# MODERN FACE RECOGNITION ATTENDANCE SYSTEM USING OPEN CV

## MINI PROJECT REPORT

Submitted by:

**ANASWARA RAJ (EKC22EC005)**

**MOHAMMED FAVAZ CK (EKC2EC017)**

**MOHAMMED SHAMIL KP (EKC22EC018)**

**ROHITH P (EKC22EC028)**

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Of

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In

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**Department of Electronics and Communication Engineering**

**Eranad Knowledge City Technical Campus**

**Manjeri-Malappuram**

**Kerala**

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# DECLARATION

We under signed hereby declare that the Mini Project Report **"MODERN FACE RECOGNITION ATTENDANCE SYSTEM USING OPEN CV"**, submitted for partial fulfilment of the requirements for the award of degree of Bachelor of Technology of the APJ Abdul Kalam Technological University, Kerala is a Bonafide work done by me under supervision of **Ms. ASHMITA MOIDU** (Assistant Professor of ECE Department) this submission represents my ideas in my own words and where ideas or words of others have been included, we have adequately and accurately cited and referenced the original sources we also declare that we have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in my submission. We understand that any violation of the above will be a cause for disciplinary action by the institute and/or the university and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title of any other university

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# MANJERI, MALAPPURAM

## DEPARTMENT OF ELECTRONICS AND COMMUNICATIONS ENGINEERING

## CERTIFICATE

This is to certify that the Mini Project Report entitled **"MODERN FACE RECOGNITION ATTENDANCE SYSTEM USING OPEN CV"** is the Bonafide record of the work done by **ANASWARA RAJ (EKC22EC005), MOHAMMED FAVAZ CK (EKC2EC017), MOHAMMED SHAMIL KP (EKC22EC018), ROHITH P (EKC22EC028)** of Sixth Semester, Electronics and Communication Engineering. Eranad Knowledge City Technical Campus, towards the partial fulfilment of the requirements for the award of the Degree of Bachelor of Technology by the APJ Abdul Kalam Technological University. This report in any form has not been submitted to any other University or Institute for any purpose.

**Mini Project Guide**

**Mini Project Coordinator** **Head of the Department**

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**ANASWARA RAJ**

**MOHAMMED FAVAZ CK**

**MOHAMMED SHAMIL KP**

**ROHITH P**

# ABSTRACT

Traditional attendance tracking methods, such as manual entry and RFID-based systems, are often inefficient, error-prone, and require physical interaction. To address these limitations, this project presents a face recognition-based attendance system that provides a modern, contactless, and automated solution. Utilizing an ESP32 camera module and OpenCV, the system captures facial images in real-time, processes them using machine learning-based facial recognition algorithms, and matches them against a pre-registered database to log attendance automatically. The integration of a microcontroller allows seamless management of peripheral components, including display units, buzzers, and IoT-based cloud storage, enabling real-time tracking, remote access, and automated updates. OpenCV ensures efficient image processing, even in dynamic lighting conditions and varying facial orientations, while edge computing optimizes performance by handling image processing locally before transmitting data to a central server. This approach enhances speed, security, and reliability by reducing data transmission and dependency on external networks. Designed to be cost-effective, scalable, and secure, the system is ideal for schools, workplaces, and organizations requiring accurate and automated attendance management. It can also be integrated with existing platforms to provide real-time notifications, analytics, and reporting, enhancing administrative efficiency and offering valuable insights into attendance patterns. By eliminating manual record-keeping and minimizing human intervention, this system streamlines attendance management, reduces errors, and ensures compliance with organizational policies, demonstrating a practical and intelligent approach to modernizing attendance tracking through computer vision and embedded systems.

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# ABBREVIATIONS

| | |
|---|---|
| **AI** | ARTIFICIAL INTELLIGENCE |
| **CNN** | CONVOLUTIONAL NEURAL NETWORK |
| **ESP** | ESPRESSIF SYSTEMS PLATFORM |
| **FTDI** | FUTURE TECHNOLOGY DEVICES INTERNATIONAL |
| **FPS** | FRAMES PER SECOND |
| **GPIO** | GENERAL PURPOSE INPUT/OUTPUT |
| **12C** | INTER-INTEGRATED CIRCUIT |
| **LCD** | LIQUID CRYSTAL DISPLAY |
| **LED** | LIGHT EMITTING DIODE |
| **ML** | MACHINE LEARNING |
| **OCR** | OPTICAL CHARACTER RECOGNITION |
| **OpenCV** | OPEN-SOURCE COMPUTER VISION LIBRARY |
| **RAM** | RANDOM ACCESS MEMORY |
| **RGB** | RED GREEN BLUE |
| **RTOS** | REAL-TIME OPERATING SYSTEM |
| **SPI** | SERIAL PERIPHERAL INTERFACE |
| **UART** | UNIVERSAL ASYNCHRONOUS RECEIVER-TRANSMITTER |
| **USB** | UNIVERSAL SERIAL BUS |
| **Wi-Fi** | WIRELESS FIDELITY |

# CHAPTER 1

## INTRODUCTION

With advancements in automation and artificial intelligence, traditional attendance tracking methods are being replaced by smart, contactless solutions. This project presents a Face Recognition-Based Attendance System that leverages OpenCV and an ESP32 camera module to enhance the efficiency, accuracy, and security of attendance management. Unlike conventional methods such as manual registers, RFID-based authentication, or fingerprint scanners, this system offers a fully automated and non-intrusive solution, eliminating the need for physical contact and minimizing the risk of fraud.

