

IOT BASED ANTI-THEFT FLOORING SYSTEM (USING RASPBERRY PI)

Submitted in partial fulfillment of the requirements for the award of

Bachelor of Engineering Degree in

Electrical and Electronics Engineering

By

Alagu Priya S (Register No. 37140006)

L. Angelin Aishwarya (Register No. 37140008)



**DEPARTMENT OF ELECTRICAL AND ELECTRONICS
ENGINEERING**

SCHOOL OF ELECTRICAL AND ELECTRONICS ENGINEERING

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade “A” by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119



SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited "A" Grade by NAAC | 12B Status by UGC | Approved by AICTE

www.sathyabama.ac.in

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Alagu Priya S** (Reg. No. 37140006) and **L. Angelin Aishwarya** (Reg. No. 37140008) who have carried out the project entitled "**IOT BASED ANTI-THEFT FLOORING SYSTEM (USING RASPBERRY PI)**" as a team under our supervision from December 2020 to April 2021.

DR.W. ABITHA MEMALA

Internal Guide

Dr. V. SIVACHIDAMBARANATHAN

Head of the Department

Submitted for Viva voice Examination held on _____

Name:

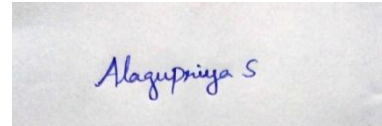
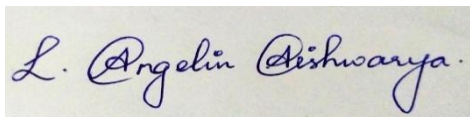
Signature:

Internal Examiner

External Examiner

DECLARATION

IALAGU PRIYA S(Reg. No.37140006) and **L. ANGELIN AISHWARYA**
(Reg. No. 37140008) hereby declare that the Project Report entitled “**IOT BASED ANTI-THEFT FLOORING SYSTEM (USING RASPBERRY PI)**” was done by us under the guidance of **Dr. W. ABITHA MEMALA**(Internal) is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electrical and Electronics Engineering.

A rectangular box containing a handwritten signature in blue ink that reads "Alagupriya S".A rectangular box containing a handwritten signature in blue ink that reads "L. Angelin Aishwarya".

SIGNATURE OF THE CANDIDATES

Date:

Place:

ACKNOWLEDGEMENT

We are pleased to acknowledge our sincere thanks to the Board of Management of **SATHYABAMA** for their encouragement in doing this project and for helping us complete it successfully. We are grateful to them.

We convey our thanks to **Dr. N. M. Nandhita., Dean, School of Electrical and Electronics Engineering**, and **Dr. V. Sivachidambaranathan, Head of the Department, Dept. of Electrical and Electronics Engineering** for providing us the necessary support and details at the right time during the progressive reviews.

We would like to express our sincere and deep sense of gratitude to our Project Guide **Dr. W. Abitha Memala** for her valuable guidance, suggestions, and constant encouragement which paved way for the successful completion of our project.

IOT BASED ANTI-THEFT FLOORING SYSTEM (USING RASPBERRY PI)

ABSTRACT

Security and safety have become a matter of cardinal importance. With the fast urbanization and expansion of large cities and towns, the graph of crimes is also on the increase. The IoT-based Anti-theft Flooring system serves to address this issue by securing and guarding our house in our absence using Raspberry Pi. Whenever someone steps on the floor or tries to enter the house, a message is sent over IOT to the e-mail account of the owner, and the entire incident is live-streamed on the owner's device right away.

Technology has reached a stage where mounting cameras to capture video imagery is cheap, but finding available human resources to sit and watch is imagery. CCTV cameras, which are generally used for monitoring, are expensive because of using computers. It takes up too much space for continuous recording and it also requires workers to identify the unauthorized Activity. Raspberry Pi, on the other hand, is cost-efficient, with better resolution and low power-usage features when compared to the actual system.

TITLE	PAGE NUMBER
ABSTRACT	V
LIST OF FIGURES	X
1. INTRODUCTION	
1.1. GENERALINTRODUCTION	13
1.1.1. DEFINITION OF SECURITY SYSTEMS	13
1.1.2. EVOLUTION OF SECURITY SYSTEMS	13
2. LITERATURE SURVEY	
2.1. LITERATURE SURVEY	15
3. AIM AND SCOPE OF THE PRESENT INVESTIGATION	
3.1. AIM OF THE PROJECT	20
3.2. SCOPE OF THE PROJECT	20
3.2.1. JUSTIFICATION	20
4. EXPERIMENTAL MATERIALS, METHODS, AND ALGORITHMS USED	
4.1. METHODS	21
4.1.1. SYSTEM CURRENTLY IN EFFECT	21
4.1.2. PAIN POINTS	21
4.2. OBJECTIVES	21
4.3. PROPOSED STATE	21
4.3.1. BLOCK DIAGRAM	22
4.3.2. HARDWARE REQUIREMENTS	22

4.3.3. EXPERIMENTAL SETUP	23
4.3.4. PROPOSED SYSTEM - OPERATION	23
4.3.5. FLOWCHART	24
4.4. HARDWARE DESCRIPTION	25
4.4.1. RASPBERRY PI	25
4.4.1.1. PIN DIAGRAM OF RASPBERRY Pi	25
4.4.1.2. PARTS OF RASPBERRY Pi	26
4.4.2. PIEZO SENSOR	26
4.4.3. PIR SENSOR	25
a. PRINCIPLE OF OPERATION	27
b. PARTS OF THE PIR SENSOR	28
4.4.4. SERVO MOTOR	28
4.4.5. BUZZER	29
4.4.6. RPI CAMERA MODULE	30
4.5. HARDWARE IMPLEMENTATION	30
4.5.1. ACCESS RASPBERRY Pi MODEL 3 B+ IN WINDOWS	31
4.5.2. SET UP THE INTERNET CONNECTION OF THE RASPBERRY Pi	32
4.5.3. ENABLE Pi CAMERA	32
4.5.4. SET UP THE PASSIVE INFRARED SENSOR	34
4.5.5. SET UP THE VIBRATION SENSOR	
4.5.6. SET UP THE SERVO MOTOR	34
	34
4.6. SOFTWARE DESCRIPTION	
4.6.1. PROGRAMMING THE RASPBERRY Pi	35
4.6.2. RASPBERRY PI HARDWARE AND SOFTWARE DESIGN	35
4.6.3. PSEUDOCODE	
4.6.4. DEVELOPING THE FULL CODE LISTING	37
4.7. SOFTWARE IMPLEMENTATION USING THE VNC	38

VIEWER	38
4.7.1. VIRTUAL NETWORK COMPUTING	38
4.7.2. INSTRUCTIONS FOR ENABLING THE VNC SERVER	39
4.7.3. CONNECTTHE RASPBERRY PI WITH VNC VIEWER	40
4.7.4. AUTHORIZE THE VNC SERVER	40
4.7.5. OPERATION OF THE DEVICE AFTER SOFTWARE IS IMPLEMENTED	42
5. RESULTS, DISCUSSIONS AND PERFORMANCE ANALYSIS	
5.1.ASSEMBLING THE HARDWARE COMPONENTS	43
a. PIEZO SENSOR	43
b. PIR SENSOR	44
c. SERVO MOTOR	45
d. BUZZER	46
5.2.HARDWARE SETUP	47
5.3.SOFTWARE IMPLEMENTATION USING VNC SOFTWARE	47
5.4.RESULTS	49
5.4.1. OUTPUT	49
6. SUMMARY AND CONCLUSION	
6.1.SUMMARY	56
6.1.1. PROS, CONS, AND APPLICATIONS OF THE PROPOSED STATE	56

6.2. INFERENCE	56
6.3. EXTENDED SCOPE	57
6.4. RECORDS OF RELATED WORKS ON SECURITY SYSTEMS	57

LIST OF FIGURES

FIGURENo.	TITLE	PAGE No.
4.3.1.	Block Diagram	22
4.3.3.	Experimental setup	23
4.3.5.	Flowchart	24
4.4.1.1.	Pin diagram of Raspberry Pi	25
4.4.1.2.	Parts of Raspberry Pi	26
4.4.2.	Piezo electric sensor	27
4.4.3.	a. Operation of PIR	28
	b. Parts of PIR	28
4.4.4.	Servo motor	29
4.4.5.	Piezo buzzer module	29
4.4.6.	Raspberry Pi camera module	30
4.5.2.	Setting up the internet connection on the Raspberry Pi	32
4.5.3.	RPi camera module	33
4.6.5.	a. Hardware design	35
	b. Flowchart	36
4.7.1.	VNC viewer	39
4.7.3.	Discovering Raspberry Pi's private IP address	40
4.7.4.	Creating a virtual desktop	41
5.1	a. Piezo sensor	43
	b. PIR sensor	44
	c. Servo motor	45
	d. Buzzer	46
5.2	Hardware setup	47

5.3	VNC viewer	48
5.4	Results	49
5.4.1	Output	49
	a. Experimental setup using VNC viewer application	49
	b. email notification to the owner's device	50
	c. Image attachments	51
	d. Image attachments till 360 degrees	52
	e. Image captured at 90 degrees	53
	f. Image captured at 0 degrees	53
	g. Image captured at 180 degrees	54
	h. Images stored in the database for the owner's reference	54
	i. Image of the live-streamed video	55

ABBREVIATIONS

RPi	-	Raspberry Pi
PIR	-	Passive Infrared Sensor
VNC	-	Virtual Network Computing

CHAPTER 1

INTRODUCTION

1.1 GENERAL BACKGROUND

1.1.1 *Definition of Security system*

Security refers to the way or strategy of obtaining something through the arrangement of interoperable parts and accessories. Furthermore, the security framework is an organization that incorporates electronic gadgets that are used in conjunction with the focus control board to prevent thieves and other fatal accidents that may occur. The working principle of the security framework is to bring the traffic focus into the home, and introduce sensors that talk to the control panel or war room in the favorable area. The sensor is usually placed in the channel, like a window that is effectively available. The general home security framework includes the following parts: the control panel is the basic controller of the security structure, which is set up in the entrance and window sensors, developing sensors, wired or remote observation cameras, high-decibel warnings or alarms and window stickers.

1.1.2 *Evolution of safety systems*

Today, the requirements for the video observation framework are rapidly expanding. One of the main issues of the scouting framework that individuals need to consider is whether they are willing to conduct remote investigations with them via the Internet. Some time ago, the security framework had to be followed by a janitor who was confined to a room throughout the day, guarding the screen to ensure that no improper behavior occurred. Another option is to go back and investigate the records in case of a robbery. Therefore, analysts and researchers need to develop methods to combat theft or theft to improve security in a loose state. Commercial spaces, universities, hospitals, casinos, and warehouses all require a video capture framework that can monitor and record intruder alarms and videos in real time (except for real-time video). The advancement of video observation innovation makes it possible to see remote surveillance cameras from any network, a powerful PC, or from a mobile phone anywhere on the planet. This includes the use of CCTV (DVR) frameworks and IP cameras. Although this

innovation is excellent at checking and robbing locations, its execution cost has proven to be an obstacle, especially for small houses. The Raspberry Pi microcomputer is equipped with functions for implementing a cost-effective security framework for different applications. This emerging innovation for safety provides a pleasant and safe environment for small houses. The different goal of the framework is to distinguish and capture pictures of the floodgates by delivering alarm messages to all office owners.

Therefore, it considered conducting remote research on offices elsewhere in the world. The planned framework cannot completely replace the work of CCTV cameras and IP reconnaissance cameras, especially in large-scale commercial arrangements, but it will enable low-paid mortgage loan holders to easily inspect their homes at a moderate cost. Although the Raspberry Pi board is medium, the camera used in this case is usually medium compared to other cameras. The entire security framework hardware is basic and easy to implement. Picture preparation is a term used for demonstrating pictures or video outline processing. This information is treated as information, and the result set of processing is a series of relevant boundaries of the picture. The motivation of image processing is perception, that is, attention to items that are not obvious.

The examination of human motion is the latest and mainstream research topic in advanced image processing, and people in development are an important part of human body recognition and motion research. The basic expectation is to distinguish human actions from basic pictures in video groups.

CHAPTER 2

LITERATURE REVIEW

2.1 LITERATURE REVIEW

A literature review or narrative review is a sort of review. A literature review is a scholarly paper that presents the present knowledge, including substantive findings and theoretical and methodological contributions to a specific topic. Literature reviews are secondary sources and don't report new or original experimental work. most frequently related to academic-oriented literature, such reviews are found in academic journals and aren't to be confused with book reviews, which can also appear within the same publication. Literature reviews are a basis for research in nearly every academic field. A narrow-scope literature review could also be included as a part of a peer-reviewed journal article presenting new research, serving to situate the present study within the body of the relevant literature and to supply context for the reader. In such a case, the review usually precedes the technique and leads to sections of the work.

Paper 1: Smart surveillance camera using Raspberry Pi 2 AND OpenCV

The requirement for a security framework is wanted by each person. The most ordinarily used framework, Closed Circuit Television (CCTV), is being used in emergency clinics, stockrooms, parking areas, structures, and so forth. Nonetheless, this very framework, though successful, has its drawback about cost. Afterward, the requirement for a savvy framework is required. The current framework for observation is a surveillance camera with night vision capacities using Raspberry Pi and OpenCV. This is a financially savvy technique that uses a Mastercard estimated chip RPI. The picture is caught and each edge is prepared. The picture is put away and an email is sent if a human is identified. The current framework has an exactness of around 83 %. In this venture, we propose to use an improved, ongoing model-raspberry pi. 2, which has a working pace 900MHz. Likewise, we use a pi camera. So the picture is caught employing the pi camera and it is shipped off the raspberry pi-2 for handling for face and human identification with the assistance of OpenCV. At that point, the face identified is contrasted and the information base if the human recognized

is known (guest) or not (stranger) and dependent on the yield, the sound yield is delivered and a message is shipped off to the owner.

Paper 2: Low-cost smart security cameras with night vision capabilities with Raspberry Pi and PIR sensors

To provide security, a closed-circuit television (CCTV) reconnaissance framework is being used. The inspection confirmed the plan and execution of easy-to-understand surveillance cameras with night vision using Raspberry Pi (RPI) with PIR. The framework is intended to be used in warehouses. . It has human detection and smoke detection functions, and can provide preventive measures for potential crimes and potential fires. A credit card-sized Raspberry Pi (RPI) with a passive infrared sensor (PIR sensor) can handle moving objects, control alarm algorithms, and send captured pictures to users' emails via Or Bluetooth. As part of its warning frame, it will play a voice: the sound of an intrusion during recognition. The frame uses an ordinary webcam, but its infrared channel has been taken out to have night vision capabilities.

