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VIRTUAL REALITY GAMING TECHNOLOGY FOR MENTAL STIMULATION AND THERAPY

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Abstract: Requirement for rehabilitation from injuries is a major requirement for several victims of injury and trauma in recent days. Several mechanisms for patient engagement such as videogames and so on are developed for therapy and mental simulation. In this paper, a Virtual Reality (VR) gaming system is developed integrating electromyography (EMG) signals and integrating motion capture. Yei-3 space sensors or Azure Kinect, Myo armband and Saitek's rudder foot pedal provides the inputs to the motion capture system. The user input is measured in terms of bicep or muscle efforts. A HTC Vive VR headset is used that is synchronised with the sensors for the videogame sequence controls. The system is tested on 15 subjects and provided 96% accurate control results.

Keywords: Video game, Virtual reality, mental stimulation, Azure Kinect, Myo armband

1. INTRODUCTION

The use of serious games - electronic games for psychotherapy (EGP) and off-the-shelf games- electronic games for entertainment (EGE) are used for therapeutic, leisure and commercial purposes [6]. Improving the psychosocial and physical functioning and health promotion can be done in patients by the use of these techniques. The physical efficacy, knowledge, engagement, attention, motivation and such factors can be increased by means of such games. Emotional expression, therapeutic imagery, immediate feedback, practice and physical activity are made possible in these gaming environment.

Aggression, anxiety disorder, brain injury, post-stroke therapy, Attention deficit hyperactivity disorder (ADHD), Autism, Personality and psychotic disorders can make use of virtual reality gaming for therapy and mental stimulation. Improving socialization in case of vehicle interventions in kids with autism is implemented with computer games with therapeutic simulation that allows users to be aware of safety in rule-based environments. Playing video games that are intrinsically motivating in ADHD affected children who lack hyperactivity will stimulate huge amount of attention [1].

It is essential for stroke affected patients to relearn performing the basic motor activities [5]. Practice and feedback and provided to enable learning and to improve its efficiency. For stroke rehabilitation, the core elements

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involve improving limb functions. Several interventions are made in this regard. Neural plasticity is a key factor for post stroke recovery. Active engagement, training and practice for motor relearning for maximization of neural plasticity enables successful rehabilitation after stroke.

Enduring impairments is a common manifestation of disabilities due to stroke in adults [7]. By harnessing the underlying mechanisms of neuronal reorganization, recovering information is possible also owing to the life-long plasticity of the brain. Rehabilitation methodologies available has led to post-stroke depression to around 30% of the patients. For performing activities of daily living (ADL), the recovery rate is reduced due to PSD. The recovery process is slowed down and the effects of therapy is decreased due to depression. In order to represent and predict emotions, concepts and actions, embodied replications of the body are created by the brain for effective regulation and control of the body as defined by neuroscience [11]. Prediction of the best response for an impending sensory occurrence and forthcoming sensory occurrence outside and inside the body is made possible.

The key success therapy includes maintaining high motivation level of the patient [13]. Virtual therapy gains more attention due to the exploration, challenges and other such entertaining gaming features. The gratifying messages generated by the interactions in the game is another typical element that contributes towards the attractiveness of such therapy. The motivation level of the patient can be maintained high as the cognitive load requirement is calibrated in games that are tailored to actual impairments and skills.

Powerful treatment routines are essential for patients with cognitive impairments that require shifting of the patients to clinical environment. The familial reference is missed out by the patients when they stay in the hospital environment which creates stress and trouble by itself. In natural environment, the skills of patients with major neurocognitive disorders are improved and generalized by a suite of EPGs for simulation of rehabilitative chores [15]. Furthermore, the verification of feasibility of the training is also performed.

2. EXISTING LITERATURE

Ana Grasielle et al [2] proposed a musical game that works on augmented reality called GenVirtual for assisting people to overcome their learning disabilities. Assisting patients in motor coordination, visual perception, hearing, ready-response, concentration, planning, memory storage, memory retrieval, attention and creativity is made possible in this system. Keith R. Lohse et al [3] provided an extensive study of commercial gaming and virtual environments for adults in post-stroke VR therapy. Systematic search of Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, PEDro, DARE, PSYCInfo, ERIC, EMBASE, CINAHL and MEDLINE is done. People with neurological disorders, cerebral palsy, adults post-stroke are included in this study. Physiotherapy Evidence Database Scale is used for assessment of the quality of studies.