The system operates by utilizing an ESP32 camera module to capture real-time images of individuals as they approach the attendance checkpoint. These images are processed using OpenCV, an open-source computer vision library, which detects and extracts facial features with high precision. The extracted data is then transmitted to a Raspberry Pi, which serves as the central processing unit. Using facial recognition algorithms, the Raspberry Pi compares the captured facial data against a pre-registered database of authorized individuals. If a match is found, the system automatically logs the attendance and updates the record in real time. The attendance status is displayed on an LCD or LED screen, providing immediate confirmation to users. Additionally, the Wi-Fi-enabled ESP32 ensures seamless wireless communication between components, allowing real-time data updates and integration with external databases for remote access and monitoring.

One of the most significant advantages of this face recognition-based attendance system is its ability to completely eliminate the need for human intervention in the attendance-taking process. Traditional methods, such as manual roll calls or RFID card systems, are often time-consuming, prone to human error, and susceptible to misuse such as buddy punching or proxy attendance. By automating the process through advanced facial recognition technology, the system ensures a much higher level of accuracy, reliability, and consistency in attendance tracking. This feature is particularly advantageous in structured environments like corporate offices, educational institutions, and high-security zones, where maintaining precise records of individuals is crucial for operational transparency and security.

Moreover, the hygienic, contactless operation of the system adds a layer of safety, making it highly suitable in today’s post-pandemic world, where reducing physical contact is a priority in public and shared spaces. Unlike biometric fingerprint systems or ID cards that require physical interaction, this system allows individuals to be identified from a distance, making the process faster, safer, and more user-friendly. The touch-free functionality enhances user acceptance and minimizes the spread of germs, aligning with modern health and safety standards.

The system is also designed to be highly scalable and flexible, allowing for future upgrades and integrations. Possible enhancements include cloud-based data storage for secure and centralized record-keeping, mobile app integration for remote access and real-time alerts, as well as automated email or SMS notifications for attendance summaries or alerts on unknown person detection. Additionally, by incorporating IoT-based analytics, administrators can gain deep insights into attendance trends, late arrivals, or absenteeism patterns through easily generated reports and dashboards.

With the growing need for intelligent automation and AI-powered systems, this project is well-aligned with the future of smart workplaces, digital classrooms, and tech-enabled environments. By leveraging OpenCV's powerful image processing and face recognition capabilities, the ESP32-CAM’s efficient live video streaming, and the processing capabilities of Python and Raspberry Pi, this system delivers a cost-effective yet high-performance solution for real-time attendance monitoring. It streamlines day-to-day administrative tasks, enhances security, and sets a strong foundation for integrating next-generation technologies such as machine learning, edge computing, and cloud services. Ultimately, this project showcases how a well-designed combination of hardware and software can transform routine tasks into intelligent, automated solutions, supporting the vision of smarter, safer, and more connected environments.

# CHAPTER 2

# LITERATURE SURVEY

## 2.1 ATTENDANCE MARKING SYSTEM USING FACE RECOGNITION

**Authors: Pooja L Kanth and Salva Biswal**
**Year: 2020**

The article discusses the concept and implementation of a suitable method for marking attendance automatically. Automating the attendance is necessary these days because many of the universities/institutions are particular about their student’s attendance in the classroom. But the usual method of marking attendance is proven to be tedious, inaccurate and time-consuming when the number of students in a class is more. Proxy attendance is another big issue for the teachers.

This study proposes a method for marking attendance automatically using Principle Component Analysis (PCA) as a face recognition technique. The image of all the students seated in the classroom is captured and then compared with the student’s database, based on which attendance of individual students is marked. An e-mail is sent to those parents whose wards were not present in the class.

The students are successfully detected using Viola Jones Algorithm and recognized/identified using PCA analysis method. The database constantly updates the status of attendance of every student. This system works well even in different light settings. It can identify a person even if some of his/her features are changed. For example, it could identify a person with different haircuts, a person with or without spectacles, a reasonably old photo vs new photo etc.

Thus, the classroom time can be effectively utilized without compromising attendance. Viola Jones algorithm accurately detects faces. PCA analysis algorithm utilizes the detected faces to recognize the students by comparing it with the database.

Attendance has been a major issue for universities these days. Lecturers are finding it hard to evaluate the attendance of students accurately due to time constraints. With time, the student strength per classroom is drastically going to increase and the syllabus is going is be vaster and difficult. The teachers will be able to focus their attention on these factors, only if their classroom time is not wasted. An effort had been made earlier to automate this process; however, they were not accurate. Face recognition is gaining a lot of popularity in various domains as it is easy to use, accurate and faster in detection.

