SMART INTRUDER ALERT SYSTEM

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Department of Physical Science
Faculty of Applied Science
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Project Report for the fulfillment of course unit **IT3162-Group Project** for the degree of Bachelor of Science in Information Technology

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Declaration

We hereby declare that the project submitted for evaluation of course module IT3162 leading to the Bachelor of Information Technology award is entirely our work, and the contents taken from the work of others have been cited and acknowledged within the text. This proposal has not been submitted for any degree at this university

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I recommended the project be carried out by this group of members.

…… Date

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…… Date

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Acknowledgment

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Thank you.

Abstract

This project intended to design and implement a security alert system with the capability of human detection. As the number of crimes is increasing every day, there has to be a security system that ensures the safety of us. There are many alert systems already existing in the market. Although they serve the purpose, they lack the sense of detecting human intruders. The general alert systems work if any intruders or a motion is sensed in a premise where the alert system is configured. However, the probability of finding only human intruders is rare and it makes the property owners irritated due to false alarm. Hence, we hope to give a more accurate and cost-efficient system where it can detect and alerts the owners only if human intruders are found outdoors or indoors. The basic idea behind this project is where the security system is set up with the PIR sensor fixed in an area where a camera also fixed. When the sensor detects heat radiation that is emitted from a living organism, the camera will first capture an image of the area and then process it using python programming language. A python program is written to detect whether the image is captured with a human figure or not. Suppose, it detects a human figure, then it infers that an intruder has appeared and it will immediately send an alert message to the mobile application which we developed for this system using flutter and also it will send the image of the intruder to the owner.

This project involves the use of Arduino, a camera, a simple Python program and a mobile application using flutter. The ESP32 camera is used to capture the image of the area when the PIR sensor senses a motion. The Python program is used to specifically detects if the human image is found or not in the captured background and if it's a human, then it triggers the alert. The triggered alert is directly sent to the mobile application and the captured image is stored in the firebase real-time database for the image retrieval of the intruder by the property owner. This helps the people to entrust the system with detecting the humans-only intrusion and capturing the intruder's image. Moreover, this expected to be more convenient and cost-effective security alert system that could be existing in the market.

Contents

1. Chapter 01

1.1. Introduction

Security is crucial today to safeguard our possessions from theft in both residential and commercial areas. Closed-Circuit Television (CCTV) is the conventional home security option prevailing in the present era as a way of surveillance. As technology has advanced, some systems are already available for detecting intruders in our homes. These systems typically combine sensors with IoT technology to detect the intrusion in an area. However, the main problem with existing systems for intruder detection is that they can detect any heat sensation or motion detected in a place and alert you to the presence of an intruder. These can sense even if there are animals in the vicinity, and it will notify the resident as an intruder. Therefore, we can say that these alert systems are most appropriate for indoor areas like flats or apartments because, if our home is completely closed, we can assume that humans are the majority of indoor intruders as the systems get activated for any type of thermal sensation or motion detection in the outdoors. This causes numerous opportunities for false alarms. Therefore, to avoid these issues, we have developed a smart intruder alert system that can identify only the humans as intruders in outdoors.

We propose a system that combines the concepts of IoT and machine intelligence. This system focuses on commercial areas and houses in Sri Lanka. In Sri Lanka, homes are constructed on fairly large plots of land that anyone can enter without the owner's knowledge. The surroundings of the home may contain people’s belongings, which a thief could steal. It is very rare for the residents to realize a theft is happening in their residential area. To make aware of the residents the intruders in their residential area, we have developed this system. This system can be used both indoors and outdoors and will alert the owner, only if a human intruder enters the premises. The system has an ESP32 camera, PIR sensor, and Arduino. The camera captures the image of the intruder whenever the PIR sensor detects a heat sensation in the surrounding. The captured image will be sent to firebase database. The camera and the PIR sensor are connected to Arduino. If that captured image is detected consisting a human figure, the system will send an alert message along with the captured image to the owner through a mobile application developed using flutter, which is connected to our system.

1.2.Background

The primary objective of the system is to secure residential areas. Our system will only emit an alert if a human is found in the resident's place, in contrast to existing systems. The resident will receive a notification that an intruder has entered his home from this system, along with the intruder's photograph taken by the camera. The existing systems in the marketplace can detect humans but also detect if there are any false images of humans, as intruders. So that will lead to false alarms. To overcome this problem our system will be useful as the system can specifically identify the human. When the intruder is detected through the device, it will send a notification with the image of the intruder which was captured by the camera to the mobile application through the connected server. We have created a system using Arduino as the main microcontroller and a PIR sensor, which detects the movement in the house. An ESP32 Camera module is installed, which can capture the image as soon as any movement is detected. The user can be able to manually check the image of the intruder via the notification received. Our system can be created at a low cost, and it is easy to install and maintain.

