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VIRTUAL REALITY A REVOLUTIONIZED TREATMENT FOR STROKE: A SYSTEMATIC REVIEW

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Abstract: ***Stroke rehabilitation requires repetitive, intensive, goal-oriented therapy. Virtual reality has the potential to satisfy these requirements. Game-based therapy can promote patients engagement in rehabilitation therapy as a more interesting and a motivating tool. This review describes the development of virtual reality for rehabilitation purpose. The main objective is to develop virtual reality applications for post-stroke rehabilitation. There are two applications that have been developed to serve motor dysfunction and balance impairment. The main technology employed is immersive virtual reality and Kinect based rehabilitation gaming system. Virtual reality is commonly used in clinical rehabilitation, and commercial VR gaming systems may have mixed effects in patients with stroke. Therefore, a task-specific interactive game-based VR system for post-stroke rehabilitation of the upper extremities, and assessed its usability and clinical efficacy. The use of VR headset enables an individual to expose the three-dimensional virtual environment. Then, the immersive virtual reality is capable to offer mirror therapy in post-stroke rehabilitation and thus aids in recovery.***

Keywords: *Virtual reality, stoke-rehabilitation, Kinect based, video gaming, Goal oriented therapy.*

I INTRODUCTION

Virtual reality based rehabilitation is a method that allows the integration of our understanding of rehabilitation with advanced interactive multi-media technology that can be focused on delivering individualized 'optimal' therapy. It is estimated that stroke affects approximately 15 million people worldwide every year and among those, between 55% and 75% of these survivors continue with motor deficits and reduced quality of life following the event. These motor deficits include motor control, strength, fine motor skills and dual-task coordination abilities, which all have the potential for significant effects on individuals' independence and quality of life. In an effort to assist these individuals with motor recovery, virtual reality (VR) systems were developed. VR is defined as a "computer-based technology that allows users to interact with a multisensory simulated environment and receive 'real-time' feedback on performance". The interactive games are designed to provide the patient with real-life scenarios and activities relevant to daily living. The software is able to provide key concepts required for motor learning including frequency, intensity, repetition and task-oriented training while enabling the user to feel involved in their rehabilitation. These systems have many settings that allow accommodation for patient needs, abilities and goals through the manipulation of the degree of difficulty, focus on the extremity of choice as well as options for game tasks. VR systems incorporate several theories of neuroscience and motor learning. In virtual reality patient is able to interact with virtual arm and leg to perform a task. For an example, a patient with balance impairment is instructed to walk in the virtual environment. As the patient eyes are folded with a Virtual Reality (VR) headset, the patient only relies on the sensation. While the virtual foot touching the floor in virtual

environment, an intervention given to patient to force his brain to repair the damaged neurons or activate new neurons in order to feel his leg in real world is actually touching the floor. Some VR games have an option of a VR teacher that performs the task, enabling the chance for "learning by imitation" by stimulating mirror neurons. In addition, the VR system provides the use of augmented feedback on performance that is provided concurrently with performance, immediately following a performance based on results (knowledge of results) or after several trials as summary feedback. Therefore, VR systems allow for individualized training sessions that allow patients to practice practical skills in an engaging way.

II METHODOLOGY

A] System structure- The major devices that involved in this system are a Virtual Reality headset, personal computer, Leap motion sensor and Microsoft Kinect sensor. The Microsoft Kinect Sensor and Leap Motion Sensor are utilized to capture the information of body motion of the user and they are known as the inputs of the system. The information is given to the personal computer for processing. Then, the object and environment that displayed on the virtual reality will be updated according to the processed data. The virtual reality headset is known as the output of the system by producing display for the user. Figure 1 shows the block diagram of entire system.

