OWI-535 EDGE Robotic Arm Control using ElectroMyoGram (EMG) Signals

Shobhitha Ann Job, R.Jegan, Melwin Abraham C

Abstract— As science advances day by day, people rely upon technology for their assistance. Compared to older days, people who are handicapped and who have disabilities of limbs due to old age have been increased today. Several availabilities have been introduced by the new technology to overcome this problem. One of the best options among them is the human-assisting robot . These robots can be controlled by a human in different ways. An Electromygraphy (EMG) is a signal which is produced due to the electrical activity when muscle contracts. These signals can be used as control signals for serving the robot. In this paper, a pick and place robotic arm is controlled using the EMG signals acquired from the arm of the user in real time. EMG signals are acquired from the forearm of the user with the help of surface electrodes attached to the user's skin. It is found to be more robust when compared to other ideas.

Index Terms— Electromyographic (EMG) signals, LabVIEW, Robotic arm, Root Mean Square (RMS) value

I. INTRODUCTION

In the present era, robots find their usefulness in many fields. While considering several studies we can see that the human-robot interface has been proposed for many purposes. Most of the previous work proposes complex mechanisms where the user should be trained to map his/her action to the motion desired for the robot. In this paper, a new means of control interface is proposed, in which the user performs natural motions with his/her hand. Surface electrodes record the Electromyography (EMG) activity of the muscles of the forearm by placing them on the user's skin. The recorded muscle activity was processed so that they are used to control the robot arm. We use a pick and place edge robotic arm which moves according to the human arm movements.

EMG signals have often been used as control interfaces for robotic devices specially robotic arms. However, since the EMG signals are non-stationary signals, only discrete control has been realized. While going through the earlier studies, we can see that some people developed an upper-arm EMG-based robot control system using the adaptive neuro-fuzzy inference system (ANFIS) [1].Others considered the hand-arm robotic system using haptic technology[3],which has data Glove with flex sensors and Micro-Electro Mechanical System (MEMS). Other was a prosthetic finger system based on the EMG signals and uses the Hilbert transform [5]. As in [6], some designed robotic arm with four degrees of freedom in which servomotors are used. Here the input is given using arm made of polycarbonate fitted with potentiometers with a certain angle of rotation. Kyriakopoulos and Artemiadis [7] proposed an EMG-based position and force control scheme for robot arm which had training and real time phases.

In this paper, real time control of robotic arm using surface EMG signals is proposed. The signals are taken from the forearm of the user and processed to give control signals to the robotic arm. As trial procedure, a training process was done by collecting EMG signals from the forearm of different persons who are having similar features (height, weight etc). After processing these signals calculated the range. In the next step robotic arm was controlled by the EMG signals in real time.

II. METHODOLOGY

A. Problem Definition

The EMG signals are non stationary signals which are complex in nature. These signals can be used for interfacing the human with the robotic devices. In this paper, a human-robotic arm interface is proposed using the EMG signals from the human arm. The EMG signals are used for controlling the robotic arm. For simplifying the work only two movements, that is, flexion and extension are considered.

An EMG signal represents the electrical activity of the muscle because of the potential difference due to muscle contraction when the electrode is placed. The amplitude of the electrical signal generated by the activation of the muscles depends upon the velocity of muscle contraction, the angle of muscle pull when it contracts and the force applied to move the joint. Fig.1 represents the proposed model for the human-robotic arm interface.

Here, using the EMG signals a robotic arm is controlled in real time. For this task accomplishment, as in Fig.1, the initial step is to acquire the EMG signals from the fore arm of a person. Here, surface electrodes are used to collect the EMG signals from different persons. They are asked to do the two motions, flexion and extension, each for a time duration of 10seconds. This process was repeated 10 times. These signals are then processed in the LabVIEW software. The corresponding digital values are given to the robotic arm and thus it is controlled in real time. In order to control the robotic arm we have to extract the features of the signal. The features can be Root Mean Square value (RMS), Mean Absolute Value(MAV),Variance etc. Here we are calculating the RMS value of the signal to obtain the control signals.