1.3.Aim of the project

The main aim of the project is to develop a system that can detect only the human intruder in the resident’s place and alert the owner that an intruder has appeared in your place. The camera will capture the image whenever the heat sensation is detected in the environment. The captured image will be processed by the system. If any human is detected it will notify the owner through the mobile application.

1.3.1. Specifying the problem

Apart from the problems such as burglaries and stranger unusual activities, the problem we consider here is providing a system that can detect the human intruder in the resident’s place when the owner is away from his/her place. The system should be able to alert the owner whenever it detects any human intruder only in both indoors and outdoors. Our system will notify the owner through a mobile application with an image of an intruder that a human intruder has been detected.

1.4. Objectives

Our objective is to create a smart intruder system. Its goal is to detect if any unwanted strangers enter the house.

- Protecting possessions – replacing our possessions is hard, especially sentimental items, which cannot be replaced. Having an intruder system means that we can worry less about a criminal breaking in and taking your valuable items. If a criminal does get into your house, the owner gets a notification and easily catches the criminal.

- Provides convenience and comfort – we can't be home all the time. A monitored security system allows us to go to work, go to school or head out on vacation without having to worry about the homestead. While we are away, this smart intruder system will send an alert to us and we can check from our smartphone wherever we have an Internet/Wi-Fi connection. This allows us to live our lives without having to stay home to protect our property.

1.5. Benefits

- The system will notify the information of the intruder.
- The circuitry is not that complicated and thus can be easily configured.
- Easy installation.
- Even if the owner is away from home, with the alert through the system, (s)he can take necessary actions accordingly.
- Not much human intervention. Less management after installation.

1.6. Limitations of the project

- We proposed to do the system with the thermal camera but that was expensive and out of resources, so we substitute it with a PIR sensor.
- The PIR sensor captures only <120 degrees. So, the detection is limited to that radius. But a proper place to fix the PIR sensor can improve the outcome.
- Power supply needed to properly function the system.
- Wireless connection is compulsory.

1.7. Justification

- Provide systems that are affordable to the users.
- Easy to setup.
- Easy to handle.
- Advanced knowledge of technology is not necessary, anyone can handle it.
- Detects only humans, so we can use it for outdoor and indoor security purposes.
- Devices are easily replaceable. Very cost-effective.

1.8.Scope of the study

Security is very much important to our properties. They can't be replaced easily. In earlier times CCTV surveillance was used for security needs but they are hard to maintain. Thereafter some human detection systems were introduced into the market. They are unable to deliver accurate information about the intruder. They use ultrasound and other sensors to detect humans through motion, heat sensation, and hindrances in the surrounding. They will alert the resident if any sensation is captured in the place where it is fixed. There are no sensors that can detect any disturbances in the surrounding area, including humans. Animals are one kind of disturbance that can be sensed by humans. So, when we are using such sensors, they may create an alert for any kind of disturbances detected in the surrounding area. Due to this, most of the time false alarms will be given to the owner. As it notifies everything as an alert, it creates irritations for the owner.

So, to overcome these problems we have created a system that can detect the human intruder only. It uses a PIR sensor to detect the heat sensation in the surroundings and captures the image of the intruder. The captured image will be processed by the system. If the system detects any human in the captured image, it will send an alert and the image to the owner through the mobile application connected to the system.

2. Chapter 02

LITERATURE REVIEW

2.1.Overview

In this chapter, we conducted a literature review mainly on the studies of existing intruder alert system to find how it works. We also focused on studying the technologies and tools involved in making those intruder alert system.

2.2.Existing Systems

- "IoT Based Smart Intruder Detection System For Smart Homes"
  https://www.researchgate.net/publication/354297728_IoT_Based_Smart_Intruder_Detection_System_For_Smart_Homes

  This system is an automated system with a microcontroller and ultrasonic sensor. The system is connected to an Arduino and gsm module. It will send notifications through the Blynk application. This system notifies the owner with an alarm. But there is no evidence that the intruder is not sending any images or videos to the owner.

- "An IoT-based House Intruder Detection and Alert System using Histogram of Oriented Gradients"
  https://thescipub.com/pdf/jcssp.2019.1108.1122.pdf

  This system is implemented using Raspberry Pi 3 and Arduino which is connected by a USB cable. The PIR sensor is installed on Arduino and webcam is mounted on Raspberry Pi 3. The Raspberry Pi is used to process inputs from sensors and process images for human detection. Object recognition is performed using a Histogram of Oriented Gradients. This system is a little much complicated and expensive.

- "Home Security System"
  https://www.instructables.com/Arduino-Home-Security-System/

  Some of the components involved in this project are the PIR sensor, LEDs, a camera, a relay for on and off the camera, and a keypad to operate the system by entering a pin. This solution helps to detect theft activities or unusual activities taking place at the home. This project is limited to small areas.

