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EMG Signal Analysis on Flexion Extension Movements of The Hand and Leg Using Matlab

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Abstract
Muscle Spiker Shield is a tool used to record electrical signals generated by the muscles of the human body. These signals can provide important information about the health and activities of organisms, especially humans. As technology advances, more and more devices can be used to record the activity of these signals, including the Muscle Spiker Shield. One of the uses of the Muscle Spiker Shield is to monitor muscle wave activity. Human muscle waves are electrical signals generated by muscles and can provide information about the state of a person's movement activity. Monitoring human muscle wave activity can help in various fields, such as medicine, psychology, and sports. Currently, an electromyograph has been developed which functions as a voltage meter for all muscles to detect muscles in a state of tension and relaxation with the help of a microcontroller. On the Electromyography signal output then to the Arduino uno microcontroller. When using the Muscle Spiker Shield tool withMATLAB, the signals recorded by the tool are imported into the MATLAB software. Then, the data can be processed using various signal analysis techniques, such as filtering, peak detection and statistical processing. Some of the applications that can be done are monitoring leg and hand muscle wave activity during meditation, monitoring muscle wave activity to determine a person's movements, and monitoringmuscle wave activity during exercise.

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1. Introduction

The use of Matlab, which is identical to matrices, is of course closely related to the fields of mathematics and computing. Various mathematical problems can be easily solved with Maltab, as well as in the field of computing. Matlab is a high level programming language specifically for technical computing, visualization and programming needs such as mathematical computing, data analysis, algorithm development, simulation and modeling and calculation graphics [1]. Biomedical signals that can be obtained from in the human body there are several types, including Electrooculography (EOG) signals which carry information about eye movement, Electromyography (EMG) signals which carry information from arm muscle movements. These biomedical signals are not only used to detect disturbances in the tissues or organs of the human body, but can also be used to provide an overview of an organ carrying out a work mechanism carried out by the human body. By knowing the working mechanism of an organ, the information obtained from biomedical signals can be used as input for the control system [2].

Raw EMG signals are acquired from a number of electrodes positioned over the muscle that contain a large amount of data but little information. If raw EMG data is used as input in the classification process, the classification accuracy will be low and the calculation time will increase [3]. This bionic hand can be controlled by electromygraphy (EMG) signals. EMG signals are a signal to detect muscle contractions in the human body. The signals produced by the hand muscles can be acquired using a microcontroller and used to control the bionic hand, so that the bionic hand can make movements according to the hand movements [4].

Human muscles move based on contraction movements and relaxation caused by nerve cells resulting in electrical potential stimulation. This bioelectric signal will later be captured to become the basis for an initial diagnosis to determine the activity of the muscle. Medical electronics technology is needed to detect and monitor the activity of the human body's muscles [5]. EMG signals can be obtained in two ways, namely by implanting electrodes directly in the muscles, such as and electrodes placed on the surface of the skin, such as. Implanted electrodes provide a better signal because they come directly from the desired muscle source [6].

Myo armband is a tool that is able to capture hand movements which works based on the electromyograph (EMG) principle, namely capturing movements based on the activity of the hand muscles when they are contracting and relaxing. Because the EMG signal is the result of reading muscle activity, the EMG signal has no effect on environmental conditions [7]. EMG signals can be classified in various ways, for example with two EMG signals produced from the flexor muscles of the right and left hand, these two signals allow for a simple classification [8]. For the experiment, several frequently used hand gestures were used to test and compare methods using the time domain and frequency domain [9].

When a muscle contracts, the muscle will emit an electrical potential of a certain magnitude and when the muscle relaxes, the electrical potential will decrease periodically. The electrical potential generated from the leg muscles can be recorded and measured with a device called an electromyograph (EMG) [10]. Skeletal muscle tissue is mainly attached to bones and functions to move parts of the skeleton. Skeletal muscle tissue is voluntary because it contracts and relaxes under conscious control [11]. The muscles that work in the hand can be divided into two groups, namely the extrinsic muscles located in the anterior and posterior compartments of the forearm, which control gross movements and produce a strong grip [12].

