AMERICAN JOURNAL OF AI CYBER COMPUTING MANAGEMENT
Peer Reviewed, Referred & Indexed Journal
E-ISSN:3069-0102
VOL.6, NO. 1(2026)

VIRTUAL DASHBOARD USING OPENCV

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Abstract:

Human machine interaction has undergone tremendous changes with the development of computer vision techniques. In this project we are designed the real-time gesture-based virtual dashboard control using OpenCV and Arduino technology. This virtual dashboard control system allows users to perform touch-free interaction through the recognition of hand gestures using a normal webcam. The detected hand gestures are processed using Python programming with the support of the Media Pipe hand tracking library, while the control signals are sent to the Arduino Uno microcontroller through serial communication. The 4-channel relay module is utilized for the control of external hardware devices such as the 12V DC fan, 12V geared motor and AC bulb. The gesture-based virtual dashboard control system avoids direct contact with the control switch, thereby providing improved hygienic, flexible, and convenient features.

Index Terms — *OpenCV, Gesture Recognition, Arduino Uno, Virtual Dashboard, Relay Module, Human–Computer Interaction.*

I. INTRODUCTION

Human-machine interaction technologies have evolved from mechanical switch interaction to graphical interaction, and further to touchless interaction technologies. Conventional control panel interaction involves the use of mechanical switches that demand direct interaction with the machine.

In many applications, such as kiosk interaction, laboratory equipment, hospital equipment, and automation systems, the use of touch interaction technologies may not be suitable due to hygiene concerns. Recent advancements in computer vision technologies have led to the development of gesture interaction technologies that permit touchless interaction with machines. Gesture interaction technologies recognize hand movements and translate them into machine-interpretable actions. OpenCV and Media Pipe libraries offer the possibility of building gesture interaction technologies using standard webcam devices.

This paper proposes the development of a real-time gesture interaction-controlled virtual dashboard that utilizes computer vision technologies. The interaction involves the detection of the position of the fingertips of the user over the virtual on-screen buttons. The output devices will be controlled using the Arduino microcontroller. The primary aim of the project is to create a flexible, cost-effective, and reliable touchless interaction control panel.

II. LITERATURE REVIEW

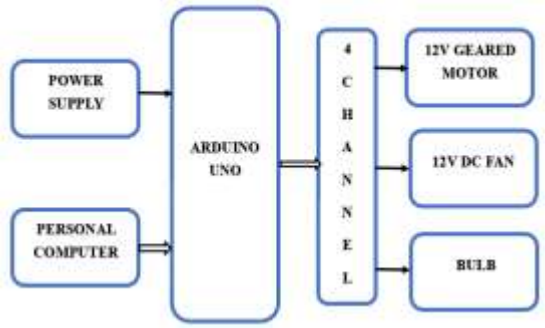
Gesture-based human-computer interaction has now gained momentum as a viable solution compared to traditional touch-based and mechanical interfaces. Traditionally, sensor-based techniques such as data glove, infrared sensor, motion detection, etc., were employed for gesture-based interaction, which led to a costlier

solution. Recently, with the advent of computer vision technology, camera-based gesture recognition systems gained popularity as a cost-effective solution.

The availability of OpenCV libraries helped in detecting hand gestures through image processing techniques. Recently, frameworks such as Media Pipe were introduced for more accurate hand landmark detection using standard RGB cameras. Although many studies have proven the efficacy of gesture-based control for virtual interfaces and multimedia systems, not many studies have been conducted for integrating vision-based gesture recognition with physical hardware control. This system extends the concept of existing solutions by integrating hand-tracking-based control with Arduino-based relay control.

III. PROPOSED SYSTEM

The system to be developed is a real-time virtual dashboard for controlling electrical devices using gestures without any physical contact. The system integrates OpenCV for hand detection with Arduino to control devices using virtual buttons.



The hand gestures are processed by the personal computer, and the control signals are sent to the Arduino Uno through serial communication. The Arduino Uno then powers the 4-channel relay module, which in turn powers the 12V geared motor, 12V DC fan, and the bulb using the power supply.

A. Arduino Uno

The Arduino Uno is an open-source microcontroller based on the ATmega328P processor, commonly used in embedded system designs and automation systems. This controller has 14 digital input/output pins, along with 6 Analog input pins, allowing for communication protocols such as UART, I2C, SPI, etc., to be used for communication with external devices. The Arduino Uno operates at a voltage of 5V with a clock speed of 16MHz to ensure the proper and timely execution of the program. In the proposed system, Arduino Uno serves as the hardware controller that accepts serial commands from the computer to effectively manage the external devices connected to the relay module.



B. Personal Computer

The personal computer acts as the main processing device in the suggested architecture, which implements Python-based algorithms for real-time gesture recognition via OpenCV. It can process video input from the webcam, hand landmark recognition, and detect interactions between fingertips and virtual buttons. Depending on the recognized gesture, the PC can send corresponding control signals to the Arduino Uno via serial communication. This design allows for effective differentiation between image

processing and hardware control, which can facilitate system reliability.



C. 4 Channel Relay Module

The 4 channel 5V relay module is a device that will be used as an interface between the low voltage Arduino controller and the electrical devices. The device will be able to switch the electrical devices using low-level signals. It will be able to switch the devices up to 250V AC or 30V DC. The device will be connected to the Arduino, and the NO and COM terminals will be used to control the electrical devices such as the bulb, DC fan, and the geared motor.



