

Myo-Electric Prosthetic Arm

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ABSTRACT: This paper describes the design features of artificial limbs that are lightweight, compact and dexterous, that mimics human anatomy and maintain a high capability. The proposal focuses mainly on extract electromyogram (EMG) signals generated during contraction of the biceps. The EMG signals are first amplified and filtered by a laboratory-designed electronic circuit and then reprocessed using a microcontroller to drive the servomotor so that the designed prosthesis can be properly controlled. In India most of the people lost their hand due to road accident, disease and soldiers lost their arm in war. Prosthesis is an artificial extension that replaces a missing body part. Prostheses are typically used to replace parts lost by injury or missing from birth or to supplement defective body parts. One of the main requirements of artificial arm is that functionally, it should be as near to the natural hand as possible. The design had to account for mechanical and electrical design reliability and size. The signals recorded by the surface electrodes are sufficient to control the movements of a virtual prosthesis.

KEYWORDS: Electromyogram (EMG), Microcontroller, Virtual prosthesis.

I. INTRODUCTION

In India most of the people lost their hand due to road accident, disease and soldiers lost their arm in war. The human body is a wonder of nature. The functioning of human body is an intriguing and fascinating activity. The myoelectric hand prosthesis is an alternative to conventional hook prostheses for patients with traumatic or congenital absence of forearm(s) and hand(s). The myoelectric prostheses are user controlled by contraction of specific muscles triggering prosthesis movement through ElectroMyoGraphic (EMG) signals. These Myoelectric signals (MES) can be read by myoelectrodes and amplified to measure a muscle's naturally generated electricity. After processing via designed processing units, these signals can be designated to control a particular degree of freedom in the prosthesis. Many researchers are working in the development of prosthetic devices to aid the physically challenged people in their routine activities. Potential beneficiaries include adults and children, military veterans and civilian casualties, people who have lost their arms in accidents and in medical procedures, irrespective of socioeconomic status.

II. EXISTING SYSTEM

Functional arm prosthetics can be broadly categorized into two camps: body-powered and externally-powered prosthetics. Body-powered prosthetics use cables and harnesses strapped to the individual to mechanically maneuver the artificial limb through muscle, shoulder, and arm movement. While they are highly durable, they often sacrifice a natural appearance for moderate functionality. As well, though the user experiences direct control and feedback through its mechanical operation, the process can be fatiguing. Externally-powered artificial limbs are an attempt to solve this physical exertion through using battery and an electronic system to control movement. The primary disadvantages of this kind of prosthetic are currently their weight and cost. At the forefront of this technology is the myoelectric prosthetics are on the cutting edge of innovative technology.

III. PROPOSED SYSTEM

The main aim is to create an affordable prosthetic arm that is lightweight, easy to use, and performs as similar as possible to a natural arm. The first task was to detect myoelectric signals from muscle contractions, process them and convert them to a form suitable as input to a microcontroller. We made analog circuitry to process the

electromyographic (EMG) signal by bandpass filtering, rectification and amplification. We also made a functional elbow joint and a palm with fingers capable of independent movement, minimizing weight and construction cost while maintaining structural strength. The proposed partial-prosthesis mechanism is controlled by a built-in program. The palm will open when the EMG signal ceases as the muscle is at rest. Although its only functions are opening and closing of the palm, the simplified prosthesis is still practical and is a favourable. The focus of this project was to design a low-cost upper limb prosthetic capable of elbow movement in response to electrical signals from the residual limb.

