A Project on

Performance Enhancement of Myoelectric Prosthetic Arm

Submitted by :

Richa Jaiswal (2021031057)

Shubham Yadav (2021031075)

Aman Dubey (2021031011)

Esha Kumari (2021031033)

Vagisha Singh (2021031084)

Supervisor :

Prof. V. K. Giri

ELECTRICAL ENGINEERING DEPARTMENT

MADAN MOHAN MALAVIYA UNIVERSITY OF TECHNOLOGY

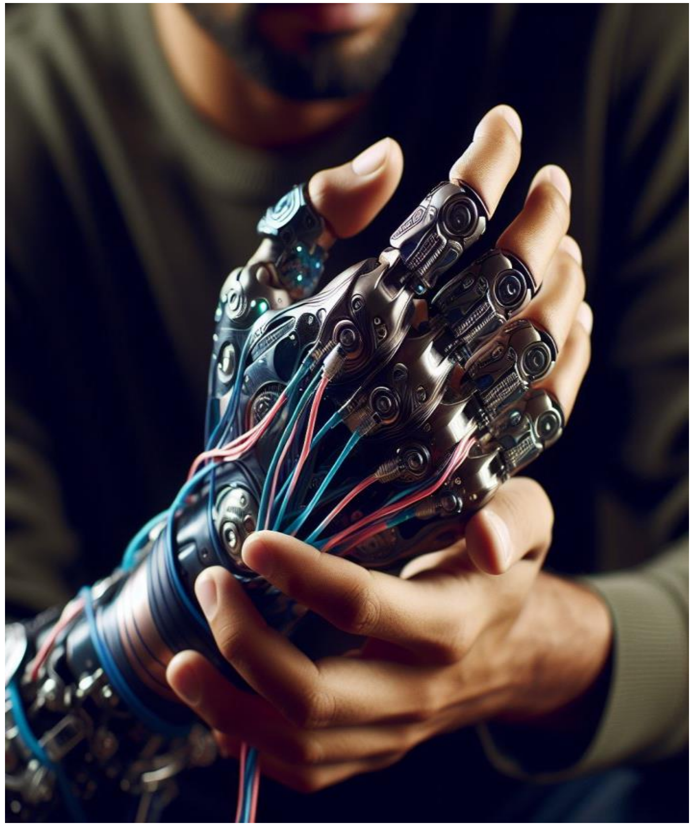
CONTENT

INTRODUCTION

- Myoelectric = utilizing electricity generated in muscles

  Prosthetic Arm = Artificial Arm

- Myoelectric prosthetic arm uses muscle signals from the **amputees' residual limb** to control movement.