Biometric is the most widely used attendance marking system. It uses fingerprint or speech to identify a person. However, biometric could be easily hacked or manipulated by students. Radio Frequency Identification (RFID) cards could be used to mark the attendance by providing different RFID tags to each student.[7] However, RFID has got its own set of disadvantages. Some of the disadvantages are: the student cannot enter the class if his/her card is not working, RFID tags could be misused by other students and RFID tags do not work in presence of other magnetic fields. By entering the database online: This method could be productive if a large number of databases need to be maintained and a lot of operations need to be performed on it. However, this method cannot be considered as effective as it is not completely automated.

Here in this study, an attendance marking system using face recognition is being proposed. A limited number of studies have been carried out in this area. The method is to detect the faces of students in the image and match the faces with the database to identify the face and mark the attendance of the student for the class.

## 2.2 SMART ATTENDANCE MONITORING SYSTEM USING FACIAL RECOGNITION

**Authors: Muhammed Amjad, Muhammed Farooq-I-Azam, Ejaz Ahmad Ansari**

**Year: 2021**

“Smart Attendance monitoring using Facial Recognition" which presents a smart attendance system using Radio Frequency Identification (RFID) technology for class attendance monitoring. The Radio Frequency Identification (RFID) innovation is one of a robotization innovation that is advantageous in improving current traditional method of marking student attendance, as each tag has its own novel ID, it is not difficult to separate each label holder. A Radio Frequency Identification (RFID) innovation RFID tag is an item that can be applied to or embedded into an item, individual, or creature with the end goal of recognition and monitoring utilizing radio waves. A few labels can be read from a few centimetres or meters away and past the view of the reader. Likewise, a Graphical User Interface (GUI) gives more productive approach to survey the student's attendance.

A Conceptual Model for Automated Attendance Marking System Using Facial Recognition propose a model for systematic marking of attendance. They made use of two database in which one is respiratory database and the other use for keeping student's information. The respiratory database contains the generally assembled pictures and the covers determined by the facial fiducially point of the students to such an extent that of nose, eyes and lips principally. The other data set known as student's data set will be utilized to check the attendance of the students. A camera will be fixed in the class in the front, at such a point where the image of the entire class can be taken. When the picture is caught, clamour will be computed and foundation will likewise be limited. Gabor Filters or Jets will be applied after that through which each individual student's 31 facial fiducially focuses will be determined. It will figure the estimations of the facial highlights and afterward they will be coordinated to the picture data put away in the capacity information base.

This all calculation will be going on the worker. When the matches are done, the student's attendance is set apart to address the issue of approval of the student present in the class or not.

Mart Attendance Portal Using Facial Recognition shows the colossal advancement accomplished by the deep learning techniques. The primary piece of the research work is Convolutional Neural Network based facial recognition and identification, and its application over simplifying the everyday life is the illustration on how far these innovations have come. The execution of the facial recognition gives a decent exactness and the limitation in recognition can remove the greatest farce assaults which can be utilized to deceive the system. This present reality execution will have a few key components into play like execution of the facial recognition unit, no of focuses for taking inputting attendance, association speed, and nature of camera.

Smart Attendance System using OPENCV based on Facial Recognition highlights the most profitable Open CV face recognition technique open for the management of attendance. The framework has been executed utilizing the local binary pattern histogram algorithm. The local binary pattern histogram algorithm dominates different techniques by certainty factor of 2-5 and has least sound obstruction. The execution of the Smart Attendance System depicts the presence of a student between the facial recognition measure and the limit esteem. Along these lines, the local binary pattern histogram is the most credible and capable face recognition algorithm found in Open CV for the recognizable proof of the student in an instructive organization and denoting their participation enough by turning away intermediaries.

Smart attendance system via facial recognition using Tensor flow Face net model adopted a Tensor flow Face net model for facial recognition of students. Recognizable proof framework is utilized to carefully confirm an individual by contrasting each known face and data comparing to the data set. The Tensor flow Face net model is the method utilized for the facial recognition where it's called as one-shot model where straight learning and planning the face pictures into Euclidean space where distances are utilized to figure the similitude of countenances. With the facial recognition highlight, this framework can undoubtedly oversee and mechanize marking of attendance and securely record it in the data set.

Smart Attendance System using QR Code proposed a model which is partitioned into three modules: the primary module is the module of the administrators, which comprises of 3 kinds: administrator, head of study program and executive of the investigation program. The head of study deals with the exercises of the system like adding courses, altering and erasing courses. The subsequent module is the attendance management, which will be helped out through a gadget in every study hall that will be associated with a camera gadget and the internet. It will empower QR code perusing utilizing the Instascan JS library, the framework will scan the QR code which contains the lone teacher or student ID. At that point, in view of the day and time span, the framework begins the class that the educator ought to go to that day, and it consequently enlists the class as finished and for that date embeds all students attending to that course with 'Absent' status. Another page opens and the camera opens to scan the QR code, but now the students’ needs to scan his/her code to the gadget. There is the entire rundown of students attending to the course and every student scan their remarkable QR code to change their status to 'Present'. The third module is about the lecturer and student’s module, where the lecturer and the student can sign into the framework with their information got from the administrator.

