AMRITA VISHWA VIDYAPEETHAM
DEEMED TO BE UNIVERSITY

Smart Prosthetic hand

INTRODUCTION TO NN, CNN AND GNN
ANALOG SYSTEM DESIGN

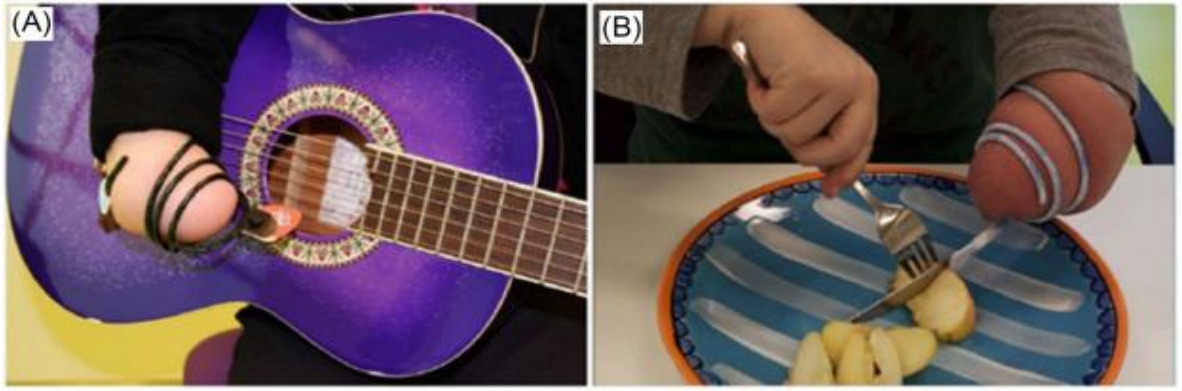
Guru Jaya Surya Yadav	CB.AI.U4AIM24101.
J. Tej Krishna Sai	CB.AI.U4AIM24117.
P. Teja Prakash Royal	CB.AI.U4AIM24136.
S. Ankith	CB.AI.U4AIM24147.

Guided by

Dr. Snigdhatanu Acharya

Dr. Amrutha Veluppal

RECAP:



A smart prosthetic hand designed to provide real-time sensory feedback to users.

Uses CNN based movement prediction for smooth operation.

Uses deep learning to predict user intentions for smoother, natural movements.

FEEDBACK

TAKE A SAMPLE DATASET AND BUILD A CNN MODEL.

ASKED FOR A PROTOTYPE OF THE DESIGN

ASKED ABOUT COMPONENTS AND THEIR INTEGRATION

SOLUTIONS

- Built a CNN model with sample data
- Built a prototype for prosthetic hand

EMG Sensor V3 (Electromyography Sensor)

Working Principle:

- Detects electrical signals from muscles when they contract.
- Converts them into analog voltage signals.
- Microcontroller (Arduino) reads these signals to control the servo motors.

How It Works in our Prosthetic Hand:

- User flexes muscles → EMG sensor detects signals → Arduino processes them → Servo motors move fingers.

Specifications

- Operating Voltage: ~3.3V – 5V
- Signal Output: Analog voltage is proportional to muscle activity

SG90 SERVO MOTORS (FINGER MOVEMENT)

Working Principle

- Rotates to a specific angle based on the input signal from Arduino.
- Can rotate 0° to 180°.

How It Works in our Prosthetic Hand

- 5 motors control each finger's movement.
- The position of fingers is determined by EMG signals.

FSR SENSOR (FORCE-SENSITIVE RESISTOR)

Working Principle:

- The resistance changes when pressure is applied.
- Arduino converts this change into a force value (light touch vs. strong grip).

How It Works in our Prosthetic Hand:

- Placed on fingertips or palm → Detects how hard the user is gripping an object → Sends feedback to the system.

Specifications:

- Operating Voltage:~3.3V – 5V
- Response Time:~10ms

RASPBERRY PI

Raspberry Pi is a small, affordable computer developed by the Raspberry Pi Foundation. It runs Linux-based OS like Raspberry Pi OS and has USB, HDMI, Wi-Fi, and GPIO pins.

