

UNLOCKING HOME AUTOMATION SYSTEM BY FACE DETECTION USING ESP32 CAMERA

A PROJECT WORK PHASE - II

Submitted in partial fulfilment of requirements for the award of Bachelor of Engineering

in

Electronics and Communication Engineering

by

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

SCHOOL OF ELECTRONICS

SATHYABAMA

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

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BONAFAIDE CERTIFICATE

This is to certify that this Final Year Project Report is the bonafide work of G.RAVI KIRAN (REG NO: 39130152) AND K.CH.V.SURESH KUMAR(REG NO: 39130193) who have done the project work as an individual who carried out the project entitled “UNLOCKING HOME AUTOMATION SYSTEM BY FACE DETECTION USING ESP32 CAMERA” under my supervision from Jan 2023 to April 2023.

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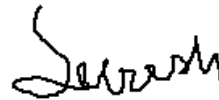
We, G.RAVI KIRAN (39130152) and K. CH.V.SURESH KUMAR (39130193) hereby declare that Project Report entitled “**UNLOCKING HOME AUTOMATION SYSTEM BY FACE DETECTION USING ESP32 CAMERA**” done by us under the guidance of **Dr.T.Vino, M.E., Ph.D.** Assistant Professor is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in **Electronics and Communication Engineering**.

1.



DATE: 23.4.2023

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ABSTRACT

The Covid-19 outbreak has proven to be the deadliest in human history. Millions of people have died, causing countries to go into lockdown and economic recession. Given the lack of a specific antiviral treatment for Covid-19 infection,” social distance” is likely the most successful method in preventing the virus’s spread thus far.

This study proposes an IoT-based doorbell that notifies the homeowner when a guest arrives. All of the system’s readings are logged in the Firebase online database, and a companion mobile app is also available. we propose a smart home security system, using IoT as well as face recognition. In our system, the web camera is used which is connected to the Arduino accompanied by a switch such as the Six legs on/off button mini. On motion detection camera captures an image of the person in front of the door then real-time face recognition is done using a local binary pattern histogram (LBPH). Face recognition is effective in multi-face recognition and stranger identification, both of which are important for home security. In the event of a power outage, this system is battery-powered. Furthermore, the house owner can utilize an android and web application connected to the Arduino through the internet to keep track of what is going on in the house.. Without physical contact, the person’s identity can be determined without the use of any specific hardware. Face recognition is performed using a deep learning technique. Deep learning is one of a larger category of machine learning methods that are based on learning data representations rather than task-specific algorithms. Learning can be supervised, semi-supervised, or unsupervised. The system is upgraded on a regular basis thanks to deep learning. As a result, the accuracy is improved. One example of an Internet of Things (IoT) application is home security. The Internet of Things (IoT) is a network of connected physical devices that can communicate and exchange data without the need for human intervention.

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CHAPTER 1

Introduction

Nowadays biometric systems bring in an added layer of security to networks, applications, personal computers, and physical facilities. Face recognition has swiftly made an entry into the real world and has proved to be the most successful and bang-on technology which is no more just in the world of science fiction. People can use it as a surveillance system, criminal identification, identity verification access or attendance system, home automation, etc. From 2D algorithms like PCA, Eigenfaces, Fisher faces, LDA, and IDA to SVM, CNN, and now deep learning, ML, and artificial intelligence, face recognition technology has evolved immensely. In this project, the face recognition process is initiated by a Contactless doorbell. This will turn on the integrated camera and capture images. The image captured will be compared with the one stored in the backend database. On matching, the name of the person at the doorstep will be announced. In case, the face is not present in the database, it will be stored newly. Compared to the old traditional doorbell, this improvised one notifies us of the person at the door.

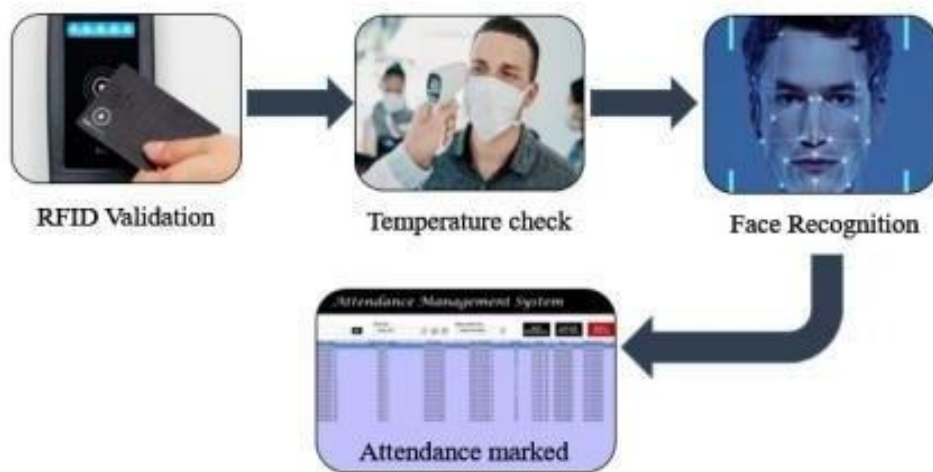


Figure 1.1 – Evaluation Protocol of our Proposed System

This will be helpful for persons with disabilities, particularly blind people. The created data set will be the face recognition image data of the code, the training and recognition process is done by the LBPH algorithm, and the image will store in the database by the person's name. After that whenever that authorized person will come in front of the user's door it will detect easily that person's identity and will send a notification to the user via showing the green/red light. This will turn on the

integrated camera and capture images. The image captured will be compared with the one stored in the backend database. On matching, the name of the person at the doorstep will be announced. In case, the face is not present in the database, it will be stored newly.

Problem Statement:

It revolves around the need to enhance home security and improve the convenience of home automation. Home security has become an increasingly important issue in recent years, with burglary and theft being a prevalent concern for homeowners. Similarly, home automation has been gaining popularity as it offers convenience and ease in managing various home appliances and systems. However, the existing home automation systems require the use of physical keys, passwords, or smartphones for authentication, which can be cumbersome and inconvenient.

To address these issues, the project aims to develop a home automation system that uses face detection technology to provide a secure and convenient access control mechanism. The system will be based on the ESP32 camera module, which is a low-cost and efficient solution for capturing images and performing image processing. By utilizing this technology, the system will allow authorized individuals to unlock the home automation system by simply looking at the camera.

The primary objective of the project is to design and develop a system that is reliable, efficient, and user-friendly. The system must be capable of accurately identifying the authorized individuals and distinguishing them from unauthorized persons. The system must also be capable of processing the captured images quickly and efficiently, providing a fast response time to the user.

To achieve these objectives, the project will utilize various image processing techniques, including face detection, face recognition, and machine learning algorithms. These techniques will enable the system to recognize the authorized individuals based on their facial features and provide access to the home automation system. The system will also be integrated with the existing home automation infrastructure, allowing users to control various appliances and systems through a user-friendly interface.

One of the critical challenges in developing such a system is ensuring the security and privacy of the users. The system must be designed in a way that prevents unauthorized access to the user's personal data and ensures that the system cannot be easily hacked or manipulated. The system must also be designed to work under various lighting conditions and account for changes in the facial features of the users, such as facial hair, glasses, or makeup.

Overall, the project aims to provide a reliable, efficient, and user-friendly home automation system that utilizes face detection technology for access control. By developing such a system, the project hopes to enhance home security, improve the convenience of home automation, and provide a unique and innovative solution to the growing need for secure and easy-to-use access control mechanisms.

Objectives:

To develop a standalone contactless doorbell system with security access protocol. In addition, we suggest a Smart power-saving protocol based on human activity. Unauthorized person entry will be framed on the screen to the cloud database for future reference. Management of employee attendance is a major facet of the proper functioning of enterprises. There are dominantly two different methods to attain this. One includes various manual operations, which is complicated and involve roll call and paperwork that consumes a lot of time and can even lead to a plethora of errors. It can also result in proxy attendance. Another technique utilizes particular amenities such as bar code scan, IC card scan, iris recognition, and facial recognition to record employee attendance data. A verification process by RFID alone can sometimes be misused. Therefore, this model which uses both RFID and face recognition simultaneously can eliminate limitations by the single security check. Moreover, the biometric fingerprint attendance system invokes a greater risk spreading of contagious diseases, hence justifying the usage of a contactless attendance system.

Productivity in a company can be assured by monitoring the mental wellbeing of the employees, well-being to capture the emotion of individuals at the entry-level itself. In conditions where an employee records a negative emotion for more than a specified threshold number of days, he/she would be directed to take counseling. Also, one cannot access the workplace at any time as they wish as different categories of staff are given different entry timings. For facial recognition, a dataset

is created with four classes, each class consisting of about 1000 images where 700 are set for training and 300 for testing. The FER2013 dataset has been used for training the model for emotion recognition. Google Collaboratory is used to train and test the above dataset due to its advantages like pre-installed modules, excellent performance, and free-of-cost GPU.

Scope of the Project:

Our project is contactless so in the COVID-19 pandemic, we can maintain social distance by using our touchless doorbell. This model will also help people to keep their homes safe and secure from trespassers. People are able to see who is standing in front of the door without going outside. Using this device, they can see everything by the device which is connected to the doorbell. The proposed system for attendance initially performs RFID validation that is followed by a contactless temperature check. Following this, the details of the employee corresponding to the RFID card along with the status of the temperature (high or normal) are pushed to the database. In case of high temperature, an alert message containing the details of the employee corresponding to the RFID card is sent to the concerned authorities. On the other hand, if the temperature is normal, the access time verification for the corresponding employee will be done. In case the access time doesn't match, a message "Please come after some time" will be displayed else a message "Authorized access" is displayed. The next step of verification is facial recognition in which a random image of the employee is given as input from the dataset created. If the predicted face matches the face associated with the corresponding RFID card, a message "Thank you for cooperating for the second tier of security" is displayed and his/her access is granted, else "The wrong face detected" is displayed. The image given as input to the facial recognition system will further be given to the emotion recognition system.

Applications of the Project

The project has numerous applications in home automation, security, and surveillance. Some of the potential applications of the project are:

Home Automation: The system can be used to control various components of the home automation infrastructure such as lights, fans, air conditioning, and security

systems based on the user's input. The system provides a convenient and secure access control mechanism for home automation.

Security and Surveillance: The system can be used for security and surveillance applications by identifying and tracking individuals in real-time. The system can be integrated with a surveillance camera network to monitor and record activities in the vicinity.

Attendance System: The system can be used as an attendance system by recording the attendance of individuals based on their face recognition. The system can be used in schools, colleges, and offices for attendance purposes.

