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Advancements in Myoelectric Hand Prosthetics: Integrating Smart Features for Improved Functionality

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***Abstract* — These days the population is growing exponentially, which directly corresponds to an increase in the demand for jobs and technology. This demand may not be fulfilled; which can cause increase the risk of accidents or lack of medical facilities, as poverty remains an important issue in such scenarios.**

Our goal is to help individuals with physical challenges, especially those impacting their hands, at lower costs. Prosthetics are important in today's technology; thus, we aim to bridge the gap between current research and future potential. Currently, many prostheses resemble real hands and perform nearly half the functions of natural hands. The latest models are controlled by mental or nerve signals. However, the cost is often too high for individuals with average incomes. This project aims to develop a low-cost hand prototype using 3D printing and muscle signals for movement control.

Index Terms— Bionic hand, Prosthesis, Amputees, Robotic hand.

I. INTRODUCTION

The human hand possesses a remarkable ability to execute a diverse range of intricate movements, which enables us to interact with our surroundings and communicate with each other. In order to perform complex hand movements, we must process a vast amount of somesthetic information about our environment, including fine touch, vibration, pain, temperature, and proprioception. The loss of a hand can be a devastating experience, it can result in catastrophic functional limitations. Amputation at any level can result in varying degrees of disability, which may permanently limit an individual's ability to perform basic activities such as feeding and grooming. Replicating the functions of the human hand using a bionic device is a significant challenge due to the inherent complexity of the hand. In order for a bionic limb to be advantageous over a non-functioning alternative, it must be easy, reliable, and quick to control. The most commonly used method of control in commercially available bionic limbs is myoelectric control. Myoelectric prosthesis uses muscle activity from the remaining limb of the amputee for the control of movement of forehand. When one moves his natural limb, his brain sends nerve signals to the muscles, which in turn move the limb. When a limb is amputated, the brain still sends these signals even though some of the muscles are no longer there to react to them. These signals are known as Electromyographic (EMG) signals.

There are some methods of detection of the EMG signals in the muscles which are as follows:

- Myoelectric Direct Control: It uses one or two EMG sensors for a single movement muscle detection of contraction and relaxation of the muscles i.e. detection of closing and opening of hand.
- Myoelectric Pattern Recognition: Here, three to eight EMG sensors are used to detect muscle movement patterns and each muscle pattern is mapped for a specific action.
- Surgical Implementation of Myoelectric Sensors for Pattern Recognition: EMG sensors are surgically implanted in the muscle tissue which can detect deeper muscle movements with movements near the skin. This is more reliable as it allows easier simultaneous detection of multiple movements.
- Mechanomyogram (MMG) Control: It monitors mechanical signals generated by muscle movements.

This project focuses on study of current myoelectric hand prosthetics technology which aims to replicate the functionality of a human hand and filling their gaps with some smart features.

II. LITERATURE SURVEY

The field of bionic hands is advancing rapidly with increasing research and a large body of work exploring recent progress. Researchers focus on myoelectric control systems that use electric signals from muscles to move the bionic hand. Another focus is sensory feedback systems meant to provide users a sense of touch and feeling from the bionic hand. Researchers have achieved this in various ways like electronic sensors and direct interfaces with the nervous system but this invasive technology of Neural interface causes risk to neurons. Scientists have also explored advanced materials and manufacturing techniques to make more durable, lightweight and comfortable bionic hands for users. This includes 3D printing and other additive manufacturing to create custom prosthetics tailored to individuals.

Researchers also study the social and psychological impacts of bionic hand use. They examine how bionic hands affect users' self-esteem, body image and quality of life plus social and cultural factors that influence acceptance and adoption.

Overall, research on bionic hands reflects a fast-changing field driven by technology advances, material science progress, and neuroscience as well as growing focus on user-centered design and social factors in developing these devices.

III. PROBLEM STATEMENT

A bionic hand is a prosthetic tool created to operate in the place of a missing or amputated natural hand. The foremost objective of employing a bionic hand is to improve the quality of life and restore functioning for those who have lost a limb. Bionic hands can replicate a variety of real-world hand movements and emotions. The objective of this project is to design a prototype hand that can be attached to the forearm. This project aims to highlight the significance of hands in our daily lives and the potential benefits of bionic hands in improving the quality of life for those with hand amputations.

IV. EXPERIMENTAL WORK

1. Sensing

Our hands play a crucial role in enabling us to interact with the world around us. We rely on tactile sensory inputs to refine our movements and avoid harm. Sensation in a bionic limb can come in two forms: sensory information interpreted by the device itself, and sensation perceived by the user. Modern bionic limbs have developed simple techniques to interpret tactile sensory data they utilize internally to modify activity. For instance, grasp strength information prevents the user from breaking objects by gripping too tightly, while sound detectors embedded in the hand ensure objects aren't dropped. While these features improve functionality, they provide no sensory information for the user.

