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# An Efficient Prosthetic Limb with Sense of Touch and High DOF for Disaster Victims

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## ABSTRACT

Disasters have impact on disability, by affecting people with existing disabilities and by creating new generations with disabilities. Intervention of Rehabilitation is of critical importance in disaster management. This paper focuses on post disaster rehabilitation of human life. The lost limbs of victims of disasters are restored with the help of prosthetic limbs. we have proposed a system that could work similar to our biological limb which could provide high degree of freedom and that could feel the sense of touch with sensors inbuilt. In order to strengthen and decrease the weight of Prosthesis we have proposed a Carbon fiber Sandwich (tegris) biomaterial.

**Keywords:** DC motor, Degree Of Freedom (DOF), Myoelectric arm, Pylon, Rehabilitation, Servo motor.

## INTRODUCTION

Disaster rehabilitation may be considered as a transitional phase between relief and recovery. People affected by disaster are posed to both physical and mental illness. Physical injury will be in terms of missing body parts. Amputees at present have the option of several kinds of prosthetic devices. One of the main requirement of prosthetic device is that it should be as near to the human hand as possible. Myoelectric arm is one such prosthetic which is stimulated by muscle signal available at the stump of the amputee. This EMG signal is proportional to the strength and speed of the grip [1]. Post disaster effects include the stress experienced by the disabled people due to change in their life style. This prosthetic arm aims to bring back the predisaster life style to the affected people by making them to control this prosthetic by their intention, similar to that of their biological limbs. The idea of being able to feel things with an artificial hand can be made possible with sensory devices that register pressure, texture and temperature which is engineered in to a prosthetic limb. An electrical sensory signal from the prosthesis is used to stimulate the sensory nerve. It can also transmit impulses of a motor nerve to the appropriate mechanical actuator with in prosthesis.

Initially researches were carried out to increase the degree of freedom from 3 degree to 6 degree and attempts were made to increase the degree of wrist, elbow and shoulders individually. Further research on degree of freedom resulted to a maximum of 16 degree, but with a renervation surgery. Recent studies have proved that with a help of foot controlled switch 22 degree of freedom can be achieved. So far many compatible materials are tried to build a prosthetic arm including silicon, carbon, titanium, aluminium etc. Research results have proved carbon to be more compatible.

## MYOELECTRIC PROSTHESIS

Myoelectric Prosthesis is an externally powered artificial limb which is controlled with electrical signals generated by our muscles [6]. The EMG signal is obtained for different user intended actions using four channel signal acquisition system. This four channel system includes Electrodes, Amplifier, Filter and Rectifier. The EMG signals are used as input to the Microcontroller and converted to digital ones in the comparator. According to these signals the program built in the microcontroller make decisions to control the servomotor to drive the prosthesis [3]. For those with problem in nerves or muscles in residual limb, muscles from chest and back can be used to control the prosthetic. Apart from natural electricity created my muscles, this prosthetic requires battery for charging where in some cases the battery is removed and in other a cable from charging unit is connected to the prosthetic. A myoelectric socket is connected to the residual limb with the help of custom fabricated socket. The user pulls in the socket with donning sock which creates suction and help suspend the socket.

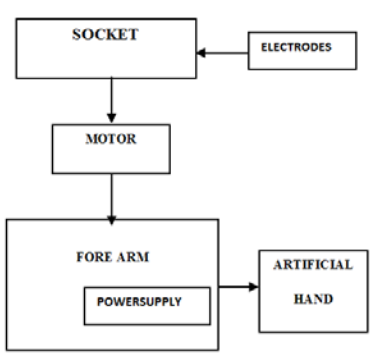


Fig 1: A simple Myoelectric prosthetic arm Block diagram

**Smart Hand**

In Smart hand miniaturized actuators are integrated in the fingers of the artificial hand. The flexible fingers of artificial hand are able to wrap around objects of different sizes and shapes [12]. Feedback actuators give more information about the gripping process beyond a pure visual feedback .This includes elbows that flex and extend with muscle signals so that the amputee can reach for any beverage and bring that to lips, wrists that bend and rotate allowing an amputee to position objects, hand that can hold a suit case and an egg without cracking it, thumb that can change orientation to multiple hand positions.

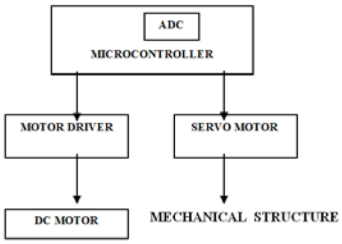


Fig 2:Block Diagram of smart hand

**Servo Motor**

Servo motors are rotary actuators that allows for precise control of angular position, velocity and acceleration. It consists of a motor coupled to a sensor for position feedback. Servomotors are used to control wrist motion. It can be moved in desired direction by sending PWM signals from microcontroller to the control wire of prosthetic wrist. The width of the pulse determines the angular position. Each finger of the arm uses a servo motor of 10kg –cm torque. It enables it to carry a payload of 10Kg.Similarly the wrist can be equipped with a payload of 15Kg-cm to carry payload and the finger. In order to create a prosthetic arm capable of natural movement it is necessary to mimic both the sophisticated system and intricate interactions between them. This can be achieved by using actuators, microcontroller embedded software. Here 16 Degree of Freedom can be achieved (3 for each finger, one for thumb) and only four motors are employed for four degrees of actuation. Servo motor has the capability to rotate precisely according to the degree assigned [1]. Two motors are employed to control flexion / extension of thumb and index finger, middle and little finger are joined together by adaptive grasping mechanism and controlled by a motor, another motor is meant to control the thumb abduction and adduction. Here when load increases the torque also increases thereby decreasing the speed of actuator and vice versa.