Access Control System: The system can be used as an access control system for restricted areas such as labs, data centers, and research facilities. The system can be integrated with door locks and security systems to provide secure access control.

Potential Impact of the Project

The project has the potential to make a significant impact on various fields such as home automation, security, and surveillance. Some of the potential impacts of the project are:

Convenience: The system provides a convenient access control mechanism for home automation by eliminating the need for physical keys or passwords.

Security: The system provides a secure access control mechanism for home automation, security, and surveillance applications by using face recognition technology.

Efficiency: The system improves the efficiency of home automation by providing real-time control of various components based on the user's input.

Accuracy: The system provides accurate face recognition and detection, reducing the chances of false positives and false negatives.

Cost-Effective: The system is cost-effective compared to other biometric authentication systems such as fingerprint scanners and iris scanners.

Future Scope of the Project

The project has a vast potential for future enhancements and improvements. Some of the future scope of the project are:

Integration with Voice Recognition: The system can be integrated with voice recognition technology to provide a more convenient and secure access control mechanism.

Real-Time Tracking: The system can be enhanced to provide real-time tracking of individuals for security and surveillance applications.

Multi-Factor Authentication: The system can be enhanced to provide multi-factor authentication by combining face recognition with other biometric authentication systems such as fingerprint scanners and iris scanners.

Cloud-Based Infrastructure: The system can be enhanced to provide cloud-based infrastructure for storing and retrieving face recognition data.

Improved Image Processing Techniques: The system can be enhanced by using improved image processing techniques such as deep learning for face recognition and detection.

Methodology:

The created data set will be the face recognition image data of the code, the training and recognition process is done by the LBPH algorithm, and the image will store in the database by the person's name. After that whenever that authorized person will come in front of the user's door it will detect easily that person's identity and will send a notification to the user via showing the green/red light

Problem Definition:

1. The proposed system uses hardware components namely NodeMCU, temperature sensor, RFID card reader, and RFID tags for individual employees.
2. software platforms namely Arduino for processing inputs received in the NodeMCU, Google Colab for checking access time, training the models for facial and emotion recognition, MIT app inventor for creating an application to send messages to the authorities in case of high temperature.
3. The database used in this project is Firebase for cloud storage. All the hardware components are connected
4. NodeMCU, having a built-in WIFI module, facilitates pushing the relevant details of the employee to the database.

5. The RFID reader used in this work is MFRC522 which has a read range of 5cm. The RFID cards are unique for each employee where the card reader uses an electromagnetic field to transfer data with a frequency of 13.56 MHz
6. The sensor used for detecting temperature is MLX90614 which has an infrared thermopile detector and a signal-conditioning application processor.
7. Since firebase allows free cloud storage, it is used for storing the necessary details of the employee that are read as inputs

There are dominantly two different methods to attain this. One includes various manual operations, which are complicated and involve roll calls and paperwork that consumes a lot of time and can even lead to a plethora of errors. Another technique utilizes particular amenities such as bar code scan, IC card scan, iris recognition, and facial recognition to record employee attendance data. Therefore, this model which uses both RFID and face recognition simultaneously can eliminate the limitations by single-tier security.

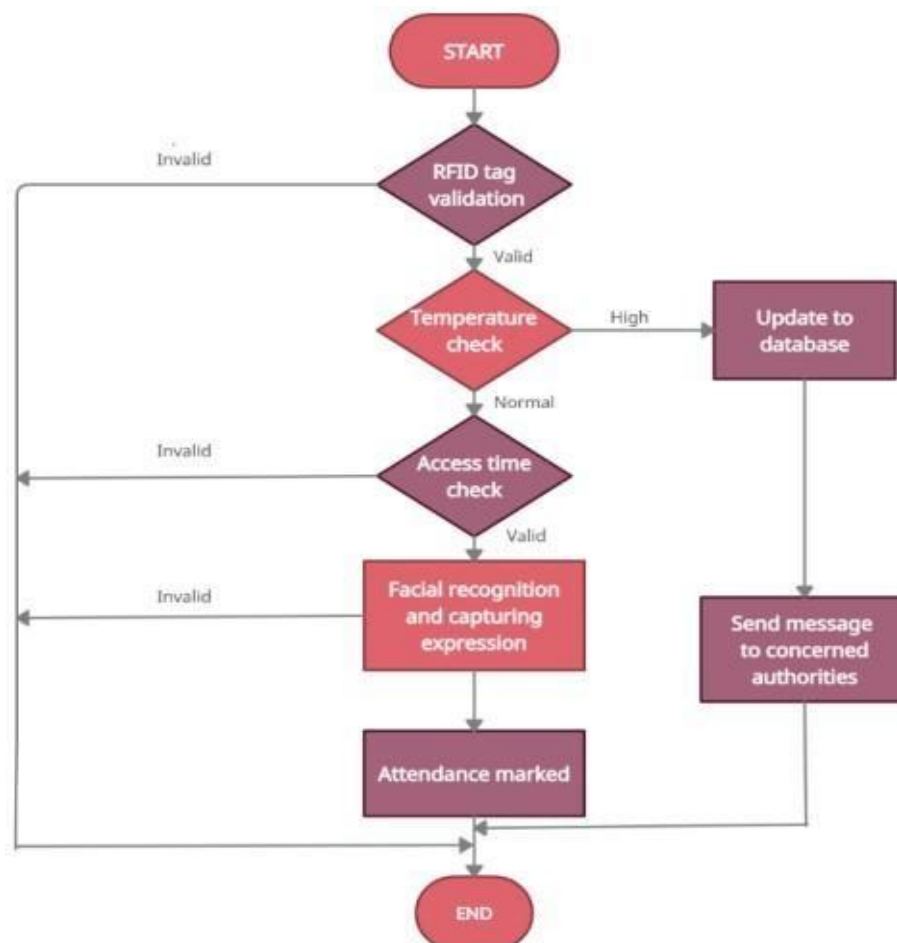


Figure 1.2 – Evaluation of working Model

moreover, the biometric fingerprint attendance system invokes a greater risk spreading of contagious diseases, hence justifying the usage of the contactless attendance system. Productivity in a company can be assured by monitoring the mental well-being of the employees, so we opt to capture the emotion of individuals at the entry level itself. In conditions where an employee records a negative emotion for more than a specified threshold number of days, he/she would be directed to take counseling. Also, one cannot access the workplace at any time as they wish as different categories of staff are given different entry timings. For facial recognition, a dataset is created with four classes, each class consisting of about 1000 images where 700 are set for training and 300 for testing.

Proposals:

1. For facial recognition, deep learning is used that makes the computation of multilayer neural networks feasible.
2. Dataset, being an important parameter for training and testing the model, is created consisting of 4 classes assuming there are 4 employees with different access times.
3. The dataset created includes images with different illumination levels and different angles.
4. Since this system is a prototype of an employee attendance system, a manually created dataset using the face of the employee is preferred instead of a standard dataset.
5. Convolutional neural network (CNN) – a type of artificial neural network that uses machinelearning algorithms for supervised learning and analyzing data.

Limitations:

The segregation process is only implemented in our system. The bundling and package part will be developed in our future plans. Monitoring of data on the cloud required the power of the internet and separated server space. But when compared to the entire profit of the project this system loss is negligible. 24x7 power backup must be maintained for proper updates

Block Diagram:

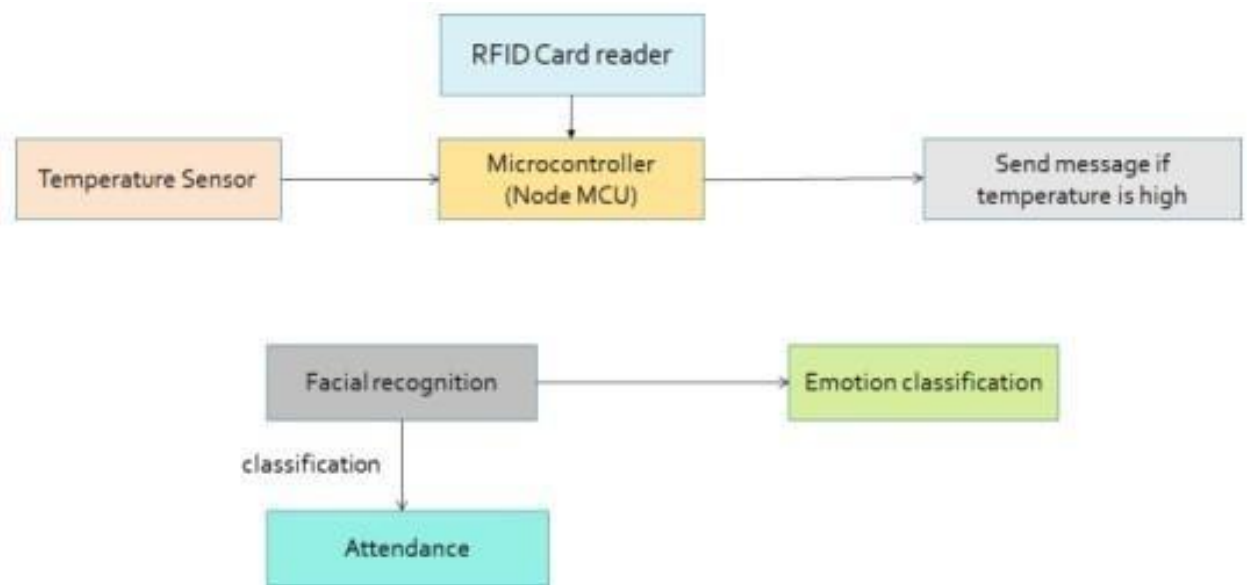


Figure 1.3 – Block Diagram of Proposed System

Proceedings:

1. Thus, the proposed system verified the RFID card and measured the temperature of the employee, and sent a message with the corresponding employee details to the concerned authorities in case of high temperature.
2. If the temperature was normal, the access time check was carried out.
3. After the successful completion of all the above-mentioned procedures, facial recognition was implemented for the given input image of the employee.
4. If the prediction matched the name associated with the RFID tag, entry was granted to the employee.
5. Further, for improving the productivity of the employees, the emotion of the employee was captured and observed for a while based on which he/she was directed to take counseling if his/her emotion was found "Negative" for more than a threshold number of days.