2. Methods

The study of EMG signals during muscle extension and flexion movements helps in a deeper understanding of the basic mechanisms of these movements. This is important in the context of physiotherapy, exercise, and medical science because a better understanding of how muscles contract and work can help in the design of more effective exercise or treatment programs. EMG research in the context of extension and flexion movements also has great relevance in health and fitness research. It helps in identifying muscle contraction patterns during physical exercise and can help in designing more effective exercise programs for increased muscle strength and performance. This research was also carried out directly on a predetermined object so that the results obtained in the experiment could clearly show the differences and changes in amplitude (Figure 1).

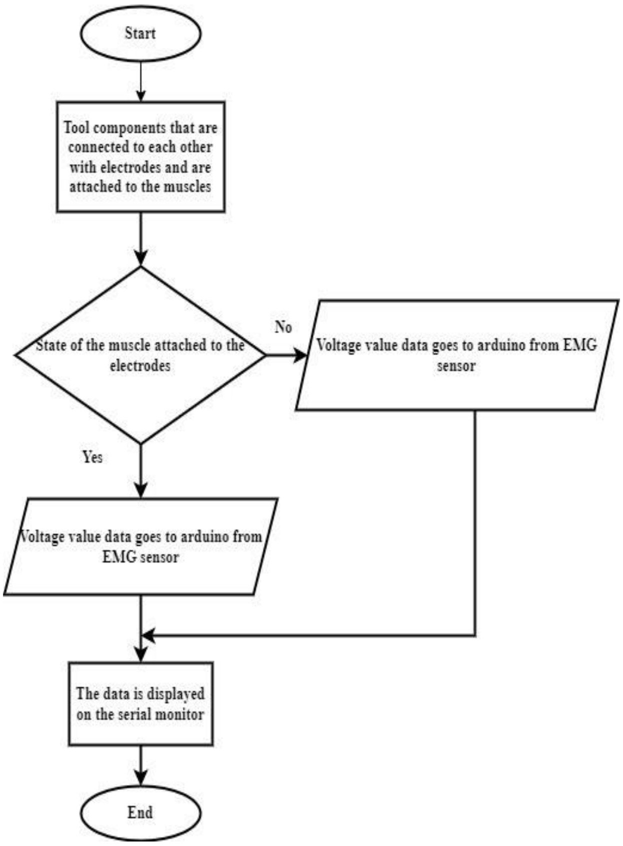

Figure 1. Flowchart

In this research, the development of Electromyograph (EMG) sensors was carried out to detect signals in the muscles of the hands and feet. To get a good signal, Electromyograph (EMG) sensors can be placed on human hands or feet. System flow from analyzing leg muscle wave activity in real time using the EMG sensor with Matlab from the EMG sensor in monitoring leg muscle wave activity with Matlab as a whole starting from the beginning to the end of the system. If the muscle waves have been detected by the EMG sensor, this sensor produces a signal that is converted into digital data. The data collected by the EMG sensor is then sent to the Arduino Uno. The data received by the Arduino Uno is sent to the Matlab software, where data processing of muscle wave activity occurs. feet in graphic form. In the Matlab software, we can clearly see the differences and changes in the graphics resulting from the muscle Spiker Shield, which has electrodes attached, then attached to the muscles of the hands and feet. The design of a muscle wave activity monitoring system can be seen in Figure 2.

