CONTACTLESS FAN AUTOMATION FOR DIFFERENTLY ABLED

Final Project Report

submitted by

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in partial fulfilment for

HUMAN COMPUTER AND INTERACTION

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PROF. SWARNALATHA P

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SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

1) Scope

The fan used in today’s world is very old fashioned and not that advance. Most human feels the inconvenient about changing the fan speed level, turning it on/off manually when he wants to change. It is very hard for specially-abled people to operate an ordinary fan also. Our proposed project will be helpful in eradicating the following problems –

• Old aged people can easily operate it without much to remember how to use it.

• Specially-abled peoples face a lot of issues to use a fan

2) Abstract

Microcontrollers are being developed with the intention of automating various aspects of human existence in order to better the lot of the poor and disadvantaged. Product applications of gesture and motion detection algorithms, such as the 'Gesture-based Fan. Using camera sensors for motion detection, we can determine whether or not there is a human presence in a space. The fan's speed and on/off switch can be controlled by gestures of the hand. There are some human emotions that are better conveyed through physical gestures than through words. The global community is searching for a cutting-edge, low-priced option.

3) Objective

Our project fulfils the objective of creating an affordable Smart Fan which does not need any remote control, rather it works on the principles of Hand Gesture Recognition and Motion Detection. Following are some of the objectives –

• To recognize fingers in the environment.

• Detecting special gestures for turning on/off.

• Detecting the presence of person in the room whether the person is present or not.

• Counting the fingers so that the speed of the fan can be changed.

4) Requirement Specification:

A possible set of requirement specifications for the proposed system is,

4.1) Hardware Requirement

- Arduino Board
- Connection wires
- 5V Fan
- 2G RAM

4.2) Software Requirement

- Python environment
- Port Manager
- VS CODE
- Arduino IDE

5) Storyboarding

Panel 1: A person with limited mobility is sitting in a room, trying to adjust the fan speed using a traditional fan controller that is difficult for them to use.

Panel 2: The person sees a laptop with a camera and comes up with an idea to use hand gestures to control the fan, which would be easier for them to do.

Panel 3: The person starts researching and experimenting with different computer vision libraries and gesture recognition algorithms that are tailored to their unique needs.

Panel 4: The person settles on using the Mediapipe and OpenCV libraries to detect hand gestures in real-time, and modifies the gesture recognition algorithm to suit their specific hand movements.

Panel 5: The person connects an Arduino board to the laptop and writes a code to control the fan speed based on the detected hand gesture.

Panel 6: The person tests the system and successfully controls the fan speed using hand gestures, feeling empowered by the ability to control their environment independently.

Panel 7: The person decides to share the system with others who have limited mobility or other disabilities that make traditional fan controllers difficult to use.

Panel 8: The system gains popularity among the differently abled community, and the person receives positive feedback from users who find it easy and intuitive to use.

Panel 9: The person continues to improve the system, adding features such as customizable gestures and voice control to make it even more accessible and convenient for users.

Panel 10: The project inspires others to develop similar assistive technologies that leverage the power of computer vision and gesture recognition to empower the differently abled community.

6) Literature Survey

6.1) Smart Home with a Residential Gateway .

They propose the Smart Home Security Protocol, a unique cryptographic protocol, in addition to a safe smart home network (SHSP). A residential gateway .(RG) is required to conduct the essential authentication, key distribution, and encryption tasks to secure a smart house . Based on the characteristics of networks and associated devices, we define smart homes into three distinct sub-network groups, and these networks are interconnected via the RG. Several secure scheme types are deployed based on the subnetwork to reduce workload and device wait times while retaining adequate security. Several embedded system configurations are used to create and validate the proposed smart house security paradigm.

6.2) Design of a Novel IoT Framework for Home Automation using Google Assistant

Automating the home with Node MCU and Google Assistant. Home automation is anything that simplifies and improves the lighting, heating, and appliance performance in a home. All of your home's major utilities, from heating to lighting, can be managed by a single remote or automated system. You can customise the options to suit your needs. Wireless technology is prioritised because it is easier to deploy than wired alternatives.

6.3) Modeling of Intelligent Sensor Duty Cycling for Smart Home Automation

The sensors in a smart home network are divided into several groups using the dynamic temporal warping (DTW) algorithms and recurrent neural network (RNN) in order to foresee events with high accuracy and minimal energy consumption. A RNN model with bidirectional long-short-term memory (BLSTM) is used to anticipate the future behaviour of smart home users in order to select the sensors that are most likely to predict those behaviours. Similarly, DTW is utilised to select a guard sensor from among sensors with a high degree of similarity in order to predict unanticipated home user activities. To maintain a balance between energy consumption and precision, the function of the sensor switches between multiple modes. To determine the effectiveness of the suggested strategy for integrating data from reliable sources, a considerable number of simulations are done.

6.4) IoT Based Home Automation Using App & AWS

They have implemented AWS DynamoDB, a fully-managed NoSQL database solution that enables substantially more rapid, consistent, and predictable performance. Integrating the Raspberry Pi, AWS, and MQTT App makes this possible. Because the user may choose with whom to share data, integrating IoT home automation with AWS is a fantastic idea for data management and privacy.