2.3.Supporting Technologies

- ### IoT Technology

  The Internet of Things (IoT) technologies allow devices to exchange data over a network. There are many IoT use cases today such as access to low-cost, low-power sensor technology, and connectivity which means a host of network protocols for the internet has made it easy to connect sensors to the cloud, cloud computing platforms, machine learning, etc. An IoT ecosystem consists of web-enabled smart devices that use embedded systems, such as processors sensors, and communication hardware, to collect, send and act on data they acquire from their environments.

  The power of IoT lies in its ability to connect a vast array of devices and systems, allowing them to work together seamlessly and share information in real-time. This can lead to increased efficiency, improved safety, and enhanced user experiences. For example, a smart home might use IoT devices to adjust the temperature, turn off the lights, and lock the doors automatically, based on the homeowner's preferences and habits.

- ### Flutter

  Flutter is a free and open-source mobile UI framework created by Google's for crafting beautiful, natively compiled applications for mobile, web and desktop from a single codebase. Flutter works with existing code, is used by developers and organizations around the world, and is free and open source.
  Flutter consists of two important parts:
  - An SDK (Software Development Kit): A collection of tools that are going to help you develop your applications.
  - A Framework (UI Library based on widgets): A collection of reusable UI elements (buttons, text inputs, sliders, and so on) that we can personalize our own needs.

  In our project we have used flutter framework to design our mobile application which notifies information about intruder to the user.

- ### Firebase

  Firebase is a backend-as-a-service. It provides developers with a variety of tools and services to help them develop quality apps, grow their user base, and earn profit. It is built on Google's infrastructure. Firebase is categorized as a NoSQL database program, which stores data in JSON-like documents. In our project, we have used firebase storage to store the captured image by the system's camera. Moreover, the captured image will be image processed using python coding and the processed image will be uploaded to the firebase storage.

- ## Arduino Mega

  Arduino refers to an open-source electronics platform or board and the software used to program it. The Arduino board can be powered by the USB cable from our pc or laptop. Arduino boards can read analog or digital input signals from different sensors and turn them into an output such as activating a motor, turning LED on/off, connecting to the cloud, and many other things. We can control the board by sending a set of instructions to the microcontroller on the board via Arduino IDE. Arduino Mega has 54 digital input/output pins, and 15 of them can be used as pulse width modulation (PWM) output pins and 16 as analog input.

  - Pins 0 (Rx) and 1 (Tx): Receiver (Rx) pin and Transmitter (Tx) pin are used to receive and transmit transistor-Transistor Logic (TTL) serial data.
  - Pins 2 and 3: These are called external interrupt pins. These pins are configured to change the value when they are triggered.
  - Pins 3,5,6,9 and 11: These pins provide an 8-bit PWM (Pulse Width Modulation) output.
  - Pins 10(SS), 11 (MOSI), 12 (MISO), and 13 (SCK): These pins are used for SPI communication.
  - Pin 13: This pin has a built-in LED. If pin 13 is receiving any power, then the LED will be switched 'ON', otherwise it is 'OFF'.
  - Reset pin: It is used to reset the microcontroller.

- ## ESP32 camera

  The ESP32-CAM is a small-size, low-power consumption camera module based on ESP32. This is a small camera with a module including a micro-SD card slot. The images shot by the ESP32-CAM can be saved on a micro-SD-card.
  It is a 2-megapixel camera with dimensions of 40.5 mm x 27 mm x 4.5 mm. The ESP32 web camera's internal memory includes:

  - 448 kB of ROM for booting and core functions.
  - 520 kB of on-chip SRAM for data and instructions
  - Embedded flash.

Figure 1: ESP32-CAM

- **PIR Sensor**

  A PIR sensor is a small low-priced Passive Infrared motion detector sensor. As the name suggests, it doesn't emit radiation but detects the changes in infrared radiation of the source. PIR sensor consists of a Fresnel lens and pyroelectric material. A Fresnel lens is made of high-density polyethylene that concentrates the incoming infrared radiations so that they fall on the pyroelectric material. PIR Sensor detects the motion and gives a corresponding digital output. When the human or animal body comes in the range of this sensor it will detect a movement of infrared radiation.

  The supply voltage of the PIR sensor is 5V and the output voltage is 3.3V TTL. This PIR sensor has high sensitivity. It can distinguish between object movement and human movement. The power of consumption is low, just about 65mA. The operating temperature of this sensor is from -20^{o}C to +80^{o}C.

