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Analysis of the EMG Output Characteristic in Response to Activation of Muscle for the Human Intention Judgment

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Abstract

This paper analyzes the data of the biological signals for controlling the robot controller through the EMG signal and proves intelligent user's judgment of intention is possible. For that, the DSP control board for electromyogram measurement was designed, it was utilized in the experiments by mounting a circuit for biological signal processing. In order to find the relation between the EMG output form as user muscle contration and human intention, we make a plan the experiment circumstance which is perform specific operation, and extrac tthe output data of EMG repeatedly. The output of the extracted data is converted to digital filtered control signal, and then we proceed experiment that this output form of the data can show the intention of the user. Incertain circumstances, we utilize three kinds of data, biceps and triceps, forearm triceps, and we gain the result data between the concentric and eccentric contraction of muscle during the time of no load. Using this experiment result, we prove that the outputform of the biological signal is associated withthe user's intention,it can be expected to affect the number of studiesof the biological signal processing and control applicationsin future studies.

Keywords: Component, Electromyogram, Filtering Circuit, Intention Judgment, Muscle Construction

1. Introduction

Electromyogram is a naturally occurring biological signals includes several linear characteristics of the user motion associated with muscle contraction. Disabled people can not use the part of the body via the signal output from the EMG signal may be used as a control signal such as aprosthetic hand or artificial leg. Further, even when the general user, by utilizing the electromyogram signal to the external systems, such as the exoskeleton robot, and can be utilized as a system capable of prolonged use less energy. However, in order to confirm the recognition and judgment result of people through the electromyogram signal, more accurate signal of pattern analysis and signal extraction is important more than anything. Form of the output, muscleconditions, sex, depending on theage, different values of the respective results, even measured measured in the same environmental conditions, it is possible to measure the value is different. For the reliability of the signal that can be applied from these signals in common, by referring to the output characteristics that can be inferred from the results, it is necessary processes can be utilized for the controller. About today's complex cognitive process, it is difficult to give some meaning of EMG result data, but some of simple cast about true or false judgment, estimation of intention, linearity judgment of load is able to have an reliability. To do this,the processfor obtaining reliable data on the level of EMG measurement process is important and, based on this data, it is an important process that finds the definition of the data analysis methodology according to the experimental environment. To solve these problems, various EMG pattern recognition methods have been applied to the study. In the feature vector of the time domain, there

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is a method that utilizes amplitude and zero crossing rate, histogram, the auto regressive model coefficients[1-3], as a frequency of the feature vectors, there is a fourier transform coefficients and cepstrum coefficients for recognition rate improvement method[4,5]. When trying to classify the features of many researchers, as the number of classification objects increases, it can extend the channel, using the method of expanding the dimensions and tries to classify the current situation and operation, Recently, there search to classify EMG data is in progress through a combination of time and frequency domain[6,7]. In addition, such as Bayesian classifier and Gaussian mixture model from the feature vector by dimension expansion, hidden Markoffmodel, multilayer neural network, fuzzy classifier which are utilizing the pattern classification methods, are cognition rate improved method for classifying a desired operation shows various results. However the important point for EMG signal analysis, even though the pattern classification is complete, if the situation or fatigue degree of muscle will be changed, classification or recognition may fail, When the output of thesignal changes, the accuracy of the existing classification algorithms may be significantly reduced. Based on these characteristics, the point to be presented inthis paper is the definition of reference value and the muscles information does not change during operation as possible. Compared to the beginning of the EMG, in case of EMG when the operation is repeated is different, and By increasing the degree of muscle fatigue can be confusing to the output[7]. In order to prevent this, there is a need to apply the reference differential data along a line distribution median frequency moves, this approach can help to improve the operation of recognition rate. In the future, this control result can be applied by exoskeleton robot arm, it is possible to configure the experimental environment based on the biological signal that is linked with the signal pattern classification algorithm based on the user's intention. Moreover Based on the EMG signal, intention of the people using the EMG, by designing a reliable intelligent controller, it is possible to ensure there liability of the control signal can be trusted, it is possible to ensure the reliability of the control signal.

