Bionic ARM for Prosthetist

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***Abstract*-Bionic arm plays an influential role in the recovery of an amputee and also helps gain his/her confidence. Lives of people have changed drastically with the help of artificial limbs, as they increase mobility and facilitate the performance of daily chores, as well as provide the means to live independently. Working of the bionic arm depends on the signals collected from the amputee's muscles. When an amputee uses the bionic arm and flexes his/her residual limb muscle, naturally generated electric signals are detected by the special sensors and are converted into appropriate bionic hand movements. The bionic arm acts as a real limb simply by thinking actions to be performed. Small electrical signals, produced by neurons in the body, help in controlling these actions. They are generated by muscle contractions and can be measured with electrodes on the skin that the user is capable of feeling. Two electrodes, that are inserted into the prosthetic shaft are used to detect the myoelectric signals and these signals are passed to the control electronics, then these signals are amplified and are used to activate the five electric motors (one for each finger) that move the fingers and thumb and the hand opens or closes by itself. As a result, the strength of the muscle contraction controls the speed and the gripping force: a weak signal generates a slow movement, a strong signal generates a quick movement.**

Keywords: Brain Signals, rehabilitation, Bionic arm, sensors, electrical signals, neurons, neural network.

I. INTRODUCTION

Humans as they are, have always evolved and found out new ways to improvise their lives in technological formats. With new advancements happening in the A.I field we have created humanoid robots which have the potential to change the future. Many people across the globe have suffered from accidents and have lost their arms and legs, it is necessary that these people recover and come out of the feeling of emptiness into the real world. This has become possible with help of Medicines, Mechanics, Neural Networks, Sensors and Machine Learning. Human hands can perform all complex activities and they can be used to interact with people and the surrounding environment. Our ancestors (apes) progressed themselves using opposable thumbs and evolved themselves into humans. Losing a hand is nothing less than a catastrophe, since almost everything is done using our hands. Most of our daily chores involve arm movements and it is very difficult for an amputee to do his/her tasks on a daily basis without the help of prosthesis. Hand movements are more complex compared to the leg. The loss of body parts can have various psychological consequences on a person. It can cause anxiety or depression that can be related to the personal vulnerability of the patient. Use of a fake arm which consist of Plaster and foam is of no use if a person cannot do anything with it, it simply works as a prop. “Gregory Clark” introduced the concept of a “Brain Controlled Arm” where the Robotic arm is controlled through brain signals. This brain-controlled arm is later modified with machine learning algorithms which help the arm to learn patterns and develop by itself.

II. BIONIC

It is a branch of science and engineering which consists of constructing artificial systems which are similar to that of living systems. Here we use these systems in order to find innovative ideas for useful artificial networks of systems, cybernetics to find the true purpose of a person’s behavioral patterns. Bionic arm is a concept of using brain waves (signals) and capturing them with motors (sensors) to move the respected arm using neuron signals which goes the through nerves. For this, scientists used electrode cells which capture the electrical particle (neurons) sent through nerves and collect them on the surface of chest muscle instead of the arm. These electrodes control each motor associated with them and later it is used to move that particular robotic (joint) part. Hence, when a person thinks about moving his arm, those specific signals are ignited by the brain which are travel through the nerves, then electrode cells pick these signals and use it to move the Bionic arm. While receiving the signal the part of the muscle that is contracted the most shows the neurons in that cell are activated and the signal is being generated. Like this each nerve is attached to the electrode by six different motors which help in hand rotation and movements.

III. IMPLEMENTATION

To redirect these nerves of a prosthetic person was difficult but Rd. Todd Chuken developed a muscle reinnervation procedure which helped in this case. Nerves in this case were diverted to the working muscle and with that cells they were able to pick the nerve signals. It usually takes up to a half a year to regenerate these nerves so they can work properly. After this, these nerves are used to redirect the signals to motor cortex which sends it to the bionic arm.

