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A REPORT on

Coordinate Detection and Visual Inspection using Raspberry Pi

By

Dhruv Pathak, E008

PBO Plus Pvt Ltd

PROCESS CONSULTING | INTERFACES & AI | AUTOMATION |

A REPORT ON

Coordinate Detection and Visual Inspection using Raspberry Pi

By

Dhruv Pathak

B. Tech Computer Engineering

3rd Year

SAP ID: 70021018074

Roll No: E008

in partial fulfilment of the requirements of 4 years B. Tech Program

At Mukesh Patel School of Technology Management & Engineering, NMIMS

Distribution List:
Prof. Mohini Reddy (*College Mentor***)**
Prof. Deepa Pai (*Department Assistant***)**

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This is to certify that the project entitled “Coordinate Detection and Visual Inspection using Raspberry Pi” is the bona-fide work carried out by Dhruv Pathak of B. Tech (Computer Engineering), MPSTME (NMIMS), Mumbai, during the VI semester of the academic year 2020-2021, in partial fulfillment of the requirements for the award of the Degree of Bachelors of Engineering as per the norms prescribed by NMIMS. Theproject work has been assessed and found to be satisfactory.

Mohini Reddy

Internal Mentor

Examiner 1

Examiner 2

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TECHNICAL INTERNSHIP REPORT Semester VI – B TECH

Submitted in Partial Fulfillment of the requirements for Technical Project/Training for VI Semester B. Tech.

Name of the Student: Dhruv Pathak

Roll No.: E008 & Batch: B. Tech CS

Academic Year: 2020-2021

Name of the Discipline: B. Tech CS

Name and Address of the Company: PBO Plus Pvt Ltd,

Plot No 64, Basement, Okhla Phase III, Okhla Industrial Estate, New Delhi, Delhi 110020

Training Period: From 3rd May 2021 To 9th July 2021

THIS IS TO CERTIFY THAT

Mr. Dhruv Pathak

Exam Seat No. *70021018074* has, Satisfactorily Completed his Training/Project Work, submitted the training report and appeared for the Presentation & Viva as required.

External Examiner **Internal Examiner** **Head of Dept.** **Chairperson/Dean**

Date:

Place:

Seal of the University

Completion Certificate

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Completion Certificate

This is certify that Kum. DHRUV PATHAK, Roll No. E008 has completed the training and project as a part of Technical Internship Programme in our company as mentioned below and the report is also submitted.

i. Project Title: Coordinate System and Raspberry Pi Projects
ii. Date of joining: 3rd May, 2021
iii. Date of Completion: 9th July, 2021

In partial fulfilment of VI Semester Technical Internship Programme for B.Tech program of Mukesh Patel School of Technology Management and Engineering, Narsee Monjee Institute of Management Studies (NMIMS | Deemed-to-be University), Mumbai.

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Place: New Delhi

Acknowledgements

The technical internship at PBO Plus Pvt Ltd has been a professionally satisfying experience. The opportunity helped me to greatly expand my knowledge base and gain insights about working in the robotics domain. It enabled me to interact with individuals displaying profound intellect and professionalism.

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I would like to acknowledge the backing and guidance of all the Professors and staff of NMIMS' MPSTME for enabling students to go through a comprehensive industrial training to get a first-hand experience of working in the industry. I would also like to thank my Faculty Supervisor, Ms. Mohini Reddy for his continuous support and eagerness to help me throughout the duration of the internship.

I would like to express my gratitude to my colleagues for their guidance during the entire period of the training that helped make this internship a memorable experience.

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Abstract

In today's society, technology is advancing at a breakneck speed. Today, everything is getting mechanized. The trajectory of our daily lives has been altered by smart robots and sensors. The goal of automation and visual inception in a Raspberry Pi using Python, is to manage and command small scaled sensors and components, as well as to assist them in making decisions on their own based on learning data and currently accessible data.

These commands can help automate different areas of work for better yield and ease of work. The fundamental challenge of all robotics is this that it is impossible to ever know the true state of the environment. Robot control software can only guess the state of the real world based on measurements returned by its sensors. It can only attempt to change the state of the real world through the generation of control signals.

During the TIP, the intent is to provide the company with a basic working models on a Raspberry Pi and multiple visual detection code using OpenCV library. These modules can be integrated and used for various processes such as manufacturing or production factories etc. These small scale modules will be help in understanding the hurdles that might be caused during a larger scale implementation and help the company tackle these problems more efficiently.

Introduction

❖ PURPOSE

The purpose and goals of creating Raspberry Pi modules and Vision Detection Programs is:

1. **Control Lights:**
   Basic LED module connected to a Raspberry Pi can easily control the status (ON / OFF) of the LED, its behaviors (BLINKING) and its illumination (BRIGHTNESS) from simple code. These help in Smart IoT Lights implementation.

2. **Security:**
   With the help on a camera and a motion sensor connected to a Raspberry Pi, it is possible to capture images when motion is detected. These systems act as security systems to help prevent from theft and burglary.

3. **Face Detection:**
   OpenCV library in Python is widely used for vision inception and face detection can be used for video surveillance, facial recognition, biometrics etc. It can also be advanced by using different machine learning techniques to not just detect a face on the screen but also be able to recognize who it is by learning for sample test data.

4. **Real Time Object Detection**:
   To be able to detect multiple objects on screen helps in traffic, autonomous cars, factories, etc. It can also be improved by detection what object is being captured in the camera. For example a car, a person etc.

5. **Web Server, Cloud Storage, VPN etc**
   A Raspberry Pi is a multi-purposed computer and with the help of different Python libraries it can be used as a web server to host websites locally or on the internet. It can also be used as a cloud storage to backup data and it also has the capability to act as a virtual private network (VPN). It can also be used as a NAS, a bot for Twitter, digital photo frames etc.

❖ SCOPE

The scope of this project is creating small scaled projects that help in the understanding of how Robotics works and how every component has a different set of rules, advantages and disadvantages. It is aimed to help beginners in the field understand that robotic modules are built with multiple sensors and cameras and it is highly complex for all of their sensors to work in co-ordination with one another. Taking inputs in different formats and give outputs in different formats that is accessible and understandable to other sensors and the programmers is required.

❖ TECHNOLOGIES USED

1. Python

Python is an interpreted, high-level, general-purpose programming language. Python's design philosophy emphasizes code readability with its notable use of significant whitespace. Its language constructs and object-oriented approach aims to help programmers write clear, logical code for small and large-scale projects.

Python is dynamically typed and garbage-collected. It supports multiple programming paradigms, including procedural, object-oriented, and functional programming. Python is often described as a "batteries included" language due to its comprehensive standard library.

- Use of Python in the project: Implementation of all modules and control of General Purposed Input Output Pins (GPIO Pins) is done using Python programming language

2. OpenCV

OpenCV (Open Source Computer Vision Library) is an open source computer vision and machine learning software library. OpenCV was built to provide a common infrastructure for computer vision applications and to accelerate the use of machine perception in the commercial products. Being a BSD-licensed product, OpenCV makes it easy for businesses to utilize and modify the code.

The library has more than 2500 optimized algorithms, which includes a comprehensive set of both classic and state-of-the-art computer vision and machine learning algorithms. These algorithms can be used to detect and recognize faces, identify objects, classify human actions in videos, track camera movements, track moving objects, extract 3D models of objects, produce 3D point clouds from stereo cameras, stitch images together

to produce a high resolution image of an entire scene, find similar images from an image database, remove red eyes from images taken using flash, follow eye movements, recognize scenery and establish markers to overlay it with augmented reality, etc.

- Use of OpenCV in the project: This Python library is used in multiple modules like face detection, object detection etc.

3. Raspberry Pi

The Raspberry Pi is a series of small single-board computers developed in the United Kingdom by the Raspberry Pi Foundation in association with Broadcom. The Raspberry Pi project originally leaned towards the promotion of teaching basic computer science in schools and in developing countries. The original model became more popular than anticipated, selling outside its target market for uses such as robotics. It is widely used in many areas, such as for weather monitoring, security cameras etc. because of its low cost, modularity, and open design.

It is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python.

- Use of Raspberry Pi in the project: It is the heart of the project as all circuits and modules made are connected and coded on the Raspberry Pi.
- Model Used: Raspberry Pi 3 B+

4.HTML

The Hyper Text Markup Language, or HTML is the standard markup language for documents that are to be designed for being displayed in a web browser. It is assisted by technologies such as Cascading Style Sheets and scripting languages such as JavaScript.

- Use of HTML in the project: HTML is create a simple webpage for Smart Lights IoT implementation.

5. CSS

Cascading Style Sheets is a style sheet language used for describing the presentation of a document written in a markup language such as HTML. CSS is an integral part of the World Wide Web, alongside HTML and JavaScript.