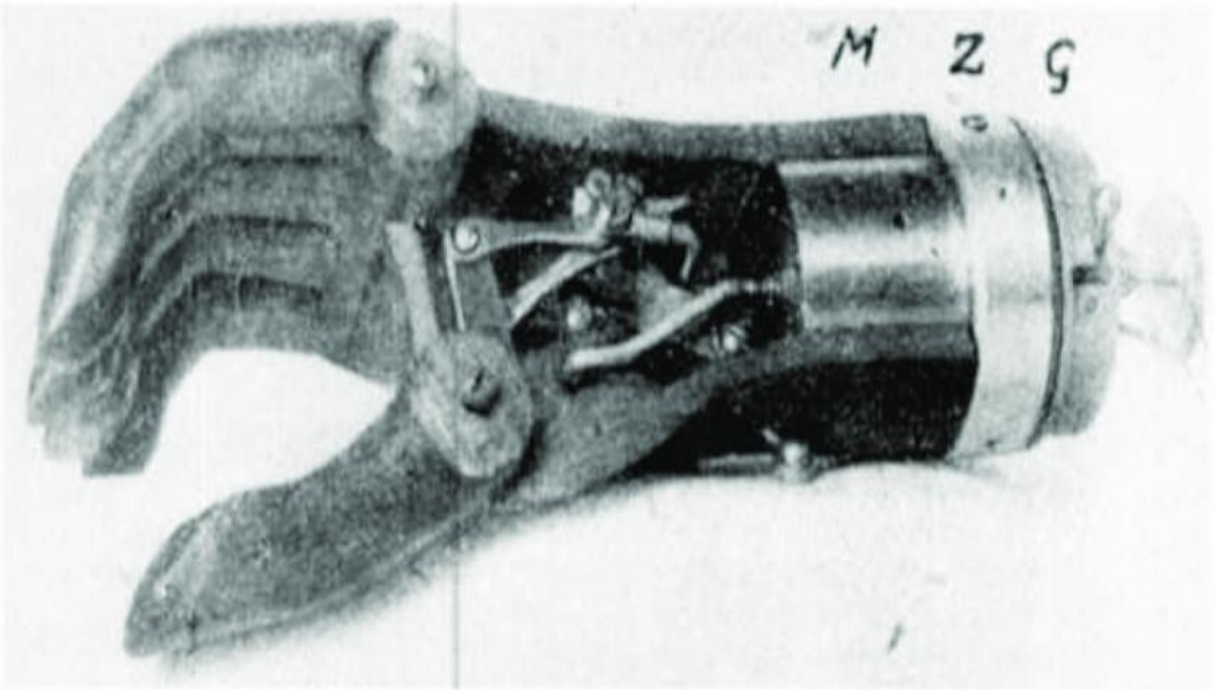
Myoelectric Prosthetic Arm

HISTORY

- In the 1940s, the concept of using electrical signals from muscles for prosthetic control emerged.

- **Reinhold Reiter** developed the first myoelectric prosthesis in Germany.

- The Russian scientist Alexander Kobrinski developed the first commercially available myoelectric arm.



Photograph of the first electric-powered myoelectric prosthetic hand used by the inventor Reinhold Reiter (Circa 1943)

OBJECTIVE

- According to a survey by the World Health Organization, the estimated number of amputees in the developing world is **40 million**. In India, as per the 2011 census, the population of persons with disabilities was approximately 2.68 crore, which accounts for **2.22% of India’s population**.

- The prosthetic arm aims to replicate the functions of a human arm as closely as possible.

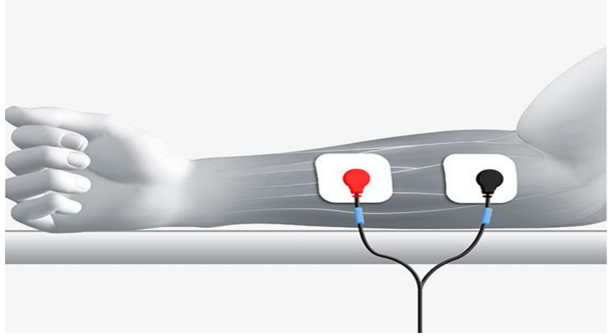
- This project aims to make a prosthetic arm controlled by the user’s brain and perform actions like **holding, pulling, pushing, pinching, pointing, and movement of different combinations of fingers**.

EMG Sensors & Operating Frequency

1. **Surface EMG Sensors**: Surface EMG sensors are non-invasive and **placed on the skin surface**. sEMG signals fall within the range of **20 Hz to 500 Hz**. They detect electrical activity from superficial muscles.

2. **Intramuscular EMG Sensors**: Intramuscular EMG sensors are invasive and **inserted directly into the muscle tissue**. They provide more accurate recordings from deep muscles. iEMG signals cover a broader range, typically from **20 Hz to 10 kHz**.

