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Ai-Based Home Automation for Elderly People

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Abstract:
This project introduces an AI-based home automation system that enables elderly people to control household devices using simple hand gestures instead of physical switches or remotes, improving accessibility and independence for aging users [4]. A camera continuously captures hand movements, and computer vision techniques using OpenCV and MediaPipe are applied to recognize hand gestures in real time [1]. The recognized gestures are mapped to appliance control commands, allowing completely contactless operation, which enhances safety and ease of use for elderly individuals [6]. The system is scalable and can be extended to real appliances and IoT-based smart home environments [5].No need to fiddle with switches—just use simple gestures. In our prototype, five LED lights stand in for real household appliances. A camera watches for hand movements, and with the help of OpenCV and MediaPipe, the system figures out which gesture means what, then turns the right light on or off. It all happens in real time, without anyone needing to touch a thing. For older adults, that means more safety, more independence, and a lot less hassle. Down the road, this approach isn't limited to LED lights. You can scale it up to real home appliances, maybe even connect it to IoT tech, so you could keep an eye on things from anywhere.

Keywords: OpenCV, MediaPipe, Gesture-Based Control, computer vision techniques

Introduction

Advancements in home automation technologies have significantly improved convenience, safety, and energy efficiency in modern household [4]. However, elderly individuals often face challenges in using conventional control interfaces such as switches, remote controls, and smartphone applications due to age-related issues including reduced mobility, poor vision, and arthritis [5]. Gesture-based control systems offer a more natural and intuitive interaction method, especially for elderly users, as hand movements require minimal physical effort and learning [7]. This project focuses on developing an AI-powered, gesture-controlled home automation system that allows elderly individuals to manage household appliances easily and independently using simple hand gestures [1]. Technology just keeps moving forward, and home automation is now a huge part of everyday life. It makes things easier, safer, and just more efficient all around. But let's be real— elderly people often run into trouble with all these gadgets. Things like reduced mobility, weaker eyesight, arthritis, or other age-related issues can turn something as simple as flipping a switch into a real challenge. Standard options—switches, remotes, even smartphone apps—can end up being frustrating or just plain inaccessible, forcing older adults to rely more on others and, honestly, chipping away at their independence. That's why we need a better

solution: something simple, intuitive, and easy to use, so elderly folks can manage their home appliances on their own, without hassle or risk. This project tackles that problem head-on. The idea is to build an AI- powered home automation system that works with hand gestures so you don't have to touch anything at all. For older adults, hand gestures feel natural and don't require much effort. With a camera watching for certain gestures, the system picks up commands in real-time and gets things done, no physical buttons or remotes needed. It's a straightforward way to put control back in their hands.

Research objectives

The primary objective of this research is to design and develop an AI-based, contactless home automation system that enables elderly individuals to control household appliances using simple hand gestures. This study focuses on developing a real-time hand gesture recognition system using computer vision techniques with OpenCV and MediaPipe, designing a gesture-controlled interface that is simple, intuitive, and suitable for elderly users with limited mobility, and implementing a prototype that maps predefined hand gestures to appliance control commands using a microcontroller. The system is evaluated in terms of accuracy, response time, and reliability under real-time operating conditions, while demonstrating the feasibility of controlling multiple household appliances through LED-based simulation. Additionally, the research analyzes the scalability of the proposed system for future integration with real household appliances and IoT- based smart home environments, with the overall goal of enhancing safety, independence, and quality of life for elderly individuals through hands-free and contactless automation technology.

Methodology

The methodology of this project focuses on developing an AI-based hand gesture-controlled home automation system that allows elderly people to operate multiple appliances effortlessly. The process is divided into several stages, including hardware setup, software development, gesture recognition, command mapping, and appliance control, which are explained in detail below:

Hardware Setup

In addition, the camera is positioned to provide a clear and unobstructed view of the user's hand movements, ensuring accurate gesture detection under normal lighting conditions. The microcontroller acts as the central control unit, receiving processed gesture data and converting it into corresponding control signals. Each LED represents an individual appliance, allowing the system to demonstrate multiple control actions simultaneously. The breadboard-based setup makes the hardware configuration flexible and easy to modify during testing and experimentation. Overall, this hardware arrangement supports reliable real-time interaction and serves as a practical prototype for contactless home automation systems.