2. Methodology

2.1 EMG Measurement

It is possible to extract an electrical signal by attaching the electrode electrolyte is attached to the biceps and triceps for extracting the signal. Electrodes used for signal extracted is bipolar snap electrode (2-pole Electrode Shield Cable), and this electrode isa disposable pre-gelled electrode of Ag / Agcl (silver/silver chloride) is used[8]. Wecan measure the EMG by attach to the muscle. The block diagram for the signal measurement is Figure 1. The EMG signal is replaced with an absolute value via the DSP processor. This value is stored in the output as the muscle activity through the digital LP filter of 12Hz.

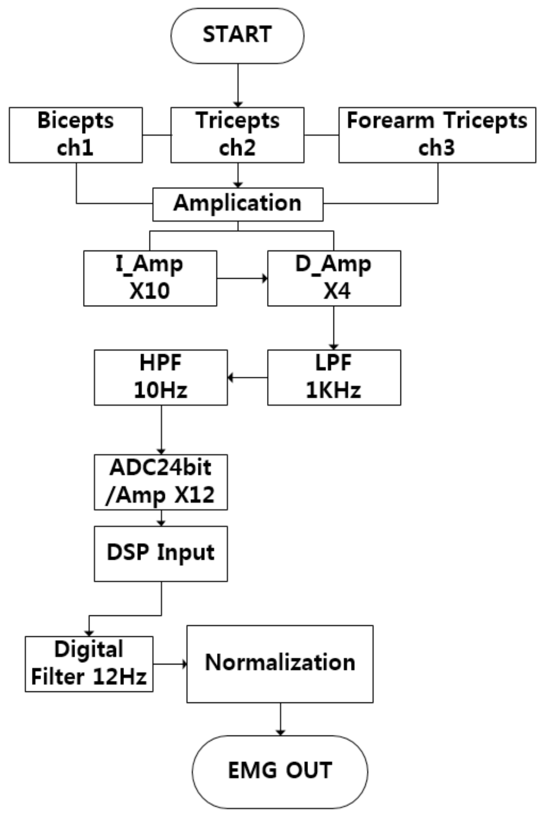


Figure 1. EMG extraction diagram.

We utilize the EMG signal from the biceps and triceps and forearm triceps. The output of the biceps and triceps are measured to show the EMG output when the muscles' concentric and eccentric contraction. And also forearm triceps measures in order to use the signals when lift up or down the shoulder. In order to verify the possibility of classification and similarity of pattern during muscle contraction, and selects the three muscles, position of muscle can be confirmed in Figure 2.

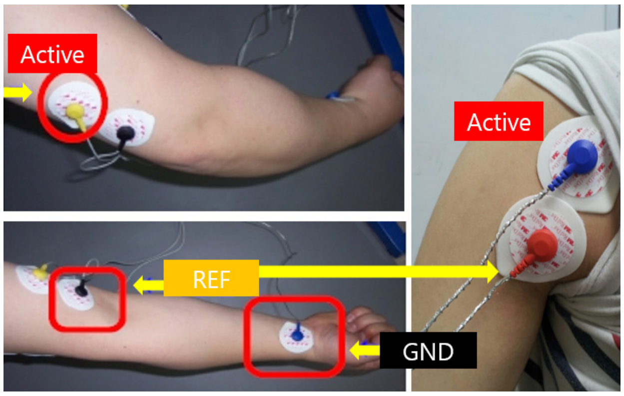


Figure 2. Sensing position of the electrodes and muscle attachment.

2.1.1 EMG Extraction Circuit Design

IIn order to measure the surface EMG, in this paper, we have developed the EMG sensor board directly.
Each board has a DSP unit for analog amplification circuit, to filter the EMG signal from the amplified data valid filter circuit, a digital signal processing for the input portion and the amplified analog data signal, respectively, the power supply and configure the external input and output ports was composed of a power supply circuit. EMG measurement data is implemented via the CCS compiler enables real-time transmission of the original signal via Bluetooth, and then in Figure 3 shows the appearance of the board used in this study to measure the EMG. Each module features are as follows:

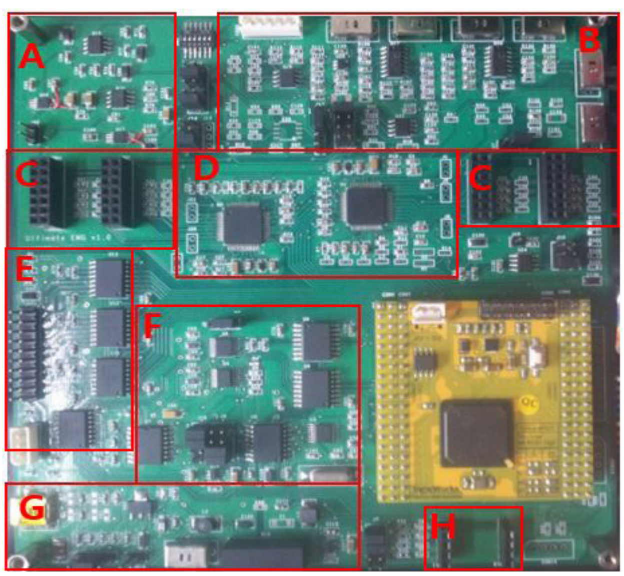


Figure 3. EMG control board.

Part A in Figure 3 generates REF 2.5V voltage and, used in a filter unit necessary for VGND 2.5V ADC. Part B is designed to extract only the signal in the 10 ~ 1000Hz to an analog filter circuit portion. Part C is an extension socket of the extracted signal. Since part B can be measured only 1CH EMG, which can be expanded up to 4 channels via an additional socket. Part D is additionally performs signal amplification process. Thus, it is responsible for the function of converting the analog data that has been filtered ADS1298 circuit into a digital signal. Part E was electrically insulated by using ISOLATION IC to the connecting portion of the motor and the encoder. EMG was additionally configured to connect the output of the motor and the encoder to take advantage of a particular system. Part F is configured to be able to analyze by sending an electromyogram data as a circuit for providing multiple communications to another subsystem. Part G is the part of the input power to the USB communication & USB board. Using a regulator and DC converter, to create VDD 5V and VDD 3.3V, and the DSP can be configured to apply power to the power that is isolated from the external power source. (It can drive board using battery) Part H was further configured to connect the device for Bluetooth communication with the Bluetooth socket. EMG measuring equipment is very important part of the circuit. In this paper, it is necessary to use as a controller of the control signals from the analysis of the near signal, in order to utilize the output of the signal, were utilized in manufactured directly without using an existing commercial equipment.

2.1.1 Data Extraction and Measuring the Reference Value

Extracting the data with existing algorithms, it is often difficult part is utilized as a control signal. Because severe changes with time, the amplification process of fine signals in order to take advantage of a linear control signal is necessary, it is necessary to analog filter processing to extract only certain EMG. Also requires the ADC output process of EMG, In this paper, we design the part of the AD converter circuit separately using 28346DSP chip. Amplification, amplifies the 10 times amp has a 4times amplification gain of the differential amplifier, so that the individually from the ADC portion of 12times amplification. Therefore, the amplification ratio of the total of 480 times showed amplifies from the raw EMG signal. For analog filter, the analog EMG data filtered using a band pass filter having a filter performance of 10~1000Hz is sampled at 2KHz through the ADC and input to the DSP. Preferentially, using the maximum and minimum values of the EMG data, and stores the user EMG reference data. Then EMG data has a generalization process based on the reference data. Reference value corresponding to the user, as the time goes, generally decreases, resulting in a change in the output value of the median frequency as a muscle's fatigue ratio increasing. Therefore, EMG output is changed when the load is increased by the high degree of fatigue increases the exercise. In order to design the control system using the EMG, it is necessary to adjust the output based on the user properly reference data measurements and experimental EMG signal. Reference data is shown in Equation (1). This reference data has been set relative to the maximum value that may occur with respect to a particular EMG output load. EMG output can be generalized on the basis of this value, This data is output at a rate of 0 to 100%, based on the maximum output value.

$$\mathbf{EMG[k]} = \frac{EMG_{Present}[k]}{EMG_{ref}[k]} \quad for\ k = 1,2,3,\ldots,n$$

EMGref[k] = EMG[k]max
EMGpresent[k] = Present EMG value(1)