Providing sensory inputs from a bionic limb that the user can perceive is highly complex. One approach utilizes multimodal plasticity where loss of one sense is compensated by others. Another approach replicates sensation by transferring stimuli from electronic sensors in the bionic limb to natural sensors on the limb stump, perceived as originating from the amputated limb. Direct interfaces with the peripheral or central nervous systems may offer an enhanced sensation solution from bionic hands, ultimately coming closest to restoring the original sensory perceptions of the hand.

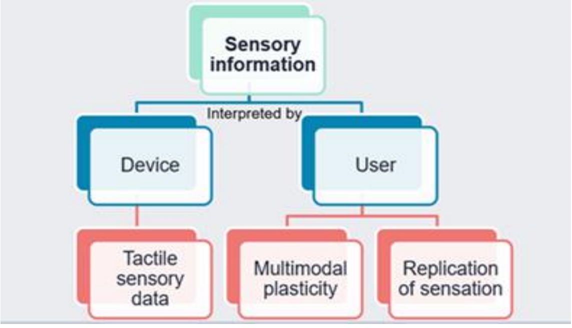

Figure 1 Ways of sensation in a bionic hand

2. Controlling:

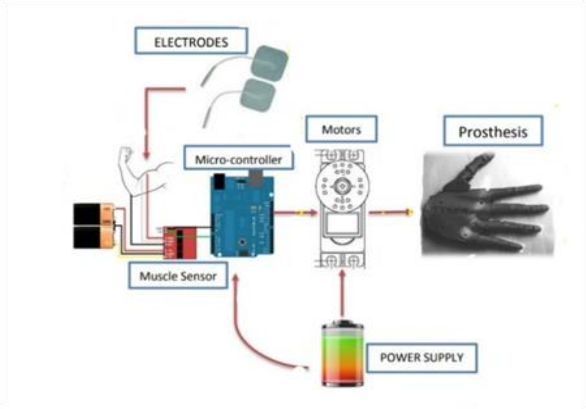

Figure 2 Block diagram of Bionic hand circuitry

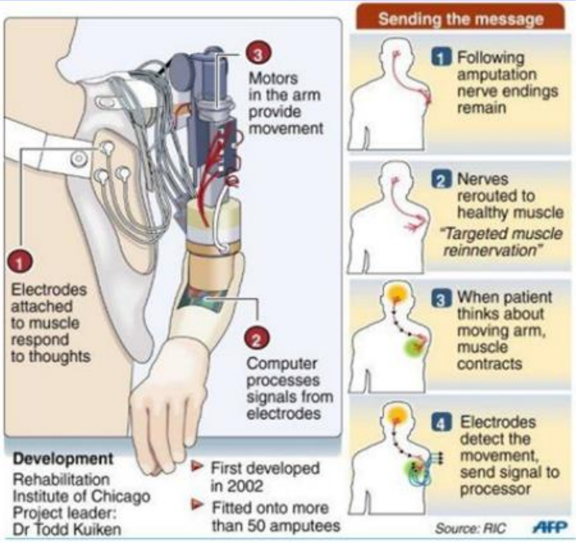

Figure 3 Prosthetic arm controlled by thought

Brain sends the signals to the specific muscles for movement. The signals are known as Electromyographic (EMG) signals which are very small 5-20μV with very small value. These EMG signals are identified, then amplified which are then processed to interpret the limb movement. Here the details about controlling of bionic hand using myoelectric control is elaborated.

A myoelectric sensor, widely referred to as an electromyogram (EMG) sensor, is a device that recognizes and evaluates the electrical activity of muscles. To detect the electrical impulses produced by muscular contractions, these sensors employ electrodes positioned on the skin's surface. The myoelectric control method utilizes complex algorithms to interpret the extensive electrical activity in the stump, which can be influenced by various factors such as movement in the shoulder or elbow, as well as the heartbeat. Electrical pattern recognition techniques can activate entire muscle groups that are involved in specific movements. However, mastering the use of a myoelectrically controlled prosthesis can be a challenging and time-consuming process, and there must be sufficient electrical activity in the limb stump for the prosthesis to function properly.

A wearable device resembling an armband has 5 to 8 myoelectric sensors and a pressure sensor that utilizes a dual-site myoelectric sensor system to monitor and evaluate the electrical activity of the Lateral Antebrachial cutan and Medial Antebrachial cut. The myoelectric sensors in the armband of the bionic hand detect the electrical impulses produced when the user contracts a muscle in their residual limb and transmit this information to the microprocessor. Integrating solar power with battery backup in a myoelectric bionic hand prosthetic is a challenging task. It can be achieved by using a solar panel to charge a battery that powers the prosthetic hand. A solar panel that is small and flexible enough to fit on the prosthetic hand but powerful enough to generate sufficient energy to charge the battery can be used.

Figure 4 Wearable sensors band

In order to generate direct current power, a solar panel is utilized; the electricity is then stored in batteries. The information received by the microprocessor from the EMG sensor is subsequently converted into motion by the battery-powered motor that drives a gearing system to move the main MCP joint, which then moves the second and third joints via a bar linkage system.

