Virtual Reality Based Physiotherapy Center

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Abstract: Stroke is one of the main causes of disability in the world. In order for stroke survivors to reduce their disability, they need to go through a rehabilitation process to regain back their independence and improve their quality of life. To guide patients in their rehabilitation process and improve their receptiveness in performing repetitive exercises, a new rehabilitation training program using Virtual Reality (VR) technology has been introduced. This has attracted many researchers to explore more on VR technology as a new tool for stroke patient's rehabilitation. We propose a system where patients can open the software, then simply select the task they want to do and then start the therapy. Once the scenario is loaded the patient has to complete the given task within the fixed time. When the task completes the user will get a notification on the screen giving him the time it took him to complete the task and also the time which is required by a normal person to complete the same task. By performing tasks through Virtual Reality system the affected brain cells will be triggered and it will allow the patient to recover faster. This paper presents a review on existing VR systems that have been developed for stroke rehabilitation. First, recent VR systems utilized for rehabilitation after stroke are delineated and categorized. Each of these categories concludes with a discussion on limitations and any issues that arise from it. Finally, a concise summary with significant findings and future possibilities in VR rehabilitation research is presented in table format.

IndexTerms **– Leap Motion Controller, Physiotherapy, Therapy, Upper Limb Therapy, Virtual Reality, VR.**

I. INTRODUCTION

Stroke occurs when there is an interruption of blood supply to the brain or as a result of the rupture of a blood vessel. Although stroke is a disease of the brain, it can affect other body parts where the brain is damaged. A common disability that stroke survivors suffer is complete paralysis of one side of the body or one-sided weakness. Stroke survivors need a rehabilitation program to aid their recovery from many complications suffered to regain as much as possible their life condition and ability before stroke .The time taken for a patient to achieve full recovery depends on the cause and severity of injury. For example, a first-degree ankle sprain may take a few weeks to recover, compared to injuries involving the spine or brain which usually take months. To achieve the fastest possible recovery time, the physiotherapist administers exercises that are repetitive as this is essential in motion recovery process. Repetition allows simultaneous improvement in muscles and joints that are affected. Particularly for neurologic patients, this repetitive exercise helps the patient to re-learn the kinetic movements of their affected limbs. Concerning stroke survivors, the goal of their rehabilitation process is to regain independence and improve the quality of life. This process often involves physical therapy, occupational therapy and speech therapy. Patients need to learn again the skills they lost when part of the brain was damaged. The severity of stroke complications and their ability to recover vary for each patient. Depending on which part of the body or ability affected, physical activities or exercises that may be administered by a therapist.

II. REVIEW OF LITERATURE

Stroke is one of the leading causes of long term disability globally. It is also rated as third largest cause of death in Malaysia. There are 40,000 people in Malaysia who are suffering from stroke every year. Majority of stroke patients are able to survive with the improvised development of medical technology nowadays. However, they are still suffering from post-stroke symptoms as stroke has damaged certain parts of their brain controlling the body movement. Stroke can bring balance impairment, motor dysfunction, vision, controlling bladder and bowel, perception and cognitive impairment.[1]

Motor and balance ability can be restored again through physical rehabilitation training in hospital or rehabilitation center. However, it could take months or years. Therefore, Virtual Reality therapy is introduced to the rehabilitation field in order to accelerate recovery. Virtual reality therapy contributes to home-based rehabilitation training.[1]

Leap Motion is a device that can acquire the position of each joint of both hands with an installed infrared camera. In addition, by using Unity Core Assets provided on the official site of Leap Motion, it is possible to acquire the state of bending and stretching of each finger. Also, this device can be attached not only to head mounted display (HMD) such as Oculus Rift and HTC Vive, but also to mobile VR. In addition these devices do not hinder the use of other controllers.[2]

Then a system was proposed by Monica S. Cameirao which included 5DT data gloves (Fifth Dimension Technologies, Pretoria, South Africa). The system consisted of a PC with graphics accelerator, a 19 inches LCD display, a color CCD camera positioned on top of the display that through a vision based motion capture system tracks color patches in specific locations of the upper extremities(elbows and wrists), and 5DT data gloves that use optic fiber technology to measure finger flexure.[4]

