IOT BASED BIOMETRICS IMPLEMENTATION USING RASPBERRY PI ON

STUDENT MARKS MANAGEMENT SYSTEM

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PROJECT REPORT ON

IOT BASED BIOMETRICS IMPLEMENTATION USING RASPBERRY PI

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23/10/2021

UNDERTAKING

I Declare that the work presented in this project titled "**IOT BASED BIOMETRICS IMPLEMENTATION USING RASPBERRY PI",** submitted to the All india council of robotics and automation, for the award of the internship in '**INTERNET OF THINGS**' is my original work. I have not plaglarized or submitted the same work for the award of any other internship. In case this undertaking is found incorrect, I accept that my project may be unconditionally withdrawn.

October, 2021

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CERTIFICATE

I certified that the work contained in the project titled "IOT BASED BIOMETRICS IMPLEMENTATION USING RASPBERRY PI", by NAGARAJ BIRADAR & MD AZHAR , has been carried out under any supervision and that this work has not been submitted elsewhere for a internship…

All India Council of Robotics and Automation

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ABSTRACT

Internet of things (IoT) has a rapid growth technology at nowadays and very useful for the society, where it is possible to control physical devices by using the internet. Building smart homes and cities is necessary to provide security and protection as the growth of society is getting bigger and must have a safety and security system to be provided to prevent from crimes and unwanted people to get an access to these types of properties such as homes, offices and banks. This project is about using a human face recognition security system based on IoT method to detect and recognize human faces to get an access to unlock doors, and once the face is recognized by the system the door will be unlocked automatically with the help of electromagnetic lock. Meanwhile, if the human face was detected and wasn't recognized by the system, access will be denied, and the door will remain locked also it will capture the human face image and send notification via email to the user. In addition, the raspberry pi with the camera module is used for the face recognition and a PIR sensor to detect the human face.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

IoT	Internet of Things
PIR	Passive Infrared
SoC	System on Chip
CSI	Camera serial interface
OpenCV	OpenSource Computer Vision
OS	Operating System
GPIO	General purpose input/output
FACS	Facial Action Coding System
IP	Internet Protocol
AI	Artificial Intelligence
LBP	Local Binary Pattern
USB	Universal Serial Bus
GSM	Global System for Mobile Communication
SMS	Short message service
SMTP	Simple Mail Transfer Protocol
IMAP	Internet Message Access Protocol
LFW	Labeled Faces in the Wild

LIST OF SYMBOLS

S   Seconds

C1   Capacitor 1

R1   Resister 1

V   Volts

1 INTRODUCTION

We can find various rapid technology growth everyday life, home security and smart cities is very important due to the high growth of the society, and it is necessary to keep people safe and protected from intruders and unwanted people by providing a security recognition system to log in homes or any other properties. A human face recognition and detection can be implemented to enter homes, offices and banks. With the use of a standard USB camera can able to snapshot images for identification to the person who is trying to log in and also providing a PIR sensor along with the camera module to detect the movement of a person. This security system enables Automated door unlocking for authorized people by recognizing them in the saved images of visitors in the database in real time which utilizes internet connection via camera web. For people who aren't identified the door will remain locked and send an email notification with attached image of the person's face who tries to login to the owner. In addition, this system will also provide monitoring and control including remotely date and time can be visualized in real time once bell is been triggered. The technology of IoT will provide sensing communication actuation in this security system easily automation and with low cost and power consumption of the electricity with a huge rate of efficiency as a result of an significant impact in the modern world and making the system self-instructed device which also made this kind of gadget technology as well hard to be breakdown or hacked by the recognition of the human face technique. The effectives of OpenCV method will provide Recognition and classification of human faces and verifies the identity of a person, as the human face is an important key to security in the biometric acknowledgment innovation confront as this framework will concentrate on the person's character using facial images by the pi camera and compares it with face database images.
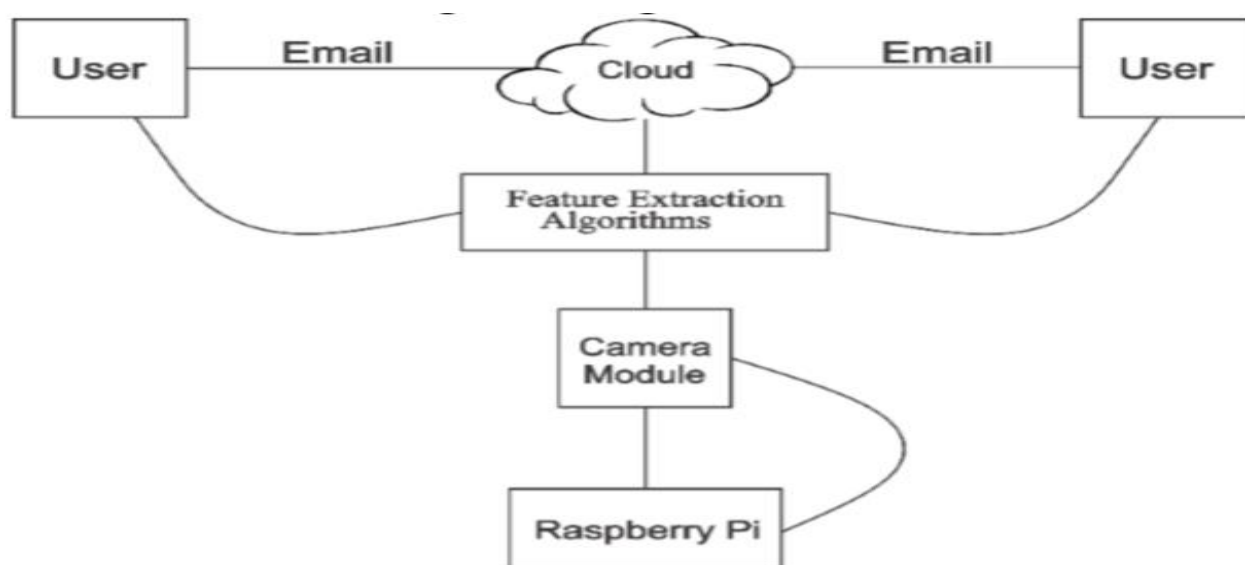
Figure 1.1 Architecture for Face and Emotion Detection (Kumar and Kaur, 2019

1.1 Background of the Project

This project topic is selected by seeing some intruders and unwanted people roaming around the cities and most homes don't have a proper security system which will provide monitoring and detection in real time. The old security system is out of date such as fixed analog cameras which can't provide notifications in real time and unclear footage of the people around the area or visitors at homes. It is necessary to provide high level efficient security system as the growth of the society is increasing and to provide safety and protection such in homes and offices from intruders by enabling monitoring and movement detection in real time. The project aims to have a significant security system with low power consumption and cost. In addition, the programmable device of Raspberry pi which consist a built in WI-FI connected to the internet will enable of using the Internet of things (IoT) technology method which will be linked to sensors used such as a digitized camera used to capture faces of visitors who will approach the home door bell and a PIR sensor which is used to detect movements of the person as a result to provide monitoring continuously and emails notification will be received with attached image to the user, which will identify authorized people to enter the property and unlocking the door, on the other hand if the person wasn't identified the door lock will remain locked and a notification will be received to the owner to take an action. With the IoT method images will

be saved in the database for identified and unidentified people for future references to make the system more efficient for collecting various facial images in the network with date and time. The main aim for this project to provide protection and safety at homes from intruders and reduces number of crimes in the city by enabling real time monitoring system. (Anjali and Ashok, 2017)

1.2　Proposed Approach

1.2.1　Project Aim

The aim of the project is to design a security system for the property of people that can detect motion and identify to allow or deny the access into the belongings with a notification system to the owner.

1.2.2　Project Objectives

- To Detect the presence of human using PIR motion sensor.
- To capture and classify human face images by using a USB camera.
- Recognize and classify human faces using OpenCV algorithm in the database.
- To open and close doors based on using an electromagnetic lock.
- Sending notification of the detected face in real time through email and update the information on IoT by analyzed database method.

1.3　Project Applications

This system can easily be implemented in any of the place, where the entry for only authorized person is allowed as:

- Homes,
- Offices,
- Banks Locker's Room,
- Restaurant's Kitchen,
- Pantries, or
- Any other private places.

1.4 Project limitations

- Internet network availability which can cause delay in receiving email notifications to the user due to weak internet coverage in the area.
- Limited power supply as this system doesn't consist of a backup battery causing failure to the system to be function whenever the power supply is shutdown at the property.
- Camera quality can affect to detect and recognize human face if kept in a dark area which will lead to lack of detecting and recognizing human face image.

1.5 Overview of the Project Report

In this project planning report, it consists of six chapters and each chapter contains sections which discusses about various kind of information required in the next stage of the project to build in the coming semester. In the first chapter the introduction will be written and includes background of the project, objectives, limitations and the overview of the project report. Second chapter is the Methodology giving the information about various types of methodologies are been used for building big and small projects also providing information of the chosen methodology used to build the current project. Third chapter contains the Literature review, discusses different reviews of journal research papers and articles related to the project. It provides information about components and materials required, as well comparing various technologies by other researchers in the current project system including advantages, disadvantages and future scope of their articles. Fourth chapter contains the Budgeting and project management which provides information in the cost of the required project to be including the management time period schedule by using the Gantt chart weekly based of the project planning and the risk management encountered managing for building the project. Fifth chapter is the design and analysis for the each section, information is provided in various contents for the project required to build which will contain as well the different block diagram in each stage of the present project including the flow system chart with software and hardware used and components for implementing the project, also schematic diagram showing the circuit connection to get the resulted output. The sixth chapter which is the last of the report chapters, which provides the whole conclusion and summary of the related project planning work resulting the future work implementation of the project.

2 METHODOLOGY

The over-all term to define Methodology is "methods of system utilized in specific field of studies or activities" (press, 2017). However, in every generation since 1960s until our time the word meaning of methodology in its vocabulary has been reshaped and the word evolved and recall to the type of study as having a new identity to be given to the Methodology term. Speaking about project management methodology it is considered a combination structured of procedure of orientation logically for the determination of operation techniques to create strategy and regulate the task during the time of implementation step until the valid time of submission including scientifically deployment proven and discipline.