Emg electrodes

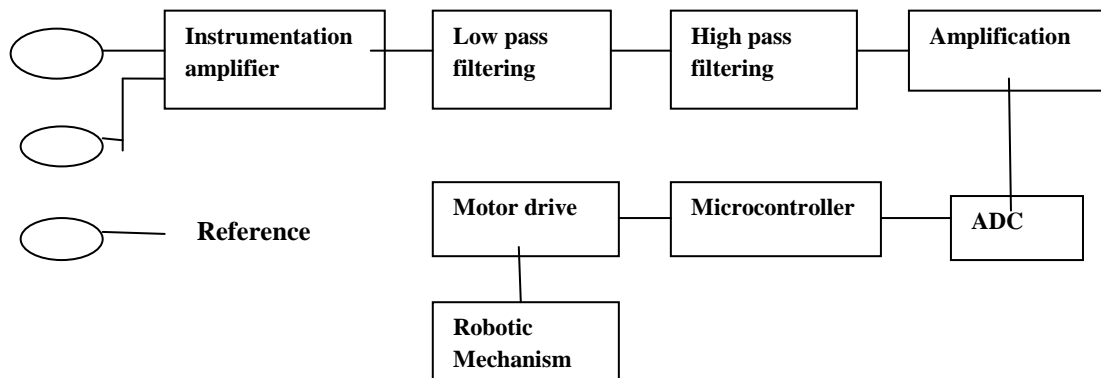


Fig.1. Block Diagram of prosthetic arm

IV. EMGELECTRODE PLACEMENT AND MUSCLE CONTRACTION

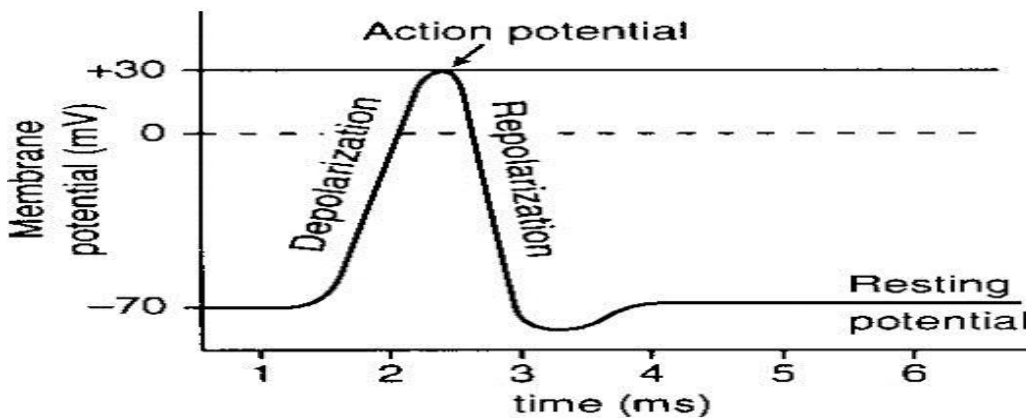


Figure.2. The stages of an action potential

The central nervous system in the brain generates what is known as an action potential. This action potential is what stimulates a particular function within the body. In this case, we are picking up action potentials that signal the muscles to move. These action potentials travel down axons.

A summary of the steps are diagrammed in Figure 2.

1. Resting membrane potential occurs when all voltage-gated ion channels are closed.
2. When a stimulus is received, the sodium activation gate opens and the permeability to sodium in the cell increases. Sodium floods into the cell. This causes an explosive depolarization of the cell. This is the rising phase of an action potential.

3. At the peak of an action potential, the sodium inactivation gate closes, and the cell's permeability to sodium falls. This causes movement of sodium into the cell to decrease. At the same time, the potassium activation gate opens, and the cell's permeability to potassium increases. Potassium floods out of the cell.
 4. As potassium leaves the cell, the cell begins to repolarize towards resting potential. This is the falling phase of an action potential.
 5. When the cell returns to resting membrane potential, the sodium activation gate closes, while the inactivation gate opens. This allows the cell to be ready for another depolarizing event.
 6. During this time, there is still outward movement of potassium, causing a hyperpolarization of the cell.
 7. The potassium activation gate then closes and the membrane is able to fully return to resting membrane potential.
- A muscle contraction is performed by using the above mechanism. The EMG signal is then based on reading the depolarization and repolarisation events of these action potentials of a muscle fiber.

V. SIGNAL ACQUISITION TECHNIQUE

The concept is that when muscle groups are activated (contract/relax), there is a voltage difference in the order of a few millivolts. This difference can be easily detected using surface electrodes. We used Ag/AgCl surface electrodes with hydrogel. EMG signals generally lie in the amplitude range of 20-2000 μ V depending on the muscle unit selected and the electrodes – but they are extremely noisy. To reduce this noise, we have used three surface electrodes, namely E1, E2 and E3. E1 and E2 are used to record muscle activity from two separate groups of muscles, such as biceps and triceps. E3 is a reference electrode placed on a muscle group isolated from these muscle sets. Electrodes are generally passive or active, needle based or surface based. Here, we use Ag/AgCl surface electrodes with adhesive conductive hydrogel for easy removability. This makes them conform easily to the skin and ensure good trace quality, leading to good EMG signal acquisition.

VI. DESIGN AND IMPLEMENTATION

In this circuit there are three electrodes are used to measure the EMG waves in which two electrode is fixed with left hand another one electrode is fixed in the right leg which acts as reference ground electrode. Electrode 1 and Electrode 2 pick up the EMG waves from the hands. Then the ECG waves are given to instrumentation amplifier section. The instrumentation is constructed by TL082 operational amplifier.

The TL082 are high speed J-FET input dual operational amplifier incorporating well matched, high voltage J-FET and bipolar transistors in a monolithic integrated circuit. The devices feature high slew rates, low input bias and offset current and low offset voltage temperature coefficient. The instrumentation amplifier amplify the differential signal from the both electrode. This amplified ECG waves contains the line frequency, high frequency and low frequency noise signals. So the ECG wave is fed to filter section. The filter section consists of high pass filter and low pass filter which is used to remove the high frequency and low frequency noise signal. After the filtration the ECG wave is given to pulse width modulation unit. In this section the ECG wave convert to pulse format in order to perform the isolation. The isolation is construct by the opto coupler. The isolation is necessary to isolate the human body and monitoring equipment such as CRO, PC etc. Then the ECG pulse format wave is given to PWM demodulation unit in which the pulse format is reconstruct to original wave. Then the wave is fed to notch filter section in order to remove the line frequency noise signal. A notch filter is a band-stop filter with a narrow stop band (high Q factor). Notch filters are used in live sound reproduction (Public Address systems, also known as PA systems) and in instrument amplifier (especially amplifiers or preamplifiers for acoustic instruments such as acoustic guitar, mandolin, bass instrument amplifier, etc.) to reduce or prevent feedback, while having little noticeable effect on the rest of the frequency spectrum. Other names include 'band limit filter', 'T-notch filter', 'band-elimination filter', and 'band-rejection filter'.