6.5) Automized Gesture Controlled Switch

The APDS-9960 motion sensor and Arduino are the brains of a proposed contactless appliance control system. Hand gestures and other motions are used as commands in gesture recognition. The reflected infrared signal from the user's hand is transformed into control signals by the Photodiodes present in the APDS9960 sensors.

6.6) Smart Home Automation for Differently Abled Person using Controller and IoT

It is an Internet of Things (IoT) gadget for automating the house, and its controller is a "atmega328p." This controller facilitates communication between various sensors, including those used to detect gas, fire, and infrared heat. Infrared sensors pick up on light, gas sensors pick up on alarms, and fire sensors pick up on fires .Lights, fans, and other home electronics can all be controlled just by speaking a command.

6.7) Intelligent Home Automation System for Disabled People

In this study, numerous home appliances are controlled using an Android smartphone in conjunction with a Raspberry Pi 3 Model B running the Blynk software. When PIR sensors detect motion, an alert is immediately activated. The Blynk app manages everything. The alarm will continue to ring until you push the "OFF" button. When adequate light is detected, the camera immediately turns on and begins photographing the user.

6.8) Hand Gesture Based Home Automation System for Physically Challenged Humans

Home appliances can be controlled by moving the hand left, right, and up and down. The APDS 9960 sensor and the Arduino Uno board are the main components. Each one has its own microcontroller connected to the motion detector. The APDS-9960 sensor's gesture recognition capabilities trigger the switch, which in turn activates the devices.

6.9) Smart Home Automation System for Elderly and Handicapped People Using Mobile Phone

It's an internet-based smartphone app. In order for the model to function, the user must make a choice within the mobile app. The Raspberry Pi's controller can communicate with the database via the GPS connection. In order to turn on or off the appliances in a home, it first reads the value from a database and then sends the corresponding voltage signal to a relay.

6.10) Home Automation System for People with Visual and Motor Disabilities in Colombia

A smartphone's touch-to-speech functionality serves as the foundation for this. The technology design is based on a web server that was built with the help of an Arduino Uno and a Wi-Fi Shield. In addition, a wireless router supports its dual LANs. The network to which the mobile device is attached helps us pinpoint the disabled person's exact location inside the house. A mobile application relays this data to the user and also allows them to remotely power off or restart devices.

7) Inference from Survey

7.1) Design and Implementation of a Secure Smart Home with a Residential Gateway For Secure Smart Home, the response time can be improved.

7.2) Design of a Novel IoT Framework for Home Automation using Google Assistant , An inadequate network connection may be the reason something does not work. Those who are unable to pay the monthly Wi-Fi expenses cannot purchase these items.

7.3) Modeling of Intelligent Sensor Duty Cycling for Smart Home Automation This does not work with datasets made up of ADLs of more than two residents, such as those from smart cities and buildings.

7.4) IoT Based Home Automation Using App & AWS Automated Home can be problematic as it might produce false positives.

7.5) Automized Gesture Controlled Switch The usage is limited to Switch ON and Switch OFF Functionalities. Limited Range (7) of commands.

7.6) Smart Home Automation for Differently Abled Person using Controller and IoT This device will not be of much use for people who have a difficulty in speaking or certain speech related disorders.

7.7) Intelligent Home Automation System for Disabled People The range of PIR sensor is 5 meters. The device will not function if the user is further apart from the sensor. And, the camera fails to capture image if the surroundings are dimly lit.

7.8) Hand Gesture Based Home Automation System for Physically Challenged Humans This system is not feasible when the user has a disability where they cannot move their hand.

7.9) Smart Home Automation System for Elderly and Handicapped People Using Mobile Phone This project is based on a mobile application and thus if someone doesn't own a mobile or if they are not familiar with mobile applications, they cannot use it.

7.10) Home Automation System for People with Visual and Motor Disabilities in Colombia This system is based on a smartphone which makes it difficult to use for people unfamiliar with phone applications and for those who cannot purchase a smartphone.