One of the main principles of utilizing the Methodology is to gain much proficiency for the whole project to resolve problems and gaining decision direction technique for ensuring successful guidance in the processes in the selected method. The Methodology is also defined as the skeleton of the entire project to be demonstrate every detail in steps in addition it will also provide knowledge in step of budget and schedule to the specification client. Two groups are the methodologies divided, traditional and it consists of waterfall and critical path method (CPM), the modern type which consist the Agile, management, and process based. To select the suitable and finest Methodology is easy to execute the project until it's accomplished to the client satisfaction and to perform productivity in time. Most communities are using the traditional method to fulfill any project with measurements to be followed in its structure to obtain the output results.

2.1 Applied Method

The methodology selected for the project is the V-Model type, which also can be defined as a life cycle development software which in a unique linear and following a typical waterfall having a stage of step by step strictly stage. The beginning stages consist of design then it will lead to implementation stage coding then follows back to testing stage until the entire project is accomplished. The V-model method will cross in various stages at the time of life cycle software development starting from the above left-hand side stage and continuing towards time to the above right hint which is similar to waterfall model.

Figure 2.1.1: V-Model Methodology (airbrake, 2016)
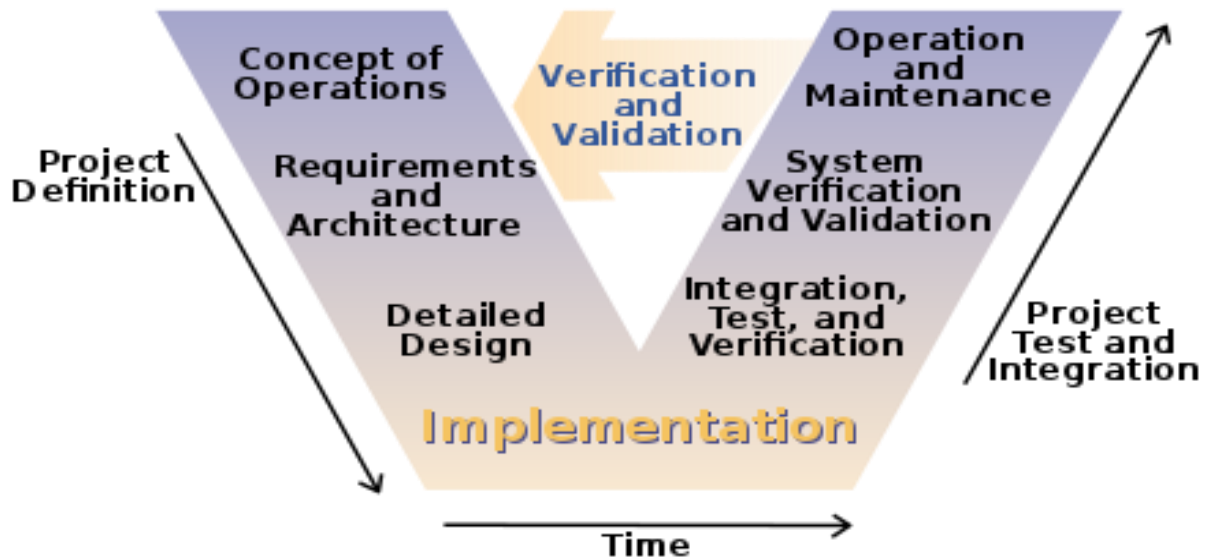
Project Definition:

In this stage consisting the concept operation as a first step in a project to enable the understanding the principles of the project before initiating. As this principle used in the project selected to identify topics within the project by having knowledge of the background then finalizing decided project topic as IoT based security system for Human face recognition. Upcoming step is to forward with the requirements project which is performed in the literature review chapter of the project stage planning by collecting various information guided by searching and understanding different journal articles to the related project. Coming to the next step is to design the project circuit and meeting with the project objectives, which will be explained in the design and analysis of the chapter 5, providing the drawing block diagram and components used for the project are explained. The types of components are been used for this project are PIR sensors, Raspberry pi with pi camera module, IoT, electromagnetic door lock and a power supply, including the schematic explain, with all the steps are done in the stage of planning of the project.

Project test and integration:

For this stage it will desire in the implementation of the project, at first is integrating the system to be assembled all components on the PCB Board, testing the system and verification on the output resulted. Coming to the next step is to verify fixed nearby values in the coding software

for the expected reading such as current and voltage readings and testing all components by using the Proteus simulation software and double check the circuit board by using a multimeter. At the end the maintenance and operation part, as the project is ready, and model is all fixed at a selected area and maintaining regularly for increasing the project's lifetime span. (airbrake, 2016)

2.2 Justification

One of the main reasons of selecting the V-model type of Methodology because it has low risks in the project meanwhile, the errors can be obtain at early phase stage of the project and can be implemented in small projects making the requirements clear and easy to understand to be used The benefit of using this type of model has the ability of reducing project risks and providing information in the way of performed connect action guiding the following steps to be used, which makes this model more flexible and easier to use for small projects and doesn't have any complexity, which makes it suitable of electronic field consisting of hardware and software components. For the same methodology it can be implemented in the present project of "IoT based security system for Human face recognition". It is also can be considered that the V- model can be described for its efficient software testing crossing development tests process management. (Sonali and Shaily, 2010).

2.3 Illustration Diagrams or Pictorial Representation

Figure 2.3.1: V-Model verification and validation phases (Jay Abraham, 2015*)*
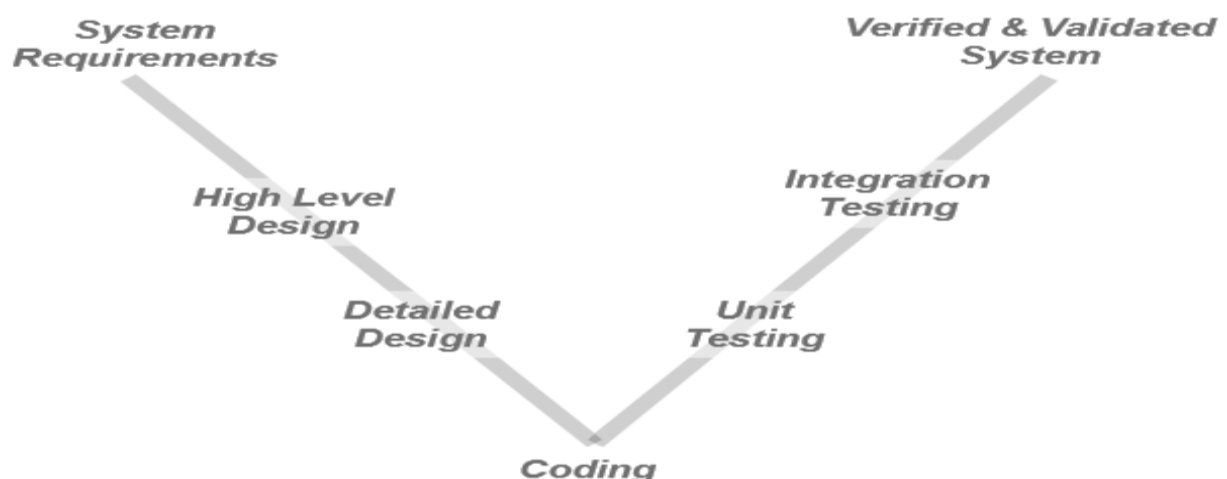
As shown in the figure above the definition of the V-Model validation and verification (V&V) the Validation consists of dynamic technique the function and non-function where tests obtained by executing the code and verification is static technique where tests obtained without executing the code. For these kinds of analysis of verification properties utilized to reporting whether designing is meeting with the functional requirements or not. Later on, when the code is set to be verified with static method analysis, it can be implemented on host PC. It can be concludee that these activities starts in applying models initially, then to be continued to coding step confirming the traceability design with the requirements, which can begin at an early stage in the design development phasing, and discovering run time errors Static range from the performed on the code sourcing. On the other hand, loop testing provides that software is acting as the achieved target processor. (Jay Abraham, 2015).

2.4   Related Phases

There is a total of nine phase stages can be concluded in the V-Model Methodology and to be gathered to perform a complete product shown below:

3   **Requirements:** at the beginning performing the analysis and requirements are involved to be considered the set features needed of the client and to create for the user requirements by providing enough time and documentation and later to be implemented to the corresponding tests with the phase requirements. (airbrake, 2016).

4   **System design:** feedback is necessary for the documents at the requirements stage phase having the technical components for example logics and data layers and during this stage testing is designed for the upcoming use.

5   **Architecture design:** drawing up the specifications considering in the way of linking up the application with its different components whether internally or integration which is referring to high level design.

6   **Module design:** in this design which contains low level design dedicated to the system and its all functionality including the logic coded business interface and components.

7   **Coding:** at this stage it is considered as halfway point among the process making the coding occur with the implementation and generated design as much time for converting documents into a function system code and accomplished the full stage to be tested.

8   **Unit testing:** moving the direction upside of the V-model to be considered in the inverse testing initiating sign phase and eliminating of bugs and issues also covering any possible issues which can appear in the system.

9   **Integration Testing:** phases to has to be executed at the architecture to ensure all functions of the system crossing various components integrations.

10   **System testing:** at the system design tests must be ensured to be created and to focus in the performance.

11   **Acceptance testing:** at the end, it is considered to perform all tests and implementing process at the initial side of the phase requirements to obtain the function of the system in live environment with critical data to ensure deployment.