3. **Wireless EMG Sensors**: Wireless EMG sensors eliminate the need for cables. They transmit data wirelessly to a receiver or mobile device. Wireless EMG signals operate within the **20 Hz to 500 Hz range.**



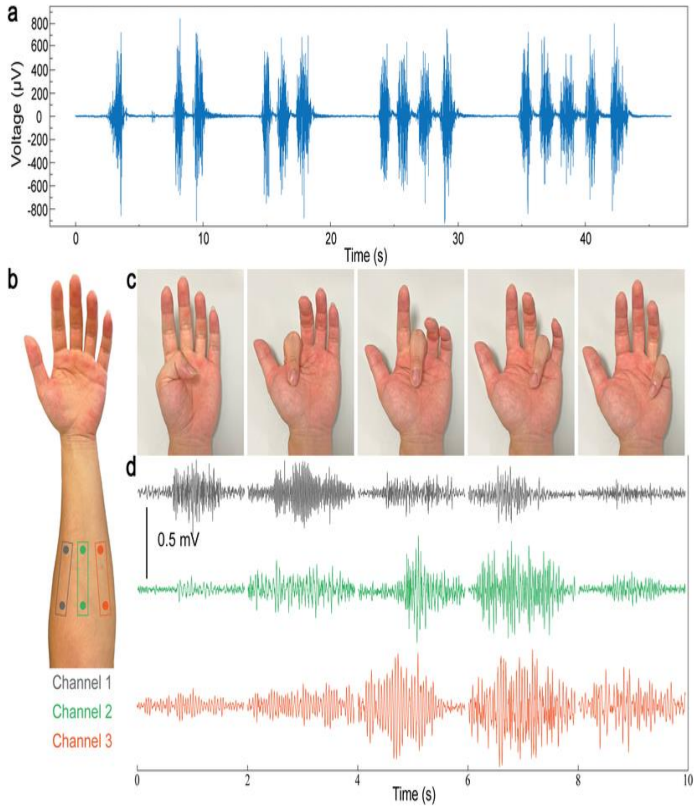
sEMG

iEMG

Wireless EMG

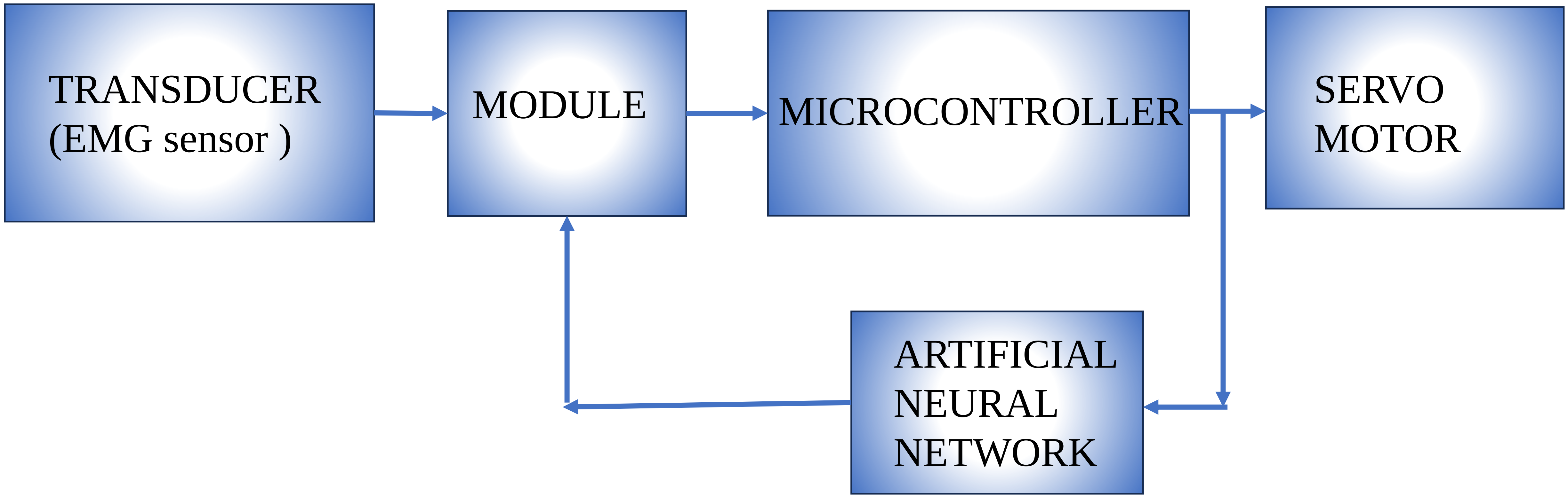
Recording of EMG Signals

- Recording an electromyography (EMG) signal involves measuring the electrical activity produced by skeletal muscles.
- Clean the skin where the electrodes will be placed to reduce impedance.
- Place EMG sensors over the muscle of interest.
- Connect the surface or needle electrodes to the EMG amplifier.
- Ensure the EMG amplifier is correctly calibrated.
- Connect the amplifier to the data acquisition system.