Paper 3: Monitoring system based on motion sensor and facial recognition using Raspberry Pi

An astute reconnaissance framework is a brilliant checking framework that is created from the security perspective. The goal of this task is to build up a framework that screens the zone where it is being carried out. An Intelligent reconnaissance framework is right in the territory where nobody is reasonable to enter; likewise, where we need to distinguish if any movement has been detected. For this, an advanced camera is used. By joining the PIR sensor and camera, this framework can identify the movement. The Camera is used to capture live pictures of the area where the movement was detected. The captured pictures are put away in a specific envelope. The put-away pictures will be then helpful to deal with. As the PIR sensor perceives the movement, it uses a nearly double example histogram (LBPH) and matches his/her face with the information given in the data set. On the off-chance that the face isn't coordinated with the information base, he is unapproved and the buzzer begins to ring along with the message to the owner's device.

Paper 4: Object Detection on Raspberry Pi

Object discovery and the following are essential testing undertakings in various PC applications, for example, reconnaissance, vehicle route, and self-enough robot route. Question recognition includes finding objects in the casing of a video succession. Each strategy requires a question-recognition component, either on each edge or when the protest first shows up in the video. For instance, figuring the measure of a planet(astronomy), distinguishing disease in a mammography scan(medicine), abstaining from controlling into an obstacle(robotics), and identifying a man's eye shading or hair color(security). The goal is to construct a model that can recognize the protest of written shading, that makes use of open-source equipment, and that chips away at the premise of visual information caught from an ordinary webcam that has a reasonable lucidity. Having a picture-preparing calculation that distinguishes a protest first and after that tracks it the length of it is in the observable pathway of the camera. As the protest moves, the PC/portable PC/implanted Board offers a flag to the engine to turn the camera, which is mounted on a stepper engine. The proposed calculation on the Raspberry Pi board was executed using OpenCV on the Linux foundation. It is a proficient protest-following technique.

Paper 5: Intelligent surveillance system using Raspberry Pi and facial recognition

This paper proposes the Smart Surveillance System using Raspberry Pi and Image Processing. This system will serve as a smart security module for monitoring. Traditional surveillance systems only record the activities based on motion, but this system serves the purpose of facial recognition to reduce the error caused due to motion detection. Raspberry Pi camera module is used to capture images once the motion is detected by the PIR Sensor. This system starts monitoring when motion is detected and checks for the faces in the image captured and with the help of face recognition alerts if the face detected is not stored in the database.

Paper 6:Survey Paper on Smart Surveillance System

This article involves the investigation of the intelligent monitoring system using Raspberry Pi. As far as security is concerned, video surveillance is essential. Commercial spaces, schools and hospitals, warehouses, and other challenging indoor and outdoor environments all require high-end cameras. The current technology requires RFID to be too expensive, so the security field has become expensive in general, so it needs to be studied. This article introduces the use of a low-cost stand-alone computer Raspberry Pi. This new technology is cheaper, and in this project, it is used as an independent platform for image processing. It increases the use of mobile technology, thereby providing the necessary security protection for our houses and other control applications. The proposed home security system will capture the information and use the web application Raspberry Pi to transmit it to the smartphone via a 3G dongle.

Paper 7:Enhanced Home Security Using IoT and Raspberry Pi

The ingenious family application highlights the extraordinary help to our daily normal lives. The framework revives the space of the house by adding greater safety highlights, making it develop into a dazzling house. The improvement of the safety perspective provides creative and useful meaning for the way of life. Each of these qualities can be adjusted by using the Internet of Things (IoT) and Raspberry Pi. In savvy home applications, identification problems have always been problematic. Therefore, it is known or concealed to perform conditioning to identify an intruder by using an image preparation process for facial recognition. Usually, this will solve various problems related to authentication. The security tool will notify the homeowner as needed and show what is happening in the customer's home in a reasonable way. The sensor-based framework has many bright spots: it can be widely used. The fire sensor recognizes any temperature expansion in the family room and publishes its status to the URL provided to the customer. The gas sensor helps to identify if there is any gas leak, depending on the power of the gas visible around. With the assistance of the DC motor, the automatic door lock tool is pushed. This is very valuable. All states are handled between the sensor and the owner through IoT. Raspberry Pi is suitable for every market segment and provides appropriate functions for the entire bundle. The

strategy used here is simple. Therefore, even novice users can understand the advanced functions of the system and use them easily. The use of surveillance cameras also helps to identify the presence of flames, so the buzzer will be activated when a fire is detected

Paper 8:Real-Time Face Detection and Tracking Using OpenCV

This paper intends to implement real-time Face detection and tracking the head pose position from high definition video using Haar Classifier through Raspberry Pi BCM2835 CPU processor which is a combination of SoC with GPU-based Architecture. SimpleCV and OpenCV libraries are used for face detection and tracking the head poses position. The experimental result computed by using computer vision SimpleCV and OpenCV framework libraries along with the above-mentioned hardware results were obtained through 30 fps under 1080p resolutions for higher accuracy and speediness for face detection and tracking the head poses position.

CHAPTER 3

AIM AND SCOPE OF THE PRESENT INVESTIGATION

3.1 AIM OF THE PROJECT

To build an IoT-based Anti-theft Flooring System to secure and guard our house in our absence.

3.2 SCOPE OF THE PROJECT

The project focuses on the development of a surveillance system that can detect movement and respond quickly by capturing images and forwarding them to the administrator's device via the Internet platform. The system will require a Raspberry Pi module, vibration detector, motion detection sensor, camera and internet connection. Users can monitor the system from anywhere in the world. However, the project will not attempt to design motion detection equipment, cameras or Raspberry Pi. Instead, it will use these systems and appropriate program scripts to implement the required real-time monitoring system.

3.2.1 Reasons

In the last 30 years, big cities and towns have seen rapid growth in urbanization. This also increases the risk of crime. Recent theft events with Lalitha Jewellery in Trichy and Chennai are not only an example of this rising crime but also a major safety concern that needs to be addressed.

CHAPTER 4

EXPERIMENTAL METHODS, MATERIALS & ALGORITHMS

4.1 METHODS

4.1.1 *The system currently in effect*

The existing system uses a limit switch (electromechanical device) which is operated when a physical force is applied to it by an object. They detect the presence of an object by defining the limit of travel of an object, and as a result, they were named Limit Switch.

4.1.2 *Pain points*

- Less accuracy
- The cost of maintenance is high
- Low flexibility

4.2 Objectives

- The proposed state must provide basic theft protection and loss avoidance
- The system should be able to detect movement (intruder), activate the camera to take video frames after sensing the movement, and then send an alert to the facility owner via email with image attachments.
- A cost-effective surveillance and theft detection system need to be developed using innovative technology.
- The solution should be scalable to support future enhancements.

4.3 Proposed state

The IoT-based Anti-theft Flooring System secures and guards our house in our absence and monitors the entire floor for movement. A single step anywhere on the floor is tracked and the user is alarmed through the mail over IoT. The solution uses Image processing on live video to identify the theft using motion and also features the area where the act had occurred. The captured images are shared with the owners via email and the incident is live-streamed on the owner's device.

4.3.1 Block diagram

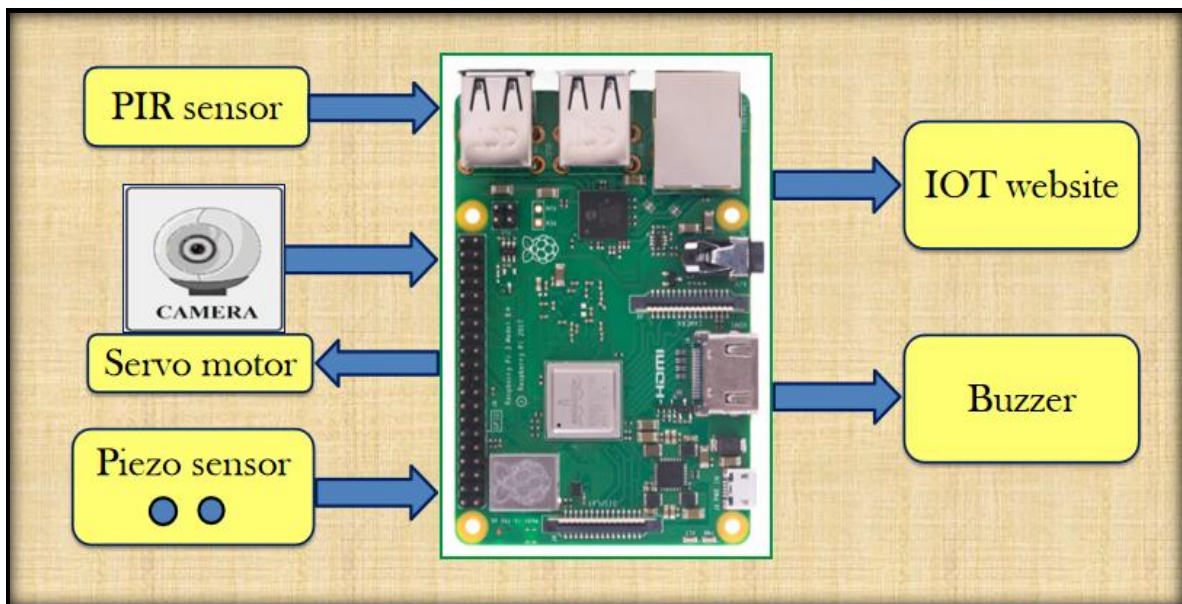


Fig. 4.3.1 - Block diagram

4.3.2 Hardware requirements

1. Microprocessor: Raspberry Pi 3
2. SoC: Broadcom BCM2837
3. CPU: 4 ARM Cortex-A53, 1.2GHz
4. GPU: Broadcom VideoCore IV
5. RAM: 1GB LPDDR2 (900 MHz)
6. Networking: 10/100 Ethernet, 2.4GHz 802.11n wireless
7. Bluetooth: Bluetooth 4.1 Classic, Bluetooth Low Energy
8. Storage: microSD
9. GPIO: 40-pin header, populated
10. Ports: HDMI, 3.5mm analog audio-video jack, 4 USB 2.0, Ethernet, Camera Serial Interface (CSI), Display Serial Interface (DSI)

11. Camera: Raspberry Pi Camera Module
12. Operating System: Raspbian
13. PIR Sensor
14. Vibration Detector
15. Servo Motor
16. Software Requirements
17. Operating System: Linux
18. Coding Language: Python

4.3.3 Experimental setup

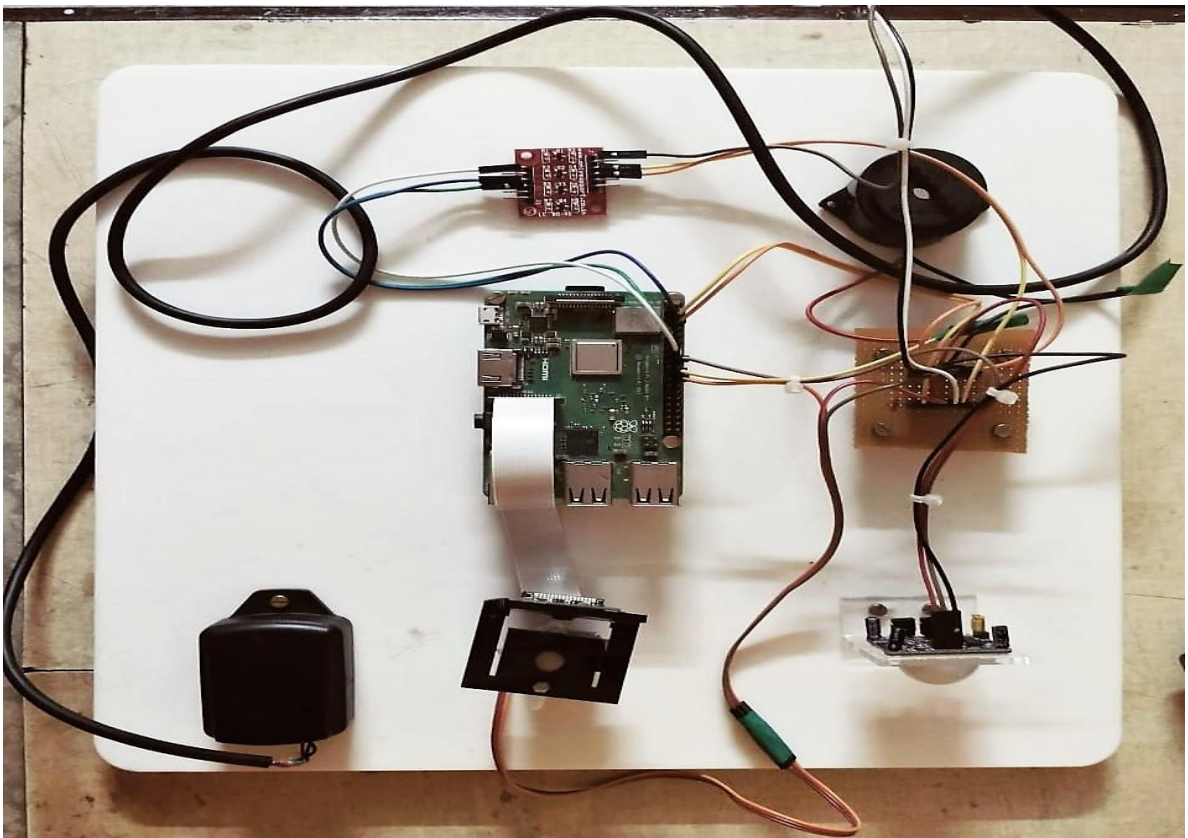


Fig. 4.3.3 - Experimental setup

4.3.4 Proposed System – Operation

1. The flooring tile is connected with IoT and the system is to be turned on before leaving the house
2. The vibration sensor senses the vibrations if a person steps on floor
3. PIR sensor detects the motion of the human using IR
4. These sensors pass on the signal to the Raspberry Pi controller
5. The controller processes it to be a valid signal and the buzzer starts ringing
6. The servomotor rotates the camera (90 degrees until 180 degrees) to the area where the vibration was detected
7. The Rpi camera captures the images
8. The captured images are transmitted to the email account of the owner via the internet

