RECOGNITION OF HAND GESTURES WITH MACHINE LEARNING

With the usage of an Integrated Webcam, Hands held in front of it are detected and the position of fingers are mapped. This information is used to drive an Arduino Uno to light up LEDs to indicate the position.

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ABSTRACT

The following project serves the purpose of identifying and tracking hands with the help of Python. The basic principle mainly applied here is Machine learning. The webcam which is available inbuilt is integrated with python and is used for this project. Hands which are shown in front of the camera are detected whether right or left.

Finger tracking is another feature available in this project. A particular selected finger is being tracked and realtime information is obtained.

The other feature of the project is the Arduino Uno board used. This is used as an example to establish a physical representation of the functioning of the program being implemented. In this project, simple LEDs are used and lighting up the LEDs based on conditions would be the evidence that the program is working correctly and serving its purpose.

INTRODUCTION

In this project, the goal is to implement Machine Learning to identify hands and track them. This project is currently done in a small scale with a time duration of 15 days. This project can simply be done by an individual with some basic research across the web. Hand tracking have various applications in the real world and can be applied in solving various test cases. The project is versatile and can be implemented in various situations and is configurable.

The concepts used and working of the project are provided below in detail

LITERATURE SURVEY

Pycharm Community

PyCharm is a dedicated Python Integrated Development Environment (IDE) providing a wide range of essential tools for Python developers, tightly integrated to create a convenient environment for productive Python, web, and data science development.

Arduino Uno

The Arduino Uno is a Board which mainly consists of both Microprocessors and Microcontrollers. The design of this is open source and available for replication anywhere, anytime. This makes the Arduino a well-known board. The Uno version is a pretty basic one and mainly consists of a Microprocessor and a Microcontroller and other components assembled on it. There are both digital and analog pins available on the board for input and output. A code is usually written in the Arduino IDE and uploaded to the storage of the board and the microprocessor reads the lines of code and processes it and the microcontroller drives the output pins. The Uno is a very convenient board as it can be used with various modules and perform a variety of functions.

OpenCV:

OpenCV is a library of programming functions mainly aimed at real-time computer vision. The OpenCv library can implement the manipulation of video and images in python. Realtime video can also be captured from a camera attached to a personal computer and various factors like frame rate, window size, color etc. can be manipulated.

Mediapipe

Mediapipe is a library which consists of files that applies machine learning algorithms to track hands, entire bodies, objects and various other structures. This library does consist of hand landmarks built in which help in tracking fingers.