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Carolyn McGregor et al [4] created Athena, a platform for Big Data analytics. In a simulation game environment of military shooter combat, real-time acquisition of data is done. A multisensory garment based muscle simulation component is used for acquisition of data from ArmA 3. Data representing physiological responses to being hit and weapon fire such as saturation of blood oxygen, breathing behaviour, heart rate and so on are provided as a feedback for communication with the wearer by means of ARAIG. Jeonghun Ku [5] performed rehabilitation of post-stroke patients by assessment of intrinsically interesting issues, curiosity, attention, usability issues and so on with the help of neuromuscular electrical stimulation (MG-NMES) based mobile games.

Mónica S et al [7] introduced a system to provide automated and personalized training with psychometric evaluation and rehabilitative principles with the help of RGS in a neuro-rehabilitation paradigm. Individualized rehabilitation protocols were deployed by effective adjustment of RGS to the features based on the individual user. Anat Mirelman et al [8] worked on patients with Parkinson's disease for the improvement of gait and balance with therapeutic intervention for mobility assessment using motor imagery and VR. The mobility, balance, gait and cognitive or motor functions were assessed on patients based on their eligibility for the inclusion of these technologies.

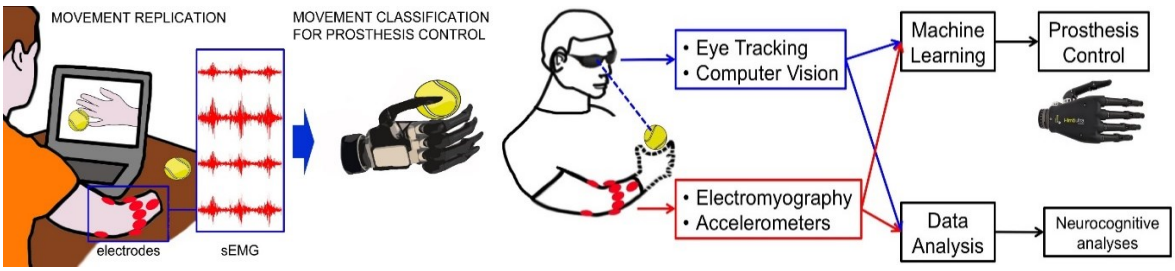

Figure 1: EMG based movement replication system by Nina Pro and Megane Pro

Karina Iglesia et al [9] discussed that, in the recent past, clinical practices and research is focused on rehabilitation by means of interactive gaming using virtual reality through active video game and exergames. In older population, the efficiency of the system is limited. In older adults, the physical functions are improved by the use of exergames and its summary is provided. Six databases namely ISI Web of Knowledge, PEDro, Cochrane data base, PsyInfo, MEDLINE and EMBASE are used for analysis of the randomized controlled trials. Helmi Adly et al [10] worked towards the benefit of autism affected patients by means of serious games and performed the review on the research and developments in this domain. They also work towards developing the identification of autism level as high, medium or low functioning individual.

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Vitor Antônio et al [12] compared the stroke survivors based standalone methods for combination of proprioceptive neuromuscular facilitation (PNF) and VR games and the program used for this purpose. This assists in virtual rehabilitation. Alfonso Monaco [13] worked on the person project for training the cognitive abilities of individuals through game solutions and its related developmental tools. These tools involve haptic devices, electroencephalography (EEG) and brain-computer interface based serious games centred on virtual reality platforms.

3. PROPOSED WORK

For every organ function – muscles, eyes, heart and brain, various bioelectric signals are generated by the human body. From the excitable cells, action potentials are generated and their sum leads to the generation of these signals. When pathologies are produced in the organs, bioelectric signals are used for their diagnosis. The excitable cells and their action potentials are added to produce these signals. The pathologies in organs producing the bioelectric signals are detected and diagnosed. The shortening and contraction of skeletal muscles lead to the production of EMG signals.