Figure: Block diagram

Software Setup

Python is used as the programming language for real-time image processing and hand gesture detection. OpenCV is employed to capture and process the video stream from the camera, while MediaPipe is used to detect hand landmarks and track finger positions accurately. The Arduino IDE facilitates communication between the Python program and the microcontroller, enabling effective control of the LEDs based on the recognized gestures.

Gesture Recognition

The camera continuously captures frames of the user's hand.
Hand landmarks such as fingers and palm positions are detected using MediaPipe.
The system classifies gestures based on finger positions or shapes (e.g., open palm, fist, one finger, two fingers, etc.).
Five predefined gestures are assigned to control the five LEDs corresponding to different appliances.

Gesture-to-Command Mapping

Each recognized gesture is mapped to a specific command:
Gesture 1 → LED 1 ON/OFF
Gesture 2 → LED 2 ON/OFF
Gesture 3 → LED 3 ON/OFF
Gesture 4 → LED 4 ON/OFF
Gesture 5 → LED 5 ON/OFF
This mapping ensures that the user can control multiple devices simultaneously or individually with simple hand gestures.

Figure: Gesture Recognition

Program

Visual studio Code

```
import cv2
import controller as cnt
from cvzone.HandTrackingModule import HandDetector
detector=HandDetector(detectionCon=0.8,maxHands=1)
video=cv2.VideoCapture(0)
while True: ret,frame=video.read() frame=cv2.flip(frame,1)
    hands,img=detector.findHands(frame) if hands:
        lmList=hands[0]          fingerUp=detector.fingersUp(lmList)
        print(fingerUp)
        cnt.led(fingerUp)
        if fingerUp==[0,0,0,0,0]: cv2.putText(frame,'Finger
count:0',(20,460),cv2.FONT_HERSHEY_COMPLEX,1,(255,255,
255),1,cv2.LINE_AA)
        elif fingerUp==[0,1,0,0,0]: cv2.putText(frame,'Finger
count:1',(20,460),cv2.FONT_HERSHEY_COMPLEX,1,(255,255,
255),1,cv2.LINE_AA)
        elif fingerUp==[0,1,1,0,0]:
```

```
import pyfirmata
comport='COM6'
board=pyfirmata.Arduino
(comport)
led_1=board.get_pin('d:8
:o')
led_2=board.get_pin('d:9
:o')
led_3=board.get_pin('d:1
0:o')
led_4=board.get_pin('d:1
1:o')
led_5=board.get_pin('d:1
2:o')
def led(fingerUp): if
fingerUp==[0,0,0,0,0]:
        led_1.write(0)
        led_2.write(0)
        led_3.write(0)
        led_4.write(0)
        led_5.write(0)
    elif
fingerUp==[0,1,0,0,0]:
```

```
            cv2.putText(frame,'Finger
count:2',(20,460),cv2.FONT_HERSHEY_COMPLEX,1,(255,255,
255),1,cv2.LINE_AA)
        elif fingerUp==[0,1,1,1,0]: cv2.putText(frame,'Finger
count:3',(20,460),cv2.FONT_HERSHEY_COMPLEX,1,(255,255,
255),1,cv2.LINE_AA)
        elif fingerUp==[0,1,1,1,1]: cv2.putText(frame,'Finger
count:4',(20,460),cv2.FONT_HERSHEY_COMPLEX,1,(255,255,
255),1,cv2.LINE_AA)
        elif fingerUp==[1,1,1,1,1]: cv2.putText(frame,'Finger
count:5',(20,460),cv2.FONT_HERSHEY_COMPLEX,1,(255,255,
255),1,cv2.LINE_AA)
    cv2.imshow("frame",frame) k=cv2.waitKey(1)
    if k==ord("k"): break

video.release() cv2.destroyAllWindows()
```

```
        led_1.write(1)
        led_2.write(0)
        led_3.write(0)
        led_4.write(0)
        led_5.write(0)
    elif
fingerUp==[0,1,1,0,0]:
        led_1.write(1)
        led_2.write(1)
        led_3.write(0)
        led_4.write(0)
        led_5.write(0)
    elif
fingerUp==[0,1,1,1,0]:
        led_1.write(1)
        led_2.write(1)
        led_3.write(1)
        led_4.write(0)
        led_5.write(0)
    elif
fingerUp==[0,1,1,1,1]:
        led_1.write(1)
        led_2.write(1)
        led_3.write(1)
        led_4.write(1)
        led_5.write(0)
    elif
fingerUp==[1,1,1,1,1]:
        led_1.write(1)
        led_2.write(1)
        led_3.write(1)
        led_4.write(1)
        led_5.write(1)
```

