

Home Security System Controlled with Raspberry PI via Google Cloud

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Abstract - Nowadays, it is very important to ensure the security of our homes. We have designed, developed, and implemented a home security system that consists of a webcam and a motion sensor detector connected to a Raspberry Pi. The Raspberry Pi is a low-cost small computer. We have used the Raspberry Pi 4 which has a built in Bluetooth and Wi-Fi connections onboard to connect with our home Wi-Fi router with the cloud server. When the motion sensor detects an object, the webcam will take the images and save it to the pre-install memory card temporarily, then those images will be moved into the Google cloud and notify via email to the registered user of this device.

Keywords: Cloud Computing, Email, Memory, Raspberry PI, Sensors, Webcam

1. Introduction

The primary objective of our project has been to design, develop and implement a home security system. It is highly recommended to install a home security system to secure our family and property. Having a home security system installed means that our home and valuables are protected and our family is safe from potential break-ins by burglars. Every 13 seconds a home burglary takes place, 4 burglaries a minute, 240 an hour and nearly 6,000 a day [1]. Furthermore, if we have a home security installed at our house, we can always relax by knowing that there is an extra set of eyes watching our house 24/7.

Our implemented home security system consists of a webcam and a motion sensor detector connected to the Raspberry Pi 4. The Raspberry Pi is a low-cost computer that enables people to learn how to program in different languages and uses a standard keyboard and mouse. It can do everything you would expect a desktop computer to do, from browsing the Internet and playing high-definition video, to make spreadsheets, word processing, and playing games [2]. Besides the Raspberry Pi our system has a webcam that acts as an external camera to capture light through a small lens at the front using a tiny grid of microscopic light-detector built into an image-sensing microchip. The image sensor and its circuitry convert the picture at front of the camera into digital format a string of zeros and ones that a computer knows how to handle [3]. The use of an image sensor chip is to catch moving images and convert them into streams of digits that are uploaded over the Internet. Our system consists of a Passive Infra Red (PIR) sensor. The PIR is a type of motion sensor which has two slots. Each slot is made of a special material that is sensitive to IR. It works in such a way when the sensor is idle, both slots detect the same amount of IR wave from the room or walls or outdoors. When a warm body such as human or animal passes by; it first intercepts one half of the PIR sensor, which causes a positive differential change between the two halves. When the warm body leaves the sensing area, the reverse happens. Therefore, the sensor generates a negative differential change. These change pulses are what is detected by the PIR sensor [4].

The “Cloud” refers to servers, software and database that run on those servers and are accessed over the Internet. Cloud servers are located in data centres all over the world. By using cloud computing, users and companies do not have to manage physical servers themselves or run software applications on their own machines. Cloud computing is possible because of a technology called virtualization [5]. Virtualization allows for the creation of a simulated, digital-only “virtual” computer that behaves as if it were a physical computer with its own hardware. The technical term for

such a computer is virtual machine. There are different types of clouds deployments, private cloud, public cloud, hybrid cloud and multi-cloud. Our solution makes use of a public cloud, more specifically the Google Cloud.

In the above paragraphs we presented a brief background of our system, next in section 2, we present Description and Project Implementation, then in Section 3, a sample of Experimental Result is shown; and finally our Conclusion is included in Section 4.

2. Description and Project Implementation

The Internet of Things (IoT) device built using Raspberry Pi 4 has a simple and straight forward operation. The device detects motion by the PIR sensor and as it detects motion, it starts capturing images. The images are stored on the MicroSD card and sent on the registered email of the user. All of this is managed by a python script running over the Raspbian Operating System (OS). Before running the python script, it is essential to install the Raspbian OS on the Raspberry Pi 4 and add the required libraries such as the OpenCV. During the installation of the Operating System, the libraries and the python script, the Raspberry Pi should be connected to a display monitor using Micro-HDMI cable.

To install the Raspbian Operating System, first go to the Raspberry Pi website and download the Raspberry Pi imager. Run the Raspberry Pi imager and format the SD card (Fig 1). Burn the Raspberry Pi OS (32-bit) Image to the SD Card, as seen in Fig. 1. During this process, just be patient and wait for this process to complete. If you remove the SD card, unplug the card reader, or shut down the computer at any point during this process, the card will become bricked and unusable. Once Raspberry Pi Imager has finished writing the files to the SD card, it will verify that the image on the SD card is identical to the image file used to burn the image. This usually takes less than a minute but could take longer. When the verification process is complete, a notification window will open letting you know that the write was successful and that it's now safe to remove the SD card.