4.3.5 Flow chart

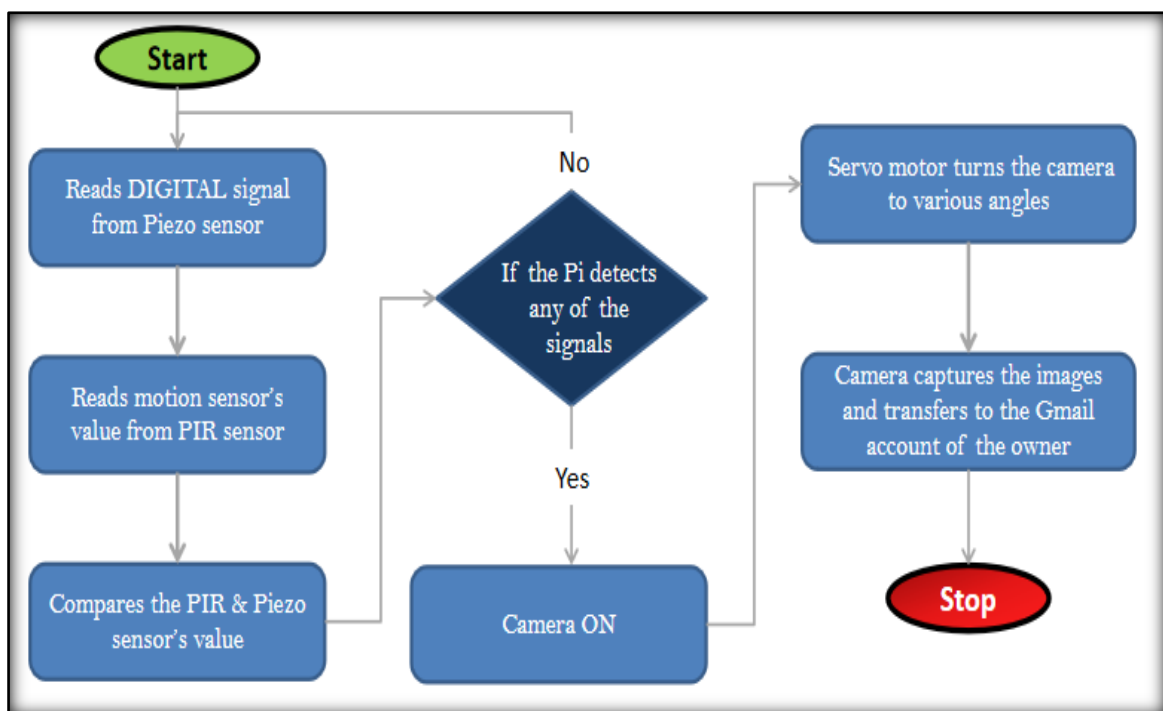


Fig. 4.3.5 – Flowchart

4.4 HARDWARE DESCRIPTION

4.4.1 Raspberry Pi

4.4.1.1 Pin diagram of the Raspberry pi

The Raspberry Pi is a cheap computer that Linux can operate on. There are GPIO (general purpose input/output) pins that control electronic components for physical computing and (IoT) Internet of Things.

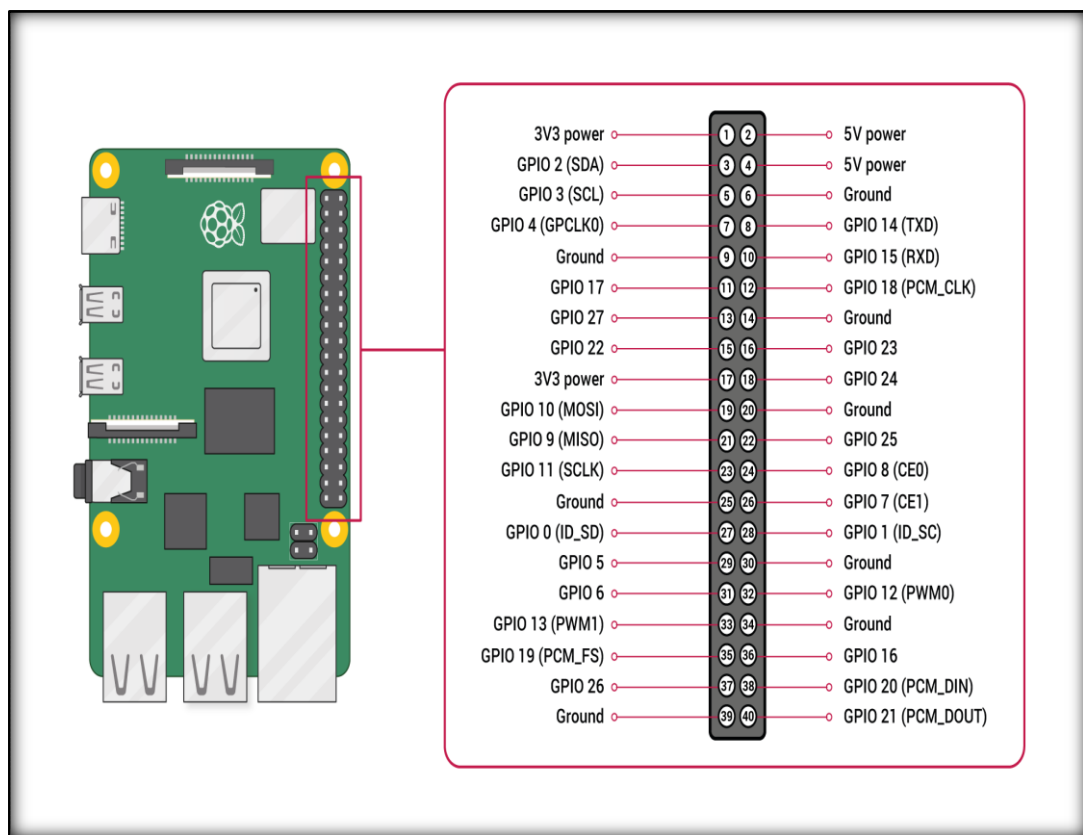


Fig. 4.4.1.1 – Pin diagram of the Raspberry pi

Raspberry Pi model used – Raspberry Pi 3 B+

The Raspberry Pi 3 B+ model is an upgraded version of the B model.

It has the following characteristics:

- 4 USB ports

- 40 pins on the GPIO header
- Improved power supply circuit, can connect and hot-swappable USB devices with higher power.
- The full-size composite video connector of model B has been removed, the function has been replaced with a 3.5 mm audio/video jack, and the full-size SD card slot of model B has also been replaced with another MicroSD slot.

4.4.1.2 Parts of Raspberry Pi

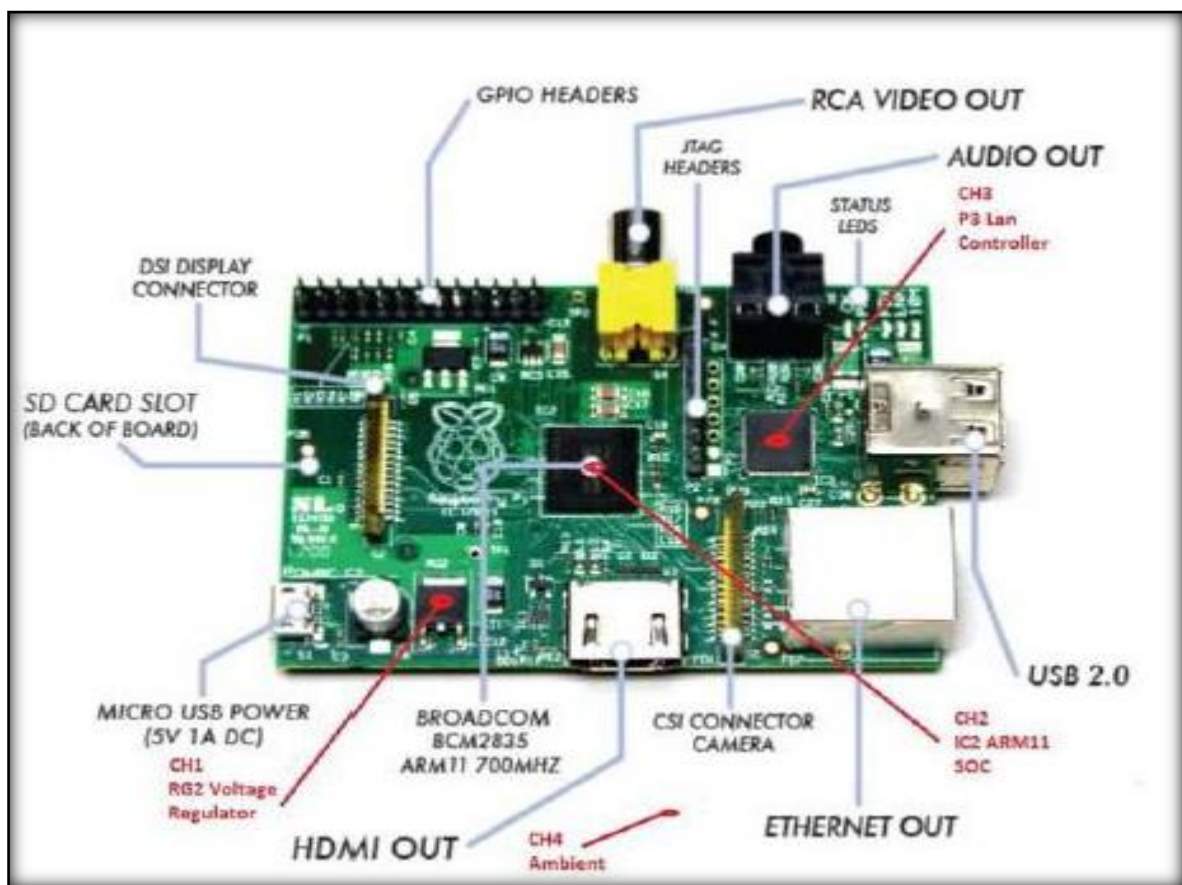


Fig. 4.4.1.2 – Parts of Raspberry Pi 3 B+ model

4.4.2 Piezo vibration sensor

A piezoelectric sensor, also called a piezoelectric transducer, uses the piezoelectric effect to measure changes in pressure, acceleration, temperature, strain, or force by converting these changes into electrical charges. The prefix piezo comes from the Greek word for press or to squeeze. The ability of

piezoelectric material to convert mechanical stress into electrical charge is called a piezoelectric effect. Pressure will be applied to the solid piezoelectric crystal materials, and generate piezoelectricity proportional to the pressure applied.

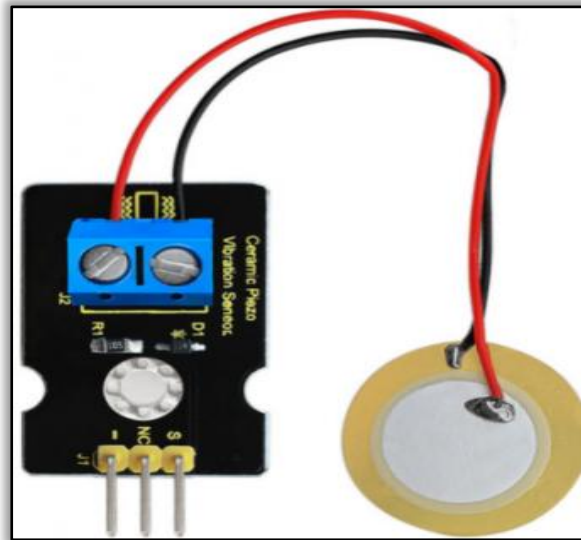


Fig. 4.4.2 - Piezoelectric sensor

4.4.3 PIR sensor (Passive Infrared Sensor)

a. Principle of operation

A single PIR sensor detects a change in the amount of infrared radiation hitting it, which depends on the temperature and surface characteristics of the object in front of the sensor. When a person passes in front of the wall, the temperature at that point in the sensor's field of view will rise from room temperature to body temperature, and then return. The sensor converts the final change of incident infrared radiation into a change in output voltage, thereby triggering detection. Objects with similar temperature but different surface features may also have different infrared emission patterns, so moving them near the background may also trigger the detector. PIR is used as a digital output, so if the pin is flipped high (object detected) or low (object not detected).

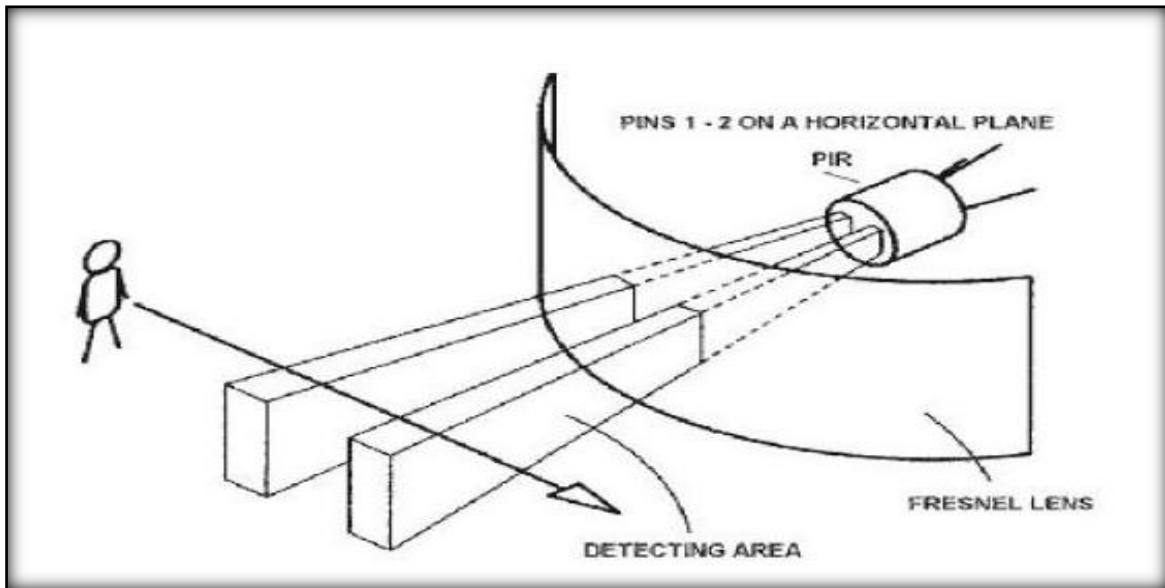


Fig. 4.4.3 a. - Operation of PIR

b. Parts of PIR sensor

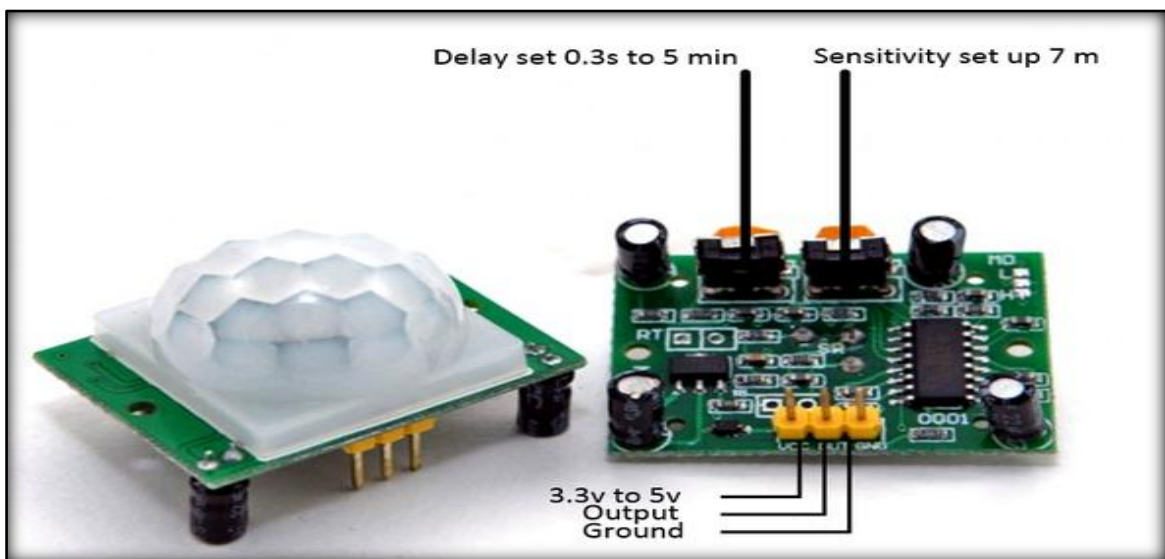


Fig. 4.4.3 b. - Parts of the PIR sensor

4.4.4 Servo Motor

Attach the servo to a GPIO of the Raspberry pi and control its rotation utilizing pulse-width modulation. A 6V battery pack is used to power the servo.

