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Finger Movement Detection Based on Multiple EMG Positions

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***Abstract*— The use of ElectroMyoGraphy (EMG) has been widely applied to many applications. To further develop more sophisticated applications, the more advanced techniques of EMG detections have to be studied. So far there are a few works to study the detection of finger movements using EMG. However, they cannot provide the exact solution of finger detection using only one EMG position. Therefore, this paper presents the finger movement detection based on multiple EMG positions. The investigation is carried out by using Myoware muscle sensors to record EMG signals. The measured EMG signals are captured and processed in a low computational processing unit. The results indicate the successful finding of finger movement detection based on multiple EMG positions.**

Keywords*—*EMG, Finger Movement, Detection

I. INTRODUCTION

So far, ElectroMyoGraphy (EMG) has been widely used in engineering filed as it can represent the response of muscle movement [1]. The signal strength of EMG signal can be measured by electrodes, which varies according to the position of muscle and movement. The EMG signal amplitude is in the range of ±500mV. Also, from literatures, the utilized frequency is from 6 to 500 Hz but the most effective one can be found between 20 to 150 Hz [2-3]. The work presented in [4] has indicated that the EMG signal is relatively sensitive to the muscle movement. So, the volunteers have to be relax their bodies before performing the signal recording in order to get the accurate EMG signal and also to avoid the interference from adjacent muscle. So far, Myoware Muscle Sensor has been used to record EMG signal. Then, the recorded signal is passed to the processing boards for performing some computational methods. The work presented in [5] has used Arduino employing Support Vector Machine (SVM) to monitor the muscle movement and also utilized Multi-Input and Multi-Output Nonlinear ARX model (MISO-NARX model) to analyze the angle of movement. From literatures, all detections of finger movement have been studied based on the one position of EMG sensor. This cannot provide the exact solution to detect each finger movement. For near future application, the use of finger movement detection will become more interesting to apply on bionic devices. Hence, the new finding on finger movement is still on focus.

In this paper, the EMG signal strengths measured with many positions have been studied according to each finger movement. Also, an algorithm with low signal processing is proposed to decrease the burden and cost of processing boards. The experimental setup is described in next section which is followed by the section of results and discussion. Then, the conclusion of this paper is given in Section IV.

II. EXPERIMENTAL SETUP

A. Measuremnt Method

For this research work, a volunteer (male, 23 years old, 175 cm in height, 56 kg in weight) who does not have any problem involving the muscle and nerve in superficial flexors of the forearm. While performing the signal record, the volunteer has to relaxingly sit on insulated chair as there is no metal or conductor on the chair to avoid some error during the measurement.

EMG/ECG Foam Solid Gel Electrodes are safely used to stick the electrodes with the volunteer's arm. The 3 electrodes are connected to MyoWare Muscle Sensor to measure voltages from muscles when they stretch and shrink, as shown in Fig. 1. Note that these voltages represent the EMG signal strength.

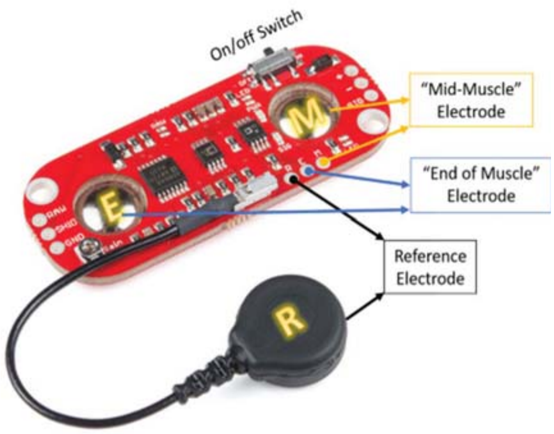

Fig.1: MyoWare Muscle Sensor [6].

The MyoWare Muscle Sensor consists of Mid-Muscle Electrode and End of Muscle Electrode which are places at the position providing the highest voltage. Moreover, the Reference Electrode is used to refer the normal level of voltage from the volunteer.

