Research Assignment

VIRTUAL REALITY
FOR SOCIAL PHOBIA AND AGORAPHOBIA TREATMENT

Fitri Nurdini Rahayu (1116010)

Supervisor:
Charles van der Mast

Informatietechnologie en Systemen
Technische Universiteit Delft
April 2003

Table of Contents

1. Introduction

Virtual reality is a technology that creates new definition of Human Computer Interaction (HCI). HCI involves relation between human and technology, especially computer technology. Human acts as the user of computer technology. User Interface (UI) helps user to interact with computer system. UI development relates to display technology development. Before Graphical User Interface (GUI) exists, user interacts with the computer by typing command. For example, when users want to delete a file, they have to type the delete command and the file name. When GUI is introduced, it opens the new possibility for UI diversity. Direct manipulation is one of the interactions between user and computer system that emerges because of GUI. Direct manipulation uses a representation of reality that can be manipulated [20]. For example, one of the reality representations that are widely known is Recycle Bin icon featured in Windows Desktop. If users want to delete a file, they can drag the image or icon that represents the file and drop it to the Recycle Bin. Direct manipulation interface provides dynamic interaction between user and two-dimensional (2D) objects of interest [21].

Unlike regular direct manipulation, Virtual Reality (VR) presents three-dimensional (3D) graphical representation of real environment for users to interact with as if the user is actually in the environment [19][21][20]. Users can freely wander through the Virtual Environment (VE) space. Therefore VE, which is 3D computer generated environment, offers moveable views onto 3D spaces. VR gives impression of involvement in a VE rather than external observation of such environment. VR is multi-sensory experience since it involves 3D stereoscopic display, tracker, and sound. Hence VR is able to make an immersive computer generated world, which creates feel of presence to the user. It means that the cognitive aspect becomes important.

In the literature, sometimes presence has different meaning. There is a definition of presence that can differentiate between immersion and presence. [1] Immersion is an objective description of the VR system such as display resolution. Presence is a subjective phenomenon such as sensation of being in a virtual environment (VE). There is also a definition of presence that is described empirically. Based on this definition, presence is categorized into two types as follow:

- Subjective presence. It is a chance that person assesses himself of herself to physically present in the VE.
- Objective presence. It is a chance that person is able to complete his or her task successfully. It relates to the ability of VE to work.

Presence is caused by several factors, such as vividness, interactivity, and user characteristic. [1] Vividness refers the capacity of a technology to generate a sensorially rich environment. It relates to the content of VE. Interactivity is the ability of users to take part in modifying the form and content of VE in a real time. User characteristic means that different person when being faced with the same VE can feel different level of presence because each person has different individuality.

VR attracts so much interest because it can provide lots of benefit to many different application areas. [19] VR can be used as scientific visualization. Scientific visualization is sometimes needed for interpreting masses of data or developing better models of system. Architecture visualization also can use VR technology. Architect can do experiment with building development freely without committing production cost. VR is also applicable to the psychology area. There are several researches on treating phobia patients with VR. Virtual Reality Exposure Therapy (VRET) puts the patients in the virtual world where they can be subjected to different kinds of stimuli related to their phobia. The patients will be assisted with the therapist in the VRET process.

Many researchers have experimented with different types of phobia using VR. Researchers from Mediamatica Department, Delft University of Technology in collaboration with Faculty of Psychology, University of Amsterdam has also done several research projects on VRET. The VR system used in the project is developed in TU Delft. Several VEs has been developed for different kinds of phobia exposure. Two of the VEs are virtual fire stairs and rooftop terrace for the acrophobia treatment. There are also VEs that are intended for claustrophobia treatment such as virtual hallway, virtual closet, and elevators. Virtual flight and virtual airport also has been developed for treating patients with fear of flying. However VEs aimed at social phobia and agoraphobia exposure therapy hasn't been developed in Mediamatica Department, TU Delft.

The statement below is adapted from Global Ideas Bank from a man in Devon, UK, who has social phobia. Global Ideas Bank (www.globalideasbank.org) is a global suggestion box for socially innovative ideas and projects in UK.

> "Even now, writing this, the thought of those eyes looking at me is getting my heart pounding, palms sweating
>
> I suffer from a social phobia of not being able to talk to any groups of people. I have a massive mental block and even now, writing this, the thought of those eyes looking at me is getting my heart pounding, palms sweating and I am starting to feel shortening breaths.
>
> I have looked but cannot find any self-support groups for people with my problem.
>
> In a group of people with the same problem, everyone could work it out together. Otherwise a social phobic does not develop enough social skills, and this feeling of being unable to cope develops into a downward spiral.
>
> If someone were to develop a virtual reality program of a group of people looking at the headset wearer, I feel it would be of great benefit to people like myself."

The statement shows how VR exposure technology for social phobia sufferer is needed. For phobia sufferer who thinks that in vivo exposure is too extreme and too hard, virtual reality exposure is the answer.

The research assignment about virtual reality and social phobia/agoraphobia is conducted as an early step for TU Delft to develop a Virtual Reality system for curing social phobia or agoraphobia. The literature study is one of the methods for conducting the research assignment. After the research assignment is finished, hopefully it is a milestone for the next step, which is developing pilot virtual reality environment for social phobia or agoraphobia treatment.

1.1 Research Goal

The research assignment is conducted as a preparation for writer's Master of Science thesis project in Delft University of Technology, which is developing pilot VE that is aimed for social phobia or agoraphobia VRET.

The goals of the research assignment are as follow:

- Learning about social phobia and agoraphobia VRET.
- Learning the VR system that has been developed in Mediamatica Department, Faculty of Information Technology and System, Delft University of Technology. The VR system consists of hardware and software components.

- Proposing pilot Virtual Environment (VE) that is going to be used for social phobia or agoraphobia VRET

1.2 Research Methods

In order to accomplish the goal, the research assignment is conducted by these following methods:

- Doing literature study. The literatures, which are utilized as information source, consist of documents, papers, and books related to VRET, especially social phobia and agoraphobia VRET. Literatures about social phobia, agoraphobia, and Virtual Reality also will be needed. Hence, these following issues can be solved by literature study:
  - What is social phobia and agoraphobia?
  - Why can VR be used as a phobia treatment?
  - Are there any social phobia or agoraphobia VRET researches before?
- Analyzing the VR system. By doing this kind of activity, problems and limitations that may arise when developing VE for social phobia or agoraphobia VRET hopefully will be identified.
- Learning the VE development tool in order to be able to build the VE.
- Discussing topics related to the research assignment, such as social phobia, agoraphobia, and VRET with the experts. The discussion assists the final decision of VE that is going to be developed for the social phobia or agoraphobia VRET project since the experts know what types of VE, which can be used for social phobia or agoraphobia VRET.
- Interviewing other VRET researchers about their project.

1.3 Research Outline

First chapter explains the introduction part, which also includes the research goal, research methods, and research outline.

Second chapter covers the basic and general explanation on social phobia, agoraphobia and its treatment.

The current social phobia or agoraphobia VRET project will be discussed in third chapter.

In chapter 4, TU Delft VR system that is used for VRET research will be written in detail.

The design of VE aimed at social phobia or agoraphobia exposure therapy will be covered in fifth chapter.

In chapter 5, which is the last chapter, the conclusion of the research assignment will be written.

2. Social Phobia, Agoraphobia and Treatment

2.1 Anxiety Disorder

Anxiety is normal. [9] People will have mild and brief anxiety sometimes. The anxiety may be caused by first date, important presentation, job interview or first day at school. However if the anxiety is chronic, it becomes a serious medical illness. It is called anxiety disorder, which may influence adults and children. If it is not treated, the illness will grow gradually worse. Anxiety disorders are the most common psychiatric problem.

There are different kinds of anxiety disorders [5]:

- Generalized Anxiety Disorder (GAD)
  A person who suffers GAD is a pessimist person. They anticipate the worst so that they worry too much about money, job, family, or health. Hence they cannot relax, which sometimes lead to physical symptoms, such as nausea, headache, fatigue, muscle tension or trembling.

- Obsessive-Compulsive Disorder (OCD)
  People with OCD cannot control the repetitive and obsession behaviors. The repetitive behaviors, such as counting or cleaning are intended for making the obsession go away. However it only gives a temporary relief. If the repetitive behaviors are not performed, the anxiety will increase. Both children and adult can suffer OCD.

- Panic Disorder
  People with panic disorder usually develop it in late adolescence or early adulthood. Panic disorder is distinguished with intense fear that attacks often and repeatedly. It is accompanied with physical symptoms such as chest pain, dizziness, shortness of breath, fear of dying, or abdominal distress. The symptoms sometimes imitate life-threatening medical conditions, such as heart attack.

- Post Traumatic Stress Disorder (PSTD)
  It is an anxiety disorder that happens after experiencing frightening events, such as assaults, disasters, or wars. These events are traumatic events for the victims. They will trigger PSTD to the victims. Family members of victims sometimes also develop PSTD. People with PSTD may have nightmares, flashbacks, numbing of emotions, depression or feeling angry as the result of their illness.

- Phobias
  Among anxiety disorders, phobias are the most frequent ones. [5] Phobias are divided into two major types. They are specific phobia and social phobia. A person, who has specific phobia, has irrational fear of something that has little or no real danger. There are several types of specific phobia. Some of them are fear of height, fear of spiders, fear of flying, fear of closed-in places, and agoraphobia. People with specific phobias will get panic attack or severe anxiety when they face or think about confronting the feared object or situation.

2.2 Agoraphobia

Agoraphobia comprises intense fear and avoidance of any situation or place where escape might be difficult and embarrassing. They also have problems in the situation from which help may not be available when a panic attack hit them [5]. Therefore they tend to have these following behaviors [22]:

- Avoidance of these following situations: traveling in a car or public transportation, being in crowded area, being alone outside of the home.
- Needing another person's company, such as family member or friend when they go to the place that they fear.

Agoraphobia sufferers are seriously disabled by their 'condition'. They may be unable to work, to shop, etc. They will rely heavily on another persons for shopping or traveling outside their house. People with agoraphobia may stay in their house for years, resulting impairment of social relationship. Hence they live a life of great discomfort and extreme dependency.

2.3 Social Phobia

Based on the diagnostic and statistical manual of mental disorders (DSM-IV), social phobia is one of the anxiety disorders [5]. There are 7.8 % percents of general population of the Netherlands who suffer from social phobia. The number was taken from the study that was held in 1998 [10]. In the world, social phobia ranked as the third largest psychological problems.

