Hand Gesture Recognition Automation System

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Abstract. Our efforts were mainly focused to have machine and software interaction during this project. We were determined to build a small rotor car with miniature components and have it establish connection with our laptop through several media. Software is coded in python and detects hand gestures and our attempt was to amplify these gestures in the form of signals which are discussed later. The goal was to achieve mechanical movement of any nature or mechanical response using a non-mechanical approach. In this project we drove a small mechanical rotor car using various small commands generated by our hand gestures hence achieving our objective and supporting our research. We discovered through this project that a machine – software interaction is possible and can be amplified beyond imagination. In this project let us explore one simple but fascinating possibility of such phenomenon.

Keywords: Hand gesture recognition, Automation System, Gestural interaction,
Human Computer Interaction

1 Introduction

Our aim is to establish a connection between mechanical devices and software to 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 privileges 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 paralyzed. In order to enhance and improve life experience we are attempting to build a bridge between electronic devices and software interfaces to explore possibilities for these people. Some situations require hands free interaction with the electronic appliances like quarantine situations, we will just test this phenomenon on a smaller scale and prove that such technology bridge exists and can be used for greater good of society.

We are using hand gestures to send data to an Arduino Uno chip using the PyFimata library, set conditions based on the gestures that the code reads, and further use these gestures to operate robots (by extracting the important points from the Python library). Left tilt, right tilt, forward tilt, backward tilt and no tilt are the hand motions used to drive the robot in a left, right, forward, backward and stop respectively. With this capability, the robot can be utilised as a wheelchair or other object by using hand gestures, which offers a more schematic method of directing it. With the use of wireless connection, it is simpler to communicate with the robot in a user friendly manner because human hand motions are natural. The robot’s movement depends upon the hand gestures. The objective of this project is to build a wireless bridge between hand gesture and a robot using an Arduino Uno.

2 Literature Review

A real-time system and algorithm to recognize hand gestures can be created using a number of earlier studies on hand gesture identification as a guide. There are a number of techniques that employ various strategies to use various algorithms for a variety of purposes.

RaySarkar, Arpita & Sanyal, Prof(Dr.) Goutam & Majumder, Somajyoti. (2013). Hand Gesture Recognition Systems: A Survey. International Journal of Computer Applications. 71. 25-37. 10.5120/12435-9123. These Human-Computer interactions (HCI) methods vary from simple keyboard inputs to advanced vision-based gesture recognition systems [1]. Hand gesture recognition is one of the most exciting and important HCI methods [2]. Hand gesture recognition opens up a very interesting research domain as it can be used to enable communication for many applications such as mobile phones, smart TVs, robot controls, medical devices, access control systems, smart vehicles, and so on

Sharrma, Ananyaa & Khandelwal, Ayush & Kaur, Kavleen & Joshi, Shivani & Upadhyay, Richa & Prabhu, Sameer. (2017). Vision based static hand gesture recognition techniques. 0705-0709. 10.1109/ICCSP.2017.8286451.The work presented in Himadri et al. (2018) used Support Vector Machine (SVM), Artificial Neural Network, Naive Bayes and K-Nearest Neighbor (K-NN) classifiers as the training methods to recognize the features extracted. In contrast, in Ananyaa et al. (2017) the best classification accuracy was achieved using Euclidean distance and Eigen vector, but this result is for a very small dataset, and the best result was a dataset containing nearly 720 images that used Support vector machine for classification of images; also, using Artificial Neural Network provided an accuracy of 89.48%.

Choudhury, Ananya & Talukdar, Anjan & Sarma, Kandarpa. (2015). A Review on Vision-Based Hand Gesture Recognition and Applications. 10.4018/978-1-4666-8493-5.ch011. In the present scenario, vision-based hand gesture recognition has become a highly emerging research area for the purpose of human computer interaction. Such recognition systems are deployed to serve as a replacement for the commonly used human-machine interactive devices such as keyboard, mouse, joystick etc. in real world situations.

Rosalina, & Yusnita, Lita & Hadisukmana, Nur & Wahyu, Rb & Roestam, Rusdianto & Wahyu, Yuyu. (2017).”Implementation of real-time static hand gesture recognition using artificial neural network”. 1-6. 10.1109/CAIPT.2017.8320692. Implemented two distinct methods of vision-based hand gesture detection and one method based on data from a glove. These are methods for detecting both static and live hand gestures. The glove used in the data glove-based approach featured five flex sensors. According to the results, the vision-based technique was more dependable and steady than the data glove-based technique. Gestures of the hands were determined by analyzing the contours that the picture segmentation had captured. This might be utilized with a cutting-edge data glove called YoBu to gather information for gesture detection and display the results in the form of robot movement [9].