3. Data Analysis

3.1 EMG Signal Output Form

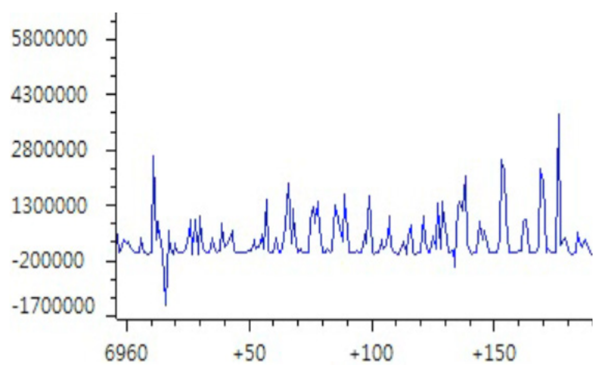
The signal extracted through the EMG circuit exhibits different characteristics depending on the meaning of the EMG signal processing method.After being obtained source material (Raw data) preferential rectified (Rectification) through the EMG system, the smoothing process (Digital Smoothing, Moving Average, Root Mean Square) to perform tasks that go through. These data can be processed and utilized several forms like the maximum value at the maximum autonomous contractions(MVC), integrated values of the near-activity time (IEMG), an average data (AD), maximum value and the median value, the slope change in the integrated value (Integrate slope), density reaches a threshold level (Integrate to preset voltage) such as can be utilized. In this study, The EMG signal is extracted based on the time to be started the concentric contraction of user. This signal has aprocess of rectifying, so that adding the 0 or less of the signal through the smoothing for making the real EMG signal. After that we get the data at a sampling frequency of 2KHz EMG signal. Each data is stored as an operation unit, and can be interpreted as the mean and median values, maximum value. In this paper, we use the MAX value of EMG signals from a number of outputs. Data input through the ADC is subjected to a generalization process based on the reference data. Since the output system continuously stores the data, and outputs a change form according to the user's movementas a graph. EMG Electromyography initial measurement system outputs a signal according to the user's reference and expresses the EMG of the output according to the user's movement.

Through the electromyography measuring system, raw data (after changing absolute value) measured in each muscle, show up as shown in the following Figure 4 (a). Rectification and smoothing process shown in Equation (2), the original signal data is converted to digital filter. Digital filter is applied by 12Hz low pass filter to fit the specifications of the designed circuit raw EMG signalis difficult touse as a control signal. Therefore, the state of the muscles EMG data through a digital filter should be changed so as to numerically converted. The signal of EMG before digital filtering and linear envelop signal with digital filter to 12Hz are shown in Figure 4.

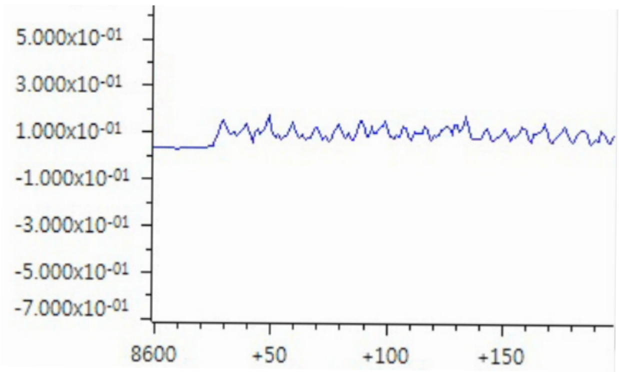
$$EMG_Y[n] =$$

$$EMG[n-1] + 2\pi f_L T(EMG_X[n] - EMG[n-1]) \quad 2$$

EMG_Y = Result EMG value
EMG_X = Analog filtered Raw EMG value
n = Sample Number
T = Sampling Frequency
f_L = Filter Frequency



(a) Raw data of EMG



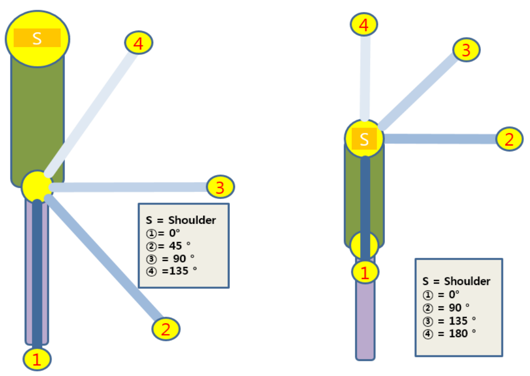
(b)Filtering Data of EMG

Figure 4. Raw EMG signal and digital filtering signal.