Figure 2: PIR Sensor

3. Chapter 03

METHODOLOGY

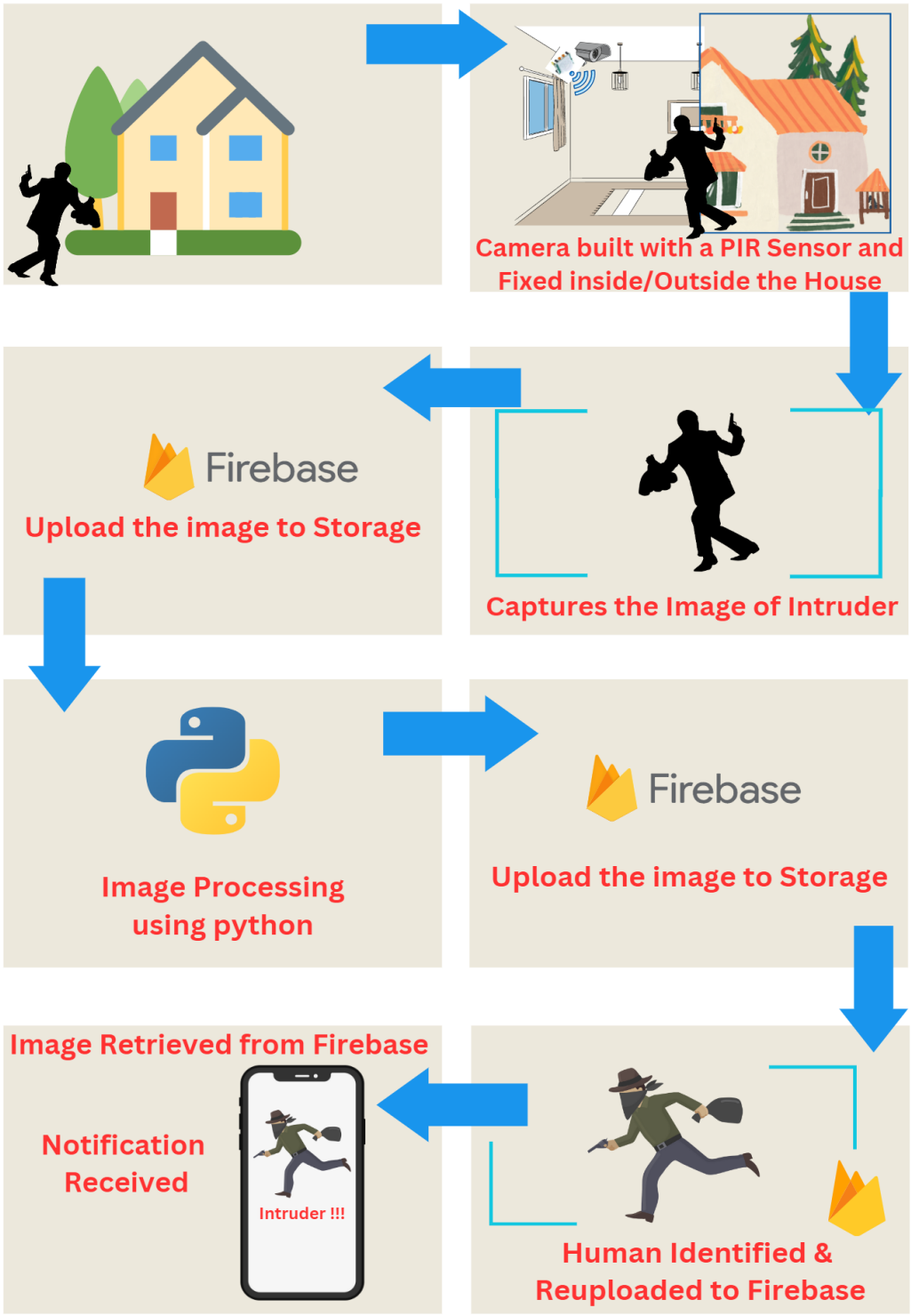
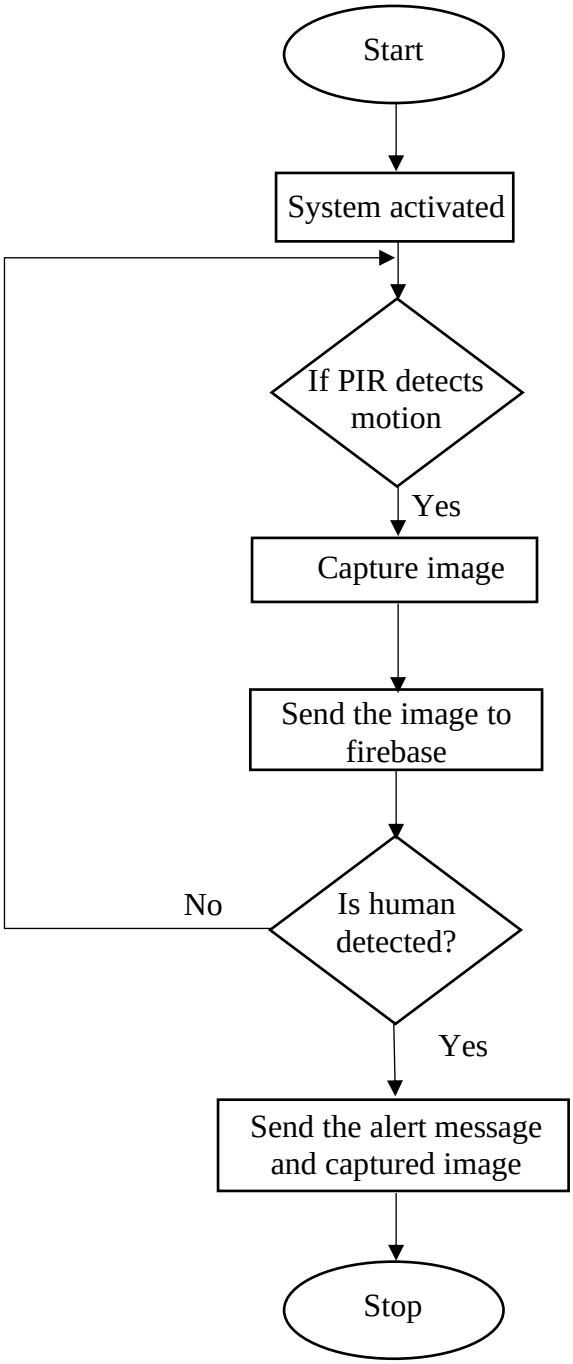


