Hand Gesture Recognition Automation System

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CERTIFICATE

This is Certified that the Mini Project report entitled "Hand gesture Recognition Automation System" has been successfully completed by Mr. Mandar Hajare, Mr. Vedang Patil, Mr. Ayush Kedar, Mr. Himanshu Samrit, Mr. Musab Shaikh, Mr. Budharam Kumbhre under the guidance of Prof. Jagdish Yadav in recognition to the partial fulfillment for the award of the degree of Bachelors of Technology in Information Technology, Yeshwantrao Chavan College of Engineering (An Autonomous Institution Affiliated to Rashtrasant Tukdoji Maharaj Nagpur University).

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Introduction

In this project our aim to establish a connection between electronic devices and software to make life easier and to operate a small motor car using hand gesture recognition algorithm. There are several parts in our society which are not able to access certain priviledges normally through physical touch. Handicapped people are not able to drive a car, or turn on or off lights if they don't have needed parts or may have been paralysed. In order to enhance and improve life experience we are attempting to build a bridge between electronic devices and software interfaces to make life easier for these people. Some situations require hands free interaction with the electronic appliances like quarantine situations , or where we need our parked car come straight to us.

we are using hand gestures (by extracting the key points from the python library), setting conditions based on the gestures that the code reads and sending data to arduino using pyFirmata library and further using this gestures to control robot. The control hand gestures for the robot are right tilt, left tilt, forward tilt, backward tilt and no tilt to drive the robot in right, left, forward, backward direction and to stop it respectively.

The main purpose of using hand gestures is that it provides a more schematic way of controlling the robot and with this feature, robot can be used as a wheelchair or etc., As human hand gestures are natural, with the help of wireless communication, it is easier to interact with the robot in a more-friendly way. The robot's movement depends upon the hand gestures. The objective of this project is to build a wireless, hand gesture controlled a robot using an Arduino Uno.

Literature Review:

There are many previous researches regarding hand gestures recognition that can be used as a reference to develop a real-time system and algorithm to detect hand gestures. There are several methods which use different approaches to use different algorithms for wide range of applications.

Rafiqul & Noor (2012), Arpita, Sanyal & Majumder (2013) and Deepali & Chitode (2012). The field of review of hand gesture recognition is very wide and a big amount of work was conducted in the last 2 to 3 years. we survey the latest researches, were done on hand gesture recognition along with compare the different techniques, applications, and challenges presented by the surveyed work. The reason why the most recent research articles from IEEE database were chosen to be studied about hand gesture recognition that we wanted to construct a valid base current situation and technologies of hand gesture recognition. Then, the articles published by IEEE in the year of 2016 to 2018 were considered to increase the intensity, focus of this study, and because the recent works were not sufficiently studied before, the older ones were studied and compared.

Ananya, Anjan Kumar & Kandarpa Kumar, 2015. Image frame acquisition or gesture acquisition is to be capture the human hand gesture image by the web cam laptop (computer). It could be done using vision-based recognition where no special gadgets are required and a web camera or a depth camera is used, then after special tools that can be utilized such as wired or wireless gloves to detect the movements of the user's hand and motion sensing input devices. The main, Fourier descriptor method which captures the palm, the fingers and the finger tips and centroid method which captures the essential structure of the hand.

Weiguo et. al. (2017), Ananyaa et. al. (2017), Alvi, Fatema & Mohammad (2016), Shome (2017). The first method is using vision-based hand gesture recognition to extract Hand gestures recognition were discussed in the work studied using different acquisition tools, parts of them used images that captured in real time and others used previous images that were recorded in databases. The another classification to be considered is the nature of the acquisition that could be either a static hand gesture recognition where the gestures represented by the constant image, or a dynamic hand gesture recognition were gestures are represented by the movement of the hand.

Rosalina et al. (2017), Danling, Yuanlong & Huaping (2016), Oinam et al. (2017) the authors implemented by the two different techniques of vision-based hand gesture recognition and one data glove-based technique. These are either static hand and real-time hand gesture recognition techniques. In data glove-based technique the glove had five flex sensors. Results were shown that the vision-based technique was more stable and too much as reliable compared to the data glove-based technique. Hand gestures obtained by evaluating the contour captured from the image segmentation. This could be used a novel data glove called YoBu to collect data for gesture recognition and show the output int he form of movement of a robot.

Salunke & Bharkad (2017), Rokhsana et al. (2017), Jessie et al. (2016) and Anshal, Heidy & Emmanuel (2017). Hand Gesture Recognition Control in Augmented Reality System (HGCARS) where the gesture recognition is to be performed using a secondary camera, reality is captured using an IP camera, the virtual object is added to the video feed obtained from an IP camera and controlled by using the position and depth of hand, measured using a webcam, used for gathering input data and show the movement of small motar car.

Anshal, Heidy & Emmanuel (2017). Human gesture recognition, the work of the Anshal, Heidy & Emmanuel (2017) processed the hand gesture image and combining image segmentation and edge detection to extract morphological information, and frames were processed the multi-modality technique used for processing individual characters. In Vedha Viyas et al. (2017), to improve recognition rate of hand gestures and various image processing techniques were used such as Histogram Equalization, Average filtering, Median filtering and Morphological filtering. The features of extraction image matching was done using cross-correlation co-efficient.