3.2 Type of the Extracted Signal Classification

3.2.1 *The Output signal of Bicepts*

Figure 5 shows the angle of the arm for EMG output experiment.



(a) bicepts&tricepts (b) forearm tricepts

Figure 5. Experimental operation..

After updating the reference signal, we check the EMG output when the biceps and triceps, forearm triceps output is no load, it is possible to confirm the output of the biceps in Figure 6.

Figure 6 (a) ~ (c) shows the measured output at the biceps EMG with no load. The output of the biceps was repeatedly measured 10 times, depending on the angle of arm. The output of the biceps is shown to increase the characteristic time for the operation according to the folding arms, when returned to the previous state, returns to the state of the EMG signal completely out stretched arms. EMG amplitude increment is increased depending on the angle, the output is displayed in a specific range. The output of biceps EMG is increase until a specific value that reflected by the user's lift up intention, and then decrease at the initial point of lift down to zero. Shows that the amplitude is increased and decreased in accordance with the user's operation with respect to time for relaxation and contraction.

3.2.2 *The Output signal of Triceps*

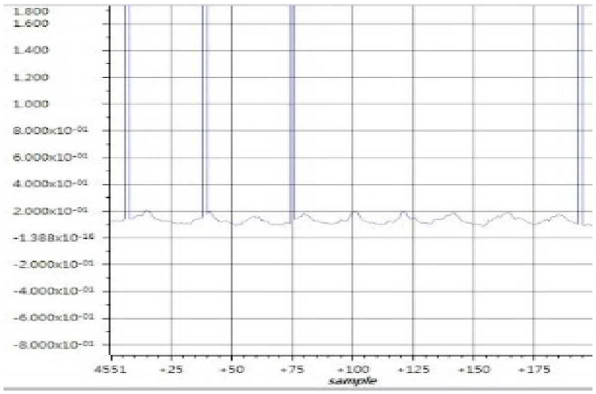
Figure 7 shows the output form of thetriceps. In the no load, the output signal of the triceps varies based on the location of the arm depending on the angle. This output is smaller than the biceps in the amplitude and changing rate, but it has a linearity feature about the muscle contraction.

3.2.3 *The Output Signal of Forearm Triceps*

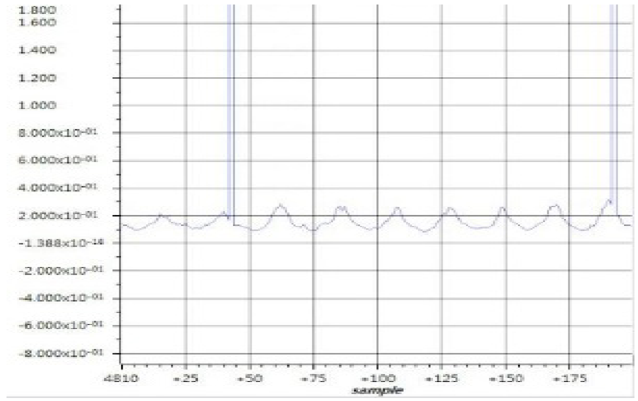
Figure 8 shows the outputof the forearm triceps. If it is raised, as shown in Figure 5. (b) from 0°, its hows the output of the EMG of the forearm triceps according to the angle.When lifting the upper limb of this muscle, the output is increased. The change of output is a constant corresponding to the angle of arm as compared to the biceps. Also, if there is a small influence of the upper limbs, the use of the output signal is very independent. Therefore, when the operation of use of the upper limb is increased, it is possible to express the intention ofthe user through the activity of the muscle.