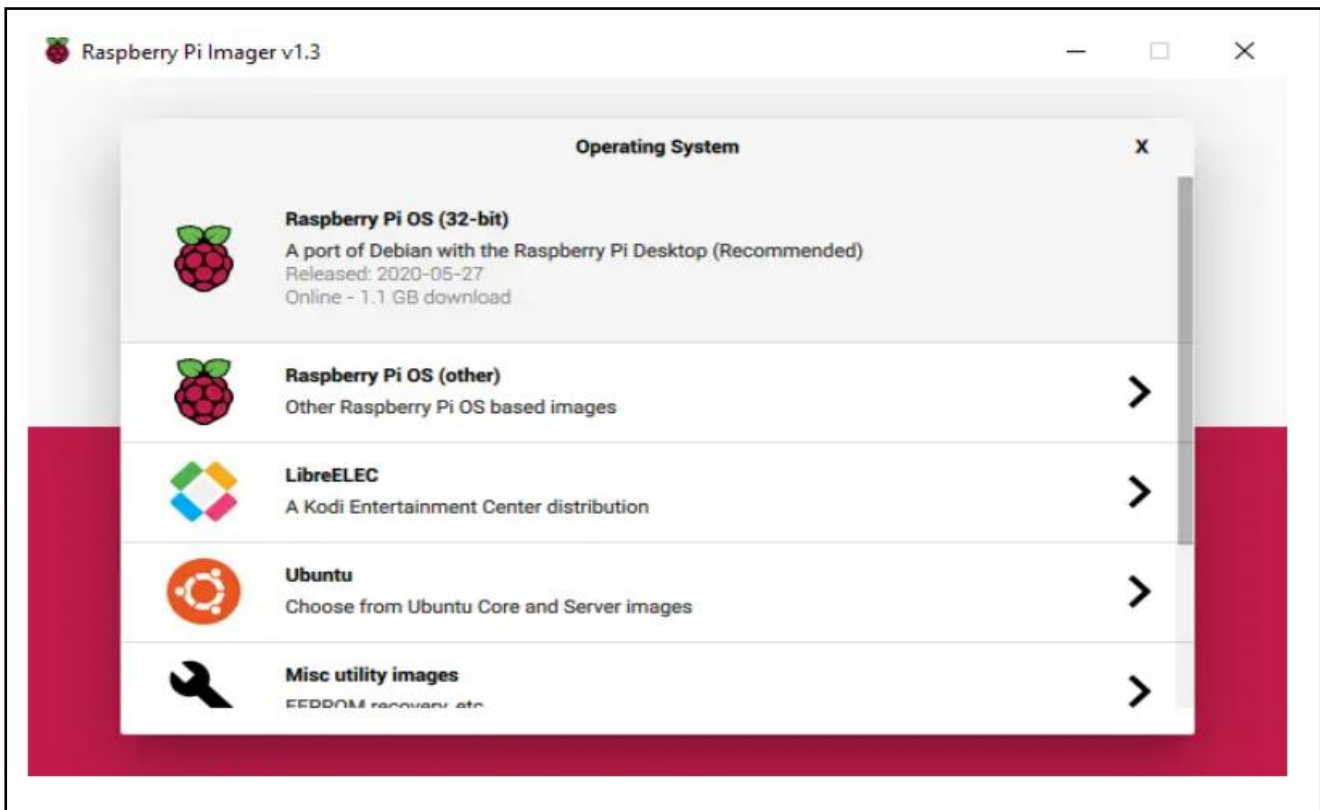


Fig. 1: Installing Raspbian Operating System in the SD card

2.1. Raspberry Pi

The Raspberry Pi 4 model B, shown in Fig. 2, is the fourth generation Raspberry Pi. It is a miniature marvel, with considerable computing power into a footprint no larger than a credit card. The processor at the heart of the Pi system is a Broadcom BCM2711 System-on-Chip 64-bit (SoC) which houses a 1.5 GHz Quad Core ARM Cortex-A72 processor.