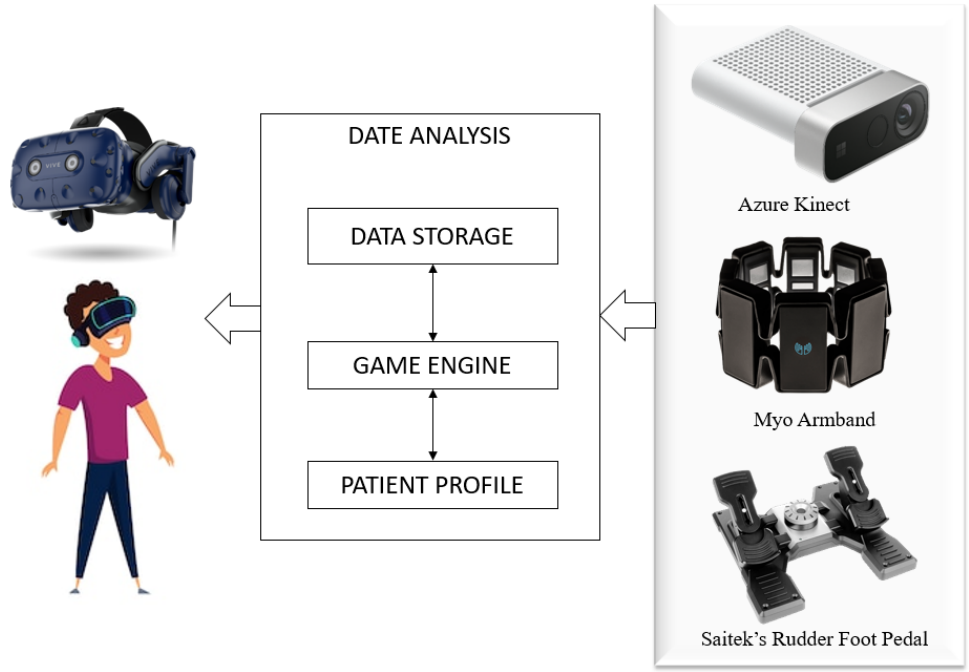

Figure 2: Proposed VR gaming system

Data acquisition and motion capture in this system is done by means of azure Kinect [17], myo armband [18] and Saitek's rudder foot pedal [19]. Also, a gaming environment is created and the motion inputs are interfaced with the HTC Vive VR headset [16]. Ottobock, Delsys Trigno, Cyberglove and several other device

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models can be used for acquiring the same data. We use the Ninapro software and data acquisition protocol for processing the accumulated information. Timestamps are applied to this data and interfaced with GUI (Graphical User Interface). Data analysis, classification and processing is also performed. The signal recording may be affected by power line interference. Hampel filter is used to avoid such interference in this system.

In subjects with physical disabilities, for stress and therapy due to trauma caused by accidents and so on, this environment will provide an optimal solution for mental simulation and therapy. Azure Kinect offers sophisticated speech and computer vision models with cutting-edge AI sensors. It offers a versatile combination of multi-mode orientation sensors, video camera, spatial microphone array, and depth sensors. The Myo Armband for Gesture Control is used for reading and monitoring muscle activity. It uses ARM Cortex processor and EMG sensors of medical grade along with three-axis magnetometer, three-axis accelerometer, three-axis gyroscope and nine-axis IMU.

Saitek's rudder foot pedal is used for controlling the setup of flight simulation. This can be of great use in therapy for patients affected by trauma in accidents especially while driving. This system provides complete coverage of the limbs and motion control of the individual. Figure 3 represents the remaining forearm of the amputated subjects. This system can also support such subjects in regaining their confidence and overcoming certain issues due to their disability. These VR games can also be used as a simulation environment for people to use robotic arms and limbs.