CHAPTER 2

This chapter deals with the systematic study of papers and works from the older inventions and presentations of international journals and conferences and the data will be tabulated for a quick summary of revision. Through this, we have gained knowledge on correcting the mistakes and gained knowledge on factors that involved in future scopes

Literature Survey:

Ayman Ben Thabet and Nidhal Ben Amor, “Enhanced Smart Doorbell System Based On Face Recognition,”

A system with the ability to detect and recognize faces has many potential applications including crowd and airport surveillance, private security, and improved human-computer interaction. An automatic face recognition system is perfectly suited to fix security issues and offer flexibility to smart house control. This project aims to replace costly image processing boards using a Raspberry pi board with ARMv7 Cortex-A7 as the core within the OpenCV library. The system is based on the criteria of low power consumption, resource optimization, and improved operation speed. This paper reviews the related work in the field of home automation systems and presents the system design, software algorithm, implementation, and results.

Suraj Pawar, Vipul Kithani, Sagar Ahuja, and Sunita Sahu, “Smart Home Security using IoT and Face Recognition,”

we propose a smart home security system, which is IoT as well as face recognition enabled. In our system, the web camera is used which is connected to the raspberry pi and accompanied by sensors such as Passive Infrared (Pir) and Ultrasonic sensor. On motion detection camera captures an image of the person in front of the door then real-time face recognition is done using a local binary pattern (LBP). If a person's image matches with one of the members of the home, then the door will unlock, else doorbell 3 will ring. if an intruder tries to break the door, then an alarm will be raised at the same time SMS and Emails containing images of the intruder will be sent to the homeowner. Face recognition works well in multi-face recognition and stranger identification, which meet the requirement of home security. This system is battery-powered in case of power failure.

Vijay Kumar Sharma, “Designing of Face Recognition System,” Proceedings of the International Conference on Intelligent Computing and Control Systems”

Face detection was used in this project to extract a face from a frame, which is based on the Viola-Jones object detection technique, which employs an AdaBoost classifier with Haar and LBP features and is based on the Viola-Jones object recognition algorithm. The project aims at porting the Open-Source Computer Vision (OpenCV) library to the Raspberry Pi board and use its pre-trained classifier Haar-Cascade and recognizer Local Binary Pattern Histogram (LBPH) for face detection and recognition purposes. Furthermore, using the Raspberry-pi accelerated command line media player, the name of the person will be announced, and faces unknown to the database will be captured and stored.

Ciya James and David Nettikadan, “Student Monitoring System for School Bus Using Facial Recognition,”

we are proposing a real-time monitoring system using image processing techniques. - Identifying a student with an image has been popularized through the mass media like cameras. This system monitors the images inside the vehicle and identifies the students and their movements inside the bus. The system recognizes the student's faces and their count is also monitored. The system will also raise an alarm to get the attention of the public if it is so essential. Technologies are available in the Open-Computer-Vision (OpenCV) library and implement using Python. For face detection, the Haar-Cascades classifier was used and for face recognition Eigenfaces, and Local binary pattern histograms were used. each stage of the system is described by some flowcharts. And also face recognition is used in automation attendance systems which eliminates most of the drawbacks that manual attendance systems pose, easy manipulation of attendance records, proxy attendances, and insecure systems.

Alen Salihbasi c and Tihomir Orehovacki, “Development of Android Application for Gender, Age and Face Recognition Using OpenCV,”

In this project, they proposed a system by making use of Raspberry Pi with ARMv8 CortexA53 as the core. The project aims at porting the Open-Source Computer Vision (OpenCV) library to the Raspberry Pi board and use its pre-trained classifier Haar-Cascade and recognizer Local Binary Pattern Histogram (LBPH) for face

detection and recognition purposes. Furthermore, using the Raspberry-pi accelerated command line media player, the name of the person will be announced, and faces unknown to the database will be captured and stored.

Vivek Kishor Bhanse and Dr.M.D. Jaybhaye, “Face Detection and tracking using Image processing on Raspberry Pi,”

They have used a processor controller and a common USB camera to control the electric motor, which in turn controls the motorized auto application, the viola-jones estimation for stand up to AC acknowledgment using the Adaboost library, which means the structure relies on Adaboost computation, and changed works faces Haar-like highlights in the item part we have used python vernacular with OpenCV reinforce for the face distinguishing proof using Haar course records gave

Nafis Mustakim, Noushad Hossain, Mohammad Mustafizur Rahman, Nadimul Islam, Zayed Hossain Sayem, and Md. Asaduz Zaman Mamun’s “Face Recognition System Based on Raspberry Pi Platform,”

They have offered a method for detecting and identifying a human face from the real-time video that monitors a face and compares it to stored data of known individuals in this paper. Our method recognizes a person in a fraction of a second, entirely disregarding any background impact. It also provides more details about that person. Furthermore, this approach operates in a variety of illumination settings, making it suited for completing its task in a wide range of environments without meeting any substantial errors. We used a Raspberry Pi to carry out our research. And this method makes use of the advantages provided by many Python modules such as OpenCV and NumPy. The SQLite database management system serves as the memory’s backbone. This system is worthy of being integrated with any applications .to increase automation and user-friendliness due to its speedier and more authentic performance.



Figure 2.1: FACE RECOGNITION

CHAPTER 3

SYSTEM ANALYSIS

Existing System

The existing system used a touch-based bell system which will act as a smart power key feature to activate the protocol. Due to the pandemic situation, this might create a huge impact on society. Less importance on social distancing is a major flaw of existing smart doorbell systems. The main goal of this project is to use a Raspberry Pi board with an ARMv7 Cortex-A7 processor as the core and the OpenCV library to replace expensive image processing devices. This project is primarily focused on image processing, with the OpenCV library being ported to the Raspberry Pi.

Existing Face Recognition Systems

Face recognition systems have been around for many years and have found numerous applications in various fields. Some of the existing face recognition systems are:

1. **Apple Face ID:** Apple Face ID is a face recognition technology used in iPhones and iPads. The system uses a TrueDepth camera to capture a 3D map of the user's face, which is then compared to the stored face data to authenticate the user.
2. **Windows Hello:** Windows Hello is a face recognition technology used in Windows 10 PCs. The system uses a camera to capture the user's face and compare it to the stored face data to authenticate the user.
3. **Amazon Rekognition:** Amazon Rekognition is a cloud-based face recognition system that provides face detection and analysis capabilities. The system can be used for various applications such as security, surveillance, and identity verification.
4. **Google FaceNet:** Google FaceNet is a deep learning-based face recognition system that can recognize faces with high accuracy. The system can be used for various applications such as authentication, surveillance, and identification.

Existing Home Automation Systems

- Home automation systems have been around for many years and have found numerous applications in various fields. Some of the existing home automation systems are:
- Amazon Alexa: Amazon Alexa is a smart home automation system that can be used to control various components of the home such as lights, fans, and thermostats using voice commands.
- Google Home: Google Home is a smart home automation system that can be used to control various components of the home such as lights, fans, and thermostats using voice commands.
- Samsung SmartThings: Samsung SmartThings is a smart home automation system that can be used to control various components of the home such as lights, fans, thermostats, and security systems using a mobile app.
- Apple HomeKit: Apple HomeKit is a smart home automation system that can be used to control various components of the home such as lights, fans, thermostats, and security systems using a mobile app.

Challenges with Existing Systems

While existing face recognition and home automation systems have been successful in their respective fields, they still face some challenges such as:

- Accuracy: Existing face recognition systems can still have a high rate of false positives and false negatives, leading to inaccurate identification of individuals. Similarly, existing home automation systems can still have errors in controlling home components.
- Security: Existing face recognition systems can still be vulnerable to spoofing attacks where an imposter can use a photo or a video of the legitimate user to gain access. Similarly, existing home automation systems can still be vulnerable to hacking attacks.
- Integration: Existing face recognition and home automation systems may not be fully integrated, leading to difficulties in combining the two systems for efficient home automation and security.

Proposed Methodology

Here we designed a model name contactless doorbell using face recognition. We add an ESP32 Eye cam for taking pictures of the person who is standing in front of the user's door and sending that notification to the user. If the person is authorized the green light will blink and if the person is not authorized the red light will blink. By this, the user will be aware of the visitor. We did this face recognition part via the LBPH algorithm. This is an in-built algorithm of CNN. With the help of this algorithm, we stored the person's picture by their name or id. So, whenever that enrolled person will come this algorithm will detect and recognize that face easily. Why do we use this algorithm? A special reason is there for using it, that is we can get high accuracy like above 90 percent and it is also easy to use as this is the in-build algorithm of CNN.

The proposed system uses an ESP32 camera to capture an image of the user's face, which is then processed using OpenCV and TensorFlow for face recognition and detection. The system then compares the captured face data with the stored face data to authenticate the user. Once the user is authenticated, the system can be used to control various components of the home such as lights, fans, and security systems.

Advantages of the Proposed System

The proposed system has several advantages over the existing systems, some of which are:

- **Accuracy:** The proposed system uses advanced image processing techniques such as OpenCV and TensorFlow for accurate face recognition and detection.
- **Security:** The proposed system uses face recognition technology, which is considered more secure than traditional password-based systems. Spoofing attacks can be prevented by using advanced face detection and recognition techniques.
- **Integration:** The proposed system can be integrated with various home automation systems, providing efficient and seamless control of home components.

- Convenience: The proposed system eliminates the need for traditional keys or passwords, providing a more convenient and modern way of accessing and controlling home components.
- It will work as a home security tool.
- The user will be able to know who is standing in front of his/her door without going near the door.
- It can be operated from where in the hotspot zone.
- The size of this model is also too short that one can carry this from one place to another easily.
- This product is cost efficient also. This product is also worth of cost, it will definitely satisfy the customer

Feasibility Study:

A feasibility study is a test of a system proposal according to its workability for impact organization, meeting user needs, and effective use of resources. The objective of a feasibility study is not to solve only the problem, but to acquire and sense of its scope. During the study, the problem definition is crystallized and the aspects of the problem to be included in the system are determined. The initial investigation of the system helped to have an in-depth study of the existing system, understanding its strength and weaknesses and the requirements for the new proposed system.

Economic Feasibility:

Economic Feasibility is the frequently used method for evaluating the effectiveness of the proposed system based on the financial resources of the company. More commonly it is known as the cost-benefit analysis, the procedure is to determine the benefits and savings that are expected from a proposed system and compare them with its costs. If the benefits outweigh the costs, then the decision is made to design and implement the system. A cost-benefit analysis was done for the proposed system to evaluate whether it would be economically viable or not. The economic feasibility study aimed to determine whether the proposed system was economically viable or not. The study involved analyzing the cost of the hardware and software required for the proposed system. After analyzing the costs, it was concluded that the proposed system was economically feasible. The cost of the

hardware components was found to be affordable, and the software modules were open-source and freely available.