In the system proposed by Edwin Daniel Ona, he introduced a new hardware Microsoft Kinect™ sensor which tracks the movement of the complete body that is in the range of the sensor. He included two types of games, The Reach game and The Balance game. The reach game focuses on shoulder flexion, shoulder adduction and hand flexion.[5]

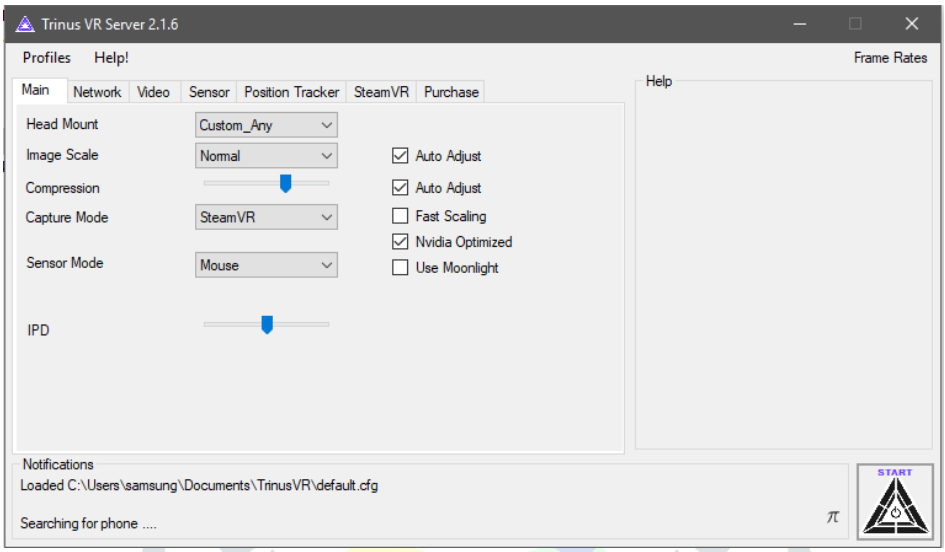
III. Design And Implementation

3.1 Methodology

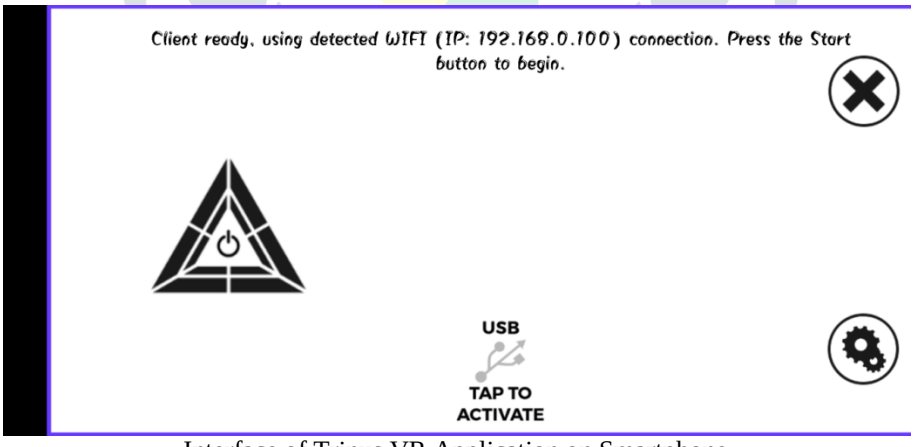
The major devices that involved in this system is a Virtual Reality headset, personal computer and Leap motion sensor. The Leap Motion Sensor are utilized to capture the information of body motion of the user. This is known as the inputs of the system. The information is fed into the personal computer 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.

3.2 Software

There are few types of software involved in this system for developing applications in order to implement the virtual reality physiotherapy system. First, Trinus VR is software that is able to turn a mobile based VR system into a PC-based VR system. Trinus VR software is one the best recommendable approach since it can connect PC to the Leap motion sensor and VR headset in the mean time.