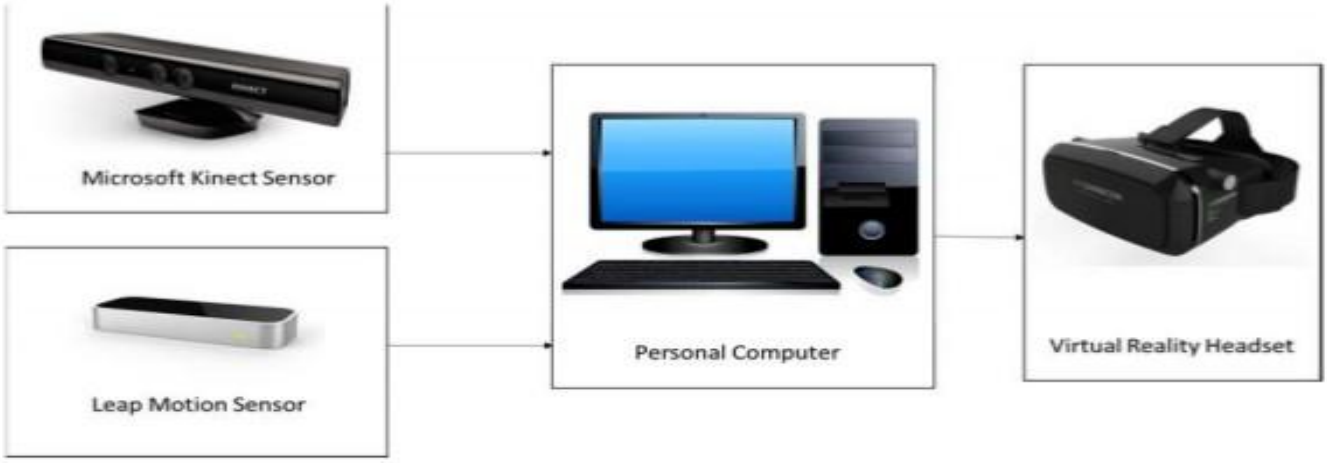

Figure 1: Block Diagram of Entire System

B] Software :- The Virtual Reality system makes uses of few types of software for developing applications. First, Trinus VR is software that is able to turn a mobile based VR system into a PC-based VR system. The software streams the computer display to phone display with router or USB tethering communication. It also utilizes the phone sensors to allow positional tracking. This software is utilized due to Leap motion sensors which is only compatible with computer. Thus, in order to embed the Leap motion sensor into the virtual reality system, Trinus VR software is the best approach since it can connect PC to the Leap motion sensor and VR headset in the mean time.

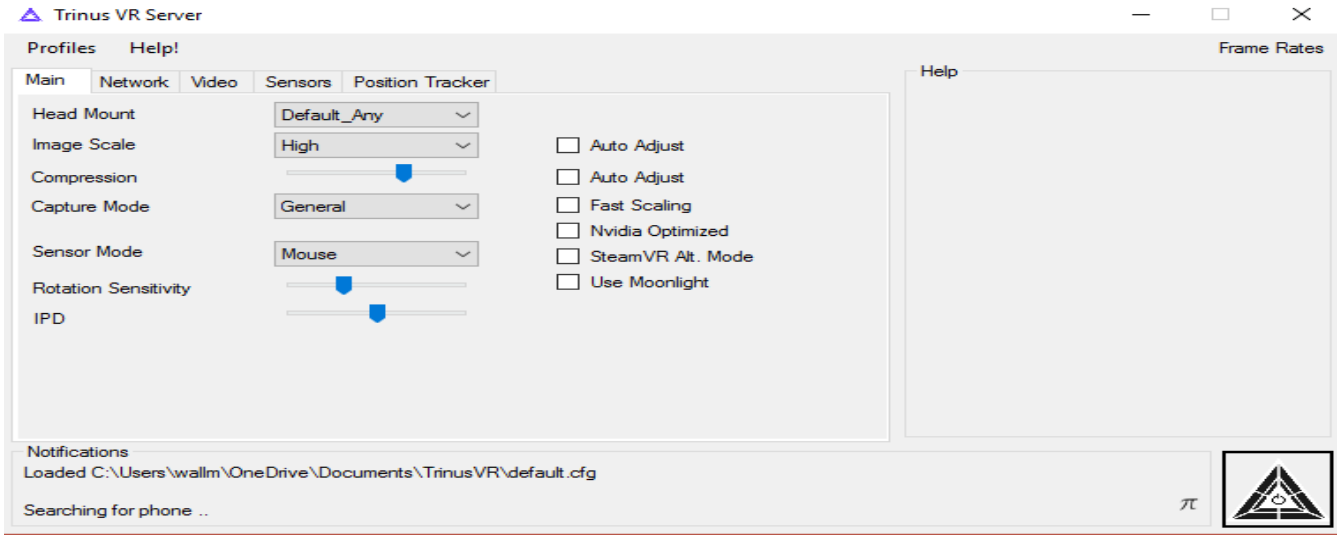

Figure 2 Shows the interface of trinus VR on computer.