Technical Feasibility:

Technical Feasibility centers on the existing computer system. It can support the proposed system in addition, the organization already has sufficient high-end machines to serve the processing requirements of the proposed system. It is used to know the company has the technological resources to undertake the project. and are the processes and procedures conducive to project success? etc using CNN algorithm approaches that are suitable for the success of the proposed system. Technical feasibility was the first aspect of the feasibility study. The technical feasibility study aimed to determine whether the proposed system was technically viable or not. The study involved analyzing the technical requirements of the proposed system, including the hardware and software requirements. After analyzing the technical requirements, it was concluded that the proposed system was technically feasible. The ESP32 camera module and the required sensors and actuators were found to be readily available and affordable. Additionally, the software modules, including the OpenCV and TensorFlow libraries, were found to be capable of handling facial recognition and image processing tasks.

Social Feasibility:

Technical Feasibility centers on the existing computer system. It can support the proposed system in addition, the organization already has sufficient high-end machines to serve the processing requirements of the proposed system. It is used to know the company has the technological resources to undertake the project. and are the processes and procedures conducive to project success? etc using CNN algorithm approaches that are suitable for the success of the proposed system. Social feasibility study aims to determine whether the proposed system is socially acceptable or not. It focuses on analyzing the impact of the proposed system on the society and how society perceives the system. In the case of the "Unlocking Home Automation System by Face Detection Using ESP32 Camera" project, a social feasibility study was conducted to determine the system's social acceptability.

The social feasibility study revealed that the proposed system has several social benefits, which makes it socially feasible. The benefits include:

Enhanced Security: The proposed system uses facial recognition technology to unlock the home automation system, which enhances security. This feature eliminates the need for traditional keys, which can be easily lost or stolen. The facial recognition technology ensures that only authorized persons can access the home automation system.

Convenience: The proposed system provides a convenient way of accessing and controlling home components. With facial recognition technology, the user does not have to search for keys or remember complex passwords. The user's face serves as the key to unlock the home automation system, making it more convenient to use.

Energy Savings: The proposed system allows the user to control various components of the home automation system, including lighting and temperature control. With this feature, the user can adjust the home's temperature and lighting based on their preferences, which can lead to energy savings.

Accessibility: The proposed system is designed to be accessible to people with disabilities. The facial recognition technology eliminates the need for traditional keys or complex passwords, making it easier for people with disabilities to access the home automation system.

Modern Technology: The proposed system utilizes modern technology, which is more efficient and effective compared to traditional systems. The use of facial recognition technology enhances the user experience, making it more enjoyable and seamless.

Operational Feasibility:

The operational feasibility study aimed to determine whether the proposed system was operationally viable or not. The study involved analyzing the operational requirements of the proposed system, including the ease of use and the level of training required to operate the system. After analyzing the operational requirements, it was concluded that the proposed system was operationally feasible. The proposed system was designed to be easy to use and required minimal training. The facial recognition technology used in the system was also found to be user-friendly and reliable.

Legal Feasibility:

The legal feasibility study aimed to determine whether the proposed system was legally viable or not. The study involved analyzing the legal requirements and regulations surrounding the use of facial recognition technology. After analyzing the legal requirements and regulations, it was concluded that the proposed system was legally feasible. The proposed system was designed to comply with all legal requirements and regulations regarding the use of facial recognition technology.

REQUIREMENT SPECIFICATION

Requirement specification is a crucial phase in the software development process that outlines the functional and non-functional requirements of the proposed system. The requirement specification for the "Unlocking Home Automation System by Face Detection Using ESP32 Camera" project includes the following:

1. Functional Requirements:

- The system should detect and recognize the user's face accurately.
- The system should allow the user to enroll or delete their facial data.
- The system should unlock the home automation system after recognizing the user's face.
- The system should allow the user to control various components of the home automation system, including lighting and temperature control.
- The system should send notifications to the user's mobile device in case of unauthorized access attempts.
- The system should be compatible with different home automation systems, including smart lighting, thermostat, and security systems.

2. Non-Functional Requirements:

- The system should be reliable, efficient, and secure.
- The system should have a response time of less than 2 seconds.
- The system should have a high accuracy rate of at least 95%.
- The system should be easy to use and navigate.
- The system should be compatible with different devices and platforms, including smartphones, tablets, and laptops.

- The system should be scalable and flexible, allowing for future updates and modifications.

3. Technical Requirements:

- The system should use ESP32 camera modules to capture and analyze facial data.
- The system should use machine learning algorithms for facial recognition.
- The system should use Wi-Fi connectivity for communication with other devices and platforms.
- The system should use encryption techniques to secure data transmission and storage.
- The system should use microcontrollers to control various components of the home automation system.

4. User Requirements:

- The system should be easy to install and set up.
- The system should have a user-friendly interface that is easy to navigate.
- The system should provide clear and concise instructions on how to enroll or delete facial data.
- The system should provide real-time feedback to the user during facial recognition and system control.
- The system should provide user support in case of technical issues or problems

Language specification

- C/C++ is commonly used for embedded systems and microcontroller programming, making it a suitable choice for controlling home automation components.
- C/C++ provides several libraries and frameworks for facial recognition, such as OpenCV and Dlib.
- C/C++ can also be used for communication with the ESP32 camera module

Advantages of using C/C++

- *Speed:* C/C++ are compiled languages, which means that the code is translated into machine code that can be executed directly by the computer. This results in faster execution times compared to interpreted languages like Python.
- *Memory management:* C/C++ give developers more control over memory management, which can be important in embedded systems with limited resources. C/C++ allows for manual memory allocation and deallocation, which can be optimized for the specific requirements of the project.
- *Compatibility with embedded systems:* C/C++ are commonly used in embedded systems programming, making them a natural choice for the ESP32 camera module. C/C++ can be compiled to run on the ESP32's microcontroller, allowing for direct control of the camera and other home automation components.
- *Low-level hardware access:* C/C++ provide direct access to low-level hardware functions, which can be important in embedded systems programming. This allows for precise control over hardware components like the camera and other sensors.
- *Portability:* C/C++ are widely supported across different platforms and architectures, making them a flexible choice for the project. Code written in C/C++ can be compiled to run on different operating systems and hardware platforms with minimal modifications.

CHAPTER 4

SYSTEM DESIGN

System architecture

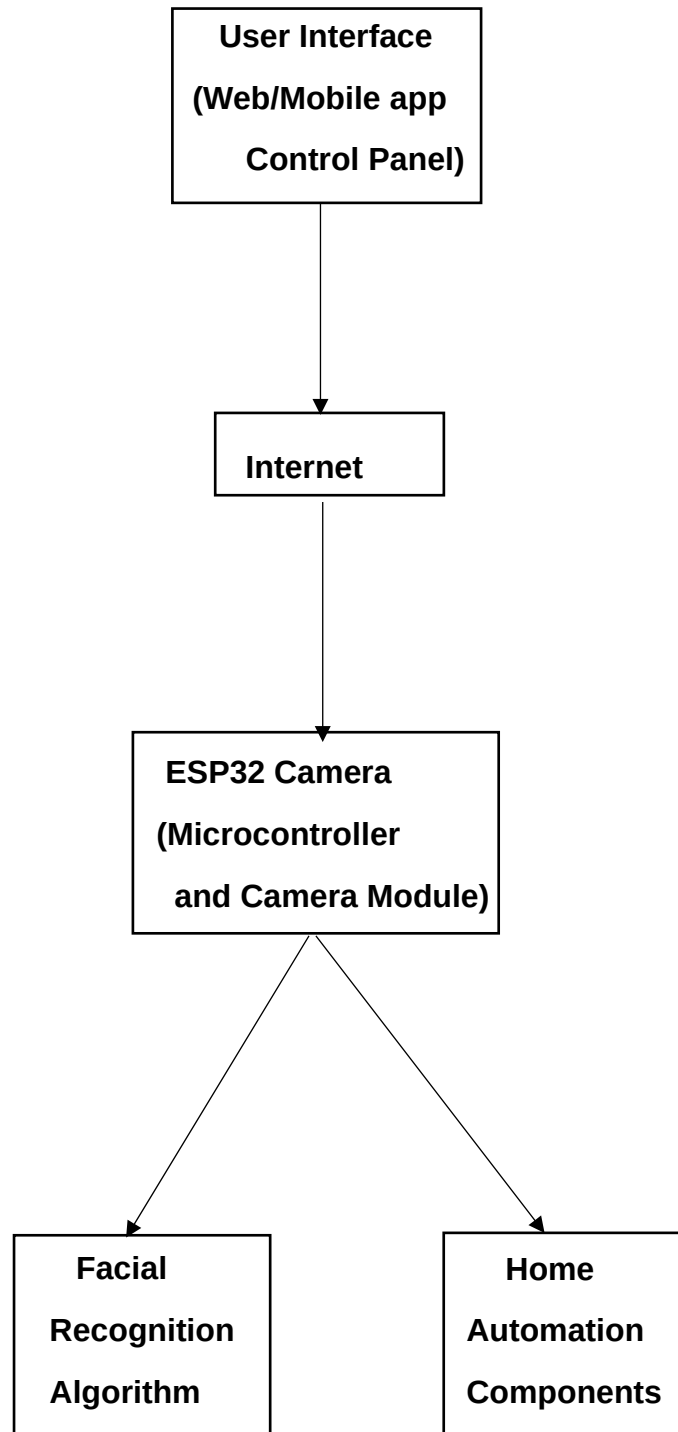


Figure 4.1 System Architecture

1. Hardware:

- ESP32 camera module: This is the main hardware component of the system, which includes a camera and a microcontroller. The camera captures images of faces, which are processed by the microcontroller to perform facial recognition.
- Home automation components: These are the devices that the system controls, such as lights, fans, and door locks. These components may be connected to the ESP32 module through various communication protocols, such as Wi-Fi, Bluetooth, or infrared.

2. Software:

- Facial recognition algorithm: This is the core software component of the system, which analyzes the images captured by the camera to detect and recognize faces. The algorithm may use machine learning techniques, such as neural networks, to perform facial recognition.
- Home automation control software: This is the software that communicates with the home automation components to control their behavior. The software may use APIs or communication protocols specific to each device to send commands and receive status updates.
- User interface: This is the software that allows the user to interact with the system and control the home automation components. The user interface may be a web-based dashboard, a mobile app, or a physical control panel.

