Development of Low Cost Bionic Arm for Rehabilitation of Paralyzed Patient

Sami Ehtesam Raza
PG, Electrical Engineering, Jorhat Engineering College, Jorhat, India
swapnilneil08723@gmail.com
Nilanjana Baruah
HOD, Department of Instrumentation Engineering, Jorhat Engineering College, Jorhat, India
neelanjana.bb@gmail.com
Nabasmita Phukan
Asstt. Professor, Department of Electrical Engineering, Jorhat Engineering College, Jorhat, India
nabasmitaphukan17@gmail.com

Abstract: In this paper, implementation of Micro Controller and Bio-Electric sensors are used in the design of low cost bionic arm using servo controllers as final control element. The signal from muscle is sensed by EMG and is fed to the controller. Also the controller received information from the gyroscopic sensor. In order to keep the system cost effective without compromising its accuracy, Micro Controller with built-in controller platform (AURDINO UNO) is used, which not only makes the system accurate but also power effective. Gyroscopic sensor sensed the position of the working hand of the subject and mimic it to the bionic arm through controller.

Keywords - Bionic arm, ARDUINO UNO, gyroscopic sensor, ECG, servo motors

I. INTRODUCTION

Now a days due to lack of physical exercise, stress, consumption of adulterate food, many neural disease occurs due to the degeneration of the neuron leading to paralysis. Due to this interrupted neural connection to the brain, the muscle gets paralyzed. Functional Electrical Stimulator is a process that uses low electrical energy pulses which artificially gives the movement to the paralyzed muscle.

In recent days, many advanced FES has been developed for the people suffering from paralysis. For the last few decades, researchers are working hard on this topic for many advanced and updated FES.

In 1965, Vodovnik et al. [1] designed a one-channel electronic bypass stimulator which was designed to fit for left hand of the patient. The stimulator consisted of three parts viz. stimulator, modulator and amplifier circuit. The stimulator designed by Dou et al. [2] was a multichannel, flexible and versatile. The designed was made to fit for upper and lower extremity of paralyzed patient. Mohammed et al. [3] implemented a closed loop position control FES which was actuated by quadriceps muscles performing flexion extension. Mohammed et al. [4] presented a novel approach to optimize pattern to recognized system using Genetic Algorithm which identify the type of hand motion, employing Artificial Neural Network. Their proposed network with a small size can recognize 10 hand motion with 98% of accuracy. The designed proposed by Sharma et al. [5] presents various method like wavelet approach, auto regressive method in the field of feature extraction of EMG signal. In 2012 a new FES was introduced whose novel power stage merged a flyback and switch-capacitor converter. The designed was proposed by Huerta et al. [6] and they got improved current slew rate and got around 1.5 times lower pulse rate. Raurale et al. [7] developed a FES for better EMG signal and for better classification of movement. The model was proposed by Wavelet transformation which was followed by efficient time frequency ANN.

Till date various numbers of FES have been developed and many new ways has been proposed for the better functioning of the FES. Many advanced and costly FES has also been developed by the researchers but in this paper I have designed a hand prosthesis which overcomes various problems that were seen on the other FES. Firstly, this hand prosthesis is of very low cost, that means it will help the people of the lower class society. The model that I have designed is based on the working hand of the patient and it replicates the movement of the other hand. It is very simple prosthesis which mainly comprises of a Robotic Hand Arm, Arduino UNO, Gyro-Sensors, Capacitive Sensors and Metallic Servo.

II. BLOCK DIAGRAM

In this paper, the Fig 1 shows the basic block diagram of the system.

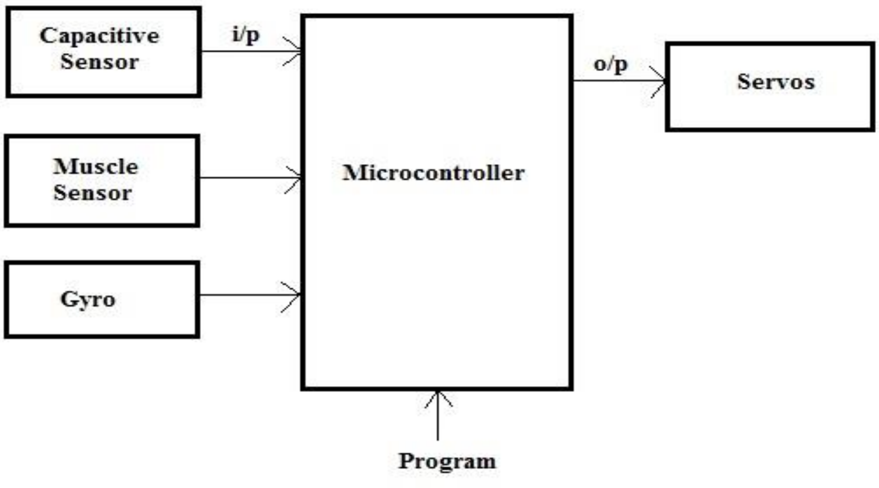

Fig. 1. Block Diagram of the system

III. CIRCUIT DIAGRAM

The circuit diagram of the whole system is shown in the Fig 2.