Next, software utilized in this project is the Unity Software. Unity software is an ultimate game development platform. The cross-platform ability allows the software to deploy application for PC, gaming consoles, mobile devices and websites. It also has introduced built-in support for VR devices. Figure 3 shows the interface of unity software.

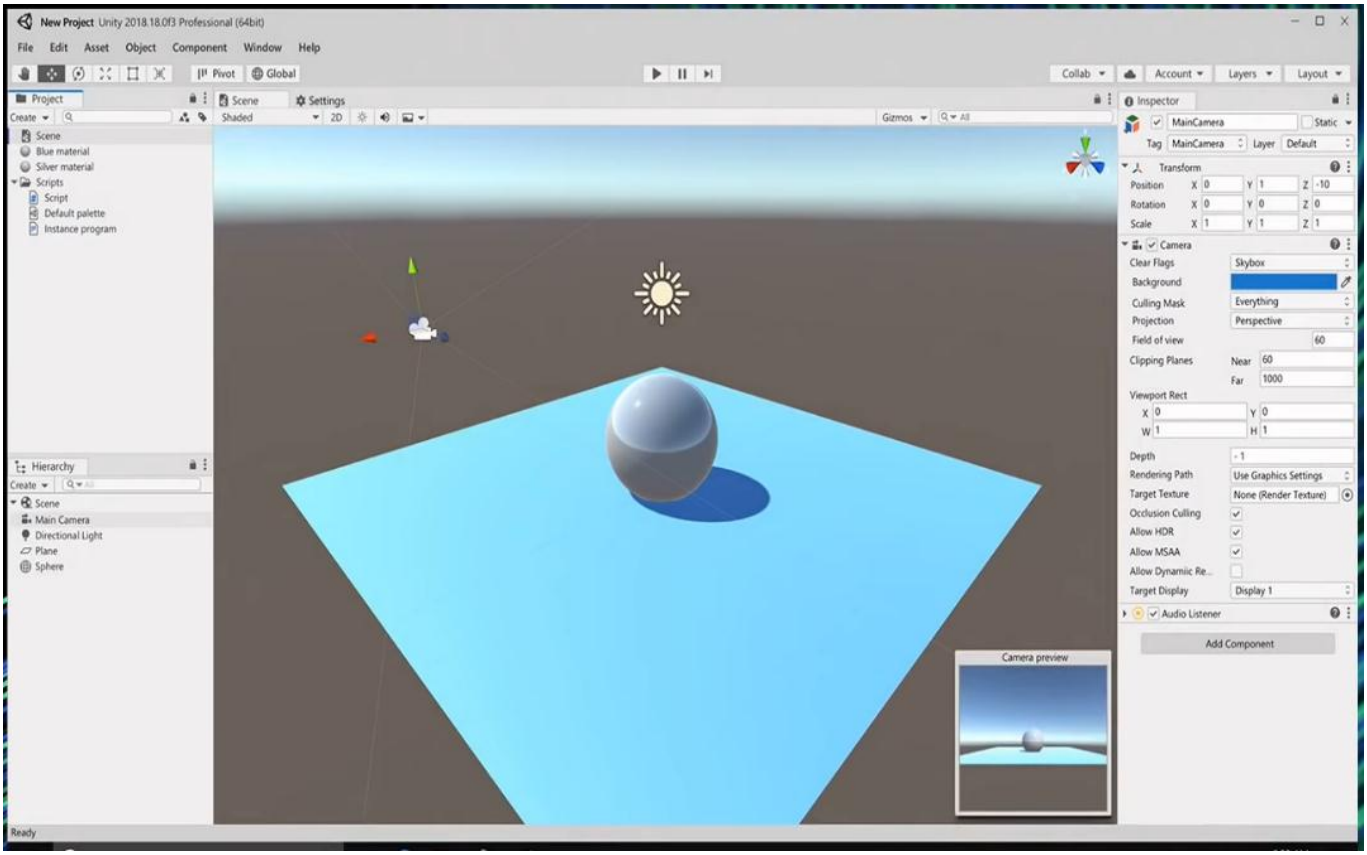

Figure 3: Iinterface of unity software.