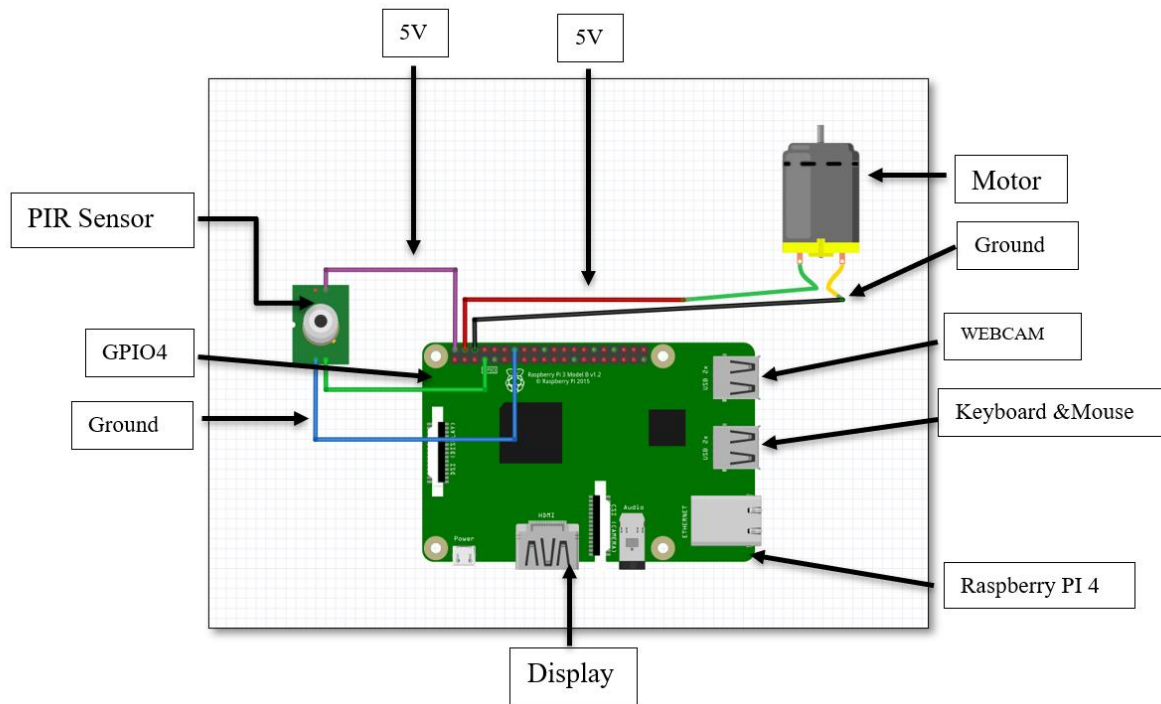


Fig. 2: Components Layout

The vast majority of the system components, including its central and graphics processing units along with the audio and communications hardware, are built onto that single component along with 2 GB LPDDR4-3200 SDRAM memory chip at center of the board. It is not just the SoC design that makes the BCM2711 different to the processor found in a typical Desktop or Laptop. However, it also uses a different Instruction Set Architecture (ISA), known as ARM.

The Raspberry Pi comes equipped with on-board Gigabit Ethernet Socket, 2 micro-HDMI ports and Composite port for video, 3.5 mm audio output jack, 2-lane MIPI Camera Serial Interface port (CSI-2), 2-lane MIPI Display Serial Interface port, Bluetooth 5.0, 2.4 GHz, and 5.0 GHz 802.11ac Wireless LAN, Micro SDIO for Micro SD Card, 2 USB 3.0 and 2 USB 2.0 Connectors, 40 pin header containing 40 GPIO pins and USB-C socket for power supply.

The Raspberry Pi is a single board computer designed to run an Operating System called GNU/Linux Raspbian. Hereafter referred to simply as Linux. Unlike Windows or OS X, Linux is open source, so it is possible to download the source code for the entire operating system and make whatever changes desired. The Raspberry Pi 4 can also run Windows 10 IoT and many other embedded operating systems that are Linux derivatives. The operating system must be loaded into a MicroSD card and boot from it. With powerful computing resources, large number of multimedia interfaces and GPIO pins, the Raspberry Pi 4 is a suitable choice to run software oriented complex IoT or embedded projects that require sufficient computing power as well as large scale sensor connectivity. With on-board Bluetooth and Wi-Fi, this 4th generation Pi can be easily deployed in an IoT network.