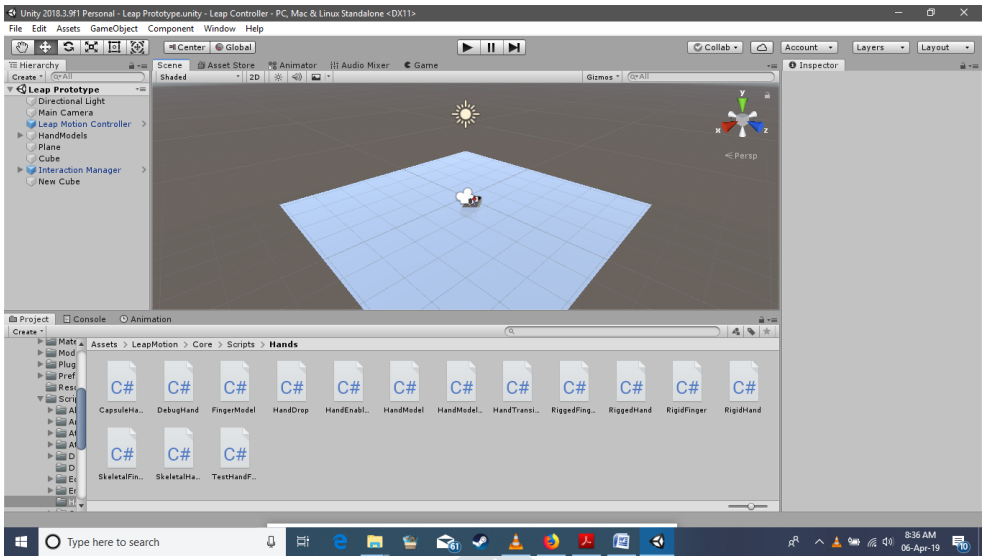


Interface of Trinus VR Application on Computer



Interface of Trinus VR Application on Smartphone

Unity based VR software is platform independent software which is used in development of 2D or 3D games and also used in other research and technologies.



Unity 3d

3.3 Leap Motion Controller

The Leap Motion controller is a small USB peripheral device which is designed to be placed on a physical desktop, facing upward. It can also be mounted onto a virtual reality headset. Using two monochromatic IR cameras and three infrared LEDs, the device observes a roughly hemispherical area, to a distance of about 1 meter. The LEDs generate pattern-less IR light and the cameras generate almost 200 frames per second of reflected data. This is then sent through a USB cable to the host computer, where it is analyzed by the Leap Motion software using "complex math" in a way that has not been disclosed by the company, in some way synthesizing 3D position data by comparing the 2D frames generated by the two cameras.

Leap Motion Controller

3.4 Virtual Reality Headset

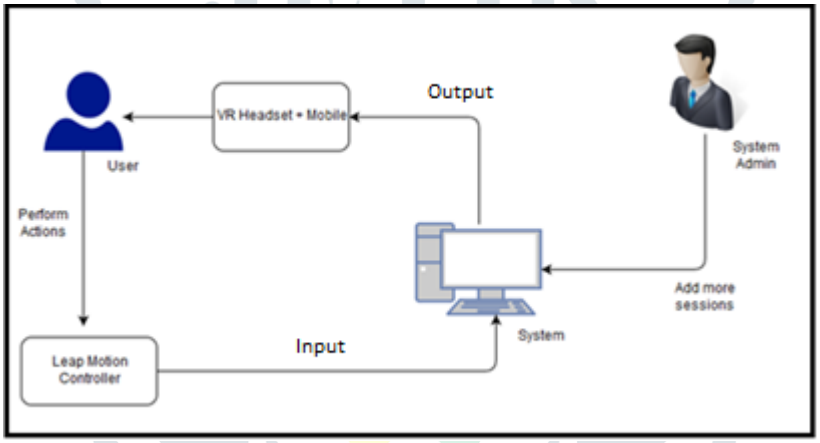
A virtual reality headset is a head-mounted device that provides virtual reality for the wearer. VR headsets are widely used with computer games but they are also used in other applications, including simulators and trainers. They comprise a stereoscopic head-mounted display (providing separate images for each eye), stereo sound, and head motion tracking sensors (which may include gyroscopes, accelerometers, structured light systems, etc.). Some VR headsets also have eye tracking sensors and gaming controllers.