Social phobia sufferers will develop their anxiety when they are in the situation that includes people. People who has social anxiety disorder has problem in public places. Anxiety may develop in these following situations [9]:

- In the long queue. The sufferers will develop a feeling that everyone watches them. Then they think that they have made embarrassing mistakes although they haven't done anything unordinary.
- When they need or want to make a call by phone. They are afraid to make a call because they don't want to feel rejected. If they want to call their friend, they might cancel it because they're afraid that their friends are busy and doesn't want to talk to them. If they want to call a stranger they might cancel it because they afraid they will offend the stranger.
- When they walk down the streets. They are afraid to make eye contact to persons whom they barely know because they do not want to say hello and make a conversation.
- In the meeting. They hate meeting because they have to speak. When the meeting is finished, the memory of the meeting will be in the back of their mind for a long time because they are sure that they have made a fool out of their self and they have made mistakes.
- They hate party. They think that the people in the party won't like them because they think that the people in the party judge them negatively
- They have problem and often struggle for starting a simple conversation.

Of course, people with social phobia will not develop severe anxiety when they are in all situations mentioned above. For example, some of them will not have anxiety when they are in a long queue but the may develop severe anxiety when they are in party. If a person develop severe anxiety when he or she is in one of the situations above, it means that this person have social phobia [9].

They know that it is irrational to feel that the public is always evaluating them, judging them, and critical to them. But still they cannot shake the feeling out so that it always clouds their mind. Sometimes they will perceive a conversation, as an interrogation. Hence the anxiety will occur. They are also very afraid of confrontation and rejection from the public. Social phobia is one of the factors that makes the sufferer has low self-esteem and depression. Therefore people with social phobia sometimes try to get rid of or to reduce the anxiety by drinking or using drugs. Some of the people with social phobia even may have other anxiety disorder such as panic disorder [9].

2.4 Treatment for Social Phobia and Agoraphobia

There are two kinds of treatment for social phobia. First treatment is using certain type of medications. They comprise antidepressants (such as Prozac), MAOI drugs, mood stabilizer and beta-blockers. Using drugs is not recommended because medications only provide short-term recovery for the sufferers. Beside that, it is suspected that drugs create unwanted side effects and withdrawal symptoms. However for some patients, this treatment may be helpful, when combined with the second treatment that is going to be mentioned next. Unlike, the first treatment, the purpose of second treatment is not for a short-term recovery. This treatment is cognitive-behavior therapy (CBT) [8].

CBT is a therapy that combines two type of psychotherapy: cognitive therapy and behavior therapy. Cognitive therapy trains the patients about particular thinking patterns, which cause symptoms, by making the patients to feel anxious. Behavior therapy assists the patients to conquer the relation between upsetting situations and patients' habitual reactions to them. Therefore changing the ways of thinking is the cognitive aspect of CBT. On the other hand, aiding a person to face the challenge, which may scare his or her, with clear and calm mind is the behavioral aspect CBT. Generally, CBT has been proven to be a better treatment for anxiety disorders than using drugs because CBT is able to avoid treatment failures and relapse that may occur after finishing the treatment [8].

Exposure therapy is the main component of CBT for social phobia patients. The patients will be presented with situation that feared them most so that in the end, the patients will become comfortable with this situation. The exposure will be gradual and will consist of several stages. Earlier stages will be easier to handle by the patients. After overcoming the easier situations, the patients will be taken to more difficult situations. [8] [9]

The conventional method of exposure is in vivo exposure. However, there is a new type of exposure for curing phobias. It is Virtual Reality (VR) exposure. From the study of Virtual Reality treatment versus exposure in vivo for acrophobia (fear of height) conducted by Department of Clinical Psychology, University of Amsterdam and Delft University of Technology, it is found that VR exposure is as effective as exposure in vivo [11]. Because of the success of VR exposure for acrophobia treatment, VR exposure will be developed for other kinds phobia, such as social phobia and agoraphobia.

As mentioned before, phobias are divided into two types. They are social phobia (or social anxiety) and specific phobias. Unlike social phobias, specific phobias, such as acrophobias, have stimuli that is clear and easily to be identified. It does not involve difficult interactions. However, stimuli of social phobias require people to be present. Each of the people who are modeled in Virtual Reality should have his or her won personality and behavior. Therefore Virtual Reality environment for social phobias exposure is harder to make.

3. Current Social Phobia and Agoraphobia Virtual Exposure Therapy Project

Virtual Reality for curing phobias is still in early stages. However there are several researches that have been conducted regarding this topic. Various studies have been carried out to validate the effectiveness of virtual reality and phobia. Some of them are Virtual Reality researches for curing social phobia and agoraphobia. The researches try to make a realistic and controllable social environment with virtual reality. This chapter shows some pilot VEs intended for social phobia or agoraphobia sufferer.

By presenting others research regarding social phobia or agoraphobia and VR, we can catch a glimpse of what we will do on our-own project since the researches, which will be covered, use state-of-the-art VR systems, techniques, and research procedures. This chapter will cover other researcher's projects about relation between virtual reality and social phobia or agoraphobia. There are several researches that will be mentioned. Information of those researches will include these following important topics:

- Social phobia and agoraphobia VRET system that has been developed. The information will contain hardware and software components. However because this information depends heavily on the literature source that we got, some of the information may be not in detail.
- Virtual Environment that is used to the patients/subjects who have social phobia or agoraphobia.
- Research procedure and research result.

The VR system information that has been acquired will be compared in the end.

3.1 Virtual Reality Technology Laboratory, Clark Atlanta University (CAU)

CAU had done research on Virtual Reality Exposure Treatment (VRET) for fear of public speaking. The research was collaboration with the U.S. Army Research Laboratory, Boeing Computer Services, and Speech Improvement Company, Inc [12].

3.1.1 VR System

The paper that wrote this project didn't cover in detail about VR system used in phobias VRET. It only mentioned that hardware components for the system was consist of Pentium based computer, head mounted display (HMD) with an attached headphone, and head tracker (Virtual – I/O). The system used amplifier to increase the sound that is generated by the VE and also to increase sound of the speakers who give speech. The amplifier is directly connected to the software and hardware so that subjects/speakers can hear the echo of their-own voices while they are giving speech, facilitated by the headphone and amplifier [12].

3.1.2 Virtual Environment

The virtual environment was made by VREAM Company. The environment used Clark Atlanta University (CAU) Research Science Building auditorium as the model. The size of virtual auditorium is 48 feet wide, 100 feet long and 55 feet high. It also had seating area that consist of

three sections of chairs and is able to house more than 100 people and had virtual wooden podium, as a place where the subject/speaker give his or her speech. The subject/speaker was able to hear the echo of his or her own voices while he or she give speech, facilitated by the headphone and the amplifier [12].

3.1.3 Procedure and Result

There were sixteen subjects, who were chosen by two stages screening process and then assigned to two treatment conditions: virtual reality therapy and a comparison group. The treatment schedule had five weekly sessions, which lasted 10 to 15 minutes [12].

The result showed that VRET was effective in decreasing self-reported anxiety. [12]

3.2 Biomedical Engineering Department, Hanyang University, Korea

Fear of Public Speaking

Hanyang University, Korea, had developed virtual environment, which was used as VRET for fear of public speaking.

3.2.1 Hardware Components

The system used these following hardware components:

- Pentium-III 550MHz PC with 256MB RAM
- DirectX 3D accelerator, which is supported by graphic card, for generating real-time imagery
- 3D sound system
- Head-Mounted Display (I-glasses)
  The research use HMD from I-glasses type. There are two kinds of I-glasses. They are mentioned below.

  I-glasses SVGA 2D
  The price of it is around $649.00. More detail specifications are as follow:
  - The display has 800x600 resolution.
  - The Field of View (FoV) is 26 degrees diagonal.
  - It comes with VGA/SVGA/XVGA connection and 9V A/C power supply.
  - The refresh rate is 120 Hz (Flicker Free).
  - It has full stereo audio
  - The weight is less than 1 kg

  I-glasses SVGA 3D
  Its price is around $999.00. The HMD is a plug and play compatible with PCs. The details is mentioned below:
  - The display resolution is 800X600 with stereoscopic 3D capability.
  - The field of View (FoV) has 26 degrees diagonal.
  - It comes with VGA/SVGA/XVGA connection and 9V A/C power supply.
  - The refresh rate is 120 Hz (Flicker Free).
  - It has full stereo audio
  - The weight is less than 1 kg

- Head Tracker

The head tracker used in the research is InterTrax. Details of specifications are as follow:

- The tracker uses sourceless microgyro technology that is continually analyzed by an onboard processor so that the tracker can calculate tracker orientation in space.
- The data sampling rate of the InterTrax is 256 Hz.
- It can track movement of the users freely. Users can look up, down, and around through 360 degrees as the walk around and interact with the environment. Its degree of freedom includes yaw, pitch, and roll movement.
- The tracker has 80 degrees angular ranges for its yaw, pitch and roll movement.
- It has zero interference. It means that it is not affected by electrical or magnetic interference.
- The head tracker is compatible with most 3D applications.
- It uses RS-232 as interface to the PC. There are two modes of connection: Mouse Emulation and Native Mode. Using Mouse Emulation mode means that the tracker reacts to the application as a serial mouse with 2 degrees of freedom. On the other hand, native mode allows the trackers to have 3 degrees of freedom.
- 9V DC is used as the power supply.
- Protocols of this tracker are mouse emulation, fast stream packet transfer, and data request.

3.2.2 Virtual Environment

The virtual environment modeled a seminar room with 8 virtual audiences who are seated. These virtual audiences or avatars had characteristics that mimic real audiences. They have face expressions, behaviors and responds by agreeing with the speakers or disagreeing. They could have a chat with another avatars. They also could yawn, clap, and cheer.

Examples of the virtual environment that had been developed can be seen below:

Fig 1 Virtual Environment for fear of public speaking exposure

Fig 2 Virtual Environment for fear of public speaking exposure

Agoraphobia

Beside, developing the world for fear of public speaking, Hanyang University, Korea also developed the environment for agoraphobic. Agoraphobia can be considered also as social phobia, because the sufferer tends to have fear of crowd/people and open space. Therefore the sufferer often avoid places, such as: subway, airplane, bridge, etc.

3.2.3 Hardware Components

The VR system in the research on VR and agoraphobia used this following hardware:

- Head Mounted Display (HMD)
  HMD used here is Provies TM XL50, Kaiser Electro-Optics Inc, with1024H X 768V, and 50 degrees diagonal.

- An electromagnetic tracker.
  The research uses FASTRAK tracker from Polhemus, Inc. Its role is as a head tracker that is used for position or orientation measuring. The tracker computes the position and orientation of a tiny single receiver as it moves through space. The data update rate of single transmitter is 120 Hz. It gives dynamic and real time six degrees of freedom measurement of position and orientation. The position is measured in X, Y, Z Cartesian coordinates and orientation is measured in pitch, yaw, and roll. RS-232 and USB is used as an interface to the PC. The FASTRAK tracker uses low-frequency magnetic transducing technology so that the line of sight between receiver and transmitter does not have to be clear in order to transmit data well.