12EXISTING SYTEM

12.1 Face recognition system using IoT

13   Kulkarni et al. (2017), in their article ''Face recognition system using IoT'' discusses how home security is very important for human safety while the growth in rapid technology in the field by using IoT method, especially for identifying visitors. A prototype USB camera is installed within the system to identify people who are coming home in real time. At the door if the person was recognized it will be greeting them by name which will unlock the door to that visitor, meanwhile when the visitor is not identified the door will remain locked. He also mentioned that this security system enables of movement detection and human face recognition same time, which is utilized with a web basic camera, which also makes this system have a great feature of monitoring and controlling for unlocking doors. Another feature which is added to the system for home automation is that the unauthorized access user tries to log in, quickly the system will capture the face and send a notification e-mail with an attached image. By providing a greater security level to homes, IoT technology will be used in this system, which is bringing out a huge impact of modern world. IoT is a technology which has the capability of doing things in a way of self-instructed and as well of transferring data over the network worldwide. Since the society is experiencing significant growth during the decades, a very high advanced security systems must be available for safety and protection to properties such as homes from intruders and criminals to break in and they are able to hack older security systems, avoiding these kinds of situations, IoT will be present as a developed security system and enhance security level as well to intrusion from anyone to the system, making the controlling and monitoring remotely with the use of face recognition method based on Internet of things having the ability of communication and sensing in the system. In addition the main device is used for the system is the raspberry pi which is very suitable when it comes to face and image processing, having a small in size, programmable device and operating system function such as windows and Linux, consisting a chip memory, Bluetooth feature and weighting 45 grams. Other component must be installed to the raspberry is the camera module which will be used for image processing and recognition by storing human various faces and compares with other faces stored in the database for authentication to enter the house when the face is recognized in the database, leading to open doors by utilizing a stepper motor installed at the door latch and it is programmed in

a way such that when a human face is recognized through standing in front of the camera leading the motor to rotate and unlock the latch door. Algorithm is very important to
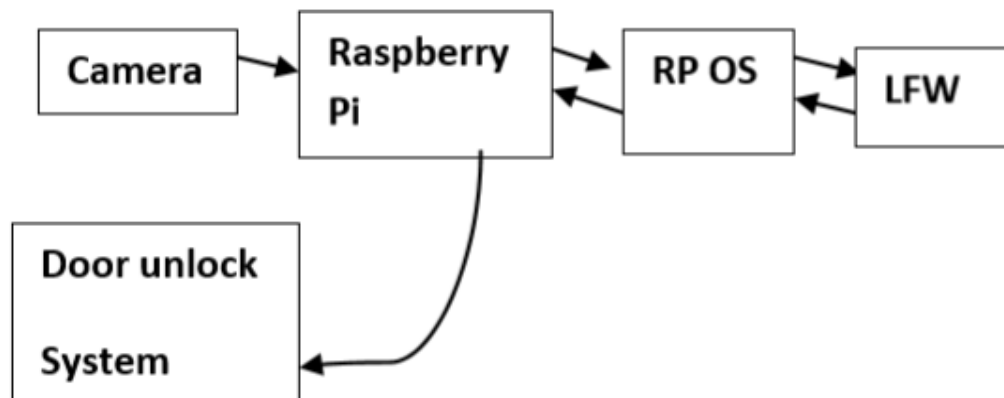
recognize the human face for detecting classifying the human face by analyzing the nose, eyes and mouth so the system will know the detected object whether a human or an animal. A part of this article discusses about the Distinguished faces must be analyzed in the database with proper study of the image collected from various resources over 13000 faces are labelled related to their names which made analysis of pictures much easier. On 2007 the database was released for face aiding recognition LFW distinguished a number of four sets over a deep image superior funnel produced. At the end of the article the benefit of this system with its low cost and power consumption having a high security level output results with combining two methods of IoT and face recognition technology as a result of the modern development rapidly growth in the industries as the scientists are still under process of improving and doing more researches on them making a significant development impact on security which enables the hacking issues almost impossible.

3.1.1: Figure Face recognition system architecture (Kulkarni et al., (2017)

13.1 Face recognition using OpenCV based on IoT for smart door

Moreover, this article "Face recognition using OpenCV based on IoT for smart door" (Deshmukh et al 2019) this work shows the useful of using a smart door based on IoT technology utilizing the OpenCV algorithm method of classifying and analyzing the human face recognition. They mentioned in their work about the huge advanced automated systems in the today's world in the field of surveillance to be highly proven effectiveness. This paper brings information to the user of using open source technology such as OpenCV and LBPH

algorithms and the raspberry pi with the camera module to be implemented in properties such as homes and offices in real time face recognition and detection once the door bell is been trigged, meanwhile the system will capture the human face image quickly for face process and analysis in the particular database if it's a match, as a result the access is granted and door will open. On the contrary while the access is denied and face did not match the system will capture an image of the face and send a notification to the user's e-mail with the attached which is retrieved on raspberry and wait for the users response based on the context message to be granted or denied access. This wireless connectivity is done by Simple Mail Transfer Protocol (SMTP) and Internet Message Access Protocol (IMAP) methods to achieve the wireless communication between the user and the security system and developed to be easy to use for a low-cost security solution. A program called classifier is necessary for this type of security system for image processing to identify if positive or negative image (face image) or (non-face image). The adopted of haar will process images in gray scale in the bundle of OpenCV, for the directory file location stored in the main program, while in the database created should consist of 45 image of person each, to enable the classifier to perform face image extract. This haar classifier is known for its high accurate detection and a low rate positive false for identifying the face and utilizing the local binary pattern histogram (LBPH) recognizer for avoiding any effects of light and to compare image structure in each pixel. For this work the hardware components are used is the raspberry pi 3 is used and programmed using python language, this programmable device is equipped with system on chip (SoC), an Arm Cortex processor with 1 GB RAM because of its high effect implementation in development of high speed in real time face recognition, operating frequency at 1.2 GHz speed clock, and built in WI-FI connectivity for sending and receiving e-mail notifications to the user. The Pi camera module resolution is 5 Mega-Pixel connected to the raspberry serial interface and linked directly to the processor enabling for transmitting data camera to the processor. An electromagnetic lock will be installed in the system functioned by a relay from raspberry pi and resulting of an electrical current which will pass through the module plate armature to get the magnet attracted of lock state condition. A Web interface must be provided in the security

system of the face recognition by using the Gmail service when the human face image is not recognized to be sent to the user.

Figure 3.2.1: Face recognition using OpenCV for smart door (Deshmukh et al.,2019)

13.2 IoT Based Facial Recognition Door Access Control Home Security System

Here is another article (Patel & Verma 2017), in their research "IoT Based Facial Recognition Door Access Control Home Security System" using the IoT method for securing automation locking door system security for bank locker and homes. They mentioned as well in their research paper about a technique capturing method system by using raspberry pi device in the control of the camera and turning on doors with a relay unlocking. The system consist of a human face recognizer which the camera captures the facial image and compares live images which are stored in the database with the support of raspberry pi after comparing both images resulting positive or negative output and giving the commands to the GSM module, to make a benefit of opening the doors if the image is found in the database, on the contrary if the image is not found in the database, the system will generate an SMS notification alert to the user by utilizing a GSM module to send a message to authorized people based on output result when
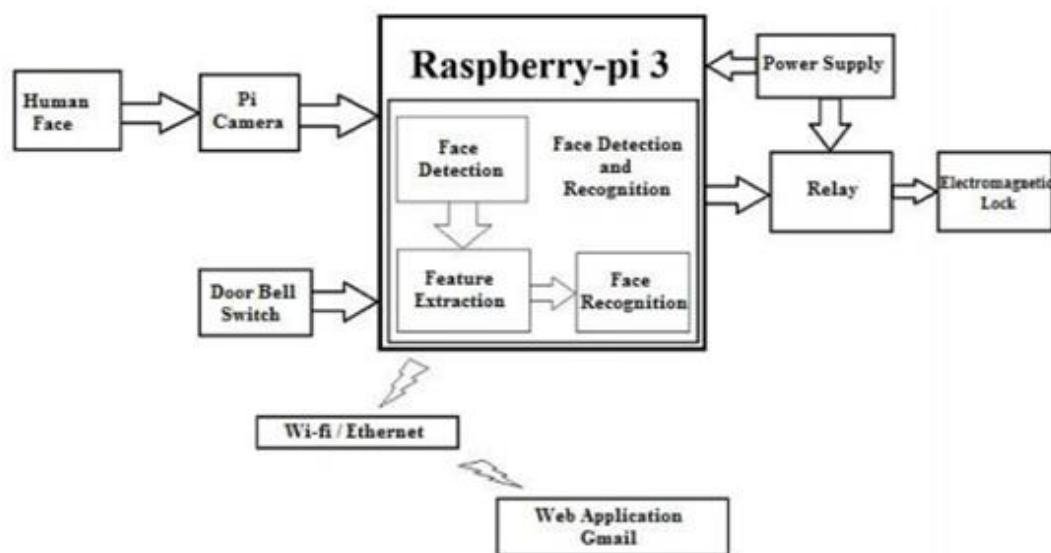
it's positive and access is granted, in case of unauthorized access it will generate a message that access is denied to the user that an intruder is trying to get an access to the door. This work paper mentions the importance of home security in the modern times as the growth of society is rapidly increasing making the city smarter, making the concept of face recognition system idea to live in a place with more secure and safe from any intruder, which is capable of

identifying a person by capturing and verifying the face image using a digital camera. The framework concept of facial pictures is to confirm the character by using a camera to be
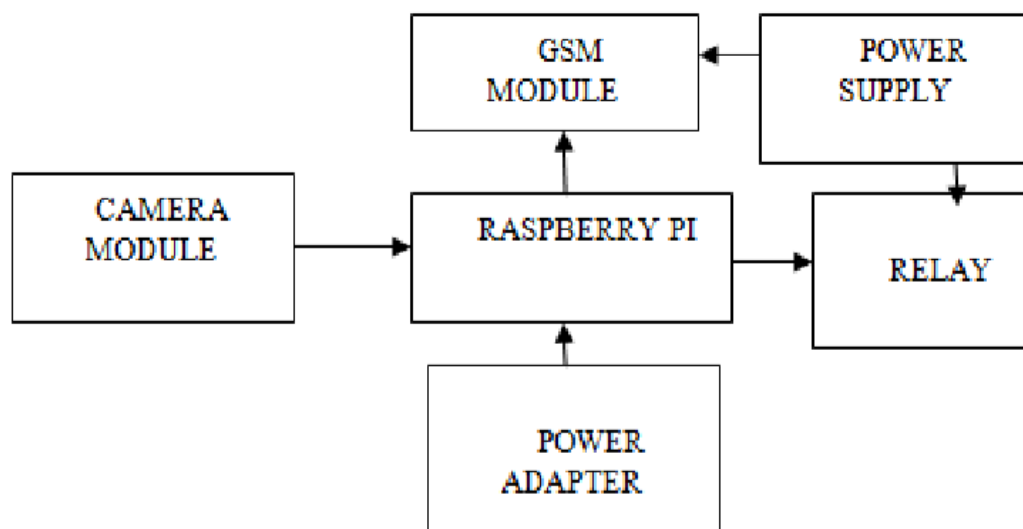
compared in the database and it's a perfect key to security with different kind of biometrics framework. Based on the internet of things (IoT), it refers to a remote-control system between the outside world items. Utilizing the raspberry pi 3 which was found in the United Kingdom with different kind of generations which is faster than the previous raspberry pi 2 by 80% having the features add to provide Bluetooth connectivity, WI-FI and a storage of 1 GB memory in micro SDHC slot. With the pi camera interfacing to raspberry pi module uses to snapshot images and send to the raspberry, as well the camera has a built in LED and flashes capable of handling light conditions by the environment. Meanwhile, the proposed works of this research paper are capturing facial images in real time by interfacing with the pi camera used and creating a database of people who have access to the property also current pictures to be captured and saved to compare images found in the database for individuals which later to determine imposters tried to access log in. A GSM module to generate SMS and calls to the user for alerting authorized people for unlocking doors. As an output to unlock the doors a relay electromagnetic lock is installed which will be provided by the system to whether to be granted access or denied.