Attendance Management System Using Face Recognition proposed an automated attendance system that will be proficient in recognizing the student whose information has been recorded in the database and automatically marks present for the student. Though different algorithms and strategies has been utilized for improving the execution of facial recognition. The idea they utilized is the Open CV. They likewise made use Raspberry Pi and camera module to take picture store them in data set. This way the attendance will be computerized. The concept of two innovations namely: Student Attendance and Feedback framework has been carried out with a Machine Learning method. This framework naturally distinguishes the performance and keeps up the student's records like attendance and their report regarding the subjects like English and Science, and so forth. In this manner the student’s attendance can be made accessible by identifying the face. On identification, the attendance subtleties and insights concerning the marks of the student is acquired as report.

Smart Attendance System Using CNN proposed an intelligent and productive system for marking attendance by utilizing face location and facial recognition. This system can be utilized to mark attendance in learning institutions or workplaces utilizing real time face recognition with the assistance of Convolution Neural Network (CNN). The ordinary strategies like Eigen countenances and Fisher faces are delicate to lighting, clamour, pose, impediment, enlightenment and so on Henceforth, they have utilized Convolutional Neural Network to identify the face and outperform such challenges. The attendance database will be refreshed consequently and put away in excel sheet just as in information base. They made utilize the MongoDB as backend information base for recording of attendance.

Location Based Smart Attendance System Using GPS proposed location-based system for tracking of student's attendance which is carried out on the android versatile application utilizing smart phone decreasing the prerequisite for added biometric scanner gadgets. Things of the association enclose a chosen area, which could be controlled by GPS. The student ought to be inside the predefined territory of the GPS to be tracked. They carried out this with the fundamental point of final year students to make the actual presence in the task hour to be inside the campus. The location of every student will be chosen by the GPS utilizing cell phones. This area is characterized as a key of some time and attendance tracking in their paper.

## 2.3 SMART ATTENDANCE MONITORING SYSTEM USING FACIAL RECOGNITION

**Authors: Natarajan S and Dr. H. Jayamangala**

**Year: 2024**

Smart Attendance System presents a smart attendance system using Radio Frequency Identification (RFID) technology for class attendance monitoring. The Radio Frequency Identification (RFID) innovation is a robotization innovation that is advantageous in improving the current traditional method of marking student attendance, as each tag has its own novel ID, it is not difficult to separate each label holder. A Radio Frequency Identification (RFID) innovation RFID tag is an item that can be applied to or embedded into an item, individual, or creature with the end goal of recognition and monitoring utilizing radio waves. A few labels can be read from a few centimetres or meters away and past the view of the reader. Likewise, a Graphical User Interface (GUI) gives a more productive approach to survey the student's attendance.

A Conceptual Model for Automated Attendance Marking System Using Facial Recognition proposes a model for systematic marking of attendance. They made use of two databases in which one is a respiratory database and the other is used for keeping student's information. The respiratory database contains the generally assembled pictures and the covers determined by the facial fiducially point of the students to such an extent that of nose, eyes and lips principally. The other data set known as the student's data set will be utilized to check the attendance of the students. A camera will be fixed in the class in the front, at such a point where the image of the entire class can be taken. When the picture is caught, clamour will be computed and foundation will likewise be limited.

Gabor Filters or Jets will be applied after that through which each individual student's 31 facial fiducially focuses will be determined. It will figure the estimations of the facial highlights and afterward they will be coordinated to the picture data put away in the capacity information base.

This all calculation will be going on the worker. When the matches are done, the student's attendance is set apart to address the issue of approval of the student present in the class or not. Mart Attendance Portal Using Facial Recognition shows the colossal advancement accomplished by the deep learning techniques. The primary piece of the research work is

Convolutional Neural Network based facial recognition and identification, and its application over simplifying everyday life is the illustration on how far these innovations have come. The execution of facial recognition gives a decent accuracy and the limitation in recognition can remove the greatest farce assaults which can be utilized to deceive the system. This present reality execution will have a few key components into play like execution of the facial recognition unit, no focus for inputting attendance, association speed, and nature of camera.

## 2.4 A SURVEY OF FACE RECOGNITION TECHNIQUES

**Authors: Rabia Jafri and Hamid R. Arabnia**

**Year: 2020**

Biometric-based techniques have emerged as the most promising option for recognizing individuals in recent years since, instead of authenticating people and granting them access to physical and virtual domains based on passwords, PINs, smart cards, plastic cards, tokens, keys and so forth, these methods examine an individual's physiological and/or behavioural characteristics in order to determine and/or ascertain his identity. Passwords and PINs are hard to remember and can be stolen or guessed; cards, tokens, keys and the like can be misplaced, forgotten, purloined or duplicated; magnetic cards can become corrupted and unreadable. However, an individual's biological traits cannot be misplaced, forgotten, stolen or forged.

