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Neuromuscular Abnormalities Detection on Stroke Patient by Using Electromyography (EMG)

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Abstract: This project is concerned with neuromuscular abnormalities detection in stroke patients by using electromyography (EMG). This project aims to recognize the EMG signal on Upper Limb using MATLAB software, which aims to generate the raw EMG using a sensor, analyze the EMG signal on the upper limb with noise minimization, and record the neuromuscular abnormalities detection in the stroke patient and healthy individual. After cardiovascular illnesses and cancer, stroke is now the third highest cause of mortality, and it is the main cause of severe disability and impairment in the industrial world. Thus, the symptoms of a stroke seem to fluctuate on which area of the brain is affected. Usually, the symptoms could quickly and without any sign, a person may not even be aware that he or she has had a stroke. As a result, when a stroke occurs, the symptoms are usually the most acute, but they may gradually worsen. To overcome these issues, Electromyography (EMG) has to be conducted by a hardware circuit to recognize the signal of a stroke patient in an autonomous way on the skin of the patient. This project includes one sensor an EMG sensor, an Arduino board, and two batteries and is connected with MATLAB software. When the power is supplied to the hardware circuit, the sensor measured the signal on the upper limb of a stroke patient and healthy individual and then has been analyze it in MATLAB software. Therefore, the results from this project contain four positions from one patient who has been diagnosed with stroke for five years and has been compared the result with a healthy individual. The results show that neuromuscular abnormalities occur in stroke patients.

Keywords: Neuromuscular Abnormalities Detection, Stroke Patient, Electromyography (EMG)

1. Introduction

Electromyography (EMG) is therefore one way of monitoring and recording the electrical activity generated by skeletal muscles. In other words, EMG is used to determine the health of muscles and the nerve cells that govern motor neurons. There are a wide variety of sensors that can pick up on these two

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types of signals. These include force sensors, gyroscopes, and accelerometers. Efficiently capturing physical data is possible using electromechanical sensors. Second, biosensors such as EEG, EMG, and MEG. Finally, it has been shown that biosensors not only analyze physical information but also transfer to the bioelectric signal, which is often regarded as a direct link to human psychological information.

However, the focus of this project is on the detection of neuromuscular abnormalities in stroke patients using electromyography (EMG) because strokes are now the world's third-leading cause of disability and the second-leading cause of mortality. These situations impact people of all ages, young and old alike. 31% of stroke victims are under the age of 65, according to WHO. As of 2017, there were 15,642 stroke fatalities in Malaysia, accounting for 11.31 percent of all deaths in Malaysia. As a result, more than 40% of stroke survivors will never be able to use their upper limbs again. Neurological, muscle structure, and function alterations have been seen in post-stroke patients, which may contribute to muscular strength and motor deficits [1]. It is possible to remedy a decrease in muscle strength by engaging in active movement that includes repetitive, task-oriented, and task-variegated activities [2].

2. Materials and Methods

This section is focusing on the materials and methods that have been used in this project.

2.1 Methods

As shown in Figure 1 b, there is a process of neuromuscular abnormalities detection in stroke patients by using electromyography (EMG) for upper limb positions. Firstly, we need to place the electrodes in the right places. Next, generate and obtain an upper limb position which contains four positions. Then, we observe if the signal is readable or not but if there is no output signal, we need to restart again. If we can generate the raw EMG on the upper limb for data collection, we will go to another process which is pre-processing, and lastly to get the result and analysis for this project. In order to get a smooth signal, we need to remove all noise by using a band pass filter 5 – 10 Hz cut-off frequency for filtering.

2.1.1 Data Collection

In this project, stroke patients and the healthy individual will be recruited. Both of them were asked to perform the four positions which are arm hanging with muscle contraction, arm hanging with muscle relaxation, straight arm reaching up (45 degrees from vertical) and arm hanging at the side, elbow bent at 90 degrees. The EMG data will be collected using an EMG sensor that is linked to Arduino and MATLAB software. The subjects were shown instruction on upper limb motions prior to data collection. They might each practice the appropriate actions for a few moments to familiarize themselves with the experiment's protocol.

Throughout the experiment, both the stroke patient and the healthy subject spontaneously stretched their arms toward the ground and executed each motion with the same force they use in daily life. Both subjects were instructed to perform four position classes sequentially in each cycle. Each contraction lasted 5 seconds and was followed by a 5-second rest period. However, several unexpected problems may occur during the testing period in which the device may simply cease working, an unexpected result may be produced due to software difficulties.