Titlee, Rokhsana & Rahman, Ashfaq & Zaman, Hasan & Rahman, Hafiz. (2017).”A novel design of an intangible hand gesture controlled computer mouse using vision based image processing.”1-4. 10.1109/EICT.2017.8275171., Our approach uses a novel skin color segmentation technique to control mouse movement. The system uses morphological operations like structuring elements and blob counting. Our system can remove other skin like objects from the background.

Joshi, Anshal & Sierra, Heidy & Arzuaga, Emmanuel. (2017). “American sign language translation using edge detection and cross correlation.” 1-6. 10.1109/ColComCon.2017.8088212. The approach consists of a gesture extraction phase followed by a gesture recognition phase. An image gesture database is collected through the application and used as training information to be used in the gesture recognition stage. We provide two different translation paradigms: 1) English characters (alphabet) and 2) complete words or phrases. In the method to recognize individual characters, the hand gesture image is processed by combining image segmentation and edge detection to extract morphological information and then processed by the gesture detection stage that recognizes the corresponding alphabet letter.

Aditya et al. (2017), Nilima & Patil (2017), and Hafz et al. (2017). Nilima & Patil. “A systematic review on hand gesture recognition techniques, challenges and applications.” The surface electromyography (sEMG) sensors with wearable hand gesture devices were the most acquisition tool used in the work studied, also Artificial Neural Network (ANN) was the most applied classifier, the most popular application was using hand gestures for sign language, the dominant environmental surrounding factor that affected the accuracy was the background color, and finally the problem of overfitting in the datasets was highly experienced.

A hand gesture-based interface for commanding a flexible robot is presented by Stefan Waldherr and Sebastian Thrun. Here, a camera was utilized to track the people and gather information about the robot's movement. However, it enables the robot's tracing capabilities and displays automated output.

Human gesture recognition was presented and shown by Rafiqul Zaman Khan and Noor Adnan as one of the primary problems with the hand gesture recognition framework. to obtain precise and suitable values for hand movement recognition that can communicate with PC programmes and automated robot applications.

3 Methodology

There are various steps involved in this system from detecting hand gestures to control robot.

Hand Gesture Recognition: We are utilizing the Hands model from Mediapipe solutions together with the OpenCV and mediapipe tools in Python to detect the motions. Google's open-source Mediapipe technology is used for processing media. It is platform-friendly or cross-platform, as we might say. Cross-platform refers to being able to run on several platforms, including Android, iOS, and the web. A Python package called OpenCV is created specifically to address computer vision issues. Numerous object-oriented programming languages, including C++, Python, Java, etc., are supported by OpenCV. It works with a variety of operating systems, including Windows, Linux, and MacOS.

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

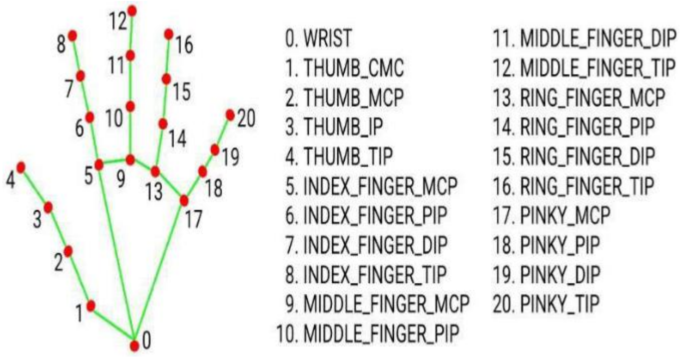


Fig.1. MediaPipe Hands

Establishing Interface Between Python IDE and Aurdino IDE using pyFirmata: The Firmata intermediate protocol, which by default uses a serial port, connects an embedded device to a host computer. Along with the Arduino IDE's support for Firmata, the Arduino platform serves as the industry standard reference implementation 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 When the software is executed , webcam is opened with the help of OpenCV where the user have to give gestures like rock,paper,scissors. Now the during this activity the small motor vehicle is connected with a data cable to the laptop for allowing data transfer or commands from pc to arduino chips. We have coded rock gesture for forward, paper gesture for backwards, scissors gesture for left and yo gesture for right. When these gestures are given and detected by the software it sends the commands to arduino and the motor vehicle moves accordingly to the software.

