

Review of Application of Highly Interactive and Immersive Computing Technologies for Enhancement of Post-Stroke Survivor's Rehabilitation

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Abstract— The objective of stroke rehabilitation exercises is to expand patients' recovery of neurologic functions, functional independence, and Activities of Daily Living (ADL). The multidisciplinary treatment band, such as physical and occupational rehabilitation, and speech pathology, exploits several traditional healing interventions to augment impulsive neurologic and functional improvement after the arrival of stroke. With an increasingly frequency of residual disability among stroke survivors; neuro-rehabilitation continues to be one of the keystones of post-stroke therapy. It contributes to effectively lessening the long-standing effects of stroke and accomplishing optimal functional retrieval for community reintegration. Various factors like financial, environmental, and personal hindrances limit the effectiveness of conventional treatment methods particularly for adult post-stroke. Comparatively, technology based rehabilitation techniques are believed to fairly improve outcomes than conventional treatment method. Artificial Intelligence is been used in fields like diagnosis, medical, etc. Stroke diagnosis and treatment is one such important area to be considered in application of AI, for recuperating the accurateness of diagnosis and the good quality of patients' care. This paper reviews the application of highly interactive and immersive computing technologies like (VR) Virtual Reality, (AR) Augmented Reality, imaging and AI in providing an attractive and motivating means for enhancement of post stroke rehabilitation treatment.

Keywords— Augmented Reality, Virtual Reality, Stroke, Rehabilitation, Artificial Intelligence

I. INTRODUCTION

Virtual reality is being used of highly interactive computer-based rehabilitation framework for Upper Limb Rehabilitation. In this review, we focused on Virtual Reality based post stroke rehabilitation by reviewing how these VR and AR systems help in Rehabilitation. Medical sector is an essential health care sector part. Diagnosis and treatment of illness and diseases can be simplified using medical devices. Some of the known medical field products are technology enhanced imaging instruments, pacemakers, implants and dialysis machines. The complete market size of the medical

sector meets 430 billion United States dollars. The global growth of medical technology every year between 2010 and 2022 is depicted in Fig.1

One of the most common causes of disability is Stroke. Regardless of gender and age, it affects men, women and even kids are no exception to this. However, the higher incidence occurs to the elderly people. Stroke at times will result in motor, sensory and cognitive disorder and also withered capability to tackle with efforts. Among the most unbearable impacts of stroke is Upper-Limb (UL), this causes major disfigurement underlying operative disability. Neuron system gives a mental exercise process associated with visual reaction for motor treatment of stroke patients, giving the impression of impaired Upper-Limb (UL) actions whilst the affected UL is inactive. Its function is viable and harmless. Assis et al. (2014) stated that the technological growths are examined for improving more efficient strategies for enhancing the disabilities caused by stroke [1].

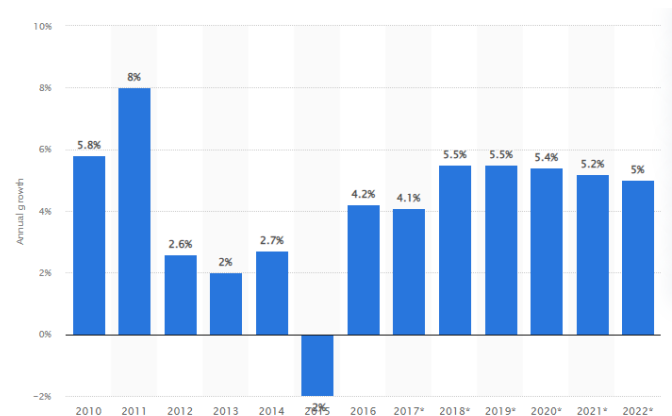


Fig 1. Growth of Medical Technology Yearly - from 2010-2022 (Source: Statista 2019)

In general, people who suffer from stroke are likely to go through loss of control in one side of their body. Consequently, patients could not be capable of performing their routine activities by themselves and this eventually affects their quality of life severely. In recent decade, Artificial Intelligence (AI) techniques have been applied increasingly in stroke-related studies. AI methods in the three major areas of stroke care include early disease diagnosis, treatment, and also prediction of outcomes and diagnosis evaluation. For analysis of stroke, neuro imaging techniques, such as MRI and CT, are considered significant for disease evaluation. Many studies have aimed at applying Machine-Learning (ML) techniques to neuro imaging data in order to support with stroke diagnosis. Comparatively, ML techniques are found to have lots of advantages in predicting performance than that of conventional methods [2]. Stroke medicine might be an appropriate application for accuracy medication and AI methods on account of the huge amount of data and multidisciplinary methods employed in making decisions related to medical domain.