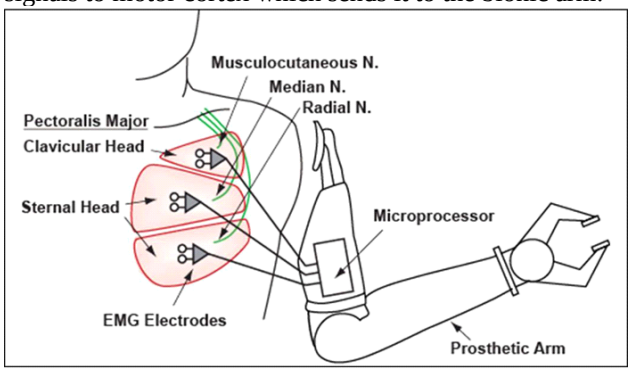

Fig.1

IV. MACHINE LEARNING

Machine Learning is used because a learning model always helps better to predict results than humans. It is used to observe the muscle signals which attempt various motions, force, grips and helps in predicting the output. The electrode cells attached to a normal person, captures the internal muscle movements and rotations that help us understand it's functioning more clearly. With basic information from robotics it can perform operations like grip, release and can be used in bionic arms. With some complex evolving algorithms, it can learn to improvise by itself and will improve the quality of the bionic arm using artificial nets. Automatically after learning from the behavioral patterns it will learn to recognize which muscle signal is sent to which nerve and arm movements will become more fluent. The robotic arm is developed at the Johns Hopkins University, where the arm has 26 joints and 'load cells' are inserted into each fingertip to detect force and torque applied to its respective knuckle. Sensors help collect data on temperature and vibration. Later this data is stored and processed to generate an output. Through this a bionic arm can mimic the movements of a normal arm and it collects sensation through sensors which are placed inside the prosthetic arm. Our bodies have control loops at various levels, and that's where Artificial Intelligence plays a vital role, because there are things that can be incorporated into the arm like anticipating responses from an object which you are interacting with and allowing the user to provide a necessary commands. These artificial networks can be used for making predictions, adaptive controls and applications where they can be trained by a dataset. Experiences will result in self-learning by machine-learning applications and they can occur within networks, which can help derive solutions for a complex and unrelated set of information.

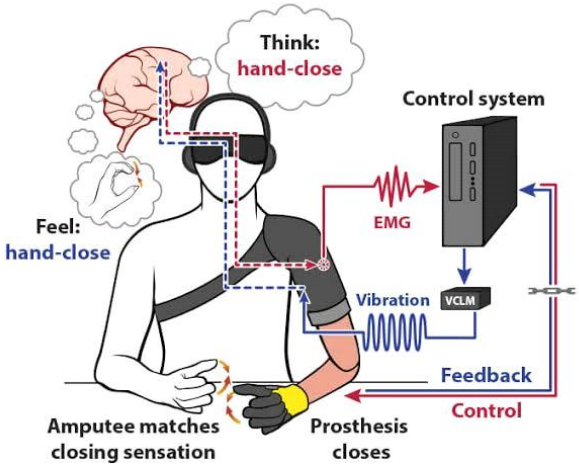

Fig. 2

V. NEURAL NETWORKS

Neural networks are a sort of computer system modelled for the human brain and hence connected to the nervous system. A neural network is collections of some connected units which is also known as artificial neurons. To have a connection between the neural networks and bionic arm there is a need to redirect those nerves into a working muscle where a chip is inserted into the backbone of skeletal area from where it takes the data of nerve signals. A neural network is best known as a circuit of neurons. The biological connectivity of neurons is modelled together and termed weights. The positive values of weights, indicate the excitatory connection and negative value of weights means the inhibitory connections. Further all inputs are developed and then put up together. The ongoing activity is termed as a linear combination. Amplitude of the output is controlled by the activation functions. 0 and 1, or −1 and 1 is usually the output range that is expected. In the past researchers, conducted a evaluation on microelectrodes which were implanted on the brain of a man to understand the functioning of brain. Collected data was pasted into neural nets which is an A.I and which helps to model the brain circuits working and this data was passed for machine learning and patterns were used to find out brain cells activities. Patients can move his/her arm more precisely and with better accuracy and less delay in system with the help of Neural net.