Figure 3: Workflow of the smart intruder alert system



The above flowchart describes how the system works. Whenever the PIR sensor detects any heat sensation, the camera will capture the intruder's image, store it, and send it to the firebase. Then the system will process the picture and detect if there is any human. If that is so, firebase will store that as an output image and send the alert message to the owner along with the output image through the mobile application which is connected to the system.

3.1.Requirement analysis

A clear understanding of the requirement analysis is much needed to start a project. Requirement analysis is one of the main phases in the development of a system. The objectives are all about what are the benefits of our project.

3.1.1. Functional requirements and non-functional requirements

3.1.1.1. Functional requirements

Functional requirements specify what the system will do.

- Heat Sensation.
- Capture image.
- Process image to find human.
- Receive the notification in the mobile application.

3.1.1.2. Non-functional requirements

- User-friendly interface.
- Reliability.
- Usability.
- Accuracy.
- Icons should be easily identifiable.

3.1.2. Performance requirements

- The system should be user friendly.
- It must be reliable.
- The system must give a response.
- It must be more accurate.
- It should omit false alerts.

3.1.3. Design requirements

- Keep the process simple and avoid errors.
- The interface should be user-friendly.
- Representing colors which could be easily understood.
- The device should be fixed according to the environment, which means as the PIR sensor can be able to monitor at <120 degree the device should be set up in a proper place to get the optimal outcome.

3.2.Model Development

3.2.1. Agile Model

According to our project's specification and requirement analysis, we found that the agile process model was the most suitable model for our project. Agile approaches divide the project into smaller iterations or sections and avoid long-term planning.

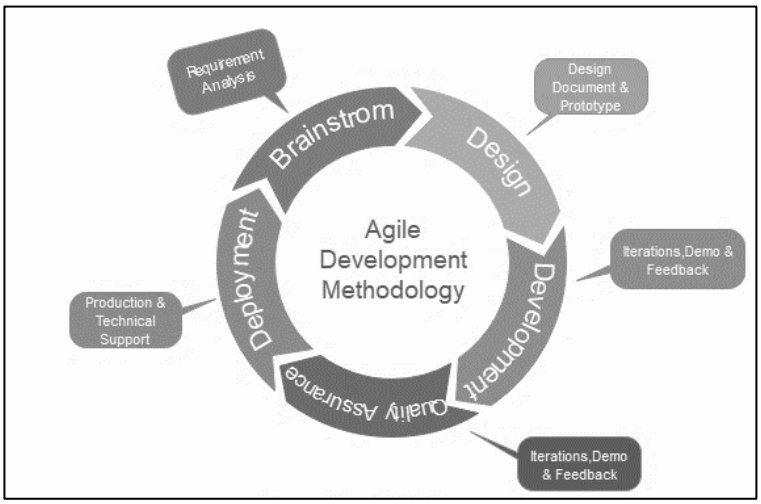


Figure 4: Agile Model

Phases in the agile model

1. Planning

   In this phase, the project team would define the scope of the smart intruder detection system, identify the goals and objectives, and create a high-level plan for how the system will be developed.