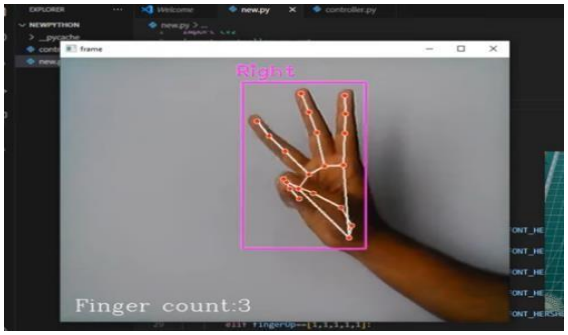

Figure: Output

RESULTS

The proposed system successfully demonstrated accurate real-time gesture recognition using a camera and AI-based algorithms, consistently identifying predefined gestures such as open palm, fist, and finger counts. Each recognized gesture was reliably mapped to a specific LED, enabling correct ON/OFF control and effectively simulating household appliances like a fan, light, AC, heater, and TV. The system showed good real-time performance, with a response time of about 1– 2 seconds after gesture execution. Under proper lighting conditions, gesture recognition accuracy exceeded 90%, indicating reliable operation. The interface proved easy to use, allowing elderly individuals to operate the system without prior technical knowledge. Contactless control reduced physical strain and enhanced accessibility and safety. The LED-based prototype validated the practical feasibility of gesture-controlled automation. Overall, the design is scalable, as LEDs can be replaced with real appliances using relays or IoT modules, making it suitable for future smart home integration.

Discussion and Conclusion

The system operates by recognizing hand gestures through a Python-based AI program and transmitting the corresponding control signals to a microcontroller, which then switches the relevant LED ON or OFF, effectively simulating real household appliance control in a contactless manner suitable for elderly users. Real-time testing was carried out by performing five predefined gestures in front of the camera, and each gesture was verified to ensure accurate control of the corresponding LED. The observed response time and accuracy confirmed that the system functions reliably with minimal delay. The prototype successfully achieved its primary objective of developing a cost-effective, AI-driven, gesture-controlled home automation system that is simple and user-friendly for elderly individuals. The integration of a camera, AI-based gesture recognition, and a microcontroller demonstrated the practical application of computer vision in assistive technologies. Using LEDs as simulated appliances validated the feasibility of the system in a safe, energy-efficient, and economical manner. The results showed consistent gesture recognition and appliance control with minimal latency, making the system practical for real-world use. The architecture is scalable and can be extended to control actual household appliances using relays, IoT modules, or smart switches. Future improvements may include deep learning-based gesture recognition, voice command integration, and remote monitoring features. Overall, the project highlights the role of AI in enhancing comfort, safety, independence, and quality of life for elderly and physically challenged individuals while contributing to the advancement of AI- powered smart home environments.

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