EMG Signal Recording

METHODOLOGY



1. Electromyogram sensor

- Electromyogram (EMG) sensors are devices used to detect and measure electrical activity produced by skeletal muscles.

- When a muscle contracts, it generates an electrical signal that can be detected by EMG sensors, which are typically placed on the skin's surface or inserted into the muscle tissue.

Electromyogram sensor (Surface EMG type)

2.EMG Module

- It is a device which performs signal conditioning .
- It consists of an amplifier to amplify the signal received from the muscles .
- Filter is used to remove noise from the collected signal .
- It makes the output of EMG sensor compatible with the microcontroller .
- Power source to drive the sensor is connected here.

EMG Sensor Module

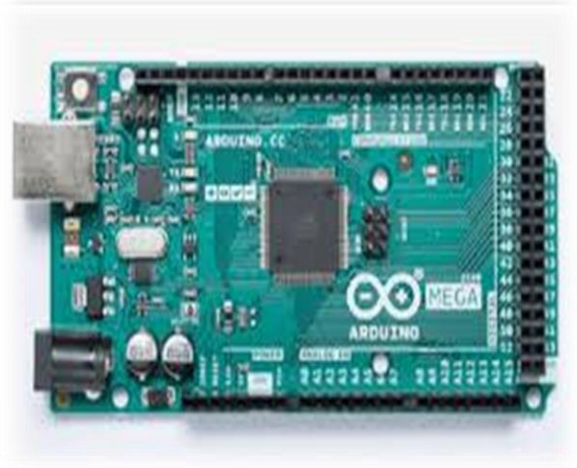
3. Microcontroller

- The microcontroller processes the EMG signals and translates them into control commands for the prosthetic hand.

- The microcontroller sets a threshold value based on the maximum and minimum muscle sensor readings.

- **If the user relaxes his muscle (signal below the threshold), the microcontroller opens the prosthetic hand.**

- **If the user contracts his muscle (signal above the threshold), the microcontroller closes the hand**.



Microcontroller (Arduino UNO)

4. Servo Motor

- 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 is given as the feedback.

- In this model, the **servomotor is interfaced with the fingers' arrangements.**

- The control signal to the servomotor is issued by the microcontroller

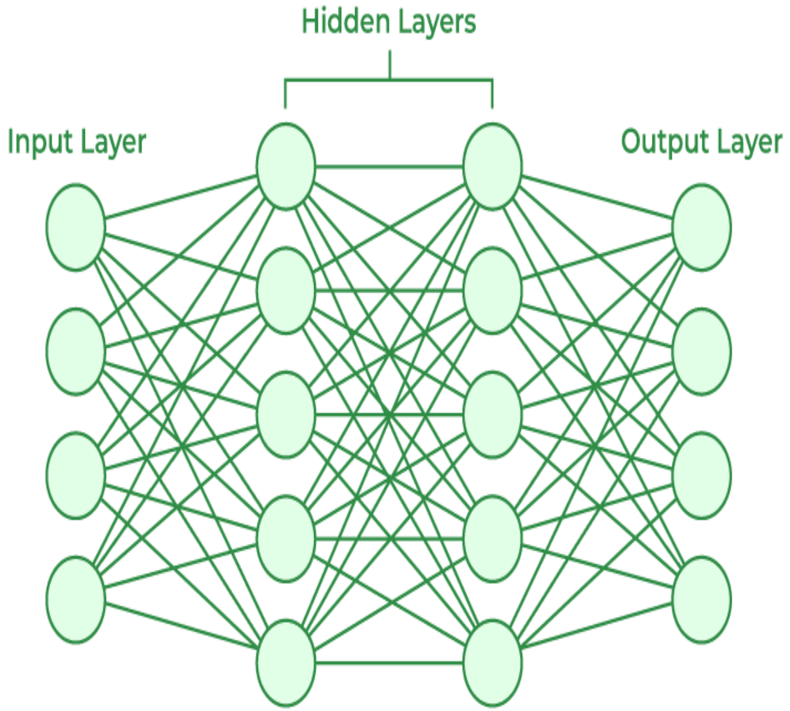
Servo Motor (MG996R)