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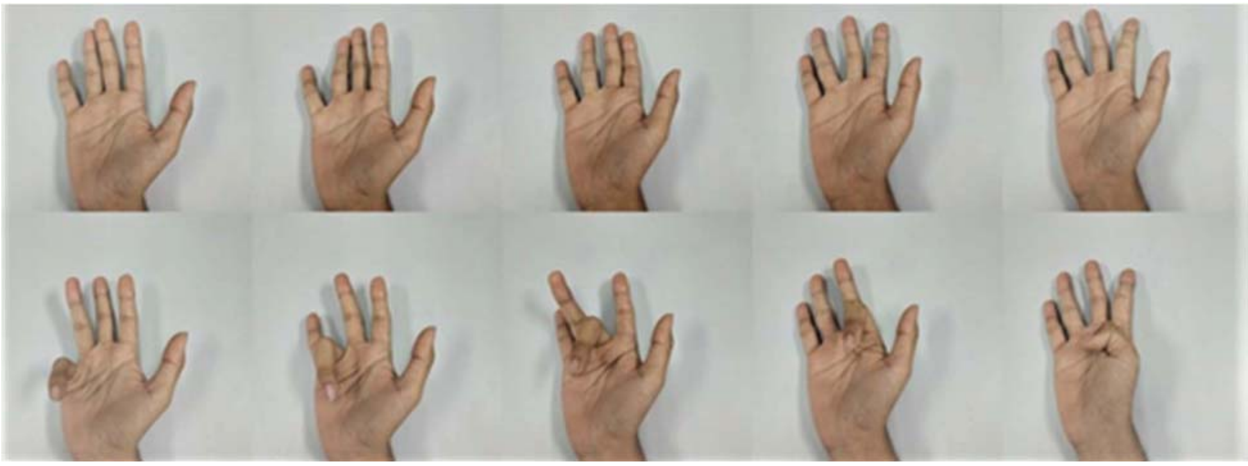

Fig.3: Finger movement pattern.

The received EMG signal from MyoWare Muscle Sensor is passed to Arduino UNO via Jumper. Arduino UNO needs DC 3.3V supply from MyoWare Muscle Sensor and receives EMG signal from 'SIG' port at MyoWare Muscle Sensor as shown in Fig. 2. The received EMG signal is possibly valued between 0-675 which needs the (1) to convert to readable amplitude as follows.

$$Amplitude(V)=\frac{Values}{675}\times 3.3 \tag{1}$$

B. Finger Movement Pattern

This research work focuses on individual finger which separately stretches and shrinks in every 1-2 seconds. The finger movement pattern is shown in Fig 3. All EMG signals will be recorded. Then, the off-line processing will be performed afterwards. Fig. 4 shows the position, called Metacarpophalangeal joint, which is focuses on this research work. This joint is between metacarpal and phalanges which has a main function for picking up things.

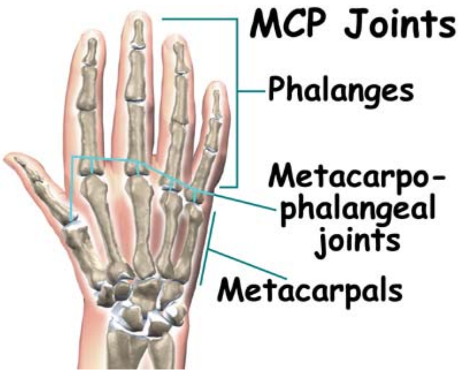

Fig. 4: The area of finger movement study [7].

The positions for attaching the electrodes have been selects for 5 position on superficial flexors of the forearm as shown in Fig. 5. Actually, there are more than 100 positions that were studied in this work but only 5 positions present the best combination for finger movement detection.

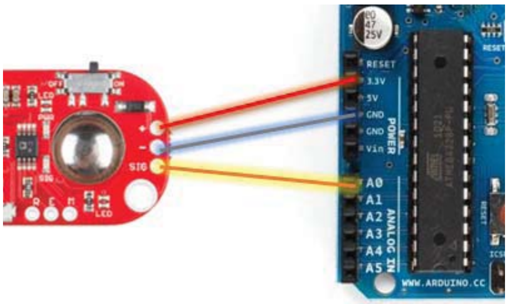

Fig. 2: MyoWare Muscle Sensor connected to Arduino UNO.

C. EMG Recording

Software named as Processing 3.4 is used to record EMG signal given from MyoWare Muscle Sensor and Arduino UNO. The recorded data contains date/month/year, EMG signal strength and the EMG signal number. Fig.6 shows the photograph of an example of measurement using MyoWare Muscle Sensor.

