2012 2nd International Conference on Power, Control and Embedded Systems

Movement Control of Robot in Real Time using EMG Signal

Sachin Sharma, Avinash Kr. Dubey

Abstract-- **The Electromyogram signals or EMG signals are generated whenever there is any muscular activity. These signals can be detected easily over the surface of the body. The surface EMG signal detected from voluntarily activated muscles can be used as a control signal for functional neuromuscular electrical stimulation. Muscle signal (EMG) based switching systems may be an option for people who retain some ability to contract certain muscles but may not be able to operate a mechanical switch. This may be because the particular muscle that can be contracted is not suitable for operating a switch or because the muscle contraction is not strong enough to operate the switch. A proper positioning of the recording electrodes in relation to the stimulation electrodes, and a proper processing of the recorded signals is required to reduce the stimulus artifact and the non-voluntary contribution. As these signals are generated whenever there is any muscular activity, so, we can recognize any muscular activity made by the human by measuring the amplitude of the signal. Based on decision made upon the amplitude of the EMG signal we can take many decisions or we can make machine of our interest. In this paper we have made a real time machine which can classify the muscle activity between two actions: relaxed position and contracted position. The prototype hardware has been tested and verified for the working in real time**.

Index Terms-- AVR Microcontroller; EMG; LabView; NI-Elvis;

I. Introduction

Around the world, there are a large number of persons with amputation due to war, disease and accidents [1]. There are many difficulties in their daily life, so it needs to design a prosthetic control device such as control nature, easy to use, the signal stability and painless to solve the problem. Surface electromyography (SEMG) is a kind of bioelectric phenomena as muscle activity associated on the skin surface, which contains an abundance of muscle movement information. SEMG can record muscle biological signals on the surface skin by electrode when the muscle movement [2]. Because of the control signal is derived from the prosthesis surface of the skin of the patient's own biological signals, the SEMG is a source of painless, steady and continuous prosthetic control [3]. For example, it is used in the mechanical arm by EMG application [4] and is used in upper limb prosthetic by control of SEMG [5]. In this paper we have developed the system which classify between the two actions of the hand whether relax or contracted in real time and generates the corresponding commands and move the robot accordingly.

II. Nature of EMG Signal

The bioelectric potentials associated with muscle activity constitute the electromyogram, abbreviated EMG. In other way we can say the contraction of the skeletal muscle results in the generation of action potentials in the individual muscle fibres, a record of which is known as electromyogram. In voluntary contraction of the skeletal muscle, the muscle potentials range from 50 µV to 5 mV and the duration from 2 to 15 ms. The values vary with anatomic position of the muscle and the size and location of the electrode. In a muscle, the intensity with which the muscle acts does not increase the net height of the action potential pulse but does increase the rate with which each muscle fibre fires and the number of fibers that are activated at any given time. The amplitude of the measured EMG waveform is the instantaneous sum of all the action potentials generated at any Some important details of EMG signals are given in reference [6-7]. Since, most EMG measurements are made to obtain an indication of the amount of activity of a given muscle, or a group of muscles, rather than of an individual muscle fibre. The EMG pattern is usually a summation of the individual action potentials from the fibres constituting the muscle or muscles being studied.

Because these action potentials occur in both positive and negative polarities at a given of electrodes, they sometimes add and sometimes cancel. Thus, the EMG waveforms appear very much like a random noise wave form [7]. Figure 1 shows the picture of row EMG signal taken from the amplifier hardware designed for making the real time prototype.

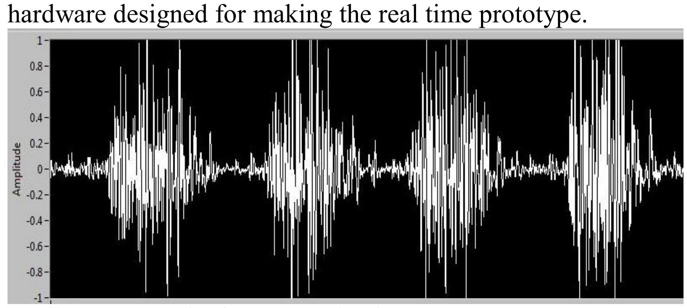

Figure 1. Example of Row EMG signal

As shown in figure these EMG burst can be easily identified and shows that during the burst interval of EMG signal there is a muscle contraction. We can use this information to design a system which will make any device active when the muscle will be contracted.