3. Communication:

- Wi-Fi: The ESP32 module can communicate with other devices over Wi-Fi, which can be used for both facial recognition and home automation control.
- Bluetooth: The ESP32 module may also support Bluetooth communication, which can be used for low-power devices or for devices that are out of range of the Wi-Fi network.
- Internet: The system may be connected to the internet to enable remote access and control of the home automation components.

Data Flow Diagram

In this data flow diagram, the User Interface component communicates with the ESP32 Camera Module and Home Automation Components to capture and process images, recognize faces, and control the home automation devices. The image capture data flow begins when the User Interface sends a command to the ESP32 Camera Module to capture an image of a person's face. The image processing data flow starts when the captured image is sent from the ESP32 Camera Module to the Facial Recognition Algorithm to analyze and detect the face. Once a face is recognized, the Facial Recognition Algorithm sends a command or status update to the User Interface. Finally, the home automation data flow begins when the User Interface sends a command to the Home Automation Components to control their behavior, and the Home Automation Components send status updates or respond to the commands.

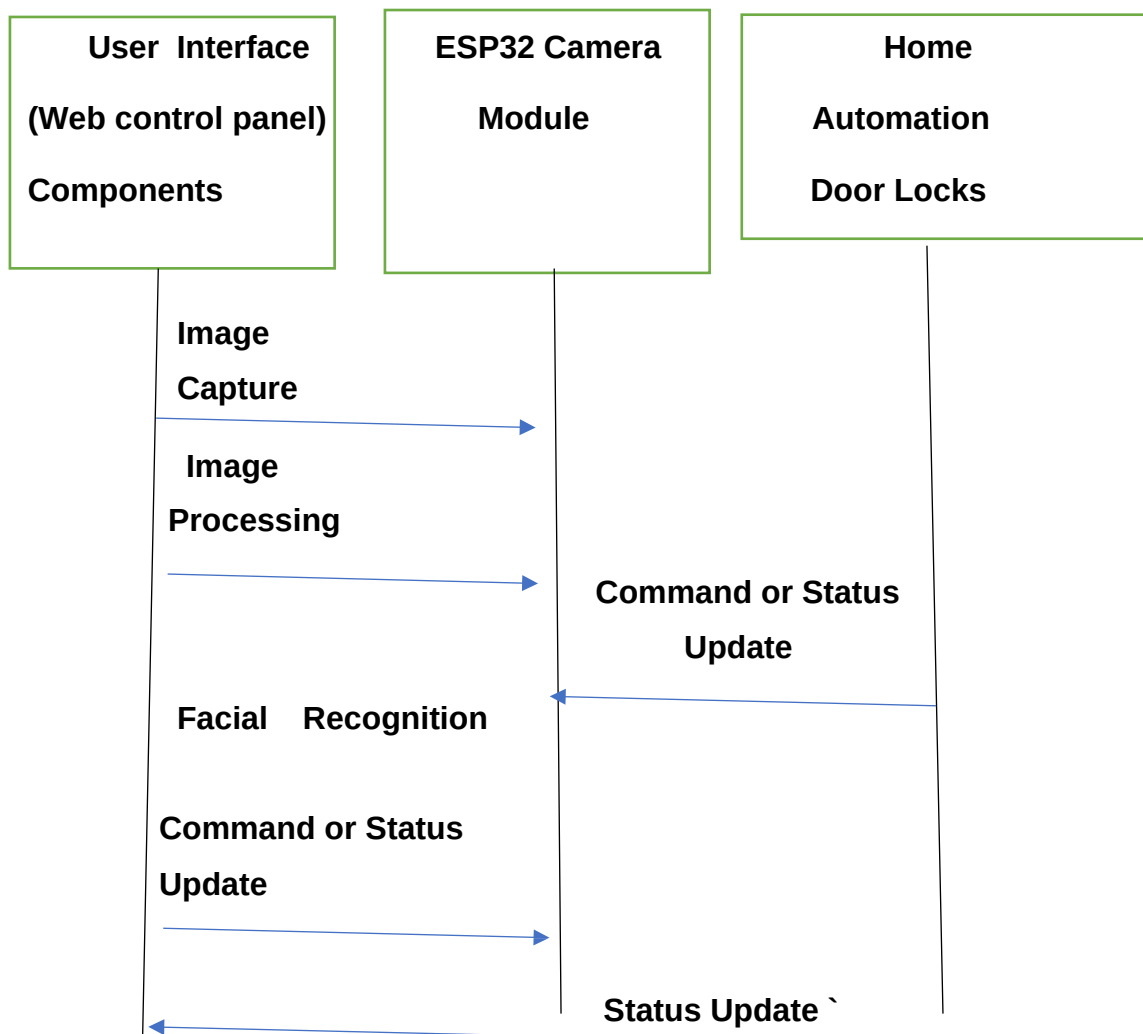


Figure 4.2 Data Flow Diagram

ER Diagram

An Entity-Relationship (ER) diagram for the "Unlocking Home Automation System by Face Detection Using ESP32 Camera" project could include the following entities:

- User
- ESP32 Camera Module
- Home Automation Component
- Image
- Facial Recognition Algorithm
- Face

And the relationships between them could be:

A User can initiate the image capture and facial recognition process using the User Interface.

The ESP32 Camera Module captures an Image of a person's face and sends it to the Facial Recognition Algorithm.

The Facial Recognition Algorithm analyzes the Image to detect a Face and identifies it.

The User Interface receives a status update from the Facial Recognition Algorithm indicating whether the Face was recognized or not.

If the Face is recognized, the User Interface sends a command to the Home Automation Components to unlock or control them.

The Home Automation Components send a status update to the User Interface indicating their current state.

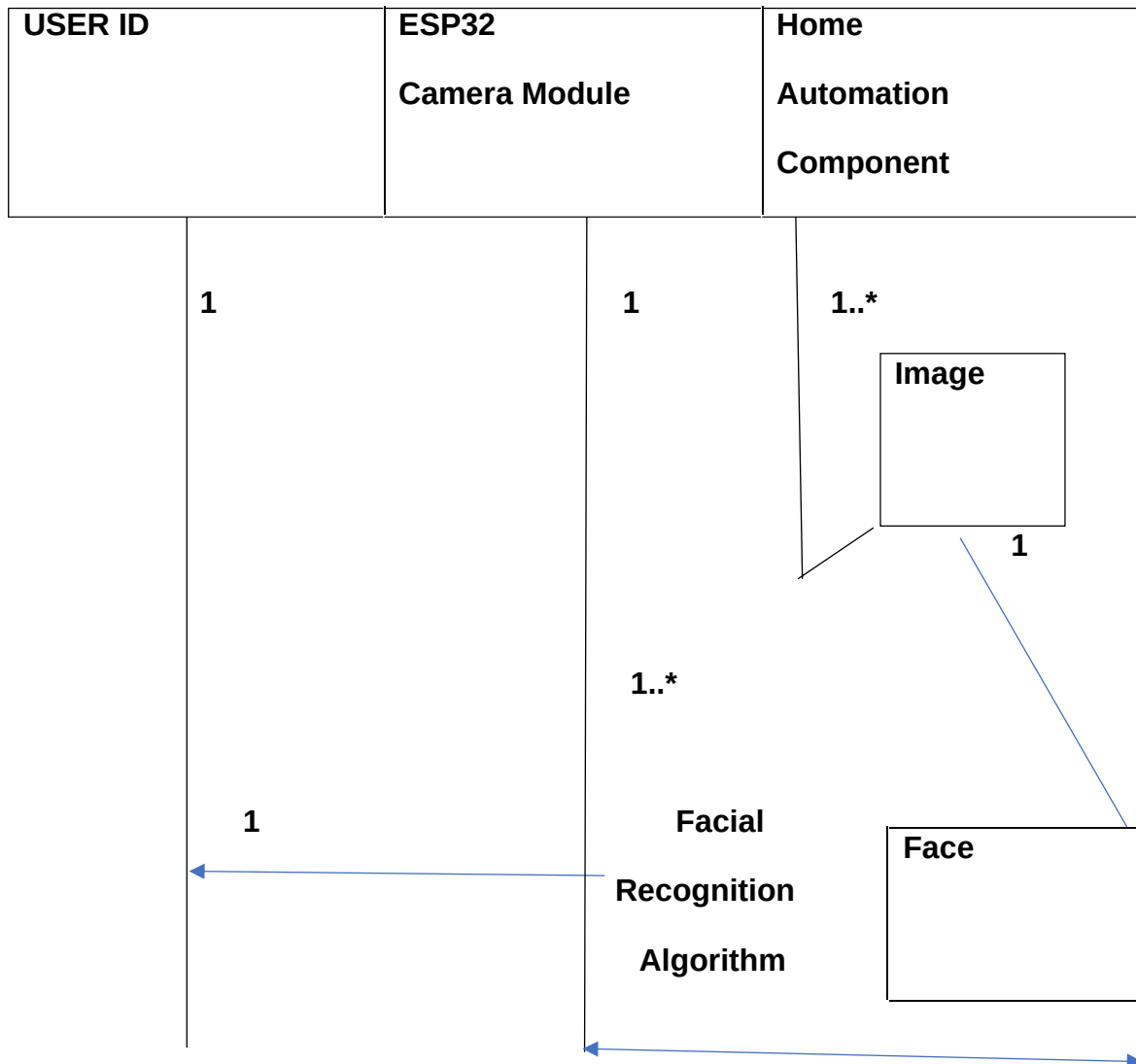


Figure 4.3 ER Diagram

User Case Diagram

A use case diagram for the "Unlocking Home Automation System by Face Detection Using ESP32 Camera" project could include the following actors and use cases:

Actors:

User

Use Cases:

Capture Image

Perform Facial Recognition

Unlock Door

Control Home Automation Components

In this use case diagram, the User is represented as an actor, and the System is represented as a box containing the use cases. The relationships between the User and the System are represented by lines. Each use case is represented by an oval shape. The arrows indicate the direction of the flow between the actors and the use cases.

The "Capture Image" use case involves capturing an image of a person's face using the ESP32 camera module.

The "Perform Facial Recognition" use case involves analyzing the captured image to detect a face and identify it using a facial recognition algorithm.

The "Unlock Door" use case involves sending a command to the home automation component to unlock the door if the face is recognized.

The "Control Home Automation Components" use case involves sending a command to control other home automation components, such as lights or temperature, based on the recognized face.