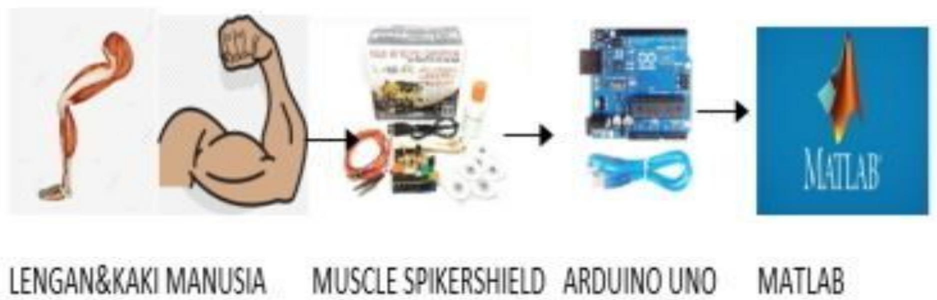

Figure 2. Block Diagram

Based on Figure 2 the research process uses a systematic approach, where the circuit process is one of the most important parts in designing a tool. From the block diagram, you can find out the working principle of the whole circuit. So that the whole block circuit diagram will produce a system that can function how the working principle of designing a system. How the EMG sensor works in monitoring leg muscle wave activity can be explained in the block diagram below. The EMG sensor is attached to the arm. This sensor works using electromyogram (EMG) technology. EMG is a technique for examining and recording muscle signaling activity. EMG signal measurement is done with a device called an electromyograph, and the recording results are called an electromyogram. An electromyograph detects the electricity generated by muscles when they are active and when they are not active. And to produce EMG signals where the muscles will experience stages, namely potential membranes, thus producing a group called MUAP (Motor Unit Action Potential). , the function of this component is as a signal conductor to send signals to the body, namely by attaching it. The data collected by the EMG sensor is then sent to Arduino Uno. The data received by Arduino Uno is sent to the Matlab software where data processing of arm and leg muscle wave activity occurs in graphical form in real time for analysis.

Electrode transformation is an appropriate tool for biomedical signal processing. because, electrodes as medical aids that can access hidden information in EMG signal waves are made possible by means of electrode analysis because Hz decomposes the signal into different scales. Therefore, it is possible to achieve different frequency components of the signal and real-time information simultaneously. By analyzing this test can also be done using the following calculations (equation 1).

$$v = \lambda f \tag{1}$$

λ = wave length (m), v = *fast wave* (m/s), f = frequency (Hz)

The technique of determining the position of the EMG signal electrode is based on the ion content to communicate. With this method bipolar I leads, II leads, and III leads are obtained. The leads for each lead are a combination of electrodes which are installed according to the following functions: (1) Black Lead : acts as a transducer between ionic transport and the flow of electrons in copper wire; (2) Red Lead : acts as an oxidation or reduction reaction that occurs at the interface of the muscle; (3) Red Lead : acts as an oxidation or reduction reaction that occurs at the interface of the muscle (Figure 3).

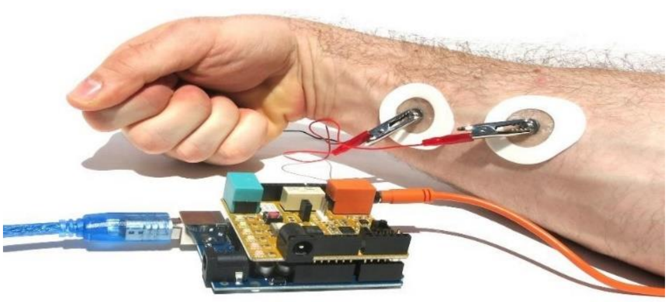

Figure 3. Electrode Lead Position

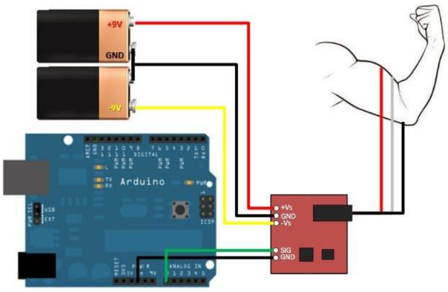

Figure 4. System Circuit Diagram

From Figure 4 it can be seen that the design of an electronic system consisting of several components is formed into a tool that can monitor and process EMG signals in real time using MATLAB software. The component consists of an EMG sensor module, Shield and Arduino Uno R3 type microcontroller.