Biometric-based technologies include identification based on physiological characteristics (such as face, fingerprints, finger geometry, hand geometry, hand veins, palm, iris, retina, ear and voice) and behavioural traits (such as gait, signature and keystroke dynamics). Face recognition appears to offer several advantages over other biometric methods, a few of which are outlined here: Almost all these technologies require some voluntary action by the user, i.e., the user needs to place his hand on a hand-rest for fingerprinting or hand geometry detection and has to stand in a fixed position in front of a camera for iris or retina identification. However, face recognition can be done passively without any explicit action or participation on the part of the user since face images can be acquired from a distance by a camera. This is particularly beneficial for security and surveillance purposes. Furthermore, data acquisition in general is fraught with problems for other biometrics: techniques that rely on hands and fingers can be rendered useless if the epidermis tissue is damaged in some way (i.e., bruised or cracked). Iris and retina identification require expensive equipment and are much too sensitive to any body motion. Voice recognition is susceptible to background noises in public places and auditory fluctuations on a phone line or tape recording. Signatures can be modified or forged. However, facial images can be easily obtained with a couple of inexpensive fixed cameras. Good face recognition algorithms and appropriate pre-processing of the images can compensate for noise and slight variations in orientation, scale and illumination. Finally, technologies that require multiple individuals to use the same equipment to capture their biological characteristics potentially expose the user to the transmission of germs and impurities from other users. However, face recognition is totally non-intrusive and does not carry any such health risks.

The method for acquiring face images depends upon the underlying application. For instance, surveillance applications may best be served by capturing face images by means of a video camera while image database investigations may require static intensity images taken by a standard camera. Some other applications, such as access to top security domains, may even necessitate the forgoing of the nonintrusive quality of face recognition by requiring the user to stand in front of a 3D scanner or an infra-red sensor. Therefore, depending on the face data acquisition methodology, face recognition techniques can be broadly divided into three categories: methods that operate on intensity images, those that deal with video sequences, and those that require other sensory data such as 3D information or infra-red imagery. The following discussion sheds some light on the methods in each category and attempts to give an idea of some of the benefits and drawbacks of the schemes mentioned therein in general.

### 2.5 SMART ATTENDANCE SYSTEM USING GEOLOCATION

**Authors: Preeti Bailke, Om Gujarathi, Sanskar Gundecha, Om Gore, Asawari Jadhav and Jayesh Chaudhari**

**Year:2024**

Proposed system is divided into four distinct modules described as follows: User Authentication, User authentication is a crucial part of the attendance tracking mobile application. This system leverages Appwrite's built-in authentication methods to enhance user authentication. Alongside the Flutter framework's authentication mechanisms, Appwrite provides an additional layer of security and convenience. Teachers and students can sign in using their Appwrite credentials, ensuring a secure login process. Furthermore, to offer more flexibility and ease of access, this system has integrated Google Sign-In functionality, enabling users to log in using their Google accounts. This seamless integration with Appwrite and the support for Google Sign-In simplifies the authentication process and enhances the user experience, making the application more user-friendly Data gloves, such as the 5DT Data Glove and Cyber Glove, excel at capturing finger articulation and hand postures with high accuracy. These gloves use sensors like flex sensors, accelerometers, and gyroscopes to measure the bending of fingers and hand movements in 3D space. Early research by Lee & Kim (1999) introduced a gesture recognition system using Hidden Markov Models (HMMs) with data gloves, focusing on human-robot interaction. The precision of the glove's sensors allowed for accurate recognition of hand signs and wrist rotations. Similarly, Cheng et al. (2014) developed a real-time hand gesture recognition system using a 5DT data glove and Support Vector Machines (SVMs), highlighting its potential for virtual reality and sign language interpretation. Zhu et al. (2018) integrated inertial measurement units (IMUs) into a data glove system, using Dynamic Time Warping (DTW) and HMMs to achieve high accuracy in real-time gesture recognition. While data gloves provide excellent finger motion tracking, they are often expensive, intrusive, and lack spatial awareness, limiting their broader adoption.