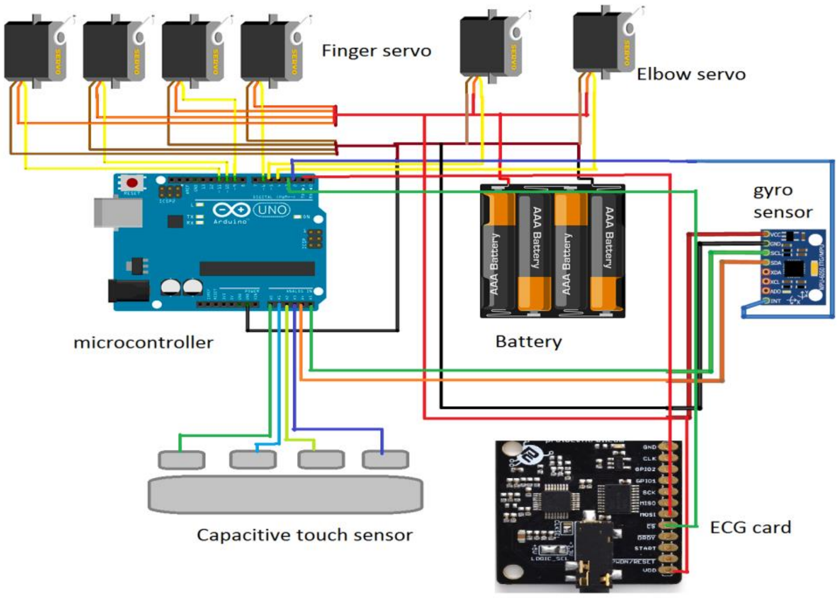

Fig. 2. Circuit Diagram

IV. METHODOLOGY

The Bionic arm is operated by a Controller "ATMEL 328P" from ATMEL corporation. "ATMEL 328P" is a single-chip Microcontroller which has 28pin operated on 5V DC supply. This controller is commonly used in many autonomous systems and projects where a simple, low-cost, low-voltage microcontroller is needed. Six pins (A0 – A5) are available as analog pin sense any change in analog voltage and fed the voltage value (value after sampling) directly to the controller. The whole project is divided in the following parts---

a. Input
b. Controller action
c. Final Control Element

Here the inputs are the capacitive touch sensor. There are four capacitive sensor, each sensor are connected to the one finger of the command hand. The working hand of the 'subject' when any of the finger touch the capacitive sensor associate with the finger itself, it start to read the value from the muscle sensor and sends the data to the controller. Controller then mapped the data to the angle of associated servo for that finger in the bionic arm and the bionic arm finger tilt to that angle. Another input to the system is the Gyroscopic sensor. It actually measures the movement of the working hand and sends the value to the controller. The controller again receive the information and mapped the value to the "pan & tilt" servo to provide pan & tilt movement to the bionic arm.

The final control element to the arm is the Servos. Total 6 servo are used to operate the arm, four servo for the fingers and two for the pan & tilt arrangement. The servo are energized from the 6V 4.5amp battery and the control signal is obtained from the Micro-controller.

In order to get the bionic signal from the movement of hand muscles, we connect the EMG card to the different hand muscles with the help of Disposal type Skin Electrode as shown in the Fig 3 below.