3. Results and Discussions

This test was carried out to observe the detected muscle wave signals for two different conditions of the human subject, namely during extension and flexion. This test involved children, adolescents, and the elderly to obtain a more detailed understanding of the results. During the test, the results of the muscle wave signal are displayed and evaluated in real time using the Matlab software. The screen displays a graph of muscle wave signals where we will see differences and changes in muscle activity as well as a frequency spectrum that shows the distribution of energy in various frequency ranges. This allows for a more in-depth analysis of the muscle activity of the subject in each of the conditions tested. At this stage, system testing is carried out using Muscle Spikershield, which is equipped with an Arduino to input various data requirements. The aims is to ensure that the computer can receive serial data from the EMG sensor so that it is connected to Matlab. An electromyograph detects the electricity produced by a muscle when it is active or inactive. And to produce an EMG signal where the muscles will experience a stage, namely the potential membrane, a collection of electrodes In this measurement, the role is very important, namely the electrodes, because where the first incoming muscle signal will be read by this tool, the function of this component is as a signal conductor to transmit a signal to the body that is attached. An example of the use and placement of an electromyography (EMG) sensor can be seen in Figure 5.


Figure 5. Examination of hand muscles in children

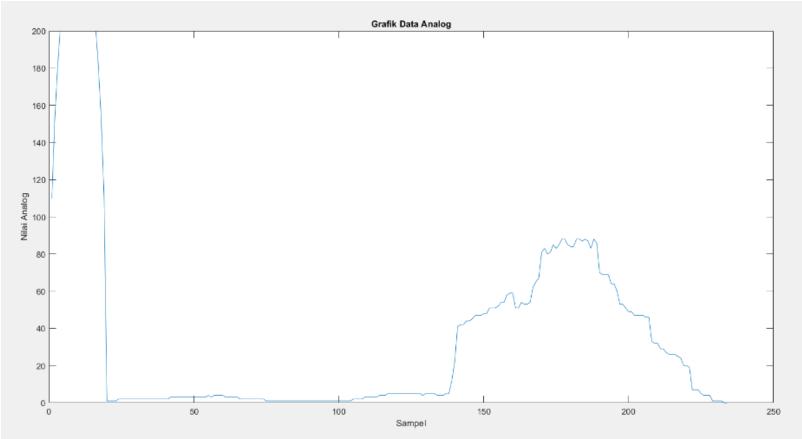

Figure 6. Children Hand Muscle Signal Wave Display

Based on Figure 5 the first test was carried out on the hand muscle wave signal of the subject of children. This test aims to observe the muscle wave signals detected in the hand muscle activity of children. Based on Figure 6, the results of the EMG sensor test displayed by the Matlab software when using the hands can be seen the differences and changes in the graphs, the signal waves show a frequency of 0-97 Hz when the muscles are in a state of extension in children.

Figure 7. Leg Muscle Experiment in Children

In Figure 7 the electrodes that have been attached to the hand of the child subject are ready to be used to determine the EMG signal wave.

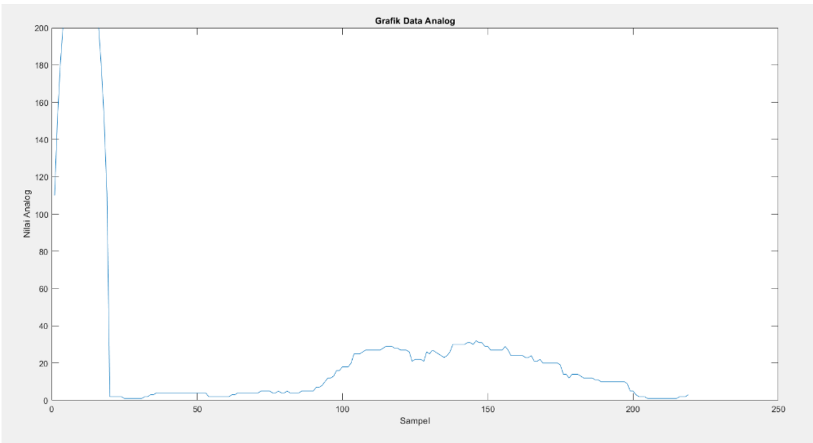

Figure 8. Display of Children's Leg Muscle Signal Waves

Based on Figure 8 the graph above which was obtained when testing in real time signal wavesshowed a frequency of 0-41 Hz for leg muscles in children. In Figure 9 it can be seen that the hands of the elderly subjects have electrodes attached and are ready to be carried out experiments using the Matlab software.