Figure 3.3.1: Block diagram of "Raspberry pi based face recognition system for door unlocking (Patel & Verma 2017)

1.1 A face recognition method in the Internet of things for security applications in smart homes and cities

Moreover, this article "A face recognition method in the Internet of things for security applications in smart homes and cities" (Othman & Aydin 2018) discusses applications based on IoT for face recognition in securing homes. Mentioning the importance of safety and security when it comes to human life, as this low-cost system capable of monitoring movements outside in real time recognition and able to response and analyses images quickly and smoothly. Main objective for this security system is to provide safety and protection for properties such as homes and offices by recognizing people who are trying to log in. The system consists of PIR sensor device to be installed which is used for detecting any movement in the surrounding area. The camera module is used to capture the facial image and send it to the raspberry pi module which both are having interface each other after its been detection and recognized, with the use of IoT notifications by attached images will be sent to a smart mobile phone by the use of telegram application. The benefit of using IoT method is to provide control and monitoring of various appliance at home. The ability of this security system to provide human face recognition to the person who is approaching in unwanted areas and maybe suspected for the environment, this is an effective method to provide high security in the recent years while there is a fast growth in the society having a wide ranges of applications in access control, information security and criminal identification, as a result of the human face is most important in the body which is extraction related to mouth, nose and eyes. We can clarify that this system consist of two stages, first the face detection secondly face recognition to analyze images of facial geometric features with the help of Local Binary Pattern (LBP) techniques of capturing face image for implementing face recognition which brings out high good results and efficiency for real time application which are generated to describe code binary local texture pattern extracted from LBP pixel histogram. It is mentioned in this paper the methodology taken place of this system structure starting from the PIR sensor to detect the movement when an images is captured, then processed by computer vision and to recognize the human face, on the other hand if there weren't any movement the status of this system will be standby and wont perform face detection and recognition. The benefit of using the algorithm method is to search for a human face then the face recognition will occur, later the image of the captured face will be sent to the mobile smartphone device. With the use of face recognition, it is desired to classify a human face whether is known or unknown via database comparison and leaving out the unknow human face. According to Haar-like method which helps to extract face features

through the LBP then to be processed to the identification to the person. The extract image technique in surrounding of pixel area coded into binary patterns combined and calculated to a single histogram feature for describing the shape and texture digitized image, these binary values are stored normally in the pixel center location of the output decimal picture number, hence these pictures via computes the among distance histogram.

Figure 3.4.1: identification and recognition procedure (Othman & Aydin, 2018)

1.1 IoT and AI Based Emotion Detection and Face Recognition System

Kumar and Kaur (2019), in their article of "IoT and AI Based Emotion Detection and Face Recognition System" made a research of two technologies are been used in modern world security in most domains in the facial recognition and emotion automated system detection are the Internet of Things (IoT) and Artificial Intelligence (AI), these both technologies are trending technology era in the field of robotics and machine operation learning, as a result intelligent machine are processed information same as a humans and able to change the environment work situation these days, it is also considered the IoT is a notable innovation which has the capability to associate physical systems that it can get involved to the internet and usually utilizes different kind of sensors to exchange information and
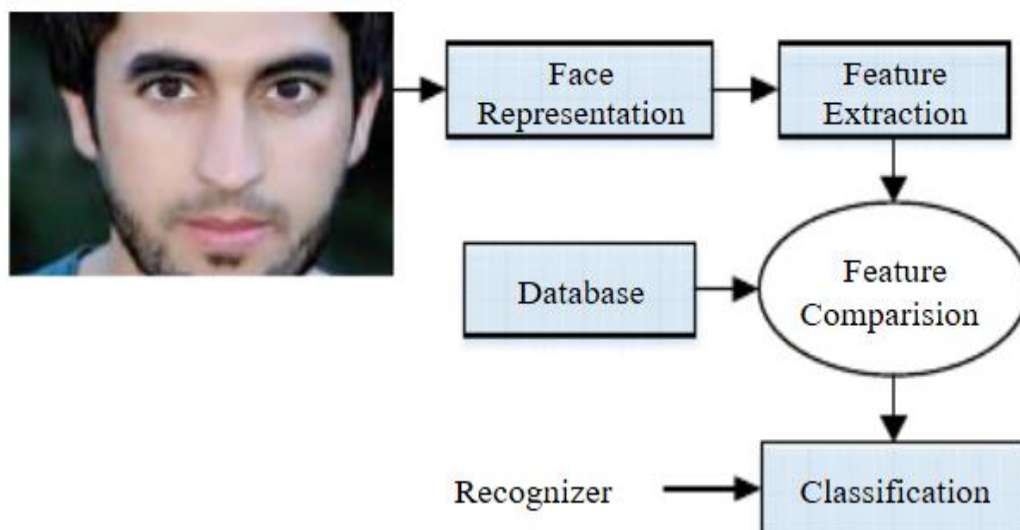
extricate data by using the Internet Protocol (IP) address. It is meant to collect all different kind of gadget sensors to work with the raspberry pi to concentrate gathered information by these different sensors. With the assistance of IoT technology method the entryway can

be programmed with different tasks and can defined as an entryway framework which enables logging in without any other's input because it perceives your face without anyone else due to the match of the pictures given and saved in the database. In case if the face wasn't perceived by the system it will automatically send a speedy notification to the house
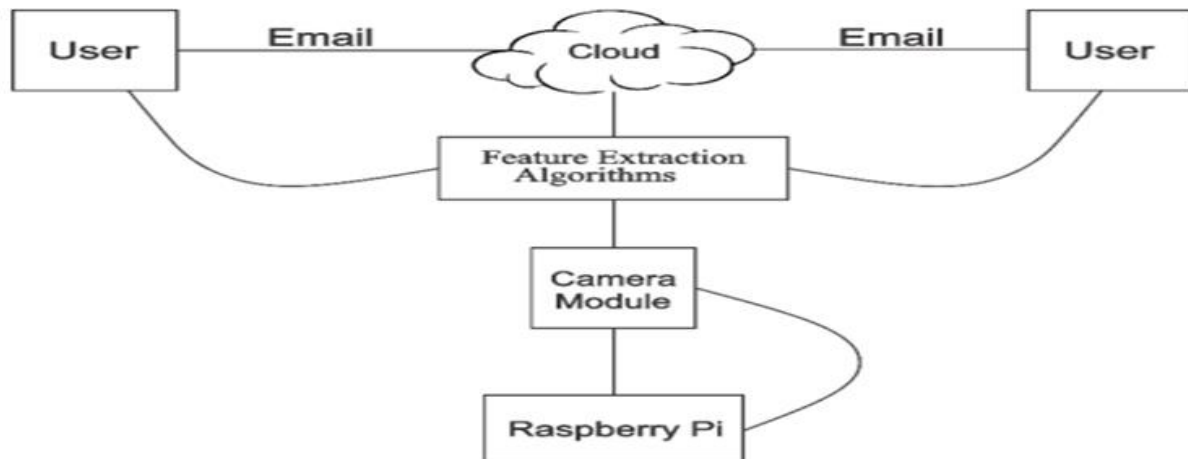
proprietor, this kind of IoT innovation gadgets utilizes the web association, and the benefit of using the face acknowledgment frameworks, which leads to very fast growth innovations, enabling to perform independently for anyone else. Fundamentally to process this system it is been utilized by raspberry pi as the base interface and PC in every gadget, moreover, the camera pi module will be operated by the gadget while switching it on which will examine images conducted by the camera and make different calculation for summing articulations, with the use of the raspberry pi web and with the assistance of the gadget date will be exchanged respectively and transferred to the cloud. Facial Action Coding system (FACS) was introduced in the year of 2014 which enabled the human activities combined with controlling systems possible with biometric in face recognition and gesture to make it universal system and to obtain the output results based on the classification method. For the OpenCV method python language programming was introduced in 2016 used to detect faces, emotions, eyes and mouth extractions for achieving the human emotions from the face expression, on the other hand in 20107 MATLAB came with a feature of detecting the emotions by the face recognition method based on the holistic approach similar to Viola Jones algorithm techniques for face detection, and without using the IoT this system will have several drawbacks such as high cost due to high consumption power and cannot collect data online because the data will be in manual monitoring, giving the importance in having the IoT in the system will give a high quality life and automated control providing less time to fetch data and the transmission data will be continuously.

Figure 3.5.1: Architecture for Face and Emotion Detection (Kumar and Kaur, 2019*)*

Table 3.1: Summary of papers reviewed comparison

Title, Author, Year	Main points (concepts/design/methods)	Limitations and/ or strengths	Suggested improvements
''Face recognition system using IoT'', Kulkarni et al., 2017	Using a standard USB camera to capture a person's face image for identification to recognize a visitor by greeting them and by unlocking the door with the use of internet connection, also remaining door locked for unidentified visitors.	The points of strengths can be obtained by having a low-cost system with low power consumption when using a raspberry pi. Homes can be monitored and controlled remotely by placing sensors at various places. Modification to the system can be done easily without interfering with other components and other technologies can be added due to the benefit of raspberry pi device.	New algorithm can be introduced for human face recognition and easily new modifications can be available and new hardware can be connected as a new smart home device.
"Face recognition using OpenCV based on IoT for smart door" Deshmukh et al., 2019)	Using OpenCV method for identification of an object to identify the human face with the use of raspberry pi camera. Opening doors based on IoT technology for identified people for entry.	The use of OpenCV method gives an important strength for designing facial recognition system and provides high level of effect in human face to be recognized.	Improving variations of training data face will have a better face recognition and lower of naming unknown human faces chance from the database also database should have clear face images.