2.1.2 Pre-processing

Real EMG data are typically contaminated with different types of noise because of ambient disturbances or other experimental factors that are unpredictable. To extract meaningful characteristics for future studies, adequate preprocessing is necessary. The three most frequent preprocessing techniques for EMG data are filtering normalization and windowing. In addition, methods for locating, removing, and replacing bad or missing data are referred to as data cleaning. According to researchers, EMG signals should first be cleaned to get accurate data about muscle activity for further research work. This step calls preprocessing of EMG signal and contains the signal rectification and bandpass filter.

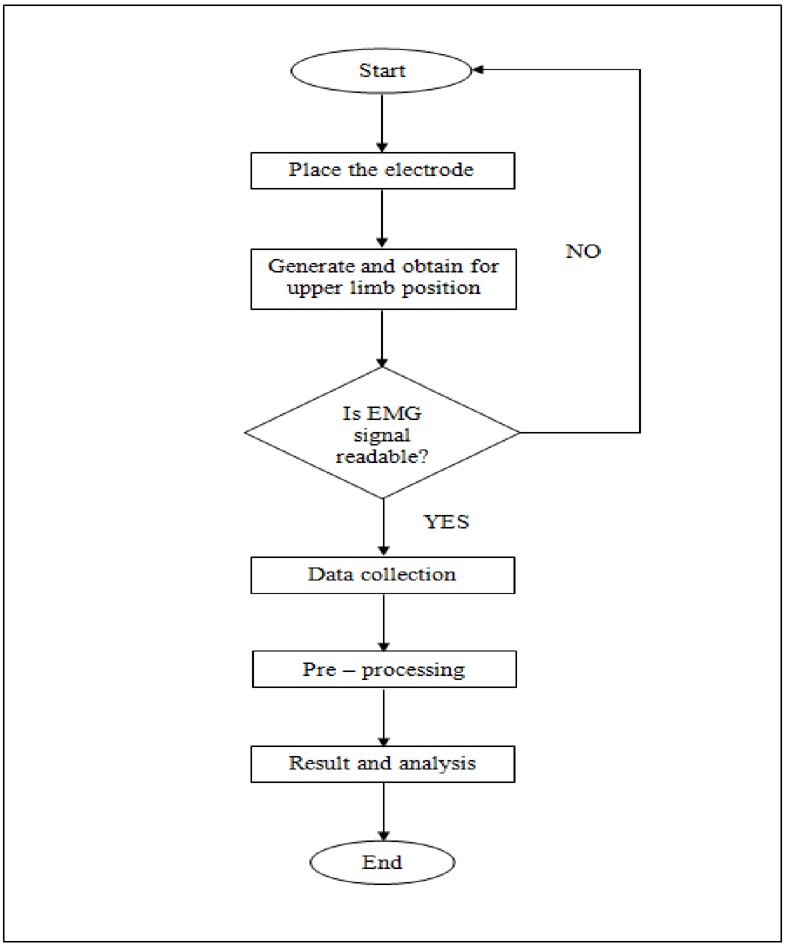

Figure 1: Flow chart of process of the neuromuscular abnormalities' detection

2.2 Materials (Hardware Component)

i. Arduino Uno

Arduino Uno is a programmable CHIP Microcontroller. All the software required is by inserting a particular instruction (program) into the Arduino board using software or Arduino IDE. Arduino then read the input information from the sensor which is the EMG sensor to process that information to drive an output such as the data of the signal. For this project, only A0 and the ground port on the Arduino will be used.

ii. EMG Sensor

EMG sensor measures small electrical signals generated by the muscles. The electrodes are placed near the muscle to record EMG signals. This project only uses non-invasive technology, it making this EMG sensor type not painful.

iii. Surface Electrodes EMG

Equipment that is attached to the skin to evaluate the electrical activity of the muscle. The surface of electrodes is used to observe the problem that occurs with muscles and nerves.

2.3 Hardware Circuit Development

Developments of hardware of this project are using Arduino Uno, an EMG sensor with three electrodes, and a jumper wire. Muscle signals are transmitted via three electrodes. For better function, each electrode must be in the proper position, which connects them to the right place. Figure 2 shows that the Arduino Uno was connected with an EMG sensor which is the red and yellow wire connected to battery positive and negative 9V, and the black wire connected to the ground. In addition, the signal port is connected to A0. Therefore, three electrodes connect to the EMG sensor. Lastly, the USB will connect between Arduino UNO and the laptop.