- Drive Simulator (TM Nascar Froce Pro, Thrustmaster, Inc)

- BooDoo (3D accelerator) for real time imagery

- PC with Pentium processor

3.2.4 Virtual Environment

The VRET experiments by Hanyang University, Korea, for agoraphobia exposure treatment used these following environments:

- Balconies
- Empty room
- Dark barn
- Dark barn with black cat
- Elevator
- Subway
- Tunnel with traffic jam
- Airplane
- Public speaking
- Theater

3.2.5 Procedure

The exposure experiments performed on 45 subjects who beforehand determined having agoraphobia by psychologist.

The procedure of experiment use a relaxation phase, before the subjects get immersed in the system. After the experiment, the subjects received questionnaires survey. Based on the survey, the environment that is most feared by the subject, is shown. The result, in particular order is: the elevator, the tunnel with traffic jam, the airplane, public speaking situation, barn with cat, theater, balcony, empty room, and last the barn.
However the result above is not significant since for each subjects, he or she may have different type of environment that fear her or him most.

Therefore the team conducted different type of experiments. The subjects were exposure only with the environment that feared them most. It used impulsive or flooding exposure. The second experiment used tunnel environment with traffic jam to the subjects.

3.3 Computer Science Department of University College, London

University College London (UCL) had started research on virtual reality for social phobia treatment since 1998. There was an attempt for fear of public speaking VR treatment. The study is not a controlled clinical trial. However it showed that VR exposure for social phobia treatment could be done, although its virtual environment is harder to make since it is not a static environment [6].

In their pilot study, it showed that virtual audiences or avatars could create anxiety to the subjects. Because of their success in making pilot system of VR for social phobia treatment, UCL had developed their study further. Some of the projects related to this development are enhancement of avatars or virtual human. They also develop another environment for social phobia sufferer, not just for fear of public speaking [6].

In the follow-up research that they conducted they choose a virtual world that represent seminar environment. It is an environment that has small numbers of virtual people, instead of a large audience. The patient will be confronted with this small group of avatars. The project use male avatars that wear formal dress. They claimed that small group environment would make them more understand the design parameters for creating virtual social events. In order to make the virtual audiences more realistic, three characteristics of virtual audiences were built. They are virtual audiences that show negative response, virtual audiences that show positive response and static virtual audiences. Emotional response of the patients to these virtual audiences is really important in this project and research. Negative or positive responses are portrayed by the avatars behaviour such as chatting, yawning, agreement, disagreement, and hand clapping. In addition showing responses to the subject who acts as a speaker, the avatars are also able to show the illusion of life. They continuously reveal illusion of life in the form of small twitching movements, blinking and shifting in their chairs. Facial expression and behaviour of the avatars can be seen below [6]:

Fig 3 Expression and behaviour of avatars

The experiment for discovering the effectiveness of the virtual environment needs some subjects who have fear of public speaking. The procedure of the experiment is as follow. All subjects at least have to be confronted to the virtual audiences twice to give a couple of minutes speech in front of the avatars. There are three types of group virtual audiences: audiences who give positive response after speech, audiences who give negative responses after speech, and audiences who don't display responses. Subjects were randomly assigned to one of these virtual audiences types [6].

The virtual reality system for the experiments use head mounted display, microphone, and headphones. Subjects wear it and stand in a dark empty room while giving their speech. An operator guided the environment at the remote terminal [6].

From the follow up study, the result showed that the subjects responded to the virtual audiences like they would respond the real audiences. The subjects would be uncomfortable if they faced negative responds from virtual audiences and they would be comfortable if the faced virtual audiences with positive respond [6].

3.4 Ecole Polytechnique Federale de Lausanne (EPFL) and Department Universitaire de Psychiatrie Adulte (DUPA), Lausanne

3.4.1 Hardware Components

For developing the VR system, they use this following hardware:

- Head Mounted Display (HMD)
  The research uses HMD Kaiser ProView XL50. The detail of this HMD is mentioned below:
  - The price of the HMD is $ 19.500,00.
  - The HMD has 1024x768 display resolution.
  - The Field of View of the HMD is 50 degrees diagonal, 30 degrees vertical, and 40 degrees horizontal.
  - It accommodates magnetic and inertial tracker sensors.
  - The vertical rate of the HMD is 60 Hz
  - The HMD uses 120 V AC, 60 Hz or 240 V AC, 50 Hz, 25 W for the power.

- Sensor that is placed on the HMD.

It is six degrees of freedom sensor made by Ascension Technology. The research uses Motion Star type. Motion Star is full body motion capture. The complete features of the product are as follow.

- The price is around under $25,000.00.
- It is integrated with fast Ethernet interface to the PC. It also has RS-232C as another interface to the PC.
- Its output is X, Y, Z position coordinates and orientation angles, rotation matrix, or quaternions
- The translation range for this sensor is around 3 m in any direction with one transmitter and around 5 m with dual transmitter.
- It tracks multiple characters simultaneously that allows multiple characters to interact with one another.
- It has DC magnetic technology. The advantages of using this technology are no data loss, less vulnerable to metallic deformation than AC eletromagnetic trackers, and five times less vulnerable to distortion caused by nearby metal.
- It has real-time motion capture feature. The feature will optimize the productivity in motion capture sessions and also will choreograph movements instantly.
- It is portable, easy to use, and performs and easily integrates with major animation program.

- PC with an accelerated graphic board. The graphic board is Nvidia Gforce2 type.

- Earphone attached to HMD for hearing sound

3.4.2 Virtual Environment and Procedure

They also developed virtual environment that simulate interview in the office where subject or patient must speak. The VE has two stages. The first stage is that the subjects must ask the secretary where her or his boss is and then in the second stage, the subject must go to the boss' office and enter it. Then subject must present in front of a man who sit behind the desk and start doing the interview.

From the Virtual Environment above, they concluded that the virtual audiences are not expressive enough. Avatars or virtual audiences are different with real human. Avatars must be able to replicate real human as much as possible so that the subject can feel real human watches them. In order to do that, avatars must be able to show some expression that mimics the real life audiences' expression. Therefore they build another virtual environment focused only on eyes because of these following reasons:

- They can concentrate more on the face horizontal elements expressiveness. Horizontal elements where mouth and eyes are located are the essential in human perception.
- People who has social phobia tend to avoid others' gaze.

For the second virtual environment, the environment placed the subject at the center of a virtual audience. The audiences are placed around the subject, in the circle so that the subject unable to avoid the audiences' gaze. The eyes will be fixed to the subjects even though the subjects move. The eyes that represented the audiences are photographs of eyes with various facial-expression. An ambient sound was added. It was created from a soundtrack recorded in amphitheater.

The therapists were also able to control number of circles, number of virtual eyes, size of the room.

Subject who participate the experiment wore the equipment that consists of HMD, sensor, earphones, and biofeedback. Before the subject immerse in the virtual world, the system presented relaxation with quiet music and a restful picture to the subjects. Finally subjects must give a speech to the virtual audiences that were represented by eyes.

Conclusion of the experiment is that the VR exposure was able to create anxiety to the subject.

3.5 Virtually Better Company

Virtual Better Company is a company, which commercially offers a ready made virtual environment for therapy to the public. Virtually Better Company also has developed environment for fear of public speaking. However we cannot find out whether the environment that they have made is effective to treat the phobia because the research result for the VR system is not published. It seems that the Virtual Reality applied here is more for improving social skills by training your ability in public speaking than for exposure treatment therapy [15].

Below are several screen captures of virtual environment that has been developed by Virtually Better for fear of public speaking exposure treatment.

Fig 4 Large audiences environment

Fig 5 Small audiences environment

The left picture of large audiences environment illustrates the virtual avatars that show positive response by clapping their hands while the subject give his or her speech. The middle and right pictures illustrate the environment that shows negative response of the virtual avatars/audiences. The middle picture shows the audiences that talk to each other while the subject gives a speech. The right picture shows one of the audiences that leave, which gives an impression of uninterested feeling for the subject's speech.

The left and middle images of small audiences environment show the positive response of the audiences by clapping their hands and applauding the subject. On the other hand, the right images show the negative response of the virtual audiences by looking restless.

3.6 Virtual Reality Medical Center (VRMC)

Virtual Reality Medical Center is medical center that uses virtual reality to treat people who have phobia. It is not a research center. Therefore research on developing virtual reality system is not available here. VRMC also doesn't explain how effective and successful the treatment is. VRMC only offers to treat several types of phobia. Two of the phobias relate to the social phobia treatment. VRMC has virtual environment that can be used for agoraphobia exposure treatment and fear of public speaking exposure treatment. The procedure of the treatment, in a nutshell, is illustrated in the figure 6 and 7 [16].