Linkages are employed to strengthen and extend the hand's longevity. Flexible cables are used to transfer motion and force from a control source to the hand. The cables are attached to the hand's fingers and thumb, allowing the hands to open and close simply by pulling or releasing the cords.

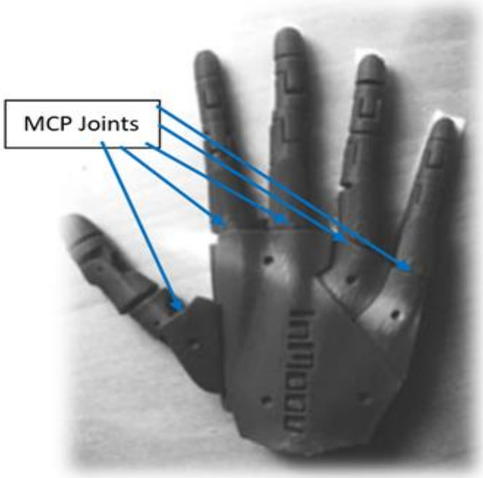

Figure 5 MCP joints of a hand

The distinguishing feature in this type of design are:

1. There is only one independent joint: the MCP joint (main knuckle). Other two joints automatically follow the lead of the first joint.

2. Use a solar panel that is both compact enough to fit on the prosthetic hand and potent enough to provide enough energy to recharge the battery.

V. RESULTS AND DISCUSSION

There are multiple ways the existing myoelectric bionic hands control system could be enhanced:

1. Use of more advanced sensors and signal processing algorithms can lead to increase in accuracy in sensing and movement precision.
2. Machine learning algorithms can improve precision by learning from users' motions and customizing to their needs.
3. Increase in degrees of freedom of a bionic hand can make the bionic hand more versatile and functional. This involves additional motors and actuators.
4. Advanced software and hardware can be used to make the interface more intuitive and user-friendly.
5. The bionic hand's battery life can extend to make it practical for daily use. This involves more efficient batteries and power consumption optimization.

These improvements require expertise in robotics, signal processing, machine learning, and human-computer interaction.

VI. FUTURE WORK

Integrating a myoelectric bionic hand with the brain can be achieved through a process called neural integration. This involves connecting the prosthetic hand to the user's nervous system, allowing them to control the hand using their thoughts. Research is going on about this.

The use of electrodes implanted into nerves is perhaps the most promising approach that likely holds the key to successfully integrating bionic limbs into the biological system. Intraneural electrodes interact directly with the nerves in the limb stump and have the ability to enable two-way communication between the bionic limb and patient. It is a major engineering challenge, but if successful, this technology enabling sense of touch could benefit more than just prosthetic users. Such an interface would al-low people to feel things in a way that was never before possible.

VII. CONCLUSION

During the Middle Ages, prosthetic hands were mainly used as props. However, today's bionic hand prostheses offer significantly better functionality, are more widely accepted by patients, and are more durable and comfortable. Despite these advancements, there are still significant challenges to overcome in order to replicate or improve upon the natural hand, and there are also economic implications to consider. Nevertheless, the field of prosthetics is advancing rapidly, and it is likely that within a decade, commercially available limbs will be able to provide both sensation and accurate motor control from the outset. While the idea of bioartificial organs that are fully integrated into the central nervous system and surpass our own capabilities may seem like science fiction, it is possible that collaborative efforts between medicine, engineering, and materials science could make it a reality.

REFERENCES

[1] Robotics. (2012). At Inmoov Available: https://inmoov.fr/download/

[2] By Rhys Clement, Chris Oliver, and Kate Ella Bugler. “Bionic Prosthetic Hands: A Review of Present Technology and Future Aspirations.”‖ in Journal of the Royal College of Surgeons of Edinburgh, December 2011, Available :https://www.researchgate.net/publication/51759015_Bionic_prosthetic_hands_A_review_of_present_technology_and_future_aspirations

[3] By Dustin J.Tyler. “Creating a Prosthetic Hand That Can Feel.”, IEEE Spectrum: Technology, Engineering, and Science News, IEEE Spectrum, 28 Apr. 2016, Available: https://spectrum. ieee.org/ creating-a-prosthetic-hand-that-can-feel

[4] “How the i-Limb Works.”— Touch Bionics, Ossur, Available: https://www.ossur.com/en-us/ prosthetics/touch-solutions

[5] By Tushar Kulkarni, and Rashmi Uddan wadiker. “Mechanism and Control of a Prosthetic Arm.” MCB, vol. 12, no. 3, ser. pp.147-195, 2015. Pp.147-195.

[6] By Julia Layton. “How Can Someone Control a Machine with Her Thoughts?” HowStuffWorks Science, HowStuffWorks, 28 June 2018, Available: https://science.howstuffworks.com/brainport.htm