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Real-Time Hand Gesture Recognition and Device Controlling System based on sEMG Signal

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ABSTRACT

A large number of impairments and disabilities in human body are increasing day by day because of different reasons like accidents, age, paralysis attack, etc. So disabilities increase in human body and also dependency on other people the quality of life decreasing day by day. The disabled or aged people need caretaker to take care of them and to help them to do movement. So, they always need someone around them to take care of them. To improve the quality of life of the disabled or aged people researchers think on the necessity of simple and natural human-machine control interface. The EMG based hand gesture can help to develop good machine interface that increases the quality of life of the disabled or aged people [5]. Different biomedical signals acquired from tissues, organ or cell system like the nervous system in human body for gesture recognition. The biomedical signals include Electro-Encephalogram (EEG), Electrooculogram (EOG), and Electromyogram (EMG). To develop simple, user friendly, robust, efficient interfacing systems or devices for the disabled sEMG signals are used. A sEMG signal based controller or interfacing system enables the physically disabled or aged people to use personal computer, prosthetic devices, robots etc. This paper presents an embedded platform for real-time hand gesture recognition and device controlling system based on sEMG signal. Firstly sEMG signal is acquired from human body and then the from acquired signal hand gesture is recognized. By using the recognized hand gesture the disabled or aged people control different devices like home appliances, wheelchair, etc. Hand gesture recognition and device controlling system based on sEMG signal is user friendly and easy to build system.

Keywords: - Surface Electromyography (SEMG), Quality Of Life (QOL), hand gesture recognition, human machine interface.

INTRODUCTION

Electromyography is the measure of electrical activity produced by the muscle tissue cells occurring during voluntary contraction. Small electrical current is produced by muscle fibers. These currents are produced by the exchange of ions across muscle fibers [8]. The EMG signal can be measured by applying electrodes on the skin surface or invasively within the muscle. Surface EMG is the most common method of measurement. The resulting electrical activity can be acquired by using surface electrodes which are placed on the skin surface and appropriate signal conditioning circuitry. Surface EMG signal measurement is dependent on a number of factors and the amplitude of sEMG signal which varies from the microvolt to millivolts range. The sEMG signals are depends on factors such as the timing and intensity of muscle contraction, the distance of the electrode from the active muscle and the quality of contact between skin and electrode. The recognition of muscular activity is based on threshold detection. Fig. 1 gives idea about different hand gestures.

EMG based hand gesture recognition is basically works on the concept on surface electromyography signal. The sEMG signal is capture by electrodes which are placed on the skin surface and then acquired by using signal conditioning circuit or data acquisition unit. Then the acquired signal is plotted in the form of graph. Then based upon the acquired signal the hand gesture is recognized. The surface EMG signal based hand

gestures are used for different applications such as controlling the different devices, computer interface and control robot [6]. EMG acquisition and hand gesture recognition mainly divided into three elements: electrodes, data acquisition system, data recognition and controlling system. For capturing signal from hand different types of electrodes can be used. But in this silver-silver chloride (Ag-AgCl) electrodes are used for capturing EMG signal [8]. The ionic current produced by muscle is converted into electronic current with Ag-AgCl electrodes placed on the skin surface [5].