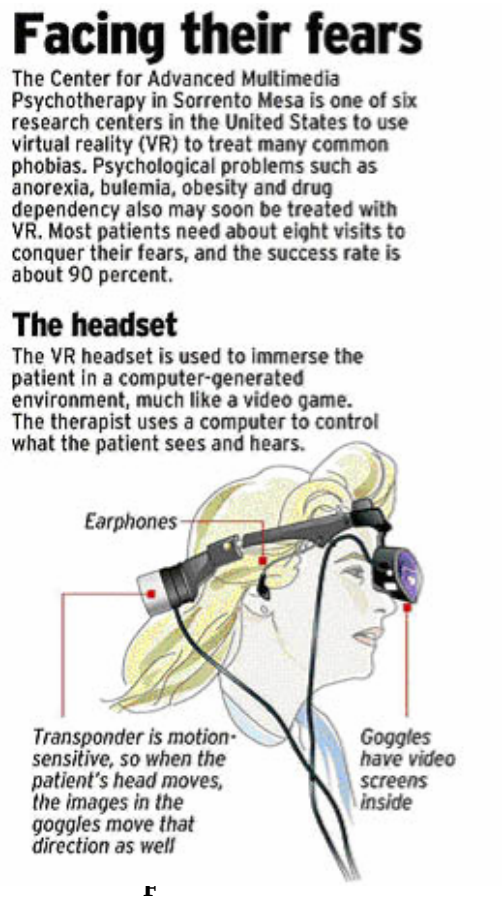

Fig 6 Illustration of VRET in VRMC

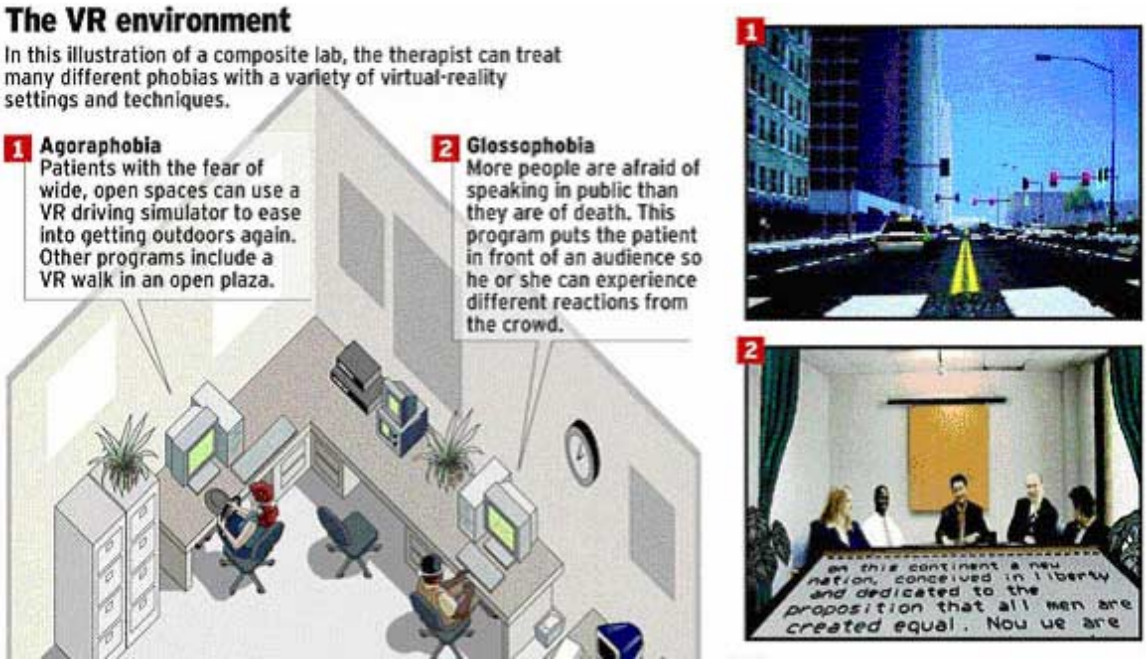

Fig 7 Illustration of VRET in VRMC

These following pictures are the screen captures of the virtual environment, which are used for fear of public speaking treatment.

Fig 8 Virtual environment for fear of public speaking

Fig 9 Virtual environment for agoraphobia

Fig 10 Virtual environment for agoraphobia

3.7 Conclusion

The VRET for social phobia and agoraphobia researches and applications are still in early stage. There must be more thorough research to show that social phobia and agoraphobia VRET can be applied to the patients as effective as other therapy method. Most of the social phobia and agoraphobia VRET sources only mentioned that the system is able to create anxiety to the patients without concluding that the system is effective for curing patients' 'condition'.

Not all information sources illustrate the social phobia and agoraphobia VRET in detail. Some of them don't even mention the VR system that is used for VRET. The overview of the information that has been gathered about VR and agoraphobia/social phobia from other researcher can be seen in the two tables below. Blank cells means that the information is unavailable from the source.

From the screen capture illustrated in this chapter, Virtually Better Company and VRMC seem related since they both use the same Virtual Environment for their therapy.

TABLE I Overview of the system

Name system	**Display**	**Modalities**	**Other input devices**	**Type of Phobia**
Clark Atlanta University	HMD	Sight Sound	Tracked Device	Fear of Public Speaking
Hanyang University	HMD	Sight Sound	Driving Controls Tracked Device	Fear of Public Speaking Agoraphobia
University College London	HMD	Sight Sound		Fear of Public Speaking
EPFL	HMD	Sight Sound	Tracked Device	Fear of Public Speaking
Virtually Better Company	HMD	Sight Sound	Tracked Device Driving Control	Fear of Public Speaking
Virtual Reality Medical Center	HMD	Sight Sound	Driving Controls Tracked Device	Fear of Public Speaking Agoraphobia

TABLE II Overview of the hardware components

Name system	**Display Resolution**	**HMD Field of View**	**Head-tracking**
Clark Atlanta University			
Hanyang University (Fear of Public Speaking)	800x600	26 degrees	3 DoF
Hanyang University (Agoraphobia)	1024x768	50 degrees	6 DoF
University College London			
EPFL	1024x768	50 degrees	6 DoF
Virtually Better Company			
Virtual Reality Medical Center			

4. Current VRET System in TU Delft

4.1 Hardware Components

Mediamatica department had developed a pilot system of VRET. The Virtual Reality (VR) system is made for prototype purpose. The VR system consists of the off-the-shelve components. Therefore it is easy to maintain, flexible, and the cost is not too expensive [3][17]. The hardware components consist of:

- Head Mounted Display (HMD) and Control Box
  HMD supports interactivity for VR system. The interaction is enough to create natural feeling of interaction for the user. Quality of the visual display of the HMD determines the vividness that relate to the sense of presence. The quality of the display is determined by resolution and Field of View (FoV).
  HMD used in the system is Visette Pro, which is manufactured by Cybermind. It is quite expensive HMD. Advantages of this HMD is:
  - It has 70 degrees Field of View (FoV). Common Fov of HMD is about 25 degrees.
  - It supports stereoscopy. It means that each eye gets an image from slightly different viewpoint by taking into the distance between eyes. Stereoscopy can increase the sense of presence.

  This type of HMD also has disadvantages
  - It is heavy
  - It has low resolution (640*480)

- Flock of Birds
  Tracking system used in the system is an Ascension Flock of Bird (FoB) tracker. It makes the computer able to track the orientation and the location of HMD. It consists of:
  - Transmitter for creating a magnetic field
  - Sensor, which is built in the rear of HMD to measure the magnetic field
  - Control unit. It uses data from the sensor to calculate the translation and rotation, and then it is fed to the computer using serial connection RS-232.

  The transmitter must be placed near the sensor because it has constraint range, about 4 feet. The transmitter also must be placed where user cannot move it in order to prevent the coordinate in the system from flipping that cause jump of location informed by the tracker. Jump of location may occurred because the coordinate system of the tracker is divided into two hemispheres that are divided by the plane going through the transmitter perpendicular to the cable attached to the transmitter. This plane is illustrated in figure below. Therefore if someone moves the sensor to another hemisphere, the coordinate system will flip.

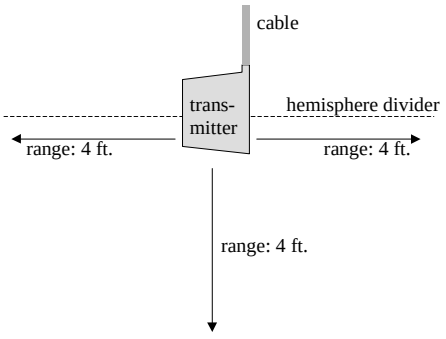

Figure 11 Flock of Birds transmitter view.

- Bass amplifier
  It is used to amplify sound for creating vibration effect in the seat of plane, for creating the effect of taxiing and flying plane. The amplifier is connected to audio-out of PC and speaker connector for connecting to the vibration devices placed near the plane seat.

- Intergraph PC
  Because of using stereoscopic HMD, two synchronized VGA outputs are required. PC with Pentium 2 450Mhz processor PC with graphics card: 3DLabs Oxygen GVX420. The graphic card hast two VGA outputs whose vertical retrace is synchronized. In order to create an output on VGA connectors and show display in HMD, screen resolution in windows must be set to dual resolution 1280x480 (two times 640x480). Intergraph PC is dedicated solely for displaying Virtual Environment (VE) in the HMD.

- PC
  This is the second computer that uses standard 3D card for controlling the VE over the network.

- A Logitech wireless trackball
  It serves as an input device for the patient or subject that wears HMD.

Picture below illustrates how the components are connected.

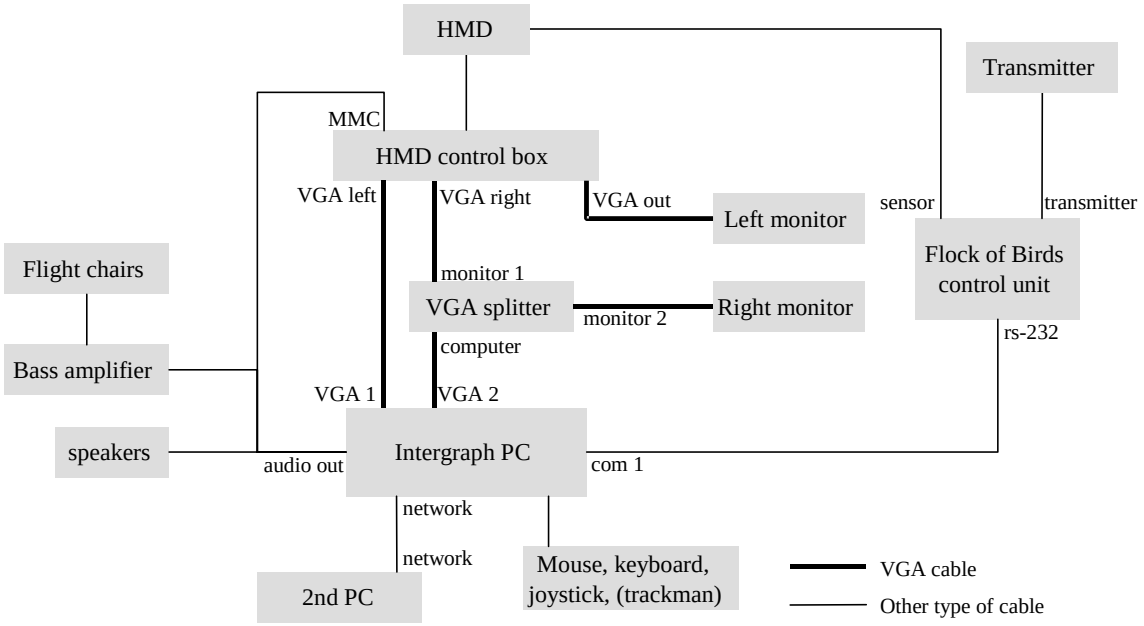

Figure 12 Overview of the components of the system and their connections

4.2 Software Components

In order to write application and make Virtual Environment (VE) easier, high level library and tools are used instead of writing application by directly using the OpenGL or Direct3D API (Application Programmers Interface) [3].

4.2.1 Libraries

Libraries have lines of code, which can be activated with a single command. Commercial libraries are available such as World ToolKit from Sense8. However many researcher develop their own because it provide higher degree of flexibility, but it is very time consuming.

4.2.2 High level tools

The tools use a graphical user interface for making and developing the VE and its attributes. There are tools that offer complete packages, which comprise geometry modelling tool for the world and scripting language for dynamics behaviour of the VE, such as Superscape VRT and WorldUp from Sense8. However the flexibility of VE dynamic behaviour controlled by script language is limited. It cannot control and implement network communication and database access. Therefore some of the tools, such as WorldUp, allow calls to Dynamic Link Libraries (DLLs). These DLLs can be written in professional software development tools such Borland Delphi and Microsoft Visual Basic.

TU Delft use WorldUp as a high level toolkit for modelling, developing, and creating VE because WorldUp offer modelling tool and library for developing VE behaviour. WorldUp is also able to call DLLs for handling more complex behaviour such as network communication and graphical user interface for the therapist. The DLLs are developed by Delphi 5.