DESIGN AND METHODOLOGY

Hand Identification Module

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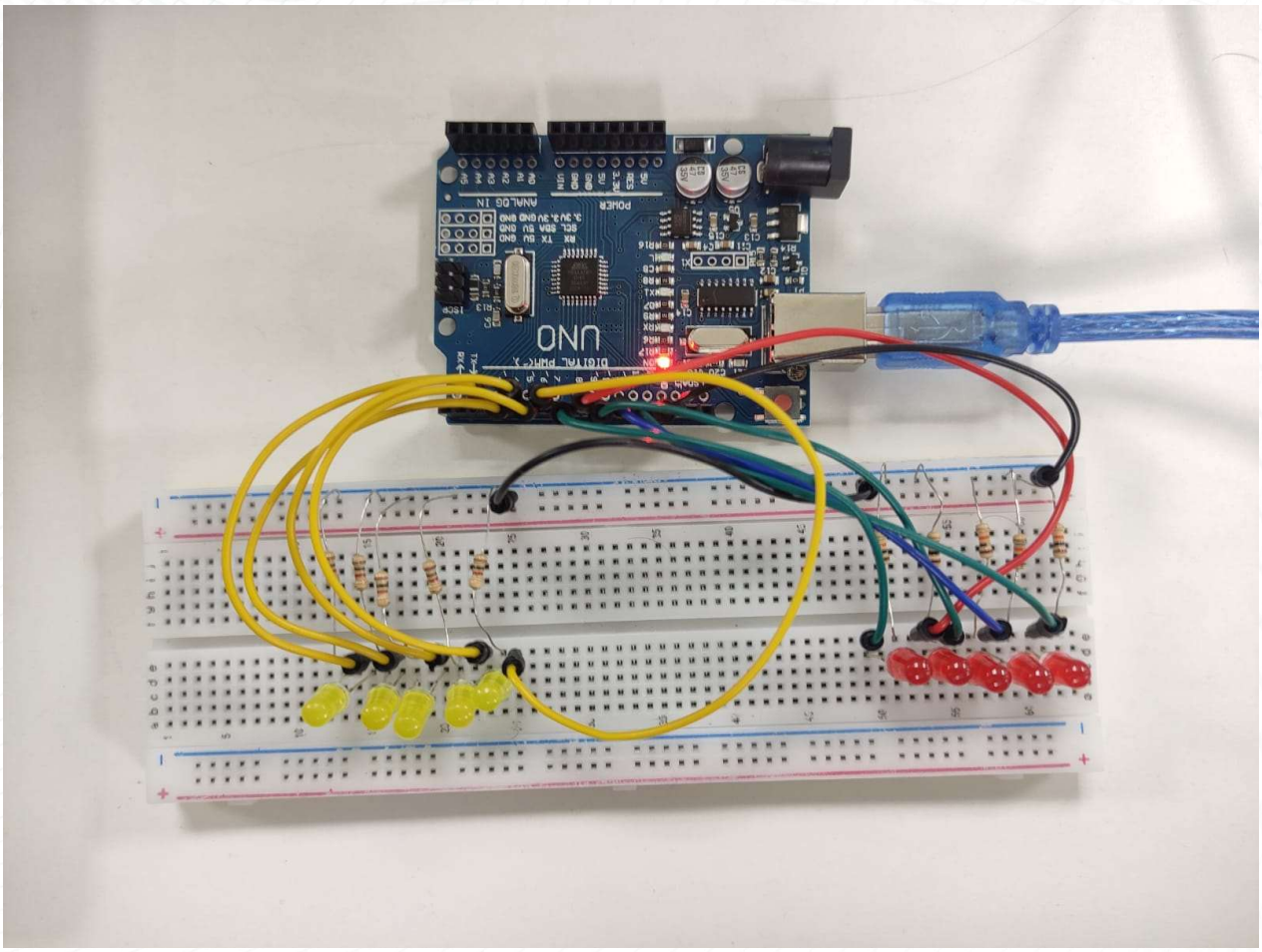
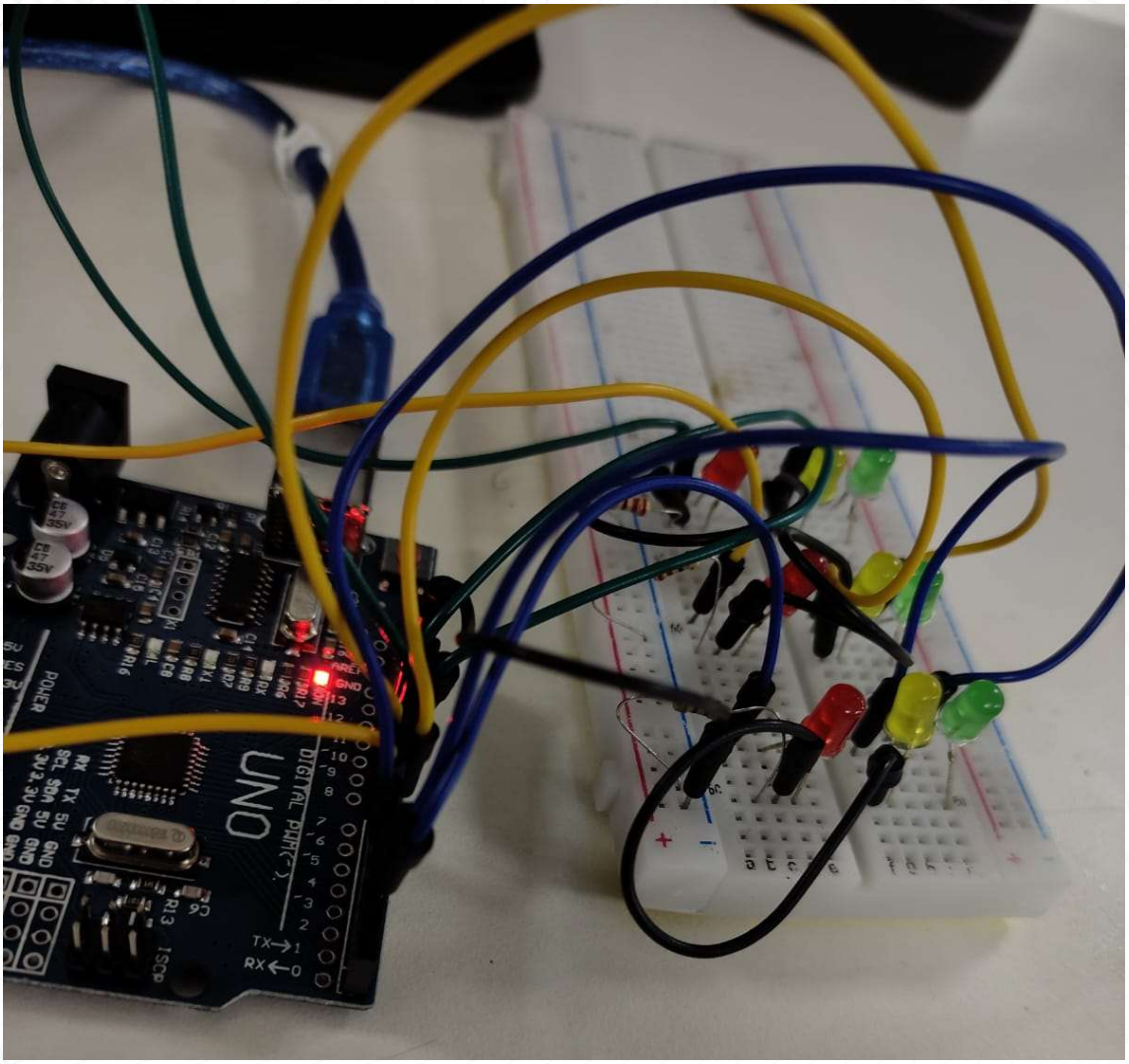


