Comparative Gait Rehabilitation with Virtual Reality Headset
Josiah Keime, Kristin Ladia, Jay Shah, Derek Lura, PhD

INTRODUCTION

Virtual reality (VR) systems refers to the immersion of an environment without actual, physical exposure using sensory stimulations, such as sound and sight. Currently, virtual reality is most commonly accomplished using a headset with a visual display mount.

With advancements made in the gaming industry leading to improved audiovisual displays and graphics, VR systems have become more affordable [1]. This has led to a more extensive use of VR as a tool, leading to various types of therapies and experimentations. For example, as a therapy solution, VR has been used to treat combat-related post-traumatic stress disorder (PTSD) and social phobias [1, 2]. However, these examples barely scratch the surface of the many uses of VR in rehabilitation.

The majority of virtual reality applications rely on the use of controllers to move the subject in the virtual environment. To create a more realistic and immersive experience, the purpose of this project aimed to develop a VR tool by successfully integrating three different systems: the Qualysis Track Manager (QTM), a motion capture system; Unity, a game development application; and the Oculus Rift, a VR headset.

The overarching goal was to allow a subject using the Oculus Rift headset to physically move around a virtual environment without the use of a controller.

METHODS

To complete the study and obtain results that could be held as conclusive to either end of the hypothesis, the research team planned to develop an apparatus that could be used to test various experimentations. To develop the apparatus, the research team needed a motion tracking device to work together with a virtual reality headset that a potential subject could wear. In order to accomplish this, the research team used the Qualysis motion tracking system with the Oculus headset. Two other systems were used to integrate the Qualysis with the Oculus: Unity software and a TCP/IP protocol used in real-time. The Qualysis system has eight motion tracking cameras placed around the room (see Figure 1). This camera tracks movement in the virtual environment. Rotational head tracking is important for the immersion of properties, as it allows the subject to look around the virtual environment.

The virtual copy of the lab, which contains the Qualisys system for this study, was created in Unity. This was done to remove any errors in the data that would arise from a change in the subject’s gait due to having to move through an unfamiliar environment. The TCP/IP protocol was used to send the position and orientation data, which was gathered from the Qualisys system, to Unity. Unity consistently updates the Oculus to show the new location within the virtual environment. This gives the subject the feeling that he or she is moving around the virtual environment with their own movements. To work the Oculus headset, it must first be plugged into a computer that supports USB and HDMI ports. Also, the computer must install Oculus Software Development Kit (SDK), Oculus Utilities for Unity, and runtime software [3]. The cables have a significant amount of weight; this can hinder a person’s gait as well as detract from the immersion of the virtual environment. To prevent these problems, the cables were run from the computer and extended to the center of the room, into the ceiling. From there, the cables attached to a running cable, which runs the length of the room. This allows for the weight of the cables to be carried, and thus the subject is able to freely move around the room.

Using this apparatus, we plan to take 10 subjects and compare their gait parameters when using virtual reality under normal conditions. Subject recruitment will be done through fliers placed in public places, mainly around the university. The subjects must be: 18 years or older; in good health; able to understand and follow verbal instructions; and capable of walking 30 meters.
comfortably. Subject selection will be done on a first come first serve basis in order to eliminate any potential bias the research may have during the selection process. The subject will have markers placed on the toe, heel, and front of the pelvis that will feed position data to the Qualysis system. The subject will be instructed to walk normally a set distance in the lab, then stop, turn around, and walk back. They will do this 5 consecutive times without the VR headset. Immediately following this, the subject will be asked to place the VR headset on their head. They will again walk the predetermined distance 5 consecutive times. Once it is determined that subject data has been gathered without error, it will be placed in a Matlab script that will identify desired gait parameters.

RESULTS

Data gathered from this experiment will be fed into an algorithm designed in Matlab to determine the subject’s gait parameters. The algorithm will be based on the published article of “Automatic detection of gait events using kinematic data” [4]. To identify a subject's gait, two events must be identified: Heel-strike (HS), and Toe-off (TO). The start of the gait cycle begins with the Heel-strike. This point will be found using the algorithm stated above; however, before implementing this algorithm, we must first determine the point with the lowest vertical velocity, which corresponds to the lowest vertical height. To identify the time of TO, which is the end of the gait cycle, the algorithm will find the point of maximum vertical velocity, which is associated with minimal virtual height [4]. The difference in the time of these two events will be the gait parameter and gait speed, respectively, to find the gait parameter of stride length, the point of maximum horizontal distance between the subject’s heel markers that is accompanied by the minimal vertical height [4]. Using the algorithm to find the average speed of the marker placed on the subject’s pelvis will give the subject’s walking speed. The parameters will be gathered from every time the subject walks the predetermined distance, one pace. All values will be averaged as a whole. The mean values of the parameters of gait with VR and gait without VR will be compared to each other using a t-test and a p-value of 0.05.

The development of the apparatus in this study will be a useful tool in later research studies. The success of the apparatus’ ability to immerse subjects in the virtual environment depends on several factors. Weight or hindrance from the cables or displays will negatively affect the subject's immersion [5]. Researchers may have to rely on more expensive means of gathering data by investing in a wireless VR headset. The use of a running cable to support the weight of the oculus cables has been found to be successful in allowing the subject to move freely around the majority of the room. The quality of the display on the virtual reality headset will also affect the immersion. A high quality HDMI cable was used for cable length and better resolution.

CONCLUSIONS

Gait rehabilitation--or gait training--is a type of rehabilitation focused both on improving gait performance and restoring walking functions [6]. Victims of strokes often suffer from neurological disorders, which in turn can cause impairment of their motor functions. Injuries to the legs, knees, or hips--which may lead to difficulties in walking or standing--often require gait rehabilitation to restore normal gait. To assist in gait recovery, physicians and physical therapists assess the patient’s gait performance, and then determine the methods and techniques to perform on the patient [7]. Physicians and physical therapists most commonly use their naked eye or video images to obtain parameters of the gait analysis, which can include the patient’s gait speed, stride length, step length, and cadence [7]. Gait techniques for improving motor function include a variety of methods, such as preparatory exercises from a physical therapist, treadmill walking, and assisted overground walking. Successful outcomes of gait rehabilitation can be attributed to the patient’s motivation, exercise engagement, goals and aims, and, finally, attention. Attention is considered one of the major factors in rehabilitation, as poor attention is associated with having negative impact on normal functions [6].

Some problems are inherent in this study. The length of the cable does not allow for the subject to move around the entire room. This limits the range of test and stimulus we can expose the subject to. Much of the work that has been done to integrate the separate systems has been with coding. Errors in the code are inherent and must go through many revisions to remove any bugs. The software is functional; however, future improvements are in planning.

By implementing the gait parameters from the subject when they are not using the VR and then comparing them to the gait parameters when they are using the VR, we hope to show that there is no sufficient change in their gait. It may not seem important to prove that the gaits of subjects will not change when using VR, but by showing the gaits are the same, it will prove supporting evidence that VR gait rehabilitation is a valid option for a physical therapist to consider when choosing a recovery program for their patients. Significant threats to the adoption of VR rehabilitation methods are limited awareness and unrealistic expectations [5]. Many physicians and physical therapists are unaware of the applications that VR has in the medical field. Some that do may not fully understand what the limitations are, or be knowledgeable of the advantages of using VR in the clinical setting. This means an increase in published work is needed to clearly identify what the benefits, side effects, and drawbacks are. This study is designed to clarify some of the misconceptions about VR. There are still many for which this study does not touch on; these should be examined in later experiments.
REFERENCES