- ❖ Use of CSS in the project: CSS is used in designing the webpage created.

6. Tkinter

Tkinter is a Python binding to the Tk GUI toolkit. It is the standard Python interface to

the Tk GUI toolkit, and is Python's de facto standard GUI. Tkinter is included with standard Linux, Microsoft Windows and Mac OS X installs of Python. The name Tkinter comes from Tk interface

- Use of GUI interface to control LEDs.

❖ Application Specification/Requirements:

❖ Functional Requirements:

- ❖ LED Control System: LED lights can be controls and the frequency of blinking and brightness is also easy to control. This programmed code is used in Smart Lights systems to implement IoT.
- ❖ Face Detection: The camera module connected to the Raspberry Pi captures an image and processes it to give an output. It also prompts the no. of faces it detected.
- ❖ Security Camera System(Motion Detection): An movement within the motion sensors range triggers the camera to capture an image of the person that activated the motion sensor.
- ❖ 3D Coordinate System: When the Raspberry Pi and the connected gyroscope senses any movement, the sensor is programmed to output the angular velocity (degree per second) that is the coordinates or the module.

❖ Non-Functional Requirements:

1. **Performance and Scalability**:

Performance defines how fast a software system or its particular piece responds to certain users' actions under certain workload. In most cases, this metric explains how much a user must wait before the target operation happens (the results, motion sensor is activated, etc.) given the sensitivity of the components (camera, gyroscope etc.) used. Scalability assesses the highest workloads under which the system will still meet the performance requirements.

2. **Portability and Compatibility**:

Portability defines how a system or its element can be launched on one environment or another. It usually includes hardware, software, or other usage platform specification. Portability also has an additional aspect called compatibility. Compatibility defines how a system can co-exist with another system in the same environment.

3. Supported Operating Systems:

Raspberry Pi supports:

1. Raspberry Pi OS
2. Raspberry Pi OS Lite
3. NOOBS
4. Ubuntu
5. Manjaro ARM Linux
6. RISC OS Pi etc.

4. Hardware:

1. Camera (5MP)
2. Motion Sensor
3. Gyroscope
4. Breadboard
5. Jumper Wires (Male to Female, Male to Male and Female to Female)
6. Resistors (1K Ohm, 300 Ohm etc.)
7. LED (Red, Green, White etc.)
8. Multi-meter
9. Display Screen
10. HDMI Cord
11. Micro USB
12. Keyboard
13. Mouse
14. Raspberry Pi

5. Compatibility Requirements:

PC: Windows® operating system, versions 10 Build 10240 or higher

MAC®: Mac OS X® 10.5 or higher

Python Version: 3.9

Pip Version: 21.1.2

6. Security:

This non-functional requirement assures that all data inside the system or its part will be protected against malware attacks or unauthorized access.

7. **Reliability**:

This quality attribute specifies how likely the system or its element would run without a failure for a given period of time under predefined conditions.

8. **Usability**:

Usability is yet another classical nonfunctional requirement that addresses a simple question: How hard is it to use the product?
Raspberry Pi is the gateway towards Robotics and AI and therefore is easy to use and beginner friendly.

❖ Python Modules Used:

Module	Version
cv2	4.5.3
picamera	1.13
numpy	1.16.2
io	3.3
gpiozero	1.6.2
time	0.3.0
smbus	1.1
GPIO	0.7.0
flask	2.0.1
Tkinter	3.9.6

❖ PROJECT METHODOLOGY

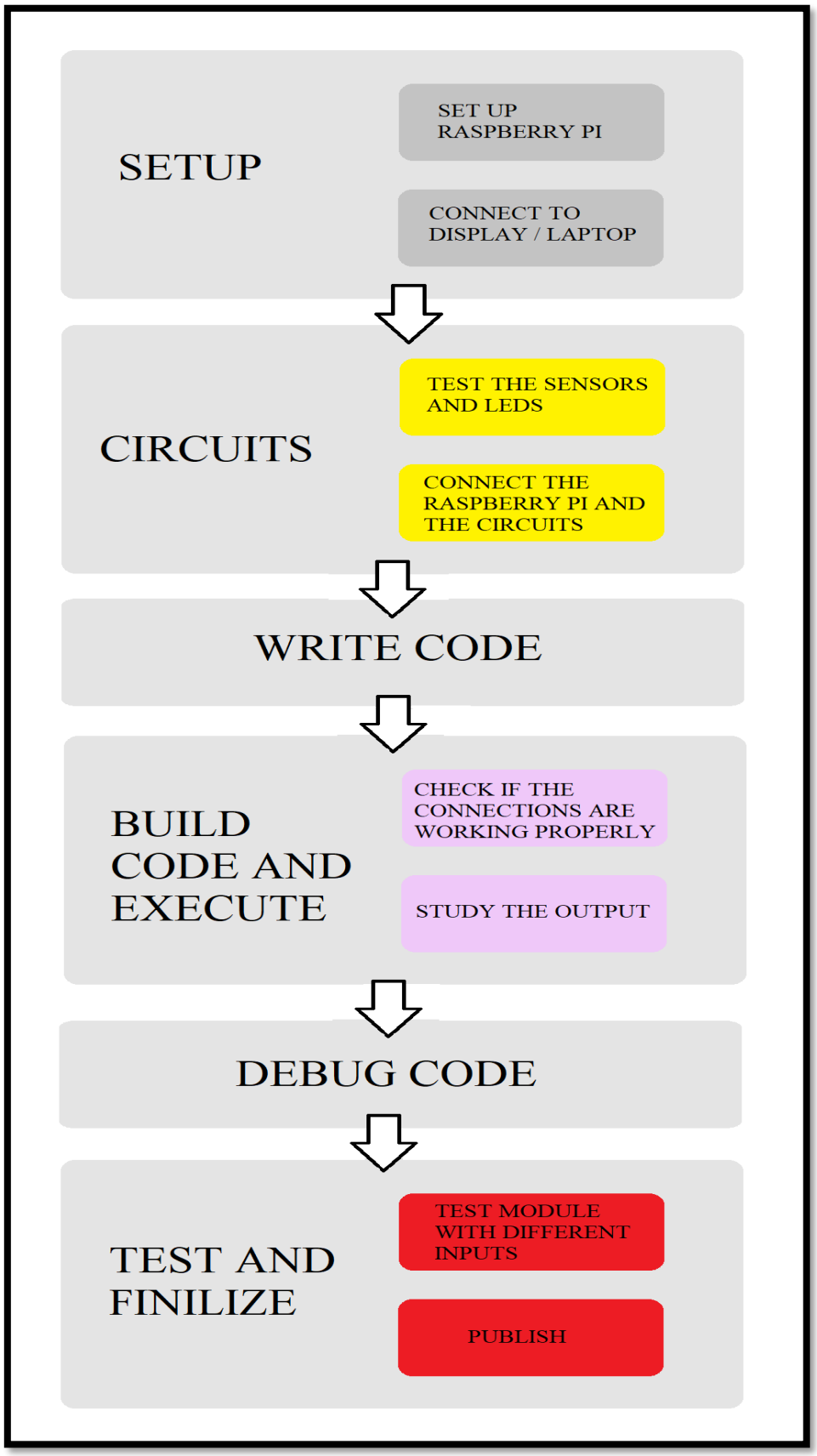

FIGURE 1

❖ UNDERSTANDING A RASPBERRY PI

Raspberry Pi is a small computing device that aims to put the power of computing and digital making into the hands of people all over the world. The Raspberry Pi Model 3 B+ can be seen below with all its components.