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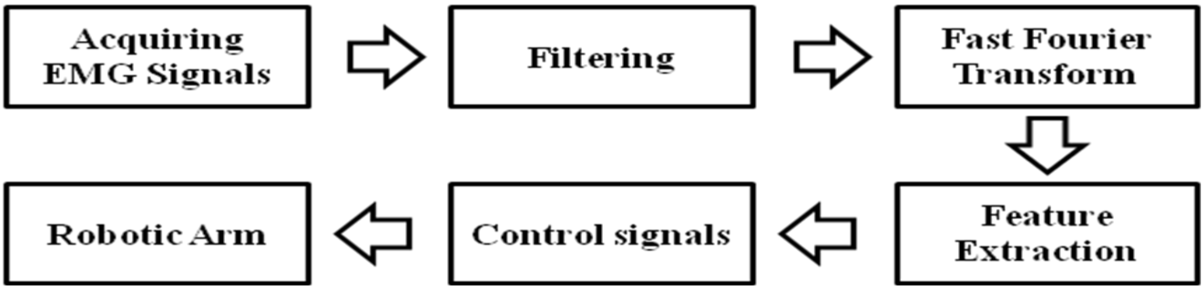

Fig.1 Proposed system model for the human-robotic arm interface

B. Filtering

The raw EMG signal usually ranges from 20Hz to 500Hz. Inorder to acquire those signals we use a Butterworth band pass filter with order 6 with cut-off frequencies ranging from 20Hz to 500Hz.

There are different artifacts which affects the EMG signals and changes its features. Line interference is the most common artifact. It comes from the power line. Inorder to remove this, we use a bandstop filter with cut-off frequencies ranging from 49Hz to 52Hz.

C. Fast Fourier Transform

The continuous signals obtained should be sampled. Here we are using Fast Fourier Transform(FFT). FFT is an algorithm to compute the discrete Fourier transform (DFT) and its inverse. The DFT is obtained by decomposing a sequence of values into components of different frequencies. This operation is useful in many fields but computing it directly from the definition is often too slow to be practical.

Windowing is applied while doing the FFT. Windowing of a simple waveform causes its Fourier transform to develop non-zero values at frequencies other than the specified frequency ω. The Hanning window is used. The Hann function is used to select a subset of a series of samples in order to perform a Fourier transform. FFT-based spectral computations assume that the finite block of signal data represents one period of a periodic signal. The computed spectrum of this effective periodically extended signal shows energy spreading into frequencies that were not present in the original signal. To reduce this spectral leakage, we use smoothing windows to taper the sharp transitions in the effective signal.

D. Root Mean Square (RMS) value

The RMS value is the square root of the arithmetic mean of the squares of the set of values. It can be described as the statistical measure of the magnitude of a varying quantity, here, the EMG signals. This will help to find the digital values required for the robotic arm control. The RMS value is calculated for the samples taken from different persons. Then the range of the value is computed. Let Xn represent the samples then RMS is given by ,

$$\mathrm{RMS} = \sqrt{\frac{1}{N}\sum_{n=0}^{N-1} Xn\,^2}$$

F. Overview

For the completion of the task of human-robot interface, the first step is to acquire the EMG signals from the person.Surface electrodes are usedfor this purpose. These surface electrodes are attached to the fore arm and thereby extracting the signals using Biokit-EMG amplifier. It filters and amplifies the EMG signals. We can acquire these signals using the National Instruments 2120 DAQ. After acquiring EMG signals, they should be processed. Here, LabVIEW software is used. After converting the features to digital values it should be given to the robotic arm. Again the 2120 DAQ is used to give the digital values corresponding to the EMG signals to the driver circuit. The driver circuit made of L293D controls the robotic arm consists of five motors. Each motor can be driven using the driver circuit by giving the digital values. Thus the movement of human arm controls the robotic arm virtually in real time. The block diagram of the system is shown in Fig.2.