Sachin Sharma is with the Department of Instrumentation & Control Engineering, NIT Jalandhar, Punjab-144011, India (e-mail: glasachin@yahoo.co.in).

Avinash Kr. Dubey is with the Department of Electrical Engineering, NIT Kurukshetra, Haryana-136119, India(e-mail: dubeyavi.ec@gmail.com).

In this paper we have designed and implemented a real time operated prototype of the robot. This prototype includes custom made EMG amplifier and a prototype robot. The signal is taken from the amplifier on labview using NI DAQ card NI-ELVIS. Signal is further processed on the labview in order to extract the information from the EMG signal. After processing the signal further commands were sent to the robot prototype through serial communication using RS232 protocol.

III. Acquisition of EMG Signal

For the EMG acquisition, group of muscles involving reciprocal movements were targeted. The flexor-pronator v. extensor-supinator group was selected due to their isolation to movement of the arm as a whole and the close relation to the hand muscles [8].

A. EMG Electrodes

The EMG can be measured by applying conductive elements or electrodes to the skin surface, or invasively within the muscle. Surface EMG is the more common method of method of measurement, since it is non-invasive and can be conducted by personnel other than medical doctors, with minimal risk to the subject [9].

Measurement of surface EMG is dependent on a number of factors and the amplitude of the surface EMG signal (sEMG) varies from μV to the low mV range. The amplitude and time and frequency domain properties of the surface EMG signal are dependent on factors such as [9]:

- The timing and intensity of muscle contractions
- The distance of the electrode from the active muscle
- area
- The properties of the overlaying tissue (e.g. thickness of
- overlying skin and adipose tissue)
- The electrode and amplifier properties
- The quality of contact between the electrode and the
- Skin

Two types of surface electrodes are commonly in use. The first one is dry electrodes in direct contact with the skin and the second one is jelled electrodes using an electrolytic jell as a chemical interface between the metallic parts of the electrode [9].

Jelled electrodes uses an electrolytic jell as a chemical interface between the skin and the metallic part of the electrode. Oxidative or reductive chemical reaction take place in the contact region of the metal surface and the jell. Silver-silver-chloride (Ag-AgCl) is the most common composite for the metallic part of gelled electrodes. The AgCl layer allows current from the muscle to pass more freely across the junction between the electrolyte and the electrode. This introduces less electrical noise into the measurement, as compared with equivalent metallic electrodes (e.g. Ag). Due to this fact, Ag-AgCl electrodes are used in over 80% of surface application [10].

Jelled electrodes can either be disposable or reusable. Disposable electrodes are the most common since they are very light. Disposable electrodes come in a wide assortment of shapes and sizes, and the materials comprising the patch and the form of the conductive jell varies between manufacturers. With proper application, disposable electrodes minimize the risk of electrode displacement even during rapid movements.

Figure 2. Disposal Jelled electrodes

In our experiment for the acquisition purpose of the EMG signal we have used disposal jelled electrodes. Figure 2 shows the picture of the electrodes used in our experiment.

B. Biomedical Amplifier

In this experiment of making an real time EMG controlled robot, we designed and implemented a biomedical amplifier [11], which was used to amplify the EMG signal to appropriate level so that it could be detected by the data acquisition device.

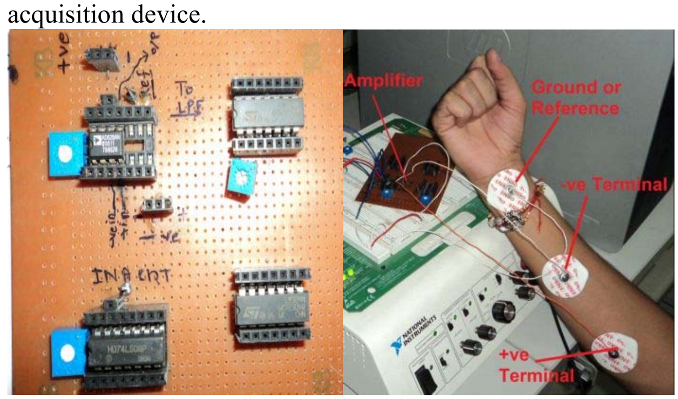

Figure 3: 2-channel Biomedical Amplifier and Connections

In this amplifier we have used two instrumentation amplifier IC's AD620, in order to make it two channel amplifier. Band pass filter and low pass filters were implemented on the hardware in order to make the signal band limited. Figure 3 shows the self-made biomedical amplifier and wire connections from signal acquisition place to the amplifier.