MODEL USED: RASPBERRY PI 3 B+

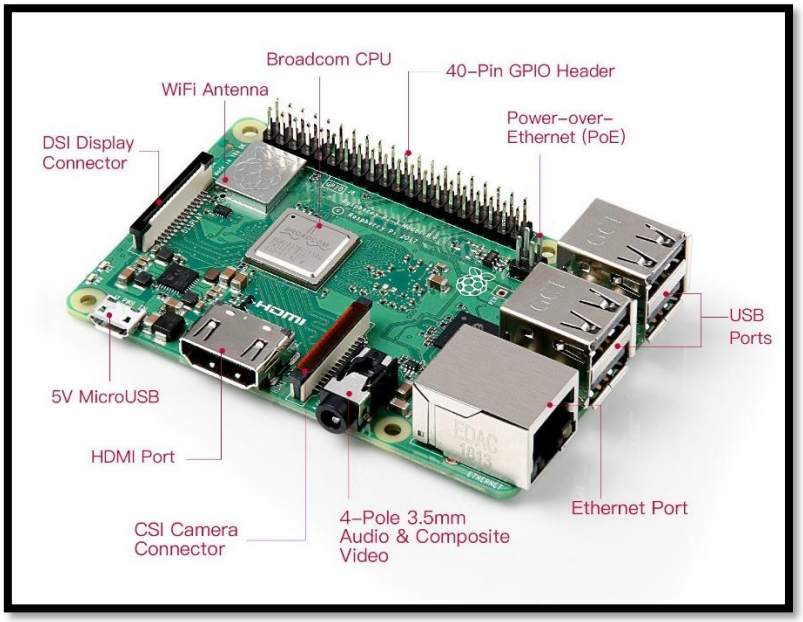

FIGURE 2

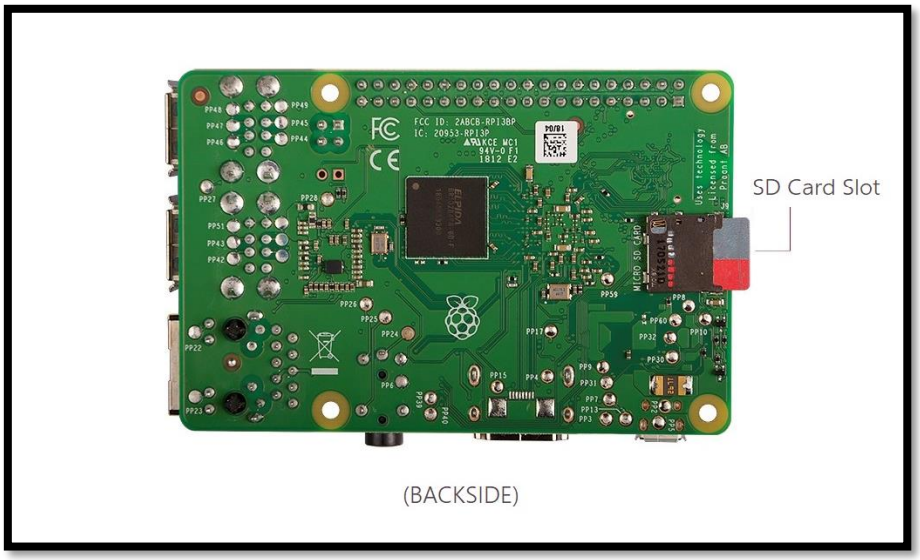

FIGURE 3

- **Components**

1. DSI Connector:
   The Raspberry Pi can connect to a serial display similar to those seen in tablets via the DSI display connector. These touch-screen display modules come in a variety of sizes, including 7 inches.

2. CSI Camera Connector:
   The CSI camera port is a connection that connects a Raspberry Pi camera module to the Raspberry Pi. Generic web cams will not work because they typically only have a USB port.

3. MicroSD Card Slot:
   Power may be supplied to the Raspberry Pi through a micro USB cable connected to the micro USB connection (preferred) or by simply feeding 5V into the 5V GPIO port.

4. Ports (HDMI / USB / Network):
   These ports link the Pi to an HDMI display, USB peripherals like mice and keyboards, and an ethernet connection for internet access. However, because the Raspberry Pi 3 has built-in Wi-Fi, it is possible to connect wirelessly.

5. GPIO Pins:
   The Raspberry Pi's most significant feature are the 40 General Purpose Input Output Pins that is GPIO pins. These pins can be used to read electrical signals from circuits and give electrical signals for controlling circuits in programs. The Raspberry Pi's GPIO pins link to electronic circuits and allow it to control and monitor the outside world. The Raspberry Pi can control LEDs, switch them on and off, and operate motors, among other things. It can also tell if a switch has been pressed, the temperature, and the amount of light. This is referred to as physical computing.

   The GPIO Pins have 2 standard method of numbering. First method is to number the pins from 1 to 40 starting from the top-left pin. This numbering is called the GPIO Board. The second method is called GPIO BCM (Broadcom SOC Channel), signified by the Broadcom SOC. Both these numberings can be seen in figures given below. Figure 6 and 7 shows the powered Raspberry Pi and 3.3V and 5V power generated at Pin 17 and Pin 2 respectively.

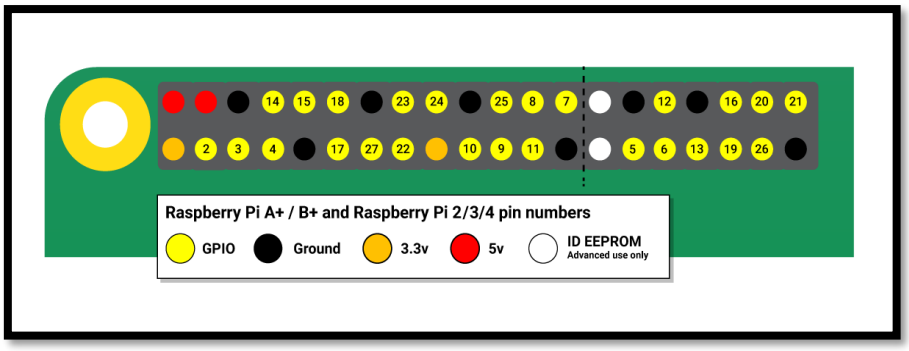

FIGURE 4

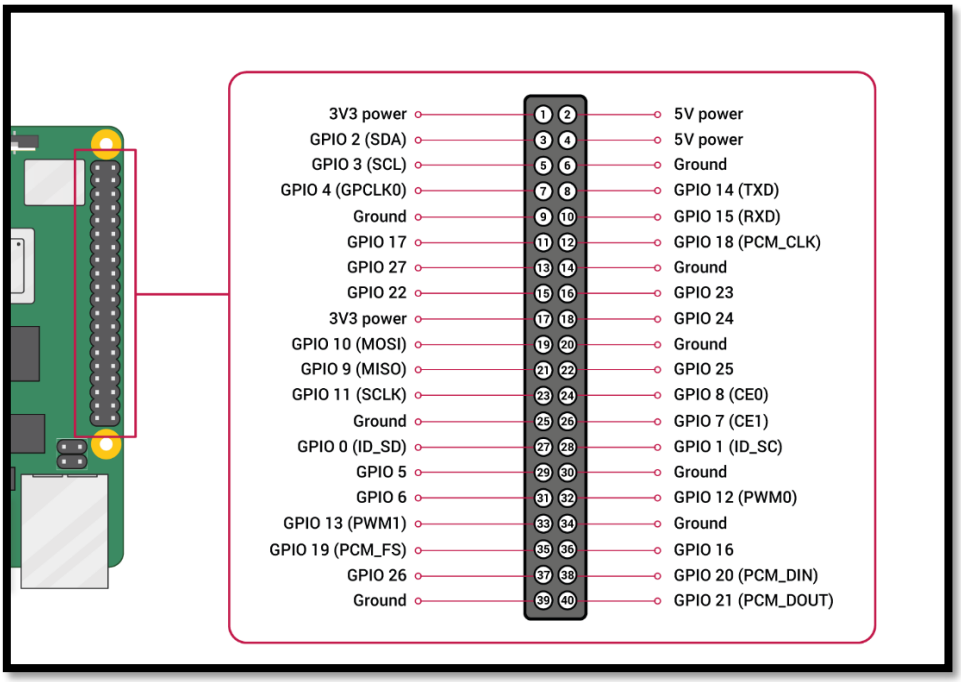

FIGURE 5

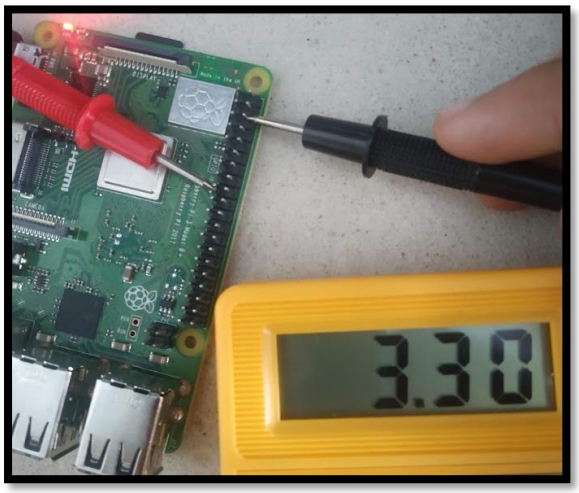

FIGURE 6

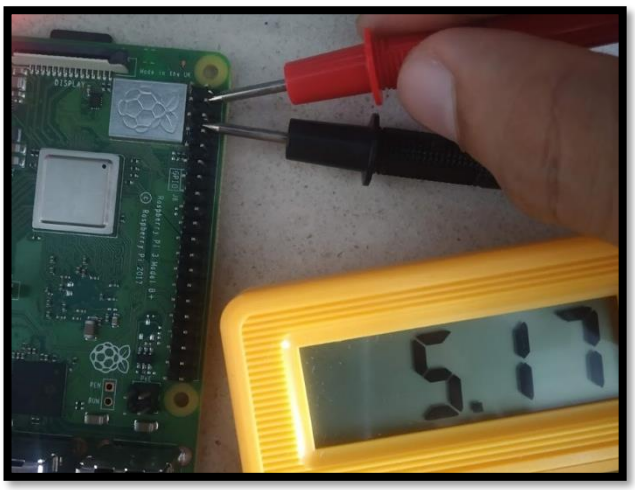

FIGURE 7

❖ SETTING UP RASPBERRY PI

- **Initial Setup:**
  To setup the Raspberry Pi for the first time ever, a few hardware requirements need to be met. The required hardware are:
  a. TV (Display Monitor)
  b. Mouse
  c. Keyboard
  d. SD Card (Minimum 4GB)
  e. Power Cord (MicroUSB Type B)
  f. HDMI Cable

  STEP 1: Use and SD Card and install an operating system on the SD Card. We will be working with the installtion on Raspberry Pi OS. The Raspberry Pi OS can be found on the offical RaspberryPi.org website. These OS files are written into the SD Card and then connected to the Raspberry Pi.