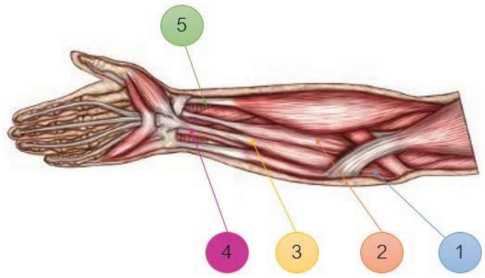

Fig. 5: Selected 5 positions for attaching EMG sensors.

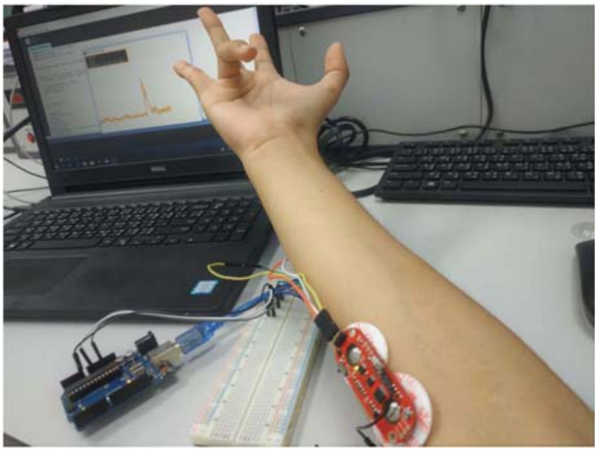

Fig. 6: photograph of an example of measurement using MyoWare Muscle Sensor.

III. Results and Discussions

MATLAB programming is used to evaluate the recorded data (EMG signals) showing the max value and average value between 1 – 160 milliseconds. The average value can be calculated using (2) as follows.

$$Average\ Value = \sum_{t=1}^{160} \frac{EMG\ signal_t}{t} \tag{2}$$

Considering the change between max value and average value obviously indicates that the movement of fingers. This change can be calculated using (3) as follows.

$$Peak\ to\ Average = Max\ Value\ \ -\ Average\ Value \tag{3}$$

Also, the change of EMG signal with respect to average value can be shown as it is creasing or decreasing using (4).

$$Increasing\ and\ Decreasing = \frac{Emg\ Signal\text{-}\ Value\ Average}{Value\ Average} \times 100 \tag{4}$$

Fig. 7 shows the example results after all calculation with those above 4 equations for the use of moving a ring finger when EMG sensors are placed at position 1 and 2. It can be seen that in the first interval (10-30 ms) the signal amplitude is suddenly high. This is because the ring finger is moving. However, in the second interval (30-120 ms) the signal amplitude is low but not stable. For the last interval (120-140 ms), the signal amplitude is temporarily a bit high and then suddenly lower than the case of the second interval. This occurs when the volunteer unfurl the finger.

When comparing between Position 1 and 2, the amplitude of EMG signal at Position 1 is much lower than Position 2. Then, it can be seen that both signals are different in level. In order to make a fair judgement, then the use of Increasing and Decreasing percentage is applied. After a whole measurement, it has to be noted that the threshold for detecting should address on the judgment criteria including with the peak to average level at more than 700 mV and the level of Increasing and Decreasing more than 150 %.

After the judging criteria has been given for peak to average and Increasing/ Decreasing, the comparison between all EMG signals from each finger movement versus 5 positions is illustrated as shown in Fig. 8. It is simply implied that the detection is occurred if the signal is higher than criteria for both parameters. From the results in Fig. 8, there are some data which can pass the Judging Criteria (straight line). The overall results are shown in Table 1. In this table, ‘Yes’ means that Peak to Average and Increasing/Decreasing are both Yes. On the other hands, ‘No’ means that Peak to Average or Increasing/Decreasing is both No.