C. Data Acquisition System (NI-ELVIS)

DAQ systems capture, measure, and analyze physical phenomena from the real world. Light, temperature, pressure, and torque are examples of the different types of signals that a DAQ system can measure. Data acquisition is the process of collecting and measuring electrical signals from transducers and test probes or fixtures, and sending them to a computer for processing. Data acquisition can also include the output of analog or digital control signals.

We used National Instruments NI-ELVIS data acquisition hardware for the acquisition purpose. NI-ELVIS uses LabVIEW-based software instruments, a multifunction DAQ device, and a custom-designed bench top workstation and prototyping board to provide the functionality of a suite of common laboratory instruments. Figure 4 shows the picture of NI-ELVIS.

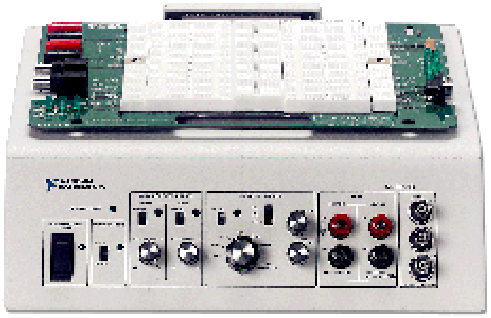

Figure 4: NI-ELVIS

The NI ELVIS hardware provides a function generator and variable power supplies from the bench top workstation. The NI ELVIS Traditional LabVIEW soft front panel (SFP) instruments combined with the functionality of the DAQ device. In addition to the SFP instruments, NI ELVIS Traditional has a set of high-level LabVIEW functions, which we can use to customize our display and experiments, to control the NI ELVIS workstation from LabVIEW. The NI ELVIS workstation is designed to work with National Instruments M Series DAQ devices, which are high-performance, multifunction analog, digital, and timing I/O devices for PCI bus computers. Supported functions on DAQ devices include AI, AO, DIO, and timing I/O (TIO).

IV. Prototype autonomous robot

In this paper we made simple robot hardware based on microcontroller. It consists of AVR microcontroller on board. AVR microcontroller works as the brain for this device and receives the commands given from the computer. We have attached two d.c. motors to it to provide the movement to the robot. There are two separate power supplies one drives the microcontroller and other drives the d.c. motors. It communicates with the computer through RS232 serial communication protocol. In order to make the commands compatible to the computer we used MAX232 IC, that converts the voltage levels of logic '1' and logic '0'. Figure 5 shows the picture of the robot.

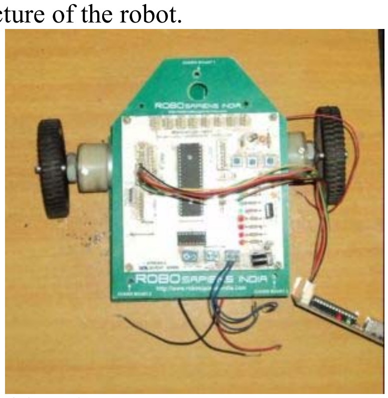

Figure 5: Photo of the Robot

The code for receiving the commands and then performing the desired operation is written in embedded C [12] and is loaded into the microcontroller. The code logic is like, If there will be '1' coming from the computer then it will move in the forward direction when there will be '0' coming from the computer the motors will stop and so as the robot will stop.

V. Result

Overall the results of the implementation of the EMG classification system were rather satisfactory. A functional demonstration of the prototype system demonstrated the ability to continuously classify the EMG signals recorded from the forearm of a subject. Based on qualitative observations, the response of the classification seemed a little delayed but satisfactory. Figure 6 shows the complete setup for the EMG signal recording and controlling.

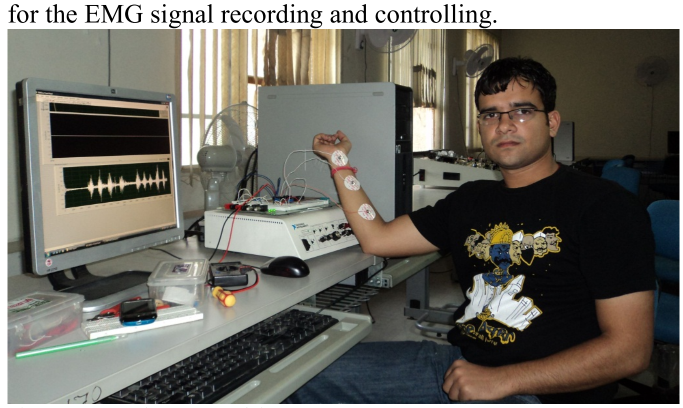

Figure 6: Complete setup of the system

EMG signal taken from the NI-ELVIS DAQ card was recorded and displayed on the LabView. The algorithm for classifying the EMG signal and then converting those decisions in the form of commands was made on LabView itself. The program for sending the commands to the microcontroller via serial communication was also made in LabView.