Comparatively, virtual reality rehabilitation is believed to fairly improve outcomes than conventional treatment method in adult post-stroke. The studies have confirmed that doing of recurring tasks will possibly develop motor impairment. Therefore, many upper limb rehabilitation methods had investigated and developed for restitution of lost functions. Such techniques take in robotic approach, Virtual Reality (VR) and augmented reality based method. Though VR based developments are believed to yield positive results, extra part of tracking device to the survivor, their large size and overall immersive in virtual world are not convenient and unsafe for sufferers particularly if the patient is an elder. Hence, as stated by Aung et al. (2010) Augmented Reality (AR) based rehabilitation movements have been established for better and harmless interactive environment. This paper reviews the application of highly interactive and immersive computing technologies such as (VR) Virtual Reality, (AR) Augmented Reality, AI and imaging in providing an attractive and motivating means for enhancement of post stroke rehabilitation treatment [3].

II. STROKE SURVIVORS IN INDIA

According to the study of Suresh Kumar (2016), major cause of death globally is Stroke, it is related with vast number of cognitive perpetual, sensory motor and impairments of behavior. These impairments post stroke might restrict the stroke survivor's capability to perform their daily activities individually for living. In the report of First Post (2018) it was stated that stroke and heart disease have raised nearly 50 percent between 1990 and 2016 in the nation. These diseases contribution to total deaths and burden of disease has doubled nearly in 25 years' time period. The heart disease is the leading cause of burden of disease in India and stroke is leading in the 5th position. The proportion of disability and deaths from heart disease was greater essentially in men than in women but was relevant among women and men for stroke.

Bonner (2015) has stated that India is evaluated that due to stroke, coronary heart disease and diabetes lead to loss of 9 billion in 2005 and predicted that it will lead to 54 billion in 2015. Stroke not only impacts healthcare and economic issue but also it causes severe impact in the patient's quality of life. Globally around 14% to 73% of the stroke patients return to work. Among the survivors of stroke in India, only about 20 percent were working post the incident and 62 percent were employed before stroke [4].

According to Khan (2016) Stroke is a common disease in developing countries, with India experiencing an incidence rate of nearly 1.2 million cases each year. Early prediction is essential because 32000 brain cells in stroke are destroyed each second when it goes not treated [5]. The former hospital related information based on India examined a greater ratio of youth stroke ranging between 15 and 30 percent. In the present report of AIIMS out of 2634 patients admitted for ischemic stroke nearly 17 percent were between ages of 18 years to 45 years.

III. PHYSICAL THERAPY REHABILITATION FOR STROKE PATIENTS

Physical therapy is one of the major disciplines in interdisciplinary rehabilitation of stroke. This study is designed to provide a proof of intervention of stroke rehabilitation in the physical therapy domain. There is a powerful proof for interventions of physical therapy favoring intensive task specific and highly repetitive task-oriented training in entire post stroke phases. The impacts are limited mostly to trained activities and functions.

In the study of Home et al. (2015) patient led therapy is used, where the patients perform sessions of therapy without direct monitoring. It is considered as a feasible way to progress the number of patients with self-therapy and without developing the staff demands. This study presents patients views on lower limb exercises and patient led mirror therapy. There were difficulties such as organizing and positioning the equipment for severe stroke [6].

Mweshi et al. (2016) in their study states one of the worldwide health related issue is stroke and it leads to main causes of impairment, disability and death globally. The results of post stroke differ vastly within and between world areas relying on a set of factors involving stroke type, demographic profile, immediate, long term and severity post stroke care. It stated early rehabilitation post stroke enhances long term good results comparing to the delayed rehabilitation although this has been disputed by certain researchers in a very early rehabilitation trial research. This study estimates the best time to rehabilitation of stroke with better results. The best time to initiate rehabilitation for a stroke patient is as soon as they are clinically stable. This study provides proof of effect of early stroke rehabilitation which must not be interpreted as an evidence of ineffectiveness of early physical rehabilitation. Each stroke is varied from one individual to another because the effect

of destruction to brain is related with various functions of many parts of brain making difficult [7].

