

# Final Project Report

**Project Title: Real-Time Hand Gesture Control System using Raspberry Pi**

## 1. Introduction

This project implements a real-time hand gesture recognition system using Raspberry Pi 3 and a USB camera. The system detects and tracks hand landmarks using computer vision techniques and maps specific gestures to control actions. The objective is to create an affordable and efficient gesture-based control interface.

## 2. Hardware Utilization

- Raspberry Pi 3 Model B
- USB Webcam (UVC compatible)
- MicroSD Card (16GB or higher)
- Power Supply (5V, 2.5A)
- HDMI Display, Keyboard, and Mouse for setup

## 3. Software and Tools Used

- Raspberry Pi OS (Debian-based)
- Python 3
- OpenCV for image processing
- MediaPipe for hand landmark detection
- NumPy for numerical operations

## 4. Methodology

Step 1: The USB camera captures real-time video frames using OpenCV. Step 2: Each frame is converted from BGR to RGB format to be compatible with MediaPipe. Step 3: MediaPipe processes the frame and detects 21 hand landmarks. Step 4: Finger positions are analyzed by comparing

fingertip coordinates with joint positions. Step 5: The number of raised fingers is calculated to identify gestures. Step 6: Detected gestures are mapped to specific control actions such as play, pause, or volume control.

## 5. Results

The system successfully detects hand gestures in real-time using Raspberry Pi 3. It accurately identifies open hand, closed fist, and single-finger gestures. The frame rate is stable under moderate lighting conditions. The system performs best with consistent lighting and minimal background noise.

## 6. Optimization Techniques

- Reduced frame resolution to improve processing speed.
- Used efficient landmark comparison instead of complex models.
- Limited processing to one hand at a time.
- Optimized loop execution to reduce CPU usage.
- Used lightweight libraries suitable for Raspberry Pi.

## 7. Conclusion

The project demonstrates a cost-effective and efficient gesture control system using Raspberry Pi. It highlights the capability of embedded systems to perform real-time computer vision tasks. Future improvements may include multi-hand tracking, gesture classification models, and integration with IoT devices for smart home control.