Extracting Pattern of Arm Movements based on EMG Signal for Stroke Therapy

Khairunizam Wan, Rashidah Suhaimi and Aswad A.R
Advanced Intelligent Computing and Sustainability Research
School of Mechatronic, Universiti Malaysia Perlis, MALAYSIA
khairunizam@unimap.edu.my

D. Hazry, Zuradzman M. Razlan and Shahriman AB
Centre of Excellence for Unmanned Aerial Systems (COEUAS)
Universiti Malaysia Perlis, MALAYSIA

Mohd Asri Ariffin and Haslina M
School of Health Science,
Kampus Kesihatan Universiti Sains Malaysia, MALAYSIA

khairunizam@unimap.edu.my

Abstract: This paper presents the investigation pattern of arm movements for the purpose of the rehabilitation for a stroke patient in the virtual reality (VR) environments. The investigation results are used to design the virtual objects in the virtual environments. The muscle activities are analyzed by using electromyography (EMG). Six EMG channel are attached to the right arm of the subject, which is at the location of deltoid anterior fibres, deltoid middle fibres, bicep, triceps, flexor and extensor while performing arm movements. The electrical signals acquired from EMG are analyzed to extract the signal's pattern by using signal processing technique. In the studies, several fundamental arm movements are performed by the subject and the acquired patterns of EMG signals are defined as muscle activities. The experimental results show that deltoid, bicep and triceps move with a significant value compared with flexor and extensor and are used to investigate the muscle activities, which is suitable to the stroke therapy.

Keywords: Stroke Therapy, Arm movement, Signal pattern

1 INTRODUCTION

Stroke rehabilitation is based on the continuous movement of the stroke patient affected limb to stimulate the brain function that has been deteriorated. The brain damage effects not only cognition impairment but also a motor impairment [1]. The motor impairment can be treated by intense use of active movement in repetitive tasks and task-orientated activities which will result in improving motor skills and muscular strength. The treatment done by first introducing the external movement to the patient to develop their muscle activity but the amount of movement done is crucial whereas to not stress the patient to much or cause movement to little that will slow the treatment [2]. Repetitive rehabilitation exercises is one of the method used in the treatment by slowly developed the muscle and motor function, but without knowing which fundamental arm movement that will affect the muscle first can halted the course of treatment. The amount of muscle activity is to be slowly increased for steady muscle development and treat the motor impairment [3].

Virtual Reality (VR) is a digital environment which can be manipulated by the respective party. VR has its various function in today's development in various applications which most have been used by the medical doctor for surgery simulation and psychological therapy for the mind [4-8].

This research paper organized as subsequent; Section 2 encompasses literature review of the related research and approach toward VR based stroke therapy. Section 3 presents the methodologies of applied procedures. Section 4 is divided into 2 sections, first section states about experiment setup where second section demonstrates the results of experiments. Finally section 5 expresses the conclusions over current research.

2 LITERATURE REVIEW

Stroke is the second leading cause of death worldwide, with fatality of 4.4 million of the total of more than 50 million deaths each year and only 10 percent recover almost completely while some other survivor have to live with few disability or impairment [1]. Thus this stroke patient needs special care and rehabilitation to gain back their body function. Obesity, high blood pressure and many other factors could be taken to considerations of early stroke [9]. Stroke is when there is a blood clot block the flow in a vessel or artery interrupting the blood flow to an area of the brain which causes the brain cells to die [10].

Kate Laver et. al [11] mentioned that virtual reality and interactive video gaming have emerged as new treatment approaches in stroke rehabilitation. These approaches may be advantageous because they provide the opportunity to practice activities that are not or cannot be practiced within the clinical environment. Furthermore, virtual reality programs are often designed to be more interesting and enjoyable than traditional therapy tasks, thereby encouraging higher numbers of repetitions. Various applications of the VR which have make rise to the development of interfacing devices such as dataglove, head-mounted display (HMD) and mechanical suit [12]. The application has various usages in the rehabilitation therapy for the stroke patient. Recently many types of equipment have been developed based on VR applications.

3 METHODOLOGIES

Fig. 1 shows the flow chart of the proposed works. In the experiments, a subject performs 22 fundamental movements. Six EMG channels are attached at to the upper and lower arms. The acquired EMG signals are analyzed by using signal processing techniques. The signal patterns are extracted and the investigation of the motion sequences are conducted based on the extracted signal patters.