D. 12V Geared Motor

The 12V DC geared motor is a high-torque electromechanical drive that is used to perform various tasks in automated systems. It is essentially a DC motor that uses a gearbox to reduce its speed while increasing its output. The 12V DC geared motor can't be directly connected to the microcontroller because it operates at 12V. It should be connected to a relay module to ensure its safe operation. The Arduino will control a relay to ensure that 12V power is supplied to the motor.



E. 12V DC Cooling Fan

The 12V DC fan is utilized as an output load to verify gesture-based hardware control in the suggested system. Once a valid hand gesture is recognized, the personal computer sends a control signal to activate the appropriate relay channel in the Arduino. The relay then turns on the 12V DC power source to the fan via the NO and COM terminals to ensure safe and isolated switching.



F. Bulb.

The AC bulb is utilized as a high-voltage output device to prove contactless control for practical electrical devices. Once a specific hand gesture is recognized, a control signal is sent from the personal computer to the Arduino, which then

activates the relay channel. The AC phase wire is switched via the COM and NO terminals, allowing the AC bulb to either turn ON or OFF. The setup is safe and validates reliable control isolation between low-voltage control and high-voltage AC devices.



IV. SYSTEM SETUP AND OUTPUT

A. Software Installation and Configuration

Python version 3.10.11, along with necessary libraries such as OpenCV, Mediapipe, NumPy, and PySerial, is available on the personal computer. The program for gesture detection is written and executed to initialize the virtual dashboard interface.

B. Virtual Dashboard Initialization

When we execute the Python program, the webcam is enabled, and a virtual dashboard with three LEDs is displayed on the screen. Initially, all LEDs are shown in red color, which means all output devices are in the OFF state.

C. Real-Time Hand Gesture Detection

The webcam continuously captures video frames, and MediaPipe detects hand landmarks in real time. The system tracks the index fingertip position to identify interaction with predefined virtual button regions.

D. Gesture Processing and Command Generation

When the fingertip enters a specific virtual button area, the system interprets it as a valid input. A corresponding control signal is generated and prepared for transmission to the Arduino Uno.

E. Serial Communication with Arduino

The generated command is transmitted from the personal computer to the Arduino Uno through serial communication. The Arduino reads the received data and determines the respective output action.

F. Relay Activation and Device Control

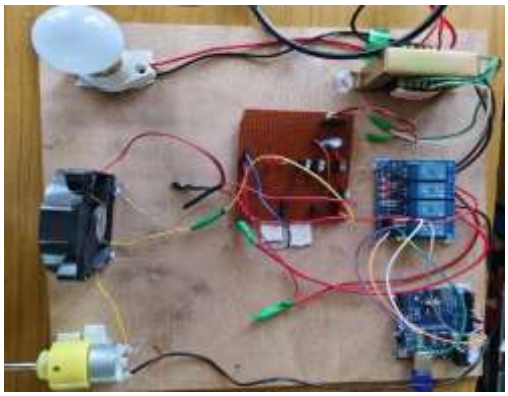
Based on the received command, the Arduino activates the appropriate relay channel. The relay switches the connected load such as the bulb, DC fan, or geared motor.

G. Output Verification and Toggle Operation

When a device is activated, the corresponding LED turns green on the dashboard, indicating ON status. Repeating the gesture toggles the device OFF, and the LED returns to red.

VI. RESULTS

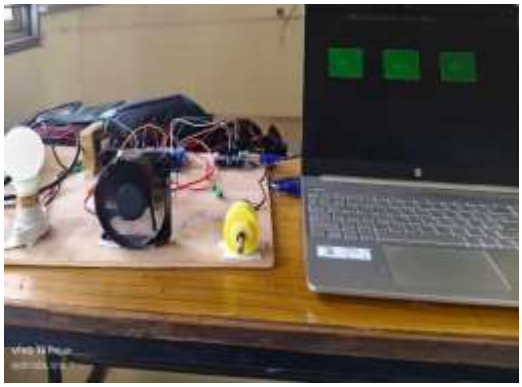
The developed virtual dashboard system was tested in real-time conditions and showed accurate hand gesture recognition with reliable device control. The bulb, DC fan, and geared motor were successfully operated through relay switching based on the detected gestures. The system provided stable on/off control and allowed multiple devices to be controlled simultaneously. This demonstrates effective coordination between the vision processing system and the embedded hardware setup.



The figure shows the complete hardware setup including the Arduino Uno, relay module, bulb, DC fan, and geared motor connected to the system. The personal computer performs gesture recognition and sends control commands to Arduino through serial communication.



The webcam captures the user's hand movement and MediaPipe detects multiple hand landmarks in real time. The system tracks the index fingertip position to interact with the virtual dashboard buttons.



When the fingertip enters a virtual button region, the system sends a command to Arduino through serial communication. The corresponding relay channel activates the **bulb, fan, or motor**, confirming successful gesture-based control.

VII. CONCLUSION

The proposed Virtual Dashboard using OpenCV successfully demonstrates a touch-free control system by integrating computer vision with Arduino-based hardware automation. Real-time hand gesture detection and relay-based device control confirm reliable and efficient system performance. The solution is cost-effective, hygienic, and scalable, making it suitable for smart automation and future contactless applications.

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