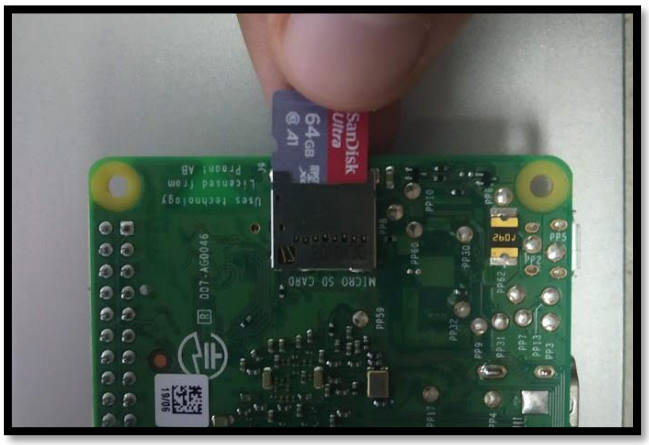

FIGURE 8

STEP 2: Connect the power cable to the Raspberry Pi and connect the HDMI cable to the TV. Also connect the mouse and keyboard to the USB ports. The connection can be seen in Figure 9.
STEP 3: Power is supplied to the Raspberry Pi and the OS boots up from the SD Card on the screen through the HDMI connection. Figure 10 shows the booting process on Raspberry Pi OS.

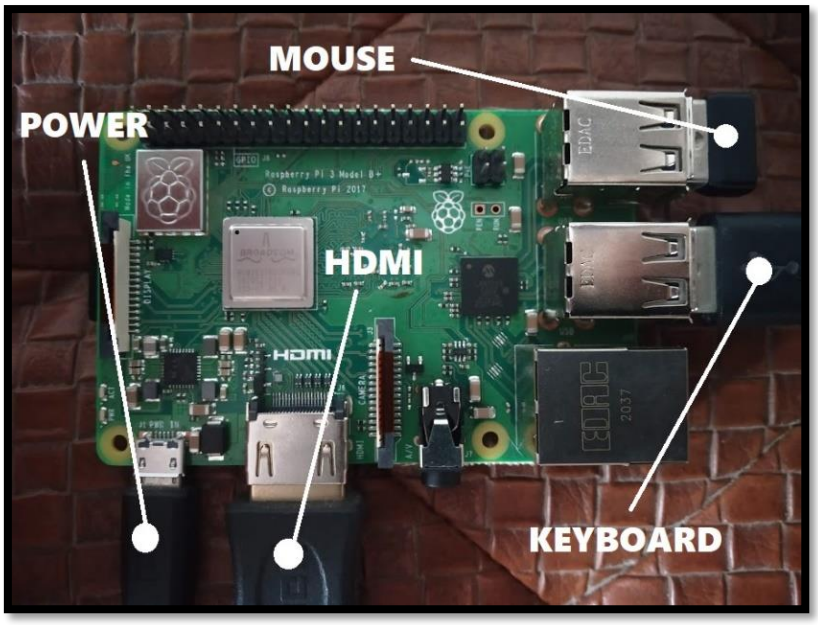

FIGURE 9

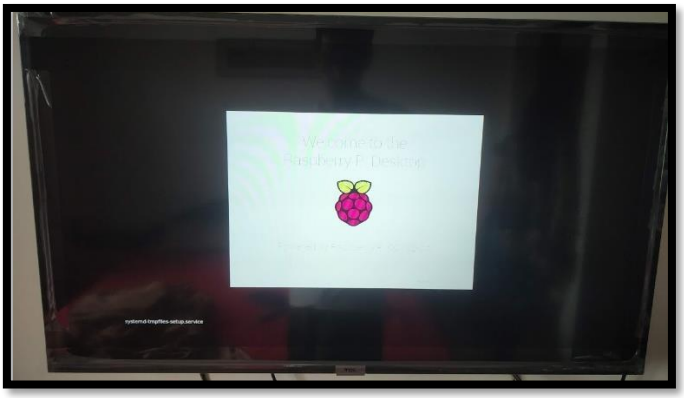

FIGURE 10

FIGURE 11

- **For Remotely Accessing Raspberry Pi on the Laptop**
  To remotely access the Raspberry Pi, one still requires to connect to a display monitor or TV once as shown above.

  STEP 1: Finding the IP Address of the Raspberry Pi. To do this, the command *ifconfig* is executed on the Terminal (To Open Terminal => Ctrl + Alt + T).

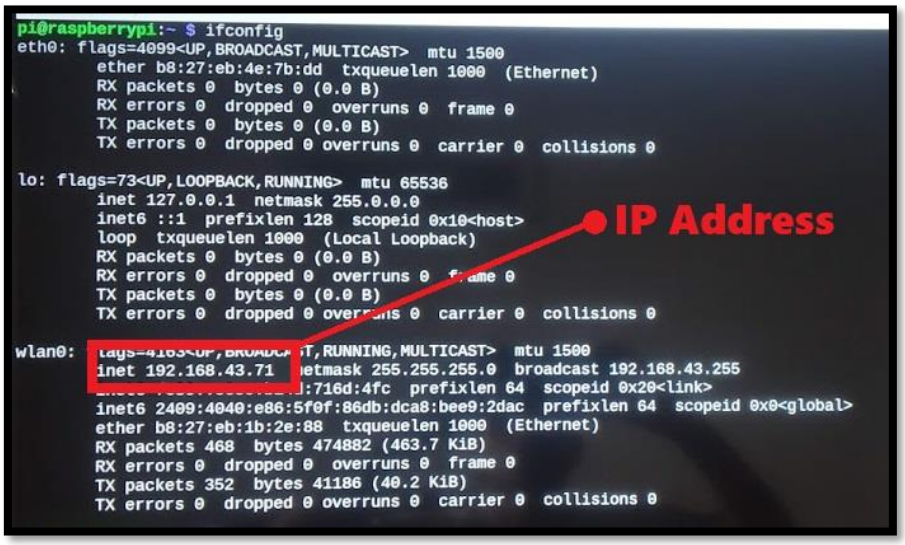

FIGURE 12

STEP 2: Execute the following command to open configuration settings :
sudo raspi-config.
STEP 3: Select Interface Options => SSH => Yes (Enable SSH) => OK.
STEP 4: Connect to the same WiFi as the Laptop for remote access. This can be done by clicking on the WiFi symbol in the top-right corner and connecting to the suitable network.

<u>For accessing the Terminal remotely :</u>
STEP 5:
MacOS - Open the terminal and execute *ssh username@ipaddress*
E.g.: ssh pi@192.168.43.71
Windows: Install Putty Software, enter the IP Address to connect.

<u>For a GUI Desktop Remote Access :</u>
STEP 6: Installation of xrdp. To fulfil this requirement the following command is run on the terminal : *sudo apt-get install xrdp*
STEP 7: Open Remote Desktop Connection, an in-built application and enter the IP Address of your Raspberry Pi and connect.
STEP 8: Enter the username (default: pi) and password (default: raspberry) to successfully access the Raspberry Pi over WiFi.