Manzoor (2018) proposed a study on stroke rehabilitation and physical therapy interventions. Long term disability is caused due to Stroke. Cardiac, hypertension diseases are some of the major risk factors for the occurrence of stroke in patients. Stroke results in dependence due to decrease in cognitive function. About 60 percent of stroke survivors can be managed with physical therapy intervention, who are affected by moderate sensory and motor impairment. The stroke risk is developed with developed levels of cholesterol and cardiac disease of patients. Some of the physical therapy interventions namely neuro facilitator method, isolated concept, adjuvant therapies, mirror therapy and constrained therapy of induced movement are well effective to develop the function after stroke which makes the patient capable for undertaking ADL and develop the quality of life [8].

IV. INTERACTIVE AND IMMERSIVE COMPUTING TECHNOLOGIES BASED TREATMENT METHODS FOR POST STROKE SURVIVORS

A. AI BASED TREATMENT METHODS

In the research of O'Neil et al. (2014) [9] present growth in methods to rehabilitation of stroke involves the video games usage as a process to develop compliance and motivation to the motor practice of upper limb. More number of task-specific moves that leads to functional recovery is employed by simulations of gaming by Virtual reality (VR). (2016) Pignolo et al., proposed a new rehabilitation treatment of paretic UL after stroke based on ARAMIS prototype and protocol treatment. In part of the post stroke patient's rehabilitation program in present years the robotic techniques use is to develop the upper limb recover which become widespread much. (ARAMIS) The Automatic Recovery Arm Motility Integrated System is a robot concept and a prototype designed to enhance the arms functional interaction in the neuro-rehabilitation of paretic upper limb. ARAMIS is a system which provides efficient approaches for rehabilitation upper limb post stroke. ARAMIS has 3 operations namely characterization of motor function of forearm, elbow, designing of motor training; and measurement quantitative indices of recovery of motor. Two PC controlled methods namely interacting and symmetric exoskeletons remunerate for insufficient accuracy and strength of the paretic arm and the impact of gravity during rehabilitation. Rehabilitation is feasible in three various modalities namely synchronous, active assisted and asynchronous. This study contrasts the efficacy of robotic rehabilitation by a prototype of exoskeleton with conventional rehabilitation in functional recovery and motor of the upper limb after stroke. The motor improvement was larger at the hand and wrist than at elbow and shoulder level in patients managed by controls and ARAMIS but it was essentially larger in ARAMIS patients than in controls [10].

Dukelow (2017) proposed a research on the possible power of robotics for upper extremity stroke rehabilitation.

Robotics is always mentioned for their capability to motivate huge practice as a means to develop movement recovery. Yet recovery of stroke is a difficult method existing across several perspectives of neurologic function beyond movement. As newer goods are enhanced and developed assessment are combined into protocol treatment the importance of robotics to develop rehabilitation will continue to develop. Robotic Stroke Rehabilitation initiated to develop in the mid of 1990s but the little uncontrollable case studies led to greater controlled trials eventually. This research proposes certain national guidelines and a Cochrane review suggests robots for treatment of upper extremity following stroke [11].

Wang et al. (2017) proposed a study on post stroke UL functional training by developing a tangible gaming board. Low patient compliance and motivation has been reported as a major challenge to efficient rehabilitation. This study targets to offer an intuitive and engaging tool to develop the elderly stroke survivor's motivation in the program of rehabilitation. This study presents a tangible gaming board for the UL fine motor and gross motor skills training. 64 red, green and blue rotary encoders of LED are distributed evenly on the board into 8 rows. A modular design permits for training of different functions of hand with interchangeable knob sizes attached on rotary encoders. Gaming board has a greater rate of acceptance among the entire participants and the interface of game is simple to perceive and the game is fun to play with. The feedback requires to be developed to make the experience of game much engaging [12].