SG90 is a small servo motor that rotates 180 degrees, 90 degrees in each direction. This motor can be controlled by any servo code or library. The motor comes with 3 arms and hardware. The digital servo motor receives and then processes the PWM signal.



Fig. 4.4.4 - Servo motor

4.4.5 Buzzer

A Piezo buzzer is a device that is used to generate beep sound (used generally for indicating a warning or alert in an embedded system). It is a two-legged device with the longer one as positive and the shortest one as negative. The buzzer rings when voltage is supplied to it. The buzzer generates a beep sound in a loop. A melody can be generated when a delay of few microseconds is given. The volume is controlled through analogwrite.

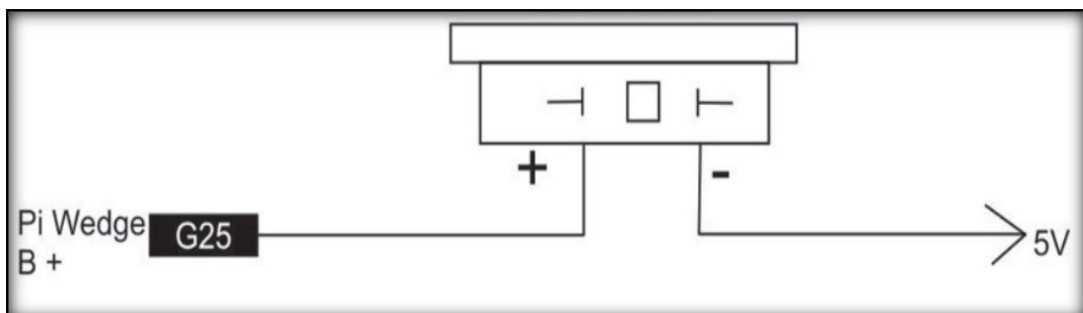


Fig. 4.4.5 - Piezo buzzer

4.4.6 Rpi camera module

The camera board on the Raspberry Pi is a small printed circuit board with a camera. The PCB is connected to a ribbon cable, and the ribbon cable is connected to the Pi itself on its port. The ribbon can be expandable. The camera on the board is very small (5MP camera), capable of capturing high-resolution images. Due to the 250mA current used, the external power supply of the Pi should be sufficient to make the camera work. Specific configuration settings are required to initialize the camera and Python script to enable it to take pictures.

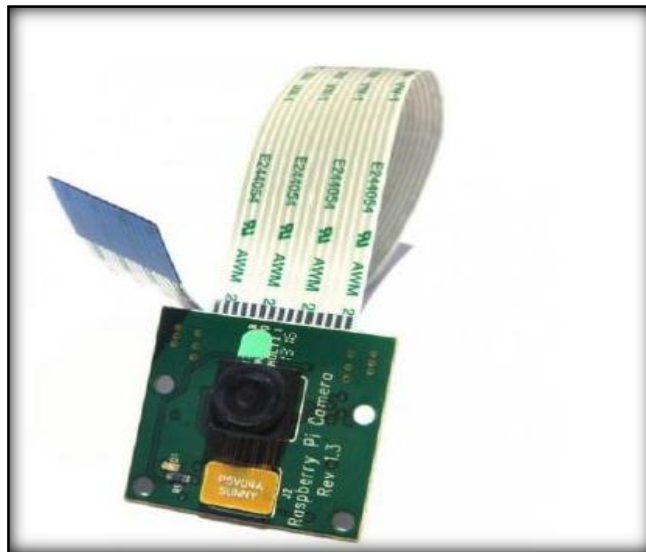


Fig. 4.4.6 - RPi Camera module

4.5 HARDWARE IMPLEMENTATION

In order to use the embedded real-time monitoring system for effective monitoring and alerting, the system must have at least three functions.

They are

- Detection
- Image processing
- Alert mechanism

Detection

Object detection is a computer technology related to computer vision and image processing that deals with detecting instances of semantic objects of a certain class in digital images and videos.

Image processing

Image processing is a method to perform some operations on an image, to get an enhanced image, or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be an image or characteristics/features associated with that image.

Alert mechanism

Devices such as alarms are used to scare an intruder away from the premises or alert the owner of a threatening situation. The parts of an alarm system work together to detect, determine, and deter danger in the home.

4.5.1 Accessing Raspberry Pi Model 3 B+ in windows

This model has the advantages of other models because it has a larger number of USB ports and a large number of GPIO pins. Start the Pi model The Raspbian "Wheezy" picture has been written into a 4GB Micro SD card. The reason for choosing to run this operating system on the Pi is that the operating system has been optimized and ported to the Raspberry Pi ARM architecture. The OS has good integration with hardware, and is pre-installed with GUI and development tools. After inserting the Micro SD card and connecting the RJ45 Ethernet cable to the Pi and a personal computer with Putty software (Putty is an SSH client used to remotely access and control the Pi from a computer running on the Windows platform), the system is powered on. Then start PuTTY and type Pi's default static IP address in the hostname field. When doing this, the Windows pc will be set to manual IP configuration. This will enable it to communicate with the Raspberry Pi.

4.5.2 Set up internet connection on Pi

The internet is required so that Pi can communicate via network protocols and allow the necessary Python packages to be installed.

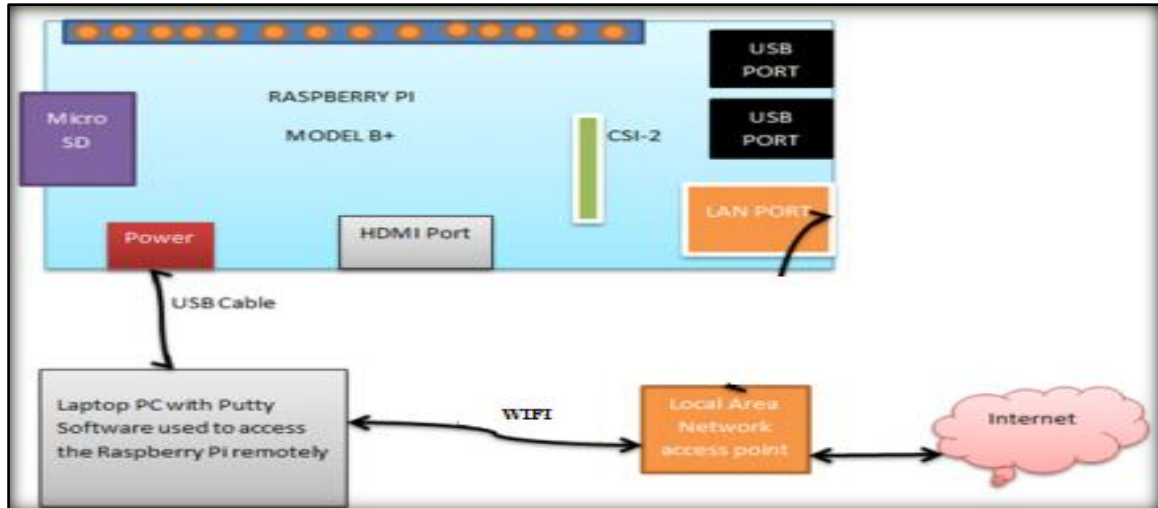


Fig. 4.5.2 – Setting up the internet in RPi

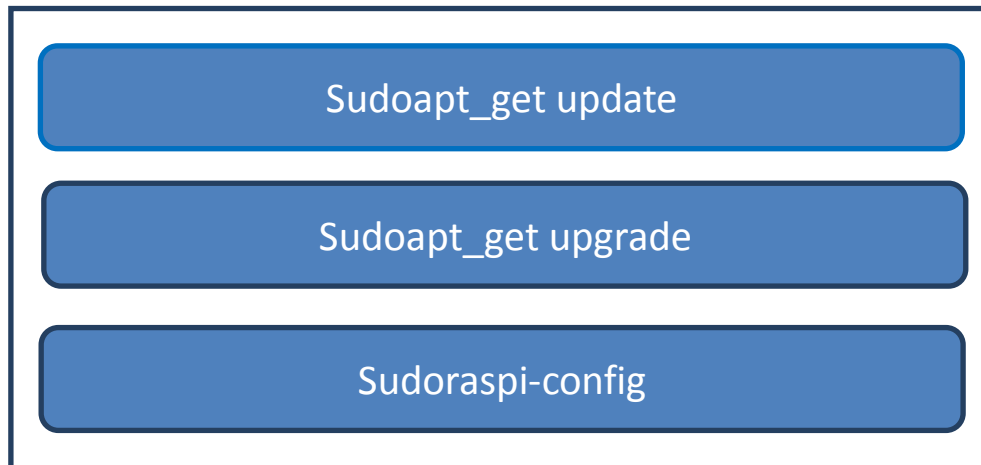
Since the broadcast router uses the Dynamic Host Configuration Protocol (DHCP) to assign IP addresses to the devices connected to it, it is necessary to change the Pi's IP address from static to dynamic. This can be done by editing the network interface file using the following command:

```
Sudo nano /etc/network/interfaces
```

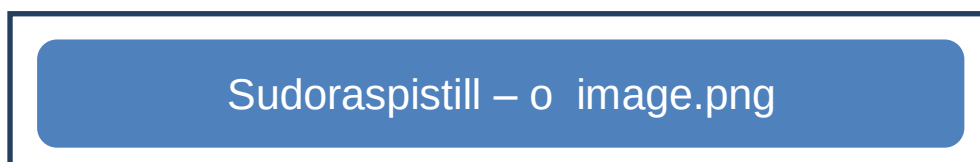
4.5.3 Enable Pi camera

The Rpi camera is dedicated to this floor system (using Raspberry Pi). It is connected to the Raspberry Pi through the CSI-2 electrical port, and it is very fast when transferring data to this port.

The following commands are to be executed at the CLI of the raspberry pi to configure and enable the camera:



After completing these configurations, the system needs to be rebooted. This is done to ensure that the camera has allocated enough space in the memory. The camera shoots 5MP images with a resolution of 1080 x 890. The following commands will be executed to ensure the configuration and functionality of the camera.



By default, this will capture 3 images and save them in a file named image.png.



Fig. 4.5.3 - Raspberry Pi camera module

4.5.4 Set up a passive infrared sensor

This is called prime mover sensor. It is used to control the operation of the entire system. The detection range is about 7 meters × 140 (degrees). It is directly powered by Pi through the 5V DC power supply pin. And the output is connected to the programmable GPIO pin as input

4.5.5 Set up the vibration Sensor

Piezoelectric sensors have two output pins, one with a positive potential and the other with a negative potential (ground). The positive potential pin is connected to the Vcc and the negative potential pin is connected to the ground. A resistor of 2 megaohms connected between them for protection. A led connected to digital pin zero to check the working of sensor output. We don't want the sensor to be activated for vibrations less than the threshold, accordingly a threshold value of '100' is assigned to the circuit. Using this, we can eliminate unwanted small vibrations. When the output voltage generated by the sensor element is greater than the threshold value the LED changes its state i.e. if it is HIGH, it goes to LOW. If the value is lower than the threshold, LED doesn't change its state and remains in its previous state.

4.5.6 Set up the servo motor

The next step is to integrate the Servo Motor with Raspberry Pi. A Servo Motor is a simple device that consists of a DC Motor, Gears, and a feed back based Position Control System. The primary advantage of a Servo Motor is its ability to maintain the angular position of its shaft.

To control a Servo Motor, a technique called the Pulse Width Modulation or PWM is implemented. A pulse of variable width is sent and accordingly the position of the Servo Motor's shaft will be determined by the width or length of the Pulse. The frequency of the PWM signal is a fixed value which is assigned based on the type of the Servo Motor. SG90 Servo Motors have a PWM frequency of 50Hz. At 50Hz i.e. at a period of 20ms, the minimum pulse width is 1ms and the maximum pulse width is 2ms. Servo motors typically have a swept area of 180 degrees i.e. 90 degrees on both sides, away from the neutral position.