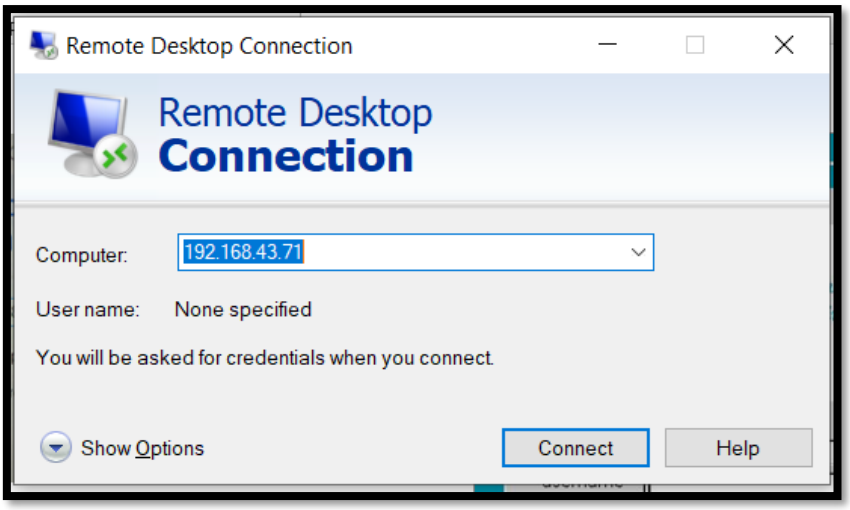

FIGURE 13

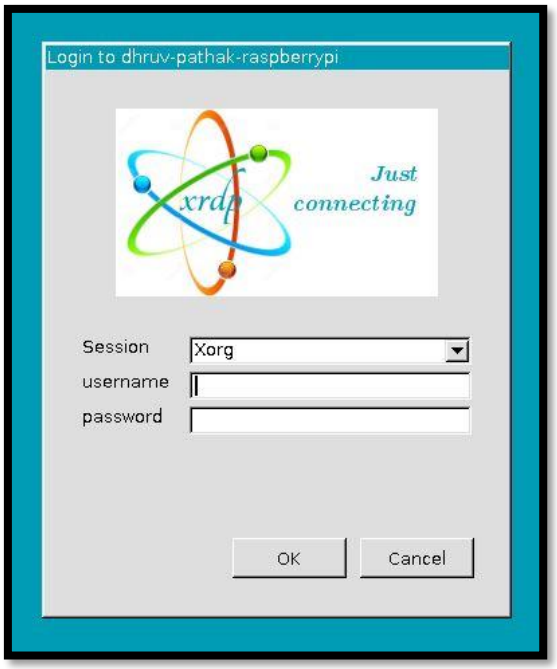

FIGURE 14

❖ Project 1 (LED Controls through GUI)

The aim of this project is to connect the LEDs in a circuit and program a connected GUI using Tkinter library in Python is such a way that the LEDs perform certain tasks based on the different buttons. The circuit consists of 2 LEDs (red and green) that can be switch on or off from buttons on the GUI. These LEDs can also be made to blink and fade in and out. For this mini project the materials required are breadboard, LEDs, jumper cables and the Raspberry Pi. The circuit connection is as shown below:

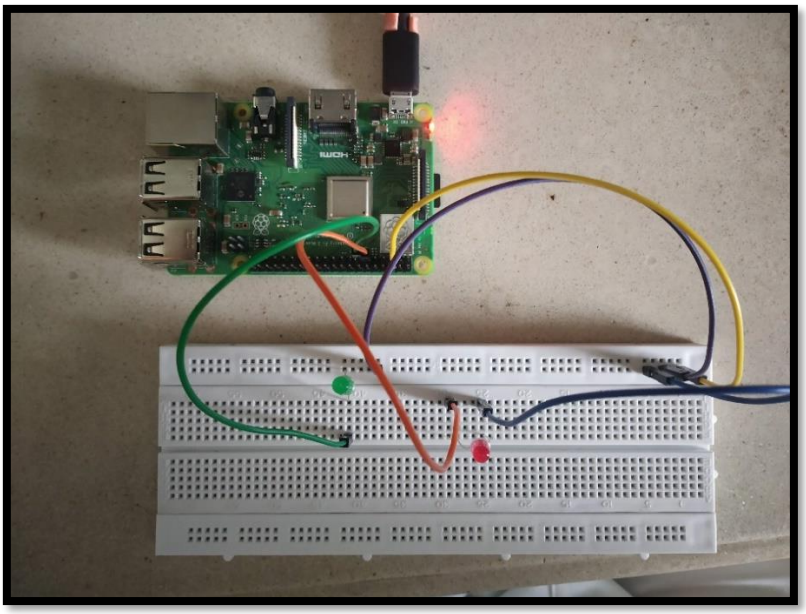

FIGURE 15

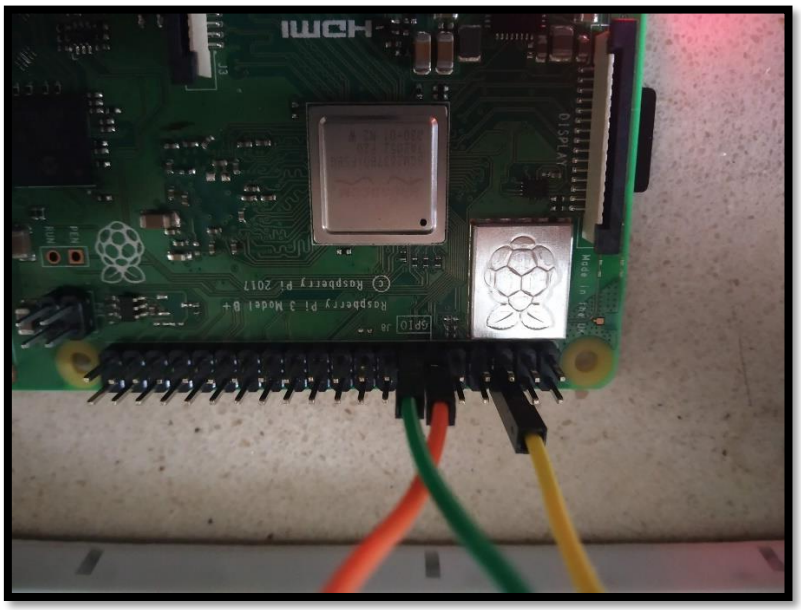

FIGURE 16

It can be observed from the circuit that GPIO PIN 17 and 27 (Board Pin 11 and 13) have been used an Output Pins and are connected to a red and green led respectively. Both these LEDs are then connected to a Ground Pin (Board Pin 6). Each pin is controlled by Python code with a user interface to the user. The GUI and output of the circuits is shown below.

