# Introduction

The objective of this project is to develop an AI-powered hand gesture recognition system that enables interaction with digital devices using hand gestures. The system uses a machine learning model trained on hand landmark data captured via a webcam. Applications of gesture recognition include touchless human-computer interaction, assistive technologies, and smart home systems.

# Objectives

* To collect and label hand gesture data using computer vision.
* To preprocess the data and train a gesture recognition model using machine learning.
* To implement gesture-based control for media playback, volume, and system interaction.
* To display on-screen feedback when a gesture is detected and an action is triggered.

# Methodology

-Data Collection

A custom dataset was created using MediaPipe Hands and OpenCV to detect and extract 21 hand landmarks from a webcam feed. Each gesture class was represented by multiple samples, and each sample included the x, y, z coordinates of the landmarks.

-Data Preprocessing

The raw coordinate data were normalized and structured into CSV format. The data were split into training and test sets. Data augmentation techniques were applied to improve model robustness.

-Model Training

A neural network model was built using TensorFlow/Keras. The model architecture included dense layers with ReLU activation and dropout layers to prevent overfitting. The model was trained to classify gestures into predefined categories (e.g., play, pause, volume up/down, exit).

-Integration & Real-Time Prediction

The trained model was integrated into a real-time webcam interface. When a gesture was detected, the system predicted its class and triggered corresponding system actions (e.g., play/pause video, change volume) using pycaw and system libraries.

-Feedback Display

For improved usability, an on-screen notification was displayed whenever a gesture was recognized and an action was executed.

# Results

The system successfully recognized and classified gestures in real-time with high accuracy. Actions such as media control and volume adjustment were reliably triggered. Gesture classification accuracy on the test set reached above 95%. Visual feedback was successfully displayed to indicate detected actions.

# Discussion

The system demonstrated robust performance under different lighting conditions and hand orientations. Challenges encountered included occasional false positives and variations in hand sizes and camera distances. These could be mitigated with more training data and dynamic thresholding.

Future improvements may include:

* Expanding the gesture vocabulary.
* Adding support for both hands.
* Implementing a more advanced user interface or mobile control.

# Conclusion

This project successfully developed an AI-based gesture recognition system that allows for real-time, touchless control of digital media. The system performed reliably in various test scenarios, validating the effectiveness of using hand landmarks and deep learning for gesture-based interaction.

# References

1. MediaPipe Documentation - https://developers.google.com/mediapipe
2. TensorFlow/Keras Documentation - https://www.tensorflow.org/
3. Pycaw Library - https://github.com/AndreMiras/pycaw
4. OpenCV Documentation - https://docs.opencv.org/
5. Course Lecture Notes - Computer Vision and Machine Learning Modules