"IoT Based Facial Recognition Door Access Control Home Security System", Patel & Verma, 2017	Automated secure locking by using IoT for door unlocking system for providing safety and security to any intruders. Control of unlocking doors utilizing the GSM module, controlling the video camera for capturing human face image and to compare the image with the database for unlocking automated doors and generate SMS to unknown person to the user.	As the strength point is the camera module is interfaced with system to receive live human face images and saving it to the database to be compared with other images. Unlocking the doors for authorized people in a form of call by using a GSM module and also an SMS. Determining the imposters who are trying to access the specific area by catching the face image to be stored for later use.	Adding the feature of blacklist who is trying to access the door an SMS will be sent to the admin by using the GSM module. Real-time intercom to speaking to the person at the door to make it higher efficient and friendly. Utilizing TLS to gain high protocol security to make sure no security breach.
"A face recognition method in the Internet of things for security applications in smart homes and cities", Othman & Aydin, 2018	Utilizing a PIR sensor to detect movement of a human face, and camera module to capture the face image. Sending and generating email notifications to the user with the use of IoT method in real time capturing to	Displaying the detected face in the area and notifying the user admin by the mobile smartphone with the capture human facial image.	Utilizing IoT with a vision computer. Mobile application to be integrated with the system for developing smarter movement and facial recognition for a specific area.

	recognize people in a specific area.		
"IoT and AI Based Emotion Detection and Face Recognition System", Kumar and Kaur, 2019	Facial detection in real-time utilized with IoT method and artificial intelligence to perform facial feelings expression to demonstrate the detection and recognition to the human face.	Python programming codes have an important feature for detecting human faces and emotion recognition with extracting the mouth, eyebrows. With the python platform virtual learning environment is used for designing emotion of the face-based base on a person face recognition.	Projects which consists of facial recognitions and detection has to based on IoT method technology to provide real time outputs and higher performance in security wise.

4 BUDGETING AND PROJECT MANAGEMENT

This chapter will be discussing about the budget on the components used with its quantities and schedule of the report mentioning the project management of the work and risk management as well occur.

16.1 Project Budget.

Table 4.1.1: Project Budget of the components used

S.NO	NAME	QUANTITY	PRICE(RO)
1	Electromagnetic door lock	1	5.000
2	Raspberry	1	35.000
3	Camera module	1	10.000
4	PIR sensor	1	1.200
5	Power supply	1	2.500
	Total	5	53.700

In the above table shows the pricing of the components which will be purchased in the store and or even online websites with total amount in Omani Rials estimated and can be varied depending on the circuit modification while implementation stage.0

16.2   Project Schedule

In the below Gantt chart table shows the work plan during the semester and each week what tasks to be followed to accomplish the proposed project planning report successfully on time.

Table 4.2.1: Project planning Gantt chart

Major task	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Selection of topic			▓												
Submitting rough draft of the proposal for review comments				▓											
Submission of proposal as per the format guidelines					▓										
Literature review					▓										
Draft submission of chapter 1 and chapter 2						▓									
Draft submission of chapter 3 Literature Review							▓								
Draft submission of chapter 4 Design and Analysis								▓							
Draft submission of chapter 5									▓						
Draft submission of chapter 6										▓					
Final Report											▓				
Perform revision as instructed by the supervisor												▓			
Final Report submission													▓		
project planning presentation															

16.3   Risk Management

In the below table it explains the risks which can across the project and threats at the implementation stage or even during the planning analysis stage and the challenges which can occur and how to process in resolving kinds of risks to mitigate them.

Table 4.3.1: Risk Management

Sr. no	Risk category	Risk	Impact	Mitigation
Internal Risks				
1.	Pricing Risk	Above the level calculation budget.	High	Analyzing the pricing inspection.
2.	Management Risk	Objectives to be incompatible	average	Approving the scope and to be defined with the supervisor.
3.	Time Risk	Time restriction.	High	Time management schedule plan to be done
4.	Technical Risk	Modern technical skills to be required.	average	Gaining new skills
External Risks				
4.	Resources Risk	Components to be out of stock or unavailable in the market or online	High	Purchasing the components in advance with doing an early project studies and research
5.	Legal Risk	Official holidays.	Low	Performing extra work in writing and studying the report in the managed holidays.

17 DESIGN AND ANALYSIS

The chapter consist of analysis and design in details with block diagram and flow chart of the proposed system and providing the components used with its technical description including the software to be utilized in the project.

18.1 System Analysis

18.1.1 System Block diagram

The figure shows the system block diagram showing the flow of inputs and outputs of the major components used. All components are connected to the raspberry pi module, which works as the brain control of the project system and needs to turn on to function with a power supply. In addition, the components such are a PIR sensor for detecting a movement of the human at a distance leading to capture of the human face by the camera module. Another component used is the electromagnetic door lock, for unlocking the door when authorized. Database is an important role for storing images of human face and later to be compared if the person is authorized for entry or not. The internet of things is present (IoT) for receiving email notifications to the admin with the captured human face image and for controlling the electromagnetic door to be locked/unlocked.
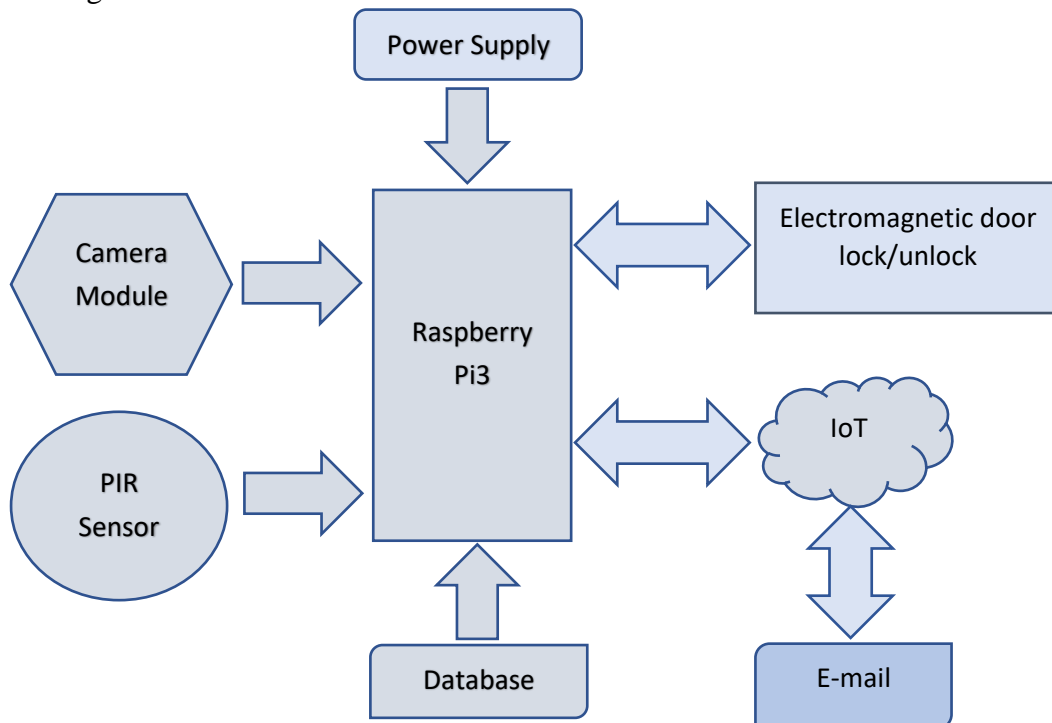
Figure 5.2.1.1: System Block Diagram

18.1.2 System Flow chart
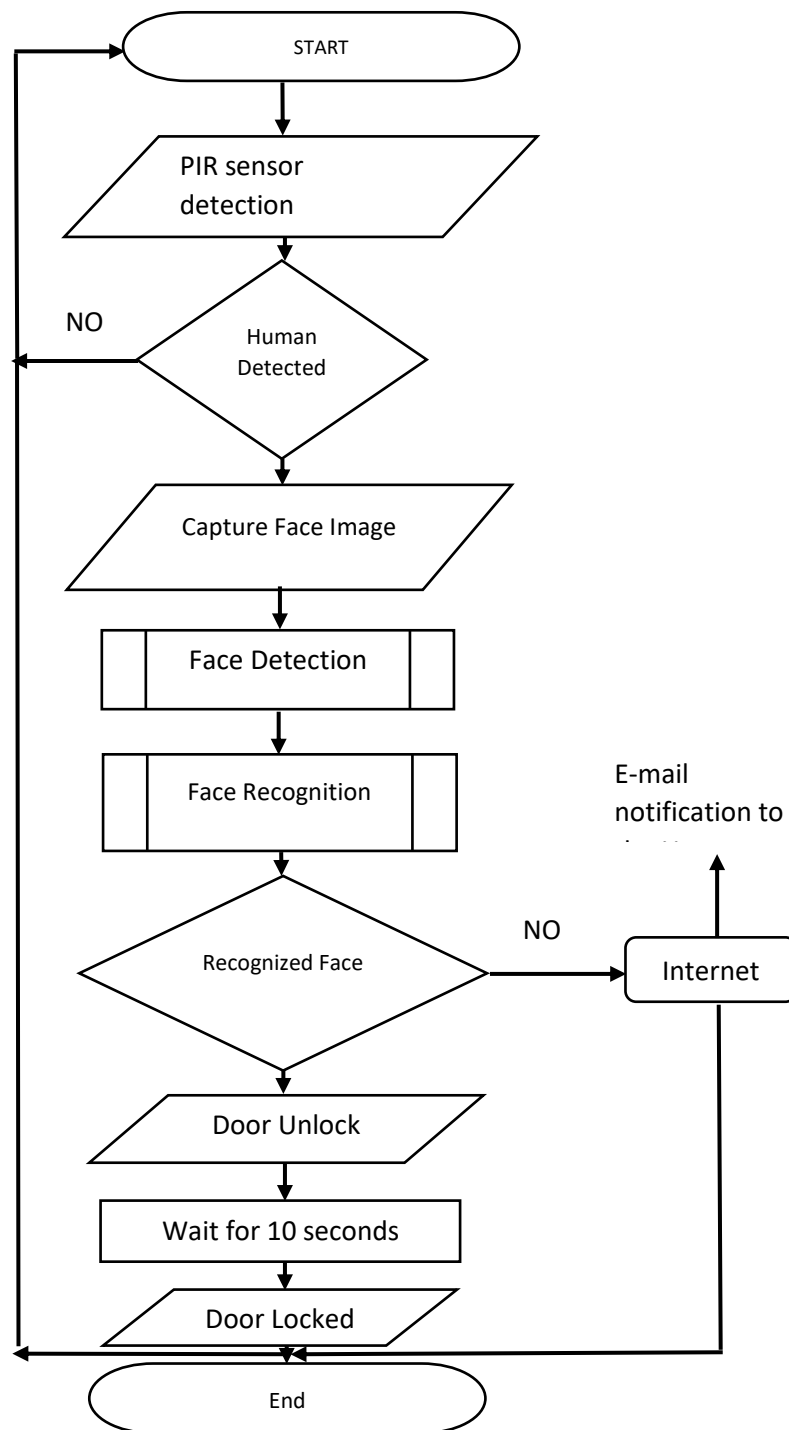
Figure 5.2.3.1: Face detection and recognition Flow chart

For the Above flow chart figure of the proposed work design system explains the procedures and steps to be implemented. At first start logic to be considered for initiating. Then comes the PIR sensor to lead of making decision of detecting the human movement, if no then goes back to the start logic, if face is present it will lead to capture the human face image then goes to the process of detection and recognition. When the face is recognized the door will be unlocked 10

seconds for entry then locks the door. Meanwhile, if the face is not recognized an e-mail will be generated to be received by the user and the door will remain locked then go back to the start logic again.

