SERVO MOTOR BASED FINGER MOVEMENT OF MYOELECTRIC HAND FOR HUMAN

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Abstract

In general, amputations need to be done subject to their severity due to vehicle collisions, gunshots, malignant diseases, etc. Particularly, hand amputation makes the humans difficult to carry out the day-to-day life activities. Hence fixing of artificial hand is essential. Admitting the need for the artificial hand, myoelectric hand utilizing servo motors for the movement of fingers has been designed. The electromyography signals obtained from the amputated hand were converted into digital signal and directed to the microcontroller. The microcontroller in turn generates the control signals required for the servomotors. Finger arrangements were interfaced with the servomotor. Consequently, the user will be able to move the fingers of the artificial hand through the impulses of the electromyography signal. Making use of the electromyography signal minimizes the need of various sensors reducing the maintenance cost.

Keywords: Amputation, Servomotor, electromyography, myoelectric hand, Microcontroller.

1. Introduction

Embedded Systems have been with us only for a few decades but their impact on our lives is profound either directly or indirectly. One such application which is useful to the mankind is the artificial hand. For those who have lost their hands as result of vehicle accidents, warfare, malignant diseases etc the artificial hand is the boon to them. In this paper, artificial hand has been designed where the fingers interfaced to the servomotor are controlled by the signal from the microcontroller.

2. Hardware

The prototype of the proposed system basically consist of the serial communication interface, microcontroller, Servomotors, artificial hand hardware arrangements etc. In actual system, electromyography signals are got from the
amputated hand through the surface electromyography electrodes. But in the model for testing purpose, the EMG signals stored in the computer were taken through serial communication interface and sent to the microcontroller. Based on the impulse of the electromyography signal the microcontroller generates the control signal for the servomotor interfaced to the finger arrangements. Hence movement of the fingers was achieved through EMG signal. Such an artificial hand is called myoelectric hand. The power supply to the components of the system can be provided with the battery. Here, in the prototype the supply were taken from the main, converted to dc by means of rectifier and then given to the system components via regulator. The block diagram of the model is shown in the fig 1.

![Fig 1. Servomotor based artificial hand system.](image)

**Electromyography Signal**

EMG is the abbreviation for electromyography. The signals which are produced due to the current impulses by the muscular movements or activation are called as electromyography signal. It is based on the EMG signal that various parts of the body make an action. EMG signals are generated by the body depending upon the desire to do something. The EMG signals can be acquired from the amputated limb through the placement of surface electrodes. Amputation is nothing but the process of removing a part of the body by operation due to accidents, diseases etc. Necessary precautions to be taken care for the placement of electrodes, to avoid movement artifact, reducing the skin impedance and filtering the noise signals. The setup for the EMG signal acquisition is shown in the fig 2.

![Fig 2. EMG signal acquisition system.](image)
Fig. 3. EMG signal without filtering.

Fig. 4. Low pass filtered EMG signal.

Fig. 5. High pass filtered EMG signal.
The EMG signal acquired through the surface electrodes will be weak and it may contain noise. The raw EMG signal is strengthened suitable for the next stage by the use of amplifiers. Instrumentation amplifier is used for this purpose because of its high input impedance and low output impedance characteristics. Low frequency noise is due to temperature fluctuations and sensor drift on skin. Interferences from the cellular networks, radio lines contribute to the high frequency noise. To remove the noise low pass filter, high pass filter and adaptive filters were integrated into the system. Adaptive filter with Least Mean Square (LMS) algorithm to filter out the differential noise. The raw EMG signal, lowpass filtered signal, high pass filtered signal and adaptive filtered signal were shown in fig 3, 4, 5 and 6 respectively.

Microcontroller

The EMG signal before sending it to the microcontroller is digitized. The microcontroller generates the necessary control signal for the movements of servomotor interfaced fingers. The AT89S52 microcontroller was used due to the following key features high performance; high performance CMOS 8-bit microcontroller with 8K bytes of In-System Programmable (ISP) Flash memory, pin outs and instruction sets are compatible with 8051 microcontroller standards, low power consumption operating voltage 4.0V to 5.5V, watch-dog timer, 32 programmable input/output lines, eight interrupts, on-chip oscillator, 16-bit timers/counters etc.

Servomotor

A servomotor is an actuator that facilitates the control of position, velocity and acceleration. The servomotor works on closed-loop servomechanism i.e the shaft motion and final position is determined based upon the present position which
Encoder is used along with the motor to provide feedback mechanism. The present position of the motor is compared with the command signal position. Based on the variation, error signal is generated which in turn makes the shaft to rotate. Once the appropriate position has been achieved, the error signal becomes zero, so the motor comes to halt.

In the model, servomotor is interfaced with the finger arrangements. The control signal to the servomotor was issued by the microcontroller through the driver IC. Hence based on the signal from microcontroller servomotor rotates. Consequently the finger position was varied.

Pulse width modulated signal is required by the servomotor for its controlling purpose. The servomotor can be turned in either direction for an angle of 90 degree. That means a total angle shift of 180 degree is possible. For every 20 ms the servomotor expects the pulse. The rotation of the motor depend upon the pulse duration For example, 90 degree position can be achieved by a pulse of 1.5ms duration. When pulse width exceeds 1.5 ms, 180 degree position and for pulses shorter than 1.5 ms zero degree position were made. The angular position of the motor with respect to the pulse width is shown in the fig 7.

**Fig 7. Pulse width signal to control servomotor position.**

When these servos are commanded to move, they will move to the position and hold that position. If an external force pushes against the servo while the servo is holding a position, the servo will resist from moving out of that position. The position pulse need to be given repeatedly to the servomotor to hold the particular position

### 3. Result and Discussion

The prototype of the proposed myoelectric hand is shown in the fig 8. For testing purpose, the EMG signal stored in the computer is taken and sent to the AT89S52 microcontroller via RS232 serial communication interface. Two line LCD is
connected to microcontroller. The LCD displays the command signal given by the microcontroller to the servomotor for finger movement. The microcontroller has been programmed by Embedded C. The movement of the finger takes place based on the servo motor rotation. Multichannel EMG signal processing can be done for multiple finger movements at a time. The power supply to the unit was provided by 12V battery. Regulated power supply IC has been used to regulate the power to the various components of the system. The proposed model is simple with minimum maintenance cost.

![Image](image_url)

**Fig 8. Snapshot of the artificial hand model.**

4. Conclusion

Electromyography senses the bio-electric potential generated by muscle cell and operates with help of servo motor connected to the microcontroller. The servo motor is connected with the fingers in the hand which in turn control the movement of the hand. The control signal which is given to the motor is based on the signal thus obtained after filtration. Electromyography performs the operation within fraction of second. Servo motors are typically good for speeds up to 5000 rpm and free of vibration and resonance. Every single finger can be operated without hassle.

Reference