Cervera et al (2018) proposed a meta-analysis on brain computer interfaces for post stroke motor rehabilitation. Brain computer interfaces can offer sensory feedback of ongoing oscillations of brain enhancing survivors of stroke to modulate their rhythms of sensory motor purposefully. Several clinical researches mentioned that repeated usage of brain computer interfaces might trigger recovery of neurons and hence developments in function of motor. This study provides a meta-analysis in estimating the clinical efficiency of brain computer interfaces based post stroke motor rehabilitation. Several researches mentioned that brain computer interface induced structural and functional neuroplasticity at a subclinical level. This recommends brain computer interface technique could be an efficient intervention for post stroke rehabilitation of upper limbs [13].

B. GESTURE RECOGNITION FOR STROKE REHABILITATION

Nowadays, modern computational techniques used in processes of rehabilitation have developed essentially in health care centers. These open wide new paradigms which develop the process of rehabilitation, hardware of robots, system of virtual reality and others. Specifically, virtual reality systems are having a greater communication with user based on real time actions where natural gestures of the user become the controller with the help of gesture

recognition sensor devices. These systems are provided as modern techniques in rehabilitation where a patient carries out a group of therapy activities which is identified as tasks of integration through simulations or games. Many health care centers are employing these strategies as their regular therapy due to the time of functional recovery is less than using the standard methods. Table 1. presents the review of gesture recognition sensor devices used for post stroke survivors. [19] AGaR game was developed by VR techniques for rehabilitation of upper limb wit using Kinect Sensor for Xbox One along with emotion sensing and Analytics SDK by Affectiva which was very useful and effective to improve upper limb movement.

Table 1: Review of gesture recognition sensor devices used for post stroke survivors.

| Author | Device Used | Findings of the study |
|---|--|---|
| Ojeda (2014) [14] | Microsoft Kinect | Greater flexibility and adaptability in the platform to embrace vast number of applications of motion detection |
| Gieser (2015) [15] | Leap Motion Controller | Usability of equipment and increased the accessibility to and predict hand gestures and motions |
| Da Gama <i>et al.</i> (2016) [16] | MirrARbilitation - Microsoft Kinect | Improves engagement of user and exercise performance results |
| Holmes (2016) [17] | Leap Motion, Myo Armband and Microsoft Kinect | Provides engaged and personalized services and tracks upper body and arm easily |
| Li <i>et al.</i> (2017) [18] | Leap Motion Controller | High processing speed, easier positioning and transportation |
| Amanda M. M. Funabashi <i>et al.</i> (2017)[19] | Kinect Sensor for Xbox One along with emotion-sensing and analytics SDK by Affectiva | The game named AGaR was developed using Virtual Reality techniques for upper limb rehabilitation. It was very useful and effective to improve |

| | | |
|------------------------------------|---|--|
| | | the upper limb movement. |
| Yang <i>et al.</i> (2018) [20] | IoT (Internet of Things) enabled Stroke Rehabilitation System | Dexterous robot hand can imitate the gesture of user in a real time way to enhance process of rehabilitation for after stroke patients |
| Haoyan Liu <i>et al.</i> 2021 [21] | Field programmable gate array smart rehabilitation system | This work presents a low-cost FPGA smart rehabilitation system that can be used in home environments |

C. TECHNIQUES AND SYSTEMS DEVELOPED FOR STROKE REHABILITATION

To enhance the process of rehabilitation for survivors of stroke to decrease the disability they are required to undergo a process of rehabilitation to move back to independence and develop their life quality. A new Training program using technologies like AR and VR has been developed for patients to help in the rehabilitation in carrying out repetitive exercises. This led to authors to describe the VR technique as new framework for rehabilitation. Various authors describe the Virtual reality and Augmented Reality based framework for rehabilitation for stroke patients. Below explains the various Techniques and systems developed for Stroke rehabilitation for patients.

De Assis (2014) determines the systems clinical feasibility based on AR for rehabilitation of upper limb motor of stroke patients. A physiotherapist guided the patients to achieve the tasks in AR surroundings where they could view themselves and their environment as in a mirror. This study examined the efficiency of training in AR surroundings to offer the recovery of motor skills of upper limb after a stroke. An augmented reality system named NeuroR system was developed in this study [22].