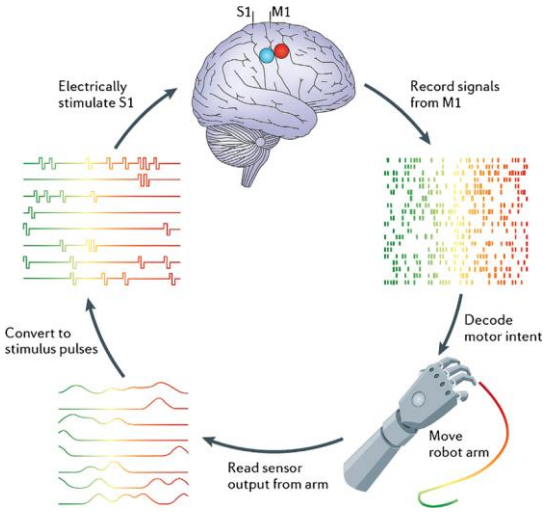

Fig. 3

VI. EMG *(Sensors)*

EMG (Electromyography) sensors help in recording the electrical activity which is generally produced inside the muscle fibers. The relation between surface EMG to torque helps measure the muscle tension which is also an important factor in the physical environment. The route for EMG signal origins is a bit hurdle for developing a quantitative description and is difficult between surface EMG and torque. The work of nervous system is to control the movements of various body parts by contracting and relaxing muscles simultaneously. These muscles have a small amount of electrical potential, which is generated by the neurons and is generally picked up by these muscle cells. Depolarization of these muscle fiber tissues is also difficult. This wave is generally travels through muscle fibers.

The muscle fibers are generally excited by nerve branches, with the help of one moto neuron in groups which is generally called as motor units and these motor units are defined as the fundamental unit of contraction and can range from a few muscle to many muscle fibers respectively and for small muscles that are present in the fingers of hands and as each motor unit contains a number of muscle fibers that are attached to the motor neuron at various parts. The summation of the action potential of each muscle fiber is called as electrical signal and in that particular electrical signal there might be phase shifting from the muscle fiber in that particular unit. Surface electrodes are used to measure the KG's and Aegis thus are used because they are easily attached to the skin. The metal conductor is placed in the middle with electrical liquid substance on each side so that signals can be read through the skin. They are easy to implement and can be removed without any harm to its user. They don't require any special training, but the disadvantage of this is that it detects the other signals from nerves which may mislead to the processor. Intramuscular procedures are very complex and electrodes are inserted into human's motor unit which controls the nerve and these can cause harm to a patient if the needle gets stuck in between the nerves. Controllers act as brain of the bionic arm. End effectors are used to perform hand operations such as open, close and rotate. Drivers are used for joints that control the movements and maneuvers.