18.2   Requirements Analysis

18.2.1 Summarizing the key parameters from the Datasheet

The key parameters and from the datasheet are as:

Table 5.1.2.1: Raspberry Pi camera module specification

Technical specifications	Raspberry pi Camera Module
Size	25×24×9 mm
Weight	3 grams
Image Resolution	5 Megapixels
Video Resolution	1080p30, 720p60, 640×480p60/90
Programming language	Python, OpenCV
Image Sensor area	3.76×2.74 mm
Focal length	3.60 mm +/- 0.01
LED flash	Supported
Image formats	JPEG, RAW, GIF, PNG, RGB888
Input Voltage	5 volts

Table 5.1.2.2: PIR Sensor specification

Technical specifications	PIR sensor
Size	32×24 mm circuit board
Weight	5.87 grams
Input voltage	5 volts
Coverage distance	7 meters and 120 degrees
Working Temperature	-15 - +70 degrees
Lens diameter	23 mm

Table 5.1.2.3: Electromagnetic door lock specifications

Technical specifications	Electromagnetic door lock
Size	55×40×28 mm
Weight	200 grams
Input voltage	12 volts
Cable Length	120 mm

Table 5.1.2.4: Raspberry Pi 3 specifications

Technical specifications	Raspberry Pi 3
Size	3.35''×2.2''×0.8''
Weight	42 grams
WI-FI	supported
Ram Size	1 GB
SD Socket	Supported
USB port	Supported
CPU	BCM2837
Program language	Python, scratch, C++
Input Voltage	5 Volts Minimum

The input parameters should interface with each other such as the Pi camera and the PIR sensor with the Raspberry pi and with its configurations libraries must be done to enable communication, having the Raspberry as well a constant input voltage of 5volts and 2 amperes to perform operations without any failure in switching on the device.

18.2.2 Initial Conditions

It is considered of using the raspberry pi device in the system of the project as an operational hardware and can defined as a small computer size programable device which can perform various operations. Since it's a programable device it must require programming platform to be installed with its operating system including the library through an SD card after been purchased in order of installation of Raspbian OS. The Python library is utilized for the raspberry pi thus providing the capability of reading from and output into the GPIO (General purpose input/output). Other various libraries are required such as:

– NumPy: using the matrix operations for image processing.
– Matplotlib: visual data.
– CV2/CV3: this kind of library used for implementing processing before training to the data manipulation.

For the USB Camera Pi Module, it must integrate with the Raspberry Pi device including of installing the configurations of various libraries, such as OpenCV (Open Source Computer Vision) written in python language, having the feature of detection and recognize including emotion, eye, eye brow, mouth extraction in order to perform identification of human face classification of a person.

18.2.3 Input and Output Parameters

The input and output parameters for each of the functional units for the execution of this system are given on next page in the form of a table:

Functional Unit	Input		Output	
	Type of signal	Value	Type of signal	Value
Raspberry Pi	Voltage for operation	5 V	Power for other modules	5 V
	Digital signal of camera module	0-5 V	Voltage signal for lock on access	5 V
	PIR Digital signal	0-5 V	Analogue signal to trigger e-mail	0 – 5 V

Camera module	Power signal (Voltage)	5 V	Analog signal of captured image	0 – 5 V
PIR sensor	Power signal (Voltage)	5 V	Digital voltage signal	0 – 5 V

18.2.4 Relations

For the desired system design, the required voltage for the Raspberry pi to operate at a minimum of 5 Volts sustainable. All components such as Pi camera, PIR sensor, and electromagnetic lock are interfaced with the raspberry device, if the voltage input is below 5 volts there are problems can occur such as failure in camera and PIR sensor detection including the operation of video applications in the GPU. For this system it is considered that the PIR sensor will detect a human movement in the surrounding area which then the Pi Camera will initiate of detection of the face image and then to perform the face recognition to enable access authorized person and access denied for unrecognized person leading to send email notification to the user. In order to perform an accurate face detection it is considered the focal length of the camera is an important parameter meaning distance from the front lens camera to the nearest object focal length approximately about 50 cm length and depth of 50 cm towards infinity, meaning the object will be in sight of the camera from at least 50 cm away from the lens its self. Having the Camera serial interface (CSI) gives the feature of high data rates to the system, but in dark environment it is difficult for the camera to perform face detection due to unclear image thus, it will fail to perform recognition to the person's face. The approximate average range for the PIR sensor to detect the human movement is between 5 – 12 meters.

To calculate the highest framerate done by the Pi camera determine at a lower exposure time by using the formula expression:

$$1 sec / \min exposure\ time\ in\ sec = Max\ framerate/sec$$

Calculating the highest exposure time can be determine at a lower framerate by using the formula expression:

$$1 sec/min\ framerate\ in\ fps = Max\ exposure\ time\ in\ sec$$

In addition, if available 500 rows in the sensor and each row to be read at 20ns minimum this will indicate that $500 \times 20ns = 10\ ms$ for reading a full frame from the hypothetical sensor as a minimum value of the exposure time.

The PIR sensor consists of two timeouts to be considered. The first is "Tx" which indicates of the time period that lit after detecting a movement, and the second is "Ti" when the LED is set to be off when no movement is detected. Considering that resistance R1 = 4.7 K and capacitor C1 = 10nF for example to calculate "Tx" can be obtained by the following expression:

$$Tx = 24576 \times R1 \times C1 = \ {\sim}1.2sec$$

On the other hand, consider that R2= 470K and C2= 0.1uF

$$Ti = 24 \times 470k \times 0.1uF = {\sim}1.2sec$$

18.2.5 Constraints

The following are the constraints for this project:

- The detection of human face in low light conditions. This is due to less exposure of light in the place of deployment of the system.
- The availability of internet connection at the place of deployment and its credibility in term of speed as well, which may affect the timely notification to the person about the security failure.

18.3 System Design

Using the formulas design and compute the various system parameters. Obtain the values of parameters for desired outcomes of every functional unit.

18.4 System Test plan

18.4.1 Identifying test points

Identify and highlight the test points in each functional unit to determine various scenarios. Different test points should be marked for hardware and software to check functionality. Determine the list of measurement (values, type of signals, etc.) at each test point. Each design test value should be compared with simulation and hardware for every functional unit.

18.4.2 Developing Test Plans

Test plan is to develop a list of the test cases for each test point of every functional unit. The test plan should be in the form

<Subject> <verb> <Object> <conditions> <values> <range> <constraints>

6 SIMULATION, TESTING AND IMPLEMENTATION

The characteristics and the performances of the circuit/application should be well discussed. They should be compared with what has been in previous literatures highlighting conformity or deviation. The purpose of the results' discussion is to communicate what was learned and how the results lead to the conclusions. The results are discussed in terms of what they show about the results and what they mean in the context of the goal of the report.

Test Cases (Hardware and Software)

➢ Provide the actual circuit diagram/ schematic diagram of the implemented hardware project (If applicable).

➢ The implemented system should be simulated using the appropriate tool (Proteus, Matlab, Multisim…etc). For all the test case scenarios listed in the chapter 5 of the different processes to obtain the objectives, *tabulate* the test observations (snapshots are optional) with a detailed description.

➢ For hardware projects, circuits mounted on PCB, should be go through all the test case conditions mentioned in chapter 5, tabulate the test observations .Verify with the simulation and design values with detailed description.

Test cases at test points	Design Value	Simulation value	Implemented value
T1			
T2			
…			

➢ Measurement of various system characteristics and performance such as resolution, efficiency, errors, accuracy, linearity, latency, power aware etc. also should be tabulated with detailed description

➢ Reflect on test results (reflect on observations also). Represent with graphs if required.

System validation

Validation should be dynamic and it should test the user requirements. The complete system is validated based on the purpose and functions carried out in design system. The desired outcomes are validated either through subjective or objective scenarios to justify the design system.

19 CRITICAL EVALUATION

An IoT based home safety and security is implemented, which makes use of digital image processing also to enable the facial recognition feature in the system to grant or decline access to an individual within the working capacity of the system. Chapter 7 presents a critical evaluation on the implementation of this project. The detailed chapter is given down below:

Identify and describe the Hardware and software Functional Units

For this subsection are the description of required hardware components used in the system design with its functionality including the software components in the proposed project.

7.1.1 Hardware components description

7.1.1.1 Raspberry Pi 3 module

A small computer chip programmable device microcontroller powered by a USB interface of 5 volts equipped with system on chip (SoC), an Arm Cortex processor with 1 GB RAM and consisting of SD card slot used to install different libraries such as OpenCV and python language and having a built in Wi-Fi module and ethernet interface.

Figure 7.1.1.1.1: Raspberry Pi 3 module

7.1.1.2 PIR sensor:

Passive Infrared Sensor (PIR) an electronic device used to detect human movement or an object in a specific area powered by 5 volts DC and having a detection range of 9 meters in an angle of 120 degrees, operating temperature from 0 to 50 Celsius.