8) Proposed Methodology

8.1) Flowchart

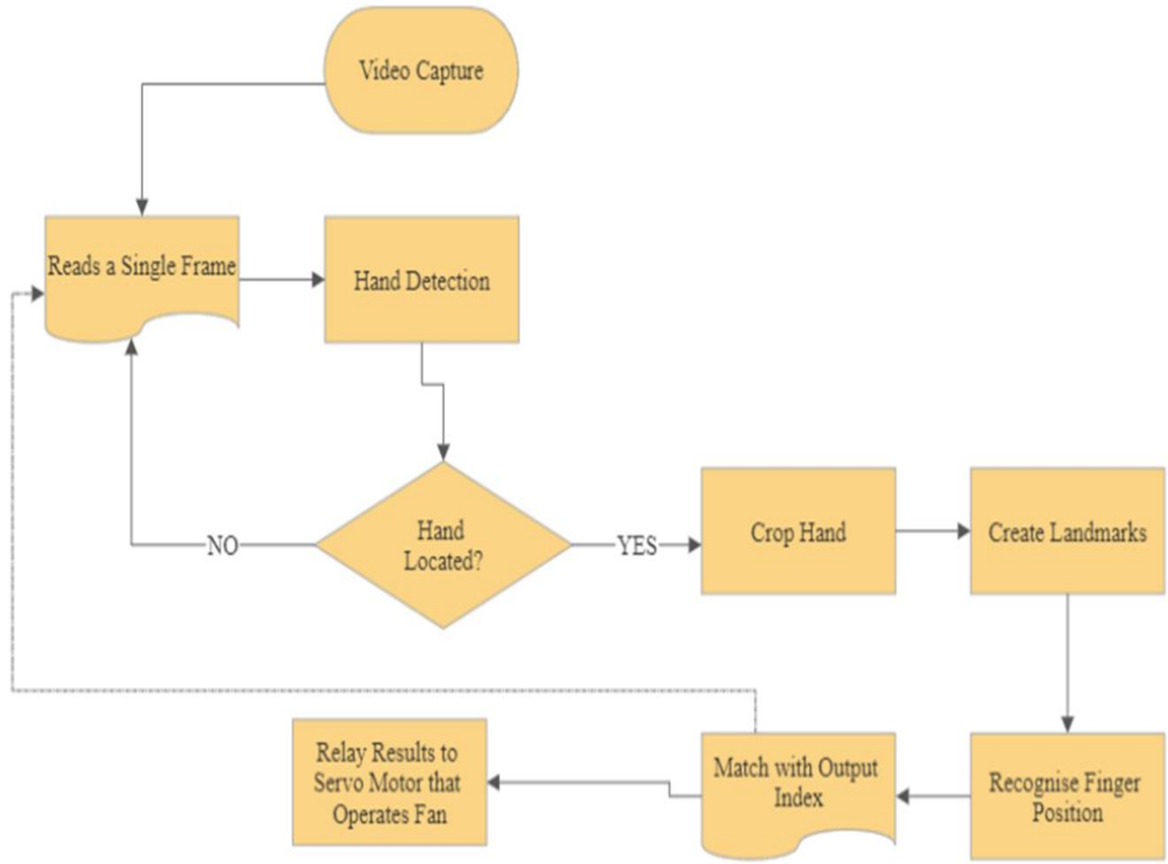


Fig 1 :- Flowchart for proposed model

8.2) State Transition Network:

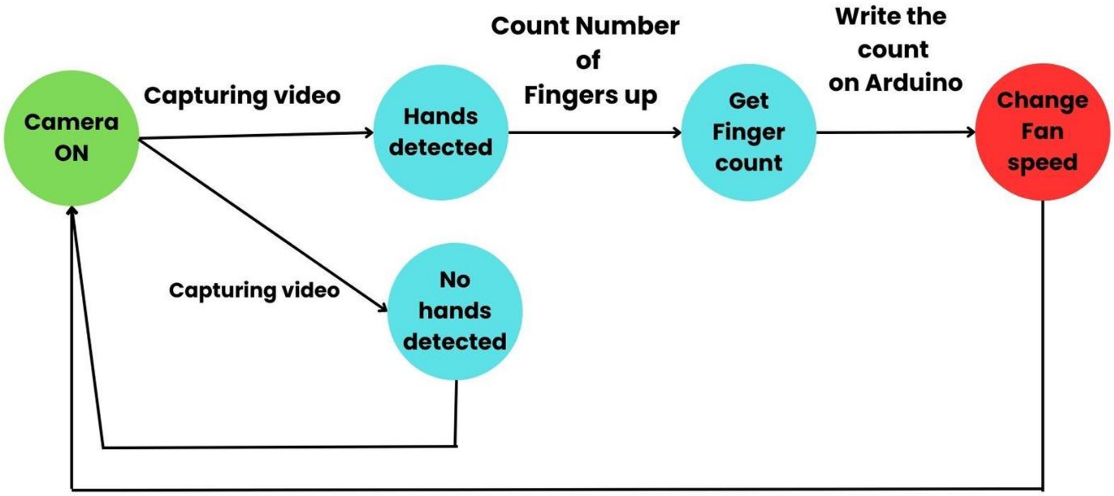


Fig 2 :- State transition network for the system

8.3) Working

Our approach prioritizes both products and equity. The preceding figure 1 depicts the process flow of our project. Those with limited mobility or who are elderly will have difficulty operating the equipment. However, our suggested paradigm shift will eliminate the need to deal with this issue in the future. Normally, turning on a fan requires either locating the remote or getting out of bed to flip the switch. This method of switching cannot be taken anywhere. But remotes can be carried about easily. The overuse of remote controls is a problem that has to be addressed. As a result, we propose a novel method of operating the fans via hand gestures, in which the user indicates his intention to do so by pointing his hands towards the camera and making various finger patterns that may be recognized by computer vision. The model's recognition capabilities are constrained to reduce the possibility of misinterpretation and guarantee that the fan's speed will not be adjusted in response to an inaccurately captured finger pattern. The model automatically creates a response whenever a pattern is recognized. The Arduino runs the code that controls the fan motor.

