# Prosthetic hand with real-time feedback

24AIM113 Introduction to NN, CNN and GNN
24AIM114 Analog system design


## Presented By

A. Guru Jaya Surya Yadav CB.AI.U4AIM24101.
J. Tej Krishna Sai CB.AI.U4AIM24117.
P. Teja Prakash Royal CB.AI.U4AIM24136.
S. Ankith CB.AI.U4AIM24147.

**GUIDED BY:**
**Dr.AmruthaV**
**Dr.Snigdhatanu Acharya**

# INTRODUCTION

1. What is a prosthetic hand?

2. Why real-time feedback?

3. What is the role of CNN

Bringing Intelligence to Prosthetics – AI for a Better Grip!

# LITERATURE REVIEW

| S. No. | Title | Year | Methodology | Key Contributions |
|---|---|---|---|---|
| 1. | Advances in AI-based prosthetics development: editorial | 2023 | Overview of AI in prosthetics | Discusses the evolution from basic prosthetics to advanced AI-integrated devices, highlighting the role of AI in enhancing prosthetic functionality. |
| 2. | The Latest Research Progress on Bionic Artificial Hands | 2023 | Development of a 19-DOF prosthetic hand | Reviews advancements in bionic prosthetic hands, focusing on control mechanisms, sensory feedback integration, and mechanical design innovations. |
| 3. | A lightweight prosthetic hand with 19-DOF dexterity and human-like appearance | 2025 | Development of semi-autonomous prosthetic hand | Introduces a lightweight, biomimetic prosthetic hand employing 19 pairs of highly integrated SMA actuators, enabling precise control and human-like appearance. |

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| 4. | Designing Prosthetic Hands With Embodied Intelligence: The KIT Prosthetic Hand | 2022 | Development of semi-autonomous prosthetic hand | Presents the development of prosthetic hands that provide intelligent mechatronics including adaptive actuation, multi-modal sensing, and on-board computing resources to enable autonomous and intuitive control |
| 5. | A highly integrated bionic hand with neural control and feedback for dexterous manipulation | 2024 | Integration of neural control and feedback | Prioritizes research on prosthetic control over the provision of sensory feedback, emphasizing the importance of control mechanisms in prosthetic development. |
| 6. | Liquid Metal Sensors and AI Could Help Prosthetic Hands to 'Feel' | 2021 | Development of liquid metal sensors | Introduces new technology combining liquid metal sensors and AI to improve the control of prosthetic hands and provide haptic feedback, enhancing the experience of touch for amputees. |

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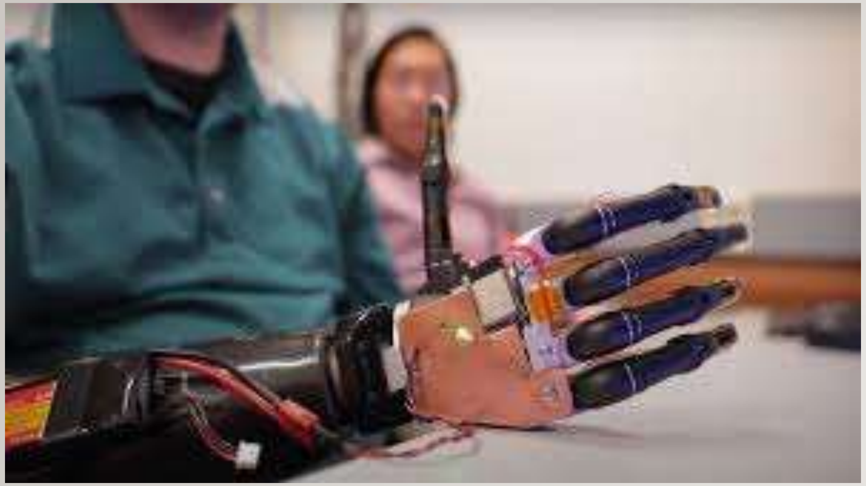
|---|---|---|---|---|
| 7. | A Perspective on Prosthetic Hands Control: From the Brain to the Hand | 2023 | Neuroscientific review | Reviews the current state of the art in hand and grasp control from a neuroscientific perspective, focusing on brain mechanisms that underlie sensory integration for hand control and engineering implications for developing artificial hands. |
| 8. | A multiarticulate pediatric prosthetic hand for clinical and research applications | 2022 | Development of pediatric prosthetic hand | Discusses and evaluates a pediatric-sized multiarticulate prosthetic hand that provides 6 degrees of actuation, designed for ease of implementation in research or clinical-research settings. |
| 9. | Artificial Intelligence Enables Real-Time and Intuitive Control of Prostheses via Nerve Interface | 2022 | AI-based neural control | Demonstrates an AI agent employing a recurrent neural network to decode six degrees-of-freedom from multichannel nerve data in real-time, enabling intuitive control of a prosthetic hand. |