Figure 7.1.1.2.1: PIR sensor

7.1.1.3 Electromagnetic door lock:

This component consists of two different parts, electromagnetic and armature plate can operate of locking and unlocking by the electric current pulse remotely and the working operation voltage between 6 to 12 volts DC.
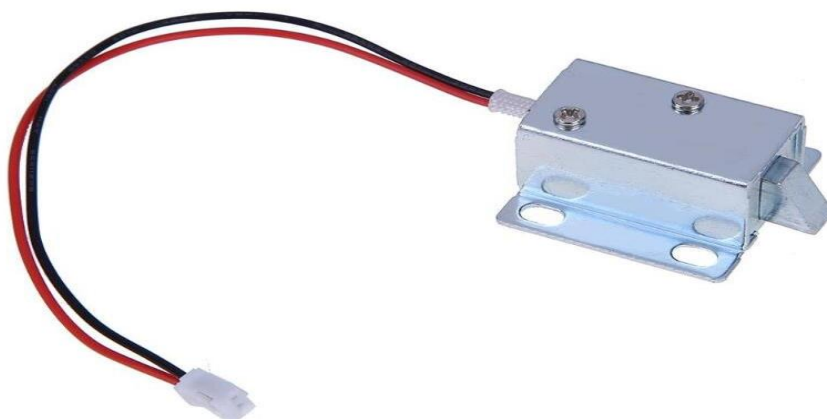

Figure 7.1.1.3.1: Electromagnetic lock

7.1.1.4 Pi Camera module:

Is a serial interface camera connected and supported via USB to the Raspberry Pi device, small in size and portable light weight component used for processing images in surveillance applications having a resolution between 5 – 8 megapixels of Sony technology image sensor this device is likely similar to mobile phone camera. Libraries can be integrated with the camera to provide various operations.

Figure 7.1.1.4.1: Pi camera module

7.1.2 Software components description

In the proposed system design project, a various of software are utilized to meet the requirement of programming the system design.

7.1.2.2 OpenCV:

This platform library is used for human face detection in face recognition in virtual learning these algorithms capable to perform eye, mouth, eyebrow extractions including the Haar method cascade used for detection of an input image characteristic at real-time vision

7.1.2.3 OpenCV:

This platform library is used for human face detection in face recognition in virtual learning these algorithms capable to perform eye, mouth, eyebrow extractions including the Haar method cascade used for detection of an input image characteristic at real-time vision
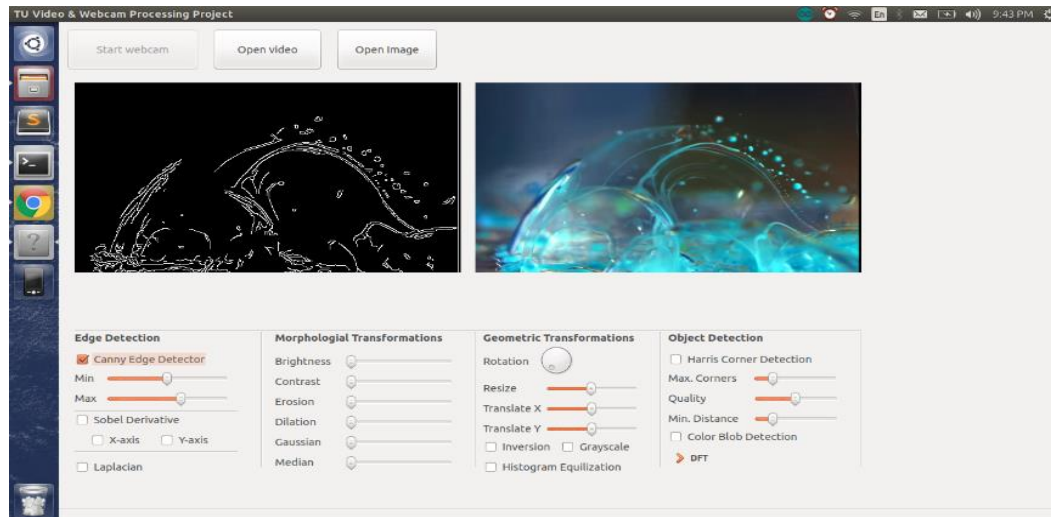

Figure 7.1.2.1.1: OpenCV software

7.1.2.4 Python:

Programming language uses the graphical user interface been connected to a specific database covering several aspects such as mathematical and algebra also it is considered for development of GUI applications and been supported in various operating systems.
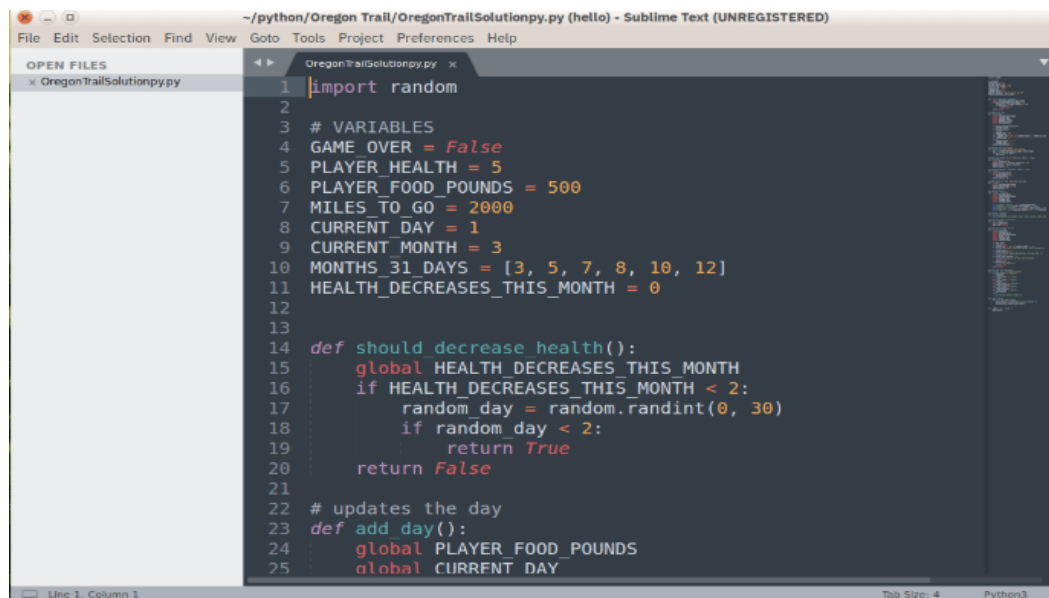

Figure 7.1.2.2.1: Python programming

7.1.2.5 Visual Studio:

This software been utilized for setting the database input faces to be compared with the saved image face for the user to have a reference of the authorized faces for the face recognition and have a full access to the system.
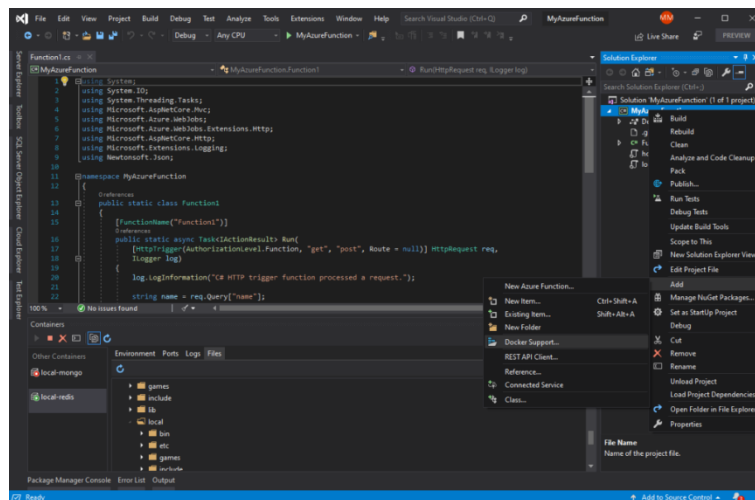
Figure 7.1.2.3.1: Visual Studio coding

7.2 Discuss the properties, issues and constraints of functional units

The project implementation has been carried out though, but along the way, there have been many hurdles that were faced. One of the main highlighted issue is the detection of human face in low light conditions. This is due to less exposure of light in the place of deployment of the system. Other issue is the availability of internet connection at the place of deployment and its credibility in term of speed as well, which may affect the timely notification to the person about the security failure.

7.3 Suggested Improvements / Solutions

The following improvement or suggestion must be considered by anyone who is planning to implement any similar system as this one:

- One may use/deploy a night vision camera and IR based motion detector, which will allow the system to detect human face as well as motion detection in low light or in dark place. An LED bulb/lightning device may be also added, which in case the motion is detected, reads the light condition via another added sensor and turn on the bulb if required. This also help to better read the face of the individual standing in front of the camera module.

8 SOCIAL, LEGAL, ETHICAL AND SUSTAINABILITY ASPECTS RELATED TO THE PROJECT

The advancement of technology is being witnessed by human day by day. Science and life have move forward from what it used to be. The implemented system is one of the proofs the advancement of technology for the betterment of the quality of human life. Having said that, while advancing and implementing systems, some legal and ethical aspects are to be followed and considered, which are being covered and discussed in this chapter.

8.1 Legal and Ethical Aspects

The implementation of this project was carried out lawfully. All the components and objects required for this project were ordered, bought and shipped through proper, allowed and legal channels without involvement of any illegal or banned party/activity. The project, its implementation or any of its components was not meant to and has not harm or hurt any individual, animal or any of the natural resources of the Earth.

Apart from that, fulfilling all the ethical aspects by all the credits adhered to the concerned person for any of the reference, research paper, article, book or other source that help in the implementation of this project.

8.2 Social Aspects

There is no deny in the fact of people breaking into someone's property without any security alert or him being brought into knowledge. This is where this system comes in handy allowing certain people access while blocking the rest.

8.3 Sustainability Aspects

The aspects of sustainability of the implemented system are as:
- The basic components used in the implementation of the security and monitoring system is readily available in most part of the world without any real effort in approaching them. All the used material weighs very light resulting in the implementation of the final project to weigh less too without any harmful emission to nature as well. The only maintenance includes is the replacement of the DC power source i.e. batteries once they are done with their life.

9   CONCLUSIONS AND RECOMMENDATIONS

9.1   Summarizing

A human face recognition and detection is implemented to enter homes, offices and banks. With the use of a standard USB camera, it snapshot images for identification to the person who is trying to log in and also providing a PIR sensor along with the camera module to detect the movement of a person. This security system enables Automated door unlocking for authorized people by recognizing them in the saved images of visitors in the database in real time which utilizes internet connection via camera web.