B. View/Manage Classes, the second step in our implementation involves utilizing the Teams feature in Appwrite to enhance classroom management within the attendance tracking mobile application. With this feature, users can create and join different classes, making it convenient for both teachers and students to organize their attendance tracking activities. Upon signing in, users have the option to create new classes or join existing ones. Teachers can create classes for various subjects or sessions and provide relevant details such as class names, schedules, and locations. Students, on the other hand, can search for and join the classes they are attending. This process streamlines the attendance marking process, ensuring that each student is part of the correct class. Furthermore, the Teams feature in Appwrite allows users to view a comprehensive list of all the classes they have joined. This feature provides a convenient overview of their class schedules and simplifies the process of managing multiple classes for both teachers and students. Administrators, typically the teachers, have access to additional privileges within the created classes. They can manage team members, which includes both adding and removing students from the class roster. This capability ensures that only the relevant students are part of a specific class, maintaining accuracy and security in the attendance tracking system. Additionally, the Teams feature allows teachers to view a list of all the students who have joined a particular class. This visibility provides valuable insights into class demographics and attendance records. Teachers can use this information to monitor class participation, identify absentees, and address attendance-related concerns effectively. In summary, implementing the Teams feature in Appwrite significantly enhances the classroom management aspect of our attendance tracking mobile application. It empowers users to create, join, and manage classes conveniently, while administrators benefit from better control over class membership. This integration simplifies attendance tracking for both teachers and students, making the application more effective and user-friendly.

C. Marking Attendance, The third step in our implementation focuses on the process of marking attendance in our mobile application. The process of marking attendance is a key functionality of our mobile application. The attendance marking begins when the teacher starts the process for a particular class from their interface. Once the attendance process is initiated, students can proceed to mark their attendance based on the three parameters. First, the application captures the student's location to ensure they are within the designated class area. Students must be physically present at the specified location to have their attendance marked. Next, the application prompts students to authenticate themselves using their biometric data, such as fingerprint verification. This biometric authentication ensures that the attendance is linked to the correct student, preventing any possibility of proxy attendance and ensuring the accuracy of the records. The attendance process can only be completed successfully when all three parameters—attendance start verification by the teacher, location proximity, and successful biometric authentication by the student—are met. By implementing this process, our mobile application ensures accurate and reliable attendance records while maintaining a user-friendly experience for both teachers and students. Teachers have control over initiating attendance for specific classes, and students can conveniently mark their attendance based on the three essential parameters, providing a robust and efficient attendance tracking system. D. Display Student Information This mobile application also allows teachers to view detailed information about each student. After logging in, teachers can access student profiles, which include their personal details, attendance history, and other relevant information. This feature helps teachers monitor and track individual student attendance, identify trends, and generate attendance reports. By displaying comprehensive student information, the application facilitates effective monitoring and analysis, ultimately enhancing the management of attendance records.

# CHAPTER 3

# METHODOLOGY

The attendance system is implemented using an ESP32 camera module for face recognition, integrated with a Raspberry Pi for processing and data management. The system operates by capturing an image of the user through the ESP32 camera, which is then processed using OpenCV for facial detection and recognition. The captured data is transmitted to the Raspberry Pi via Wi-Fi, where it is compared with stored facial data for authentication. If a match is found, the attendance is marked, and the information is displayed on an LCD or LED screen. The FTDI module is used for programming the ESP32, and power is supplied through a regulated source. The entire system follows a structured flow, from image acquisition to data storage, ensuring efficiency and accuracy.

## 3.1 BLOCK DIAGRAM

The face recognition-based attendance system starts with a power supply that powers the ESP32-CAM, Raspberry Pi, and other components. The ESP32-CAM, with its inbuilt WIFI antenna, captures images and sends them to the Raspberry Pi for processing. The FTDI module is used for programming and debugging the ESP32-CAM. The Raspberry Pi, running OpenCV, detects and recognizes faces, compares them with stored data, and records attendance in a CSV file. The display unit (LCD/LED screen) then updates and shows the

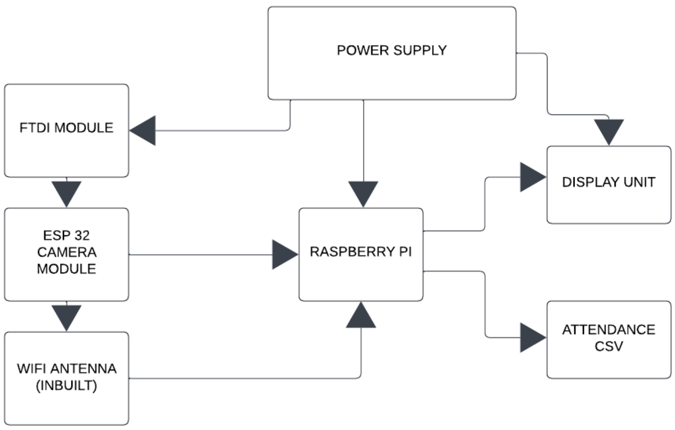


Figure 3.1 Block Diagram

attendance status in real time. This automated system ensures seamless and efficient attendance tracking.

When a person shows their face to the ESP32-CAM, the camera captures the image and sends it to the Raspberry Pi via WiFi. The Raspberry Pi processes the image using OpenCV, detects the face, and compares it with the stored database. If a match is found, the system records the attendance in a CSV file and updates the LCD/LED display with the person's status. If no match is found, the system rejects the entry, ensuring only registered individuals are marked present.

## 3.2 CIRCUIT DIAGRAM

In our proposed system Figure 3.2, The system is built using an ESP32-CAM, Raspberry Pi, and other components which are powered by the power supply.