For the identification of left and right hands, the circuit above is implemented. Here there are 2 sets of LEDs , one for the right hand and one for the left. Each LED is connected to one digital pin on the Arduino Uno. In order to safely use the LED, resistors are connected to the Cathode(-ve) between the Arduino GND and LED. The anode(+ve) is connected to the digital pins from 2 to 11.

Here 5 LEDs are used for the left and 5 for the right. The coding is done such that if the left hand is detected, the yellow ones are lit and for the right hand, the red ones. If both hands are detected, all the LEDs are lit. The board is connected to the PC using a serial USB cable for data and power.

DESIGN AND METHODOLOGY

Finger Tracking Module



For tracking fingers, the circuit shown above is constructed. Here the GND and the pins from 2 to 10 are made use of. The LEDs are assembled on the breadboard in the form of a 3x3 matrix. Each pin is separately connected to the Anode of the LED. In order to reduce complexity, one resistor is used for a single column of LEDs. Thus the cathodes of 3 LEDs are connected in series to a single resistor. Here a resistor of low value may be preferred. The grounding is shared on both halves of the breadboard for all the lights.

IMPLEMENTATION OF IDENTIFICATION OF HANDS

PyCharm Community Edition

After the creation of a new project directory, some library files are required for this project and they are: opencv, mediapipe and pyfirmata.
In the program, the libraries are imported and implemented. Cv2 libraries are used to access the webcam and capture a live video. The hand detection module from the cv files are used to identify the left and right hands. According to the hands detected, pyfirmata processes instructions to the board and LEDs are driven accordingly.

Arduino Uno

The pyfirmata program available in the example programs of Arduino IDE are uploaded initially in order to transfer live data between PyCharm and the Uno board.

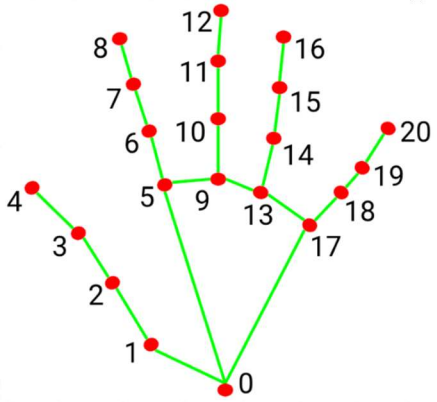
There are various types of firmata available for the Arduino. They are available in the Firmata section in the examples window. For this project, the StandardFirmata would be useful.

After the upload of the program, the python program is run. This brings up a window which begins live capture. The program is written such that the pins are defined in python and the serial port is also defined. When the right hand is shown to the camera, the LEDs on the right side light up and the left section's LEDs light up when the left hand is shown. This works for both hands as well.