5. Artificial neural network

- Artificial Neural Networks (ANNs) are computational models inspired by the structure and functioning of the human brain.

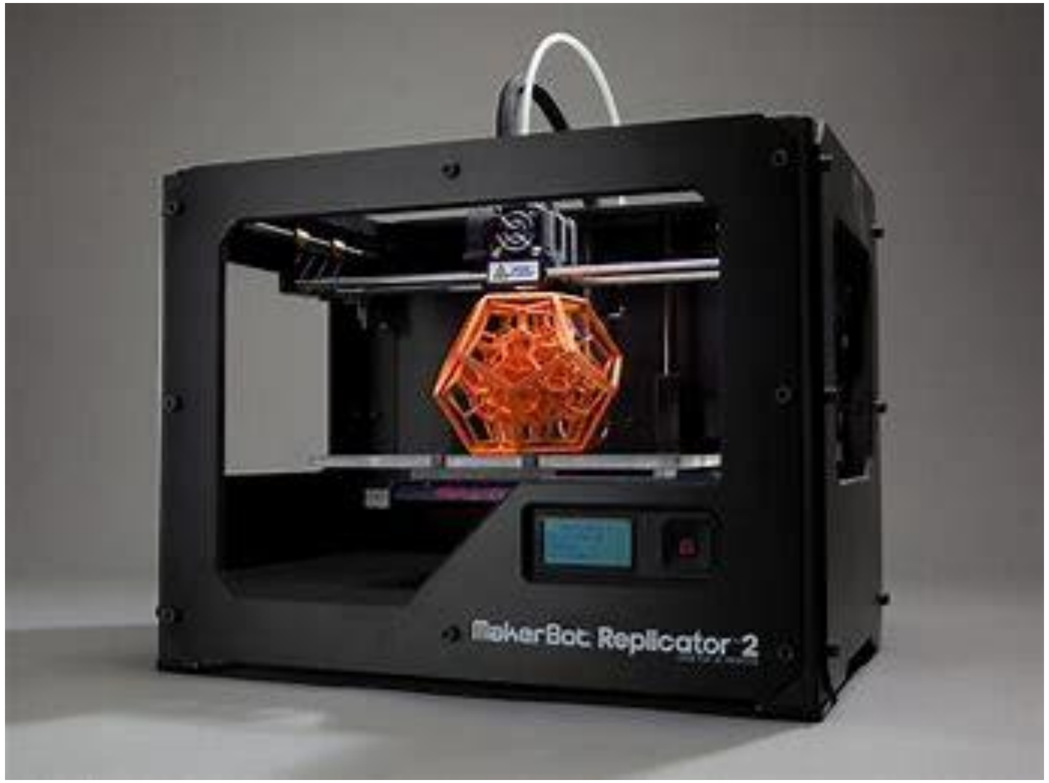
- They consist of interconnected nodes, often referred to as neurons or units, organized in layers.

- In this project, ANN will be used to train the hand to perform actions like holding, grabbing, throwing, push and pull . Taking feedback about current position from the servo motor , decisions will be taken by ANN to make the movment of hand accurate and seamless.