Our system uses a Passive Infra-Red (PIR) motion Sensor as show in Fig. 3. The PIR sensor is connected to GPIO04 (Pin 7) at the header of the Pi 4. It is a Pyroelectric device that detects motion by measuring changes in the

infrared levels emitted by surrounding objects. By incorporating a Fresnel lens and motion detection circuit, the module provides high sensitivity and low noise. The module provides an optimized circuit that can detect motion up to 6 meters away.

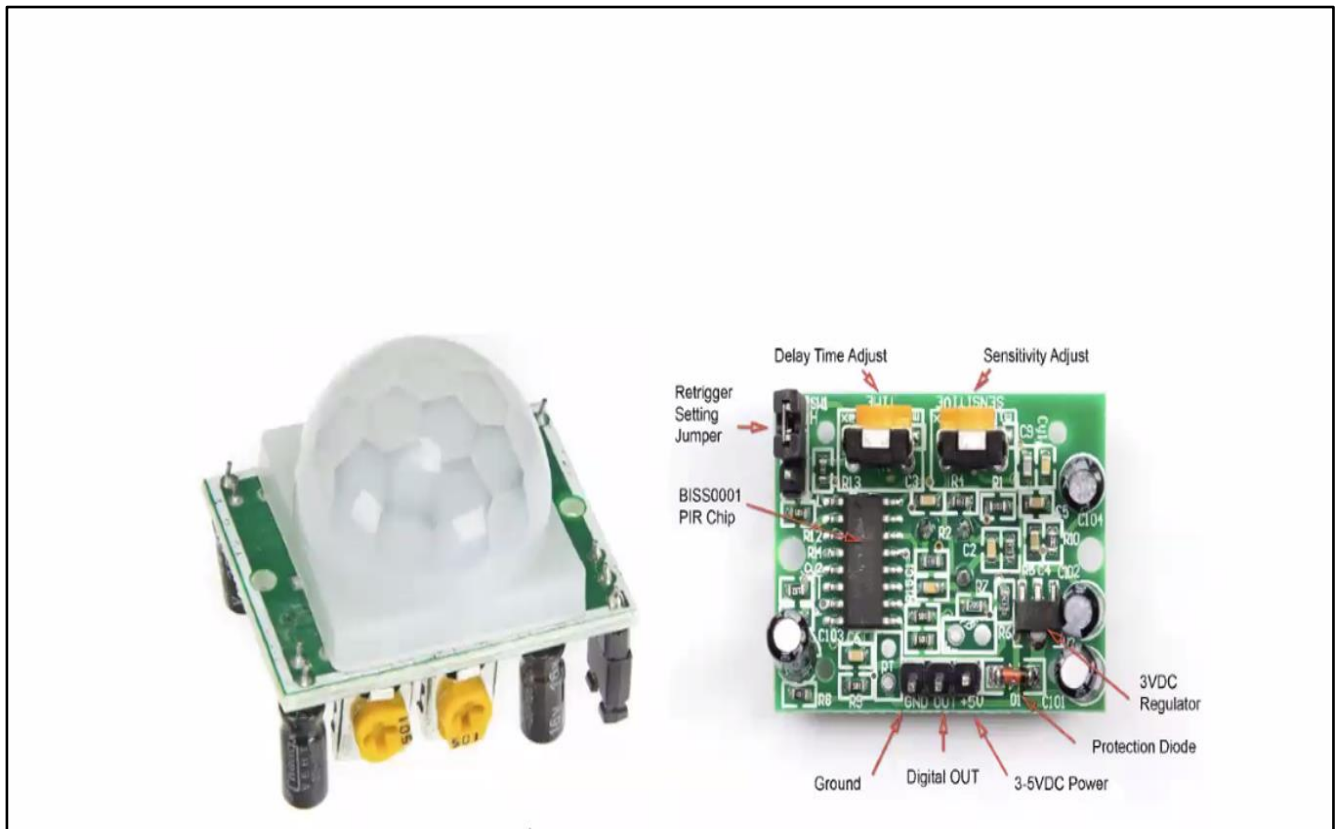


Fig. 3: Passive Infra-Red (IR) Device

There are two slots on the sensor, each made up of a special Infra-Red (IR) sensitive material. In the absence of anybody, the two slots receive the same amount of IR radiation. When a person passes by the sensor, it is intercepted by one half of the slots causing a positive potential difference across the slots. When the person leaves by the sensor, it is intercepted by another half of the slots causing a negative potential difference across the slots. This positive and negative differential generates a pulse thus detecting motion.