IMPLEMENTATION OF FINGER POSITION IDENTIFICATION

PyCharm Community Edition

The same library files used above are made use of in this project too. Here, in rather than identifying the hand as left or right using mapping, the identification of fingers is done using landmarks. These hand landmarks are already inbuilt and available in the mediapipe libraries as shown below. All we need to do is to import them.



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

For this particular program, we are choosing to track the index finger's position in the video, so we mainly power up the LEDs only when the condition finger id=8 matches. The hand detection operation of mediapipe is defined in the program with a hand tracking confidence of 0.8 and setting the maximum number of hands as 1.

In order to track the finger, a 3x3 grid is created using cvtools. The program would work for any structure of grids

such as 5x5, 3x5, 6x7. The definition of the conditions need to be provided accordingly. The conditions are established by obtaining the video resolution in pixels and divided according to the grids and their size. For a video of resolution 640x480 pixels and a 3x3 grid: the x values for the conditions are of ranges 0 to 213, 214 to 427 and 427 to 640.
The Conditional statements are used to identify the grid in which the finger is located in and LEDs arranged in a matrix are driven accordingly.

Arduino Uno

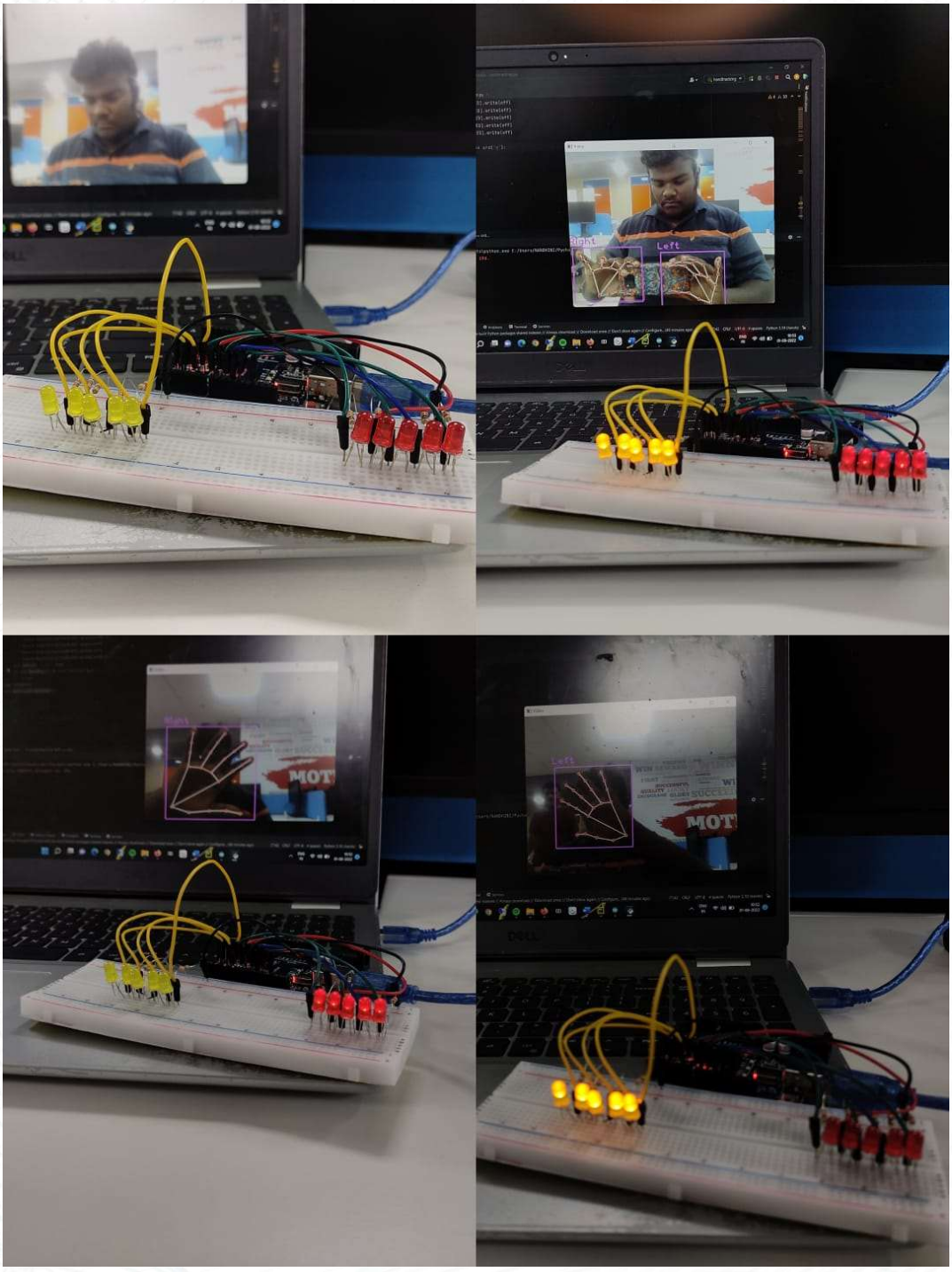
The pyfirmata program available in the example programs of Arduino IDE are uploaded initially in order to transfer live data between PyCharm and the Uno board.