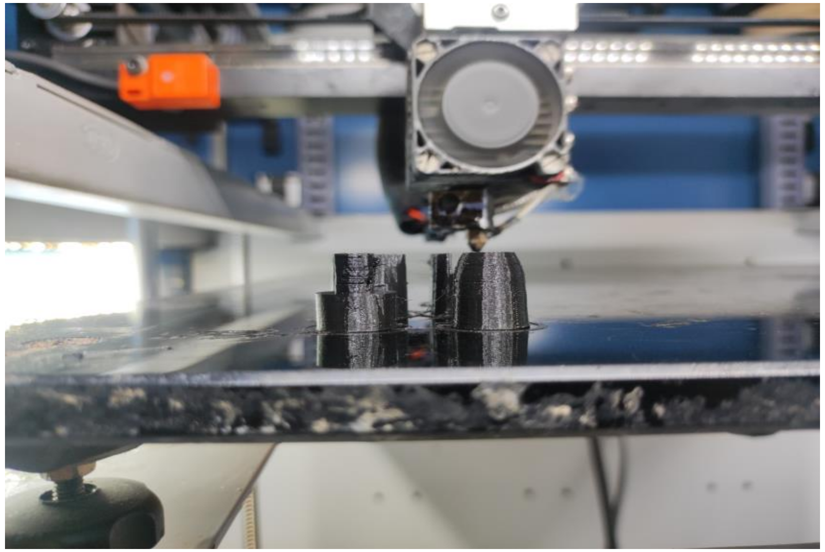
3-D Printing of the Model using PLA thermoplastic

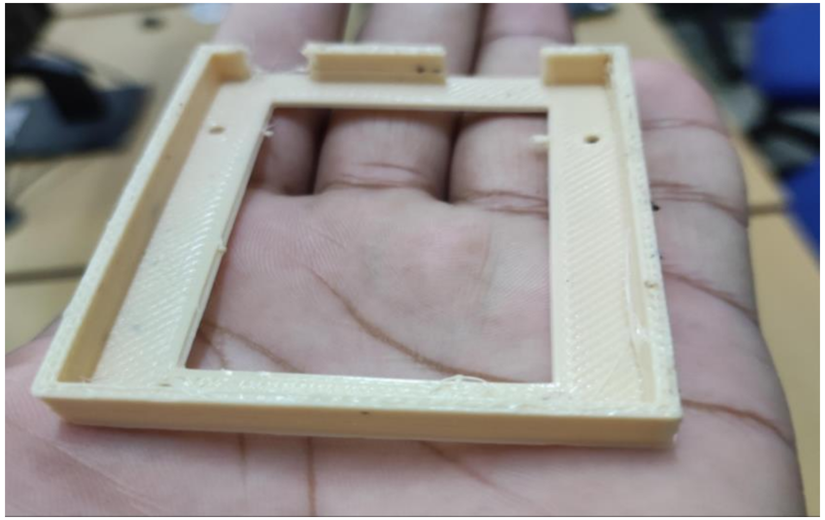
PLA thermoplastic (polylactic acid)