Xiang, Lei & Qiang (2017), Weiguo et al. (2017), Rokhsana et al. (2017) hand gesture recognition, there are several features that could be considered and extracted from the hand gestures which are highly dependent on the application. It recognized the hand shapes, orientations and movement of the hands also the alignments of the fingers, and the palm position. Open hand, wrist radial deviation, wrist extension, ulnar deviation, wrist flexion and closed fist were considered and recognized as a sample input and show the automated car output.

Stefan Waldherr and Sebastian Thrun are proposed a movement of an interfaces for controlling a versatile robot with the help of hand gestures. Here they have used camera to follow the humans and to get the signals that are included movement of the robot. However, it allows the robot for trace ability purpose and show automated output.

Rafiqul Zaman Khan and Noor Adnan, human gesture recognition, proposed and showed as a key issues of the hand gesture recognition framework. To get exact and appropriate values for recognition of the hand movement which has ability to interact with the PC applications and automated robot application too.

Aditya et al. (2017), Nilima & Patil (2017), Hafız et al. (2017), review of hand gesture recognition on top-view hand images that observed by a Time of Flight (ToF) camera in a small car for touchless interactions inside a car was proposed. The help of an image capturing devices installed on computer was implemented in Nilima & Patil (2017). The authors of Hafız et al. (2017), presented a Control MS Windows via hand Gesture (CMSWVHG) to perform numerous of windows actions using hand gestures using internal or external cameras for taking input with the help of OpenCV and to control OS on the projected screen for a virtual mouse system without any hardware requirement one camera source was required. Along with a data acquisition was done using Camera interfacing and showing output of automated car.

Analysis for Project scope

Human Gesture Recognition technology, a web camera reads the movements of the human gesture and communicates the data to a computer that uses the gestures as input and to control devices. We analysis the technique as a input form camera then tracking a hand and segmentation so that we get a exact gesture of a hand, feature extraction and then gesture recognition. For that we using OpenCV, Mediapipe and some libraries of python.

OpenCV

OpenCV (Open-source computer vision) is a computer vision algorithm which is commonly used for machine learning, image processing and image manipulation. In our project we are recognizing the gesture of human hand.

MediaPipe

MediaPipe is a Framework for building machine learning pipelines for processing time-series of a data like video, audio, etc. The Framework works on different platforms such as Desktop, Laptop, iOS, Android and embedded devices like Raspberry Pi and Jetson Nano.
Here for gesture recognition and proved as a palm we used MediaPipe. It is a machine-learning employed with high-fidelity hand and finger tracking solution.
The project scope include multiple applications in Machine learning.

Hand gesture to control the home appliances like MP3 player, TV etc.

Now a days, Hand gesture-based electronic device control. Most of an electronic devices focus on the hand gesture recognition algorithm and also the corresponding user interface. Hand Gesture Based Remote is a device to replace all other remotes used in households and perform all their functions. Normally in homes, remotes are used for various appliances like TV, Air Conditioner, CD player, DVD Player and Music System. Remotes are also used for lights ON/OFF control, Door Opener, etc. These all devices can be controlled by one Universal Remote.

Gesture-based Gaming control

Doing more entertainment and to handle gaming applications, users are eager to try new interface paradigms so they are likely immersed in a challenging game-like environment. To control games multi-touch device delivered through the user’s fingertips. The finger touches the screen is irrelevant most important is where the touch is made and the number of fingers used. So, hand-gesture-controlled games, the system must respond quickly to user gestures and the to get fast-response.

Medical Operation

For critical condition of patient its not possible to operate medical instruments too much fast so the gestures can be used to control and distribution of resources in hospitals in easy way and interact with medical instrumentation and control. Simply the hand gestures into doctor-computer interfaces describing a computer-vision system that can enables surgeons to perform standard mouse functions including pointer movement and button presses with hand gestures, also the remote surgery takes place, as the surgeons control the robot and surgery takes place.

Talking to computer

Using human gesture recognition it's possible to imagine a world in which a person putting together, presentation can add a quote or move an image instead of a click of a mouse. So in future we can easily interact in virtual reality too much as we do in actual reality, using our hands for small, modern movements like picking up a tool, pushing a button or squeezing a soft object in front of us that kind of technology is still evolving. But the computer scientists and engineers who are working on these projects say they believe they are on the making hand and gesture recognition tools practical and easy to operate.

Work Done

From detecting hand gestures to control robot, there are many steps involved in this system.