4.6 SOFTWARE DESCRIPTION

4.6.1 Program the Raspberry Pi

The Raspberry Pi must be programmed using an appropriate programming language to communicate with other devices. These languages include Java, FORTRAN, Pascal, Python, C, C++, etc. Every language has its grammar and semantics. Rpi can be programmed in any of these languages, but the Python programming language is used in this project to get the best results.

a. Hardware design

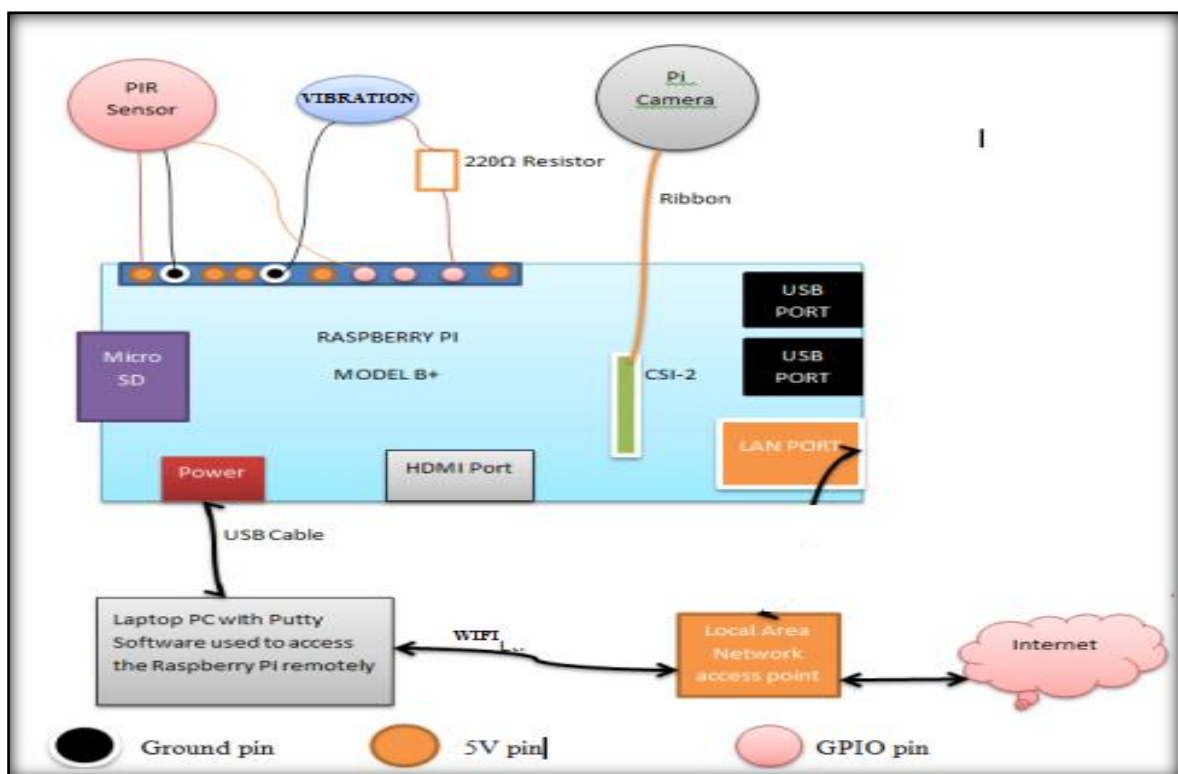


Fig. 4.6.2 a. – Hardware design

b.Design Software

The following flow chart is used to design and document the safety floor system project. It illustrates a series of events from the intrusion to the alarm. The algorithm is implemented using Python scripts.

Flowchart:

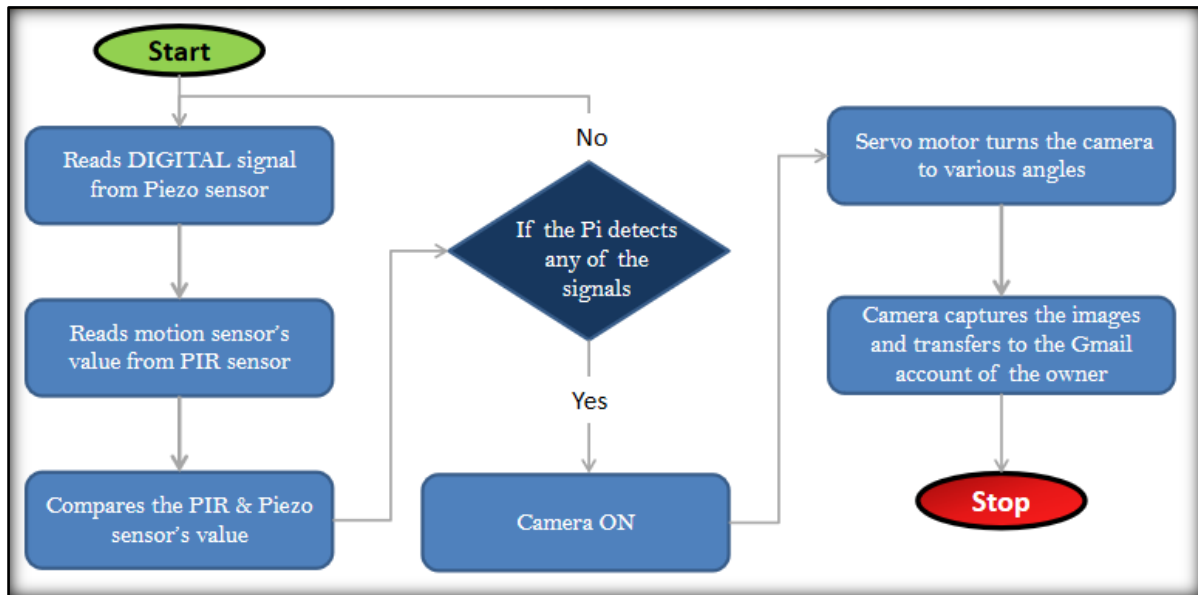


Fig. 4.6.2 b. - flowchart

Flowchart implementation of the security system involves System's initialization and configuration.

The following sequence of steps is implemented to obtain the output:

Import Python libraries and packages:

These libraries are predefined and help to make the interface module work properly.

Pi Camera setting and configuration:

GPIO settings and pin initialization:

Set the channel by using the BCM channel number. The pin channel of passive infrared, vibration sensor and servo motor is set to read mode, while the led channel is set to drive/write mode.

a. Reading channel

Read the value of any GPIO pin-GPIO.input (channel)

b. Drive channel

The channel that drives the GPIO pin-GPIO.output (channel, status)

Generate and send email:

After the system is configured to send alerts to predefined subscribers, emails must be generated and sent. Then, the Multipurpose Internet Mail Extension (MIME) package will be invoked and used to generate attachments. MIME supports characters other than ASCII, non-text attachments (audio, video, and applications), etc. Therefore, MIME extends the format of e-mail. The Simple Mail Transfer Protocol (SMTP) program is used to deliver emails from the Raspberry Pi to the configured mail center.

4.6.3Pseudocode

1. Upon restarting the system, send out an email with the boot IP assigned to a mail host.
2. Check the status of the GPIO pin. If the pin is LOW, GPIO output pin 13 should remain LOW and the system should be idle. Otherwise, the pin suddenly goes HIGH and interprets this as an interrupt.
3. While the value of the input GPIO pin is HIGH (interrupt event), set pin 13 to be HIGH. Call the function that starts the Pi Camera.

4. The system checks whether the internet is enabled on the Raspberry Pi.
5. Camera rotates and spontaneously live streams the incident.
6. If the internet is available, it sends an email to a prescribed mail host. In case of no internet, wait for 5 seconds then check again. Reset the PIR sensor's pin to LOW and recheck the status after 2 seconds. This should return the program to the main loop.

4.6.4 Steps to develop the Full Code Listing

In order to develop a Python script that executes the algorithm defined in the flowchart, the following process is performed on the CLI of the Raspberry Pi:

1. Start the Pi and use the mkdir command in the directory to create a directory.
2. Use the touch command to create a file, and use sudo chmod + x (file name) to set it as an executable file.
3. Then, use the nano command to open the editor and write the complete Python code in it. 4. Then use the following command to execute the script:



```
Sudo python filename.py
```

4.7 SOFTWARE IMPLEMENTATION USING THE VNC VIEWER

4.7.1 VNC (Virtual Network Computing)

VNC is a graphical desktop sharing system where the desktop interface of one laptop (running VNC Server) can be managed remotely from another laptop or mobile device (running VNC Viewer). VNC Viewer transmits the keyboard and mouse/ touch events to the VNC Server and receives updates to the screen. The desktop of the Raspberry Pi i can be viewed from a computer or mobile device is

seen and it can be controlled as though it was being worked on the Raspberry Pi itself.



Fig 4.7.1 – VNC viewer

VNC Connect from RealVNC is included with Raspberry Pi OS. It consists of both VNC Server (control the Raspberry Pi remotely) and VNC Viewer (control desktop computers remotely from the Raspberry Pi).

4.7.2 Instructions to enable VNC server

By default, VNC Server gives remote access to the graphical desktop that is running on the Raspberry Pi. However, the VNC Server can be used to gain graphical remote access to the Raspberry Pi if it is headless or not running a graphical desktop.

Installing VNC:

VNC can be installed on the full Raspberry Pi OS 'Recommended Software' from the Preferences menu.

Enabling VNC:

This can be done graphically or at the command line.

1. *Enabling VNC Server graphically:*

- On the Raspberry Pi, boot into the graphical desktop.
- Select **Menu > Preferences > Raspberry Pi Configuration > Interfaces**.
- Ensure **VNC** is **Enabled**.

2. *Enabling VNC Server at the command line:*

VNC Server can be enabled at the command line using **raspi-config**:

“sudo raspi-config”

- Navigate to **Interfacing Options**.
- Scroll down and select **VNC > Yes**

4.7.3 Connecting the Raspberry Pi with VNC Viewer

Establishing a direct connection

- On the Raspberry Pi (using a terminal window or via SSH) use **these instructions** or run `ifconfig` to discover the private IP address.
- On the device download VNC Viewer and enter the Raspberry Pi's private IP address into VNC Viewer:

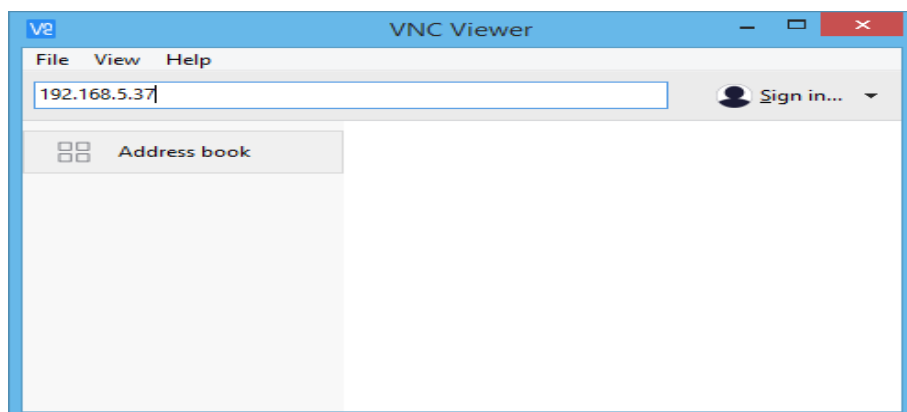


Fig 4.7.3 Discovering RPi's private IP address

4.7.4 Authorize the VNC Server

To complete the direct connection, authenticate the VNC Server.

When connecting from the **compatible VNC Viewer app** from RealVNC, enter the user name and password that would normally be used to log in to the user's account on the Raspberry Pi. By default, these credentials are `pi` and `raspberry`.

Create a virtual desktop

If the Raspberry Pi is headless (i.e. not plugged into a monitor) or controlling a robot, it is unlikely to be running a graphical desktop.

VNC Server can create a virtual desktop allowing graphical remote access on demand. This virtual desktop exists only in the Raspberry Pi's memory:

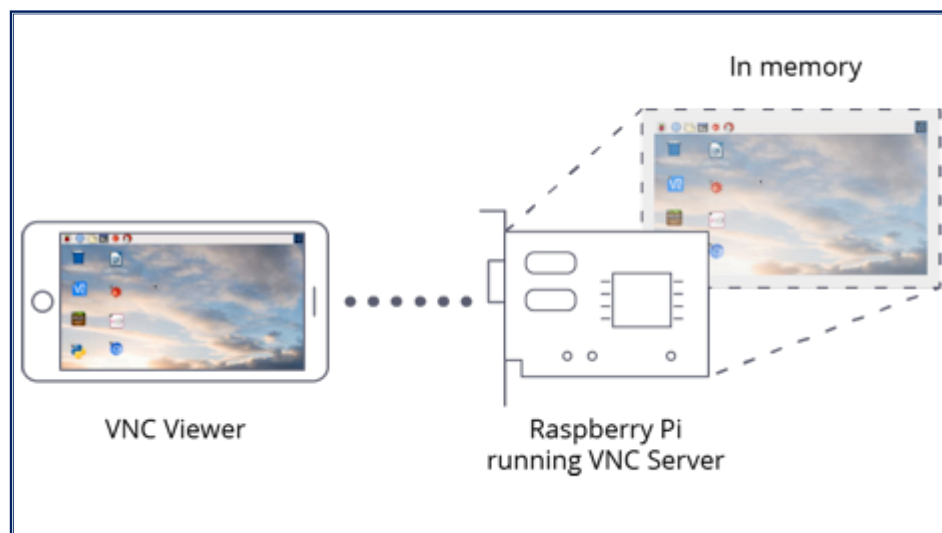


Fig. 4.7.4 - Creating a virtual desktop

To create and connect to a virtual desktop:

- On the Raspberry Pi (using Terminal or via SSH), run `vncserver`. Make note of the IP address that the VNC Server will print to the terminal (e.g. `192.167.5.149:1`).

- Enter this information into the VNC Viewer of the device to take control.

The following command is run to disable the virtual desktop:

“vncserver –kill :<display-number”

This will also stop any existing connections to this virtual desktop.

4.7.5 Operation of the device after software implementation

The programs are run in the VNC viewer and the images are sent to the email account of the owner when vibration or motion is detected. Also, the live video is streamed on the owner’s device in case of a vibration/movement.