Leon *et al.* (2014) proposed a research on AR Game Based Multi Usage Rehabilitation Therapist for Stroke patients. After the stroke, rehabilitation is needed for stroke patient survivors that are mentally and physically affected. Rehabilitation can be costly. The AR based Rehabilitation Gaming System reduces the dependency on supervised therapy [23].

Ferreira (2014) stated in his research that stroke is a disabling disease which needs huge amount of work on rehabilitation to develop patient's life quality. To develop the motivation and compliance of patients the stroke rehabilitation exercises have been evolved in a game like framework using a smart phone. These games were framed

to evaluate and promote various upper limb movements and their difficulty level is adaptable to impairment level of every patient. The feasibility of the smart phone use constructed in inertial sensors to supervise the stroke rehabilitation exercises execution has been assessed. The measures angles accuracy reduced along time and for greater angles the difference between measured and real angles are within the limits. The stroke rehabilitation exercises gamification using a smart phone is applicable and may be valuable for rehabilitation of stroke [24].

According to the study of Vourvopoulos et al. (2015) greater than 1 in 3 adults faces a cardiovascular disease globally. According to WHO nearly 15 million people faces stroke globally every year and only five million are disabled permanently. The traditional rehabilitation methods present limitations enhance the personalized tools design that can be used by therapist and patients in a home or clinical surroundings. This study presents an online game named Rehab City designed for cognitive deficits rehabilitation through a gamified method on Activities of Daily Living (ADL). In this study the design, validation and implementation of Rehab City was presented and the outcomes reveals a powerful correlation between the Mini Mental State Examination test and Rehab City Scoring system for cognitive functions clinical assessment in many domains [25].

In the research of Vogiatzaki & Krukowski (2015) stroke is regarded as one of the similar diseases of modern societies with greater effect of socio economy. Hence the rehabilitation method includes patients in their process of rehabilitation while reducing expensive participation of specialized human personnel is required. This research explains a novel method providing a combined training of rehabilitation for patients with stroke using a severe gaming method based on a Unity Three-dimensional augmented reality engine integrated with immersive user interfaces and with a set of advanced techniques. It allows caretakers and patients in rehabilitation protocols control while major physicians will be enabled to supervise the growth of rehabilitation through personal health record. Since the training can be carried out in home surroundings it results in effectiveness in rehabilitation [26].

Holmes (2016) proposed a study for upper arm VR stroke rehabilitation based on Oculus Rift and Leap motion controller. Intensified rehabilitation is essential for survivors of stroke but critical to accomplish because of restricted physiotherapy access. A virtual reality rehabilitation system is presented named Targeted Acquiring Exercise (TAGER) framed to provide centre based physiotherapy by offering personalized and engaging exercises. TAGER employs devices of natural user interfaces the Leap Motion, Myo Armband and Microsoft Kinect to track body and upper arm motion. Linear regression was used to three-dimensional user motion information using 4 familiar types of Fitts's Law and every method is evaluated. This study proposes Fitt's Law which may be applicable as the basis of a much complicate model to performance profile user [17].

Flanigan Manning & Martino (2016) have mentioned in their research that several conditions cause motor capabilities and loss of coordination in extremities. Stroke is one among the conditions that influences nearly 15 million people yearly wise globally. Several robotic systems have been evolved to support in the neurological and physical patients' rehabilitation that have faced a stroke. As an outcome of this concept an actuator is used for rehabilitation of hand by means of designed Bowden cables and visual processing. This study aims to employ the actuator design integrated with the elements of gamification to make an interface to be employed in future systems of robot rehabilitation as well as resolve the compliance issue predicted in rehabilitation [27].

Neuendorf & Schulz (2017) proposed a research on a robotic ball for upper extremity training in stroke patients a new approach in neuro-rehabilitation. Technology assisted therapy can contribute to rehabilitation of varied upper extremity symptoms resulting from stroke as neurons have the capability to organize again. Sphere 2.0 robotic ball a creative therapeutic exergaming device was predicted to be applicable and hence employed in neuro-rehabilitation for the first time. The aim was to estimate the therapy of robotic ball concept and use feasible impacts on parameters of motor. The statements of patients considering the impacts on rehabilitation after implementing the concept of therapy over many weeks were involved in the process of testing. Patients slightly or seriously impaired seemed to advantage less than moderately influenced stroke patients. Particular growth in dealing with ADL contributed to a greater encouragement for training of robotic ball. The content of training can be adapted to users with heterogeneous impairment [28].