8.4) Hierarchical Tak Analysis

Goal: Control fan speed using hand gestures

Task: Capture hand gestures

- Subtask: Start video capture
- Subtask: Detect hand in video
- Subtask: Track hand movements in real-time

Task: Recognize hand gestures

- Subtask: Identify hand gesture in video
- Subtask: Determine number of fingers raised
- Subtask: Map hand gesture to fan speed level

Task: Control fan speed

- Subtask: Send fan speed level to Arduino
- Subtask: Update fan speed based on input

Task: Provide feedback to user

- Subtask: Display current fan speed level
- Subtask: Provide visual or auditory feedback when fan speed changes

Task: Handle errors or exceptions

- Subtask: Notify user if hand is not detected
- Subtask: Notify user if gesture is not recognized
- Subtask: Notify user if communication with Arduino fail

Task: Optimize system performance

- Subtask: Improve hand detection and gesture recognition accuracy
- Subtask: Reduce latency between video capture and fan speed control
- Subtask: Improve system reliability and stability

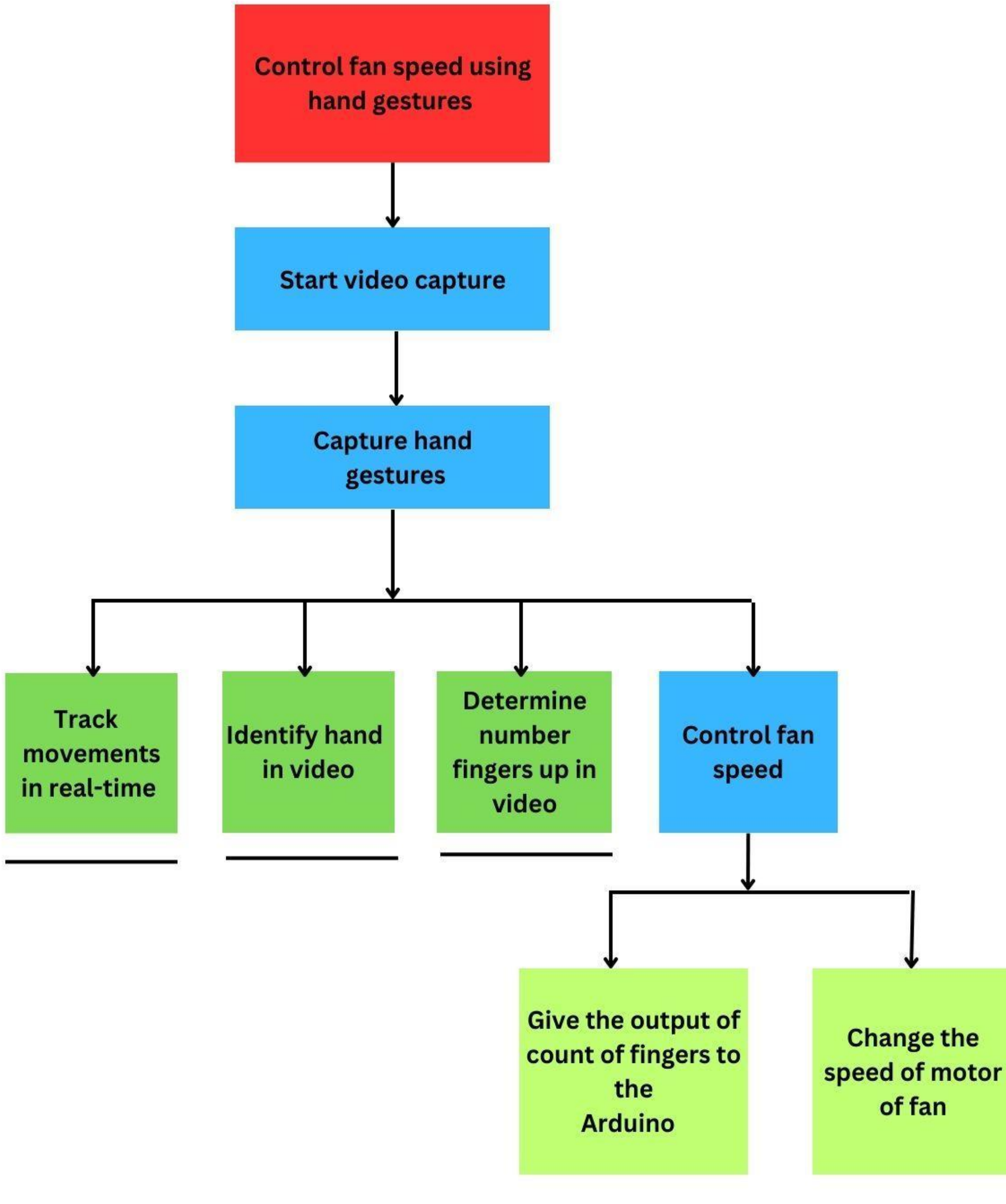


Fig 3 :- HTA of the system

9) HCI Analysis - Apply of Guidelines/Principles

9.1) Schneiderman's Heuristic Evaluation:

1. Visibility of system status: The system always keep the user informed about what is going on, through appropriate feedback within a reasonable amount of time. In the given project, the user receive feedback on the fan speed being controlled based on their hand gestures.
2. Match between system and the real world: The system speak the user's language, with words, phrases, and concepts familiar to the user. In this project, the hand gestures required to control the fan is intuitive and easy for users to understand.
3. User control and freedom: The system allow users to easily undo and redo actions and provide clear exit points for each step of the interaction. In this project, the users are able to easily adjust the fan speed according to their preferences.
4. Consistency and standards: The system follows established conventions and standards to provide a consistent user experience. In this project, the hand gestures used to control the fan is consistent with commonly used hand gestures.
5. Error prevention: The system id designed to prevent errors from occurring in the first place, through careful design and error prevention techniques. In this project, its able to detect and correct errors, such as misinterpreting the user's hand gestures.