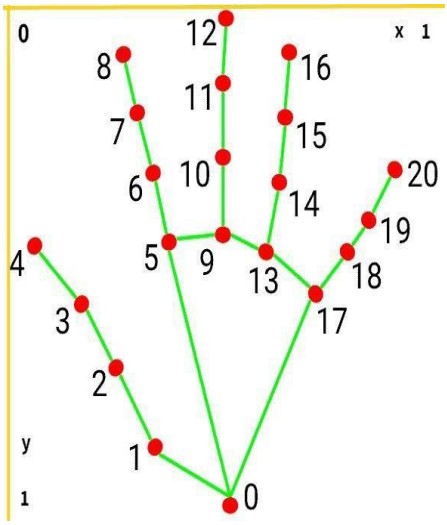
Hand Gesture Recognition

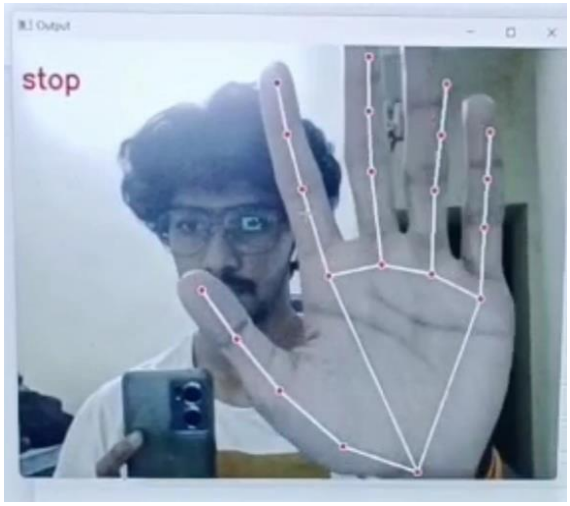
We are using mediapipe and OpenCV libraries in python to detect the gestures along with Hands model from mediapipe solutions to detect hands. Mediapipe is Google's open-source framework that are used for media processing. It is cross-platform or we can say it is platform friendly too. It can run on Android, iOS, and the web, Cross-platform means to run everywhere.

OpenCV is a Python library that's designed to solve computer vision problems. OpenCV supports a wide range variety of object oriented programming languages such as C++, Python, Java etc. It supports for multiple platforms including Windows, Linux, and MacOS.

MediaPipe Hands

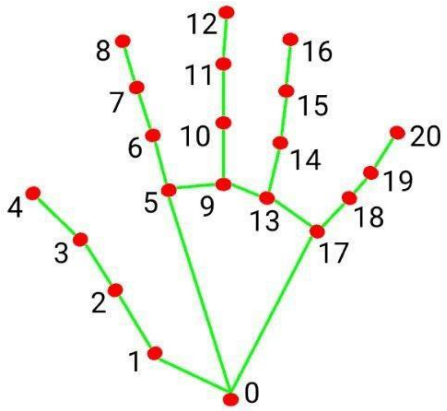
First, learn how the Coordinate system works, only then use MediaPipe Hands.





As shown above, we successfully recognized palm gestures of the hand and verified as the stop signal.

The MediaPipe Hands module will return coordinates of 20 points on fingers.



0. WRIST
1. THUMB_CMC
2. THUMB_MCP
3. THUMB_IP
4. THUMB_TIP
5. INDEX_FINGER_MCP
6. INDEX_FINGER_PIP
7. INDEX_FINGER_DIP
8. INDEX_FINGER_TIP
9. MIDDLE_FINGER_MCP
10. MIDDLE_FINGER_PIP
11. MIDDLE_FINGER_DIP
12. MIDDLE_FINGER_TIP
13. RING_FINGER_MCP
14. RING_FINGER_PIP
15. RING_FINGER_DIP
16. RING_FINGER_TIP
17. PINKY_MCP
18. PINKY_PIP
19. PINKY_DIP
20. PINKY_TIP

Establishing Interface Between Python IDE and Aurdino IDE using pyFirmata

Firmata is an intermediate protocol that connects an embedded system to a host computer and the protocol channel uses a serial port by default. The Arduino platform is standard reference implementation for Firmata along with the Arduino IDE comes with the support for Firmata.

We needed a module which declared all the pins and its functions to Arduino. In order to do that we create a microcontroller module. In python we import the library using “import pyfirmata as py” also we are going to define what port our arduino is connected to, that can be checked in the device managers in arduino IDE then we pass that port number to Arduino method which is only for Arduino Uno.

In the end of our approach application we run the main code and it opens up a window where we select if we want to run a premade window or open webcam and take commands from there.

In this way we successfully implemented the Hand Gesture Recognition Automation with the help of Arduino Uno and Machine Learning with Python, OpenCV.

Electronics Hardware Implementation

We are going to start it off with hardware implementation and construction. All the five different approaches, we implemented the Machine Learning Approach particularly in this project as it is most efficient and makes our arduino uno integration easier.