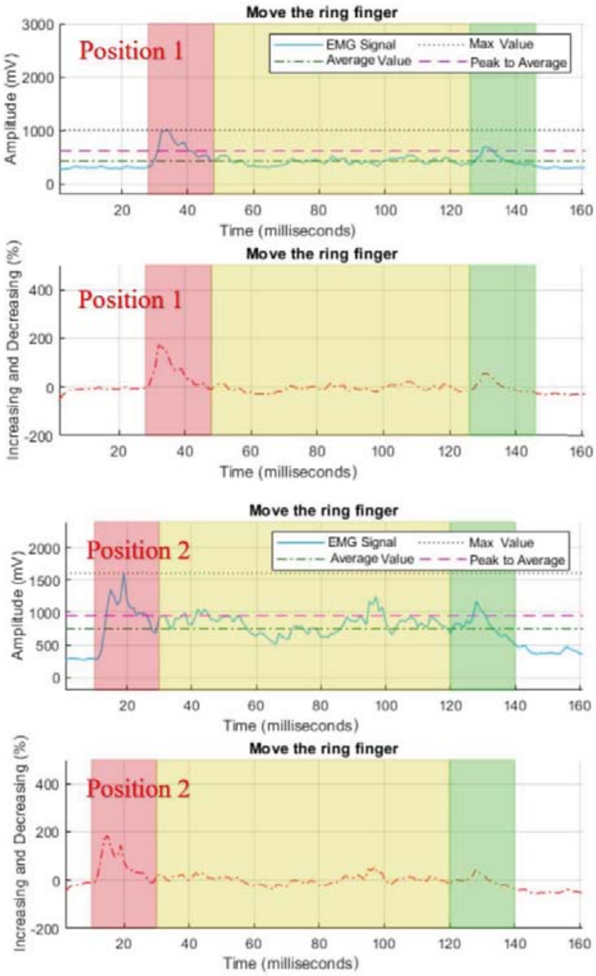

Fig. 7: Example of measured EMG signals at Position 1 and 2.

TABLE 1. Analysis of the response between EMG positions and finger movement.

Data Type	Peak to Average					Increasing and Decreasing					Overall Judging Criteria				
Finger Movement	Little	Ring	Middle	Index	Thumb	Little	Ring	Middle	Index	Thumb	Little	Ring	Middle	Index	Thumb
Position 1	No	No	Yes	No	No	Yes	Yes	Yes	Yes	No	No	No	Yes	No	No
Position 2	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No
Position 3	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Position 4	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No
Position 5	No	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes

As seen in Table 1, it can be used for detecting a finger movement by 5 EMG positions. For example, if Position 2 responds with "Yes" and the rests are "No", then it is the movement of middle finger. Also, it is very easy to implement by using overall judging criteria into a low processing unit. Then it can be applied to any devices using this finding to detect the movement of each finger.

IV. CONCLUSION

This paper has shown the judging criteria for detecting finger movement by using multiple EMG signal analysis. This new finding is able to apply to a low processing unit to reduce the system cost. However, the experiment focuses only individual finger movement. For the future works, simultaneous finger movement is interesting to be considered.

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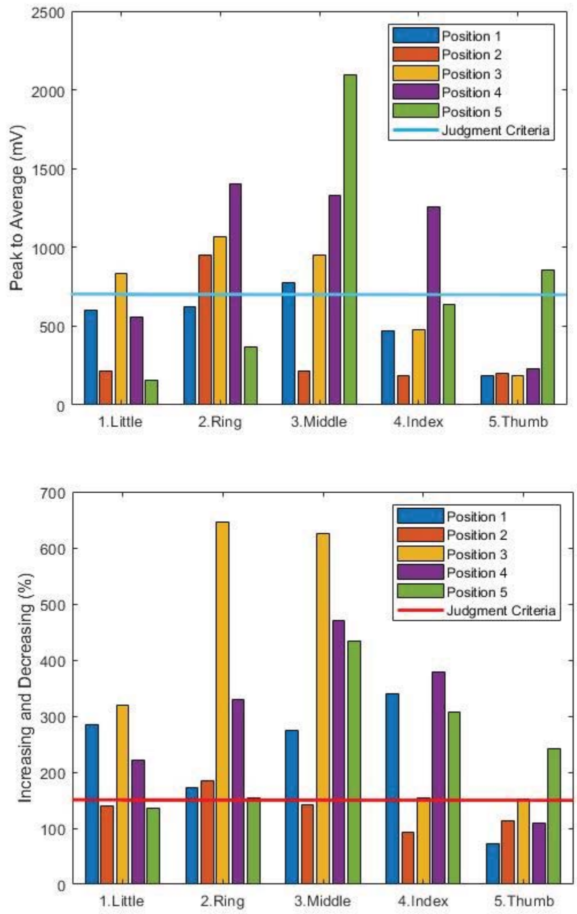

Fig. 8: Comparison between all EMG signals from each finger movement versus 5 positions