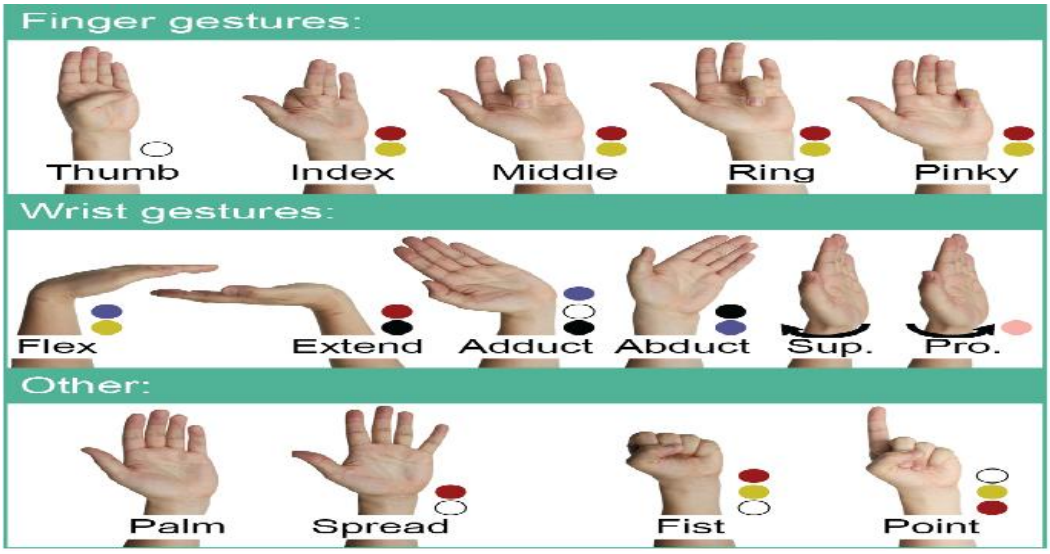

Fig. 1: Different Hand Gestures [5]

METHODOLOGY

The surface EMG acquisition and hand gesture recognition is an electronic platform for hand gesture recognition which recognizes the hand gestures & controls the device. The block diagram of EMG acquisition and hand gesture recognition is shown in Fig. 2.

In above Fig. 2, the muscle tissue movement is capture by electrodes placed on the skin surface and that capture signal is given to signal conditioning circuit to amplify and remove noise from signal [5]. After that from acquired signal the hand gesture is recognized. Also we can control device from given acquired signal as an application. EMG hand gesture recognition system having less cost, easy to build, less complex [5]. The EMG acquisition and hand gesture recognition system is divided into two parts hardware and software.

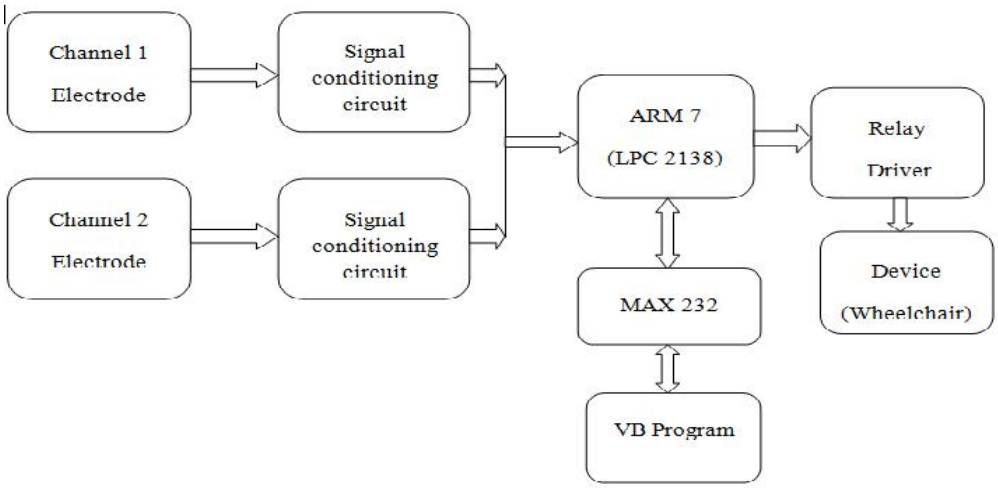

Fig. 2: Block diagram of hand gesture recognition and device controlling system using sEMG signal

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A. Hardware

1) Electrode placement

For capturing the EMG signals from hand muscle tissue contractions through channel acquisition system, three electrodes are placed on the upper part of the hand or on the skin surface and three electrodes are placed on the upper part of the other hand or on the skin surface [8]. The fig. 3 shows the placement of electrodes on the skin surface or on the upper part of hand.

Fig. 3: The placement of EMG electrodes on the subjects' forearms [1].

In this system, for capturing the EMG signal from human body Silver – silver chloride (Ag-AgCl) electrodes are used. Ag-AgCl is the most commonly used composite for the metallic part of gelled electrodes. In the Ag-AgCl electrode the AgCl layer allows current to flow from the muscle to pass more freely across the junction between the electrolyte and the electrode. So, due to this the electrical noise introduced in the measurement is less, as compared to equivalent metallic electrodes (e.g. Ag). So, Ag-AgCl electrodes are used in over 80% of surface EMG applications [5].