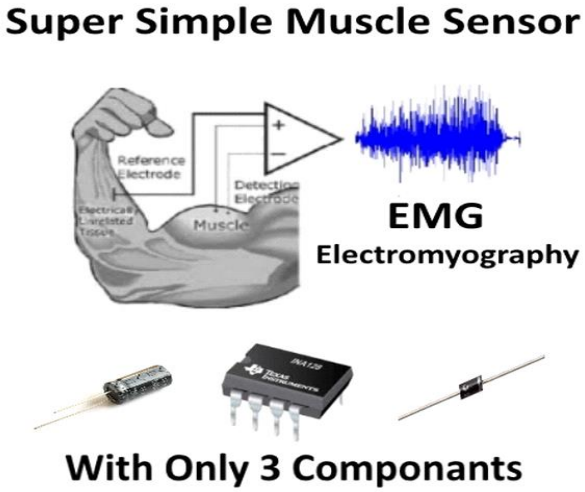

Fig. 4

VII. COMPONENTS AND FORCE SENSING RESISTORS

With the help of Servo actuators input is changed into a proportional and preferred output. As a result of this, feedback helps to enhance proprioception as illustrated in the direct force or excursion relationship to elbow, wrist, or terminal device function. There are two substrate layers in FSR and are followed by the conductive film and plastic spacer, which has an opening aligned with the active area. Following spacer layer there is the conductive print on substrate. When outer force is applied on the sensor, the film is deformed against the substrate. Air from the spacer opening is pushed through the vents, and the film comes into touch with the conductive print on the substrate. The more that the conductive ink area gets in contact with the conductive film, the lower the resistance. Conductive film is used as force resistance material. For.eg force sensitive resistor, it's a sensor that allows you to detect physical pressure, squeezing and weight. Controllers are used to act as brain of the bionic arm and end effector are used to perform hand operations such as open, close and rotate. Drivers are used for joints that controls the movements and manures.

VIII. MICROPROCESSOR AUGMENTATION

Microprocessors control the terminal devices and use them for the functioning of arm joints. The microprocessor accepts input characteristics and further filters and enhances them to generate a preferred output, which helps in optimizing the prosthetic functions and increases the ease of use. Microprocessors are mainly classified into two categories: 1) those that have an intrinsic or internal processor 2) those that use extrinsic processors. The first type (Intrinsic processors) are used by those who have long arms to reduce space distal amount. But for prosthetic people and for more effective use from minimum we use extrinsic processors. These types of processors have an advantage of

extra protection around the prosthetic interface. They are easy to replace and ability to control becomes very easy.

IX. GRAPH

This graph illustrates how patients are becoming more friendly with bionic arm products as well as how companies are making profits. Moreover, it shows how robotic arm is being evolved into bionic arm with evolution in technology and how this arm will be working as normal human arm.

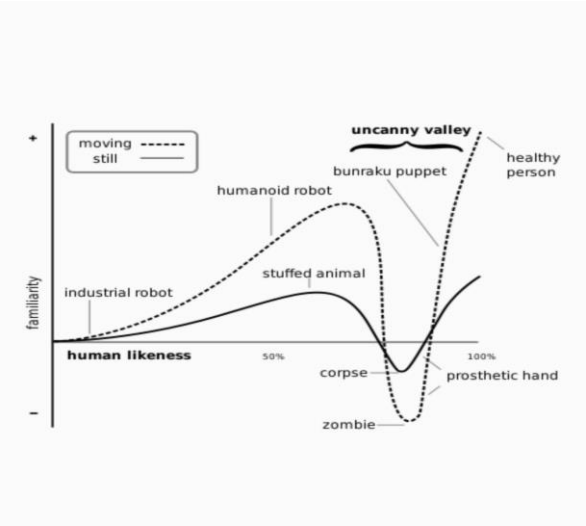

Fig. 5

CONCLUSION

• No advanced prosthetic can ever be a replacement for a flesh and blood limb, but as technology progresses, we will surely progress with it.

• The prosthetics used initially were merely used as a prop. The bionic prosthesis gives us a much better functionality, which can be acceptable to more patients, in terms of durability and comfort. However, these prostheses still have to overcome many hurdles in order to improve upon the intrinsic hand. Neuro-prosthetics is still in its infancy stage and limited mostly to medical use. These advancements are moving ahead with a faster pace, they will soon be available on a commercial basis to provide support to many amputees across the globe

• The introduction of modern materials, has given a wider and better scope for more intimate socket designs that can result in an improved prosthetic experience for the prosthetists. This facilitated development of new socket fitting techniques allow orthopedic technicians to custom-match the residual limb anatomy of each user.

• The study of these bionic prosthetic arms which mostly work in areas of forensic medicine, taught us a many thing about the current technology and its potential. To develop prosthetic arms for heavy and intense applications, mandatory heavy testing is required. Occupational challenges may then necessitate prosthetic adjustments that only appear once prosthetic devices are subjected to sufficient hard tests, depending on the user's task requirements to be fulfilled.

• When we talk of such advancements in the mere future, we should also understand that these technologies will become smarter, stronger and efficient, which could in future lead to problems. As humans become more mechanical our laws and policies will have to evolve around it, to explain how we look over the privacy, control and access of our own bodies.

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