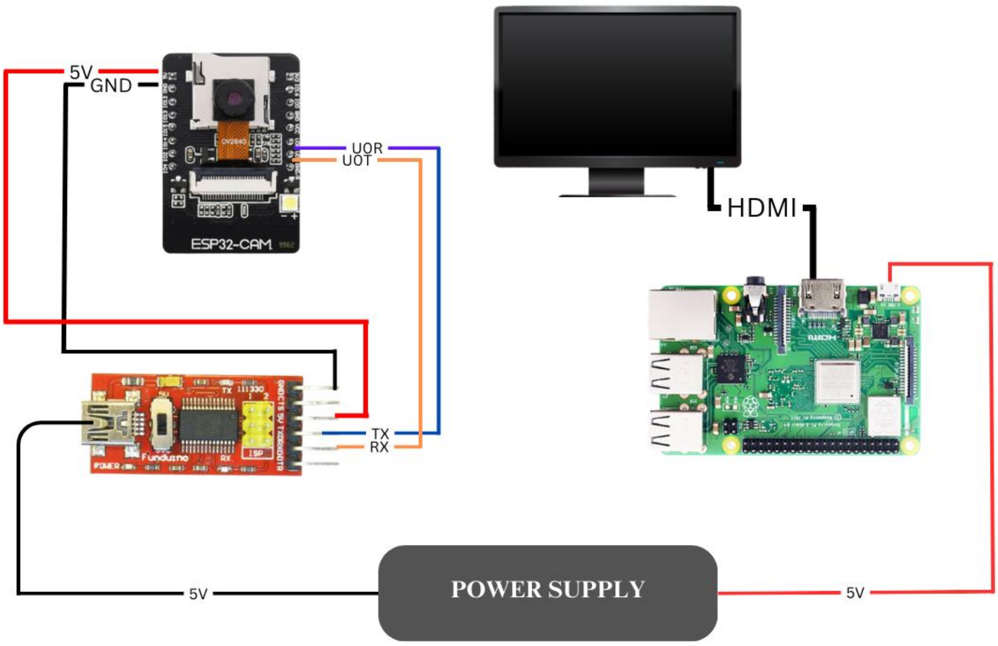


Figure 3.2 Circuit Diagram

The ESP32-CAM module captures images and transmits them to the Raspberry Pi using its inbuilt WIFI antenna. The FTDI module is connected to the ESP32-CAM for programming and debugging purposes. The Raspberry Pi, acting as the processing unit, runs OpenCV to detect and recognize faces. Once a face is identified, the attendance data is stored in a CSV file. The display unit (LCD/LED screen) is connected to the Raspberry Pi, showing real-time attendance updates. The components work together to ensure seamless and automated attendance tracking. The ESP32-CAM is responsible for capturing images using its built-in camera and streaming video over WIFI. It plays a crucial role in the system by continuously capturing real-time footage and transmitting it to the Raspberry Pi, which serves as the main processing unit. The Raspberry Pi receives the video stream and utilizes OpenCV for face recognition, analysing the captured frames to identify and verify individuals. This processed information is then used to manage the attendance system, ensuring that recognized individuals are logged accordingly. To program and debug the ESP32-CAM, a USB-to-Serial Adapter (FTDI Programmer) is used, allowing firmware to be flashed onto the ESP32-CAM and enabling serial communication between the microcontroller and a computer. For visual output, a monitor is connected to the Raspberry Pi via HDMI, displaying a graphical user interface that shows detected faces, attendance records, and system logs. The entire system is powered by a 5V power supply, which ensures a stable power source for the ESP32-CAM, Raspberry Pi, and FTDI adapter, allowing seamless operation and data processing for the face recognition attendance system.

### 3.3 FLOWCHART

This flowchart represents the working of an advanced automated face recognition-based attendance system designed to provide a contactless, real-time, and efficient method for tracking student attendance. The system eliminates the need for traditional manual attendance methods by leveraging cutting-edge technology to enhance accuracy, security, and convenience.

At its core, the system integrates the ESP32-CAM module for capturing live facial images, ensuring a seamless and automated data collection process. The captured images are then processed using OpenCV, a powerful open-source computer vision library that enables efficient face detection and recognition. The Raspberry Pi serves as the central processing unit, handling system control, data management, and decision-making, while also storing attendance records in a structured format for future reference.