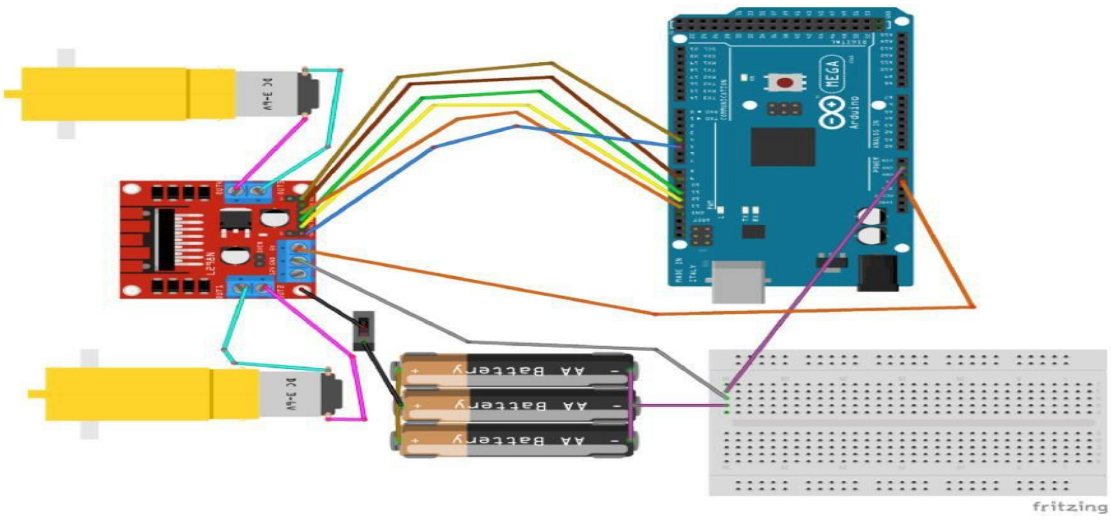
STEPS (MOTOR CAR CONSTRUCTION)

1.We are using a metal mouting board to make a base chasis for our motor car which will accommodate both Arduino Uno and Motor Driver Module and our both motor wheels.

2. We are going to connect the two motor wheels to the L298N motor driver module which is going to decide the speed and direction of motor rotation.

3. After that we will connect motor driver module needed ports to the arduino uno ports to take commands from arduino.

4. Connections was made as shown in the following schematic. We pasted the L298N motor driver module at the bottom of the metal plate along with the two motor wheels and we pasted a 12V battery supply at the top in our case we are going to give the power output from outside as an adapter. We pasted Arduino uno at the top of the motor.



STEPS (Arduino Uno Connection and Code)

1. Arduino Uno is connected with an USB port cable to the laptop where we are going to upload the code through Arduino IDE.

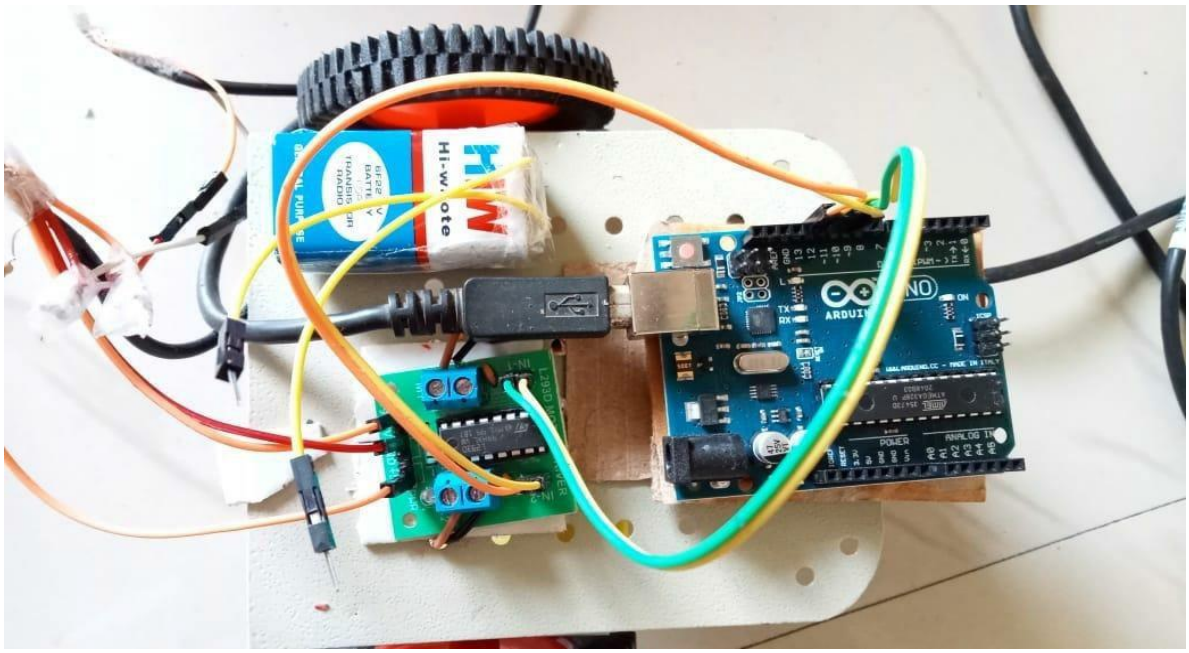
2. We are using firmata sketch in Arduino IDE in order to integrate it with python's pyfirmata interface so that we can run our python code and use arduino with it instead of coding in arduino itself. It makes the job easier.