| | | | | |
|---|---|---|---|---|
| 10. | Smart Hand: Towards Embedded Smart Hands for Prosthetic and Robotic Applications | 2021 | Development of smart embedded system | Focuses on designing a smart embedded system enabling the acquisition and real-time processing of high-resolution tactile information from a hand-shaped multi-sensor array for prosthetic and robotic applications |

# RESEARCH GAPS

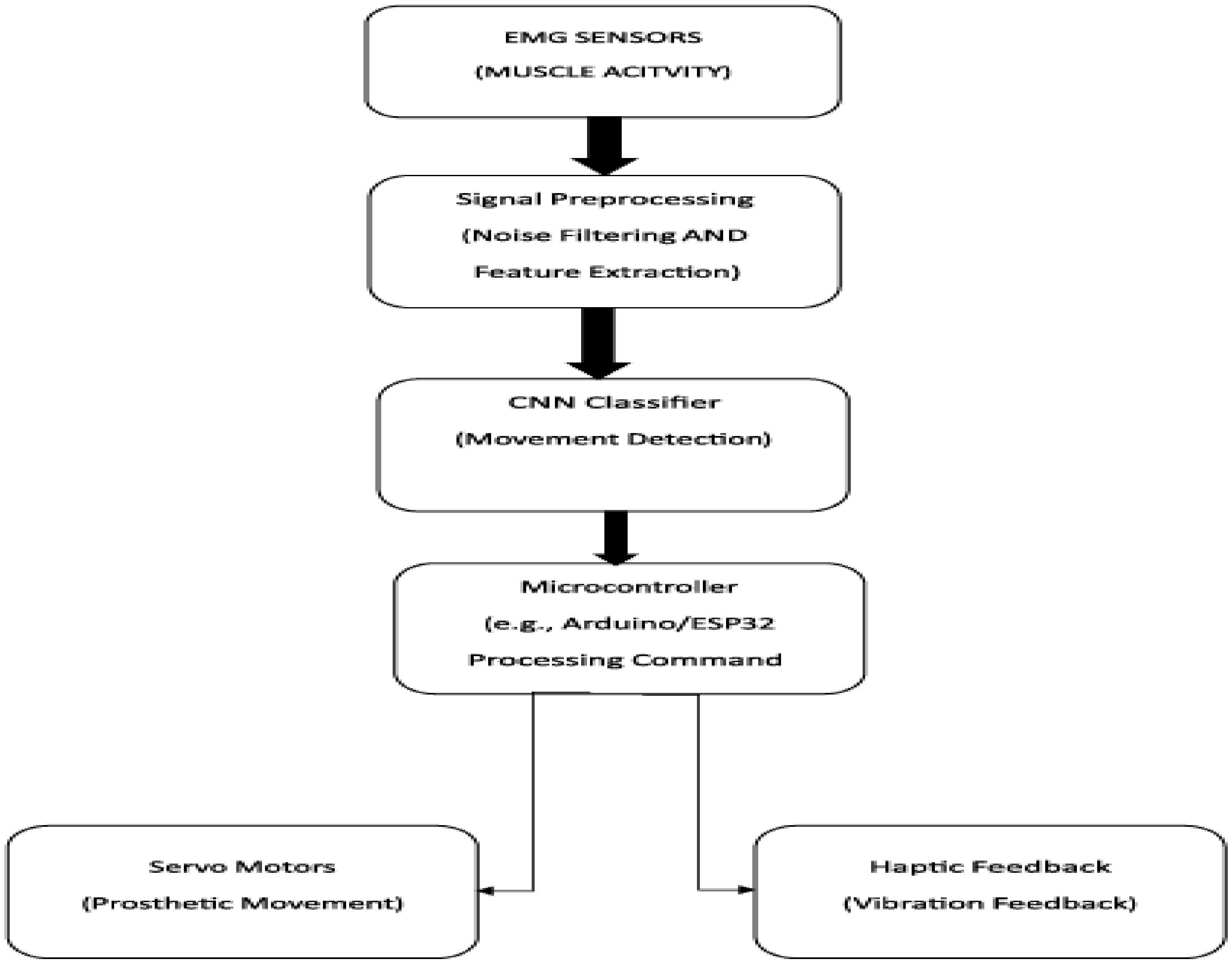
- **No real-time adaptability in existing prosthetics.**
- **Lack of datasets for training AI models.**
- **Inefficient sensor integration.**
- **High Cost and Energy Consumption**



