Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

BECE204L Microprocessors and Microcontrollers

Mini Project Report

HOME AUTOMATION
VOICE & GESTURE CONTROL

TEAM MEMBERS:
23BAI1219 – REJIT B ANTONY
23BAI1451 – RUPANKAR MAJUMDAR
23BAI1190 – SAMAR SINGH

Slot : G2
Batch.No : 2
Semester : FALL
Academic Year : 2024-2025

Home Automation with Voice and Gesture Controls

1. Problem Statement:

In the modern world, smart home automation systems have become increasingly popular, enabling convenience, energy efficiency, and enhanced control over home appliances. This project demonstrates a voice- and gesture-controlled home automation system utilizing an Arduino UNO, HC-05 Bluetooth module, Python, OpenCV, and MIT App Inventor. The system allows users to control home appliances such as fans and lights through voice commands and hand gestures, bridging communication between smartphone applications and microcontrollers. The success of the project will be evaluated based on the accuracy and reliability of the voice and gesture recognition systems, as well as the overall user experience, with a focus on simplicity and ease of use for the end user.

2. Social Need:

This project addresses the growing social need for accessible and intuitive home automation solutions that cater to diverse user groups, including children and individuals with special needs. By incorporating voice-command functionality through a user-friendly smartphone application and gesture-based control utilizing OpenCV for hand gesture recognition, the system provides an inclusive and seamless way to manage home appliances. Additionally, the integration of serial communication between OpenCV and the Arduino UNO ensures efficient and reliable gesture control. This approach emphasizes creating a simple yet effective solution that enhances convenience and accessibility for all users, regardless of their physical or technical abilities.

3. Literature Review

Reference paper	Paper Description	Limitation
Asadullah, M., & Raza, A. (2016). An overview of home automation systems. In 2016 2nd International Conference on Robotics and Artificial Intelligence (ICRAI) (pp. 27–31). IEEE. https://doi.org/10.1109/ICRAI.2016.7791223	This paper provides a comprehensive overview of current and emerging home automation systems, highlighting their components, communication protocols, and control mechanisms. It emphasizes the integration of smartphones and microcontrollers in modern home automation setups	The paper primarily focuses on the technical aspects of home automation systems and lacks detailed discussions on user accessibility, particularly for individuals with disabilities or those unfamiliar with technology.
Singh, U., & Ansari, M. A. (2019). Smart home automation system using Internet of Things. In *2019 2nd International Conference on Power Energy, Environment and Intelligent Control (PEEIC)* (pp. 144–149). IEEE. https://doi.org/10.1109/PEEIC47157.2019.8976842	This study explores the implementation of a smart home automation system leveraging IoT technologies. It discusses the use of Wi-Fi networks and smartphones to monitor and control home appliances remotely, aiming to improve user convenience and energy efficiency.	The system relies heavily on internet connectivity, which may pose challenges in areas with unstable or limited internet access. Additionally, it does not address alternative control methods beyond smartphone applications.

Stolojescu-Crisan, C., Crisan, C., & Butunoi, B. -P. (2021). An IoT-Based Smart Home Automation System. *Sensors*, *21*(11), 3784. https://doi.org/10.3390/s21113784	This paper presents a smart home automation system that interconnects sensors and actuators using an IoT platform. It introduces 'qToggle,' a system that allows users to control various home appliances through a smartphone application, emphasizing flexibility and user-friendliness.	While the system offers a user-friendly interface, it primarily depends on smartphone-based control and does not incorporate alternative input methods such as voice or gesture recognition, which could limit accessibility for certain user groups.

3. Limitations of the previous work:

- By incorporating voice commands and gesture control, our project enhances accessibility, allowing users—including children and individuals with special needs—to interact with home appliances intuitively and without relying solely on traditional interfaces.
- Our system offers offline functionality through Bluetooth communication between the smartphone application and the Arduino microcontroller, ensuring continuous operation even without internet access. Furthermore, the inclusion of gesture control provides an alternative interaction method, enhancing user flexibility.
- By integrating voice and gesture controls, our project expands the range of interaction modalities, making the system more inclusive and accommodating to users with varying needs and preferences. This approach ensures that individuals who may have difficulty using traditional smartphone interfaces can still effectively control their home environment.

4. Methodology / Proposed Work

Voice-Controlled Functionality:

1. Mobile App: We developed a custom mobile app using MIT App Inventor, which includes a voice recognition feature with RegEx implemented to pick up keywords in user's commands. Keywords for functionality control:
    a. ON- Turns Fan On
    b. OFF- Turns Fan Off
    c. START- Turns on Lights
    d. STOP- Turns off Lights
2. Bluetooth Communication: The app connects to the HC-05 module via Bluetooth. Commands from the app are transmitted to the Arduino via serial communication.
3. Arduino Execution: The Arduino, running an embedded C program, interprets the received commands and activates or deactivates the corresponding appliances
4. The App takes in user input as speech and converts to text where it matches the keyword in the backend, and sends a decimal value to the Arduino based on the input command given by the user.
5. The Arduino running a switch case will compare the decimal input and perform the required functionality.