9.2) Norman's Heuristic Evaluation:

1. Visibility: The system make all necessary functions visible, without distracting the user with irrelevant information. In this project, the user are be able to clearly see the fan speed being controlled based on their hand gestures.
2. Feedback: The system provide feedback to the user in a timely and appropriate manner. In this project, the system is able to provide immediate feedback to the user about the fan speed being controlled.
3. Constraints: The system constrain the user's actions to prevent them from making errors. In this project, the system prevent the user from accidentally changing the fan speed to an unintended level.
4. Mapping: The system have a clear mapping between the user's actions and the system's response. In this project, the hand gestures used to control the fan should have a clear and consistent mapping to the fan speed.

5. Consistency: The system have a consistent and predictable interface. In this project, the hand gestures used to control the fan should be consistent with commonly used hand gestures.

9.3) Nielsen's Heuristic Evaluation:

1. Visibility of system status: The system always keep the user informed about what is going on, through appropriate feedback within a reasonable amount of time. In this project, the user should receive feedback on the fan speed being controlled based on their hand gestures.
2. User control and freedom: The system allow users to easily undo and redo actions and provide clear exit points for each step of the interaction. In this project, the user are able to easily adjust the fan speed according to their preferences.
3. Consistency and standards: The system follow established conventions and standards to provide a consistent user experience. In this project, the hand gestures used to control the fan should be consistent with commonly used hand gestures.
4. Error prevention: The system is designed to prevent errors from occurring in the first place, through careful design and error prevention techniques. In this project, the system is able to detect and correct errors, such as misinterpreting the user's hand gestures.
5. Recognition rather than recall: The system minimize the user's memory load by making objects, actions, and options visible. In this project, the hand gestures used to control the fan is intuitive and easy for users to remember.

9.4) KLM analysis of the proposed system

9.4.1) Outside the visual area

S.NO	DESCRIPTION	OPERATOR	TIME (ms)
1	Preparing to make the motion in one's head	M	1.35
2	Making hand gesture	P	1.10
3	Making a gesture toward the eye area	H	0.4
4	Authenticating the Acknowledgement	M	1.35
			TOTAL = 4.2

9.4.2) Inside the visual area

S.NO	DESCRIPTION	OPERATOR	TIME (ms)
1	Preparing to make the motion in one's head	M	1.35
2	Making a hand gesture	P	1.10
3	Authenticating the Acknowledgement	M	1.35
			Total= 3.8

9.5) GOMS analysis

9.5.1) Inside the visual area

Method for goal: Making a gesture toward the eyes

Step 1 Direct the gesture toward the eyes.

Step 2. Come back when you're done.

Method for goal: Preparing to make the motion in one's head

Step 1. Pick the hand signal.

Step 2. Come back when you're done.

Method for goal: Making a hand gesture

Step 1. Aim the gesture right at their camera.

Step 2. Come back when you're done.

Method for goal: Authenticating the Acknowledgement

Step 1. Authenticating the Acknowledgement

Step 2. Come back when you're done.

9.5.2) Outside the visual area

Method for goal: Preparing to make the motion in one's head

Step 1. You pick the move..

Step 2. Come back when you're done.

Method for goal: Making hand gesture

Step 1. Direct the gesture at the eyes.

Step 2. Come back when you're done.

Method for goal: Making a gesture toward the eyes

Step 1. Put your gestured hand camera see it.

Step 2. Come back when you're done.

Method for goal: Authenticating the Acknowledgement

Step 1. Verify the Recognition.

Step 2. Come back when you're done.

9.6) Model Human Processor analysis

9.6.1) Inside visual area

S.NO	DESCRIPTION	OPERATOR	TIME (ms)
1	Preparing to make the motion in one's head	M	1.35
2	Making a hand gesture	P	1.10
3	Authenticating the Acknowledgement	M	1.35
			Total= 3.8

9.6.2) Outside Visual Area

S.NO	DESCRIPTION	OPERATOR	TIME (ms)
1	Preparing to make the motion in one's head	M	1.35
2	Making hand gesture	P	1.10
3	Making a gesture toward the eye area	H	0.4
4	Authenticating the Acknowledgement	M	1.35
			TOTAL = 4.2

10) Communication , Collaboration & Groupware

For the "Fan speed controller using hand gestures for differently abled" project, we needed to communicate and collaborate effectively among ourselves as the project team, as well as with the users and caregivers. We used various groupware tools to support these activities and facilitate effective collaboration. To manage our tasks, assign responsibilities, and track progress, we used project management tools such as Asana, Trello, or Jira. We also used communication tools such as Microsoft Teams to communicate with each other and with the users and caregivers. To collaborate on designing, developing, and testing the system, we used design collaboration tools such as Figma or to create and iterate on the user interface design. We also used version control tools such as Git to manage code changes and collaborate on development. To test the system with users and caregivers, we used remote collaboration tools such as Zoom or Google Meet to conduct user testing sessions. Since the system needed to be accessible to users with different abilities, we collaborated with accessibility experts and users with disabilities to ensure that the system is fully accessible and meets their needs .