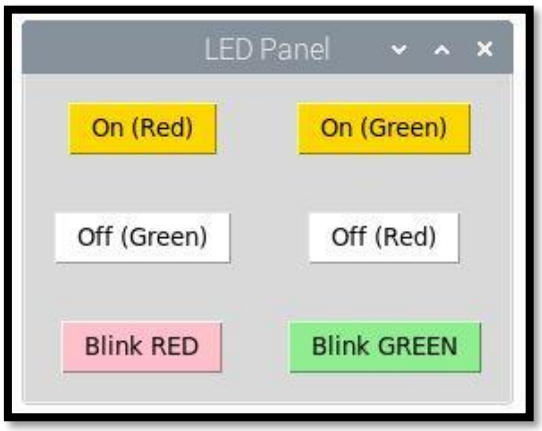

FIGURE 17

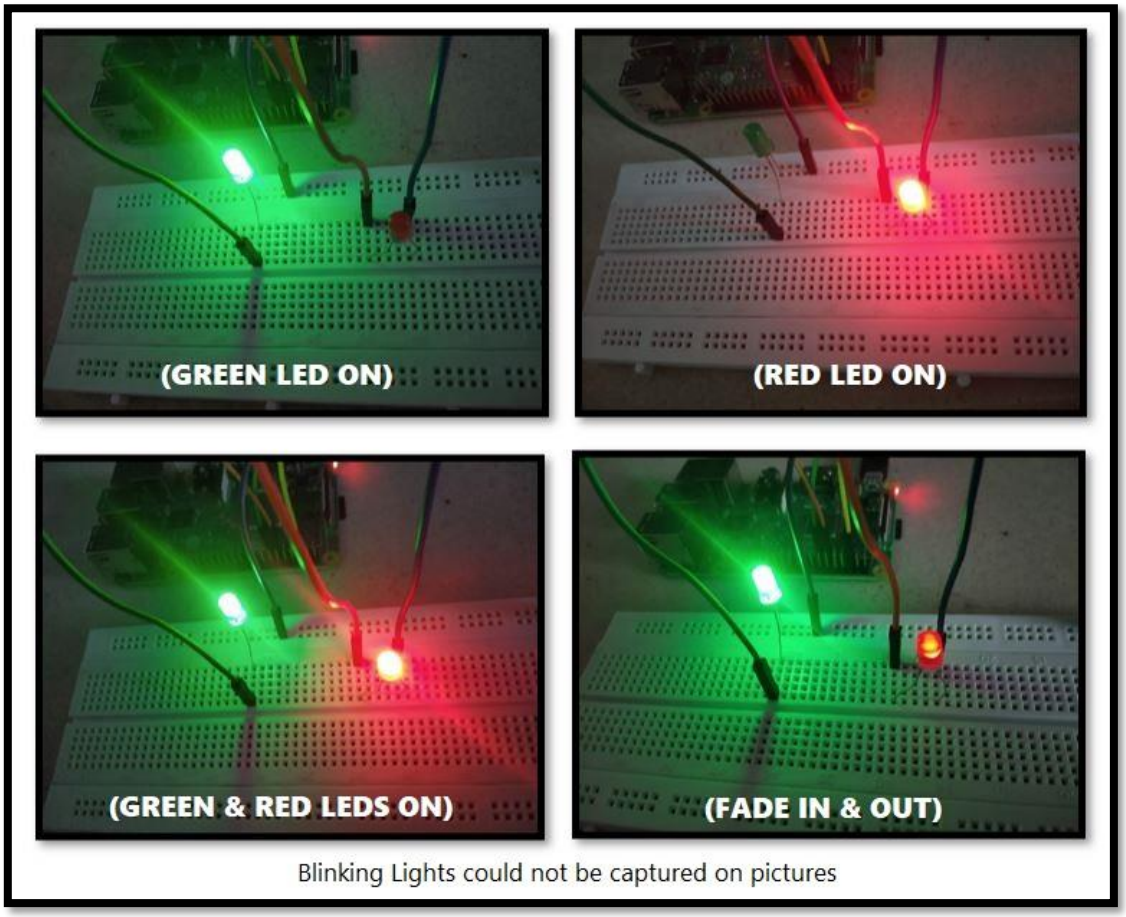

FIGURE 18

[Fade In and Out is not present in the GUI and was coded separately]

❖ Project 2 (Face Detection)

The Raspberry Pi Camera Board is a custom-designed Raspberry Pi add-on module. In still capture mode, the sensor has a native resolution of 5 megapixels. It can take video at resolutions up to 1080p at 30 frames per second in video mode. A ribbon wire connects the camera board to the Raspberry Pi. One end of the ribbon cable goes to the camera PCB and the other end attached to Raspberry Pi hardware itself. The ribbon cable connections must be made correctly or the camera will not operate. The blue backing of the wire should be facing away from the PCB on the camera PCB, and it should be towards the Ethernet connector on the Raspberry Pi hardware.

The aim of this project is to connect the camera module to capture pictures and detect the no. of faces. The execution is done using Haar Cascade methodology. Paul Viola and Michael Jones presented the Haar Cascade classifier as an effective object identification technique in their article “Rapid Object Detection with a Boosted Cascade of Simple Features” in 2001. Using the *haarcascade_frontalface_default.xml*, we will attempt to detect the faces of persons in this use-case. We scaled down the picture size for better output because the dimensions of the image we used here were very huge. This BGR channel must be converted to grey channel for image recognition applications. The reason for this is because grey channel is simple to process and technically less heavy because it just has one black-and-white channel.

There is an inbuilt function named *detectMultiScale* in the face classifier object, which is loaded with haarcascade_frontalface_default.xml. This feature will help in locating the new image's features and places. This is done by detecting the new image's features using all of the features from the face classifier object. The detectMultiScale() returns 4 values as a result of the preceding step: the X and Y coordinate, width and height of the identified facial feature. A rectangle is created around the face based on these four numbers.

For this mini project the only material required is the camera module and the Raspberry Pi. The setup of the connection is as shown below.

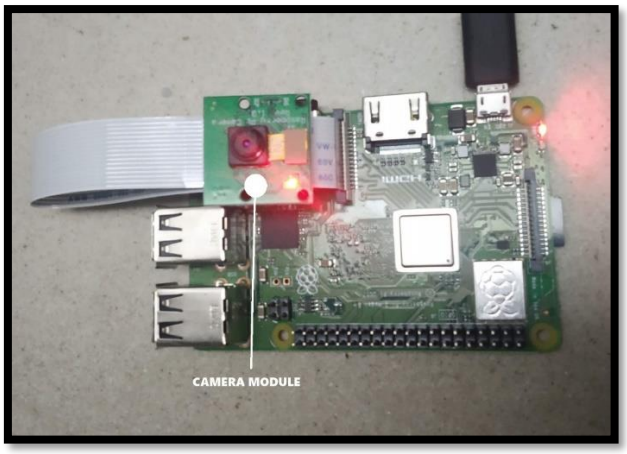

FIGURE 19

```
>>> %Run face_detection.py
  No. of Faces found: 1
```

FIGURE 20

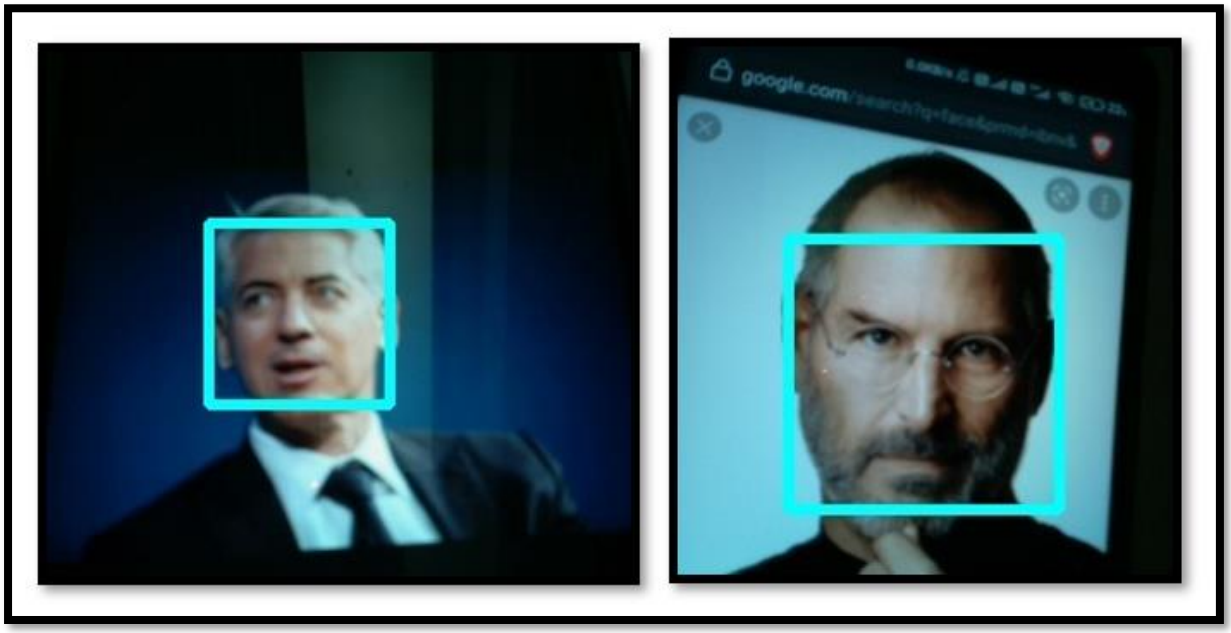

FIGURE 21

[Face detection will only work in bright and well-lit areas where faces can be seen clearly]
[Camera Interface needs to be Enabled in the Raspberry Pi for it to work]

❖ Project 3 (PIR Motion Detection)

The PIR motion sensor itself contains two slots, each of which is composed of a specific IR-sensitive substance. Because the lens employed here isn't doing anything, we can see that the two slots can 'see' out past a certain distance (basically the sensitivity of the sensor). When the sensor is turned off, both slots detect the same quantity of IR, which is the ambient amount emitted by the room, walls, or outside. When a warm body, such as a human or animal, passes by, one half of the PIR sensor is intercepted, resulting in a positive differential change between the two halves. When the heated body exits the sensing region, the sensor creates a negative differential change, causing the sensor to generate a negative differential change. These change pulses are what is detected.

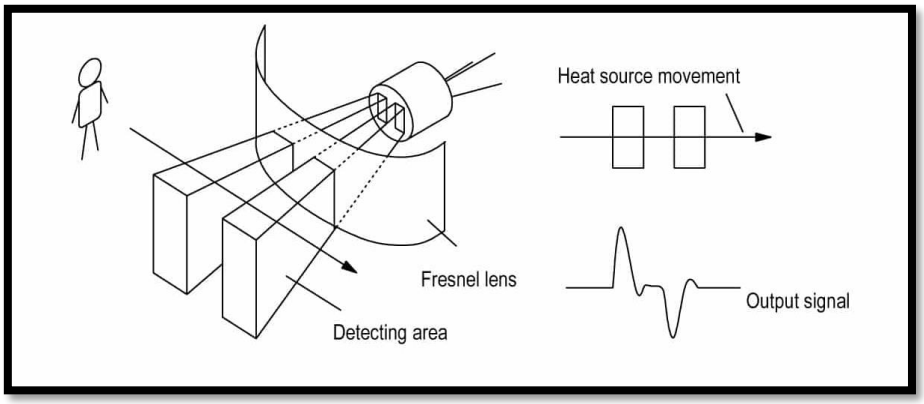

FIGURE 22

For this mini project the materials required are breadboard, jumper cables, a camera module, a Passive Infrared (PIR) motion sensor and the Raspberry Pi. The circuit connection is as shown below.