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.

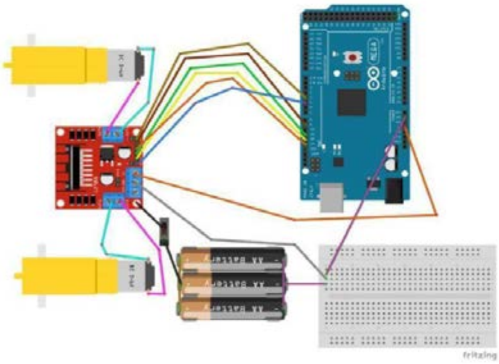


Fig.2. Motor CAR Construction

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 pyfirmata interface so that we can run our python code and use Arduino with it instead of coding in arudino itself. It makes the job as well as task 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.

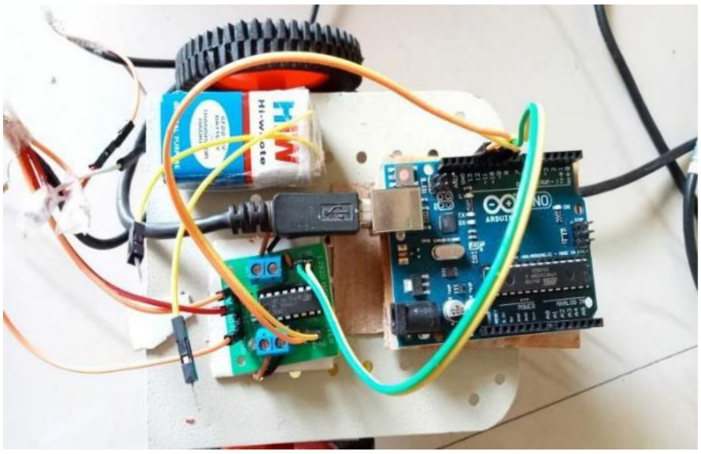


Fig.3. Hardware Model

4 Technology

Through the use of Human Gesture Recognition technology, a web camera can interpret human gestures and transmit the information to a computer for use as input and device control. 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: The computer vision algorithm known as OpenCV (Open-source computer vision) is frequently used for machine learning, image processing, and picture modification. In our project we are recognizing the gesture of human hand.

MediaPipe: The MediaPipe Framework is used to create machine learning pipelines for processing time-series of data, such as video, audio, and other types of data. The

Framework is compatible with numerous operating systems and embedded devices, including desktop, laptop, iOS, Android, Raspberry Pi, and Jetson Nano.

Here for gesture recognition and proved as a palm we used MediaPipe. It uses high-fidelity hand and finger tracking technology and machine learning. Support Vector Machines (SVM) and the Histogram of Oriented Gradient are used in the technique for recognising human gestures (HOG). The CNN model is also used to categorise gestures.

5 Implementation

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 the important concepts from the Python library are extracted, conditions are made based on the gestures that the code reads, data is sent to the Arduino using the PyFirmata library, and the gestures are then used to drive the 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) right tilt, left tilt, forward tilt, backward tilt, and no tilt, respectively, are used to move the robot in a left-to-right direction, forward, backward, and to halt it. Our quantitative evaluation findings demonstrate that our system accurately recognises and controls car movement within a suitable working range and achieves high hand gesture recognition accuracy for a fluid user experience.

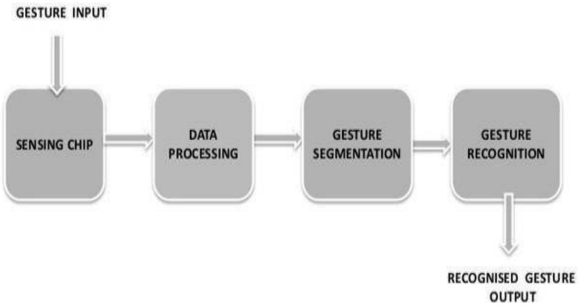


Fig.4. Input output Implementation

These are some gestures we tested on our algorithm

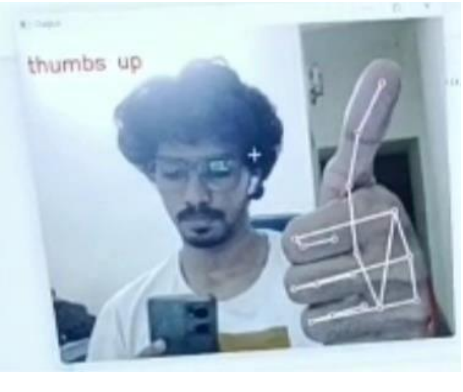


Fig.5. Recognized thumbs up gestures of the hand and verified as the thumbs up signal.