11) Testing :- Usability testing

11.1) Test case report

Test Case	Input	Expected Output	Actual Output	Verdict
1	0 -> 1	Fan speed changes to very slow	Fan speed changed to very slow	Pass
2	0 -> 2	Fan speed changes to medium	Fan speed changed to medium	Pass
3	0 -> 3	Fan speed changes to high	Fan speed changed to high	Pass
4	0 -> 4	Fan speed changes to very high	Fan speed changed to very high	Pass
5	0 -> 5	Fan speed changes to full	Fan speed changed to full	Pass
6	1 -> 0	Fan stops	Fan stopped	Pass
7	1 -> 2	Fan speed changes to medium	Fan speed changed to medium	Pass
8	1 -> 3	Fan speed changes to high	Fan speed changed to high	Pass
9	1 -> 4	Fan speed changes to very high	Fan speed changed to very high	Pass
10	1 -> 5	Fan speed changes to full	Fan speed changed to full	Pass
11	2 -> 0	Fan stops	Fan stopped	Pass

Test Case	Input	Expected Output	Actual Output	Verdict
12	2 -> 1	Fan speed changes to very slow	Fan speed changed to very slow	Pass
13	2 -> 3	Fan speed changes to high	Fan speed changed to high	Pass
14	2 -> 4	Fan speed changes to very high	Fan speed changed to very high	Pass
15	2 -> 5	Fan speed changes to full	Fan speed changed to full	Pass
16	3 -> 0	Fan stops	Fan stopped	Pass
17	3 -> 1	Fan speed changes to very slow	Fan speed changed to very slow	Pass
18	3 -> 2	Fan speed changes to medium	Fan speed changed to medium	Pass
19	3 -> 4	Fan speed changes to very high	Fan speed changed to very high	Pass
20	3 -> 5	Fan speed changes to full	Fan speed changed to full	Pass
21	4 -> 0	Fan stops	Fan stopped	Pass
22	4 -> 1	Fan speed changes to very slow	Fan speed changed to very slow	Pass

Test Case	Input	Expected Output	Actual Output	Verdict
23	4 -> 2	Fan speed changes to medium	Fan speed changed to medium	Pass
24	4 -> 3	Fan speed changes to high	Fan speed changed to high	Pass
25	4 -> 5	Fan speed changes to full	Fan speed changed to full	Pass
26	5 -> 0	Fan stops	Fan stopped	Pass
27	5 -> 1	Fan speed changes to very slow	Fan speed changed to very slow	Pass
28	5 -> 2	Fan speed changes to medium	Fan speed changed to medium	Pass
29	5 -> 3	Fan speed changes to high	Fan speed changed to high	Pass
30	5 -> 4	Fan speed changes to very high	Fan speed changed to very high	Pass
31	0->0	Fan should not rotate	Fan should not rotate	Pass
32	5->5	Fan remains at full speed	Fan remains at full speed	Pass

Based on the test cases performed, it can be concluded that the project is functioning as expected. All the expected outputs matched with the actual outputs for all the test cases performed. It is safe to say that the system is reliable and efficient in controlling the fan speed through hand gestures

11.2) Automated testing

We wrote a python script which generates random number from 0 to 5 and then these numbers are fed to Arduino as input to change the speed of fan and then the total time taken in this process is recorded for 100 such executions