CHAPTER 5

RESULTS, DISCUSSIONS AND PERFORMANCE ANALYSIS

5.1 Assembling of hardware components

Step 1:

a. Piezo sensor

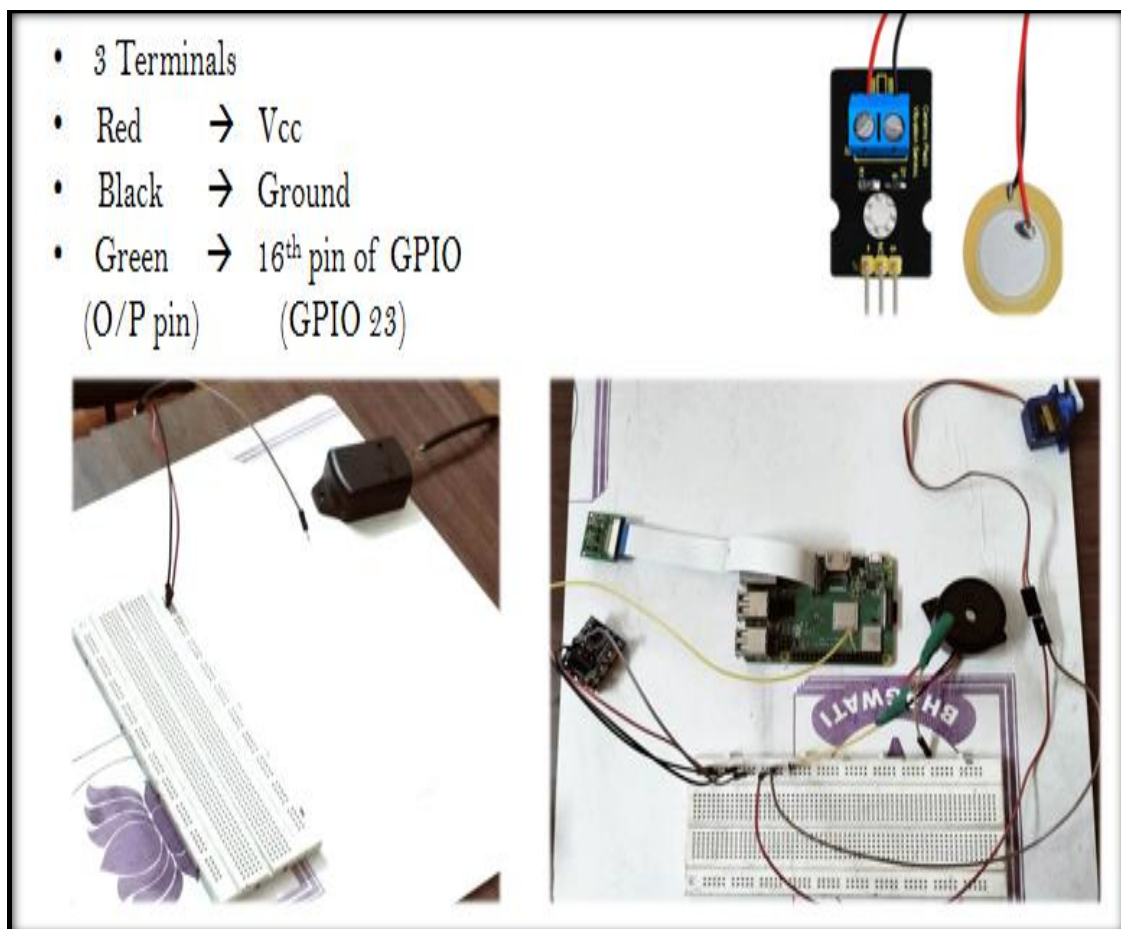


Fig. 5.1 a. - Piezo sensor

Step 2:

b. PIR sensor

- 3 Terminals
- Red → V_{cc}
- O/P pin → 18th pin of GPIO
(GPIO 24)
- Black → Ground

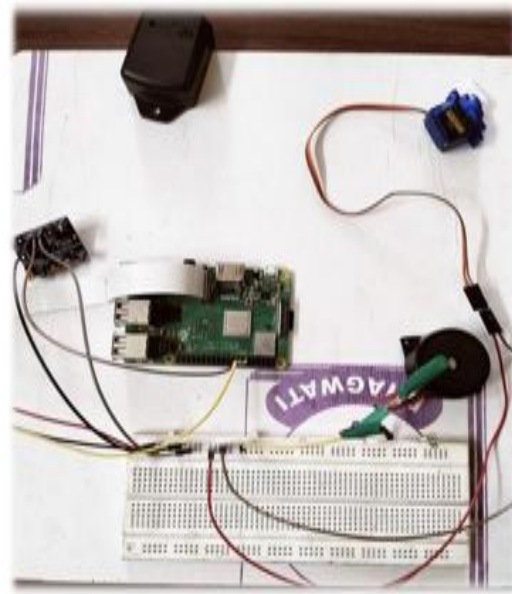


Fig. 5.1 b. - PIR sensor

Step 3:

c. Servo motor

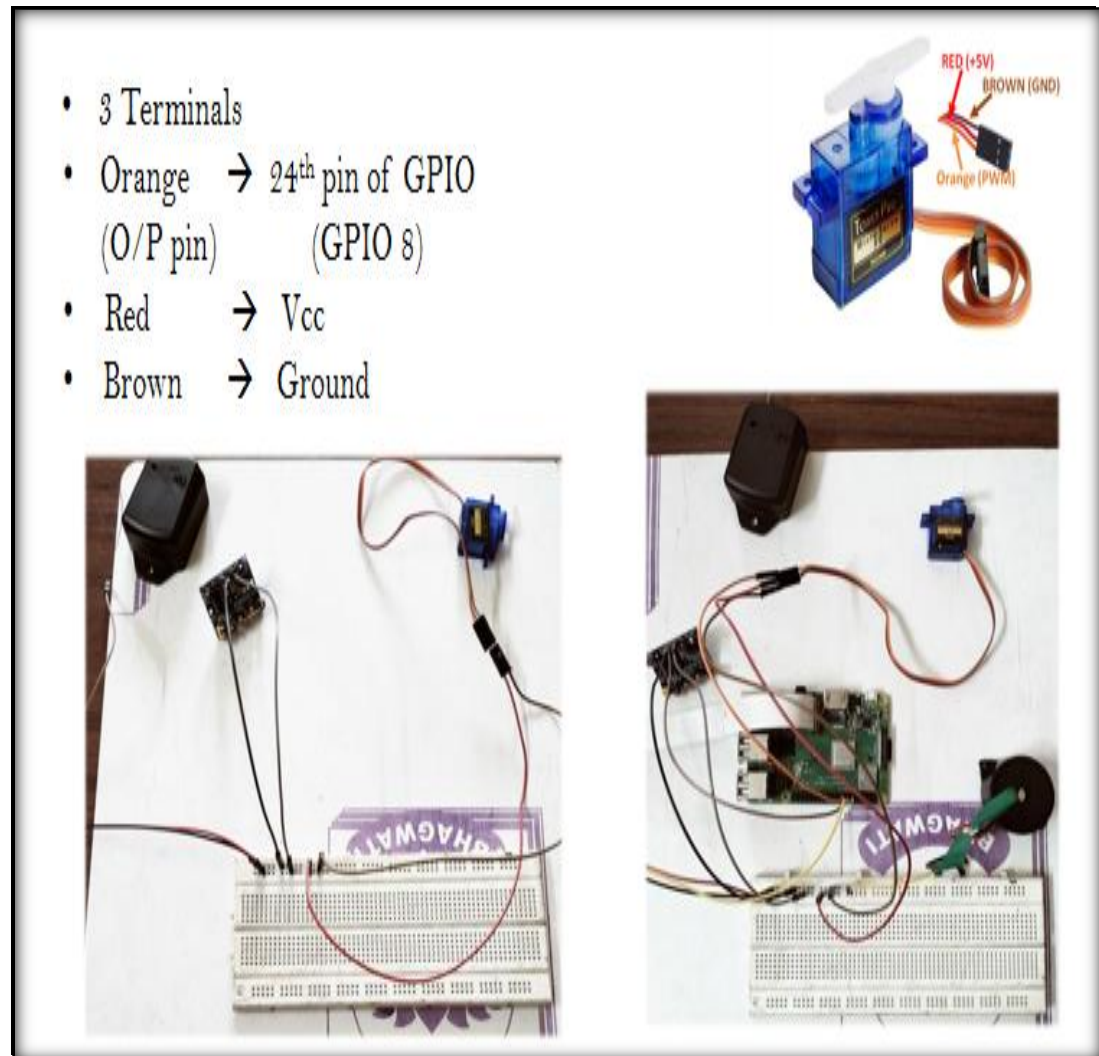


Fig. 5.1 c. - Servo motor

Step 4:

d. Buzzer

- 2 Terminals
- Red → 22th pin of GPIO
(GPIO 25)
- Black → Ground

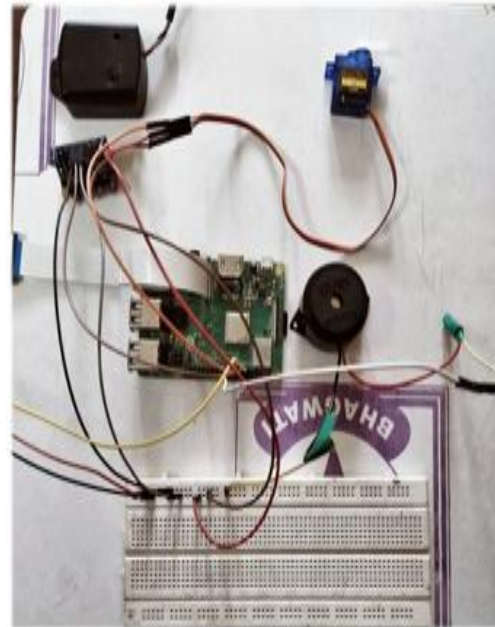


Fig. 5.1 d. - buzzer

5.2 Hardware setup

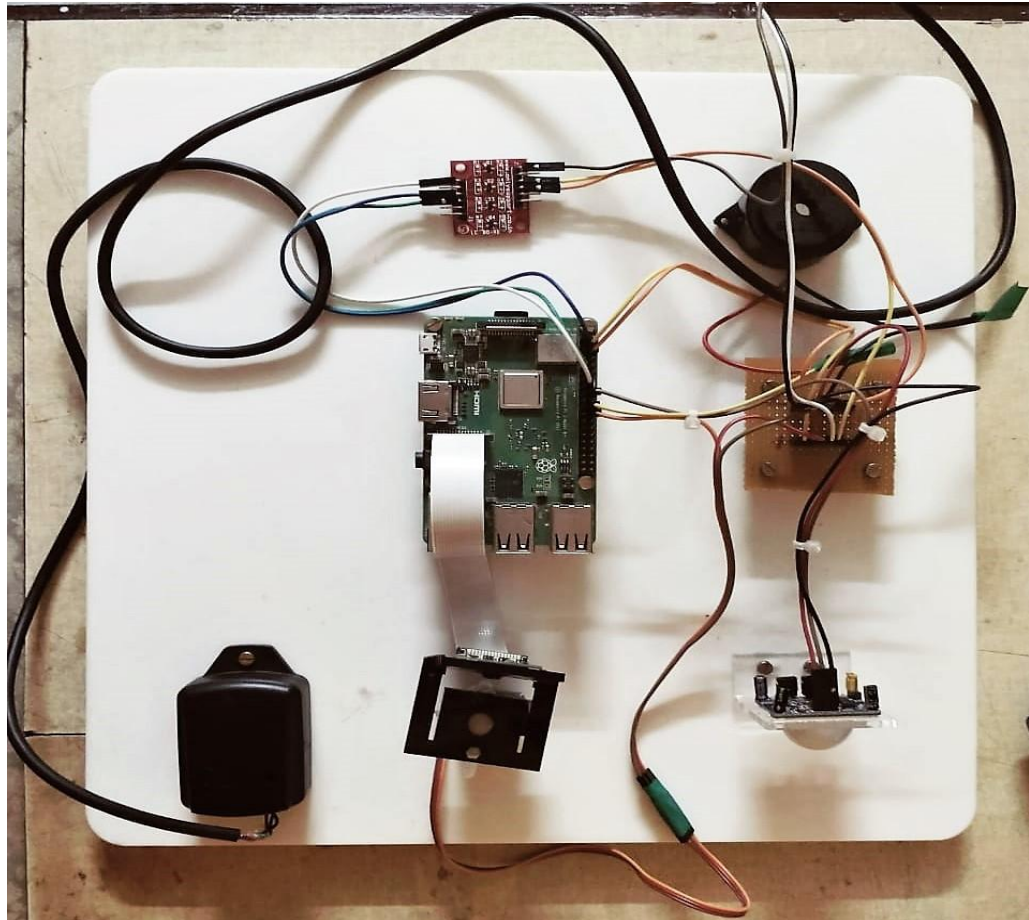


Fig. 5.2 Hardware setup

5.3 Software implementation using the VNC viewer

VNC (*Virtual Network Computing*)

VNC may be a graphical desktop sharing system that allows you to remotely manage the desktop interface of 1 laptop (running VNC Server) from another laptop or mobile device (running VNC Viewer). VNC Viewer communicates the console and either mouse or contact occasions to VNC Server and gets updates to the screen. The desktop of the Raspberry Pi inside a window of a computer or mobile device is seen and it can be controlled as though it was being worked on the Raspberry Pi itself. The programs are run in the VNC viewer and the images

are sent to the email account of the owner when vibration or motion is detected. The live video is streamed on the owner's device in case of a vibration or movement.



Fig 5.3 – VNC viewer

The programs are run in the VNC viewer and the images are sent to the email account of the owner when vibration or motion is detected. The live video is streamed on the owner's device in case of a vibration or movement.

5.4 Results

5.4.1 Output

a. *Experimental setup – with VNC viewer application*

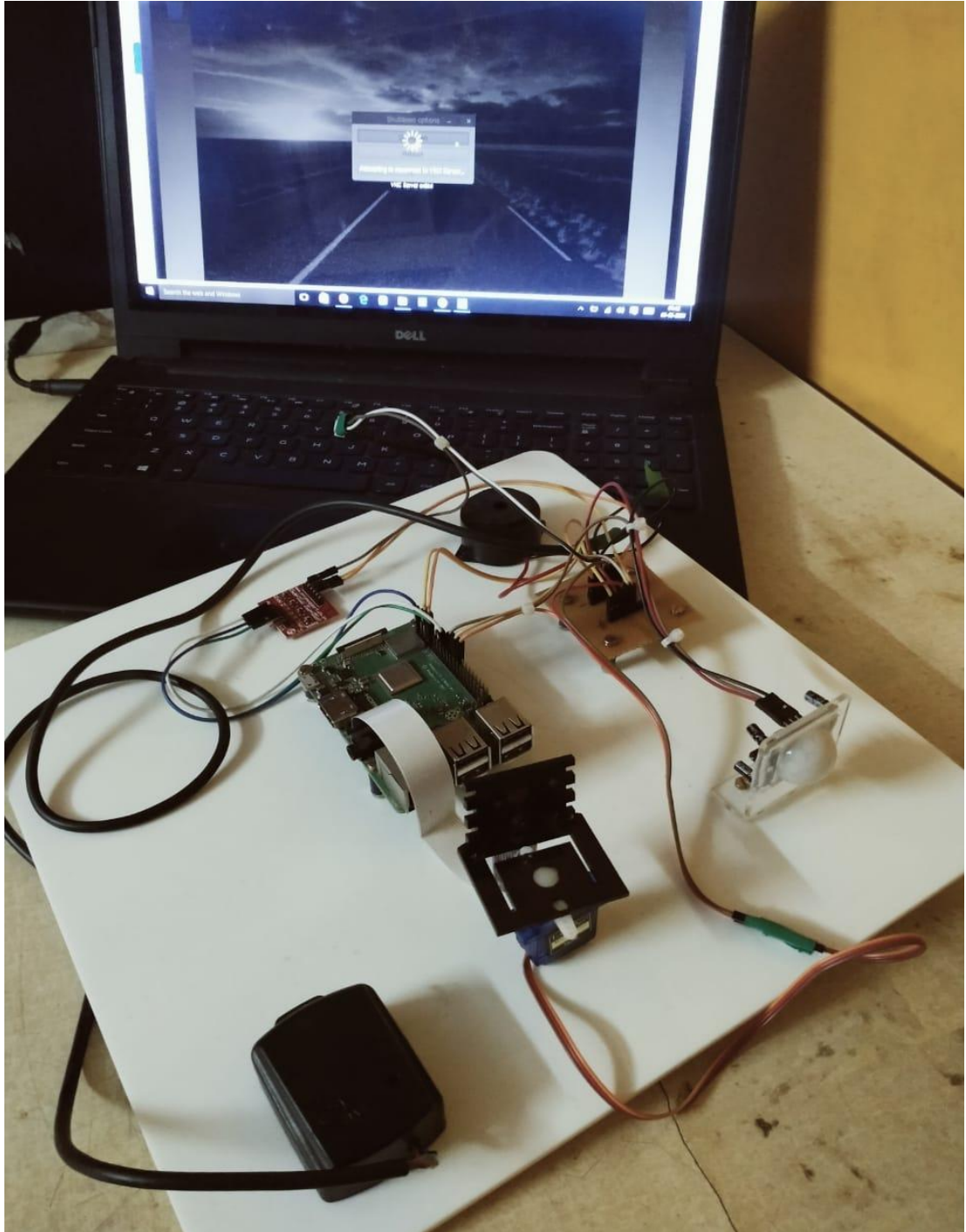


Fig. 5.4.1 a. Experimental setup – with VNC viewer application

b. email notification on the owner's device once the movement or vibration was detected