2. Requirement assembling

   In this phase our project team gathered and prioritized our hardware and software requirements to our project such as Arduino board, bread board, ESP32 camera, PIR sensor that will be used to detect intruders, as well as used to trigger alerts. These requirements are typically captured in user stories, which describe the functionality that the system should provide from the perspective of the end user.

3. Design the requirements

   When identified the project, work with the stakeholders to define requirements. This include designing the architecture of the system, specifying the types of data that will be collected and analyzed, and designing the user interface for the system.

4. Development

   In this phase, the project team begin building the system incrementally, using an iterative approach. We start by building a basic prototype of the system, and then gradually add more functionality over time.

5. Testing

   In this phase, the project team conduct comprehensive testing to ensure that the system meets the requirements and is free of defects. We conduct both functional testing (to ensure that the system is working as intended) and security testing (to identify potential vulnerabilities and ensure that the system is secure).

6. Deployment

   In this phase, the project team deploy the system to the production environment, making it available to end users. We might also provide training and support to users to help them understand how to use the system effectively.

7. Maintenance

   In this phase, the project team would provide ongoing maintenance and support for the system, addressing any issues that arise and making incremental improvements as needed. We might also collect feedback from users and use this feedback to inform future iterations of the system.

4. Chapter 04

DESIGN AND IMPLEMENTATIONS

4.1. Implementation of mobile application

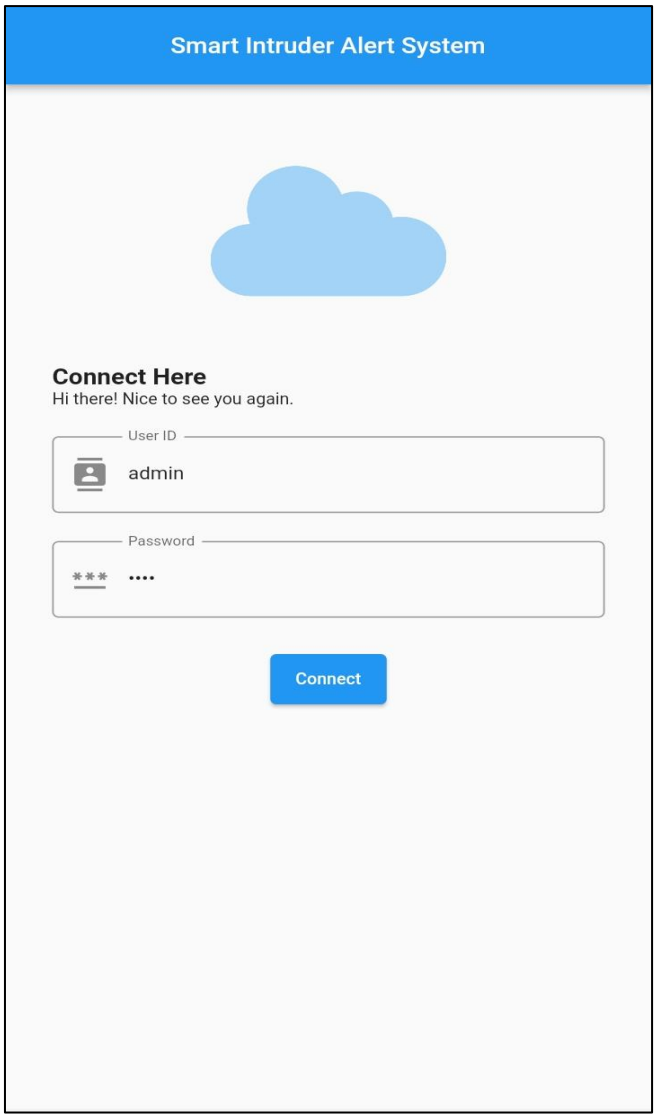


Figure 5: Home page of the Mobile App

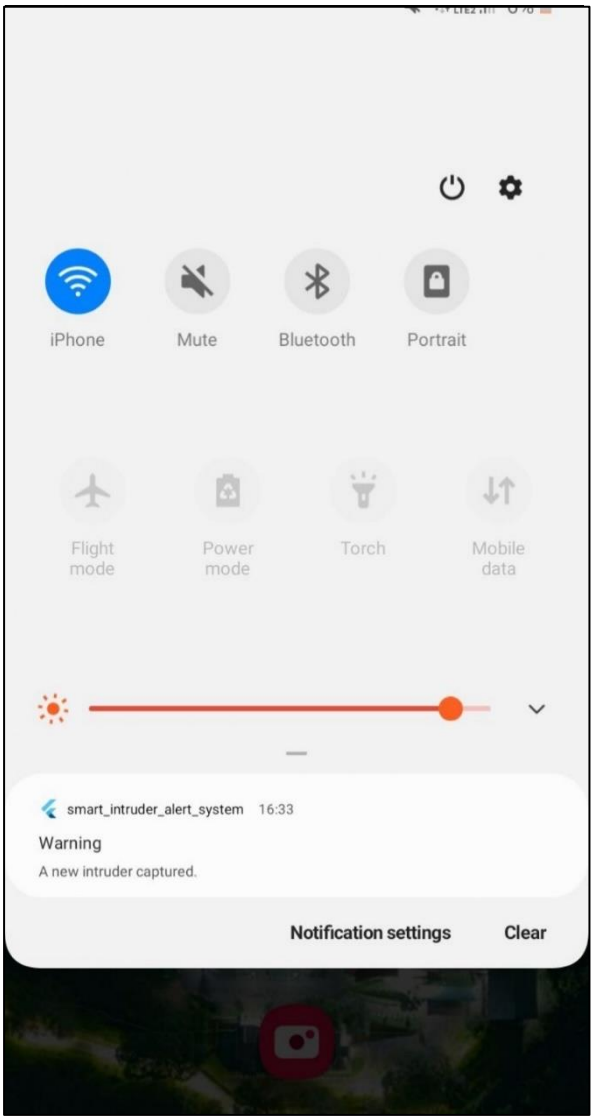