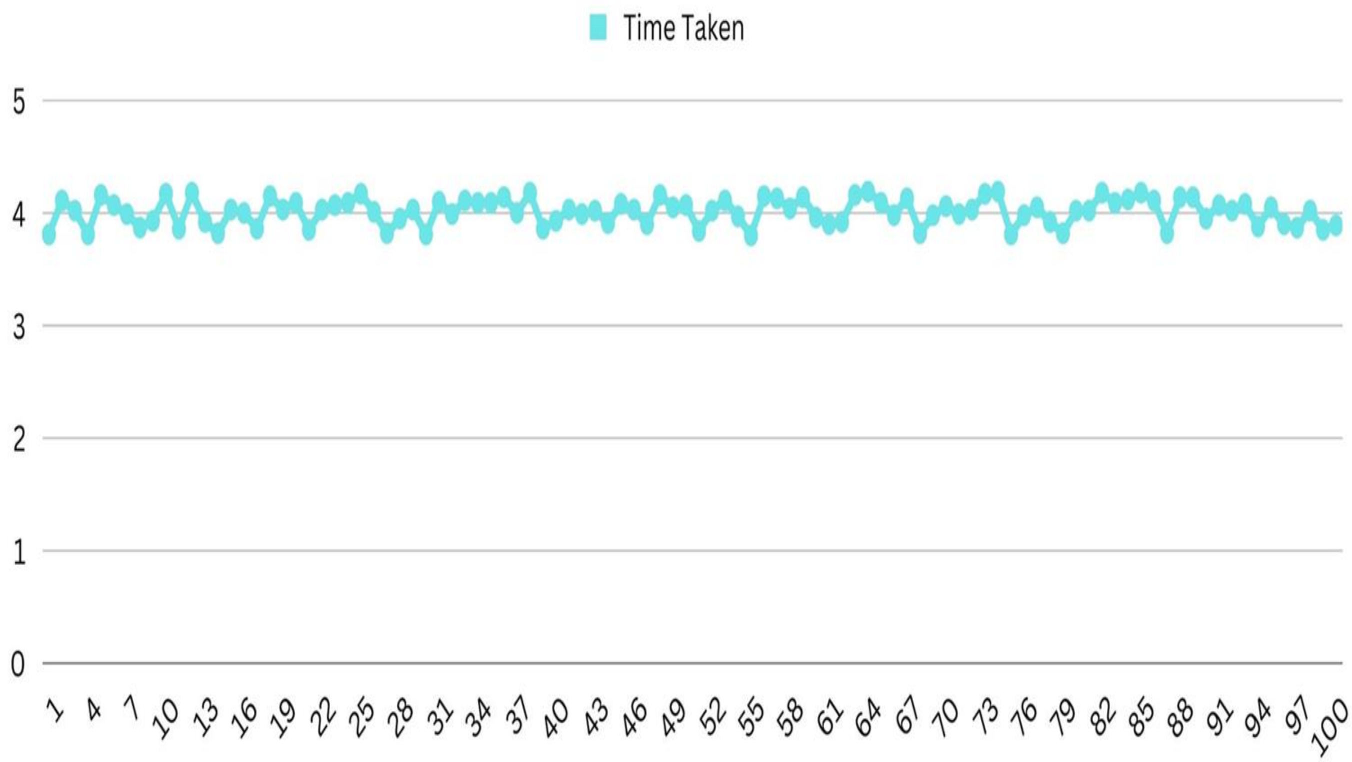
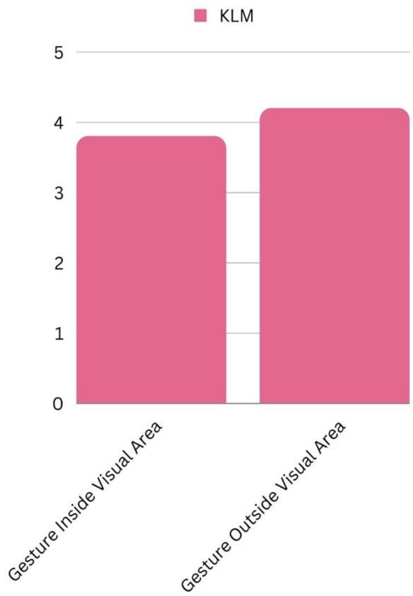


Fig 4:- Input vs output time for each input

12) Results and Discussions

Inference from KLM and MHP

	KLM	MHP
MOVE YOUR HANDS OUTSIDE THE LINE OF SIGHT	4.2	590 ms
Gesture within the field of vision	3.8	520 ms



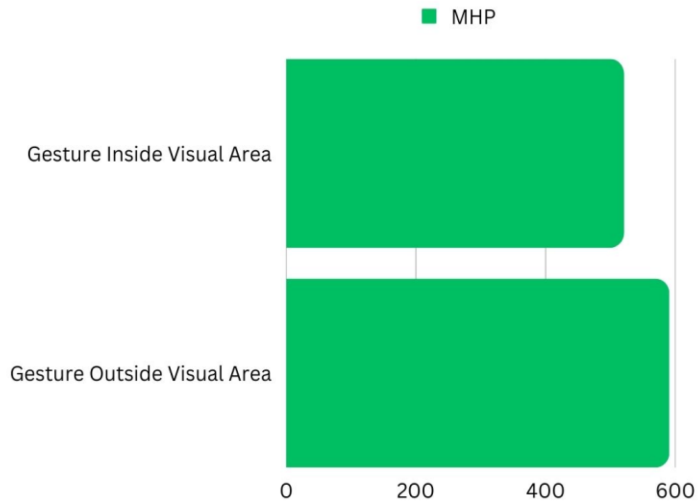
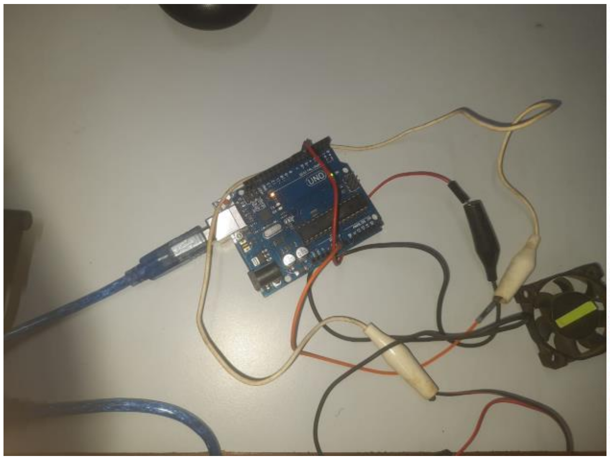


Fig 5:- KLM graph

Fig 6:- MHP graph

Figure 7 and figure 8 shows the connections and the configuration respectively. The working state of the model is shown in the figure 8.