3.3 Signal Analysis and Result

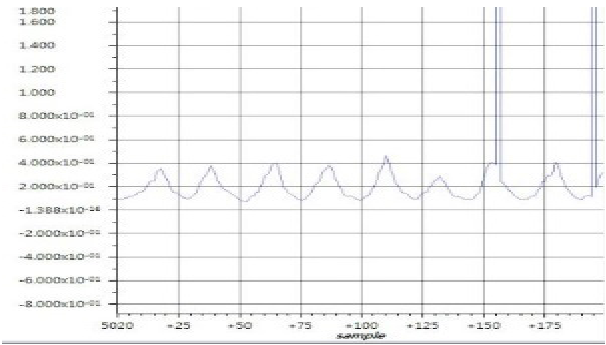
Because the EMG signal output characteristic is very complex, so we need to some kinds of essential process like filtering, amplication for to use control signal of specific system. It is possible to know that output characteristic about the user's intention appears linearized form through the measurement system. The addition output of the triceps on the basis of the output data of the biceps, it is possible to determine the user's intention more accurately. Angle of the arm through the distribution of the data can be estimated. Figure 9 shows the result of comparing the two outputs. The output of the EMG in response to the angle doesnot fully draw linear, it is possible to express the arm operation depending on the degree of muscle contraction. In addition, when the output of upper limb forearm triceps motion is added, it is confirmed that possible to apply the result for determining the user's intention.



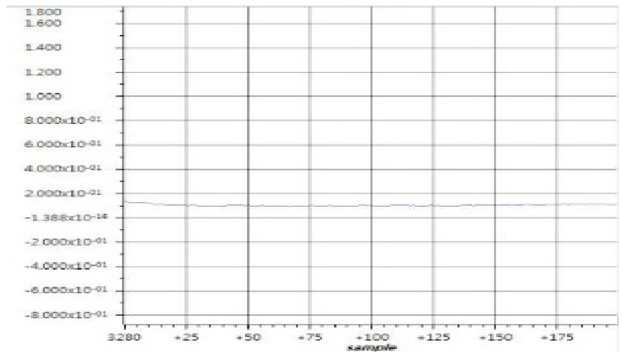
(a) no load 45°



(b) no load 90°

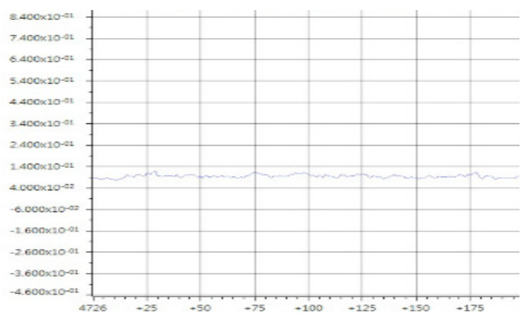


(c) no load 135°

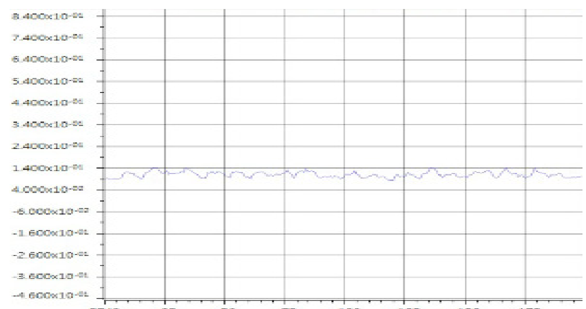


(d) no load 0°

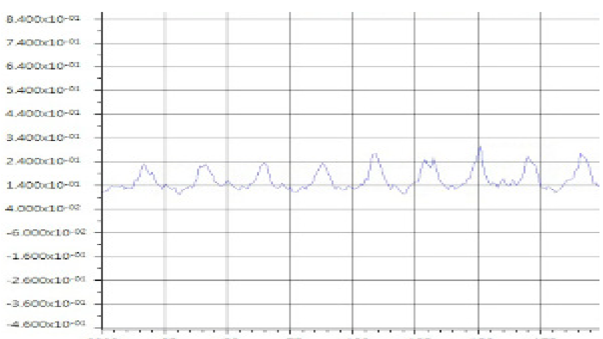
Figure 6. No-load output of the biceps EMG.