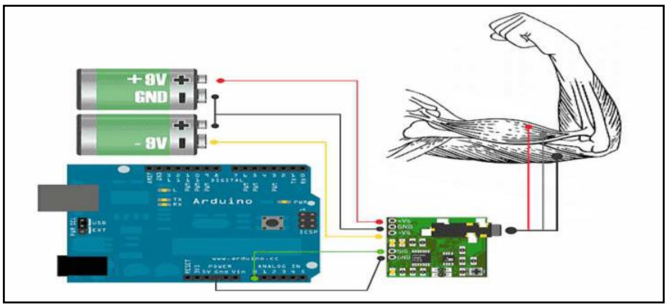

Figure 2: Hardware circuit development

3. Results and Analysis

This part will describe the analysis for this project which contains four positions for stroke patients and healthy individuals. In addition, the raw EMG data and the resulting signal after removing the noise generated by MATLAB software.

3.1 Experiment setup

The experiment setup was shown in Figure 3. During the experiment, a stroke patient and a healthy individual were instructed to sit in a relaxed and suitable position for them to rest their arm in a straight position and can make the movements. The PLX-DAQ spreadsheet will record the data and generates the raw EMG signal by MATLAB software.

Figure 3: Experiment setup for this project

3.2 Position task

The data provided by surface electromyogram (EMG) is very small in the microvolt range and can be easily modified by skin conditions and sensor placements. For example, if electrode placement between patients shifts slightly to the right, left, up, or down, this can affect EMG data. If the data is collected numerous times at different times, even with the same patient, the signal data will be different if the electrodes are not placed in the same position. They explained that before electrode placement, the surface must have to be cleaned to reduce the resistance of the skin [3]. This project has four positions: (a) arm hanging with muscle contraction, (b) arm hanging with muscle relaxation, (c) straight arm reaching up (45 degrees from vertical) and (d) arm hanging at the side, elbow bent at 90 degrees while using the same electrode position on the upper limb stroke patient and healthy individual is shown by Figure 4 and Figure 5 respectively.

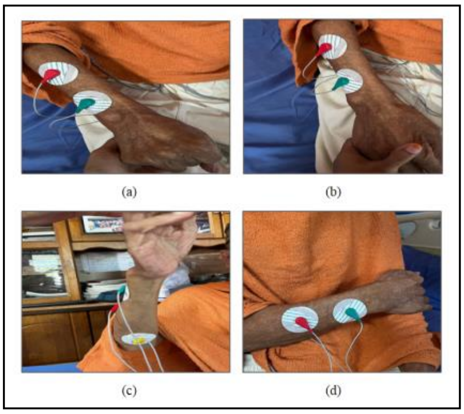

Figure 4: Stroke patient

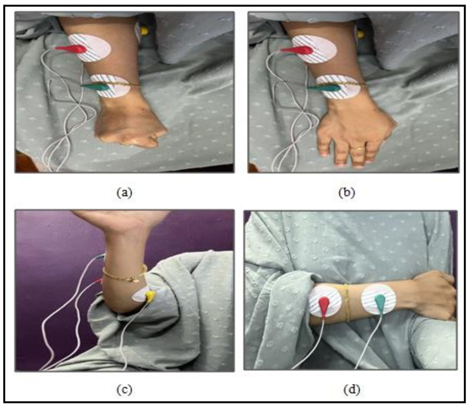

Figure 5: Healthy individual

3.3 EMG Signal Processing

i. Arm hanging with muscle contraction

As the result in Figure 6, we can see that only at the time 1 to 2 seconds the signal is high compared to the result in Figure 7, which is the signal of amplitude at the time 1 to 2 seconds, continues with 2 to 3 seconds, are highest and proves that the stronger the muscle contraction is, the higher the number of activated muscles. So, we can conclude that the stroke patient has neuromuscular abnormalities because muscle contraction occurs only 1–2 seconds compared to a healthy individual's result signal, which is the amplitude of the signal is higher frequently.