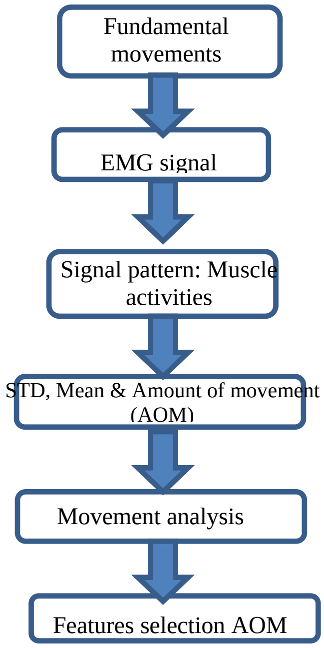


Fig. 1. Flow chart of the proposed works

3.1 Hemiparesis Stroke

Hemiparesis stroke attacks when blood flow to the brain stopped. The oxygen and blood that supply to the brain will stop which result in the damage of the brain which can affect the important body parts that control daily activities. Hemiparesis sufferer will experience one side of weakness. They often experience balance impairments which cause difficulties to perform movements such as grabbing objects, drinking from a glass, eating and using bathroom.

3.2 Fundamental Movements in Stroke Rehab

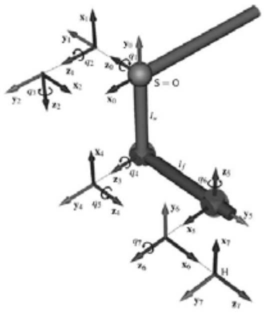


Fig. 2. Kinematics of human arm

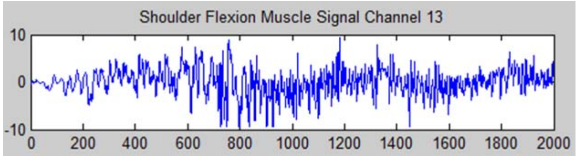
Human arm consists of seven degree of freedom, which is shoulder, elbow and wrist as shown in **Fig. 2**. In rehabilitation for disability and hemiparesis stroke patient it is important to first assess their movement and limitation. The human arm can be model by the shoulder with 3 degree of freedom, elbow 2 degree of freedom and wrist with two degree of freedom. In the shoulder deltoid muscle involves in elevation, depression, shoulder flexion, shoulder extension, abduction, adduction, horizontal abduction, horizontal adduction, external rotation and internal rotation. Biceps and triceps muscles involve in the movement associate with elbow flexion, elbow extension, elbow supination and elbow pronation. The wrist uses movement as extension, flexion, ulnar deviation and radial deviation. All these movements are being used as reference of fundamental arm movement.

3.3 Processing EMG signal

Fig. 3. (a) Placement of EMG channel, (b) EMG signal

(a)

(b)



EMG is used to record the electrical activity produces by the skeletal muscle. **Fig. 3** shows EMG signal of the deltoid muscle recorded when the subject performed the arm movements. The sampling rate is 1000 Hz/s. Butterworth low pass digital filter is used to remove noises in the signal which the cut off frequency of 10 Hz and 0.001 normalization value.

3.4 Signal patterns

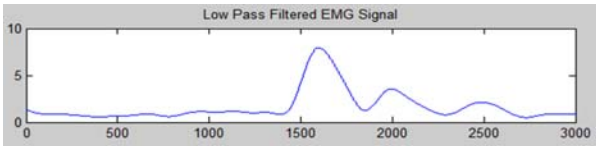


Fig. 4. EMG signal after preprocessing

Fig. 4 shows the EMG signal after processing by using signal processing technique. Then, means, standard deviation and amount of movement (AOM) of the filtered signal are extracted and are defined as features or muscle activity [13].

4 EXPERIMENTS

4.1 Experimental setup

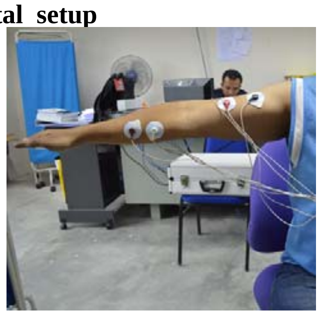
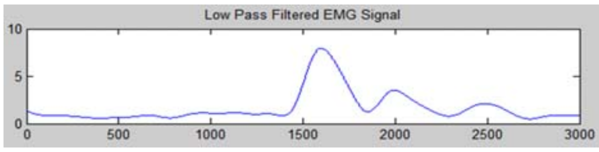


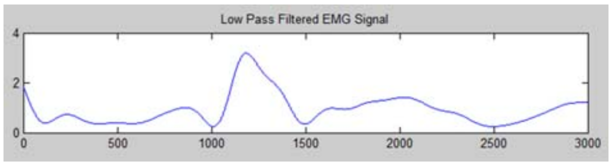
Fig. 4. Placement of EMG channel

Fig. 4 shows the locations of the electrode placement where the main muscle can be detected which were deltoid, biceps, triceps, extensor and flexor. The shoulder was to detect the deltoid muscle as for every movement that involves the shoulder for example elevation, depression, shoulder flexion, shoulder extension, abduction, adduction, horizontal abduction, horizontal adduction, external rotation and internal rotation. The second part of the arm was the elbow, the movement associate with the elbows were elbow flexion, elbow extension, elbow supination and elbow pronation. All this movements were used as references of fundamental arm movements