Gesture-Controlled Functionality:

1. OpenCV for Gesture Recognition: Using Python and OpenCV, we developed a system to recognize specific hand gestures by counting the number of fingers visible in the camera's frame.

2. Command Transmission: Based on the recognized gesture, Python sends a unique signal to the Arduino, triggering the corresponding functionality.
3. Integration with Arduino: The same embedded C code on the Arduino processes both Bluetooth commands and commands from the Python program. It activates the appliances based on the received signals.
4. The Python OpenCV program open the camera on the laptop and assigns each finger to a value in an array as either 1 (raised) or 0 (down).
5. It counts the number of fingers raised and accordingly sends a character value serially to the Arduino Uno via its COMM ports.
6. The Arduino runs a switch case and executes the functionality respective to the input given by the Python program.

Additionally, connections with an L293D motor driver is given for controlling the speeds of DC motors attached to fans and other appliances.

5. Implementation

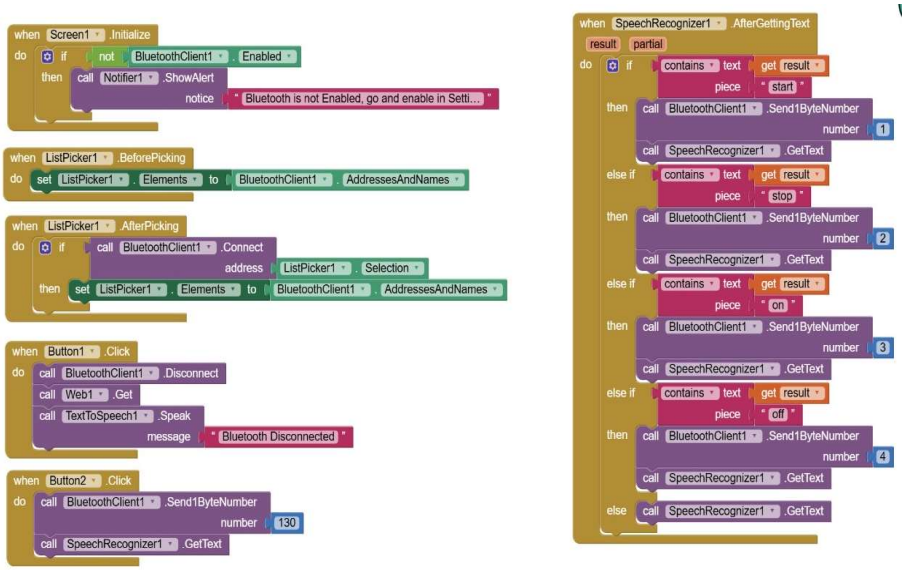
Circuit Design:

1. Fans & Lights: A simple circuit was created to connect the Arduino Uno to the Fan and Lights to the various digital pins, enabling efficient switching On and Off of the appliances.
2. HC-05 Module: The HC-05 Bluetooth module was connected to the Arduino Uno's serial RX and TX pins to receive data from the mobile app via Bluetooth.
3. Grounding: It was ensured that a common ground was maintained throughout.

Code Development:

1. Arduino Embedded C Code: The Arduino was programmed to listen for specific decimal or character values given through serial communication and execute predefined functionalities given in switch cases for appliance control.
2. Python Code with OpenCV: We wrote a Python script to capture video, detect hand gestures, and send corresponding signals to the Arduino. The gesture recognition system utilized contour and finger detection algorithms.
3. Mobile App Development: Using MIT App Inventor, we developed a mobile app with Bluetooth connectivity and speech recognition capabilities to send voice commands to the Arduino.

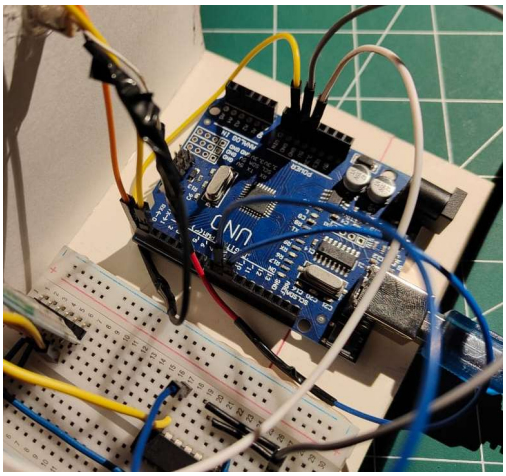
Block Representation of Voice Control app backend:

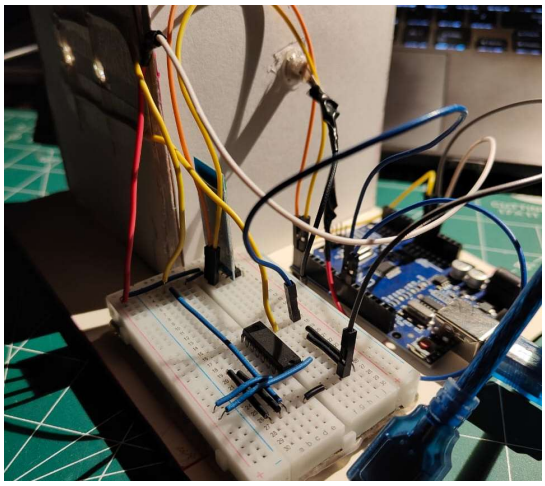


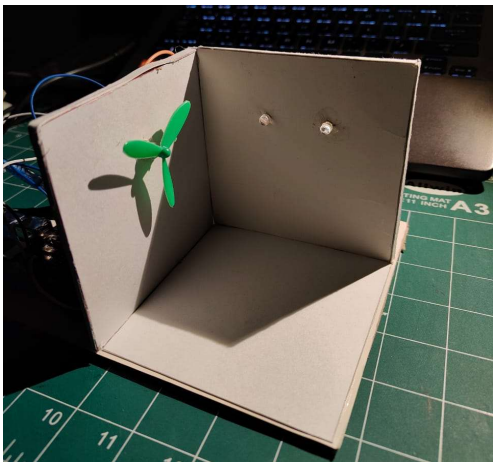
6. Budget:

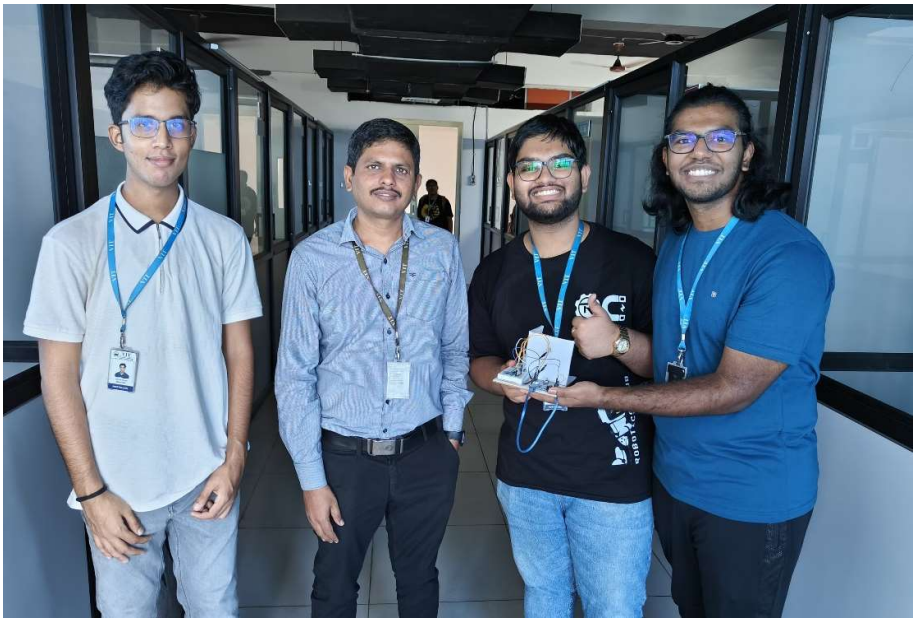
Sr. No	List of components	Number of Quantities Required	Cost per unit (₹)	Total cost (₹)
1.	Arduino Uno R3	1	210	210
2.	HC-05 Bluetooth Module	1	230	230
3.	L293D Motor Driver Chip	1	30	30
4.	Half Breadboard	1	45	45
5.	Jumper wires	12	1	12
6.	Arduino Cable	1	52	52
7.	Coreless DC Motor	1	60	60
8.	DC Motor Propellor	1	20	20
9.	LED Lights	2	10	20
Total Cost (₹)				679

7. Output









8. References

1. Asadullah, M., & Raza, A. (2016). An overview of home automation systems. In 2016 2nd International Conference on Robotics and Artificial Intelligence (ICRAI) (pp. 27–31). IEEE. https://doi.org/10.1109/ICRAI.2016.7791223

2. Singh, U., & Ansari, M. A. (2019). Smart home automation system using Internet of Things. In *2019 2nd International Conference on Power Energy, Environment and Intelligent Control (PEEIC)* (pp. 144–149). IEEE. https://doi.org/10.1109/PEEIC47157.2019.8976842

3. Stolojescu-Crisan, C., Crisan, C., & Butunoi, B. -P. (2021). An IoT-Based Smart Home Automation System. *Sensors*, *21*(11), 3784. https://doi.org/10.3390/s21113784