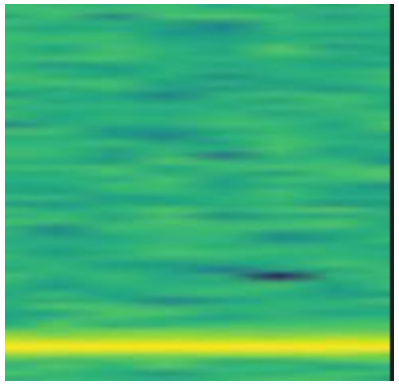
Features: Compact size, low power, supports Python & C.

Uses: IoT, robotics, AI, home automation, media center.

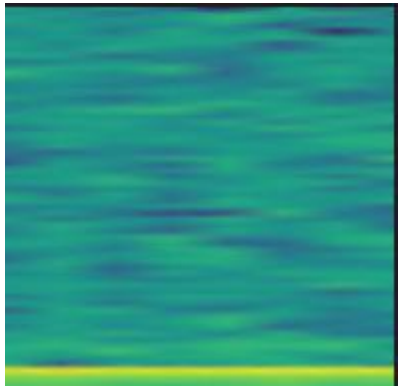
CNN MODEL BUILDING

- **Data Collection:**
  - Created a EMG signals for different hand gestures(fist,open,rest)
  - Converted signals into spectrograph images for training
- **CNN Model Training:**
  - Train a Convolutional Neural Network using TensorFlow.
  - Optimize the model for real-time inference.
- **Deployment(We are trying to do this):**
  - Convert the model to an edge-friendly format (e.g., TensorFlow Lite) for integration with the Arduino system.
- **Role in Project:**
  - Classify EMG signals to detect hand gestures.
  - Enables accurate responsive control of prosthetic hand

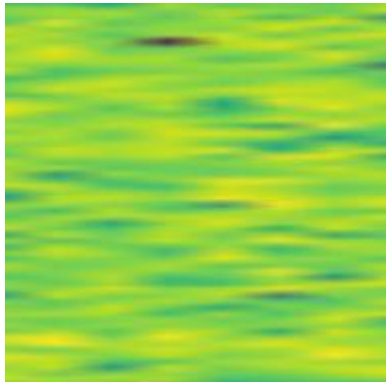
Dataset



FIST



OPEN



REST

SPECTROGRAPHS OF EACH MOVEMENT

WHAT IS CONV2D?

Conv2D applies filters to an image to extract features like edges and textures.

It slides a small matrix (kernel) over the input image and performs a dot product.

Creates a feature map that highlights important patterns.

WHAT IS MAXPOOLING?

MaxPooling reduces the size of feature maps while keeping important details.

It takes the maximum value from a small region (e.g., 2x2) of the feature map.

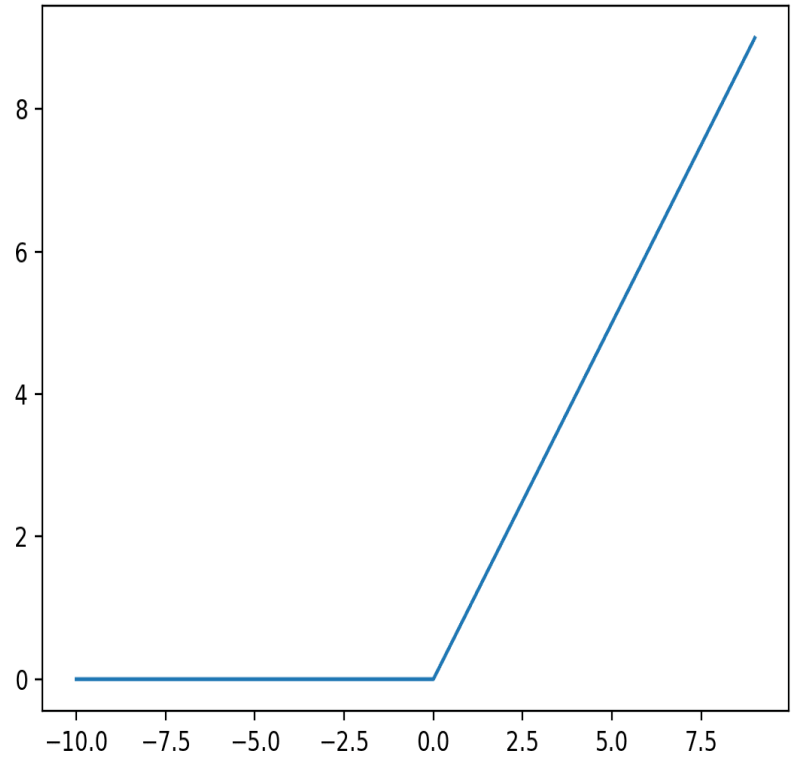
Helps in reducing computation, prevents overfitting, and retains essential features.