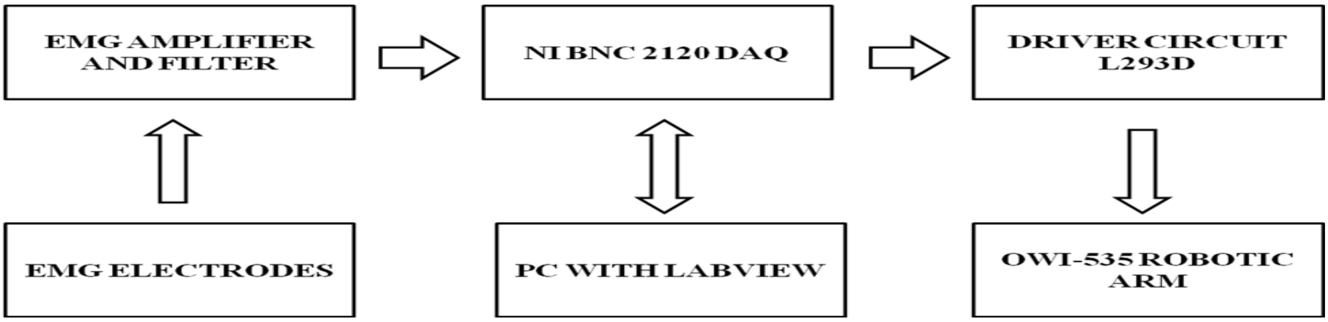

Fig.2 Block Diagram of the EMG-based robotic arm control

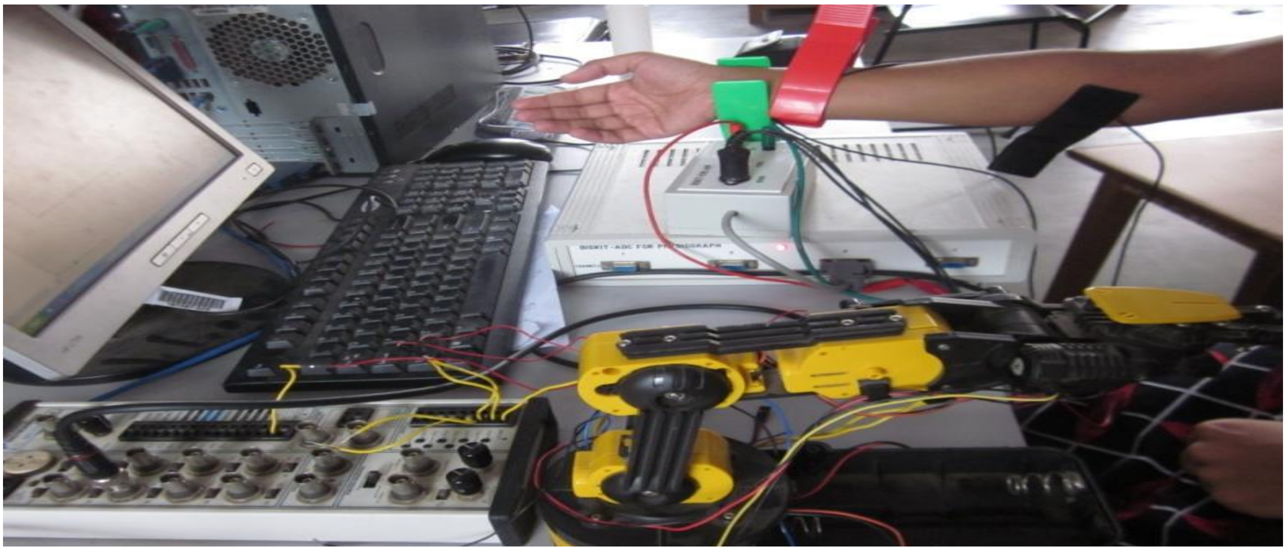

Fig.3 Experimental setup of the proposed system

III. EXPERIMENTS

At first, the surface electrodes are attached to the person's skin of the fore arm. This is accomplished by using conductive gel, and a conductive metal electrode. The electrodes are connected to the Biokit-EMG Amplifier. After collecting the EMG signals, the amplifier which amplifies the EMG signals. The NI 2120 DAQ is used to acquire the EMG signals from the arm. The LabVIEW software process these signals. The processed values of the signals, which are digital in nature are taken from the digital pins of the of the 2120 DAQ. These digital values are given to the the robotic arm through the driver circuit made of L293D which drives the DC motors and thereby moving the robot. Fig.3 shows the experimental setup.

A. Hardware

The Biokit EMG Amplifier is used to collect the EMG signals from the human. It has disk electrodes and an amplifier. The detection of the signals is done with the help of these surface electrodes. The three electrodes can be attached to the fore arm after applying the surgical gel to the particular positions. One electrode act as the ground and the other two electrodes detect the voltages. The amplifier amplifies these signals.

The NI BNC-2120 is a shielded connector block with signal-labelled BNC connectors. Here the DAQ is used to acquire the EMG signals as well as for giving control signals. The L293D driver circuit can be used to drive two DC motors (Motor A & B) or one stepper motor. The voltage at which the required for the motors are provided to the board through the connector marked Power Input. The two DC motors to be driven should be connected to Motor A and B terminals. To drive a motor, the Enable pin (En x) should be provided a logic high (5V). The direction of the motors is controlled by the other two input pins. The values for these input pins are given by the DAQ. OWI-535 EDGE robotic arm is a pick and place arm. It uses DC motors for the movement of the positions. It consists of five motors. Each one for gripper, wrist. elbow, base and for base rotation respectively. The features of them are as follows: The gripper can open and close, the wrist gives a motion of 120 degrees, the elbow range is of 300 degrees, the base rotation is of 270 degrees, and the base motion is of 180 degrees. In our system we are considering only two motions. Each motor is controlled by the digital signals provided by the software via the driver circuit.

B. Software

LabVIEW is a graphical programming language that uses icons instead of lines of text to create applications. LabVIEW can be defined as dataflow programming, where the execution is determined by the flow of data. In LabVIEW, we build a user interface with a set of objects and tools. The user interface is called as the front panel. We then add code using graphical representations of functions to control the objects in the front panel . The block diagram contains the code for front panel.