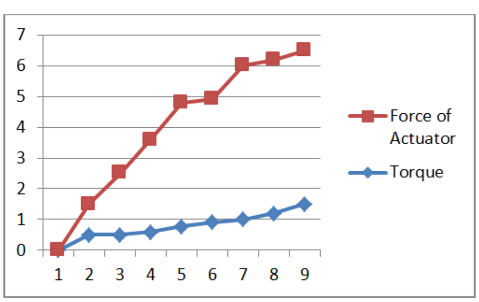


Fig 3: Torque vs Force of Actuator

***DC Motor***

The load of the circuit from elbow to finger in the prosthetic arm is difficult for the servo motors to handle. Hence elbow and shoulder prosthetics are implemented using DC motors. DC motors are easy to reverse, by simply changing the polarity of the motor [1]. As per programming, microcontroller unit will generate control signals. But the power delivered by Microcontroller may not be sufficient to drive a motor .Hence motor drivers are used which is connected to the battery.

Fig 4: Smart Hand

**Sensory feed back**

Though the arms of amputees are severed the nerves will be still functioning. Conventional myoelectric prosthesis provides user only with the weight of the object .This system provide sensory feedback to the user other than the weight. Various types of sensors like tactile sensor, temperature sensor and pressure sensor are incorporated in the prosthetic that converts the sensation in to electrical signal [5]. The prosthetics are employed with electrodes that translates these electrical signals to the nerve endings of the arm .The proprioceptive and exteroceptive sensors can be embedded in the hand, angle sensors are employed in finger joints, strain gauge based tendon tension sensors can be integrated in the finger tips, tactile or pressure sensors can be placed between the thumb and index finger.

**Sense of touch**

Sense of touch is the most important of all the senses. Without it we would not be able to grasp objects with correct amount of force and cannot differentiate the properties of object based on texture and hardness. A sensory equipped prosthesis could give back the normalcy of sense of touch to many amputees. This helps in both automatic control of the grasp and sending sensory information to the user. An array of touch sensors is incorporated underneath the shell of the prosthesis [7] [10]. Any outside force on the prosthesis will cause these sensors to compress and the resistance offered by these sensors is converted into electrical impulses by electrodes in the prosthesis. Upon the removal of outside force the sensors will return to their normal resistance thus ending the electrical transmission. This makes the patient to feel to a certain degree what the prosthesis is touching.

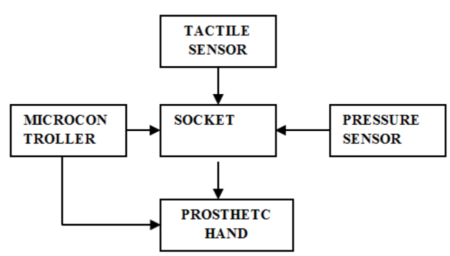


Fig 5: Block Diagram Representation of Sensory Feedback System

**Carbon fiber**

Another important discomfort with the prosthetic device is its weight. Carbon fibers are strong and light weighted. They are more commonly used for reinforcement, but pylons can be made of carbon fibers there by considerably decreasing the weight of the prosthetic. Carbon fibers have high tensile strength and specific strength when compared to other materials [8].

| Material | Tensile strength | Density | Specific Strength |
|---|---|---|---|
| Silicon carbide | 3440 | 3.16 | 1088 |
| Aluminium | 600 | 2.80 | 214 |
| Stainless steel | 2000 | 7.86 | 254 |
| Carbon Fiber | 4300 | 1.75 | 2457 |
| Titanium | 1300 | 4.51 | 288 |

Fig 6: Comparison of Various Biomaterials

The above table illustrates that Carbon fiber has high specific and tensile strength. It has high resistance to fatigue and chemical reactions. Tegris is a thermoplastic composite. It is light weight and strong. It has about 70% of strength of carbon fiber and it is only about 10% of its cost. This Tegris is fully recyclable and impact resistant. Tegris/ Carbon fiber sandwich act as a good biocompatible material and it prevents the prosthetic limb from shock while they are in motion. This combination is 18% lighter damage tolerant and it requires more energy to break.

**REHAB**

After being fitted with prosthetic it is necessary for the patient to feel comfortable with the device and learn to use it to meet daily challenges of life. They should also learn special exercises that strengthen the muscle to move prosthetic devices. A patient fitted with an artificial arm should learn to use the arm, its locking device and the hand. Along with physiotherapy Rehab also includes psychiatric treatments given to the Disaster victims to overcome the shock and stress that they were going through. For people with prosthetic limbs it is more important to make them feel confident to live the rest of their life bravely .In order to make these rehabilitation facilities available to all people the Government and NGOs have to take measures. People in the disaster affected region have to be provided with necessary medication and rehabilitation facilities.

## CONCLUSION

The proposed method of using the servomotor and dc motor can greatly help the affected people to lead their normal life. Integrating the sense of touch along with this can further make the person more comfortable and easier. Using compatible and low weight biomaterial as Tegris/ carbon fiber can make the prosthetic limbs to work similar to our biological limbs. Hence the proposed system helps in protecting precious human life that would have destined to perish from the effects caused by the disasters.

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