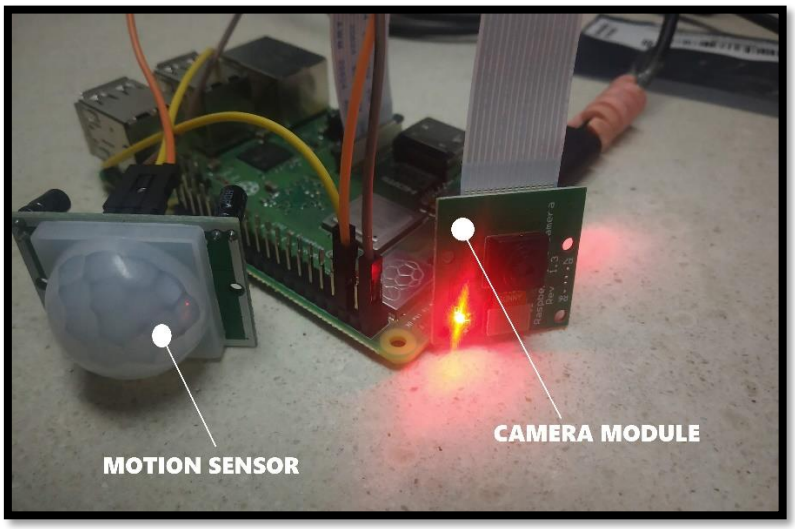

FIGURE 23

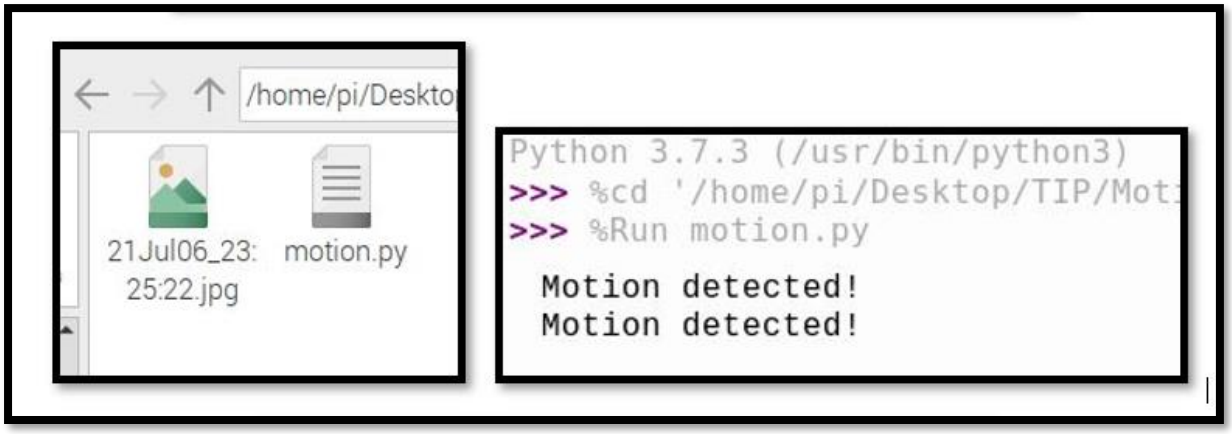

FIGURE 24

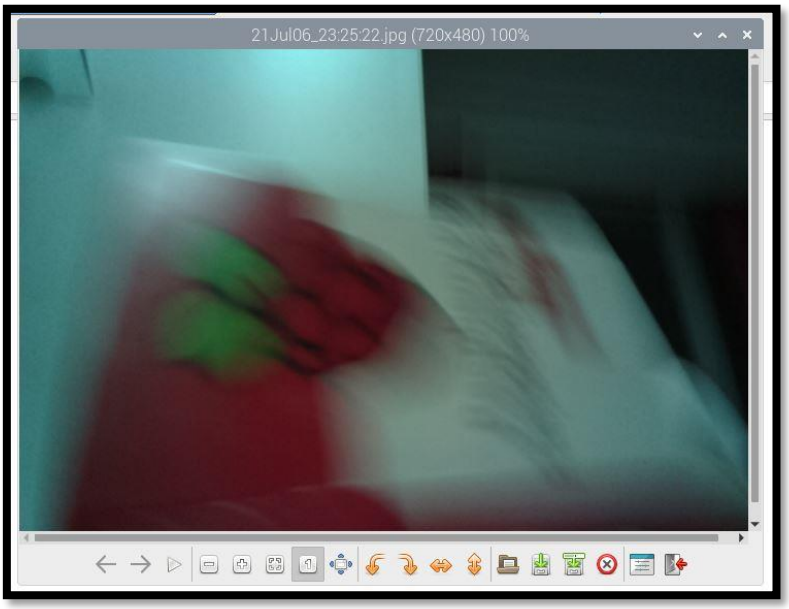

FIGURE 25

❖ Project 4 (Coordinate System)

The MPU6050 is a Micro Electro-Mechanical Systems (MEMS) with a three-axis accelerometer and three-axis gyroscope. This allows us to measure a system's or object's acceleration, velocity, direction, displacement etc. There are three forms of angular rate measurements, depending on the direction that a gyroscope can measure. When looking at an item from above, yaw is the horizontal rotation on a flat surface. Pitch is the vertical rotation of an item as seen from the front. Roll is the horizontal rotation of an item as viewed from the front.

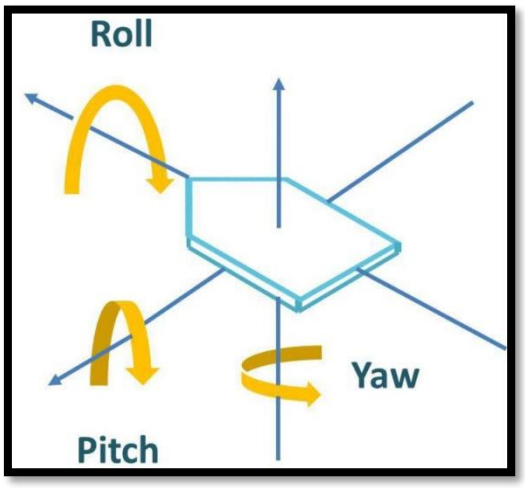

FIGURE 26

Gyroscope sensors make use of the Coriolis force idea. The rotation rate of the sensor is turned into an electrical signal in this sensor to detect the angular rate. Observing the operation of a vibration gyroscope sensor will help you understand the working principle of a gyroscope sensor. The internal vibrating element of this sensor is composed of crystal material in the shape of a double – T structure. This structure consists of a central stationary component with a ‘Sensing Arm' attached to it and ‘Drive Arms' on both sides. This symmetrical double-T structure Continuous lateral vibrations are created when an alternating vibration electrical field is given to the driving arms.

Due to the symmetry of the Drive arms, as one travels to the left, the other moves to the right, balancing out the leaking vibrations. The static portion stays at the middle, while the sensing arm remains stationary. Vertical vibrations are generated on the Drive arms when an external rotating force is applied to the sensor. This causes the Drive arms to vibrate in both the up and down directions, causing a rotating force to act on the stationary portion in the middle. The vertical vibrations in the detecting arms are caused by the rotation of the stationary portion. A change in electrical charge is recorded as a result of the vibrations in the sensor arm. As Angular rotation, this change is utilized to quantify the external rotational force delivered to the sensor.

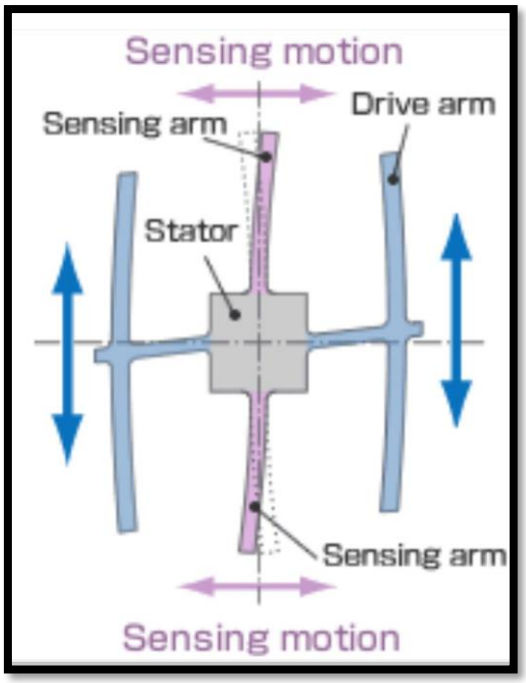

FIGURE 27

For this mini project the materials required are breadboard, a gyroscope, jumper cables and the Raspberry Pi. The circuit connection is as shown below.