Figure 6: Mobile Notification Received

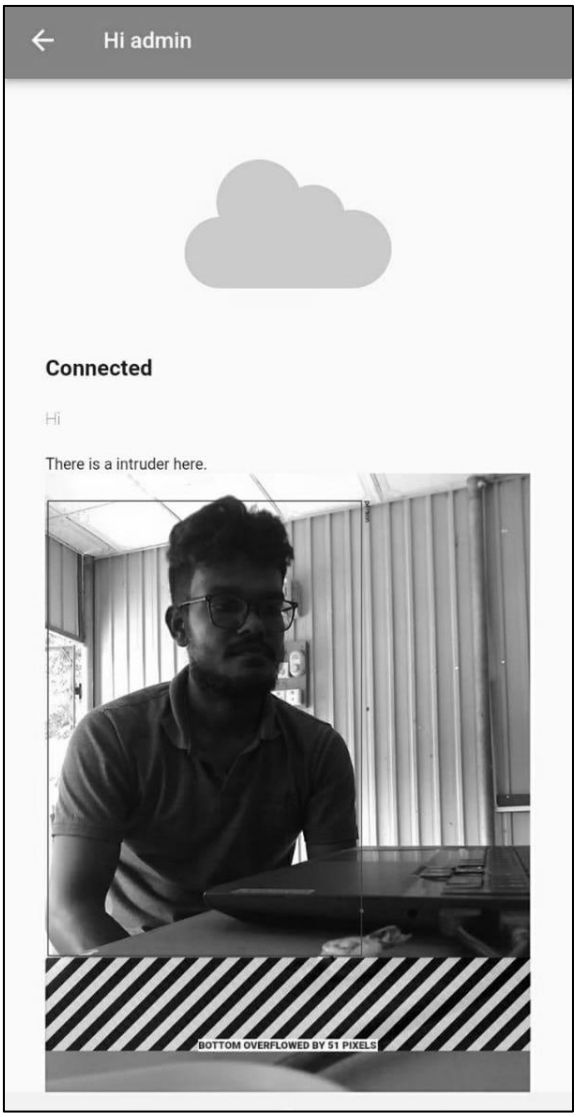


Figure 7: Retrieved image from the database

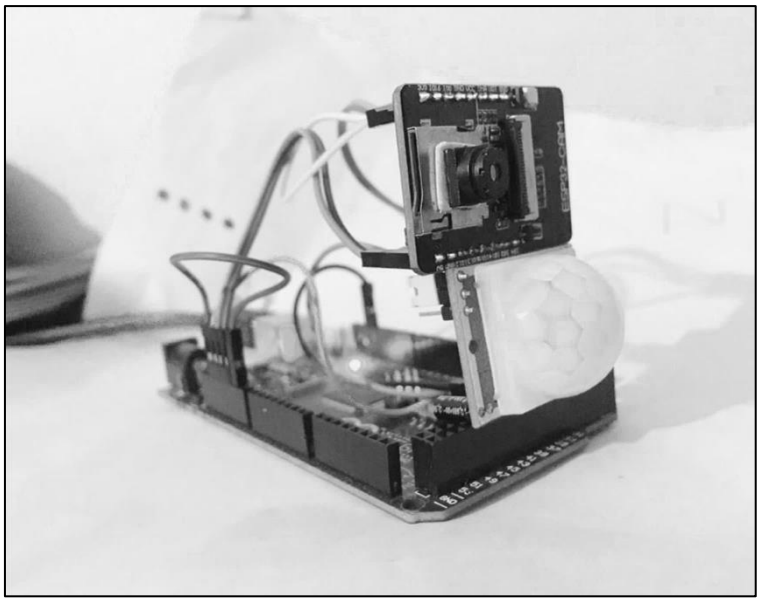


Figure 8: PIR and Camera setup

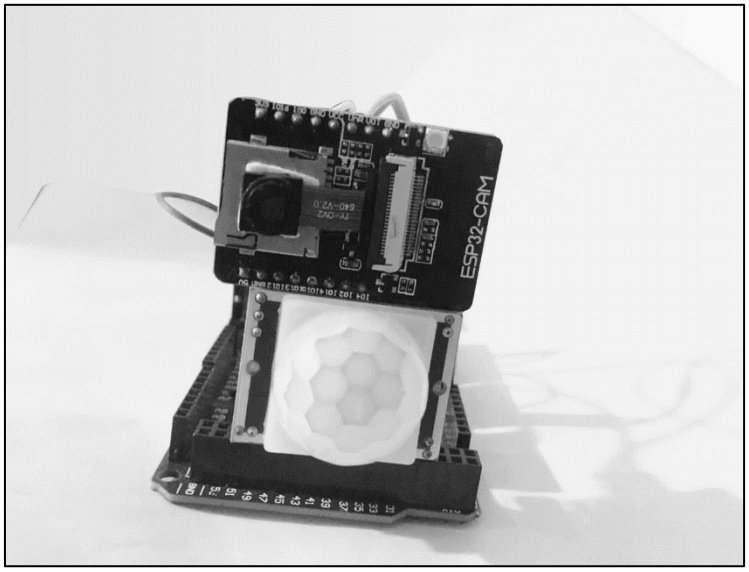


Figure 9: PIR and Camera setup

5. Chapter 05

TESTING AND RESULTS

5.1.Testing Methodology

Testing is a process of high importance hence only by testing we can determine whether we have achieved our target or not.

Testing was done in every version of the system until the final version was ensured that it met its objectives. The system is first evaluated by the development team and validated by our team and then the system will be given to the user to check whether all the requirements are fulfilled.

5.1.1. Test cases

Short description of testing	**Steps follow**	**Expected results**	**Obtained results**
Login Empty field	Click the login button without entries in either the username or password field or both.	The message box has to show the message “Please filled out this field”.	The message box showed the message “please fill out this field”.
Login incorrect. User ID or password or both	Login with wrong entries.	The message box has to show the message “your user id or password is wrong”.	The message box showed the message “Your user id or password is wrong”.
Moving an object across.	Moving an object in front of the device.	The system has not sent any alert messages.	No alert sent to the mobile app.
Moving a living being across the device	Keep moving an animal (cat, dog) in front of the device.	The system has not sent any alert messages.	No, any alert is sent to the mobile app.
Moving a human across the device	Make a human move across the device.	The system has to send an alert message with the captured image.	An alert message is received in the mobile app with the captured image.

6. Chapter 06

CONCLUSION AND FUTURE WORKS

6.1.Conclusion

6.1.1. Summary