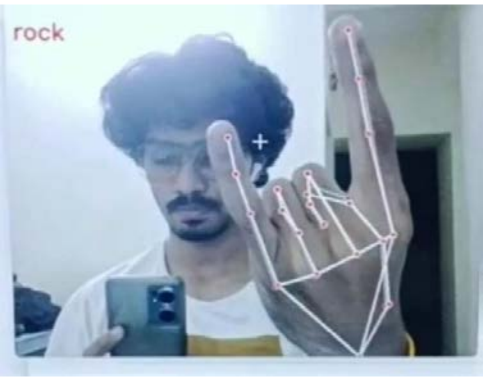


Fig.6. Recognized rock gestures of the hand and verified as the rock signal.

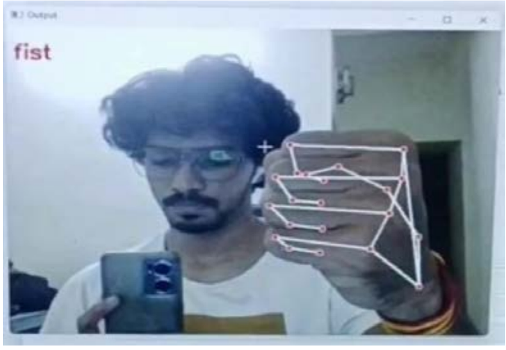
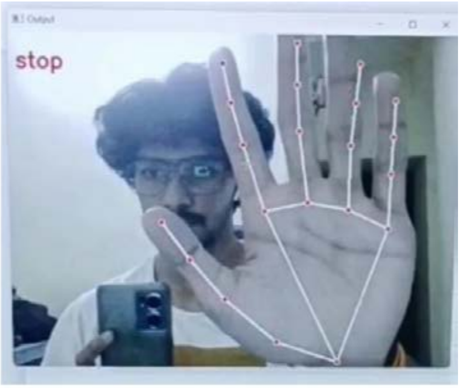
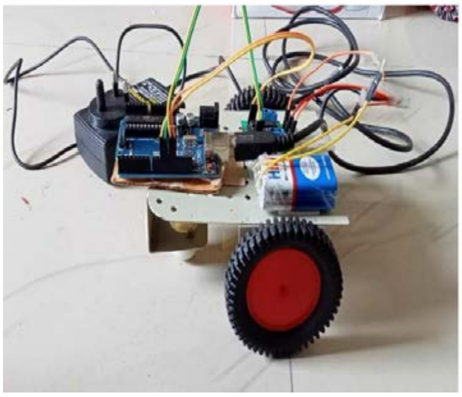


Fig.7. Recognized fist gestures of the hand and verified as the fist signal.





Thus according conditions set in arduino , when the following gestures are given in software corresponding moving commands are given to arduino chip and the motor moves accordingly establishing a connection.

6 Result and Analysis

After giving rock gesture the car moves forward, and after giving all other gestures the motor moves efficiently in set directions. There was no delay between the gesture input and mechanical output. Software worked flawlessly and the detection of hand gestures was accurate.

7 Conclusion

Gesture recognition technology is the tipping point, and more smart devices will become a part of our daily life in the future. It enables us to seamlessly manage non-touchable technological gadgets in order to build a hybrid reality that is highly interactive, fully immersive, and versatile. The technology has several uses in a variety of fields that are further changing human-computer interaction. In this project our propose an Arduino based interaction tool using Machine Learning Python approach to control robot (small vehicle, electronic devices etc.), For the system, we created a pipeline for information flow that 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 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 findings demonstrate that our system accurately recognises and controls car movement within a suitable working range and achieves high hand gesture recognition accuracy for a fluid user experience.

It's actually a completely integrated, extremely sophisticated technology that calls for employees with specific talents and suitable experience in order to guarantee positive outcomes. We successfully established bridge network between a device and a software. This interaction is based on gestures and a virtual panel, and it may be scaled to match future interface needs. We want to increase the tool's ability to communicate with more sophisticated systems, like industrial manipulators, consumer robots, and military systems.

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