4.3 The Virtual Reality System

Both PC use Microsoft Windows operating system. The Intergraph PC uses Microsoft Windows NT and the second PC use Microsoft Windows 98. WorldUp R4 from Sense8, which is software tool used for creating VE is only installed in Intergraph PC because TU Delft only have one licence. WorldUp Player is installed in the second PC. The worlds that illustrate the VE are stored in the .up files and .wup files. Files in .up format is the editable version that can be opened and run from WorldUp. On the other hand, files in .wup format are non-editable, which can be run from WorldUp Player. Additional functionality is developed by Borland Delphi 5, which creates DLLs that can be called from WorldUp [17].

Directory structure of Intergraph PC and the second can be seen in table below [17].

TABLE III Directory Structure

Intergraph PC **Directory**	**Description**
c:\dlls	Location of the DLLs called from WorldUp

d:\worlds	Location of the worlds. The directory is structured as follow:
<worldname>\	Location of the .Up and .Wup files.
<worldname>\models	Location of the geometries used in the worlds.
<worldname>\scripts	Location of the scripts and paths.
<worldname>\textures	Location of the textures.
	Location of the original Photoshop files (if available).
<worldname>\sounds	Location of the sound files.
d:\ui	Location of the sources of the DLL files.
On the 2nd PC	
c:\	Location of the phobia.ini file
c:\dlls	Location of the DLLs called from the WorldUp Player
d:\database	Location of any databases

Virtual Environment (VE) or the worlds will need some files for controlling their behavior. Table 2 below shows the list of these important files [17].

TABLE IV Important Files

File name	Description
Phobia.ini	It is a file that contains parameters. These parameters are read by other software components. This file is in located on both PC.
Listener.exe	It is an application that 'listens' to the 2nd PC. When a world on 2nd PC is activated, the application will automatically activate the corresponding world in the Intergraph PC. Therefore this application must be run at the startup of Intergraph PC.
PhobiaClient.dll	It handles the network communication on the Intergraph. WorldUp called it.
PhobiaServer.dll	It handles the network communication on the second computer. It also responsible for displaying 2D user interface and handles all input from the therapist.
Navpoints.db	It is a database, which contains the coordinates of the navigation points in each world. It is used for autopilot

Parameters, which are contained in the Phobia.ini file, consist of [17]:

- DLLdir
  It used as a path to DLLs. However it is currently not in use.
- VEdir
  It is used a path to the VEs.
- WUP

Its role is a path and filename of the WorldUp Player application.

- IPConsole
  It is an IP-number of the console computer where therapist's interface is located.
- PortConsole
  It is the port that the console computer listens to.
- IPVRstation
  It is an IP-number of the VR station, which is Integraph PC that is connected to the HMD.
- PortVRstation
  It is the port that the VR station computer listens to
- Thiscompu
  It states whether this computer is the 'Console' or the 'VRstation' (Capital sensitive!)
- NumberofBirds
  It determines the Number of Birds (Flock of Birds) connected to the computer. It is used for VRstation only.

4.3.1 World Structures

In the VE worlds, there are two human objects, which is used for representing user in the VE. The objects can be either visible or invisible. The human objects consist of humanserver and humanclient. The 'Thiscompu' parameter located in Phobia.ini file determine either the humanserver is enabled on the Console or the humanclient is enabled on the VRstation. Hence the same world can be activated on both computers [17].

Table 3 shows the list of the scripts that is used for activating VE [17].

TABLE V World Scripts

File name	Description
Startup.ebs	It will set the system as VR Station, for the Intergraph PC or as Console for the second PC. The setting will be based on the content of the Phobia.ini file. The setting is important for determining which human object is enabled, the configuration of the two 3D windows, and which DLL is loaded.
Shutdown.ebs	It ends and terminates the loaded DLL

ClientControl.ebs	It is connected to the humanclient object. It handles the control of the human object. The functions of the script is as follow: • Calculates the time since the last frame and stores it in the variable TimeFraction. • Retrieves the data from the DLL (that the DLL has received over the network). • Stores environment control data received • from the DLL in the variables E1 to E10. • Calculates the current viewpoint based on the coordinates retrieved from the Flock of Birds. • Handles any interaction technique of the patient and input from the therapist. • Handles the autopilot (based on the coordinates receives from the 2nd computer). • Handles collision detection and stairs. • Returns data to the DLL to be sent to the 2nd computer.
ServerControl.ebs	It is connected to the humanserver object. It handles the control of the human object. The functions of this script are as follow: • Calculates the time since the last frame and stores it in the variable TimeFraction. • Retrieves the data from the DLL (that the DLL has received over the network). • Stores environment control data received from the DLL in the variables E1 to E10. • Sets the location and rotation of the human object and the viewpoint according to the coordinates received from the DLL. • Sets the second viewpoint according to the data received from the DLL • Returns data concerning the status of the joystick to the DLL
EnvControl.ebs	It is connected to the humanserver and the humanclient object. Its functions are as follow: • Read the variables E1-E10. • Set elements of the world accordingly (for instance, sets the light level, opens or closes doors, sets the size of the closet). This is different for each virtual world. • Determine magnitude of transitions, which are based on the TimeFraction variable to make their speed dependent on the clock of the system instead of the frames per second.
Show-avatars.ebs	It rotates the avatars to face the user and changes the texture of the avatars depends on the viewpoint of the user.

4.3.2 DLL structures

The DLLs are written in Delphi. The important DLLs used in the VR system are as follow [17]:

- **Phobiaserver.dll**

It shows the 2D user interface part of the screen on the second computer. The user interface gives the therapist several functionalities. The can perform these following activities [17].

- Setting several environment variables of the world.
- Setting the autopilot
- Changing the free viewpoint

Depending on the LocationID that is transmitted by the host application, this Phobiaserver.DLL will display the correct map and control. Phobiaserver.DLL has four procedures that can be called from the host application. These procedures are shown in the Table 4 [17].

TABLE VI Parameters of Phobiaserver.DLL

Procedure	Parameter		Description
Initserver	LID	Location ID, number of the virtual world.	Starts the DLL and creates the form.
Serverput	Jx, Jy	x and y value of the joystick.	Transfer data to the DLL
	J1, J2	Determining whether joystick button 1 and 2 are pressed (1) or not pressed (0).	
	K	Value of any keyboard press.	
	Fx….Fw	Translation and rotation of the free viewpoint.	
Serverget	Hx...Hw	Translation and rotation of the human object.	Transfer data from the DLL to the host application
	Vx...Vw	Translation and rotation of the head.	
	E1...E10	Values for the environmental variables (different use for each VE).	
	Cx, Cy	Change in x and y translation of the free viewpoint.	
	Clr	Change in the left-right rotation of the free viewpoint.	
	Cud	Change in the up-down rotation of the free viewpoint.	
	Creset	Reset of the free viewpoint (when Creset = 1).	
	Cs	Speed with which the free viewpoint can change.	
	Cp	Whether the free viewpoint is locked on the patient.	

Killserver			Terminates the DLL, closes the form and releases any memory used by the DLL.

- **PhobiaClient.dll**
  Its job is to handle the network communication to and from the Intergraph computer, which act as VR Station. PhobiaClient.DLL is invisible. It has several procedures that are described in table 5 [17].

TABLE VII Parameters of PhobiaClient.DLL

Procedure	**Parameter**		**Description**
Initclient			It starts the DLL and creates an invisible form.
ClientGet	Jx, Jy	x and y value of the joystick.	It used to transfer data from the DLL to the host application.
	J1, J2	Whether joystick button 1 and 2 are pressed (1) or not pressed (0).	
	Ax...Aw	Target coordinates for the autopilot.	
	Ast	Autopilot status (speed of autopilot, if the value 0, it means that autopilot is off).	
	E1...E10	Values for the environmental variables (different use for each VE).	
ClientPut	Hx...Hw	Coordinates of the human object.	
	Vx...Vw	Coordinates of the head within the human object.	
KillClient			It terminates the DLL and frees any memory used.

5. Social Phobia/Agoraphobia VRET Research

The research assignment is intended for developing a social phobia or agoraphobia VRET pilot system. Mediamatica Department, Faculty of Information Technology and System, TU Delft, did research on virtual reality and phobia for several years. TU Delft developed its-own low budget prototype Virtual Reality system for research project on relation between phobia and virtual reality. The project is collaboration between Delft University of Technology and University of Amsterdam, faculty of psychology. TU Delft is responsible for Human Computer Interaction and technical part of the Virtual Reality, such as developing the system and University of Amsterdam is responsible for virtual exposure therapy and the psychological aspect. The Virtual Reality system was developed by Martijn Schumie, under the supervision of Charles van der Mast. Besides developing the hardware components, several virtual environments also has been created. The virtual environment that has been built for VRET purpose consist of:

- Environment for claustrophobia (fear of small space) sufferer.
- Environment for acrophobia (fear of height) sufferer.
- Environment for fear of flying sufferer.

University of Amsterdam has used these virtual environments to real phobia sufferer as part of its virtual exposure therapy research project. However there hasn't been any research for social phobia or agoraphobia VRET. For the purpose of social phobia or agoraphobia VRET research by using the VR system, which has been developed in TU Delft, new virtual environment must be developed. Faculty of Psychology, University of Amsterdam received lots of case regarding people who suffer social phobia, especially agoraphobia. Therefore, researcher from University of Amsterdam suggest for making virtual environment intended for agoraphobic exposure treatment.

There are two choices for developing virtual environment that is intended for agoraphobic sufferer: modifying the old new environment that has been used for others phobia treatment, or building the new environment from scratch.

5.1 Virtual Environment Design

Designing Virtual Environment (VE) or the world concerns these following factors [3]:

- Modelling the objects in Virtual Environment includes the complexity of the geometry. However creating too many details of VE will slow the rendering process down. Therefore it will create latency that is unacceptable for user. It is quicker to render flat polygons than curved surfaces so that objects in VE are created from flat polygons. Thus the amount of polygons must be limited.

- Modelling the objects in Virtual Environment also uses textures. Textures will give the impression of detail after they are applied to the objects surfaces. Textures are fast to process because of today's 3d acceleration hardware technology.

- Modelling objects that are seen far away from the user are not necessary. They can be drawn as background.

In the TU Delft Laboratory, the VE use approximately 790 to 2000 polygons per VE. Background and textures are used maximally [3].
As mentioned in the last chapter, VE will be built using World Up. In a nutshell, the construction of virtual world or VE is shown in two figures below.