RELU ACTIVATION FUNCTION

ReLU (Rectified Linear Unit) introduces non-linearity in CNNs.

It replaces negative values with zero, keeping only positive values.

Helps prevent vanishing gradients and speeds up training.



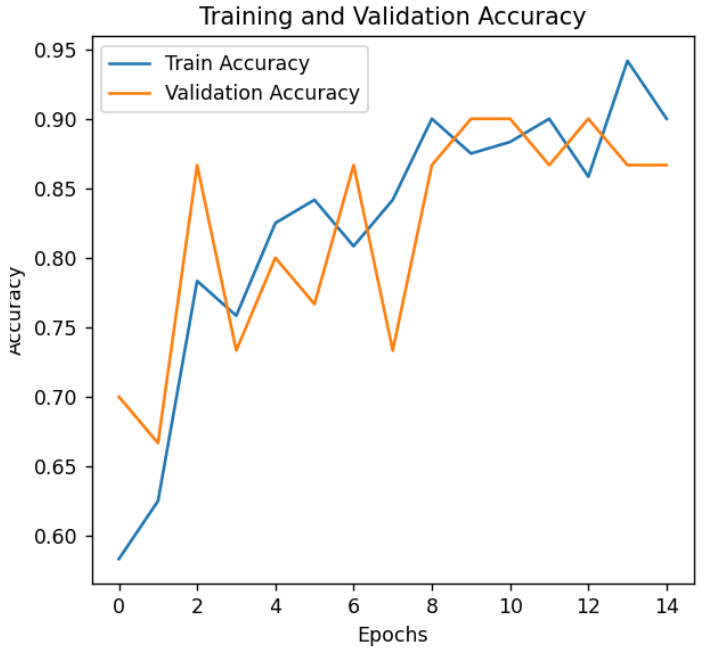
SUMMARY: WHY THESE LAYERS MATTER?

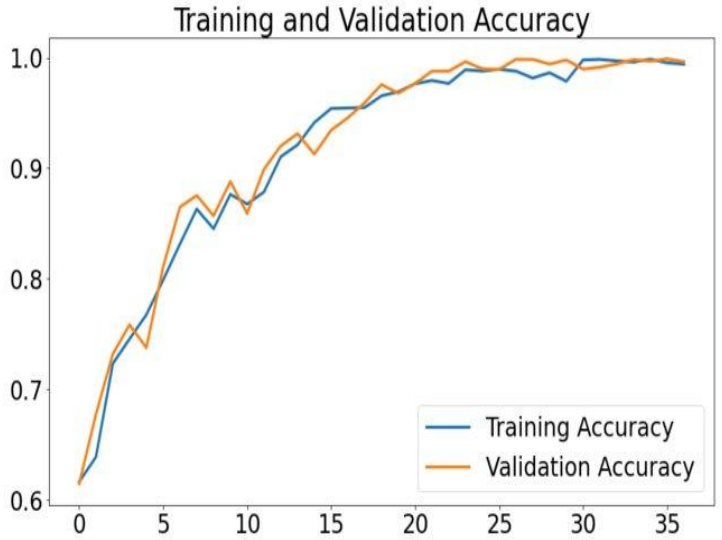
Conv2D extracts key features from images.

MaxPooling reduces feature map size, speeding up training.

ReLU ensures efficient learning by ignoring negative values.

OUR MODEL METRICS





CHALLENGES & FUTURE ENHANCEMENTS

Current Challenges:

- Managing noisy EMG signals.
- Real-time inference of the CNN model on limited hardware.
- Ensuring stable power supply and efficient power consumption.

Future Work:

- Improve signal processing techniques.
- Implement wireless communication (e.g., Bluetooth) for remote monitoring.
- Explore further integration of advanced sensors or additional feedback mechanisms.

THANK YOU