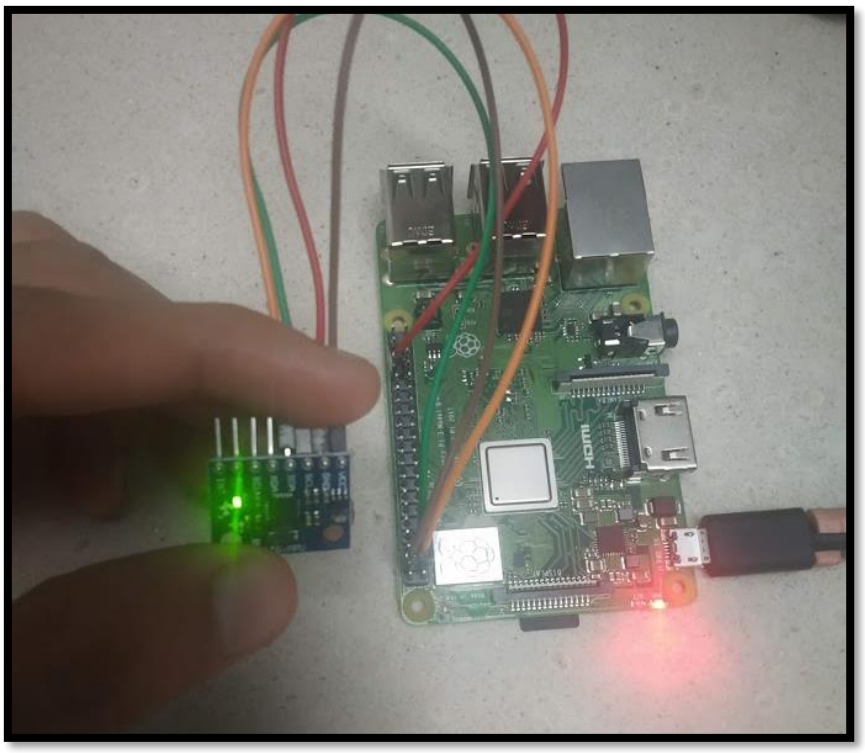

FIGURE 28

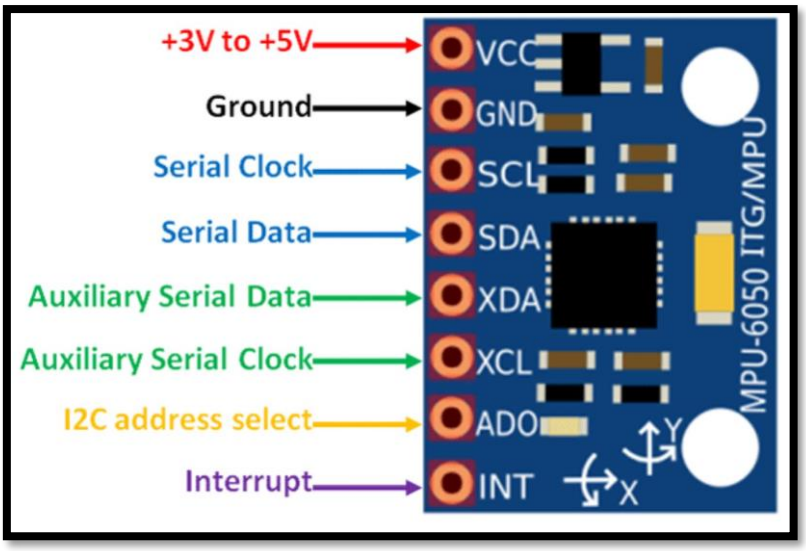

FIGURE 29

```
Temp : 36.53

Acc X : 0.0
Acc Y : 0.0
Acc Z : 0.0

Gyro X : 0.0
Gyro Y : -5.030534351145038
Gyro Z : 6.297709923664122

--------------------------------
Temp : 35.353529411764704

Acc X : -6.433219860839843
Acc Y : 2.7246014892578123
Acc Z : 7.5153990112304685

Gyro X : 1.6641221374045803
Gyro Y : -3.8091603053435112
Gyro Z : 0.12213740458015267

--------------------------------
Temp : 35.49470588235294

Acc X : -6.399701037597656
Acc Y : 2.6336218261718747
Acc Z : 7.314286071777343

Gyro X : 1.549618320610687
Gyro Y : -2.5419847328244276
Gyro Z : -1.465648854961832
```

FIGURE 30

Conclusion

➢ Project Outcome

This project was aimed to get familiar with Robotics and Automation and help understand how large scale implementations are done in real-world scenarios. This required building a strong foundation in Python and understanding of Artificial Intelligence (AI) and Machine Learning (ML) algorithms.
After gaining the basic knowledge required for the project, the next step moving forward was to implement the real-world applications on a small scale. This goal was achieved used a Raspberry Pi. Understand the power of this small computer gave high insights in the field of Robotics. Controlling LEDs from a GUI, to physically switch it ON/OFF, blink or change in brightness was similar to Smart IoT devices. Using a camera module for face detection successful was similar to its uses in facial recognition, security etc. Adding a PIR motion sensor to this camera module lead to the development of a small scale security system. The motion triggered the camera to take pictures or videos and store them in its memory. The gyroscope was used to implement a coordinate system and to be able to track the temperate, acceleration and coordinates successfully. All these small scale implementations are miniature systems of systems used in Robotics professionally.

➢ Challenges and Solutions

Having being a new entry to the field of Robotics, there were many challenges to overcome. Understand a Raspberry Pi and its purpose is difficult for any beginner. Connecting and booting up of a Raspberry Pi remotely was challenging. To understand the role of different GPIO Pins and the working of each sensor caused a significant amount of difficulty as every sensor has different connections and all 40 GPIO pins are used for specific purposes. The motion sensor and camera module were basic sensors that lead to the detection of movement and face detection to not working effectively all the time.

➢ Future Scope

The current project is focused more on the basics and the fundamentals of how Robotics work. These mini projects and components of actual complex robotic machines. Therefore, to incorporate and combine all these small modules together to form a better and more reliable integrated machine will be an advancement and future scope. Also, to upgrade the sensors to the ones with high precision and accuracy is a must. This adds more reliability and gives more control to the programmer to achieve the required targets through these projects.

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[18] YouTube Raspberry Pi Videos: https://www.youtube.com/playlist?list=PL0s3O6GgLL5cteXH7CJK7kc2Ar5wR7M81

[19] HTML and CSS: https://www.w3schools.com

Glossary

1. Web Server:
   A web server is a computer that runs websites. It's a computer program that distributes web pages as they are requisitioned. The basic objective of the web server is to store, process and deliver web pages to the users. This intercommunication is done using Hypertext Transfer Protocol (HTTP).

2. Cloud Storage:
   Cloud storage is a model of computer data storage in which the digital data is stored in logical pools, said to be on "the cloud". The physical storage spans multiple servers, and the physical environment is typically owned and managed by a hosting company.

3. VPN:
   A virtual private network extends a private network across a public network and enables users to send and receive data across shared or public networks as if their computing devices were directly connected to the private network

4. NAS:
   Network-attached storage is a file-level computer data storage server connected to a computer network providing data access to a heterogeneous group of clients. NAS is specialized for serving files either by its hardware, software, or configuration.

5. GUI:
   The graphical user interface is a form of user interface that allows users to interact with electronic devices through graphical icons and audio indicator such as primary notation, instead of text-based user interfaces, typed command labels or text navigation.

6. Broadcom:
   Broadcom Corporation is an American fabless semiconductor company that makes products for the wireless and broadband communication industry. It was acquired by Avago Technologies in 2016 and currently operates as a wholly owned subsidiary of the merged entity Broadcom Inc.

7. Putty:
   PuTTY is a free and open-source terminal emulator, serial console and network file transfer application. It supports several network protocols, including SCP, SSH,

Telnet, rlogin, and raw socket connection. It can also connect to a serial port. The name "PuTTY" has no official meaning.

8. SSH:
   The Secure Shell Protocol is a cryptographic network protocol for operating network services securely over an unsecured network. Typical applications include remote command-line, login, and remote command execution, but any network service can be secured with SSH.

9. XRDP:
   xrdp is a free and open-source implementation of Microsoft RDP server that enables operating systems other than Microsoft Windows to provide a fully functional RDP-compatible remote desktop experience. It works by bridging graphics from the X Window System to the client and relaying controls from the client back to X.