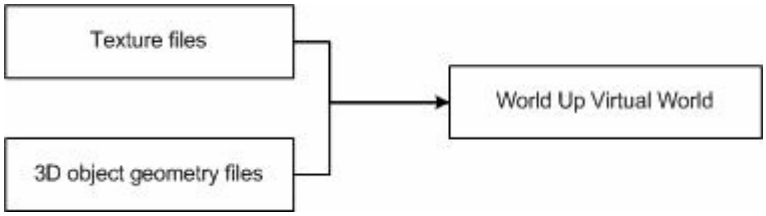

Fig 13 Overview of Level 1 VE construction

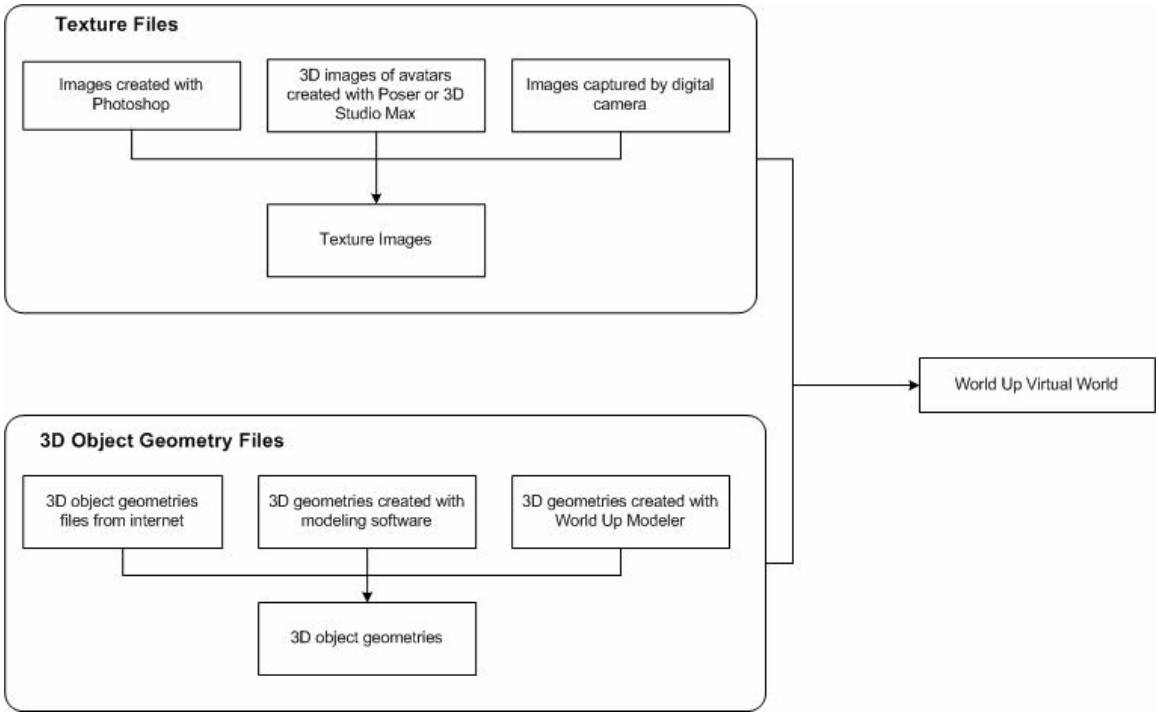

Fig 14 Overview of Level 2 VE construction

Based on the experience of researcher who had developed VE for claustrophobia, acrophobia, and fear of flight VRET, the VE development process generally consists of five stages [18, page 9]. They are as follow:

1. Requirements specifications
2. Gathering of reference materials from real world models
3. Structuring of graphical models
4. Building objects and positioning them in the VE
5. Enhancing the environment with texture, lighting, sound and interaction, and optimizing the environment

5.2 Virtual Environment for Social Phobia or Agoraphobia

Based on discussion with Paul Emmelkamp in kick off meeting on early January, using and modifying these following worlds can attain VE for agoraphobia exposure:

- Magna plaza world, which is a world or VE that resemble real mall in Amsterdam, The Netherlands. This world is formerly used for acrophobia (fear of height) VRET.
- Schiphol airport world, which is a VE that look a lot like real airport. This world is formerly used for fear of flying VRET.

From the discussion, the two VEs mentioned above are suitable for agoraphobia and social phobia sufferer if both of the VE illustrate an open environment with normal busy social

activities. However the two VEs are not hectic and busy enough to resemble the real open space situation. Hectic situation in the open space, where there are lots of people, is one of the situations that are feared greatly by agoraphobia and social phobia sufferer because it will create anxiety to the sufferers. Therefore, the VEs must be modified.

Beside, modifying the old VE, the VE for social phobia or agoraphobia also can be obtained by developing the new VE from scratch. The new VE should show public place in normal hectic situation. Some VE design ideas written below. The design ideas consist of modifying the old VE and making the new VE.

5.2.1 Magna Plaza World

The VE is made similar with the real Magna Plaza world. The Magna Plaza world basically is a building that consists of three storey, a basement, and three wings (right, left and middle wing). Because the VE formerly intended for fear of height exposure treatment, the world didn't focus and illustrate on the activities of the mall, instead it focus on the detail of the building, especially the detail of the view seen from the higher part of the mall. For example, when users or patients go to the railing on the third floor and look down, users or patients are shown with the view of lower floors with high quality. The quality of the VE is high because it pays attention to the detail. The world use lots of 3D geometries for creating graphical objects. Therefore the visual rendering in old VR system is slow. It will create disturbing and unrealistic images to the patients.

The Magna Plaza world can be used for agoraphobia or social phobia VRET if some activities that illustrate hectic situation and of the mall are portrayed. It can be achieved by adding virtual people or avatars and noises that resemble normal activities in the mall.

There are two kinds of virtual people or avatar that can be made:

- Static virtual people featured these following actions:
  - Carrying conversation with others avatars.
  - Using elevators.
  - Setting eyes on the merchandise on the stores.

- Dynamic virtual people.
  Action that differentiates dynamic avatars and static avatars is walking action.

Adding and applying avatars to the old VE can create problems since the VR system cannot execute complex and large amount of geometry primitive. There will be lagging that is unacceptable to the user/patient. Because of this problem, there must be a method to modify the old VE without causing the new version of VE hard and slow to render. Therefore we have to be able to balance the avatars with the detail of the building.

Dynamic avatars are harder to visualized in the VE because it takes more processing effort than static avatars. Therefore adding dynamic avatars must be limited in order to avoid visual lagging to the user. The challenge is how to apply these dynamic avatars effectively so that the VE can still be shown to the users smoothly.

As mentioned before we can encounter images rendering problem when modifying the world. Hence modifying Magna Plaza world is not an easy task because without adding new features to the Magna Plaza VE, the VE has already taken large amount of resource to render it. If avatars, especially dynamic avatars, are added recklessly, the worst scenario that could happen in the new VE will be happened. The VR system will face problem in rendering it. Therefore the problem must be solved if Magna Plaza world will be use for agoraphobia VRET.

The solutions that can be applied to fix this problem are as follow: because crowded and hectic situation is the most important factors for social phobia sufferer, the detail of the magna plaza building can be decrease. Decreasing the detail can be achieved by these following actions:

- Delete the basement part. Basement is not as important as others part of the building with more social activity.
- Delete one of the wings part. The patients do not have to be shown the whole area of the mall because it is not an important factor on exposure to the agoraphobics and social phobics.
- Use only two floors out of three floors in Magna Plaza world. The reason that this action could be done is the same with the reason why one of the wings part can be deleted.

5.2.2 Airport World

Airport world formerly used only for fear of flying exposure therapy. The airport world is used because some of the patients may develop anxiety before they even fly. They feel great anxiety in the airport. Therefore airport is one of the important VE in fear of flying VRET.

The airport has already featured hectic and busy situation. It already had several static avatars and sound that illustrate airport situation. The sound that generated in the airport VE illustrates very busy situation that needs lots of avatar. However, the avatars featured in airport VE are not enough since only few avatars are shown in the VE. Hence, the VE may not illustrate unrealistically social activities and hectic situations in the airport. This kind of small detail that is not consistent with the real world may damage some of the patient sense of presence.

Therefore if this airport virtual world is going to be utilized for social phobia or agoraphobia exposure treatment, the VE must be modified first by adding more avatars. The added avatars are preferably dynamic avatars.

5.2.3 Public Transport World

The public transport world is very suitable for people who have agoraphobia and social phobia. As mentioned before, they tend to avoid the hectic situation. This type of condition includes unwillingness to use public transportation as their means of transportation. Using public transportation is one of the basic necessities in normal modern people because nowadays people are very mobile. Fear of using public transportation will disturb the sufferers' life because they cannot mobile like normal people. If they want to go to a certain places, they may discourage to follow their plan because they don't want to use public transportation. Their fear prevents them to become active and mobile.

By developing public transportation world, hopefully the VE can be used for agoraphobia and social phobia sufferer to help them curing their phobia by using the VE for VRET treatment. For developing and creating virtual environment (VE), which mimic the situation of using public transport in the real world, these following worlds can be developed.

5.2.3.1 Train World

Train world will make the patients to be immersed in the train station VE and in the train VE while taking the virtual journey.

The scene in the VE features how a person uses train normally to go to a certain destination. The flowchart below illustrates the scenes sequence that will be shown to the user if train world will be built. The virtual journey will start from Delft main train station and end in the Den Haag main station.

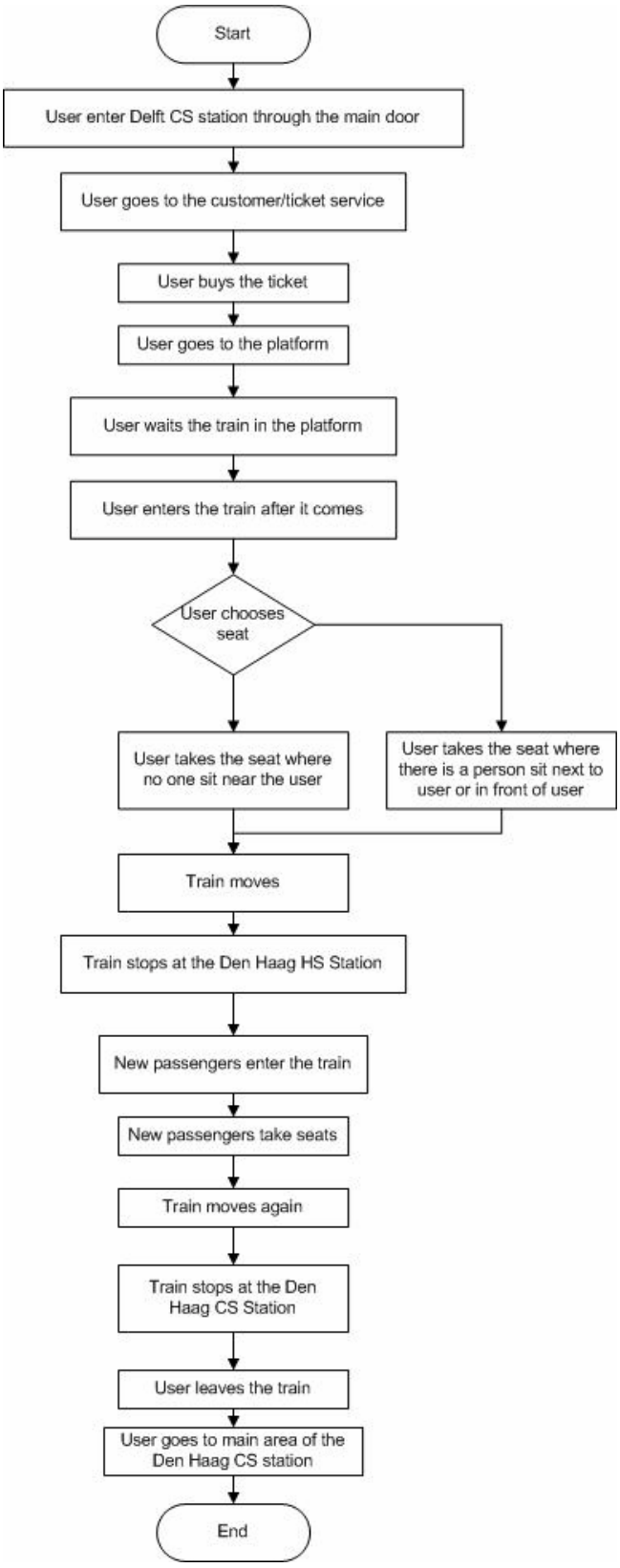

Figure 15 Flowchart of train world scene sequences

5.2.3.2 Tram World

Tram world will make the patients to be immersed in the tram VE while taking the virtual journey. The virtual world also demonstrates what will be like to wait for the tram in the tram stop with others people.