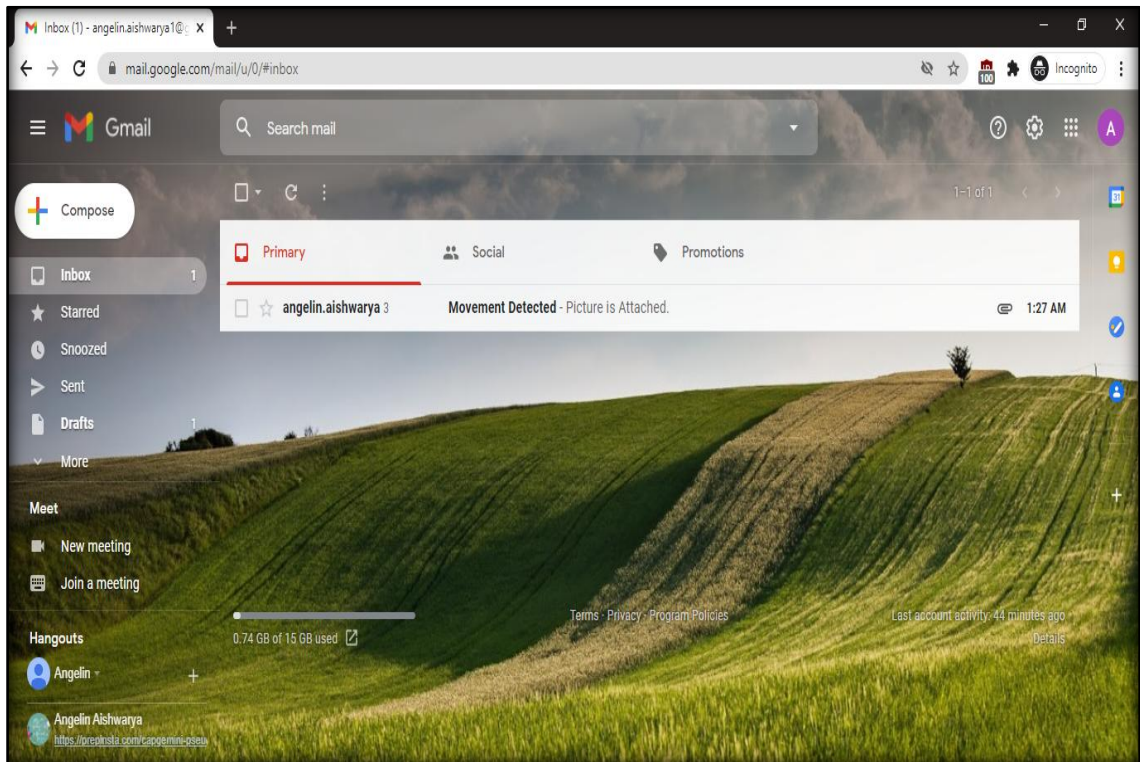


Fig. 5.4.1 b. email notification on the owner's device when the movement or vibration was detected