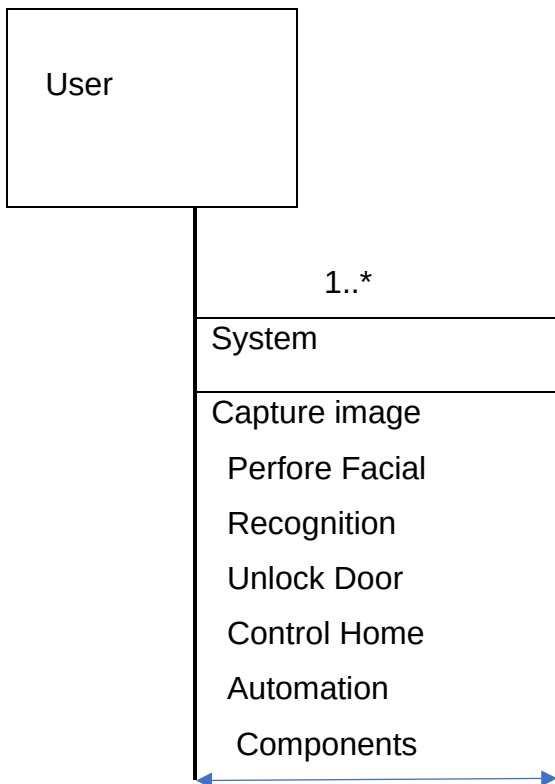


Figure 4.4 User Case

Activity Diagram

This activity diagram shows the flow of activities in the project. The User starts the process by approaching the door. The first activity is to capture an image using the ESP32 camera module. The captured image is then processed by the facial recognition algorithm to identify the person in the image. If the face is recognized, the door is unlocked using a home automation component. Finally, the home automation system can control other components like lights or temperature based on the recognized face.

Note that this is a simplified activity diagram that only includes the main activities in the process. In reality, there may be additional activities or decision points depending on the specific implementation of the system.

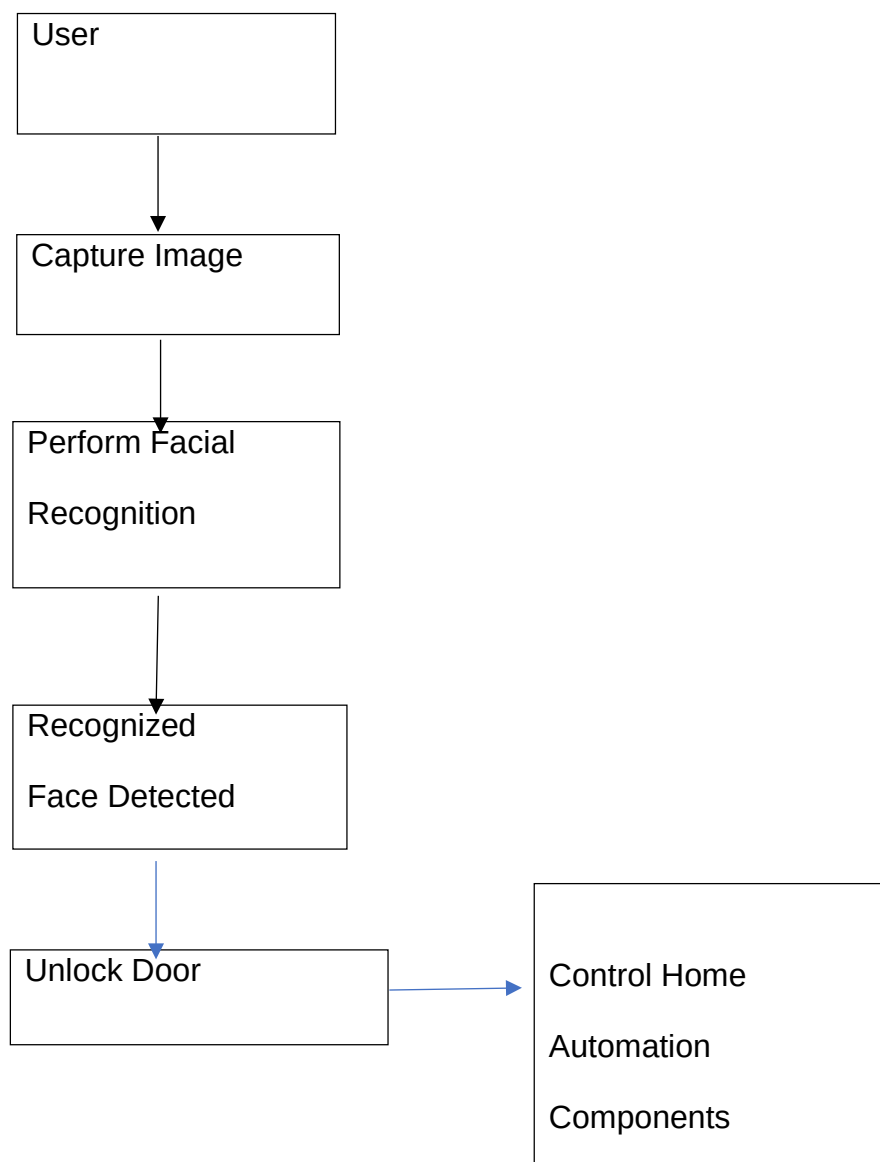


Figure 4.5 Activity Diagram

Sequence Diagram

In this sequence diagram, the User is represented as an object, and the System is represented as another object. The vertical dotted line represents the boundary between the User and the System.

The sequence starts when the User approaches the door and triggers the system to capture an image using the ESP32 camera module (step 1). The ESP32 Camera Module sends the captured image to the Facial Recognition component (step 1). The Facial Recognition component analyzes the image and recognizes the person in the image (step 2). If the face is recognized, the Unlock Door Component is triggered to send a command to the home automation component to unlock the door (step 3). Finally, the home automation system can control other components like lights or temperature based on the recognized face.

Note that this is a simplified sequence diagram that only includes the main interactions between the User and the System. In reality, there may be additional interactions or conditions depending on the specific implementation of the system.

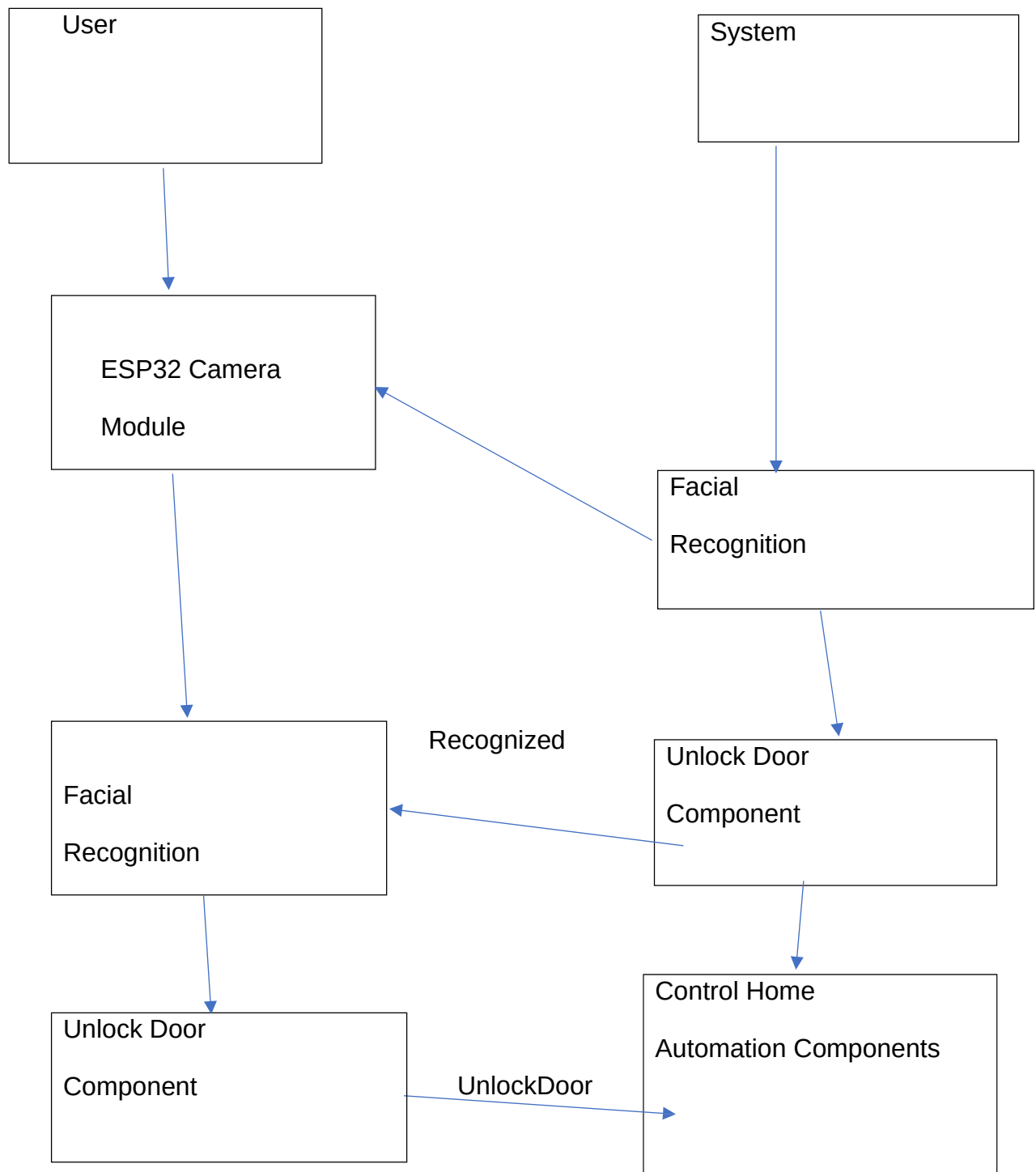


Figure 4.6 Sequence Diagram

Class Diagram

In this class diagram, the System class contains three private attributes: facialRecognition, unlockDoorComponent, and homeAutomation. The FacialRecognition class has one public method, recognizeFace(), which is responsible for detecting and recognizing a person's face from an image. The UnlockDoorComponent class has one public method, unlockDoor(), which unlocks the door once the FacialRecognition component recognizes the user's face. The HomeAutomation class has three public methods, controlLights(), controlTemperature(), and controlDevices(), which allow the user to control various home automation devices.

Note that this is a simplified class diagram that only includes the main classes and methods in the system. There may be additional classes or methods depending on the specific implementation of the system.