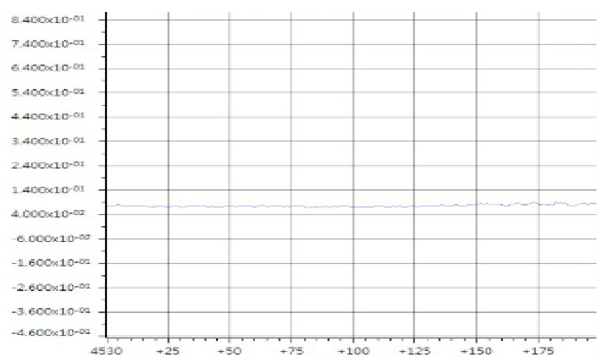
(a) no load 45°



(b) no load 90°

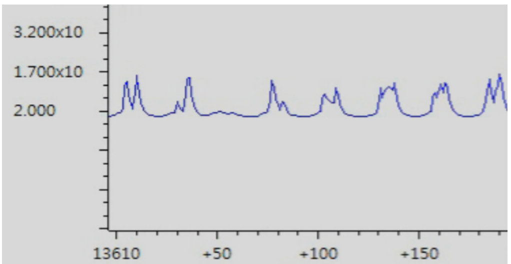


(c) no load 135°

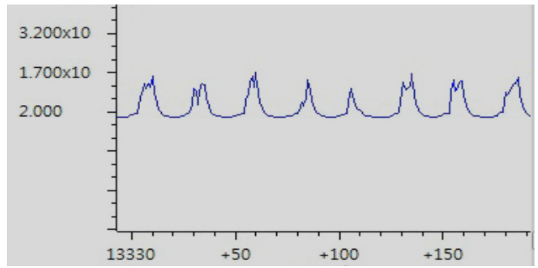


(d) no load 0°

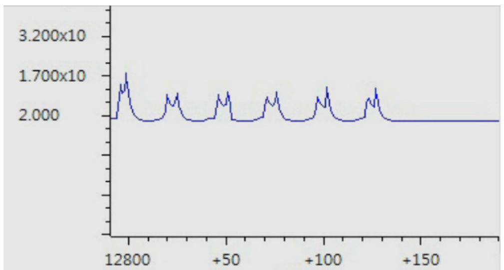
Figure 7.



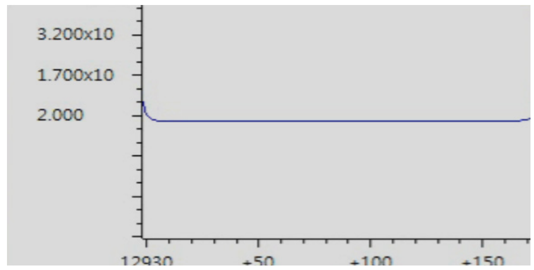
(a) no load 180°



(b) no load135°



(c) no load 90°



(d) no load 0°

Figure 8. No-load output of the forearm triceps EMG.

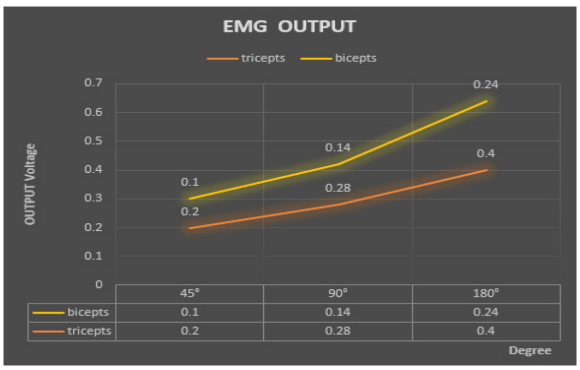


Figure 9. EMG output compare results.

4. Conclusion

Through this study, we will show the possibility of judgment of user intention with EMG signal of muscle by inducing the linearity of output, and it was confirmed thatit is possible touse as a control signal for another system. In order todrive the specific system through the signal, we need to create an appropriate algorithm to support the unstable linearity, and such as the exoskeleton robot arm is required to apply the controller. Further, in the present study, we analyzed the EMG signal through the output when there is no load. Change of the load generates a change in the output EMG. This change is more non-linear than the outputchange of the operation the change in load, it is by possibleto make a system applied predicting the user's intention that can be driven more accurately.

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