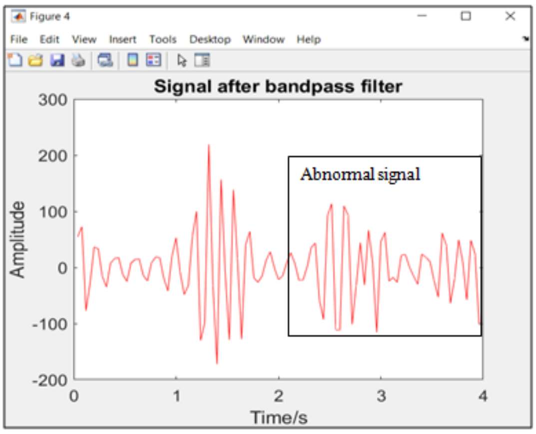

Figure 6: Result signal on stroke patient

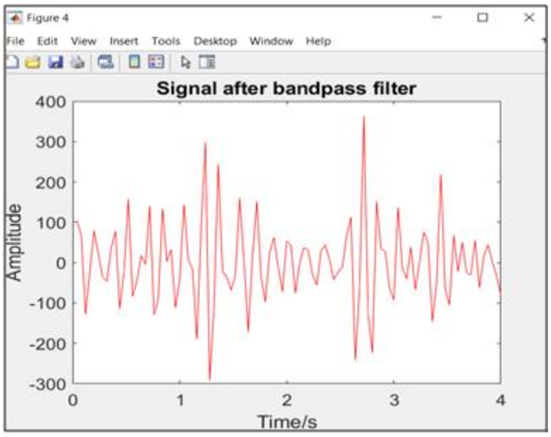

Figure 7: Result signal on a healthy individual

ii. Arm hanging with muscle relaxation

In Figure 8, after the filtering, there is only a burst moment at 3 to 4 seconds, and others are in silence moment which is the muscle in the relaxation condition. But for Figure 9, there are two burst moments at the beginning of time and before 3 seconds. Therefore, both results have the same amplitude for the relaxation condition.

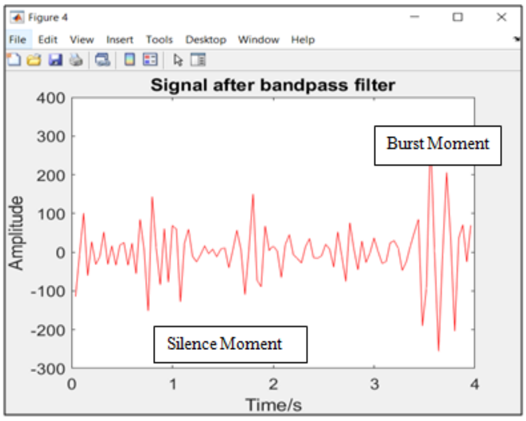

Figure 8: Result signal on stroke patient

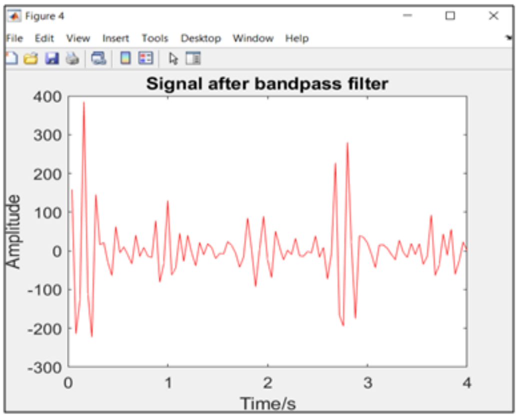

Figure 9: Result signal on a healthy individual

iii. Straight arm reaching up (45 degrees from vertical)

After noise is filtered, the result in Figure 11 shows there are many burst moments compared to the result in Figure 10, which is for stroke patients. This result can conclude that the muscles of stroke patients are less active and show abnormal signals than healthy individuals. Furthermore, the amplitude value for stroke patients is higher than for healthy individuals. During elbow extension, the amplitude of triceps EMG was maintained at a high level on both sides, but it was significantly lower in the normal subjects [4].