4.2 Experimental results

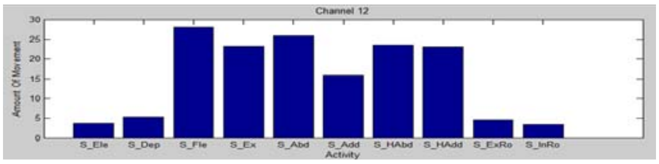


(a)

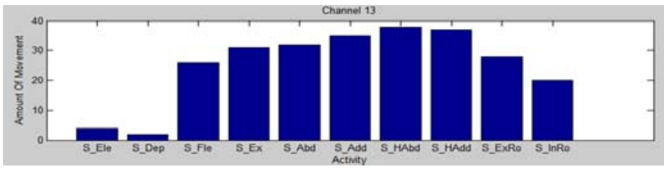


(b)

Fig. 5. (a) Elbow Flexion Signal, (b) Shoulder Flexion Signal



(a)



(b)

Fig. 6. AOM (a) Biceps (b) Triceps

Fig. 5 (a) and (b) show EMG signals of elbow and shoulder flexion after preprocessing step. The results show that the noise was removed from the signal. The motion features, which were mean, standard deviation and amount of movement (AOM) were measure from this signal. **Fig. 6** (a) and (b) show the AOM from the selected fundamental movements and it could be used to represent movement patterns of the arm. From the experiments, it was decided to use locations for EMG measurement, which were deltoid, biceps and triceps. **Fig. 7** shows the AOM for deltoid, triceps, biceps, extensor and flexor as denoted by (a), (b), (c), (d) and (e), respectively. The graphs show that the deltoid, triceps and biceps had a significant value of AOM. In the future research for the investigation of movement sequence deltoid, triceps and biceps will be used for the electrode placements. **Fig. 8** shows the placement of the electrode at the human arm.

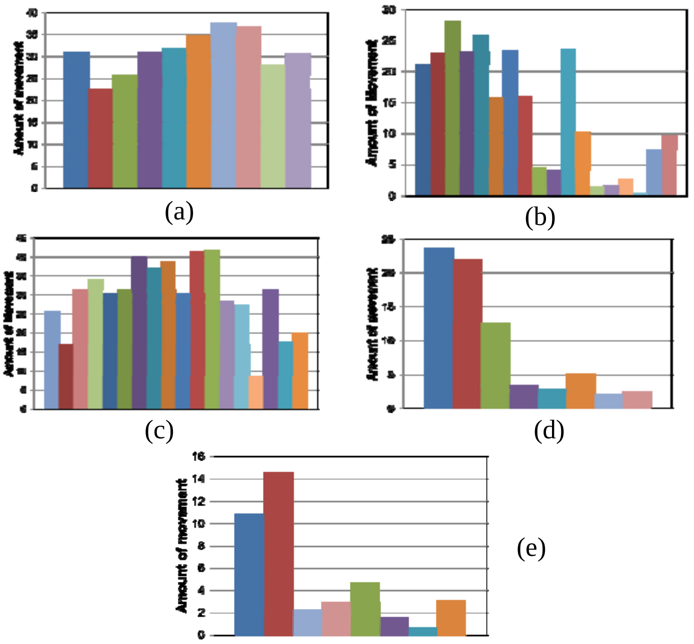


Fig. 7. Amount of movement (a) Deltoid (b) Biceps (c) Triceps (d) Extensor (e) Flexor

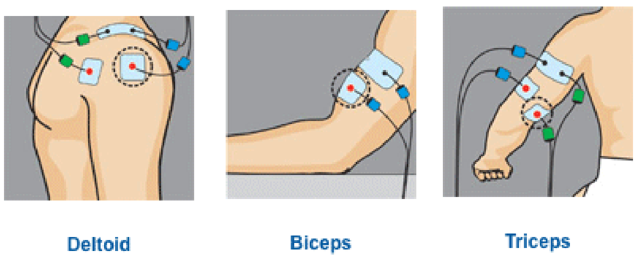


Fig. 8. (a) Elbow Flexion Signal, (b) Shoulder Flexion Signal

5 CONCLUSIONS

The paper discusses the analysis of arm movements by using EMG device. The signal processing technique is proposed to remove noises and to smoothen the acquired EMG signal. Then, the signal pattern is extracted, which is mean, standard deviation and amount of movement (AOM). The experimental results show that AOM is the best pattern to represent arm movements. In the future three electrode placement is chosen which is deltoid, triceps and biceps.

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