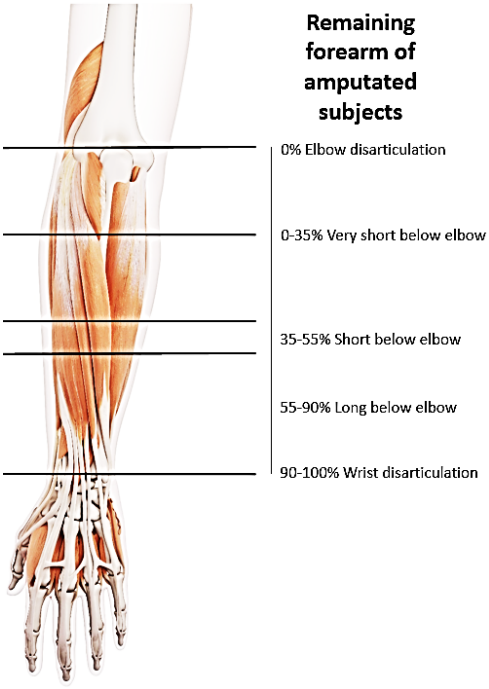

Figure 3: Representation of remaining forearm in amputated subjects

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The entire system of motion capture is further connected to the HTC vive VR headset that offers HD haptic feedback, directional audio, realistic graphics, headset tracking and 360 degree controller for complete realistic actions and movements in the virtual environment. It also provides eye relief adjustments and front-facing camera and requires an Intel core i5 processor based PC for synchronization.

4. RESULT

For motion capture, azure Kinect, Myo armband and Saitek's rudder foot pedal are used. The complete motion of the individual is captured real-time. For the sake of analysis, comparison between the arm movements is considered. The motion of the arm is captured in both real and virtual environment and are compared. The motion capture systems accuracy is of high priority. In some scenarios, the precision may mismatch due to the difference in compatibility between the devices and sensors. This is overcome in this system using the software development environment and haptic filter providing optimal performance.

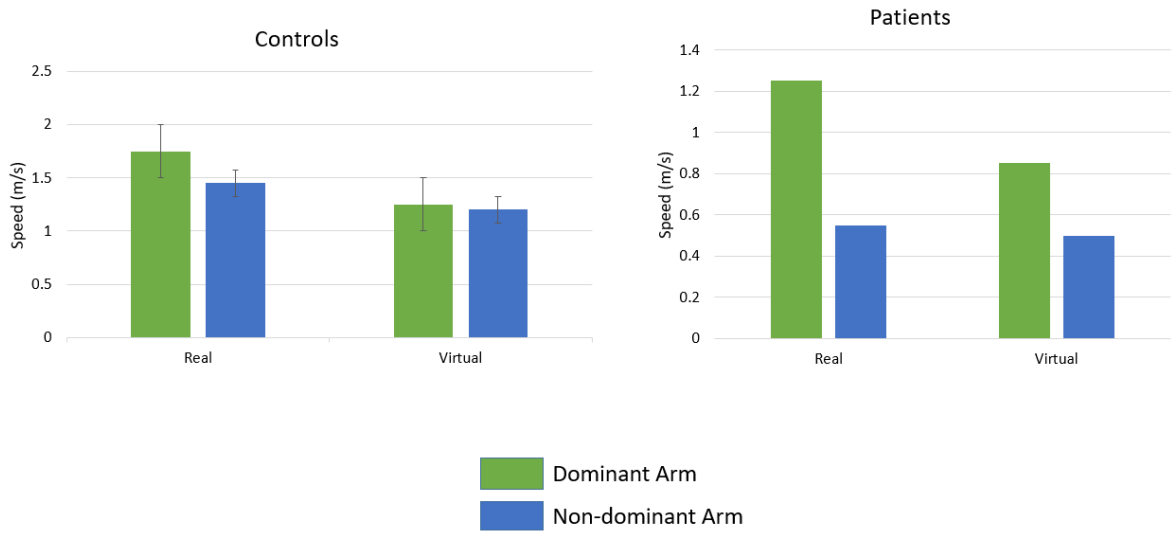

Figure 4: Comparison between real and virtual environment motion analysis

5. CONCLUSION AND FUTURE SCOPE

A novel rehabilitation service that provides mental simulation and therapy is developed with the help of VR gaming environment offering low cost and efficient personalized interactive system is developed in this paper. The analysis of controls and precision is also done to evaluate the efficiency of the system. Azure Kinect, Myo armband and Saitek's rudder foot pedal performs efficient motion capture of the patient, processes it and feeds the information to the computer where further processing of the information is performed. It is synchronized with

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the VR gaming environment and provided to the HTC vive VR headset. In the inclusion of technologies for disease monitoring, healthcare, therapy and so on, these technologies provide an efficient and low cost solution. Future work is focused on further improving the accuracy of the system and reducing the time delay between the capture and transfer of signals.

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