Figure 7 shows the recorded waveform of the EMG signal. First we made the algorithm in Matlab then by using matlabscript node available in Labview we write the Matlab code into it and called the algorithm written in Matlab through Labview.

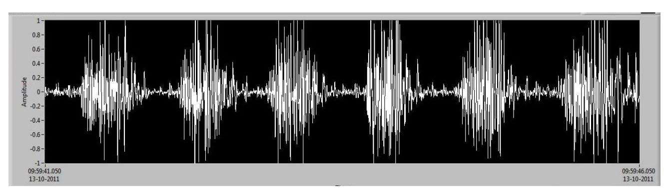

Figure 7: Recorded Waveform on LabView

The algorithm uses the concept of envelop detector which converts the burst of EMG signal into the wave envelop after passing through the low pass filter. This envelop can be converted into pulse of 0's and 1's via thresholding. The program then transmits 1 to the microcontroller when it encounters 1 in the output pulse and transmits 0 to the microcontroller when it encounters 0 in the output pulse. Microcontroller receiving on those commands works accordingly and move robot forward when it receives 1 and stops it when it receives 0. Figure 8 shows the output of the algorithm developed. Figure 9 shows the block diagram made for the controlling of robot in real time.

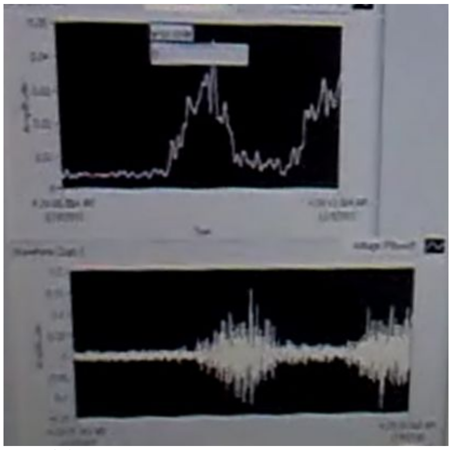

Figure 8: Output of the program

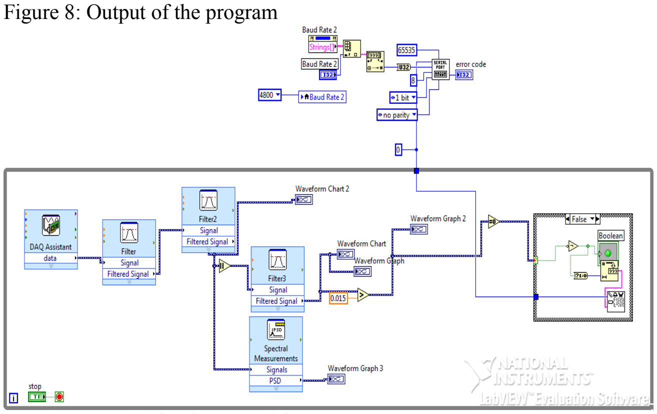

Figure 9: Block Diagram of the Program

A. Discussion on the results

These results have been verified by my guide Mr. S.K. Pahuja sir. The algorithm and labview program worked well in normal conditions but when we go for other subject the same value of the threshold doesn't work hence we have to go for some adjustment. This is primarily due to the fact that amplitude of the EMG signal is not fixed to the defined value of voltage. It depends upon the many factors like strength used to contract the muscle, electrolyte jel etc. The program was quite capable of classifying the two action of the hand.

VI. Conclusion & Future works

In this paper a real time machine prototype based on surface EMG signal has been tested and implemented. The result and working of the machine has been verified and were satisfactory. In future work will be done in order to increase the classifying capability of the machine. There are various tools like wavelet analysis, AR modeling which can be used in analyses of the EMG signal. We will put our efforts to remove the dependency of the machine on the varying nature of the EMG signal and we will try to make a machine which can be suited for various persons without any considerable changes. We will try to make this machine adaptive in terms of the amplitude of the EMG signal.

VII. References

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