We conclude that our system can achieve all the objectives that we mentioned earlier and it can overcome most of the difficulties listed. By using our system, we can ensure that our home becomes more safer from theft. Moreover, we are able to identify any intruders present in the premises. With the detection of intruders, we can take necessary actions regarding the situation. Our system consists of an Arduino, a breadboard, a camera, and a PIR sensor. The system has been developed to detect only human intruders apart from animals and send immediate alerts to the owner about the intruder. By complying to the problems, our system evades the false alarm and produces the more efficient intruder alert system.

6.1.2. Risks and Solutions

- The USB connector provides a 5V line to power the board's electronics. The camera needs 5V power for its proper work. A PIR sensor needs 3.3V to work so a 5V USB connection is not enough to make the device work properly so we provide a larger voltage power supply to overcome this problem. When we try to make a parallel circuit, that produces an excessive current which may also damage the components; so, the power supply voltage is fixed with intense care.
- Difficult to obtain the hardware components due to the limited stock and cost.

6.2.Future works

- To increase the sensing area of the PIR sensor, we can use the PIR array instead of using one PIR sensor. That will increase the detecting range of the system.
- We can advance the project to the door (lock and unlock activity) so that the chance of theft or stranger activities will be reduced.
- As it is still an image, we will provide the live streaming of the camera and provide options to save the particular frames of that stream.

REFERENCES

- "An IoT-based House Intruder Detection and Alert System using Histogram of Oriented Gradients" https://thescipub.com/pdf/jcssp.2019.1108.1122.pdf
- https://www.researchgate.net/publication/354297728_IoT_Based_Smart_Intruder_Detection_System_For_Smart_Homes
- https://www.sciencedirect.com/science/article/pii/S1877042810000236?via%3Dihub