Controlling Robot Hand Using FFT as Input to the NN Algorithm

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Abstract. To control the prosthetic hand can be used several methods; one of them is by training the system to know the movement of the muscle. This method is using an EMG sensor to read the frequency of the movement of the muscle. In this study, Myo Arm Sensors is used as a sensor and used a Neural Network algorithm. The frequencies of the signal from the sensors are measured when the hand of the subject is open, grip or half open. Moreover, these signals are grouped using octave band methods. This information is used to be learned by the system. The system enables to mimic the movement of the subject up to 87.5% accuracy.

1. Introduction
Recently, the applied of the robot technologies are used in everyday life. The robot also applied to assist people with disabilities. One of them is for the people who lost their hand. To help them robot hand is build to become a prosthetic hand. To control this type of prosthetic hand, several researchers have been developing methods. Voice is used to control robotic hand [1], also signal from the brain [2], some of the researchers use a signal which generated by the muscle or Electromyography and known as EMG [3]. The last method, using EMG are more popular than others methods. This is because the device which detects the muscle signals is easy to use and also cheaper.

To read signal EMG, the sensors/electrodes are placed inside or on the skin of the user [4-6]. Electrodes located on the skin are more used because of its simplicity. Surface EMG (SEMG) is more practical than electrodes which placed inside the skin. There are many applications which use EMG for example rehabilitation applications [7], HMI [8] and for controlling prosthetic hand [9], A Myo armband is one of the SEMG. This study will utilize this device. To control the movement of the prosthetic hand in order to mimic the motion of the user, a signal of EMG must be identified. There are three methods to recognize the EMG signal namely time domain, frequency domain, and combination between time and frequency domain. The time domain methods for example use Slope Sign Changes (SSC), Mean Absolute Value (MAV), Waveform length (WL), Root Mean Square (RMS), zero crossing (ZC) and Willison amplitude (WAMP) [10-11] Methods with frequency domain for instance are Mean Power Frequency (MPF) and Fast Fourier Transforms (FFT) [12]. Moreover, the last the methods which employ the combination between time and frequency domain is Wavelets, and Wavelets Packet Transforms (WPT) [13]. These methods are adequate to recognize the gesture of the hand of the user.

In this study, the proposed system will use the frequency domain using FFT and octave band technique. To recognize the pattern, the Neural Network algorithm is used. Moreover, the system will examine the four movements of the user's hand, namely, grasp, open all finger, relax and half open. This system will be tested on the customize hand robot.
To deliver a complete explanation, this paper is organized as follows: Section II aims to provide the proposed system to control the robot and using the ANN algorithm. Then proceed with next, Section III which presents the experiments on the proposed method by describing the potentials of the system in allowing to identify gestures of the hand. Followed by section IV, which provides the concluding remarks and the future work of this study.

2. Methods

2.1. Hardware

To examine the methods, the system is made and consists of the EMG electrodes, a PC, a controller, and a robot hand. The block diagram of the system can be seen in Figure 1. EMG electrodes are placed in the hand of the subject to detect the signal of the muscle. These sensors are connected to the computer. The system has to learn the signal which related to the gestures of the subject. This phase is called the learning phase. The Neural Network algorithm in the computer will generate the weights. After the weights are obtained, the system is connected to the controller to controlling the robot. This phase is the application phase.

![Diagram block of the system.](image)

A Myo arm sensor is used for detecting the EMG signals. This device has eight sensors, to sense EMG signal around the arm of the user. Myo armband also equipped with an IMU sensor. This sensor enabled Myo Armband to detect the movement of the hand of the user in X, Y, and Z axes. Myo armband enables to generate frequency up to 200Hz. This device communicates with the computer via Bluetooth [14]. A Myo Armband is shown in Figure 2. While Figure 3 shows the subject, who wears a Myo Armband in his arm.
Figure 2. A Myo Armband.

Figure 3. The user wears a Myo Armband.

The computer will process the information from the sensors. This device has processor AMD A8 4GB RAM. The results of gesture recognition from the computer are sent to the controller. The controller we used is an Arduino Uno. The controller will command the robot to mimic the gesture of the user. The robot is a custom robot. All the fingers of the robot enabled to move. Fingers of the robot are tied with strings. These strings are connected to servo motors. Figure 4 shows the robot hand.

Figure 4. A robot hand.

2.2. Software
To recognize the subject’s gesture, the information from the sensor must be learned. The learning algorithm we used is the Neural network. Figure 5 (a) shows the flowchart of the algorithm of the
neural network. The gestures of the subject are relaxed, grasping, open all fingers and open half all fingers. The signals of these gestures are inputted to the neural network algorithm. The Neural network algorithm has a target error. If the target error has reached, then all the weights are updated. These update weights become the weights of the forward algorithm. This algorithm will be used to the application phase. The flowchart of the application phase can be seen in figure 5 (b).

3. Results
To test the potential of this system, a twenty years old male is doing the experiments. The sensor is placed in the arm of the subject as we seen in figure 1. For the training phase, the subject train the gestures namely relax, grasping, open all the fingers and open the entire finger half. Figure 6 shows the gestures of the subject. Each gesture train 20 times for 1 second. Sixty-four data from time domain for each of the sensors are transforming become frequency domain. This transformation process is

![Flowchart](image-url)
using the FFT method. Figure 6 (a) - Figure 6(d) show the FFT signal for each gesture. The signals of the octave band are seen in Figure 7.

Figure 6. gestures of the user. (a) relax. (b) grasp. (c) open. (d) half open.
Figure 7. FFT signal when (a) relax. (b) grasp. (c) open. (d) half open.

Figure 7. Octave band signal when (a) relax. (b) grasp. (c) open. (d) half open.

These octave band signals are learned by the backpropagation neural network algorithm. The algorithm use one input layer, two hidden layers, and one output layer. Input layer and the output layer each have four nodes. While for both hidden layers have ten nodes. For the training, results can be seen in table 1.

| Hidden Layer I | Hidden Layer II | Target Error = | Momentum = | TH = 0.03 - 0.007 |
|----------------|-----------------|----------------|------------|-------------------|
| 10             | 10              | 0.00001        | 0.05       | 0.00497263073184347 |
The weights which obtain from the learning process are applied in the application process. In this process, the forward Neural Network is applied. Table 2 shows the accuracy for each gesture from twenty times trial. The average of the accuracy is 87.5%.

| Pose                  | Accuracy |
|-----------------------|----------|
| Relax                 | 100 %    |
| Grasp                 | 70 %     |
| Open all fingers      | 80%      |
| Open entire fingers half | 100%    |

4. Conclusions
This paper proposed the system which enabled to recognize the gesture of the hand of the user. The system used the EMG signal which transforms into the frequency domain. Moreover, this system used a myo arn arm sensor, a neural network algorithm, and a robot hand. This system shows the potential to mimic the gesture of the hand of the user which the accuracy of about 87.5%.

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