The sensor module has on-board 3.3V voltage regulator, protection diode, sensitivity adjustment and delay time adjust. There are three terminals on the module – ground, VCC and Digital Out. A voltage of 5V to 12 V can be supplied at the VCC pin, though 5V is the recommended power supply. When the module detects motion, the output at the Digital Out pin goes HIGH. This is a standard 5V active high signal. The Digital Out pin of the sensor is connected to GPIO pins of Raspberry Pi directly to monitor signal. It is connected to GPIO 4th pin, as shown in Fig. 4. of the Raspberry pi 4. The VCC pin of the module is connected to one of the 5V DC Power pin of the Pi 4 and ground pin of the module is connected to one of the ground pins of the Pi.

The power source is connected to the Raspberry Pi. The Pi should be powered by a 5V adapter with minimum 3A current output. The adaptor can be connected at USB-C socket. The USB Web Camera shown in Fig. 5. is connected to one of the two USB 2.0 connectors. The OpenCV Library is used to provide the functionality to work with this standard Webcam.

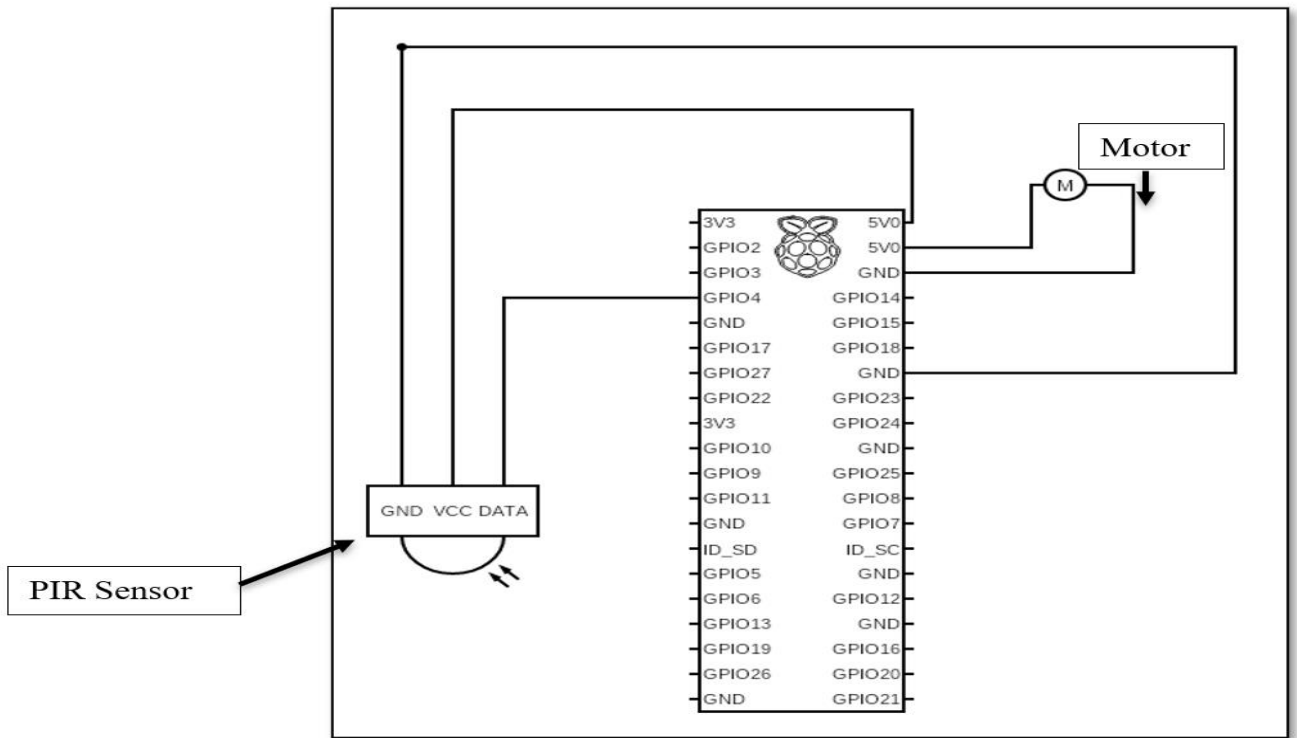


Fig. 4: Raspberry Pi 4 Pin Out

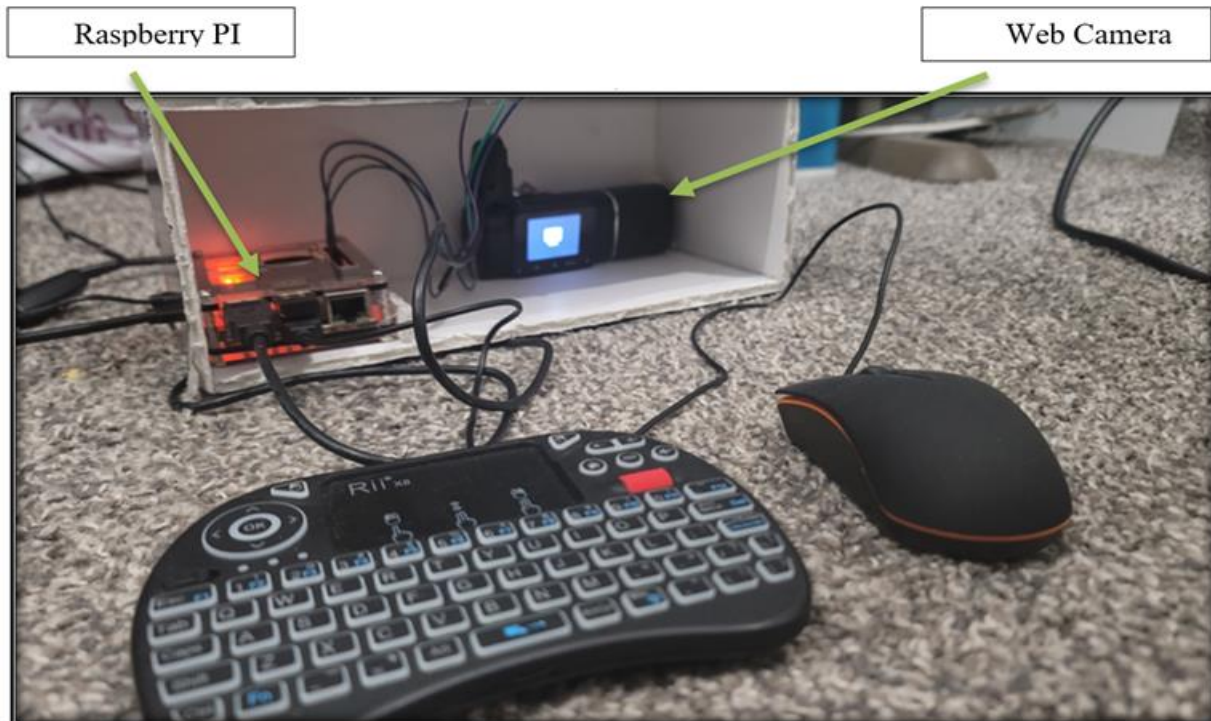
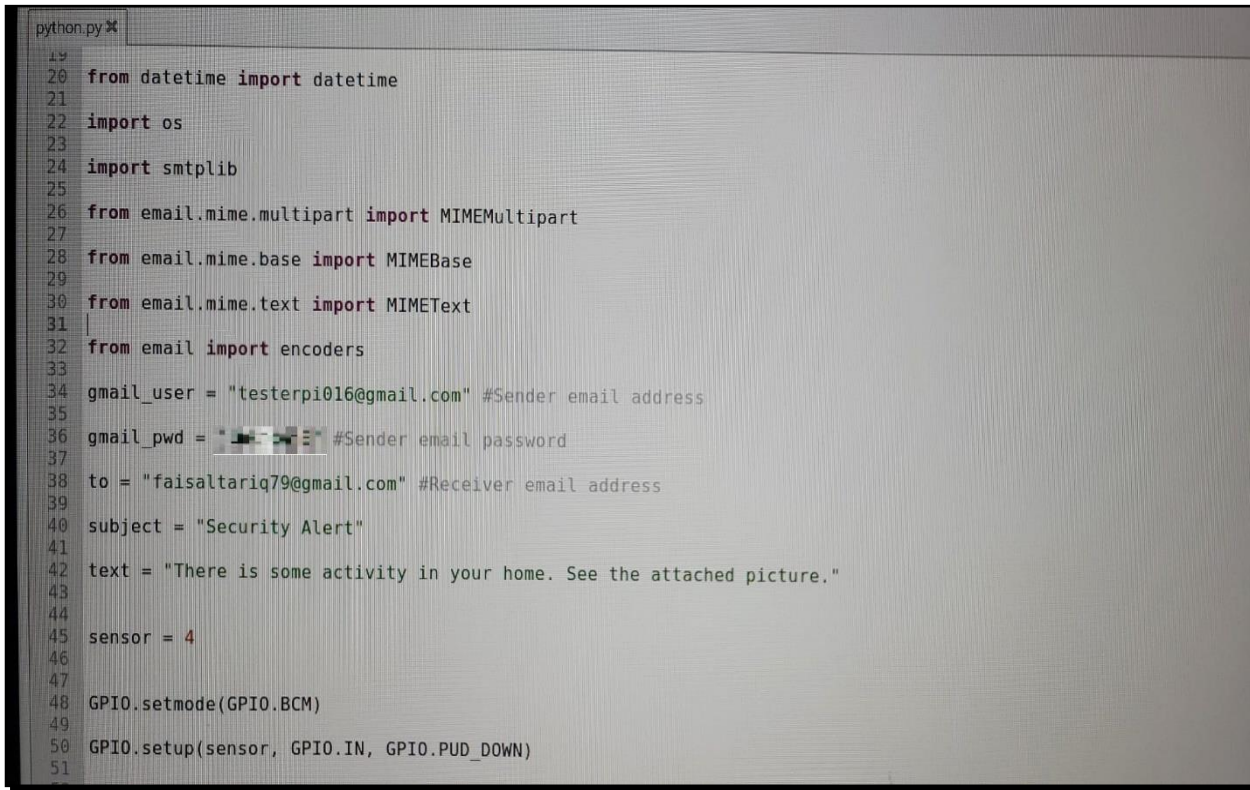


