * Scale-rate |

#### Walking by Button

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Description | Physical Translocation | Physical Movement | Parameters | Problems |
| The user walks by pressing a button. | No | No | * Speed * Acceleration * Deceleration * Scaling | * Wall Collision * Motion sickness * Scale-rate |

### Teleporting

#### Gaze-directed Teleport

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Description | Physical Translocation | Physical Movement | Parameters | Problems |
| The user Looks to a point where he wants to teleport to. He teleports by clicking a button | No | No | * Location * Camera Direction * Speed of Teleport | * Camera Direction after teleport (Wall collision) * Camera transition |

#### Pointed Teleportation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Description | Physical Translocation | Physical Movement | Parameters | Problems |
| The user points towards a location he wants to teleport to. He teleports by clicking a button. | No | No | * Location * Camera Direction * Speed of Teleport | * Camera Direction after teleport (Wall collision) * Camera transition |

#### Room-to-Room-Teleportation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Description | Physical Translocation | Physical Movement | Parameters | Problems |
| The user points towards a room he wants to teleport to. He teleports by clicking a button. The location inside the room is dependent of the current location inside the room | No | No | * Location * Camera Direction * Speed of Teleport | * Combining with other method (Walking, WIP, etc) * Camera transition |

#### Zoomed Teleportation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Description | Physical Translocation | Physical Movement | Parameters | Problems |
| The User looks into the direction he wants to go. He teleports by clicking a button | No | No | * Location * Camera Direction * Speed of Zooming | * Camera transition |

#### Jumping

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Description | Physical Translocation | Physical Movement | Parameters | Problems |
| The user jumps in place. | Yes | Yes | * Location (Head) * Camera direction * Scaling | * Mostly needs to be combined with another method (Walking, WIP, etc) |

### Other Methods

#### Climbing

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Description | Physical Translocation | Physical Movement | Parameters | Problems |
| The user climbs by using his hands to pull him upwards. | No | Yes | * Location (Head) * Camera direction * Scaling | * Mostly needs to be combined with another method (Walking, WIP, etc) |

#### Flying

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Description | Physical Translocation | Physical Movement | Parameters | Problems |
| The user flies by using his hands / Controllers to navigate horizontally and vertically | No | Yes | * Location * Camera direction * Speed * Acceleration * Deceleration * Scaling | * Wall collision * Motion sickness * Scale-rate * When does it start to fly? |

#### Flying II

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Description | Physical Translocation | Physical Movement | Parameters | Problems |
| The user navigates in a 3D-Space by pressing buttons. | No | No | * Camera direction * Speed * Acceleration * Deceleration * Scaling | * Wall collision (?) * Motion sickness |

### Researched Parameters (MARCEL)

Add Description to each parameter

• Location (X- / Y- / Z-Axis) (Head-Gear)

• Location (X- / Y- / Z-Axis) (Hand-Controller)

• Camera Direction

• Camera Angle

• Speed

• ~~Acceleration~~

• ~~Deceleration~~

• Scaling

• ~~Brightness / Darkness~~

• ~~Sound of movement~~

## Technical Research

The following subchapter will focus on the technical side of our research regarding the game engines and the virtual reality hardware.

### Game Engines

Eventuell Kapitel 3.4.1.3, welches beschreibt, warum wir unreal gewählt haben?

#### Unity 3D

Unity is a multi-plattorm game engine developed by Unity Technologies. It is commonly used for the development of video games for computers, consoles and mobile devices. Unity itself describes it as the world’s largest creative community and the number one game development platform[[1]](#footnote-1).

The included WYSIWYG editor makes it easy to get started and develop your first project. Another usefull resource for an easy start is the rapidly growing community, a variety of tutorials and a wide range of plugins and extensions freely obtainable or purchasable in the asset store.

As for the programming language, the commonly used language is C#, but other languages like JavaScript are supported as well.

Among the normal purchasable versions, Unity offers also a free-to-use version. However, when using the free version, they automatically include a predefined Unity splash screen prior to your game. If your created game or application reaches a certain amount of revenue you are forced to get one of the paid versions. There are no royalty payments.

#### UnrealEngine4

The Unreal Engine 4 is a game engine created by epic games. ADD MORE INFO

~~The included marketplace provides the user with plenty of usable content for purchase. Furthermore, it provides free sample content, tutorial and educational material.~~

As for the programming language, the commonly used languages C++ and UnrealScript (a java-based object-oriented script language).

Epic Games delivers no purchasable version of the UnrealEngine4. To compensate the free usage of the engine they ask for a 5% royalty payment after reaching $3000.- of revenue per product per quarter. However, there are some exceptions for certain types of projects. « Pay no royalty for film projects, contracting and consulting projects such as architecture, simulation and visualization. »

#### Comparison & Reason of Choice

Compared to Unity 3D the UnrealEngine4 loses in the amount of supported platforms. Unity supports a wide and still growing range of platforms, while Unreal only supports the big names.

The Unity 3D Asset Store and the UnrealEngine4 Marketplace have very little in common. The Asset Store focuses on plugins, extensions and assets, while the Marketplace strongly focuses on the distribution of asset content.

* Unreal has better graphic settings
* Unreal blueprints

Add reason why choose unreal

### VR Headsets

#### HTC Vive

The Head Mounted Device (HMD) of the HTV Vive has a visual field range of 110° (diagonally), a resolution of 2160 x 1200 overall or 1080 x 1200 for each eye and an image refresh rate of 90 Hz. The 32 built-in sensors allow for a 360° movement tracking. With the front camera it is also possible to add physical objects into the virtual world.