# PROBLEM STATEMENT

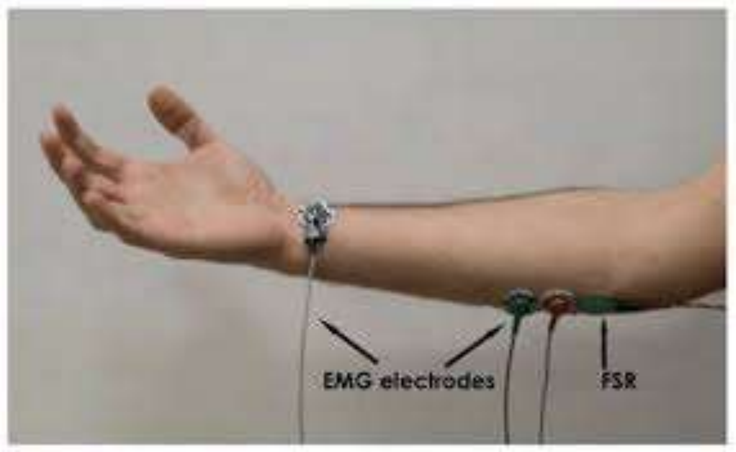
- ✓ Expensive ($10,000 - $100,000)
- ✓ Lack of real-time feedback
- ✓ Limited adaptive control
- ✓ Difficult to use

## BLOCK DIAGRAM



# HARDWARE IMPLEMENTATION

- Force Sensitive Resistors (FSR)
- Electromyography (EMG) Sensors:
- Microcontroller (ESP32)
- Rasberrypi
- Servo Motors ( SG90, MG996R)
- Vibration Motors (Coin vibration motors)
- 3D Prosthetic hand.



# ELECTROMYOGRAPHY (EMG) SENSOR

Reads muscle signals from the user's arm.

Converts these signals into electrical commands to control the prosthetic hand.

## Force Sensors (FSR)

- Detects how much pressure the user is applying when gripping an object.
- Helps prevent too much or too little force.

## Microcontroller (ESP32/ARDUINO)

- Acts as the "brain" of the prosthetic hand.
- Processes signals from sensors and tells the motors how to move.

## Raspberrypi

- Used for training the model

## Servo Motors(SG90, MG996R)

- Small motors that control the movement of the fingers.
- They help open and close the hand smoothly.

## 3D-Printed Hand Frame

- A lightweight, custom-designed structure that holds all the components together.
- Made using a 3D printer to match the user’s needs.