Fig. 5: Physical Design Setup

2.2. Google Cloud

Our implementation has made use of the Simple Mail Transfer Protocol (SMTP) for our email messaging using the Google Cloud. A python script for the email messaging realization is shown in Fig. 6. SMTP is the protocol used for sending email over the Internet. Gmail uses SMTP to send a message to the mail server, and the mail server uses SMTP to relay that message to the correct receiving mail server. SMTP was originally designed for only plain text, but MIME and other encoding methods enable executable programs and multimedia files to be attached to and transported with the email message.



```
python.py ✖
19
20 from datetime import datetime
21
22 import os
23
24 import smtplib
25
26 from email.mime.multipart import MIMEMultipart
27
28 from email.mime.base import MIMEBase
29
30 from email.mime.text import MIMEText
31
32 from email import encoders
33
34 gmail_user = "testerpi016@gmail.com" #Sender email address
35
36 gmail_pwd = " " #Sender email password
37
38 to = "faisaltariq79@gmail.com" #Receiver email address
39
40 subject = "Security Alert"
41
42 text = "There is some activity in your home. See the attached picture."
43
44
45 sensor = 4
46
47
48 GPIO.setmode(GPIO.BCM)
49
50 GPIO.setup(sensor, GPIO.IN, GPIO.PUD_DOWN)
51
```

Fig. 6: Python Script

For our implementation process we created a gmail account, to create a gmail account one has to go to google account sign in page. We also created a Python script for interacting with the functionality of the circuit we built. We imported standard libraries such as RPi.GPIO, time, CV2 and numpy, etc. These libraries were used for accessing GPIO pins, extract the system time, and use OpenCV module to capture the images. The variables were declared for the GPIO pin number for the PIR sensor and to provide the email ID to be used for sending the alert mail to the registered user.