Based on Figure 10 there are also differences and graphical changes in the muscles of the right hand of the elderly subject, because the right hand is more often used for daily activities. in a state of muscle flexion the signal wave shows 1-260 Hz, while in a state of extension the muscle wave shows a decrease from 260-0 Hz in real time. this is caused by making movements to straighten the muscles and lengthen the two bones (relaxation).

Figure 9. Hand Muscle Experiment on The Elderly

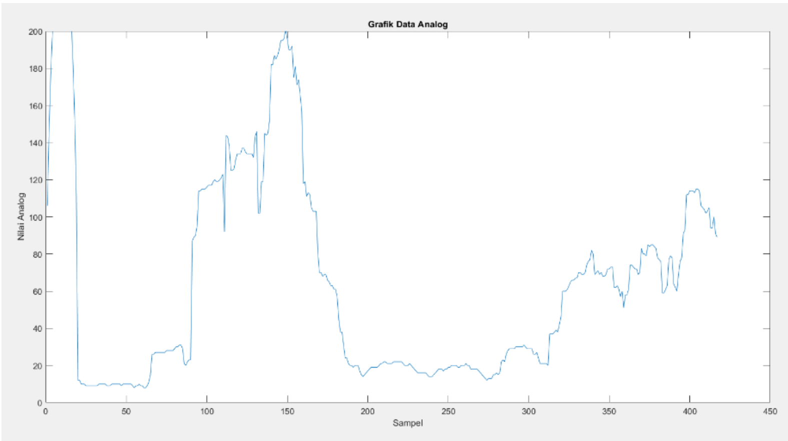

Figure 10. Display of Hand Muscle Signal Waves in The Elderly

Figure 11. Leg Muscle Experiment in The Elderly

In Figure 11 shows that electrodes have been attached to the leg muscles of the elderly subject to record Electromyograph (EMG) signals and are ready to be displayed on the Matlab screen.

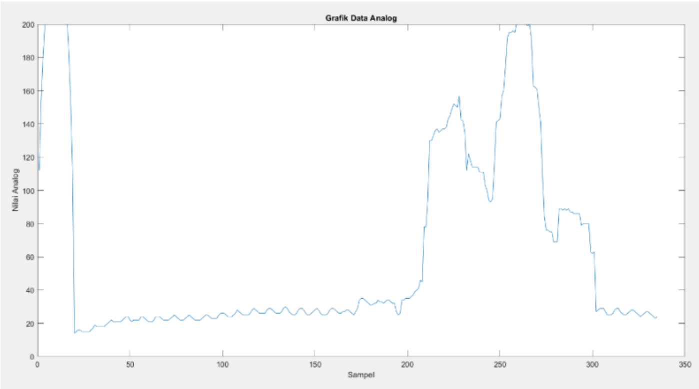

Figure 12. Display of Leg Muscle Signal Waves in The Elderly

Based on Figure 12 it can be seen from the graph of the signal waves in the right leg muscles of elderly subjects in real time that the results show that they are almost the same as the right-hand muscles in the frequency range 0-200 Hz, and the waves will decrease if the muscles are doing extension movements. The results showed a difference in percentage between the muscles of children and adults. This can be seen in Figure 13 and Figure 14.