The Microsoft Visual Studio is employed in order to develop computer application with the graphical user interface for the rehabilitation system. Microsoft Visual Studio is the Integrated Development Environment (IDE) that supports built-in language of C, C++, C#, Visual Basic and NET. Visual Studio includes a code editor, compiler and built-in tools that allow the construction of Graphical User Interface (GUI) for window application.

C. Balance and Movement Training for Post-stroke

Balance Training is designed to restore post-stroke balance skill and improve walking ability. The concept of this rehabilitation training is performed using the mobile based VR headset with Microsoft kinect sensor. A mobile based VR headset is used to provide a total immersion experience with display three dimensional images to user perspective. A Microsoft Kinect sensor is used to track user body movements and provide a realistic walking experience in the virtual environment. Then, a mobile application that provides the display of the virtual world is developed by using Unity software. A Graphical User Interface (GUI) application is developed with using Microsoft Visual Studio to establish the communication between PC and the mobile phone. In this way, if the PC and mobile are connected under the same network and commutation establish successfully, the data is able to be transferred to mobile phone and perform real time position update. The program starts with establishing a server on the input IP address and port. Once the server is set up successfully, the program enables the kinect sensor to capture raw images. Then, the raw images are analyzed in order to construct a death map. From the death map, body position is inferred with applied machine learning in the program. Skeleton is drawn by the program according to the body position coordinates. Then, the program remains idle and waits for the client to connect to the server. If client is connected to the server, the program starts streaming the coordinates of tracked body to the client application. The data transmission allows the client application to perform real time positional update in the virtual world.

D] Jintronix rehabilitation:

VR rehabilitation has been developed by Jintronix Inc which consists of a computer interfaced with a Microsoft Kinect

camera to track the upper body movements. This system promotes upper limb movements like reaching, transporting and releasing virtual objects, moving the arm through a prescribed trajectory, and performing a bilateral task using a 2D virtual game environment. The number of objects, their location, the speed of the reaching movement as well as the presence or absence of obstacles in the arm movement path can all be parameterized. The system can be used in the home or clinic and also as a telerehabilitation system. Figure 4 shows Jintronix rehabilitation game based system.

Figure 4: Jintronix rehabilitation game based system

III RESULTS AND DISCUSSION

A. Balance& Movement Training for Post Stroke

The setup of this application involves a minimum 4 meter working area as the training requires physical walking at a distance. Microsoft Kinect sensor is placed 4m away from the starting point and connected to a computer. This training can be held on any clean and empty walkway with minimum 3 meter long. However, it is recommended to use the walkway with support handrail for safety purpose. Figure 5 shows the working area setup of this training.

Figure 5: The working and setup of the balance and movement training.

As result, a user-friendly Windows based GUI application is developed to establish connection with the VR headset with computer which connected to Microsoft Kinect Sensor. Besides, a mobile application is developed to display the virtual world in the VR headset.

B. Jintronix rehabilitation game based system

Descriptive statistics will be used to note any advantages and limitations perceived by clinicians and stroke patients about the VR rehabilitation gaming system. Success rates, performance score and highest difficulty level will be averaged across sessions for each patient and will be compared with the CM score using Pearson's correlation analysis, in order to determine which of the activities, and at which difficulty level, can be performed by patients with different levels of upper limb impairment. We will also perform Pearson's correlation analysis to analyze the correlation between success rate and impairment level in order to determine the existence of a relationship between arm motor function and performance in each of the gaming activities. The results provide guidelines for therapeutic use of the Jintronix system and allow us for planning an intervention study using the system.

II CONCLUSION

VR training system highly encourages post stroke patients, and provides insights on the effectiveness of VR based motor rehabilitation. It provides individualized treatment plans developed on the basis of careful assessment and following case –by-case treatment goals. This preliminary research provides support for the development of a game that caters specifically to the key requirements of balance rehabilitation. The game-based application has the potential to be used as a therapeutic tool within the clinic and home settings by a range of patient populations. The user-centered iterative game design process allows key stakeholders to participate in the design of the system, identifying core features to be incorporated into the game. .It provides individualized treatment plans developed on the basis of careful assessment and following case –by-case treatment goals ideally, the result is a game that is fun to play, provides inappropriate level of challenge and appropriate feedback for a range of abilities, and provides clinicians with control over the game-based exercise tool.

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