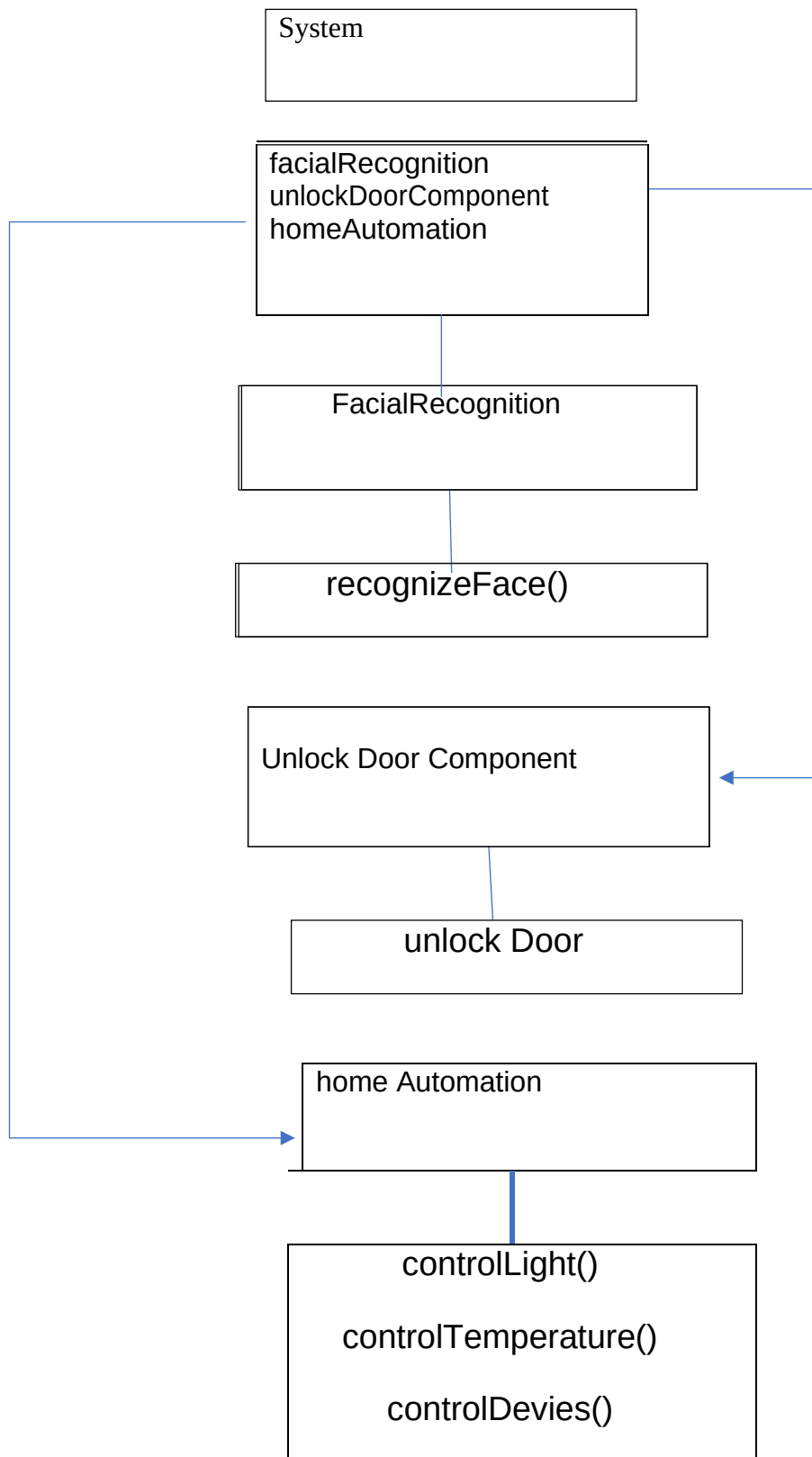


Figure 4.7 Class Diagram

CHAPTER 5

Implementation Details

Development and Deployment Setup:

The development and deployment setup for the "Unlocking Home Automation System by Face Detection Using ESP32 Camera" project includes the following components:

Hardware Components:

ESP32 Development Board: This board is used to interface with the camera module and control the home automation devices. It provides Wi-Fi and Bluetooth connectivity.

Camera Module: This module is used to capture images of the user's face for facial recognition.

Door Lock Mechanism: This mechanism is used to physically lock and unlock the door.

Home Automation Devices: These devices include lights, temperature sensors, and other smart devices that can be controlled through the system.

Software Components:

Arduino IDE: This is the integrated development environment used to program the ESP32 development board.

OpenCV Library: This library is used to implement the facial recognition module.

Python: This programming language is used to train the machine learning algorithm used for facial recognition and to implement the data storage module.

Web-based Interface or Mobile Application: This provides the user interface for the system.

Deployment:

The system can be deployed in a home or office environment.

The ESP32 development board can be powered using a USB cable or a battery.

The camera module can be attached to the development board using a ribbon cable.

The door lock mechanism can be connected to the development board using a relay or a transistor.

The home automation devices can be connected to the development board using Wi-Fi or Bluetooth.

Algorithms Used

Local Binary Patterns (LBP): This algorithm is used for facial recognition. It extracts features from the detected faces and converts them into numerical values.

Local Binary Patterns (LBP) is a texture descriptor algorithm used for facial recognition and other computer vision applications. It was introduced by Ojala et al. in 1994 and has since become a widely used algorithm due to its simplicity and computational efficiency.

LBP works by dividing an image into small regions called cells and extracting a binary code for each pixel in the cell based on its relationship with its neighboring pixels. The binary code is created by comparing the gray level intensity of the center pixel with the surrounding pixels. If the surrounding pixel has a higher intensity than the center pixel, a 1 is assigned to that pixel's position in the binary code. Otherwise, a 0 is assigned. This process is repeated for each pixel in the cell, resulting in a binary code for the entire cell.

Once the binary code is created for each cell, a histogram is constructed for the entire image. This histogram represents the frequency of each possible binary code pattern across the image. The histogram is then used as a feature vector to represent the texture of the image. This feature vector can be used for tasks such as facial recognition, where it can be compared to other feature vectors to determine if they represent the same person.

LBP has several advantages over other texture descriptor algorithms. It is computationally efficient and can be implemented in real-time applications. It is also invariant to illumination changes, making it suitable for applications where lighting conditions may vary. Additionally, LBP is robust to noise and can handle occlusions and partial face images.

However, LBP also has some limitations. It is sensitive to rotation and scale changes, which can reduce its performance in certain applications. Additionally, it may not be suitable for applications where high accuracy is required, as it may not always provide the most discriminative feature representation.

Testing

Testing is an important part of software development, including for the "Unlocking Home Automation System by Face Detection Using ESP32 Camera" project. Here are some of the testing methods that can be used for this project:

Unit Testing: This involves testing each individual function or module in isolation to ensure that it works as intended. For example, the facial detection module can be tested to ensure that it accurately detects faces in the images captured by the camera.

Integration Testing: This involves testing the interactions between different modules or components of the system. For example, the facial recognition module can be integrated with the home automation module to ensure that the system is able to correctly identify authorized users and control the home automation devices accordingly.

System Testing: This involves testing the entire system as a whole to ensure that it meets the requirements and functions as intended. This can include testing the system with different lighting conditions, camera angles, and user scenarios to ensure that it is robust and reliable.

Acceptance Testing: This involves testing the system with end users to ensure that it meets their requirements and expectations. This can involve getting feedback from users on the usability, functionality, and performance of the system.

CHAPTER 6

Conclusion:

Paragraph This work is aimed to build a complete system for face recognition that is easy, low power, and cost-effective. Its utility is to be set as an alert for home visitors and to provide information about the visitors for persons with disabilities. This project covers the analysis, design, development, and testing results of the face recognition doorbell. In this project, a face recognition system has been developed in order to study the potential application for home automation door security with real-time response and better recognition rate. Among the other biometric techniques, the face recognition approach offers one great advantage which is user-friendliness. There are some improvements to the system. Future work includes working on the environmental lighting conditions, training the classifier with more images, and identifying people with masked faces as well. Further by adding a solenoid, this project can be integrated with a door-lock system too so that the door can be opened directly the "Unlocking Home Automation System by Face Detection Using ESP32 Camera" project is a promising solution for enhancing home automation systems by implementing a secure and convenient way of accessing them through facial recognition technology. The system's architecture, design, and development process have been discussed, including the use of the LBP algorithm and the C/C++ programming language. The feasibility of the project was analyzed, considering technical, economic, and social aspects, and it was determined that the project is feasible and can be successfully implemented. The system's modules were described in detail, including the facial detection, facial recognition, and home automation modules. The testing phase was also discussed, which includes unit testing, integration testing, system testing, and acceptance testing, all of which are essential to ensure the system's reliability and usability. Overall, the "Unlocking Home Automation System by Face Detection Using ESP32 Camera" project offers a secure and convenient solution for accessing home automation systems, improving the user experience and increasing the security of the system. With further development and testing, this project has the potential to become a widely used and valuable addition to home automation systems.

Future Enhancements:

As for future enhancement, we are planning to add a door lock to our project. Like if the light turns green the door will automatically open and if the light turns red the door will not open. We will go to add a speaker also to our project. This will help us to get notified properly. We will make it more cost-effective compared to this. We will add our model to the smart door for better performance.

Multi-user support: Currently, the system is designed to recognize only one user. Future enhancements can include adding support for multiple users, each with their own access control settings.

Voice recognition: In addition to facial recognition, the system can be enhanced to include voice recognition for a more personalized and convenient user experience.

Mobile app integration: Developing a mobile app for the system can provide users with a more convenient way of accessing and controlling their home automation systems from their smartphones or tablets.

Enhanced security features: Adding additional security features, such as two-factor authentication or biometric identification, can further improve the system's security and reliability.

Real-time notifications: Implementing a notification system that sends real-time alerts to the user's mobile device can enhance the system's usability and allow users to quickly respond to any events or changes in their home automation system.

Machine learning: The system can be enhanced with machine learning algorithms to improve its accuracy and performance in recognizing faces and controlling home automation devices.

Overall, these future enhancements can further improve the functionality, usability, and security of the system and provide a more personalized and convenient user experience for the users.