The outline of the scene sequence that is going to be shown to the users is as follow:

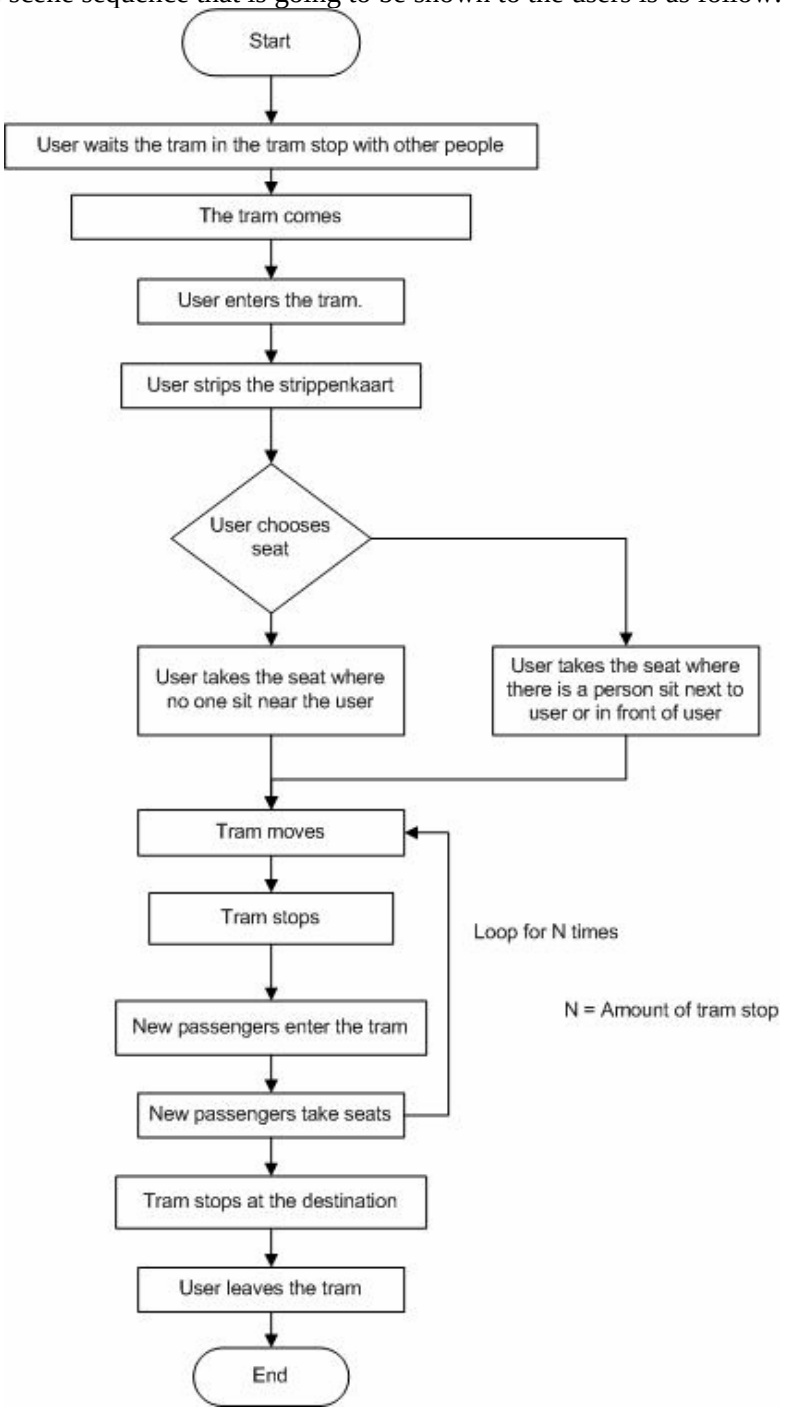

Figure 16 Flowchart of tram world scene sequences

5.2.3.3 Bus World

Bus world will make the patients to be immersed in the bus VE while taking the virtual journey. The virtual world also illustrates what would be like to wait for the bus in the bus stop with others people.

The bus world is almost similar with the tram world. The outline of the scene sequence illustrate in the figure 17.

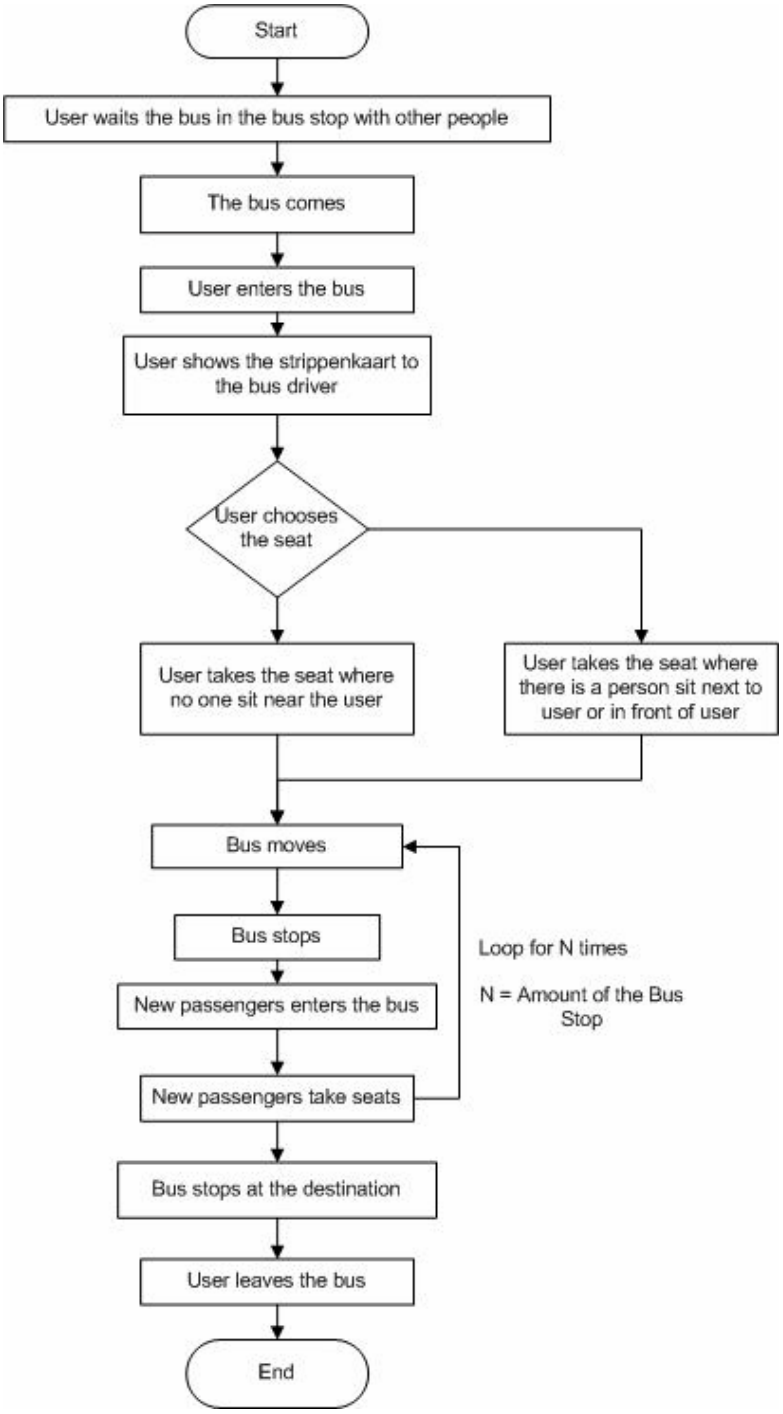

Figure 17 Flowchart of bus world scene sequences

5.2.3.4 Metro World

Metro world will make the patients to be immersed in the metro VE while taking the virtual journey.

The outline of the scene sequence illustrate in the figure 18.