There are various types of firmata available for the Arduino. They are available in the Firmata section in the examples window. For this project, the StandardFirmata would be useful.

After the upload of the program, the python program is run. This brings up a window with a grid which begins live capture. The program is written such that the pins are defined in python and the serial port is also defined. When the index finger is detected in the video, the matching LED glows. For example, if the finger is shown in the top right corner of the video, the LED in the first row and third column lights up. The board is fed with realtime data and its response changes with changes in the finger position.

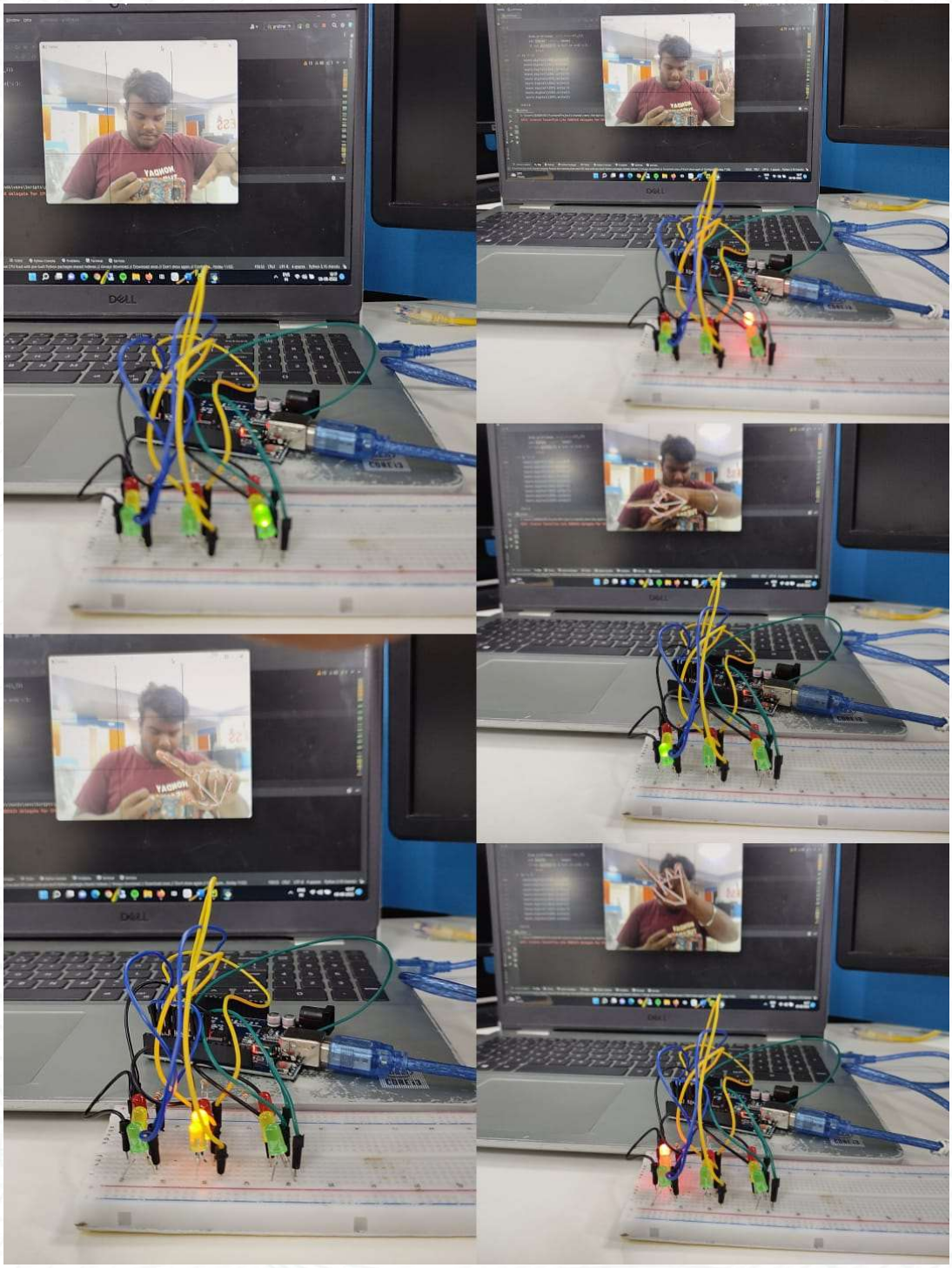
RESULTS:

Hand Detection Module



RESULTS

Finger Tracking Module



ANALYSIS

The hand tracking module works even when the fingers are not shown entirely on the screen. This shows that high accuracy of detecting hands is implemented. Any gesture may be shown up and the result would be the same for the Hand tracking module. This is rather a simple application of machine learning, just to differentiate between the Right and Left hands. A basic robot and its movement towards left or right may be controlled by using this project. The Arduino can be used to control a basic robot and if a wireless module is used, the robot's left and right movement could be controlled from a remote location. With adding conditions and libraries for hand gestures, movement in all directions can be controlled. This robot would be useful in cases where humans cannot be present. For example: Considering a Nuclear power plant where the radiation levels are high, this robot could be implemented for any task and can controlled with hand gestures. This was created as a stepping stone to the finger tracking module which has a higher accuracy and the ability to detect a finger.

The finger tracking module is slightly different than the hand tracking module. Here the programming has been done in such a manner that only a particular finger is detected according to hand landmarks and the landmark is defined while coding. The accuracy is improved such that if any other fingers are detected in other grids, they won't cause any disruption in the functioning. For this project, only the index finger's tip with the landmark number: 8 is used. This can be defined suited to our needs. Wherever the index finger points, that grid is considered and the LED is driven accordingly. But the applications need not be limited just to drive LEDs. A Real life example would be the transformation of Traffic Signal Operation. For a junction where vehicles approach from 4 sides, a 3x4 grid may be designed and controlled using the video captured. The cop could simply point to a grid which controls the Red and Green lights with a particular combination such that one set of vehicles face Green and the other 3 face Red. This would be a low budget advancement for the switching system available currently for traffic control. This would prove to be useful because the current system may lead to failure if the switch or wiring is faulty.

CONCLUSION:

Thus, an efficient project for tracking hands and fingers has been implemented with a Machine Learning Algorithm. The usage of Python and Arduino have proved to be very efficient and user friendly. The usage of Arduino was a factor which helped in identifying errors and correcting them sooner. Spotting out errors may have been much more difficult without the Arduino. The project was created within 15 days and by someone who is a beginner in python and entirely new to Arduino. The experience gained in this project is far beyond expectations and a good amount of knowledge of both python and Arduino is a good takeaway.

Trial and Error is a part of every attempt towards greatness and it provided to be very useful in the construction of this project. The learning process for this project was very much interesting and interactive. Through the days, various modules were being explored upon and self learnt. The power of Self Learning was realizable through this experience and how interesting and powerful programming can be. This project is just a starting step and advancements shall be made to it such that this could be implemented in greater applications.

REFERENCES:

Youtube Videos:

https://www.youtube.com/watch?v=3xfOa4yeOb0&list=LL&index=3

https://www.youtube.com/watch?v=aSxw3k8EZGw&list=LL&index=4

https://www.youtube.com/watch?v=fwMjVZhM08s&list=LL&index=7

https://www.youtube.com/watch?v=-ZrDjwXZGxI

https://www.youtube.com/watch?v=NZde8Xt78Iw

https://www.youtube.com/watch?v=8gPONnGIPgw

Github Repositories:

https://github.com/Muhazin/Share-Project

https://github.com/Chando0185/led_controller_python_arduino

https://github.com/wayoda/LedControl

Others:

https://www.computervision.zone/courses/ai-virtual-mouse/

https://www.computervision.zone/courses/hand-tracking/

https://www.computervision.zone/courses/finger-counter/