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APPENDIX

A.CODING

```
#include "esp_camera.h"
#include <WiFi.h>
//
// WARNING!!! PSRAM IC required for UXGA resolution and high JPEG quality
//      Ensure ESP32 Wrover Module or other board with PSRAM is selected
//      Partial images will be transmitted if image exceeds buffer size
// Select camera model
#define CAMERA_MODEL_WROVER_KIT
#define CAMERA_MODEL_ESP_EYE
#define CAMERA_MODEL_M5STACK_PSRAM
#define CAMERA_MODEL_M5STACK_WIDE
#define CAMERA_MODEL_AI_THINKER

#include "camera_pins.h"

#define RED 13
#define GREEN 14
#define LOCK 12

const char* ssid = "RaviKiran"; //WiFi SSID
const char* password = "9553766825"; //WiFi Password

void startCameraServer();

boolean matchFace = false;
boolean openLock = false;
long prevMillis=0;
int interval = 6000; //DELAY

void setup() {
```

```
pinMode(LOCK,OUTPUT);
pinMode(RED,OUTPUT);
pinMode(GREEN,OUTPUT);
digitalWrite(LOCK,LOW);
digitalWrite(RED,HIGH);
digitalWrite(GREEN,LOW);
```

```
Serial.begin(115200);
Serial.setDebugOutput(true);
Serial.println();
```

```
camera_config_t config;
config.ledc_channel = LEDC_CHANNEL_0;
config.ledc_timer = LEDC_TIMER_0;
config.pin_d0 = Y2_GPIO_NUM;
config.pin_d1 = Y3_GPIO_NUM;
config.pin_d2 = Y4_GPIO_NUM;
config.pin_d3 = Y5_GPIO_NUM;
config.pin_d4 = Y6_GPIO_NUM;
config.pin_d5 = Y7_GPIO_NUM;
config.pin_d6 = Y8_GPIO_NUM;
config.pin_d7 = Y9_GPIO_NUM;
config.pin_xclk = XCLK_GPIO_NUM;
config.pin_pclk = PCLK_GPIO_NUM;
config.pin_vsync = VSYNC_GPIO_NUM;
config.pin_href = HREF_GPIO_NUM;
config.pin_sscb_sda = SIOD_GPIO_NUM;
config.pin_sscb_scl = SIOC_GPIO_NUM;
config.pin_pwdn = PWDN_GPIO_NUM;
config.pin_reset = RESET_GPIO_NUM;
config.xclk_freq_hz = 20000000;
config.pixel_format = PIXFORMAT_JPEG;
//init with high specs to pre-allocate larger buffers
if(psramFound()){
```

```

    config.frame_size = FRAMESIZE_UXGA;
    config.jpeg_quality = 10;
    config.fb_count = 2;
} else {
    config.frame_size = FRAMESIZE_SVGA;
    config.jpeg_quality = 12;
    config.fb_count = 1;
}

#ifdef CAMERA_MODEL_ESP_EYE
    pinMode(13, INPUT_PULLUP);
    pinMode(14, INPUT_PULLUP);
#endif

// camera init
esp_err_t err = esp_camera_init(&config);
if (err != ESP_OK) {
    Serial.printf("Camera init failed with error 0x%x", err);
    return;
}

sensor_t * s = esp_camera_sensor_get();
//initial sensors are flipped vertically and colors are a bit saturated
if (s->id.PID == OV3660_PID) {
    s->set_vflip(s, 1);//flip it back
    s->set_brightness(s, 1);//up the blightness just a bit
    s->set_saturation(s, -2);//lower the saturation
}
//drop down frame size for higher initial frame rate
s->set_framesize(s, FRAMESIZE_QVGA);

#ifdef CAMERA_MODEL_M5STACK_WIDE
    s->set_vflip(s, 1);
    s->set_hmirror(s, 1);

```

```

#endif

WiFi.begin(ssid, password);
while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
}
Serial.println("");
Serial.println("WiFi connected");
startCameraServer();
Serial.print("Camera Ready! Use 'http://'");
Serial.print(WiFi.localIP());
Serial.println(" to connect");
}

void loop() {
    if(matchFace==true && openLock==false)
    {
        openLock=true;
        digitalWrite(LOCK,HIGH);
        digitalWrite(GREEN,HIGH);
        digitalWrite(RED,LOW);
        prevMillis=millis();
        Serial.print("UNLOCK DOOR");
    }
    if (openLock == true && millis()-prevMillis > interval)
    {
        openLock=false;
        matchFace=false;
        digitalWrite(LOCK,LOW);
        digitalWrite(GREEN,LOW);
        digitalWrite(RED,HIGH);
        Serial.print("LOCK DOOR");
    }
}

```

B.OUTPUT SCREEN SHOTS

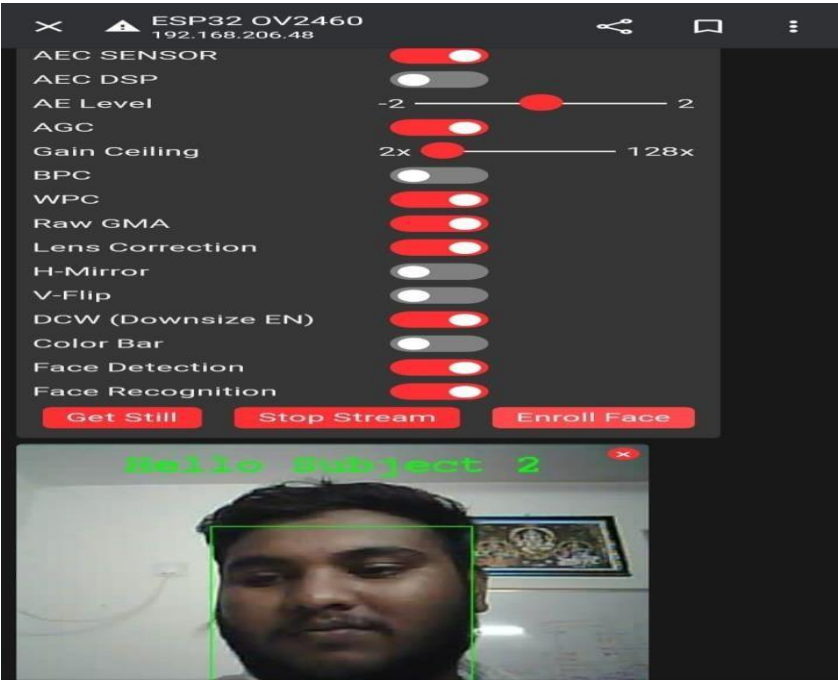


Fig7.1:Output

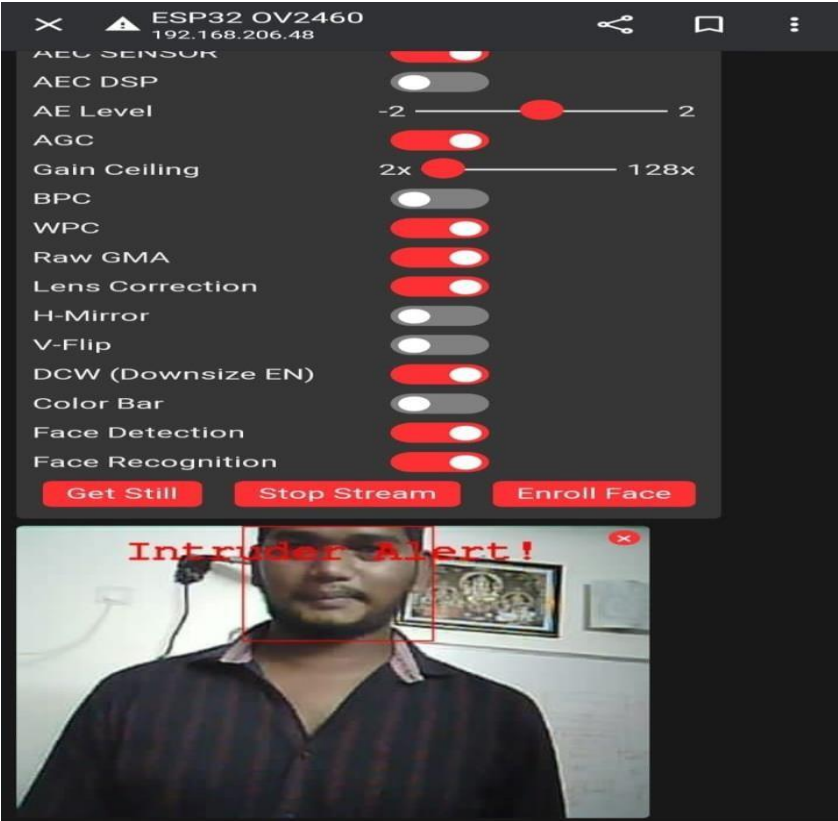


Fig7.2:Output

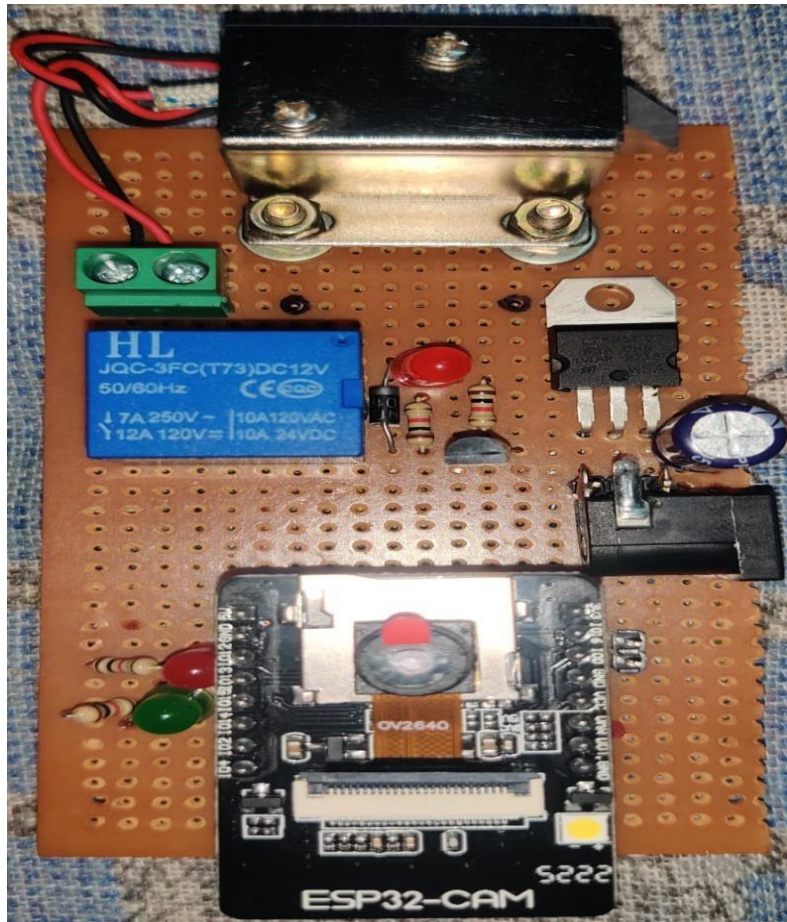


Fig7.3:Hardware of the project