Typically, the width of the stopband is less than 1 to 2 decades (that is, the highest frequency attenuated is less than 10 to 100 times the lowest frequency attenuated). In the audio band, a notch filter uses high and low frequencies that may be only semitones apart. Here the notch filter is constructed by the operational amplifier TL074. Finally noise free ECG wave is given to amplifier. Then the amplified signal is given to monitored device such as CRO, PC etc.

VII. METHODOLOGY

Once all the data was collected, the EMG would be converted to relative force output. The average amplitude for contraction force and checked for statistical significance. This information would have been imputed into the Arduino Processing code provided by the Muscle Sensor microcontroller. This information would then have been read by the Arduino, and once the muscle contraction exceeded that average amplitude, the motor would move until contraction stopped. Upon relaxation of the muscle, the motor would have moved in reverse and the arm would have moved back to its original position. The servos activate finger movement by pulling the connecting string. Strings attached to the back of the fingers allow them to return to their original positions with ease. The thumb and the index finger the middle, ring and little finger were made separately and are connected to individual servo motors. Therefore totally five servo motor are used to control the arm. The entire structure is mounted on a wooden base and support Servos have a very simple electrical interface; Servos usually have 3 wires, one for power, one for ground and the other for the pulse train. Once power (usually in the 4.8V-6.0V range) and ground is supplied to the servo, the data wire is prepared to receive encoded signal in the form of pulse width modulation (PWM). The duty-cycle is of 20ms, and the pulse width contained within those 20ms varies from 1ms to 2ms.

CONTROLLER BOARD:

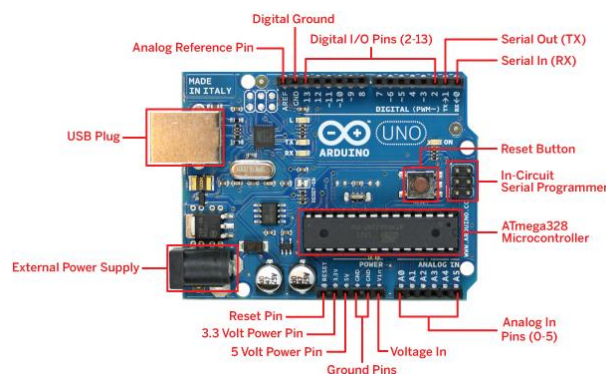


Fig.3.Arduino processor

The ATmega328P is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega328P achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Arduino programming language is loosely based on the C programming language. Arduino apart from various other microcontroller boards is its ease of use, rather cheap cost, and extreme functionality. EMG output is given to arduino board pin(A0) and ground. Arduino digital pins are connected to servomotors and led display. The ATmega/328P contains three General Purpose I/O Registers. These registers can be used for storing any information, and they are particularly useful for storing global variables and Status Flags. General Purpose I/O Registers within the address range 0x00 - 0x1F are directly bit-accessible using the SBI, CBI, SBIS, and SBIC instructions.

VIII. BENEFITS

Although the myoelectric prosthesis is heavier compared to both the cosmetic and body-powered prosthetics, it is still lighter than the typical human arm. With the careful selection of material with the optimal relationship between weight and durability, the final model of a myoelectric prosthetic arm could weigh as little as 245 grams for children, of which

45 grams is the battery and 15 grams is necessary electronics. This is much less than the average 350 grams in most four year old children. Even for adults, whose arms have an average mass of over 4000 grams, an optimal myoelectric prosthesis could have a minimum mass of 1010 grams, only about a quarter of the weight. Myoelectric prosthetics allow for a comparatively high degree of freedom compared to cosmetic and body-powered prosthetics, and it does not have the same restrictions and drawbacks as the other types do. Being powered by a rechargeable battery, the myoelectric prosthesis does not require as much physical exertion as body-powered types. This allows myoelectric prosthesis to be prescribed for patients as young as two years old. Furthermore, patients have been observed to be able to use myoelectric prosthetics to a much higher degree of control than the conventional types, even with less time and experience using them.

IX. CONCLUSION

As a conclusion, we can say that our prosthetic arm has the following features:

- Affordable (approximately 125 USD)
- Lightweight (approximately 800 grams)
- Independently moving fingers and thumb with firm grip
- A movable elbow with 120 degree clearance
- Complete EMG control with 3 surface electrodes

All this enabled us to achieve the overall objective of our project that is to make an affordable prosthetic arm available to more people irrespective of their socio-economic status. Our project will give people with above-elbow amputation an easily controllable, functional and affordable prosthetic arm

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