The measurements of the position are taken by the two base stations mounted to the ceiling of the room. Each base station contains a sensor to track the position of the HMD. The position of the HMD is measured with a gyroscope and an accelerometer. The two base stations allow for a quadratic area with adjustable side length depending on the distance between the stations.

The user inputs are controlled by two hand controllers, one for each hand. The 24 sensors of the controllers allow for precise movement tracking. The multifunctional trackpad and the double-staged triggers with haptic HD-Feedback allow an entirely new virtual reality experience.

To connect the HTC Vive with a computer are two HDMI-, two USB-, and one audio slot needed. The audio slot is needed to connect headphones to the audio slot attached to the HMD.

#### Oculus Rift

Description of Oculus Rift

#### Comparison

# Implementation (Marcel)

## Introduction (Dominic)

Praktische umsetzung, protyping process

Concept and ideas

## Walking in Place

### Concept & Idea

~~The concept of our walking in place navigation method contains the forward / backward hand movements of a person during jogging. This gives the user the feeling of movement without physically change the location in the room. But with that comes the problem of having the feeling of moving around without moving around. To change this, we wanted to find a way to add inputs based on the leg movement when literally walking in place. However, due to the lack of leg or feet sensors this is not possible yet.~~



Figure 1 - Walking in place concept draft

### Implementation

Description how it was actually implemented

Screenshot of blueprint (Different versions?)

Problems while implementing

### Parameters

Which parameters are relevant for this method

## Scaled Walking

### Concept & Idea

~~The idea of scaled walking is based on the limited physical space the user has to move, but the virtual space can be a multiple of that space. To be able to use the whole virtual space the physical movements are scaled up, so that the user can explore a multiple of the space of his physical space.~~



Figure 2 - Scaled walking concept draft

### Implementation

Description how it was actually implemented

Screenshot of blueprint (Different versions?)

Problems while implementing

### Parameters

Which parameters are relevant for this method

## Walking by Leaning

### Concept & Ideas

~~With walking by leaning the user leans towards a direction he wants to walk to. Once a certain threshold of the x-axis rotation is reached the virtual character begins to move into that direction. The problem with that idea is that it is more a head rotation than a full body leaning.~~



Figure 3 - Walking by leaning concept draft

### Implementation

Description how it was actually implemented

Screenshot of blueprint (Different versions?)

Problems while implementing

### Parameters

Which parameters are relevant for this method

## Jumping

### Concept & Idea

Description on how it was planned to be implemented



Figure 4 - Jumping concept draft

### Implementation

Description how it was actually implemented

Screenshot of blueprint (Different versions?)

Problems while implementing

### Parameters

Which parameters are relevant for this method

## Combining the navigation methods

Creation of prototype (combination of each method prototype, switch between NavMets)

# Testing (BOTH)

## Introduction (Dominic)

Introduction to the testing

## Test

what has been tested, how has it been tested, etc

* SURVEY
* Testing procedure google doc

## Expected results

* Detailed description of expected results

## Test Results

Detailreich auf Ergebnisse eingehen

Prototypen(?)

Test Results to the tests for each prototype(?)

Survey results (= Test results?)

## Problems during testing

* E.g. the ladder (or other objects) was always visible
* Button not easy usable
* etc

# Conclusion (BOTH)

## Introduction

Intro to conclusion

## Insights

Welche Erkenntnisse haben wir gemacht?

## Suggestions

Schlussfolgerung

Konzept Suggestions which NavMet where to use

Entwicklungsprozess

# Further Steps (Marcel)

## Introduction (Dominic)

Thins we could not do but are interesting or necessary

## Marketplace UE4 / Unity3D

Create version for marketplace

## Graphical Navigation Menu / UI

Create menu for switsching navmet

## Composition of Navigation methods

Combine different navmet (e.g. Jumping and scaled walking)

# Reflection (Both)

## Introduction

In this chapter we reflect on our project work. We will talk about what we have learned / gained, what was good or bad and our time management. Furthermore, we will reflect on the collaboration within the team and with the coaches.

## Lessons Learned

Persönlicher Lerngewinn

### Dominic Bär

Lessons Learned Dominic

### Marcel Groux

Lessons Learned Marcel

## Time Management

Wie sind wir mit dem Zeitmanagement zufrieden, verbesserungen?

Herausforderung

Aufwandabschätzung schwer, da vieles noch unbekannt

Zu wenig Puffer

Viel Zeit für Einarbeitung der Technologie (unreal) benötigt

## Collaboration

### Team Internal Collaboration

Wie hat die Zusammenarbeit im Team funktioniert

### Collaboration with Coaches / Clients

Wie hat die Zuammenarbeit mit Stefan und Simon funktioniert

# Index of Literature (Both)

L1. Literature

List all physical literature we used, (Did we use any?)

L2. Internet

Add all used researched papers, stated with visiting date etc. (Savedate as visiting date)

Tutorials?

L3. Existing Projects (Marcel)

List of all existing projects we used

* Base project
* teleport

# Index of Figures

Index of all figures that will be in the text.

[Figure 1 - Walking in place concept draft 15](#_Toc472005774)

[Figure 2 - Scaled walking concept draft 16](#_Toc472005775)

[Figure 3 - Walking by leaning concept draft 17](#_Toc472005776)

[Figure 4 - Jumping concept draft 17](#_Toc472005777)

1. Attachment (Dominic)
   1. Project Agreement

Project Agreement?

* 1. Test Survey

Test Survey, with analysable results?

Google sheet evaluation

* 1. Attachment 3

?

* 1. Clarification of Honest

To be written

1. https://unity3d.com [↑](#footnote-ref-1)