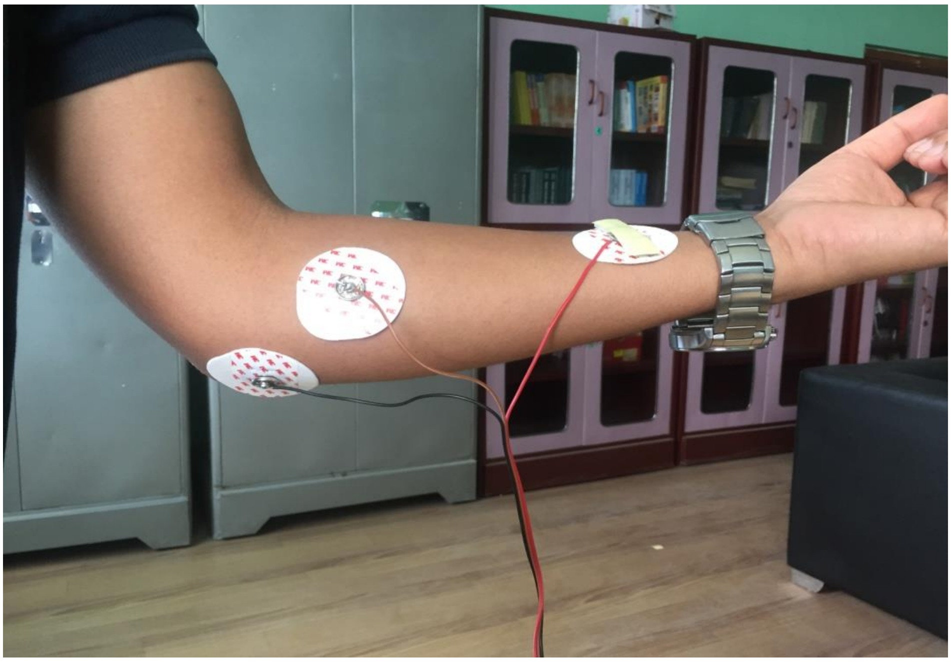

Fig. 3. Disposal type skin Electrode

The information from the EMG signal is fed to the controller after processing it from EMG card . When there is a movement the output from the EMG card contains some spikes which magnitude directly proportional to the applied tension on the working hand. This magnitude is mapped to the servo position so that the servo will moves accordingly to the tension generated by the muscle fibres. Beauty of this thing is that it allows to move the servo only to required amount which increase the precision of the work. The Fig 4 shows the actual model of the working system and it is shown below.

Fig. 4. The working model of the Bionic Arm

V. OBSERVATIONS AND EXPERIMENTS

As shown in the Fig 5, the output from the Bio-Sensor is fed to the controller through EMG card. The waveform can be observed using a free software "Brain Bay". This software graphically plot the response obtained from the potential electrode. As we observed the graph in the Fig 5, it is clearly visible that there are some spikes on the graph. This spikes are due to the grasping of the finger in the working hand. The amplitude of this spikes are proportional to the applied tension on the muscle fibres.

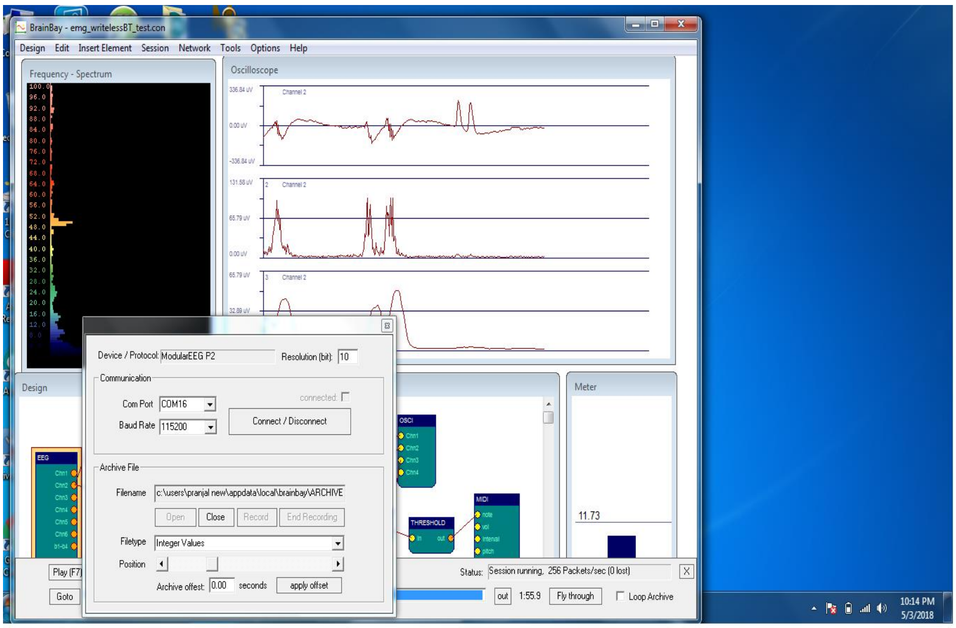

Fig. 5. EMG signal obtained from the grasping of all fingers

Here the Table 1 gives the Accuracy of the hand movement while tilting the hand and from that Expected and obtained servo angle is calculated.

TABLE 1

Sl. No.	Tilt of hand	Expected Servo Angle	Obtained Angle	Accuracy (%)
1	10^o	5^o	4.5^o	90
2	20^o	10^o	9.2^o	92
3	30^o	15^o	14^o	93.33
4	40^o	20^o	18^o	90
5	50^o	25^o	23^o	92
6	70^o	35^o	32^o	91.42
7	90^o	45^o	42^o	93.33
8	120^o	60^o	57.5^o	95.83
9	150^o	75^o	70^o	93.33
10	180^o	90^o	83^o	92.22

VI. CONCLUSION

From the above experimental table it has been seen that the Bionic Arm is giving an average of 92.35% of accuracy while tilting of the hand from 00 to 1800.

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