2.2.1. Troubleshooting

During the testing process we encountered the Raspberry Pi was not able to locate the library we installed and imported. To fix this issue we made use of the command 'sys.path.append' in our program and manually located the library from the SD card. We also had a problem running the Raspberry Pi with the SMTP library. The problem was linking the Raspberry Pi with the gmail account we created. By turning off the 2-step authentication it gave us access to the Raspberry Pi in the trusted devices. Without this fix we were not able to run the program. The way the components are connected to the Raspberry Pi is shown in Fig. 7.



Fig. 7: Raspberry Pi Connected with Monitor

3. Experimental Results

When the PIR sensor detects something in its range it will send an email notification to the registered user. From there user can open their email to check the activity. The PIR sensor will stay active and continuously send the email notification until the PIR sensor perimeter is clear – this activity is shown in Fig. 8 and Fig. 9.

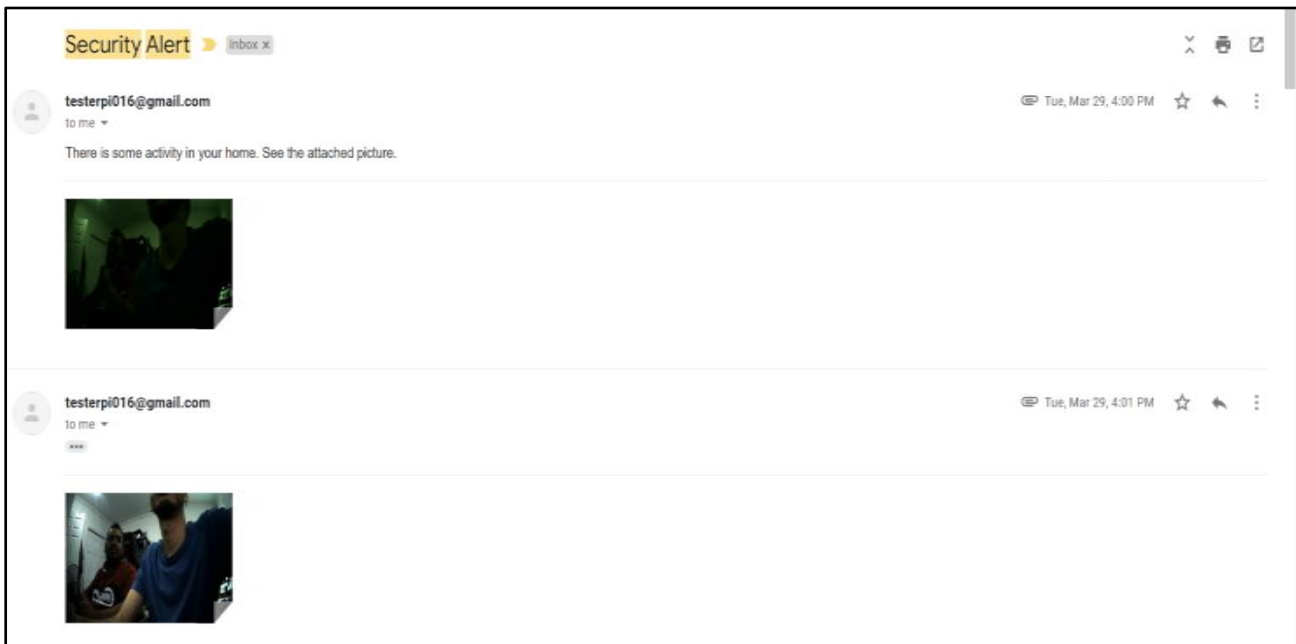


Fig. 8: Email Notification



Fig. 9: A Picture from the Camera

4. Conclusion

The Raspberry Pi-based home security system with the inclusion of the Google Cloud resulted in a great solution to secure our house from intruders. Our design and solution implementation provides an extra set of eyes in protecting and providing security for our house. Our system is able to detect any motions of objects in front of our house and notifies us via email. This technology solution can be installed anywhere as long there is a connectivity access to a WiFi, with our system plugged in, and we as a consumer will have the proof in our email.

References

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