2) Signal conditioning circuit

The EMG signals have low amplitude, in the range between micro volts to millivolts. The EMG signals are influenced by various interferences. So, signal conditioning circuit design is necessary, which reduce the interference. Signal conditioning circuit consists of protection circuit, instrumentation amplifier, isolator, filter, level shifter, adder etc. as shown in Fig. 4. The data acquisition system consists of an instrumentation amplifier and a filter to amplify and condition the raw EMG signal.

) ***Protection circuit:*** The protection circuit is used to protect the sensitive electronic circuit and user without distorting the input signal.

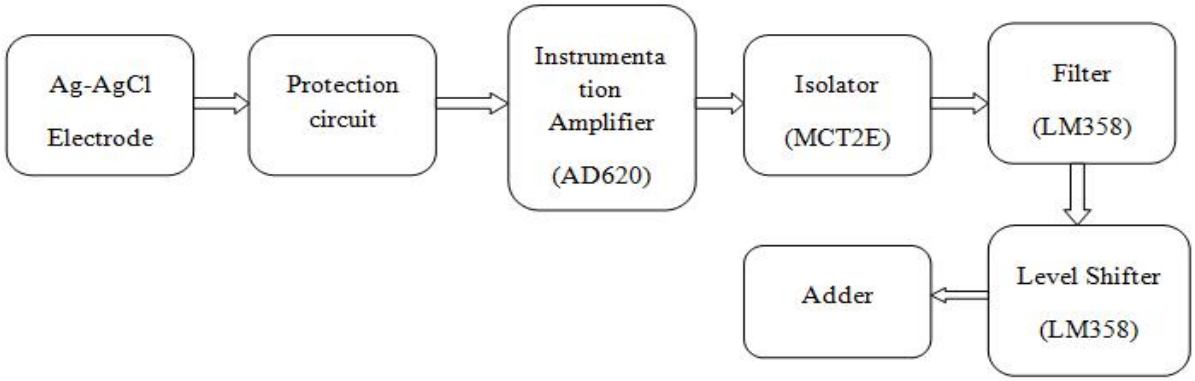

Fig. 4: Signal conditioning circuit

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- ***Instrumentation amplifier:*** Amplification is necessary to optimize the digitizing equipment or resolution of the recording. Amplifiers of high quality have adjustable gains between 100 to 10,000. Instrumentation amplifier provides the high quality adjustable gain. It also provides high CMRR, very high input impedance, low noise etc. So instrumentation amplifier is widely used for amplification.

- ***Filter:*** The raw EMG signals contain noise frequencies can be high as well as low. Low frequency noise can be caused because of DC offsets, temperature fluctuation etc. and removed by using high pass filter. High pass frequency noise can be caused because of conduction of nerve, computer etc. and removed using low pass filter. The maximum frequency of the EMG signal is in the range of 10 to 450 Hz [4]. So, band pass filter is used to remove the noise, because cut off frequency of band pass filter is between 10 Hz to 500 Hz. In band pass filter only specific band of frequency is carried forward.
- ***Isolator:*** Isolator is used to transfer electrical signals by using light between two isolated circuits. It prevents the signal received from system from high voltages. It is used to protect communication lines such as Tx and Rx lines.
- ***Level shifter:*** It is used in multivoltage design. Because in multivoltage design different blocks are working on different voltages. So, when a signal passes from one voltage level to another voltage level the level shifter is needed to pass the signal from low voltage level to another or high voltage level. It is typically used in low power design where IOs are operating at different voltages.

3) Processing and controlling

Processing and controlling is done by using ARM processor. In ARM processor ADC is inbuilt which convert analog signal into digital signal and data is acquired. To display the recognized data on PC VB programming is used and for transferring data serial communication is used.