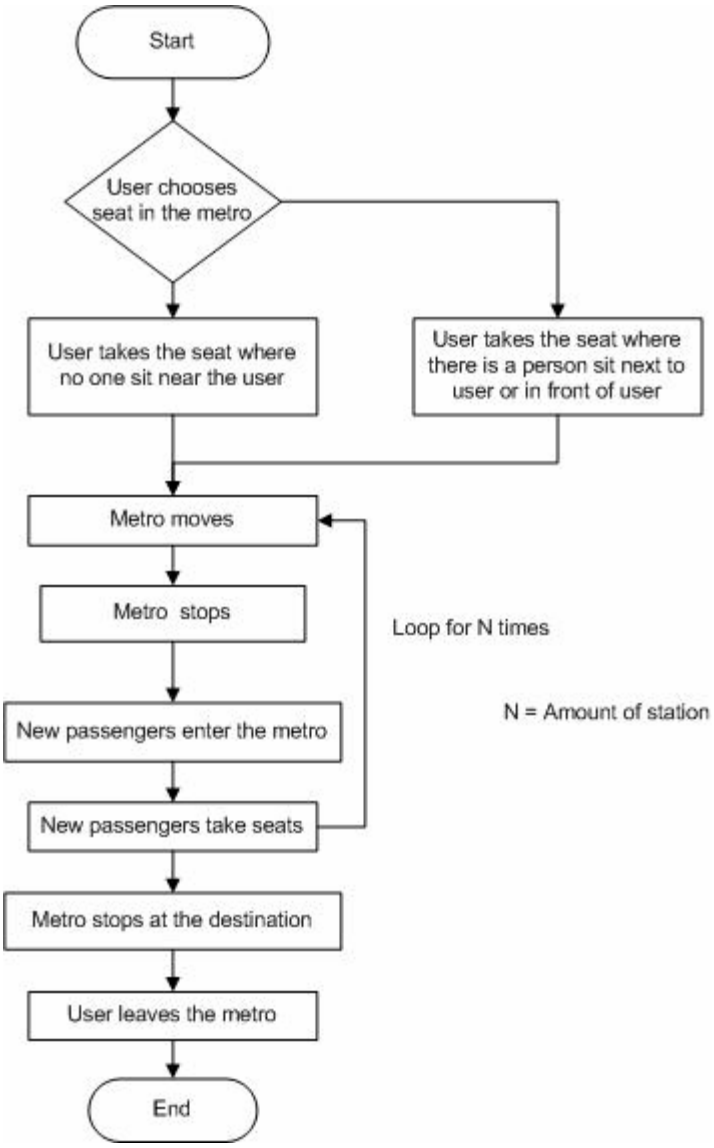

Figure 18 Flowchart of metro world scene sequences

5.3 Supermarket World

Supermarket also illustrates place that have busy social activity. If the supermarket world is going to be developed, the patients will be immersed in the situation that similar with busy environment in the real supermarket world. The outline of the scene sequences in supermarket world is as follow:

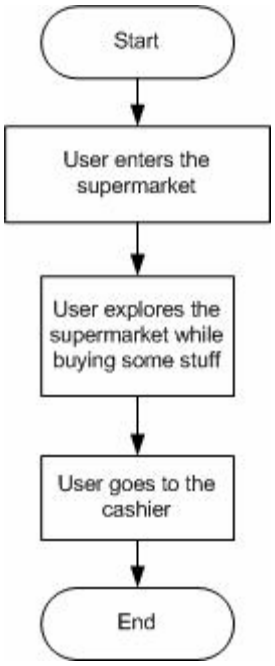

Figure 18 Flowchart of supermarket world scene sequences

5.4 Design Decision

As mentioned before, there are seven different Virtual Environments that are proposed by the writer. They can be developed for pilot research on social phobia or agoraphobia VRET. Because of time constraint, we are going to develop only one virtual world. There are several factors that contribute in taking decision of the VE that is going to be build:

- How long does it takes to learn the VR system.
- How long does it takes to learn the old world or VE, which was made by Martijn Schumie, especially the Magna Plaza world and Airport world.
- Deadline of the project. The virtual environment hopefully can be tested to the social phobia or agoraphobia patients on late May.

Difficulty that may occur based on the three factors above, are as follow:

- **Magna Plaza World**
  Rendering problem. Adding more features to the Magna Plaza virtual environment will slow the rendering process down. In the end the world cannot be used for VRET since the lagging viewed by the users is not acceptable. Although I have mentioned some solutions regarding this problem, the nature of software development is not certain. Therefore the solutions proposed may not solve the problems at all.

- **Airport World**
  Although airport world also can be used for social phobia or agoraphobia VRET, the researcher in Amsterdam University seems need new VE for social phobia or agoraphobia VRET.

- **Public transportation world**
  Although it is better to build your own world from the scratch because you in charge on your own development that makes you the master of your project, it takes longer times to build the virtual world from scratch.

- **Supermarket world**
  This world is also made from scratch, like public transportation world, which makes it longer to develop.

Based on the factors mentioned above, these following possibilities can be developed.

- Building Magna Plaza VE again from scratch instead of modifying the earlier version of Magna Plaza World. The old Magna Plaza will be used as a model for developing the new same world. Some of the 'components' of old Magna Plaza world will also be used to develop the VE.

- Instead of building Magna Plaza VE, which is large store, a smaller virtual store can be built such as Supermarket. Since the environment is smaller, it will be easier to render and balancing between avatars and the building.

- Building public transport VE, but make it less complex. The environment that takes longer to build is eliminated such as station, or bus/tram stop. Instead the world will be focused on inside the train, bus, metro, or tram and its journey. Another advantage building the 'journey' by public transport only, is that most of the avatars are not walking since creating walking avatars is a difficult process.

Based on the discussion result, the virtual world that is going to be developed is metro world. The simulation can start directly inside the metro. By eliminating the station world where user wait the metro, the VE is simplified. Another advantage of developing metro world is that the panoramic view in the journey doesn't have to be build since unlike train, bus, and tram journey, metro journey doesn't have any panoramic view. The VE based on the real journey by metro will be similar with flight journey from the flight world used as fear of flying VRET.

5.5 Time-Table

February	Finishing Research Assignment
First Week of March	Analyzing and gathering references, such as taking images/video, of the real world that is used as the model.
Second Week of March	Creating scenario of the VE
Late of March	Developing the VE
April	Developing the VE
First week of May	Developing the VE
Late May	Installing the VE and test the new VE
June	Writing the thesis report

6. Conclusion

From the literature study that I have been conducted, social phobia and agoraphobia is the hardest phobia type that can be treat by VRET because it deals with social factor. Social factor is hard to be illustrated in the virtual world because it is not a static factor. However social phobia VRET is not an impossible project. There are few VRET projects that had been done regarding social phobia/agoraphobia and virtual reality. Most of these researches are pilot researches. The results of these pilot research shows that Virtual Reality can create anxiety to the social phobia and agoraphobia patients. These positive results show that social phobia and agoraphobia VRET has a promising future.

Delft University of Technology needs VE that is intended for social phobia or agoraphobia VRET research. The project for my master thesis is developing pilot VE for social phobia or agoraphobia VRET. The important factors for developing this world is crowd and hectic. These factors illustrate social activity, which the social phobia and agoraphobia sufferers fear. The problem of developing VE might come from hardware limitation, especially the computer and HMD. VR system uses Pentium II 450 MHz processor PC, which may limit the rendering process. Most of the VE that has been developed in TU Delft use approximately 790 to 2000 polygons The VE must not use more than 2000 polygons because using more that 2000 polygons may yield unexpected result in the rendering process. The HMD has low resolution (640x480). Therefore the background and texture cannot use high resolution images. The quality of the VE may not be excellent but it is still good enough to give sense of presence to the patients. Therefore ‘smart’ technique must be applied to the VE in order to create satisfying VE for social phobia and agoraphobia VRET with limited resources.

Based on discussion result, the environment that is going to be developed in the project is environment that illustrates metro journey. The metro virtual world will show the patients situations in the real metro. The patients will be seated and will take virtual journey. Virtual avatars will be in the metro to illustrate hectic situation in the metro.

7. Reference

[1] Schuemie, M.J., van der Straaten, P., Krijn, M., and van der Mast, C.A.P.G. April 2001. *Research on Presence in VR: a Survey*, Cyberpsychology and Behavior, Vol. 4, No.2, pp. 183-202

[2] Schuemie, M.J. 2000. *Design of Virtual Reality Exposure Therapy System – Task Analysis*, CHI 2000 Extended Abstracts, ACM press, pp. 345-346

[3] Schuemie, M.J., and van der Mast, C.A.P.G. 2001. *VR Testbed Configuration for Phobia Treatment Research,* M.E. Domingon, J.C.G. Cebollada & C.P. Salvador (Eds.), Proceedings of the Euromedia 2001 Conference, Valencia, Spain, pp. 200-204

[4] Schuemie, M.J., van der Mast, C.A.P.G., Krijn, M., Emmelkampt, P.M.G. 2002. *Exploratory Design and Evaluation of a User Interface for Virtual Reality Exposure Therapy*, J.D. Westwood, H.M. Hoffman, R.A. Robb, D. Stredney (Eds.), Medicine Meets Virtual Reality, IOS Press, pp. 468-474

[5] National Institute of Mental Health (NIMH), homepage http://nimh.nih.gov

[6] Pertaub, D-P., Slater, M., and Barker, C. *An Experiment on Fear of Public Speaking in Virtual Reality*.

[7] Herbelin, B., Riquier, F., Vexo, F., and Thalmann, D., *Virtual Reality in Cognitive Behavioral Therapy: a Study on Social Anxiety Disorder*

[8] Cognitive Behavior Therapy, homepage http://www.cognitive-behavior-therapy.org

[9] Social Phobia/Social Anxiety Association, homepage http://www.socialphobia.org

[10] Bijl R., Ravelli, A., van Zessen, G. *Prevalence of psychiatric disorder in the general population: results of the Netherlands Mental Health Survey and Incidence Study (NEMESIS).* Soc Psychiatry Psychiatr Epidemiol 1998; 33:587–95.

[11] Emmelkamp, P., Krijn, M., Hulsbosch, L., de Vries, S., Schuemie, M.J., van der Mast, C.A.P.G. *Virtual Reality Treatment versus exposure in vivo: A Comparative Evaluation in Acrophobia*.

[12] North, M.M., North, S.M., Coble, J.R., *Virtual Reality Therapy: An Effective Treatment for Phobias*, 1998, Giuseppe Riva, Brenda K. Wiederhold, Enrico Molinari (Eds.), Virtual Environments in Clinical Psychology and Neuroscience, IOS Press.

[13] Virtual Reality Team of Biomedical Engineering Department, Hanyang University, Korea, homepage http://bme.hanyang.ac.kr/vr/research/psycho/PublicSpeaking.htm

[14] Dong P. Jang, Jeong H. Ku, Min B. Shin, Young H. Choi, Sun I. Kim, *Objective Validation of the Effectiveness of Virtual Reality Psychotherapy*.

[15] Virtually Better, homepage http://www.virtuallybetter.com

[16] Virtual Reality Medical Center (VRMC), homepage http://www.vrphobia.com

[17] Schuemie, M.J., *Phobias and Virtual Reality: The Computer System Version 1.0, 2002.*

[18] Schuemie, M.J., *Human-Computer Interaction and Presence in Virtual Reality Exposure Therapy*, 2003, PhD Dissertation, TU Delft.

[19] Earnshaw, R.A., Gigante, M.A., Jones, H., *Virtual Reality Systems*, 1993, Academic Press Limited.

[20] Schneider, B., *Designing the User Interface: Strategies for Effective Human-Computer Interaction*, 1998, Addison Wesley Longman.

[21] Tromp, J.G., Fraser, M.C., *Designing Flow of Interaction for Virtual Environments*, homepage http://www.mrl.nottingham.ac.uk/~mcf/publications/ueve/ueve98.html

[22] Psychology Today, homepage http://www.psychologytoday.com/

Abbreviations

DoF	Degree of Freedom
FoV	Field of View
GUI	Graphical User Interface
HMD	Head-Mounted Display
PTSD	Post Traumatic Stress Disorder
VE	Virtual Environment
VR	Virtual Reality
VRET	Virtual Reality Exposure Therapy