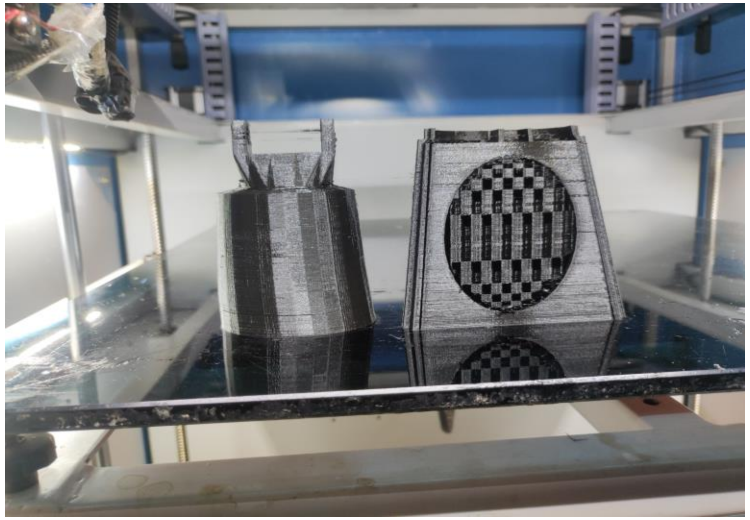


3-D Printer

Images Captured During 3-D printing of the Prosthetic Arm

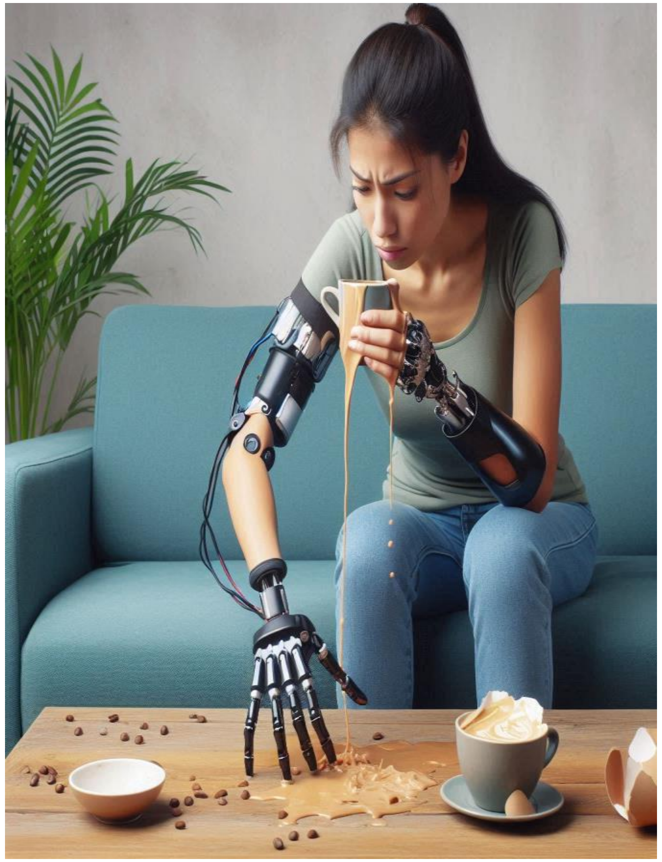






Challenges and Limitations

- **High Price**: Myoelectric prosthetic arms are often expensive; the high price can make them inaccessible for many patients.
- **Limited Battery Life**: Myoelectric prosthetic arms rely on batteries for power, which can run out quickly, especially with frequent or intensive use.
- **Weight**: Batteries add weight to the prosthesis, potentially making it heavier and less comfortable for the user
- **User Training**: Significant training is required for users to effectively control the prosthesis using their muscle signals.



Untrained user using Myoelectric Arm

Conclusion

- Myoelectric prosthetics represent a remarkable fusion of biomechanics, electronics, and neuroscience.

- These devices offer lifelike alternatives to amputees.

- Proper training is essential for users to maximize the benefits of myoelectric prosthetics.

- It also increases self-confidence and a sense of normalcy for amputees.

- Innovations like pattern recognition algorithms and machine learning contribute to more intuitive control of prosthetic movements.

REFERENCES

- Mohan C and Vinod Kumar Giri, "EMG Signal Analysis Using Microcontroller", Proceedings of National Conference on Advances in VLSI, Embedded & Communication, AVEC-2010, AL-FALAH School of Engineering & Technology, Dhauj, Faridabad, pp. 28-32, 10th August 2010.
- Mohan C, and Giri, V. K. (2011). DC Motor Control using EMG Signal for Prosthesis. *International Journal of Electronics and Comm. Technology (IJECT)*, *2*(2), 163-166
- Atkins, D.J., Sturma, A. (2021). Principles of Occupational and Physical Therapy in Upper Limb Amputations. In: Aszmann, O.C., Farina, D. (eds) Bionic Limb Reconstruction. Springer, Cham. https://doi.org/10.1007/978-3-030-60746-3_20
- Choudhury, D.N., Nayak, N. (2022). An Effective Optimization of EMG Based Artificial Prosthetic Limbs. In: Panda, M., et al. Innovations in Intelligent Computing and Communication. ICIICC 2022. Communications in Computer and Information Science, vol 1737. Springer, Cham. https://doi.org/10.1007/978-3-031-23233-6_12

THANK YOU!