- ***ARM (LPC2138):*** ARM LPC2138 is 64 bit microcontroller. Due to its tiny size & low power consumption it is used in this system. It provides 8 channel 10-bit A/D converters which is useful for this application. ARM processor acquire the signal from signal conditioning circuit and transfer to PC for monitoring and taking decision. LPC2138 is ARM 7 processor. The system required two serial ports which is satisfy by ARM processor. ARM 7 processor is low cost processor.
- ***MAX-232 & DB-9 Connector:*** MAX-232 is used for level conversion. It converts TTL logic level to RS-232 & vice versa. MAX-232 is used in applications like modems & computers. For MAX-232, the transmitter & receiver pins are used. DB-9 converter is used as serial USB connector. DB-9 connector makes use of transmitter, receiver & ground pin.
- ***LCD Display:*** LCD display is used to observe the data which is useful for users for analysis. 16*2 LCD display is used here. The data lines 6-14 are connected to the ARM7 (LPC2138). Pin 3 is connected for contrasts adjust.
- ***Relay Driver:*** Relay Driver is a logic module which provides high level system control functions such as high/low voltage alarms, load control and generator start. It is an electromagnetic switch which is used to control or on-off the low voltage circuit. A transistor is needed to control the current needed to operate the relay coil.
- ***DC motor:*** Motors come in many shapes and sizes. There are electromagnetic direct current (DC) motors and electromagnetic alternating current (AC) motors and a number of variations of each. AC motors are typically used for large applications, such as machine tools, washers, dryers, etc., and are powered by an AC power line. DC motors are commonly used for small jobs and suited the purposes of the platform very well. Figure shows the 12V DC motor use in wheelchair.

B. Software

The real time EMG acquisition and hand gesture recognition system is design to recognize the gestures. The acquired EMG signal and hand gesture recognition is built up by using visual basic 6.0 (VB). In visual basic form is created where different components are added like caption, labels, text boxes, progress bars etc. and also one special function is created for communication purpose that is MSCOMM. In visual basic graph also created to display the input-output waveform. The acquired EMG signals are displayed on PC screen by using visual basic. By using visual basic user interface creation is easy. Visual basic is event driven model. When

the DB-9 to USB cable is connected to PC, it will generate a COM port. Then according to that COM port, the port is selected in form. When the port matches, the signal is displayed on the GUI created in VB. To display the waveform of EMG signal two axis are plotted x & y. On y axis the voltage ratings are plotted and on x axis time ratings are plotted in sec. After that gesture is recognized from displayed EMG signal and name is display on screen. Two channels are used for recognition system. For each channel two gestures are recognized like hand open and hand close.

C. System Design

The designed system is shown in fig. 5. The system includes the connection of ARM, two EMG signal conditioning circuits, MAX 232, DB-9, LCD display, power supply and wheelchair.

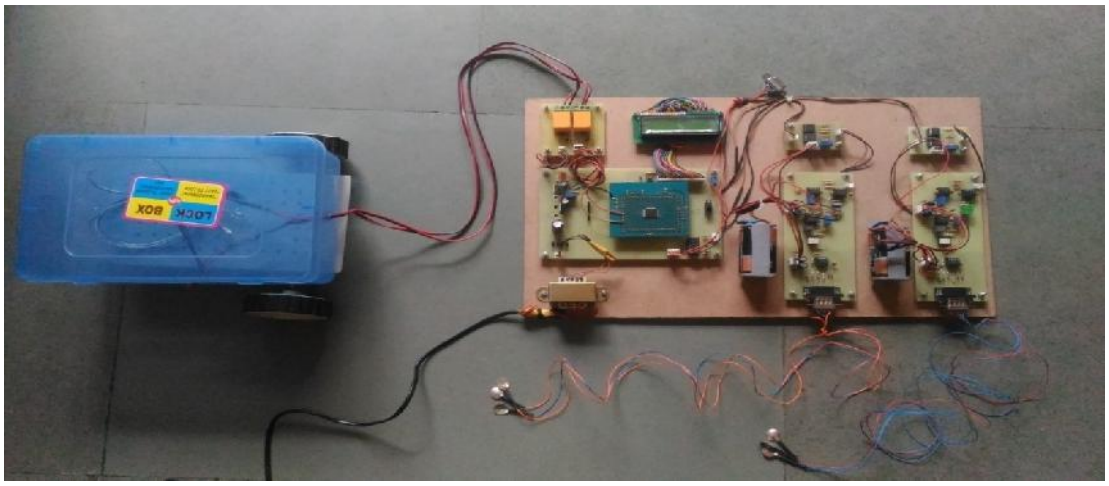

Fig.5: Designed system

RESULT AND DISCUSSION

In visual basic 6.0 back propagation algorithm is generated. The hand gestures such as hand closed and hand open is recognized for both the channels. The electrodes capture the signal from human body. The results for each are as shown in figure 6 (a) & (b) below.