c. Image attachments received once the movement or vibration was detected

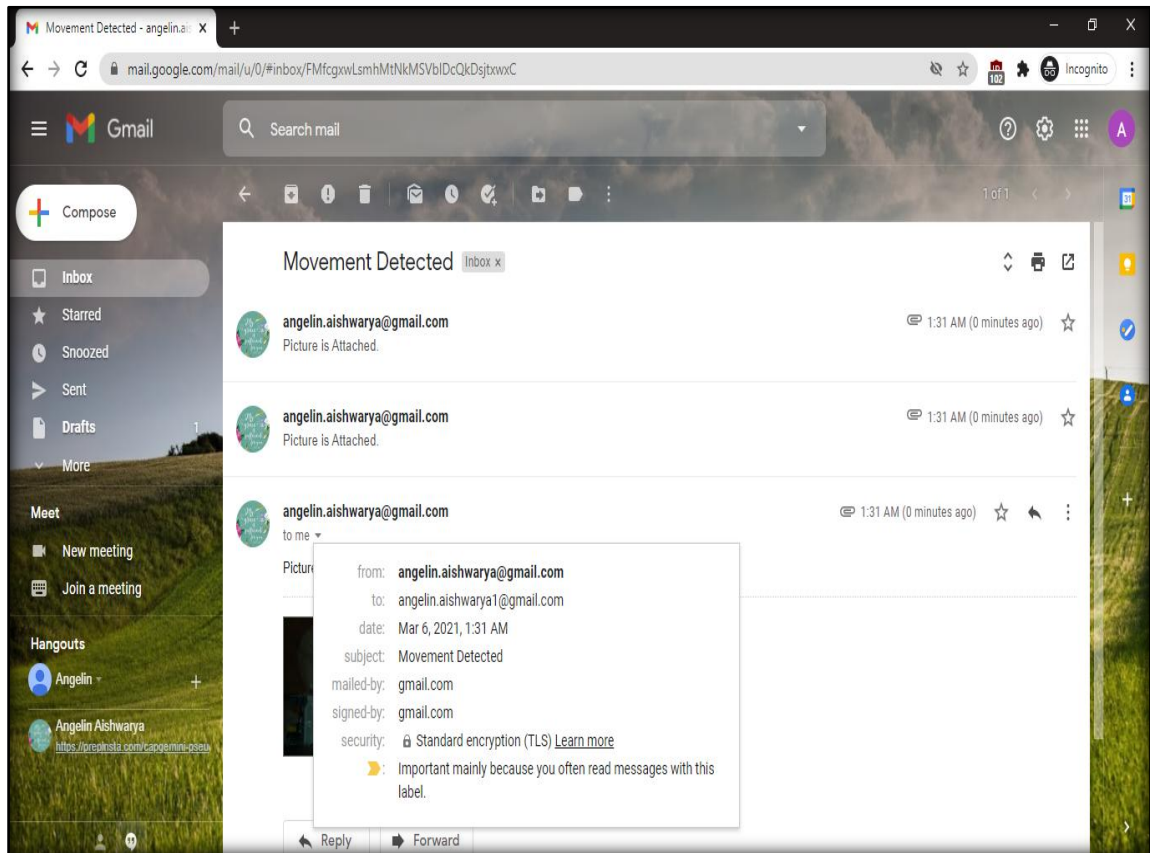


Fig. 5.4.1 c. Image attachments

d. Image attachments till 360 degrees

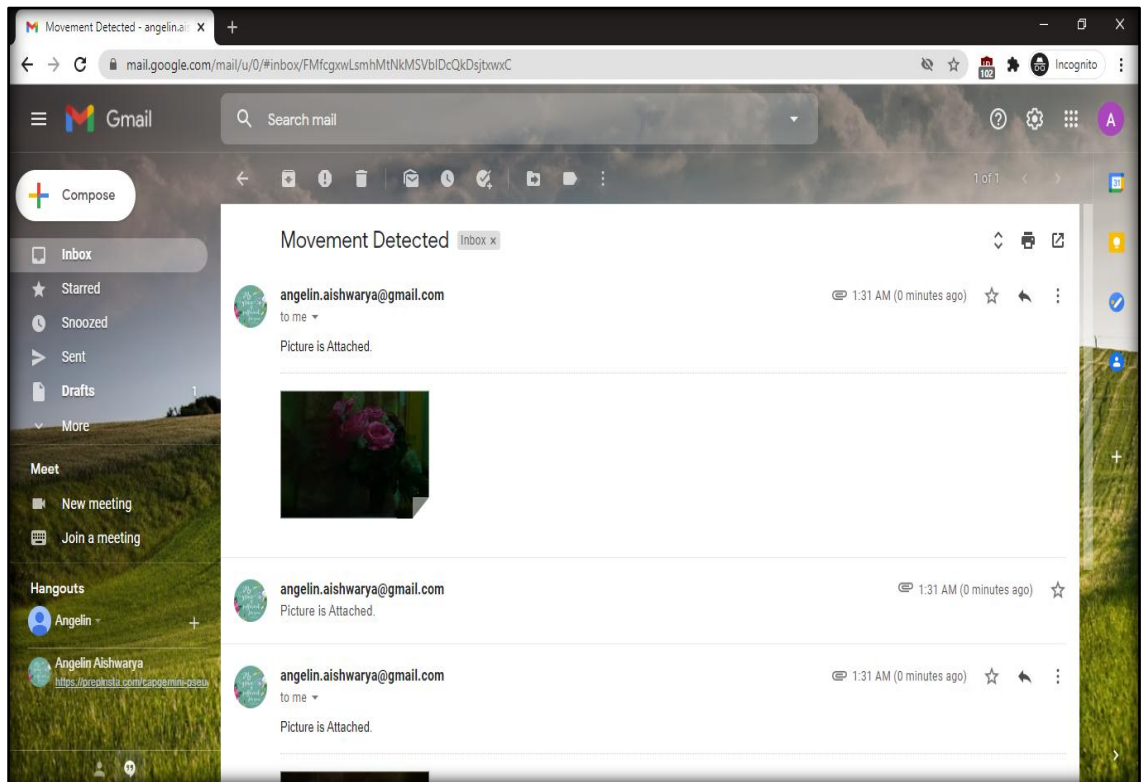


Fig. 5.4.1 d. Image attachments till 360 degrees

e. Image captured by the Rpi camera when the servo motor is at 90 degrees

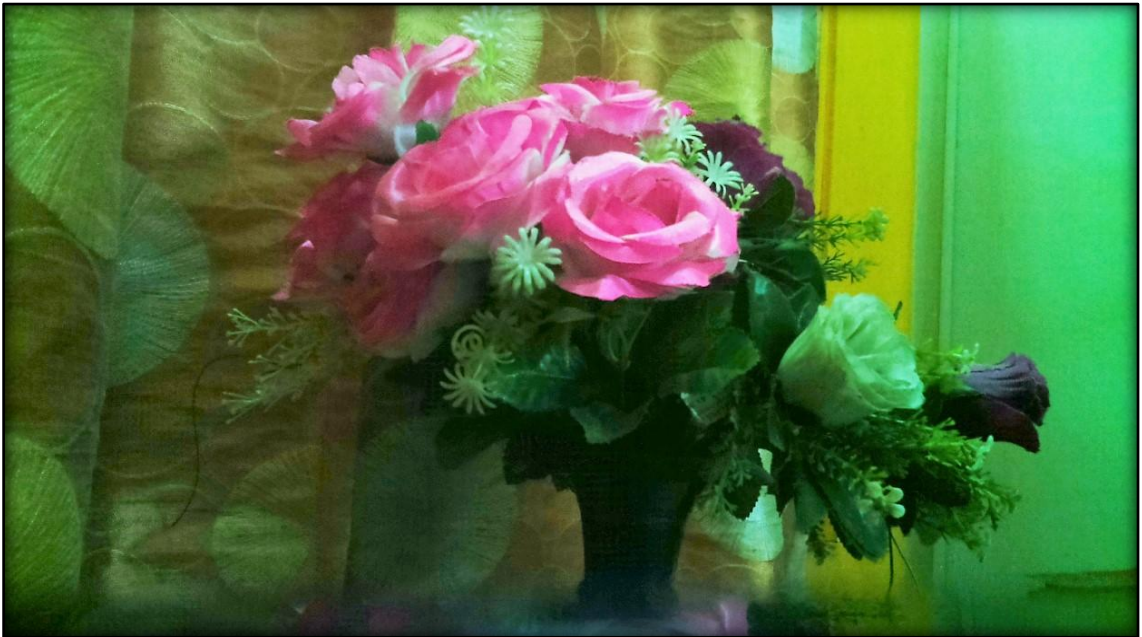


Fig. 5.4.1 e. image captured at 90 degrees

f. Image captured by the Rpi camera when the servo motor is at 0 degrees

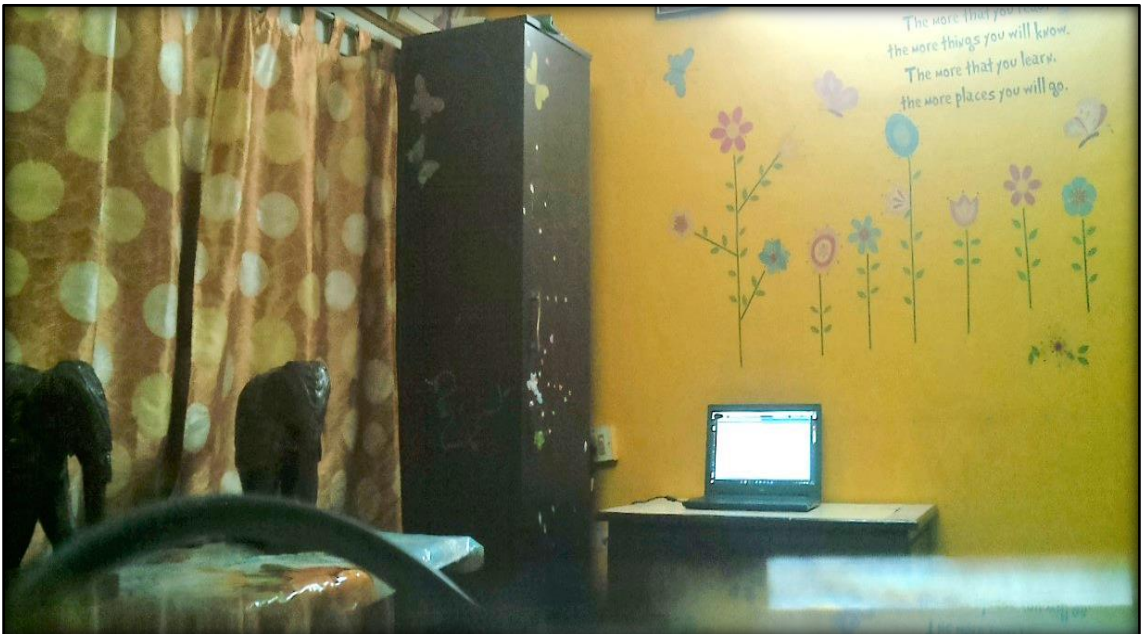


Fig. 5.4.1 f. image captured at 0 degrees

g. Image captured by the Rpi camera when the servo motor at 180 degrees



Fig. 5.4.1 g. image captured at 180 degree

h. Images stored in the database of the VNC viewer for the owner's reference

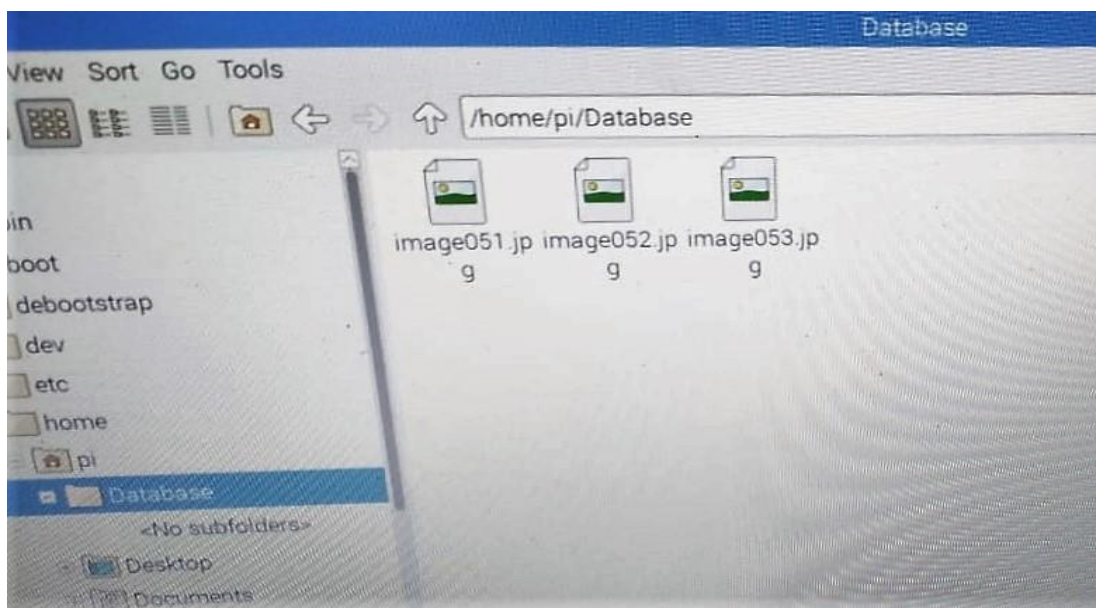


Fig. 5.4.1 h. Images stored in the database for the owner's reference

i. Image of the live-streamed video

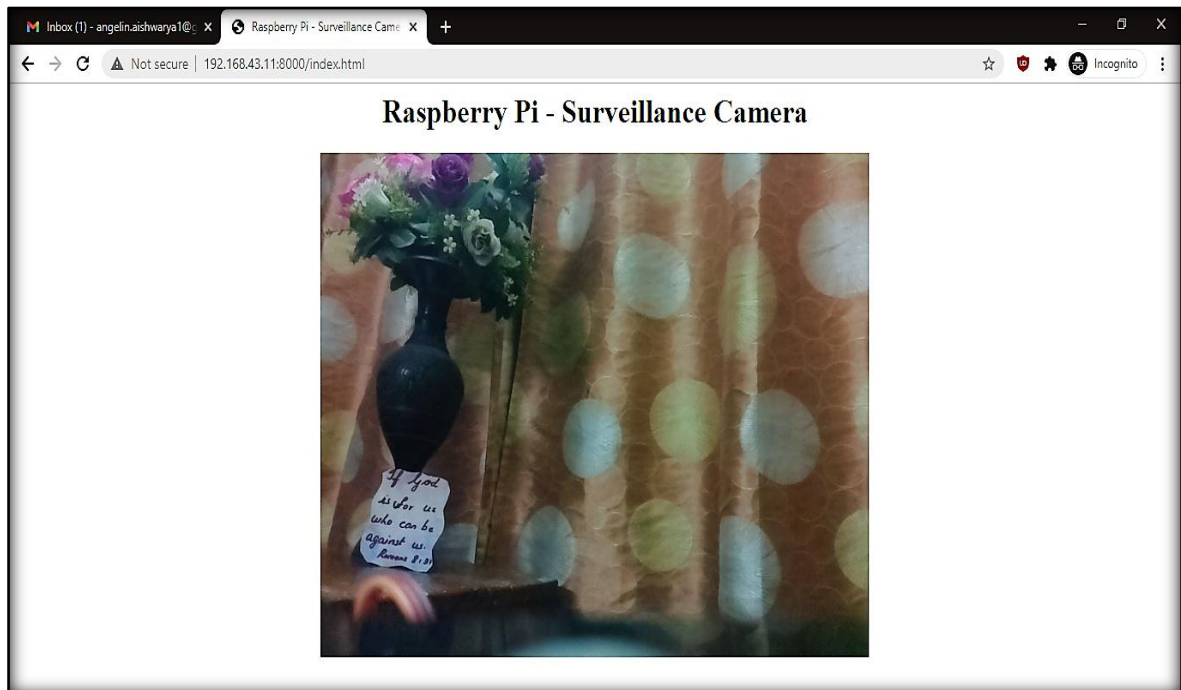


Fig. 5.4.1 i. Image of the live-streamed video

CHAPTER 6

SUMMARY AND CONCLUSION

6.1 SUMMARY

6.1.1 Pros, Cons, and Applications of the proposed state

Pros:	Free from hacking Requires less electricity so the power charge is less
Cons:	The monitoring system must be checked frequently Replacing devices in case of damage
Applications:	Jewellery shops Museums Bank locker rooms Home security

6.2 INFERENCE

- This system serves as the solution for theft detection and acts as a potential loss avoidance tool
- It is scalable
- Risk mitigation control in case of unforeseen or unpredicted difficulty
- Images captured provides critical tools (supporting evidence) for further investigation
- Any extra-human work is ruled out
- The higher the sensitivity of the sensor, the larger the detection range. PIR sensors and vibration sensors are used as the first line of defense. All other modules only depend on the GPIO pin of the PIR to go high. Once the movement is detected, the images are captured and sent to the email account of the host through SMTP protocol.

6.3 EXTENDED SCOPE

- Additional sensors along with Artificial Intelligence(AI) for accurate object detection can be implemented to the proposed system - AI implementation.
- Automatic door locking system with supported technology (smart lock system) for exception scenarios.
- Drone helps in identifying and recording the movements of the intruder if he flees.
- Processing large files (for example, file size) requires significant improvements in system processor speed. Video for effective motion detection and tracking.

6.4 SAFETY SYSTEM RELATED WORK RECORDS

Nowadays, analysts and engineers have built a wide range of observation frames for remote inspections—just like controlling errands through a reasonable and easy-to-implement equipment frame to send out alarms. So far, some have been approved, while others are still recommended. Padmashree A. Shake and Sumedha S. Borde introduced a plug-in home reconnaissance framework for investigating the execution of clever, shocking frameworks that rely on few moving positions. They are responsible for implementing moderately low-cost use, well-used assets, and a proficient reconnaissance framework using a large number of different sensors. Their framework facilitates continuous inspection of family activities from anywhere and relies on microcontrollers, which are now regarded as a restricted asset and an open source arrangement compared to SBC.

D. Jeevanand handled the work of planning an organized video capture framework using Raspberry Pi. The proposed framework eliminates the hassle of using the organizational framework to record videos and advertisements, except for warning organizations to use SMS alerts based on customer needs. Their framework is designed to work continuously under any circumstances and relies on Raspberry Pi SBC. When distinguished from other implanted frameworks, their continuous application provides customers with video screens with the help

of the warning module and the SBC stage. Sneha Singh and his team used Raspberry Pi to innovatively depict the IP camera video surveillance framework. Experts pointed out to build a framework that can capture continuous pictures and display them in the program using TCP/IP. The calculation of face discovery is performed on the Raspberry Pi, which supports video-based real-time video and the position of the face. The survey did rule out any reconnaissance response. Mahima F. Chauhan and Charge Anuradha provided plans and built a continuous video observation framework that relies on the implanted web worker Raspberry Pi B + Board. Their framework is easy to use, has high transparency and versatility, and is not difficult to keep up and redesign. Therefore, this application framework provides better security arrangements. This framework can be used to influence the security of financial halls, industries, climate and military expressions. Jadhav G. J conducted an evaluation in 2014, using different sensors, remote modules, microcontroller units, and acupuncture modules to define and implement a shrewd reconnaissance framework. He and his team acquired an ARM center as the prerequisite processor for the framework. The PIR sensor is used to recognize movement in the visual area, while the vibration sensor is used to detect any vibration conditions (such as cracking sound). The intruder identification method is proposed by using the PIR sensor, which distinguishes movement and triggers a reminder for a predetermined phone number and the arrangement of sending a short message through the GSM module. Their work can be highlighted by receiving various requested information bases, so that it will be more secure and difficult to crack.

In 2014, Sanjana Prasad and his colleagues relied on Raspberry Pi's SBC and motion detector PIR to establish a multi-functional and keen reconnaissance framework. Their progress supports compact innovation, and provides essential benefits for our daily life and family safety and even control usage. Their research goal is to establish a portable mobile phone home security framework that relies on a data capture module, combined with a delivery module that relies on 3G innovation and integration with Web applications. The SBC will control the PIR sensor to perform occasions and work on the camcorder for video, real-time and recording activities. Their framework can include the number of items in the scene. Uday Kumar used the Raspberry Pi to handle a labor-saving, remote, and

out of reach reconnaissance framework. Conventional remote CCTV cameras are usually used for the observation frame, requiring little or no effort. He and his team used a camera with a Raspberry Pi to achieve a minimal workload and a secure observation frame, and must use a 3G network dongle to move the acquired pictures to the safe deposit box. This is done efficiently using Raspberry Pi and 3G dongle.

REFERENCES

- [1] Akruti Khurana, Shiva Karpe, Dr.Gaurav Sharma, IoT based home security system, International Journal of Engineering Sciences and Research Technology, October 2019, 81- 89
- [2] Alfred Vinifred Christopher, Guresh Swaminathan, Maheedar Subramaniam, Pravin Thangaraj, Distribution line monitoring system for the detection of power theft using power line communication, Journal of the Institution of Electronics and Telecommunication Engineering, October 2014
- [3]Anitha A, Home security system using internet of things, Published under license by IOP Publishing Ltd, 2017, 1-11
- [4] Ashwitha K, Gracy A, Pooja sree, Somashekhar, Dhanyanand BR, Power theft prevention system using IoT, International Journal of Current Engineering and Scientific Research (IJCESR), Volume-6, 2019, 118-125
- [5] Deepak.S.Kumbhar, Shubhangi M.Taur, Chaudhari H.C., Shubhangi S. Bhatamrekar, IoT based home security system using Raspberry Pi-3, International Journal of Research and Analytical Reviews (IJRAR), Volume-6,January 2019, 305-309
- [6] Govinda K, Sai Krishna Prasad K, Sai ram susheel, Intrusion detection system for smart home using laser rays, International Journal for Scientific Research & Development (IJSRD),Volume-2, 2014, 176-178
- [7] Harshit Saxenal, Dr. Vineet Richariya, Intrusion detection system using K – means PSO with SVM classifier, International Journal of Emerging Technology and Advanced Engineering, February 2014
- [8] Himanshu Sawle, Sandeep Parmar, Restricted Area Security System based on IoT, SSRG International Journal of Electronics and Communication Engineering, Volume-5, 2018, 15-16

- [9] Jayashri B and Arvind S, Design and Implementation of Security for Smart Home based on GSM technology, International Journal of Smart Home, Volume-7, 2013, 201-208
- [10] Madhavarapu Chandan, Sanakkayala Sri Venkat Sumanth, Garapati, Samhita, Kathi Priyanka Reddy, Design & Development of a home security System Using IOT, International Journal of Engineering & Technology, Volume-7, 2018, 374-376
- [11] Mahima F.C., Gharge, Design, and Development of Real-Time Video Surveillance System based on Embedded Web Server Raspberry Pi B+ Board, International Journal of Advance Engineering and Research Development (IJAERD), 2015, 1-4
- [12] Nasimuzzaman Chowdhury, Shiblee Nooman, Srijon Sarker, Access Control of Door and Home Security by Raspberry Pi Through Internet, International Journal of Scientific & Engineering Research, Volume-4, November-2013, 550-558
- [13] Shaik Anwar, D.Kishore., IoT based Smart Home Security System with Alert in Door, International Journal of Engineering Research & Technology, Volume-5, December 2016, 504-509
- [14] Shreeyash Ghodke, Pushkar Chaudhari, Neha Chumbalkar, Arpit Gupta, Shilpa Lambor, IOT Based Home Security System Using Raspberry Pi, Volume-6, December 2017, 22830-22835
- [15] Sowjanya G and Nagaraju S, Design and Implementation Of Door Access Control And Security System Based On IoT Inventive Computation Technologies (ICICT), International Conference on Inventive, 2016
- [16] Sugumaran.N, Vijay. G.V., Annadevi.E, Smart surveillance monitoring system using Raspberry Pi and PIR sensor, International Journal of Innovative Research in Advanced Engineering (IJIRAE), Volume-4, April 2017, 11-15
- [17] Tanaya, K.Vadivukarasi, S.Krithiga, HomeSecurity system using IoT, International Journal of Pure and Applied Mathematics, Volume-119, 2018, 1863-1868

[18] Rani.R, Lavanya.S, Poojitha.B, IoT Based Home Security System using Raspberry Pi with Email and Voice Alert, International Journal of Advanced Research in Computer Science and Software Engineering, Volume-8, April 2018, 119-123

[19] Ruby Dinakar, Deepthi U Singh, Mir Mohammed Abbas, Mir Riya Alex, Abhishek Yadav, IoT Based Home Security System Using Raspberry Pi, International Journal of Innovative Research in Computer and Communication Engineering, Volume-6, April 2018, 3835-3842

[20] www.raspberrypi.org.in