The signal processing is done in the LabVIEW software. The feature extraction, that is, the RMS value is computed in the LabVIEW. By comparing those values, digital values corresponding to the EMG signals for the movements are produced. These digital values are used for interfacing the robotic arm with the human arm.

C. Results

The EMG signals for the flexion and extension movements were collected by attaching the electrodes to the forearm. Three persons with similar features were considered. The EMG signals were filtered using bandpass filter and notch filter inorder to remove the noise present in the signals and to get the useful signals.

The RMS feature was calculated using the Fast Fourier Transform (FFT). Thus we were able to find the range in which the movements can be differentiated as flexion or extension. In Fig.4 the front panel of the system is shown.

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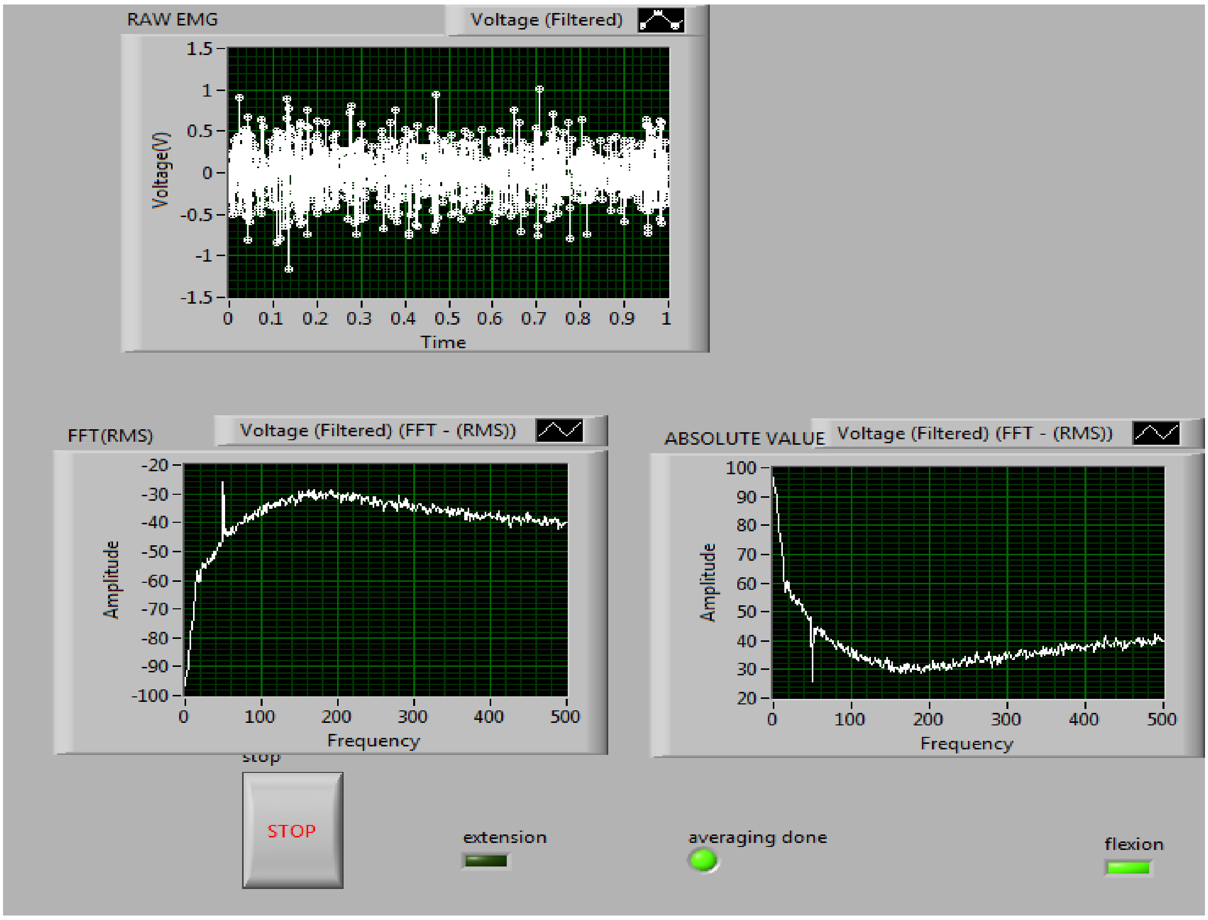

Fig.4 Front panel for robotic arm control

IV. CONCLUSION

This paper presented the controlling of EDGE Robotic Arm using the EMG signals. Via FFT, the RMS values for the flexion and extension were determined in LabVIEW.. These values were used to give the control signals to the robotic arm. As the future work, we are using microcontroller instead of DAQ by considering multiple motions of the human hand.

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