Basori & Almagrabi (2017) proposed racing gamification with NUI for post stroke rehabilitation. Basically, stroke patients endure from restricted movement in which they will not be able to manage balance well; hence the therapy that includes stability workout, harmonization and repetitive motion must be applied to them. The discovery of Kinect sensor led people to it as a component for recovering stroke patients because of its ability on tracking the human body skeleton. Racing game is very familiar among elderly, kids and adults the norm is quite understandable and easy. The integration between the natural interface and racing game will lead to creative application which is essential to be employed as home therapy for patients post stroke. Users will be needed to move certain body parts such as arm, shoulder and even hand. The body tracking is offered by depth camera which seizes and interpret the gesture recognition of human body to be employed as interaction command. To manage the car in the game the Human skeleton will be shown onto screen and the outcome of racing will be synchronized with excitement of user which is recorded through Kinect video [29].

Leung et al. (2017) in their study mentioned that rehabilitation of stroke is a challenging method which needs intensive treatment methods. In order to support stroke

patient, learn their basic skills again, repetitive exercises required to be carried out to develop the affected limbs functionality. The aim of this study is to establish actionable strategies in designing an encouraging game of stroke rehabilitation such as escape room. These actionable strategies employ concepts of game design of meaningful play, psychological concept of popularity to design game barriers and 6-11 and goal driven emotional structure applicable for aimed elderly's demography. A Video Game with sensors namely Kinect sensor and Leap Motion Controller are implemented and also estimated. The outcomes of this study represent importance in creating an immersive and also motivating experience in games of stroke rehabilitation [30].

According to the research of Xing et al. (2017) the strategies of rehabilitation for treating deficits of motor after stroke are based on neural plasticity understanding. Presently different rehabilitation robots for upper limb have been suggested for survivors of stroke to offer motor skills relearning by stimulating the nerve of motor [31]. However, many perspectives involving interaction of human robot, costing and efficient motor nerve stimulation remains as the major problems. In this study a new training system of upper limb rehabilitation referred as motion intention based virtual reality system of training is evolved to resolve the above-mentioned problems. This system recognize the intention of user motion through force sensors placed on rehabilitation robot to organize therapeutic exercises and stimulates the nerve of user's motor by establishing the immersion illusion in VR surroundings. The immersion illusion is evolved by creating a model of Virtual Exoskeleton Robot which is driven by the intention of user's motion and reflecting the states of motion in real time. The users can be present to exercises by themselves and engage wholly in VR surroundings so that they can move, relax and recreate motor neuro-pathways.

Mohammad I. Daoud et.al, (2017) [32] has proposed "Interactive Kinect-Based Rehabilitation Framework for Assisting Children with Upper Limb Cerebral Palsy" in which rehabilitation framework which is game based is used to make the Cerebral Palsy children to undergo UL exercises. The proposed design consists of five features that result in effective rehabilitation framework. The proposed prototype consists of Kinect sensor based games related to upper limb rehabilitation. The prototype results show the feasibility of the proposed rehabilitation framework.

Bank et al. (2018) has stated that in clinical practice motor impairments of upper extremity are assessed commonly with disease specific, scored subjectively and low-resolution scales of rating that always don't regard the differences in tasks and surroundings which are important perspectives of daily life. AR systems with contactless tracking of upper body and hand provide opportunities for motor dysfunction objective quantification in engaging, patient tailored and challenging surroundings. In this research the importance of augmented reality is evaluated for goal and speed movement directedness within individually decided space interaction,

hand opening adaptation to varied object size and avoidance of obstacle in healthy patients and two highly prevalent conditions of neurology [33].