3. We start Arduino IDE and we go to examples and then we go to firmata from there we go to StandardFirmata Sketch so that we can flash our arduino uno and make our arduino understand pyfirmata program.

4. Select the USB port to which your arduino uno is connected.

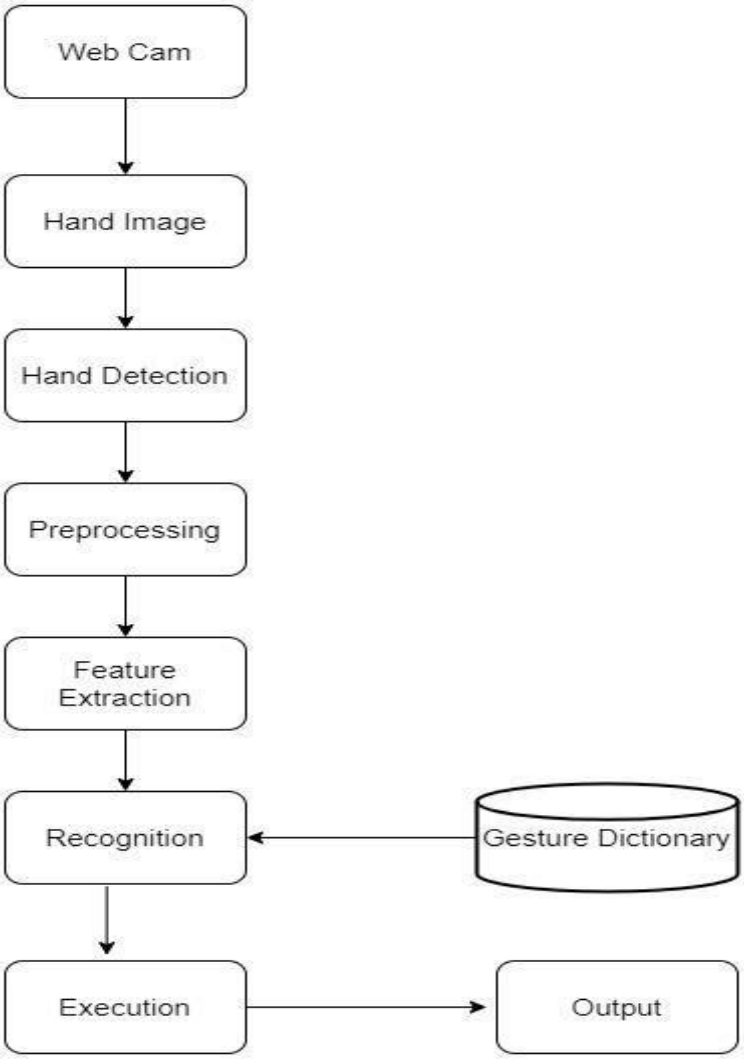
5. After that we uploaded that firmata sketch into our arduino uno model. In this way we flashed our arduino uno chipset.

6. Now our arduino uno is set for pyfirmata python interface program. We can run aur python program to manipulate the arduino uno according to our needs.