For people who aren't identified the door remains locked and an email notification with attached image of the person's face is sent to the owner who tries to login to the owner's place. In addition, this system also provides monitoring and control including remotely date and time can be visualized in real time once bell is been triggered. The technology of IoT also provide sensing communication actuation in this security system easily automation and with low cost and power consumption of the electricity with a huge rate of efficiency as a result of an significant impact in the modern world and making the system self-instructed device which also made this kind of gadget technology as well hard to be breakdown or hacked by the recognition of the human face technique. The effectives of OpenCV method provides Recognition and classification of human faces and verifies the identity of a person, as the human face is an important key to security in the biometric acknowledgment innovation confront as this framework will concentrate on the person's character using facial images by the pi camera and compares it with face database images.

9.2 Applications

This system can easily be implemented in any of the place, where the entry for only authorized person is allowed as:

- Home
- Offices
- Banks Locker's Room
- Restaurant's Kitchen
- Pantries
- Or any other private places.

9.3 Recommendations

The following improvement or suggestion must be considered by anyone who is planning to implement any similar system as this one:

- One may use/deploy a night vision camera and IR based motion detector, which will allow the system to detect human face as well as motion detection in low light or in dark place. An LED bulb/lightning device may be also added, which in case the motion is detected, reads the light condition via another added sensor and turn on the bulb if required. This also help to better read the face of the individual standing in front of the camera module.
- Instead of depending solely on the internet connection and e-mail service, the person can also be notified via third party apps like Blynk or a cellular module may also be added to enable the notification by direct message or a short call.

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APPENDIX A

GPIO Pinout Diagram

5V Power	5V Power	Ground	GPIO14 UART0_TXD	GPIO15 UART0_RXD	GPIO18 PCM_CLK	Ground	GPIO23	GPIO24	Ground	GPIO25	GPIO8 SPI0_CE0_N	GPIO7 SPI0_CE1_N	ID_SC I2C ID EEPROM	Ground	GPIO12	Ground	GPIO16	GPIO20	GPIO21
2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39
3V3 Power	GPIO2 SDA1 I2C	GPIO3 SCL1 I2C	GPIO4	Ground	GPIO17	GPIO27	GPIO22	3V3 Power	GPIO10 SPI0_MOSI	GPIO9 SPI0_MISO	GPIO11 SPI0_SCLK	Ground	ID_SD I2C ID EEPROM	GPIO5	GPIO6	GPIO13	GPIO19	GPIO26	Ground

Run Header Used to Reset the PI

4 Squarely Placed Mounting Holes

40 GPIO Headers

SMSC LAN9514 USB Ethernet Controller

2x2 USB-A Ports to PC

Broadcom BCM2835

MicroSD Card Slot (Underneath)

DSI Display Connector

Switching Regulator for Less Power Consumption

Ethernet Out Port

5V Micro USB Power

HDMI Out Port

CSI Camera Connector

3.5mm Audio and Composite Output Jack

	Pin		Pin	
3V3	1		2	5V
GPIO 2	3		4	5V
GPIO 3	5		6	GND
GPIO 4	7		8	GPIO 14
GND	9		10	GPIO 15
GPIO 17	11		12	GPIO 18
GPIO 27	13		14	GND
GPIO 22	15		16	GPIO 23
3V3	17		18	GPIO 24
GPIO 10	19		20	GND
GPIO 9	21		22	GPIO 25
GPIO 11	23		24	GPIO 8
GND	25		26	GPIO 7
ID_SC	27		28	ID_SC
GPIO 5	29		30	GND
GPIO 6	31		32	GPIO 12
GPIO 13	33		34	GND
GPIO 19	35		36	GPIO 16
GPIO 26	37		38	GPIO 20
GND	39		40	GPIO 21

KC7786

PIR Sensor Module

KC7786 is a small size PIR sensor module with built-in amplifier and logic circuit. The heart of the module is high reliable PIR controller KC778B. The PIR sensor can be manufacturer specified. The fresnel lens is included for the detection of a human body movement at a distance of 5 meters. It is suitable for automatic illumination system, intruder alarm system.

Features

- Small size, 27mm square
- Single voltage operation, 12VDC
- Open collector output, active low
- 3 pin terminal of standard 0.1" pitch
- Built-in regulator and amplifier
- High sensitivity with special noise cancellation design
- High immunity to RFI and line noise
- Signal will not detect within 25 sec when power up
- Signal output is 0.5sec min
- Small operation power consumption

### Standard Configuration

PIR Sensor : RE200B, dual element
Output duration : signal in 0.5 sec
Remark : the configuration can be specified by the customer for other sensor and output duration.

1 - V+
2 - GND
3 - OUT

Specification

Item		Condition	Symbol	Min	Typ	Max	Unit
Operation voltage			Vdd	10	12	14	V
Operation Current at 12V		Iout 0	Iop		600		µA
Standby current		Iout=0	Istd		400		
Output Voltage		R_L=10K	Vout		0.2		V
Output Duration			Tout	0.5			Sec
Lens angle	Horizontal				100		Deg
	Vertical				60		
Lens diameter					24		mm
Module Dimension					27 x 27 x 18		mm

Timing Chart

Power

Detection

Output

30sec

0.5sec

12V

VCC

R1

OUT   3

OUT

GND

KC7786
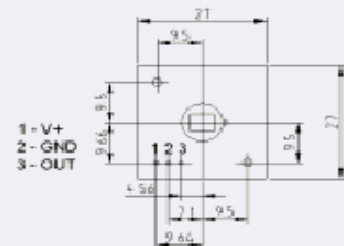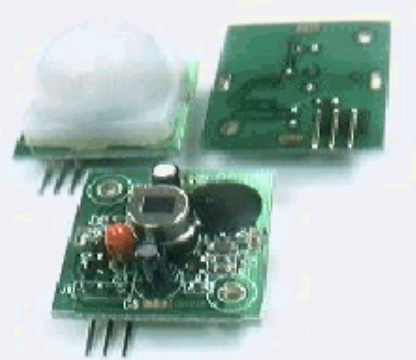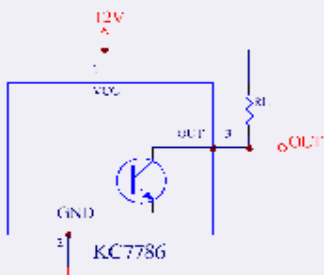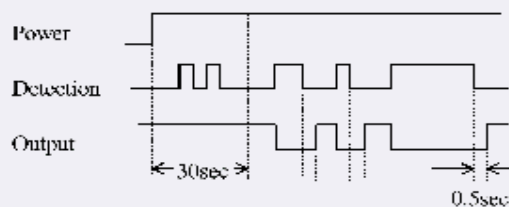
Additional features

All models
- Automatic Voltage Selection (AVS) senses the voltage applied to the lock and responds accordingly
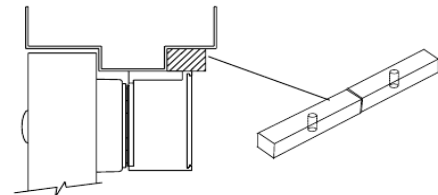
M450P/M452P
- Magnetic Bond Sensor (MBS) monitors the strength of the bond between the lock and armature so you know the door is secure
- Door Position Switch (DPS) monitors whether the door is open or closed
- Relock Time Delay (RTD) provides a relock delay that is adjustable from 0.5 to 30 seconds
- Optional accessories (P models only) ATS/LED Combines anti-tamper switch (ATS) with magnetic bond sensor in one kit.
  - ATS provides an indication that the cover of the magnet is securely fastened to the lock and that the on board circuitry is secure
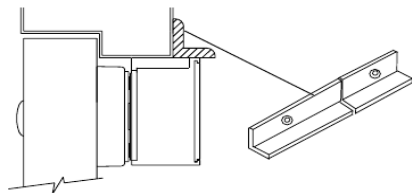 - Magnetic bond sensor indicator (LED) provides visual indication of magnetic bond at the lock

Optional accessories (for all)
- Herculite door bracket kit
- Top jamb (inswinging doors) kit
- Double door connector kit (converts two single magnetic locks to a double)

Filler Plate

Angle Bracket

M450/M452 electromagnetic lock specifications

Specification	M450/M450P	M452/M452P
Holding force	meets or exceeds BHMA standard of 1000 lbs	1000 lbs per door leaf
Door type	Single	Double
Input voltage (auto selected)	12/24 VDC	12/24 VDC
Current draw	.75A @ 12 VDC .38A @ 24 VDC	1.5A @ 12 VDC .75A @ 24 VDC
Height	3"	3"
Length	10 $\frac{1}{4}$"	20 $\frac{9}{16}$"
Depth	1 $\frac{3}{4}$"	1 $\frac{3}{4}$"
Weight (approximate)	10 lbs	20 lbs
Certifications	UL 1034, UL 10C, UL 294, ANSI/BHMA156.23, cUL, CSFM	UL 1034, UL 10C, UL 294, ANSI/BHMA156.23, cUL, CSFM
Temperature	0° to 49°C (32° to 120° F)	0° to 49°C (32° to 120° F)
Wire gauge	14-22 AWG	14-22 AWG

Filler plates and angle brackets specifications

Length	10 $\frac{1}{4}$"

Filler plates (order 2 if purchasing a double lock)

Width x Height	Plate no.
1 $\frac{1}{4}$" x $\frac{1}{8}$"	4501F
1 $\frac{1}{4}$" x $\frac{1}{4}$"	4502F
1 $\frac{1}{4}$" x $\frac{3}{8}$"	4503F
1 $\frac{1}{4}$" x $\frac{1}{2}$"	4504F
1 $\frac{1}{4}$" x $\frac{5}{8}$"	4505F
$\frac{3}{4}$" x $\frac{1}{2}$"	4506F
$\frac{3}{4}$" x $\frac{5}{8}$"	4507F
$\frac{3}{4}$" x $\frac{3}{4}$"	4508F

Angle brackets (order 2 if purchasing a double lock)

Width x Height	Bracket no.
1" x 1"	4501A
1 $\frac{1}{2}$" x 1"	4502A
1 $\frac{1}{2}$" x 1 $\frac{1}{2}$"	4503A
1 $\frac{1}{2}$" x 2"	4504A
1 $\frac{1}{2}$" x 2 $\frac{1}{2}$"	4505A

About Allegion

Allegion (NYSE: ALLE) is a global pioneer in safety and security, with leading brands like CISA®, Interflex®, LCN®, Schlage®, SimonsVoss® and Von Duprin®. Focusing on security around the door and adjacent areas, Allegion produces a range of solutions for homes, businesses, schools and other institutions. Allegion is a $2 billion company, with products sold in almost 130 countries. For more, visit **www.allegion.com.**

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