# DEEP LEARNING APPROACH

# HOW CNN WORKS IN THE PROSTHETIC HAND

**Input:** EMG signals & force sensor data

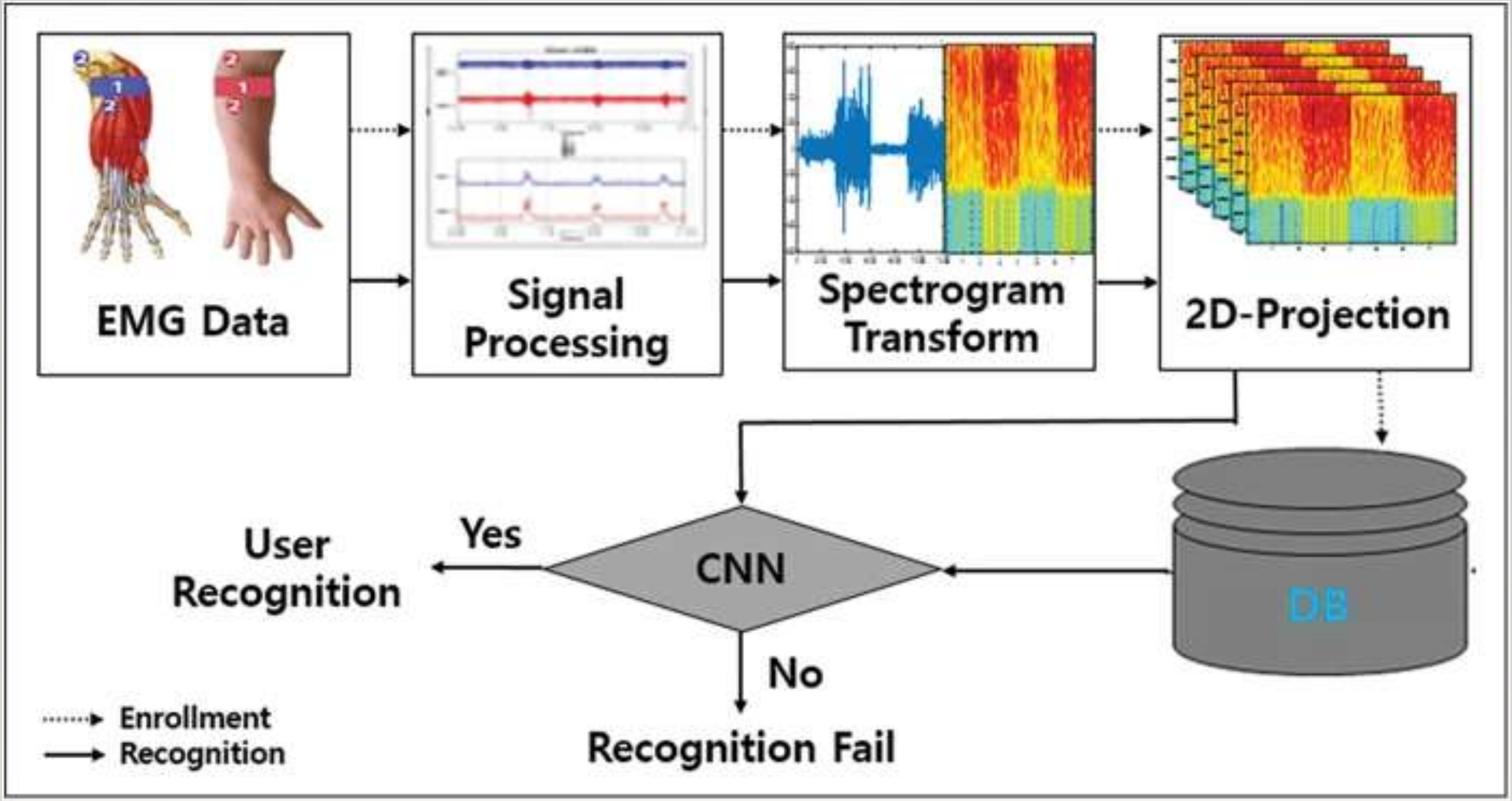
**Feature Extraction:** CNN detects muscle patterns

**Classification:** Predicts correct hand movement

**Output:** Adjusts grip force in real-time

# OUR APPROACH OF USING CNN

1. **Collect & Preprocess Data** (EMG signals & force sensor readings).
2. **Train CNN Model** to extract movement patterns.
3. **Classify Grip Type** (firm, soft, precision).
4. **Optimize Model** to reduce errors & adapt to different users.
5. **Deploy on Prosthetic Hand** for real-time feedback & control.


EMG Data
Signal Processing
Spectrogram Transform
2D-Projection
CNN
Yes
User Recognition
No
Recognition Fail
DB
Enrollment
Recognition

# WORK FLOW

| | |
|---|---|
| Research and Conceptualization | Week 1 |
| Hardware Design and Procurement | Week 2-3 |
| CNN model building | Week 3-6 |
| Integration and Assembly | Week 7-8 |
| Testing and Calibration | Week 9-10 |
| Documentation and Presentation | Week 11-12 |

# FUTURE SCOPE

Enhancements:

- Reinforcement Learning for self-improvement.

- Cloud integration for real-time analytics.

- Improved sensor accuracy.

# REFERENCES


- **Advances in AI-based prosthetics development: editorial** (2023)

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- **A lightweight prosthetic hand with 19-DOF dexterity and human-like appearance** (2025)

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- **SmartHand: Towards Embedded Smart Hands for Prosthetic and Robotic Applications** (2021)

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- **The Latest Research Progress on Bionic Artificial Hands** (2023)

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# THANK YOU