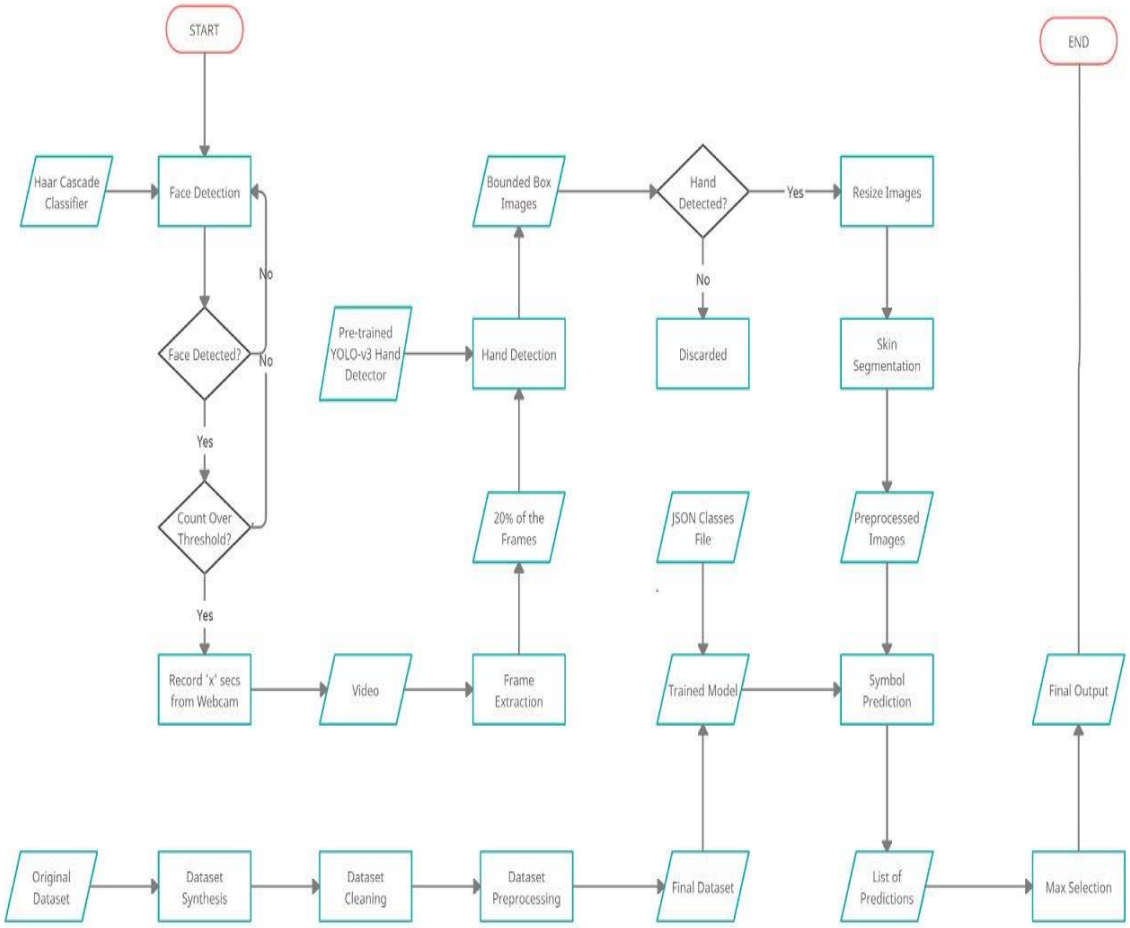


Hardware Model

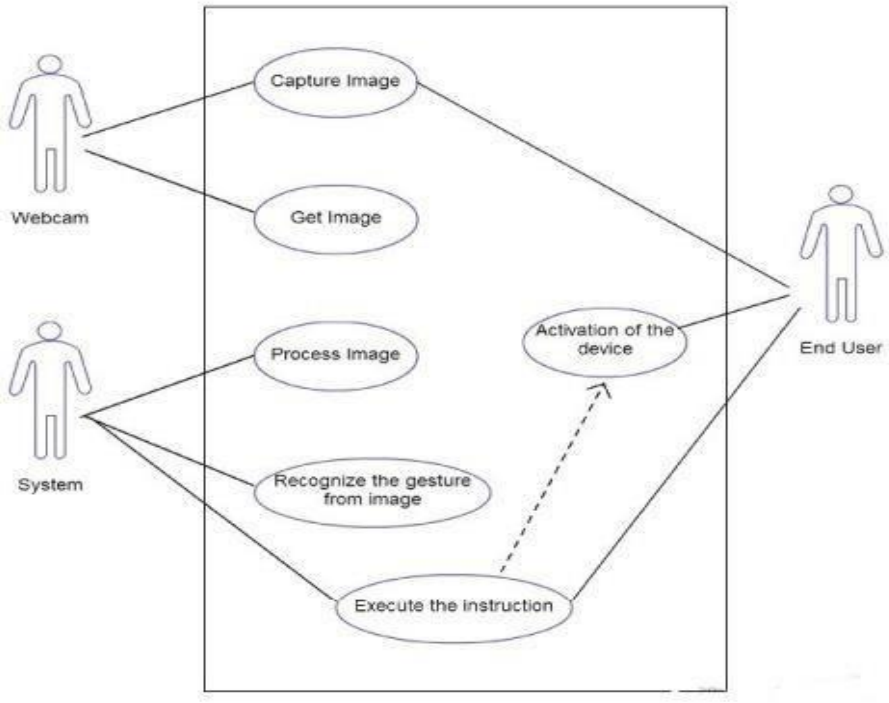
Flow Diagram



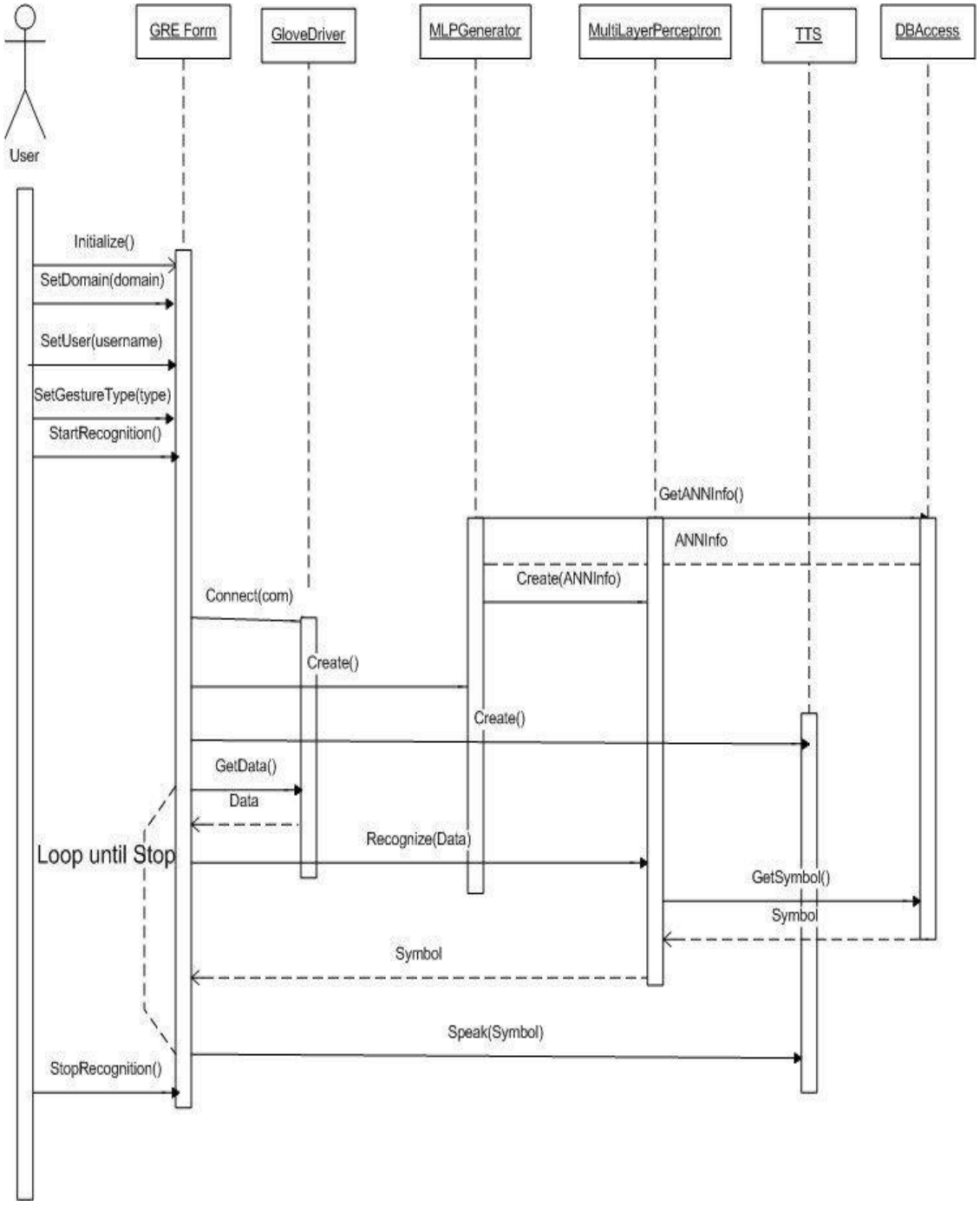
Architecture



Use Case Diagram

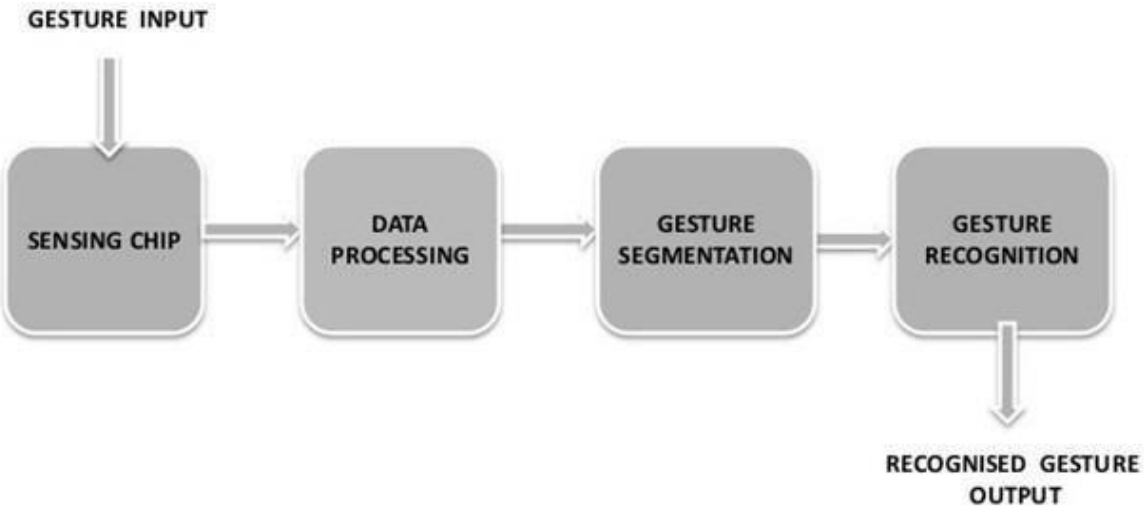


Sequence Diagram



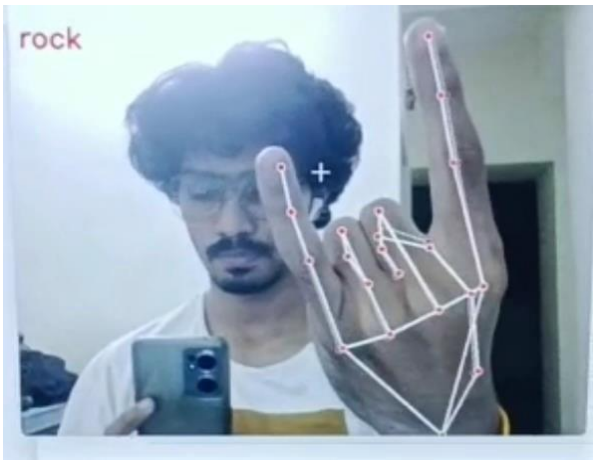
Results and Discussions

In this project we recognized hand gesture using web cam and detect the hand gesture using some python libraries such as OpenCV, MediaPipe etc. It recognized the palm and count fingers thus gesture input generated. Using hand gestures i.e by extracting the key points from the python library setting conditions based on the gestures that the code reads and sending data to arduino using pyFirmata library and further using this gestures to control robot. Here the propose of the project an Arduino based interaction tool using Machine Learning Python approach to control robot (small vehicle, electronic devices etc.). It allowing the users to control motor based car with gestures, similar way in given flow chart using web cam generate the gesture input then goes to sensing chip, data processed and then gesture segmentation takes place and recognized as a output such as the motion of robot (small car) resulting right tilt, left tilt, forward tilt, backward tilt and no tilt to drive the robot in