Virtual Reality Headset

IV. RESEARCH METHODOLOGY

4.1 Architecture

It describes the proposed architecture. The laptop/desktop and the Smartphone together make the system. The leap motion controller helps in tracking the hand movements and sending the data to the software.

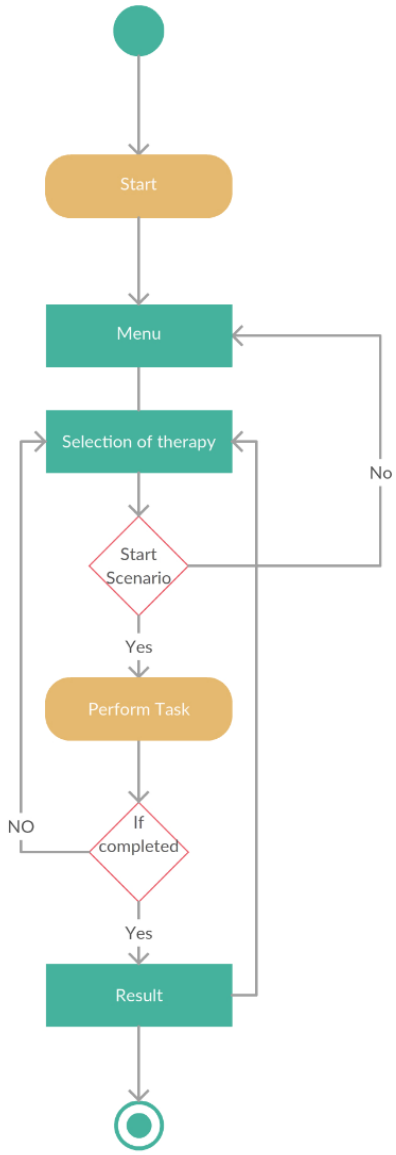


System Architecture

4.2 Flowchart

The flowchart is basically to represent the flow from one activity to another activity. The activity can be described as an operation of the system.

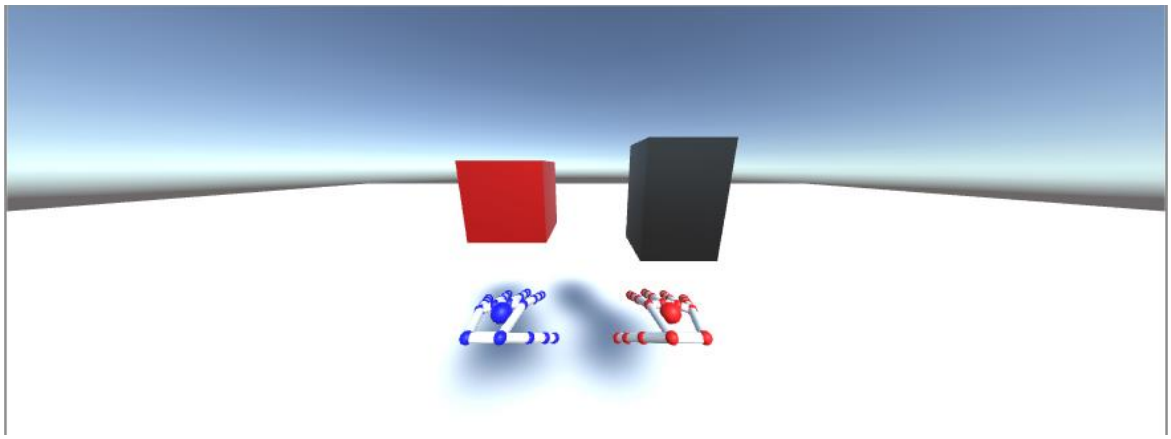
The control flow is drawn from one operation to another. This flow can be sequential, branched, or concurrent. The diagrams deals with all type of flow control by using different elements such as fork, join, etc. The flow for Virtual Reality Therapy system is as follows:



Flowchart of Proposed System

4.3 Proposed Method

The session consists of Pick and Place training which is designed to retrain patient's fine motor ability. The main aim of this application is to recover the lost neurons responsible for hand movement. The process of this rehabilitation training is completed with the help of mobile based VR headset and leap motion sensor. A mobile-based VR headset is used to provide a total immersion experience with display three dimensional image or video to user perspective. A leap motion sensor is used to track user's one hand at a time and provide a real hand presence experience in the virtual environment. An application that provide pick and place exercise is then developed with using of Unity software. Since, a mobile-based VR headset is chosen in this project, therefore Trinus VR software is used which mirrors the application screen on the VR headset.



Proposed System

V. RESULTS AND DISCUSSION

5.1 Results of Test cases

Table 5.1: Statics of time taken to complete the session

User	1st Attempt (Average of 10 days)	2nd Attempt (Average of 10 days)	3rd Attempt (Average of 10 days)
User 1	7:14	6:57	6:38
User 2	Timeout	9:36	9:42
User 3	3:45	3:40	3:36
User 4	3:07	2:57	3:22

The above table shows us the time taken by 4 different individuals while performing the experiment. Each recorded attempt is the average of data from 10 days. We have taken the medical records of all users to determine the damage that has occurred after stroke. User 1 had a minor stroke, the patient's hands where 30% paralyzed. Since the patient's hands were able to move and there was trouble with the gripping part, the patient was able to complete the sessions. The time to complete the session decreases as the patient tries to perform the task again and again. User 2 had a major stroke and the patient's hands were 60% paralyzed. This patient had trouble keeping his hands steady and therefore was not able to perform the task that efficiently. The time required to recover also depends on the percentage of paralysis. User 3 and 4 were normal healthy test subjects. Their time was in between 2 minutes 30 seconds to 3 minutes 30 seconds. The software needs a little getting used to. From the experiments we found out that the first few times the session becomes a little bit difficult because the user does not have experience with virtual reality. But once they get used to it, it becomes very easy. And also there have been improvements in their motor functions due to the sessions.

IV. CONCLUSION

The main objective of this project was to develop software that can be used in a system with minimum specifications. The purpose of the VR based therapy sessions is that it reactivates the damaged neurons, or replaces it with new neurons so to boost the efficiency of the motor functions. The patients have shown improvements in their fine motor skills in a short period of time. This is because the brain interprets the information sent by the eyes. Since the brain cannot differentiate between reality and Virtual reality it thinks that we are actually doing the exercise. In conclusion we have developed a software which will help the patients recover faster and will also be cost efficient.

V. REFERENCES

[1] Sim Kok Swee, Benny Wong, Lim Zheng You, Desmond Kho Teck Kiang "Development of Rehabilitation System Using Virtual Reality" 2017 International Conference on Robotics, Automation and Sciences (ICORAS), 08 March 2018.

[2] Kosuke Komiya ; Tatsuo Nakajima "A Japanese input method using leap motion in virtual reality" 2017 Tenth International Conference on Mobile Computing and Ubiquitous Network (ICMU), 05 April 2018.

[3] Shubhankar Ranade ; Mingshu Zhang ; Mohammed Al-Sada ; Jaryd Urbani ; Tatsuo Nakajima "Clash Tanks: An Investigation of Virtual and Augmented Reality Gaming Experience" 2017 Tenth International Conference on Mobile Computing and Ubiquitous Network (ICMU), 05 April 2018 .

[4] Monica S. Cameirao ; Sergi Bermudez i Badia ; Esther Duarte Oller ; Paul F. M. J. Verschure "Using a Multi-Task Adaptive VR System for Upper Limb Rehabilitation in the Acute Phase of Stroke" 2008 Virtual Rehabilitation, 12 September 2008.

[5] Edwin Daniel Ona˜ , Carlos Balaguer and Alberto Jardon "Towards a Framework for Rehabilitation and Assessment of Upper Limb Motor Function Based on Serious Games" 2018 IEEE 6th International Conference on Serious Games and Applications for Health (SeGAH), 02 July 2018.