**Title: AI-Based Hand Gesture Controlled Devices using OpenCV and Arduino**

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**1. Introduction**

With the rapid advancement in Artificial Intelligence (AI) and the Internet of Things (IoT), contactless control systems are becoming increasingly popular. This project explores an innovative solution using hand gesture recognition to control electronic devices without the need for physical contact or Bluetooth commands. This is achieved by integrating Python’s OpenCV library with an Arduino board via PyFirmata.

**2. Objective**

The primary objective of this project is to:

* Create a real-time hand gesture recognition system.
* Map specific finger gestures to control different devices.
* Demonstrate device control using only a webcam and hand movements.

**3. Components Used**

*Hardware Components:*

* Arduino Uno
* Jumper Wires
* LEDs to simulate devices
* Resistors (220 ohm)
* USB Cable
* Breadboard
* Laptop with webcam

*Software Components:*

* Python 3.x
* OpenCV
* cvzone (HandTrackingModule)
* PyFirmata
* Arduino IDE

**4. Working Principle**

The webcam captures the live video feed. OpenCV and the cvzone HandTrackingModule detect the presence and position of the hand and identify which fingers are raised. Each raised finger corresponds to a specific device:

* Thumb: Fan
* Index Finger: Bulb
* Middle Finger: Light
* Little Finger: Motor

The ring finger is excluded in this version. When a finger is detected as ‘up’, the associated pin on the Arduino is set LOW to simulate device ON, and HIGH when the finger is ‘down’ to simulate OFF, using inverted logic.

**5. Software Design and Flow**

1. Start video capture using OpenCV.
2. Detect hand and fingers using cvzone’s HandTrackingModule.
3. For each finger:
   * If the finger is up, turn ON the corresponding device.
   * If the finger is down, turn OFF the corresponding device.
4. Display the status of each device on the video frame.
5. Continue looping until ‘k’ is pressed to exit.

**6. Hardware Setup**

* Connect LEDs to Arduino pins 8 through 12 (except pin 11, which is unused).
* Each LED is connected in series with a 220-ohm resistor.
* The common ground is shared between the Arduino and the breadboard.
* The Arduino is connected to the PC via USB.

**7. Code Explanation**

The code initializes the Arduino board and maps each LED pin. The cvzone module is used to detect fingers. Based on which fingers are raised, the code writes LOW or HIGH to the pins:

led\_pins[finger\_index].write(0 if fingerUp[finger\_index] else 1)

This inverted logic turns on the device when the finger is raised and off when it is down.

Only the thumb, index, middle, and little fingers are used, while the ring finger is ignored.

**8. Results and Observations**

* The system successfully detects up to 5 fingers.
* Each device responds instantly to gesture changes.
* Eliminating the ring finger simplifies logic and avoids accidental triggers.
* The system runs smoothly on a regular laptop with webcam.

**Screenshot Examples:**

* Finger Count Display: “Fingers Up: 3”
* Device Status: “Fan: ON”, “Bulb: OFF”, etc.

**9. Applications and Future Scope**

*Applications:*

* Smart home automation
* Assistive technology for people with disabilities
* Touchless control in clean rooms or labs

*Future Scope:*

* Add voice recognition as a secondary input
* Include face authentication before enabling gestures
* Expand device control via WiFi or Blynk
* Integrate LCD to display device status physically

**10. Conclusion**

This project demonstrates a practical and engaging application of AI and embedded systems. By merging computer vision with Arduino hardware, we built a gesture-controlled smart system that responds in real time. It showcases how accessible and powerful AI-driven control interfaces can be for both hobbyist and industrial applications.