right, left, forward, backward direction and to stop it respectively. Our quantitative evaluation results show that our system can accurately detect and control movement of car within a proper working range, and achieves high hand gesture recognition accuracy for creating fluent user experience.

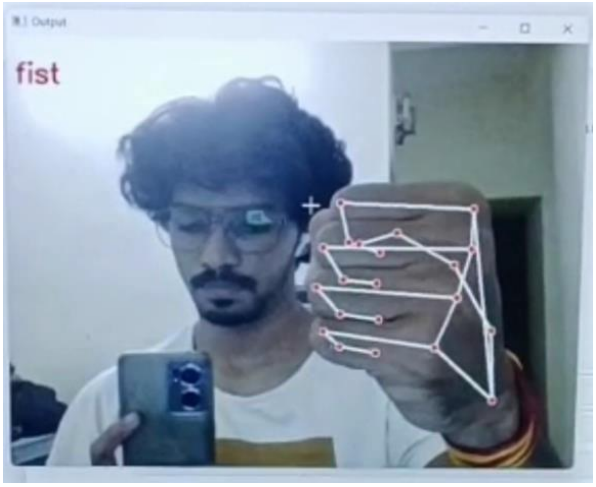


These are some gestures we tested on our algorithm

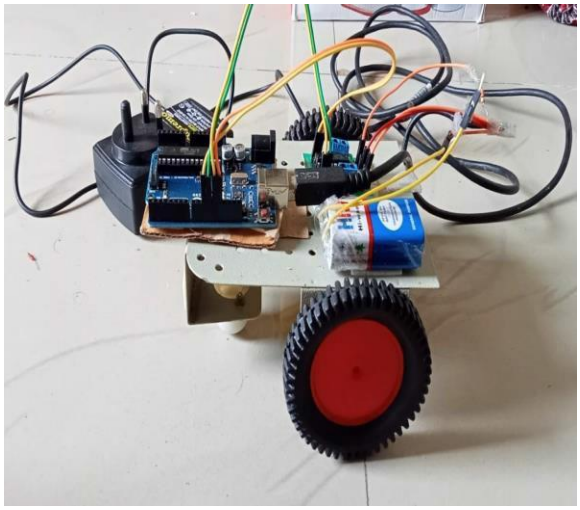
We successfully recognized thumbs up gestures of the hand and verified as the thumbs up signal.



We successfully recognized rock gestures of the hand and verified as the rock signal.



We successfully recognized fist gestures of the hand verified as the fist signal.



Thus according conditions based on the gestures that the code reads and sending data to arduino using pyFirmata library and further using this gestures to control robot.

Summary and Conclusions

Gesture recognition technology is the turning point, the future will bring about an increased number of smart devices in our daily lives. It allows us seamless, non-touchable control of computerized devices to create a highly interactive, yet fully immersive and flexible hybrid reality. The technology include multiple applications across various sectors that further revolutionizing human-computer communication. In this project our propose an Arduino based interaction tool using Machine Learning Python approach to control robot (small vehicle, electronic devices etc.), we built an information flow pipeline for the system consisting of hardware (Arduino chip,L298N motor driven model, webcam, pc/laptop) and software(Python, Arduino IDE, Jupyter Notebook, Anaconda Distribution Navigator) allowing the users to control motor based car with gestures. We built a gesture detection model, which can jointly detect hand gesture in the view and control target devices. Our quantitative evaluation results show that our system can accurately detect and control movement of car within a proper working range, and achieves high hand gesture recognition accuracy for creating fluent user experience.

It’s really a fully integrated, highly advanced technology that requires specialized skills of individuals with relevant experience that could be guarantee favorable results. We successfully established bridge network between a device and a software. This gesture and virtual panel based interaction is scalable to meet the future interface requirements. We plan to extend tool’s capabilities to interact with more complex systems such as military systems, industrial manipulators and consumer robots.

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