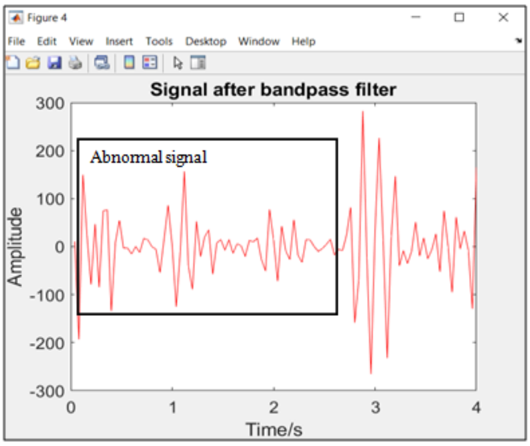

Figure 10: Result signal on stroke patient

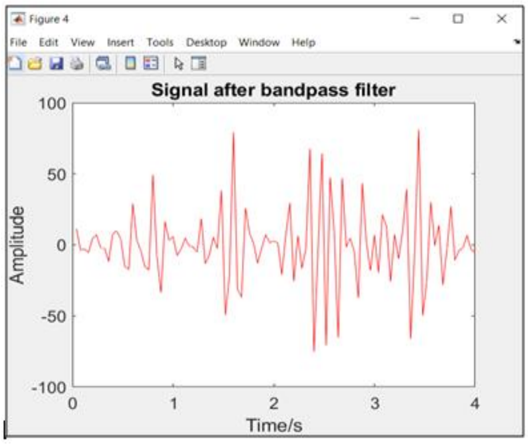

Figure 11: Result signal on a healthy individual

iv. Arm hanging at the side, elbow bent at 90 degrees

The results after filtering the noise in Figure 12 have low amplitude compared to Figure 13 on a healthy individual. At this position, we can analyze that the signal on a healthy individual has a peak amplitude at 2 until 4 seconds, which shows the energy level of muscle contraction when moving. However, in Figure 12 on stroke patients, the result shows the signal continuously consistent or in a silent moment at 3 to 4 seconds and only peak amplitude at 2 seconds. So, we can conclude that the signal in stroke patients is abnormal compared to a healthy individual.

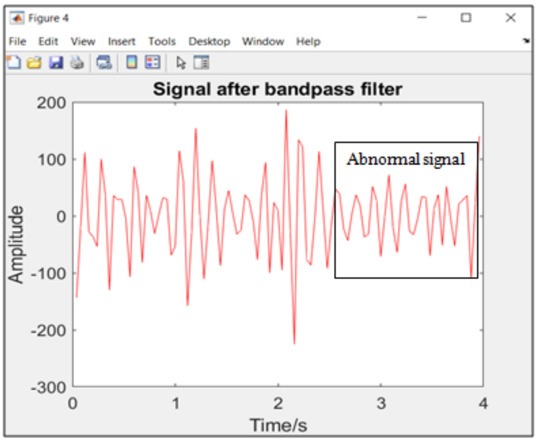

Figure 12: Result signal on stroke patient

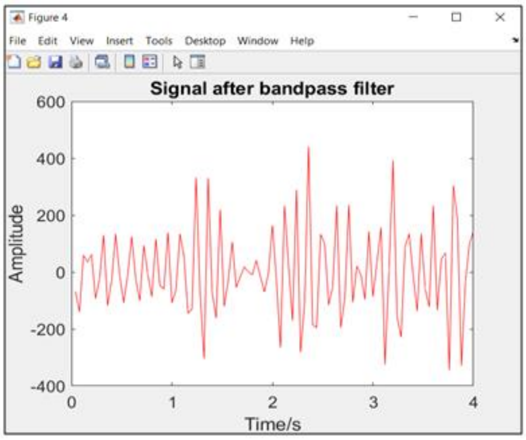

Figure 13: Result signal on a healthy individual

Based on findings from four positions, neuromuscular abnormalities in stroke patients are detected when the muscles of a stroke patient feel tight but still in weak condition. This is because when a stroke patient moves, the signal still has low amplitude compared to a healthy individual that has active muscles and high amplitude once making a movement.

4. Conclusion

In conclusion, the objective of this project is to recognize neuromuscular abnormalities detection on stroke patients by using EMG has been achieved. The muscles on the upper limb have been analyzed in this experiment. The experimental results have shown that the magnitude and amplitude of the signal data and band pass filter in the signal can be used for muscle abnormal detection to remove all noises in the signal by using MATLAB software. Therefore, the repetitive task for post-stroke rehabilitation is a suitable method for muscle weakness recovery. However, nowadays the monitoring of muscle activity is too important and must exercise on a daily routine but muscle weakness can occur when the stroke survivor exercises for the long period without rest.

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References

[1] J. E. Harris, J. J. Eng. “Strength training improves upper-limb function in individuals with stroke: a meta-analysis”. Stroke. 2010 Jan;41(1):136-40. doi: 10.1161/STROKEAHA.109.567438. Epub 2009 Nov 25. PMID: 19940277.

[2] Bruce H Dobkin, “Strategies for stroke rehabilitation”, The Lancet Neurology, vol 3, 2004.

[3] B. N. Cahyadi et al., "Upper Limb Muscle Strength Analysis For Movement Sequence Based on Maximum Voluntary Contraction Using EMG Signal," 2018 International Conference on Computational Approach in Smart Systems Design and Applications (ICASSDA), 2018, pp. 1-5, doi: 10.1109/ICASSDA.2018.8477638..

[4] D. Ao, R. Sun and R. Song, "Comparison of complexity of EMG signals between a normal subject and a patient after stroke - a case study," 2013 35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), 2013, pp. 4965-4968, doi: 10.1109/EMBC.2013.6610662.