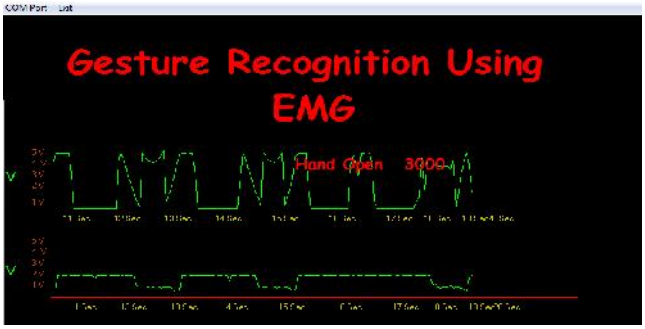

Fig.6 (a): Output results for channel 1

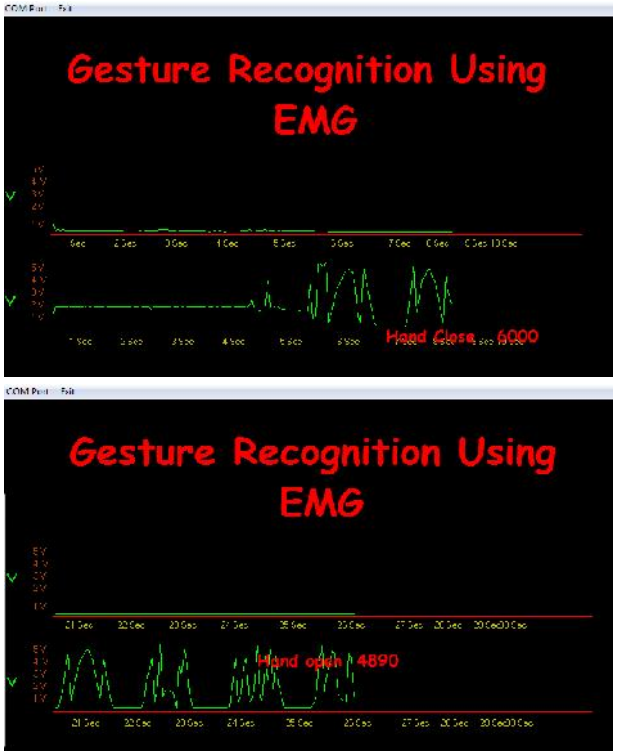

Fig.6 (b): Output results for channel 2

After the recognition of hand gestures device or wheelchair is control from that signal. If *hand opens* for channel 1 is recognized then the wheelchair move towards *forward*. If *hand closed* for channel 1 is recognized then wheelchair move towards *left side*. Similarly for channel 2, if *hand opens* then wheelchair move towards *right side* and if *hand closed* then *stop* the wheelchair.

CONCLUSION

Thus, the EMG hand gesture recognition system works on the concept of electromyography signal. It is used in variety of application. A large number of impairments and disabilities in human body are increasing day by day. To improve the quality of life of the disabled or aged people researchers think on the necessity of simple and natural human-machine control interface. So, the EMG based hand gesture can help to develop good machine interface that increases the quality of life of the disabled or aged people. Thus, depending upon the application the electrodes, data acquisition system and the data processing unit can differ. The acquired EMG signal and hand gesture recognition is built by using visual basic 6.0. Visual basic is easy to use and easy to user interface. So, visual basic is widely used for built the system. Communication through gestures has been used since early ages not only by physically challenged persons but nowadays for many other applications such as human computer interactions, robotics, sign language recognition, etc

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