Syed Ali et al. (2018) proposed research on activities of daily living rehab game play system augmented reality-based gamification therapy for automating the post stroke UL rehabilitation. The post stroke upper limb rehabilitation effectiveness can be expanded through the involvement of patient in the program of exercise training regularly with appropriate engagement and motivation to enhance recovery. The stroke patient faces from functional disability of independently performing their Activities of Daily Living (ADL) like handling, reaching, eating, dressing and grooming, etc. In spite of different external assistance an individual acquires recovered only at her or his own confidence pace. ADL rehabilitation gamification play system suggested an AR based therapy of gamification using unity 3D gaming engine software and Microsoft Kinect to create 3 dimensional scenarios of training simulation to undertake the general ADL Gamification using Natural User Interface (NUI) develops the technique of data employed by designers to encourage the players or patients so as to involve in the action actively and adds importance to rapid recovery [34]. Table 2. Reviews the techniques and systems developed for stroke rehabilitation using computing technologies.

Table 2: Review of techniques and systems developed for stroke rehabilitation using computing technologies

| Author | Technique /System Used | Findings of the study |
|-------------------------------|--------------------------------|--|
| De Assis (2014) | NeuroR system | Improves the processing of video, adding motion tracking temporal stability and correction of motion |
| Leon <i>et al.</i> (2014) | Augmented reality games | Improves the involvement of users by providing a creative rehabilitation way |
| Cordeiro & Cervi (2014) | Augmented Reality games | Greater accuracy in contactless tracking of hands and to improvements in aesthetics, functionality and price of HMDs |
| Ferriera (2014) | Smartphone | Useful for monitoring the execution of exercise and send data to therapists |
| Vogiatzaki & Krukowski (2015) | Unity3D virtual reality engine | Improves the rehabilitation effectiveness |
| Vourvopolous et al.(2015) | Rehab City | Cognitive deficits rehabilitation through a gamified method on ADL. |

| | | |
|--|--|---|
| Holmes (2016) | Target Acquiring Exercise (TAGER) | Provides engaged and personalized services and tracks upper body and arm easily |
| Flanigan Manning & Martino (2016) | Robot Rehabilitation System | Allows patients to track their growth and also feel an achievement feeling in finishing a fun and challenging activity. |
| Arip <i>et al.</i> (2017) | Virtual Reality technique | Improves receptiveness in carrying out repetitive exercises |
| Xing <i>et al.</i> (2017) | Virtual Exoskeleton Robot | Efficient for upper limb rehabilitation exoskeleton. Also Reduces the performance error in training task. |
| Mohammad I. Daoud <i>et al.</i> (2017) | Rehabilitation framework which is game based using Kinect Sensor | The proposed prototype shows Kinect sensor based games related to upper limb rehabilitation. The conclusion shows the achievability of the proposed rehabilitation framework. |
| Basori & Almagrabi (2017) | Racing gamification | Easy and understandable |
| Neuendorf & Schulz (2017) | Robotic ball Sphere 2.0 | Patients slightly or severely impaired is seen to be beneficial less than the less/moderately influenced stroke affected patients |
| Leung <i>et al.</i> (2017) | Escape Room for Stroke Rehabilitation | Helps the construction and exploration of science concepts as well as understanding associated knowledge |
| Bank <i>et al.</i> (2018) | Augmented Reality Games | Assess impairment of motor in patients and offers initiation points for further growth |
| Syed Ali <i>et al.</i> (2018) | ADL Rehab Game Play System | Motivate patients to involve in exercises actively and adds importance to quick recovery. |

V. DISCUSSION OF KEY FINDINGS

This study reviewed the highly interactive and immersive technological development that has been employed in medical domain with retraining rehabilitation applications. These systems were innovatively designed in such a way that will mimic activities of daily living which is a practical way for treatment and is advantageous to stroke patients as they are not only studying the movements of exercise but also they are learning again to carry out movements with

goals associated with daily activities of patients with stroke. The highly immersive and gesture recognition techniques and sensor devices offers a vast number of advantages in every field particularly in medical sector when it is employed properly at appropriate situations ensuing the right medical principles and practices.

VI. CONCLUSION

Thus the review paper concludes by reviewing the various interactive and immersive technological developments that has been done for rehabilitation. Also the paper reviews the various AI based Treatment methods for Stroke Rehabilitation, Gesture recognition for Stroke Rehabilitation and various techniques and systems developed for Stroke Rehabilitation by reviewing the Technologies used and the key findings in each finding.

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