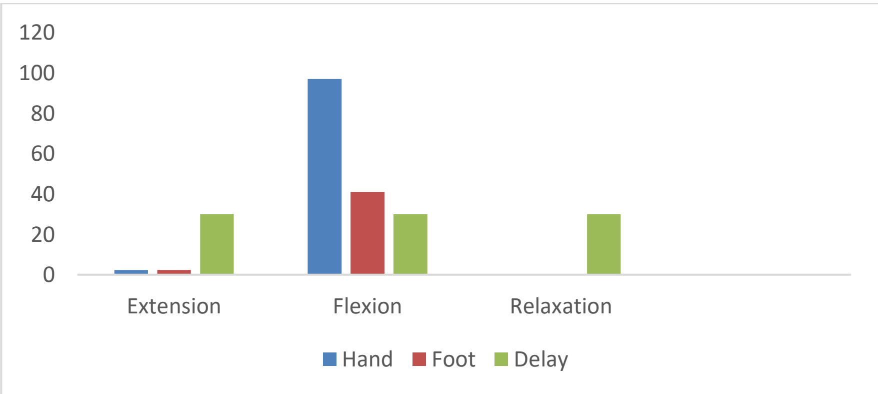

Figure 13. Percentage of Children's Muscles

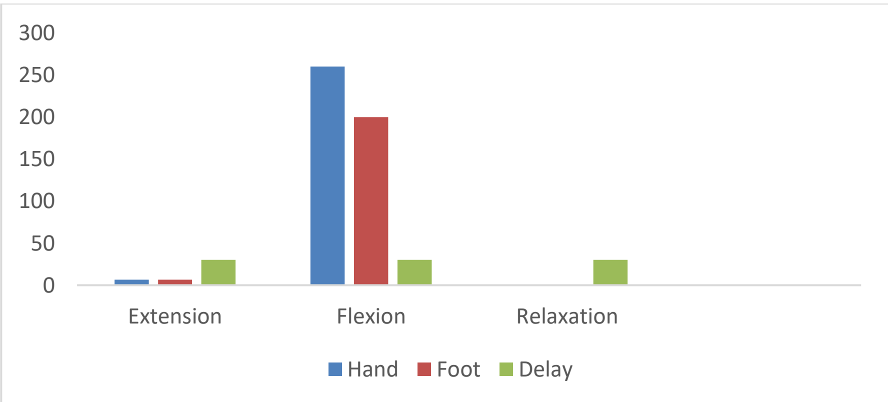

Figure 14. Percentage of Adult Muscle

Feature extraction is carried out to give uniqueness to each gesture. EMG signals in the time domain that have been signal-conditioned are entered into an amplitude analysis algorithm based on equation 1 [13]. Based on the analog value range that has been previously set with a delay of 30 the results of the analog values that have been obtained in the test results on the muscles of the left hand, which are performing flexion movements, get and take the amplitude results on the children's hands at 97 Hz and the children's feet at 41 Hz, while for the hand muscles of the elderly, the analog value for the elderly person's hand is 260 Hz and the elderly person's leg is 200 Hz. It can be concluded that the greater the angle of the arm movement, the greater the average amplitude value. This is directly influenced by the contractions that occur in the biceps muscle. When the arm moves straight, the biceps muscle is in a relaxed state, so an amplitude value close to zero is obtained. The greater the angle made by the arm, the more the biceps will contract. The results of this study are in line with the study on the comparison of EMG activation of trunk muscles between subjects with and without chronic low back pain during flexion-extension and lateral bending tasks [14].

Maximum contraction occurs when the arm moves 180°, so that the largest amplitude value is obtained compared to other arm movements. EMG sensors use electrodes to detect muscle electrical activity. Electrodes are usually placed on the skin over the muscle to be monitored. Non-invasive electrodes placed over the skin are suitable for surface muscle measurements. Once the electrodes are attached, the EMG sensor will record the electrical signals produced by the muscles during contraction. This signal consists of a muscle action potential, which is the muscle's electrical response to a nerve stimulus. The results of EMG signal analysis are used to describe muscle activity and the patient's condition. It can be used for medical diagnosis, physical therapy planning, or scientific research.

4. Conclusion

The results of testing and discussing the Muscle Spiker Shield tool using an Electromyography (EMG) sensor to detect extension and flexion muscle movements, in children and elderly subjects. It can be concluded that there appears to be a very significant difference in muscle wave frequency activity between children and parents under the same circumstances. Extension and flexion movements showed different graphic characteristics between the two groups. In the extension motion by straightening and lengthening the two bones (relaxation), the graph displayed on the Matlab software will continue to decrease to 0 Hz. Whereas in flexion by bending the two bones, the graph displayed will continue to increase from 200 Hz to 350 Hz if the strength in the muscles is continuously added. Differences and changes are also seen in the left and right hands, if the left hand is flexing, the graphic results displayed in Matlab will be different when compared to the right hand. The frequency of the signal waves on the right hand is higher and continues to rise when added to the existing strength in the muscles, while the frequency on the left hand is lower. Likewise with the right leg the signal wave frequency generated is more dominant, because the right leg is more often used for activities and its function is very important to support the balance of the human body. This suggests differences in muscle activity that may be related to development and growth.

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