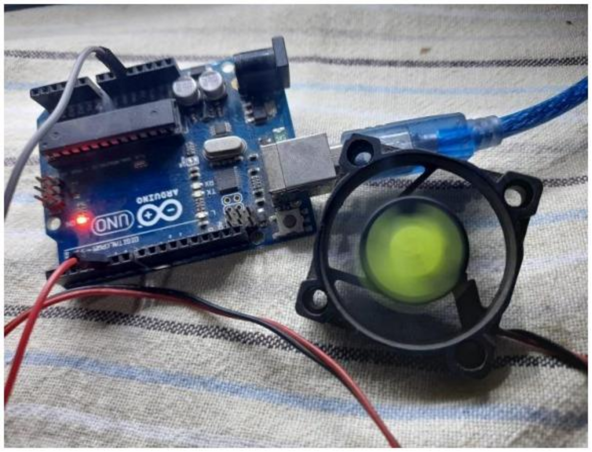


Fig 7 :- Arduino setup

Fig 8 :- Fan running

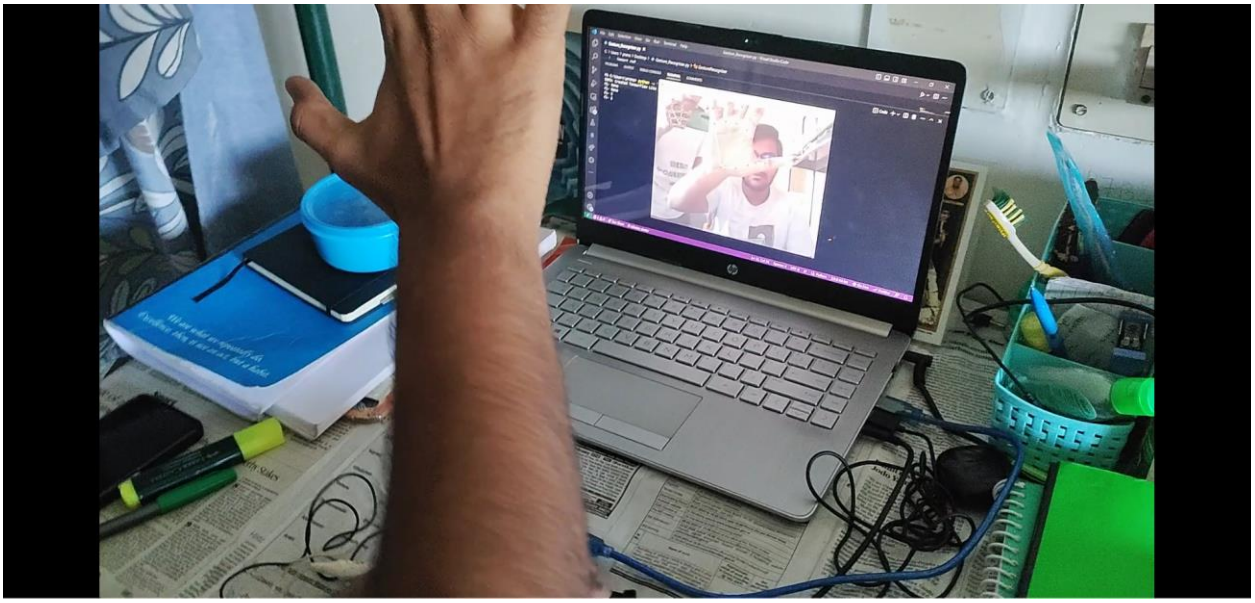


Fig 9:- System mapping finger patterns

Fingers being mapped using camera and python libraries like media pipe to change the fan speed accordingly .

13) Conclusion

The 'Gesture-Based Fan' recognizes hand gestures to function without a remote and adapt to its user's preferences. The camera detects the user's hand movements and uses image recognition to translate that into commands for the fan. This idea project designed a automated fan based on the Arduino platform, which can be operated by human motion and would thus be usable by people of varying ages and abilities.

Without having to appear on camera, we can control the fan with a custom-made app on our mobile devices. This kind of technology might be used to improve a wide variety of household products, including lights, fans, and even smart-gas hob regulators.

14) Future Scope

The "Fan Speed Controller using Hand Gestures for Differently Abled" project has several future scope for improvement and expansion. Some of the potential future scope for this project are:

1. Integration with other devices: The system can be integrated with other smart home devices such as lights and air conditioners to allow users to control multiple devices through hand gestures.
2. Improved accuracy and speed: The system can be improved to increase the accuracy and speed of hand gesture recognition, enabling a more precise control of fan speed and reducing any lag in response time.
3. Multi-user support: The system can be expanded to support multiple users with personalized settings, allowing each user to have their own preferred fan speed settings and gesture recognition patterns.
4. Integration with voice commands: The system can be integrated with voice command technology, allowing users to control fan speed and other devices using voice commands.
5. Accessibility features: The system can be enhanced with accessibility features such as audio and visual feedback to help users with hearing or visual impairments.
6. Mobile app integration: The system can be integrated with a mobile app to allow users to control the fan speed and other devices remotely, providing greater convenience and flexibility.

Overall, there is a significant potential for the "Fan Speed Controller using Hand Gestures for Differently Abled" project to expand its functionality and improve its usability to serve the needs of a wider user base.