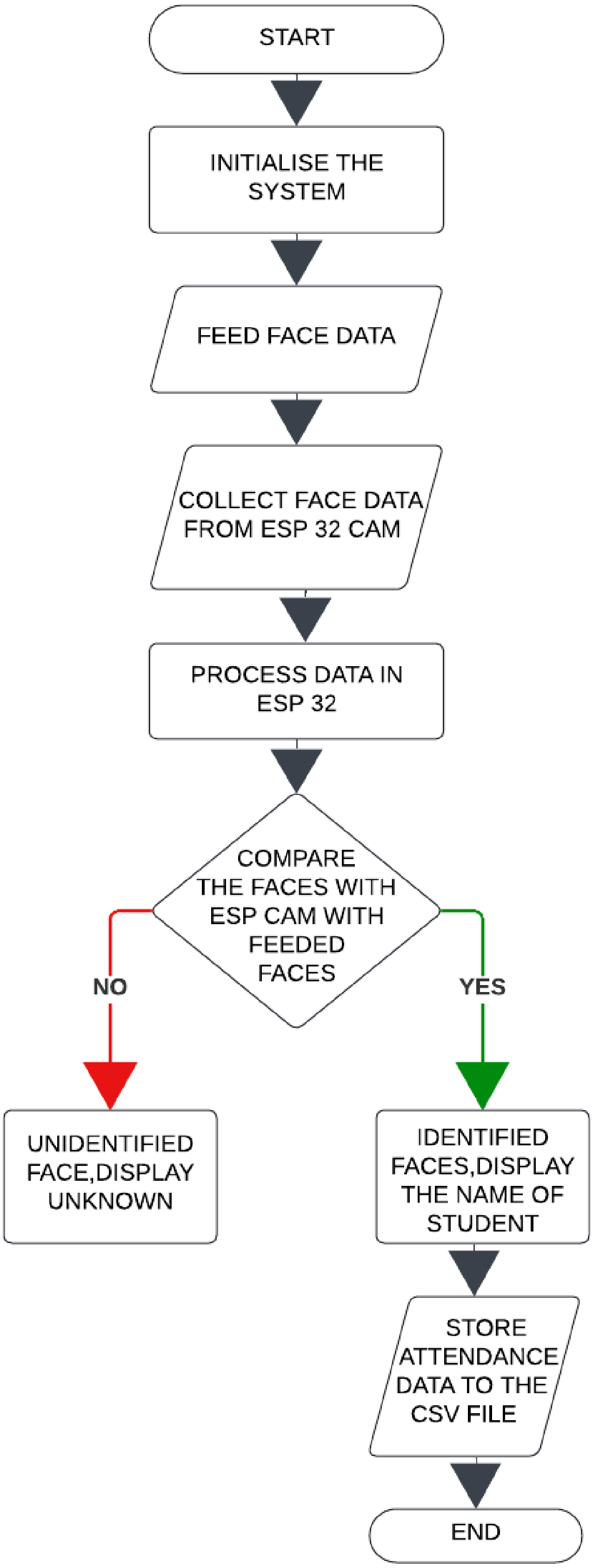


Figure 3.3 Flowchart

**Start:**

- The system is powered on, initializing all required hardware and software components to begin the attendance process.

**Initialize the System**

- The Raspberry Pi initializes OpenCV-based facial recognition algorithms.
- The ESP32-CAM module is activated to start capturing faces.
- The database containing pre-registered faces is loaded for comparison.

**Feed Face Data (Enrolment Phase)**

- The system requires students or users to register their face data.
- Multiple images of each user are captured, processed, and stored in the database.
- This data is later used for face-matching during attendance tracking.

**Collect Face Data from ESP32-CAM (Recognition Phase)**

- The ESP32-CAM captures live images of individuals standing in front of the camera.
- The captured image is sent to the Raspberry Pi for processing.

**Process Data in ESP32**

- The system extracts facial features using OpenCV-based algorithms.
- The extracted features are converted into numerical values for comparison.

**Compare the Faces from ESP32-CAM with Stored Faces**

- system matches the captured face with the pre-stored faces in the database.
- The recognition algorithm determines whether a match is found or not.

**Decision Making:**

**If Face is Identified:**

  - The system retrieves and displays the student’s name on the interface.
  - The attendance record (name, date, and time) is updated in the CSV file.

**If Face is Unidentified:**

  - The system displays "Unknown" and does not register attendance.

- Optionally, an admin alert or registration prompt can be triggered.

**Store Attendance Data**

- The attendance details (student name, timestamp) are logged in a CSV file.
- This file can be accessed later for attendance reports and analytics.

**End**

- The system completes the process and waits for the next recognition cycle

The overall working of the Face Recognition-Based Attendance System, as represented in the flow diagram, revolves around automating the process of identifying individuals through facial features captured in real time. At its core, the system utilizes the ESP32-CAM module to capture live video streams and transmit facial data to a processing unit, where it is compared against pre-fed or enrolled facial data stored in the system's database.

The moment the system is powered on and initialized; it begins scanning for faces using the ESP32-CAM. When a face is detected, it is processed and matched against the stored encodings of previously enrolled individuals. If a match is found, the person's identity is confirmed and their attendance is recorded and saved automatically into a CSV file. On the other hand, if the face does not match any of the stored records, it is labelled as "Unknown," and no attendance entry is made for that individual.

The system is capable of operating in real time, meaning identification and recording occur within seconds without the need for user interaction. It handles multiple faces sequentially, and its high detection threshold ensures accuracy and reliability. Additionally, its ability to display real-time results—whether identified or unknown—adds to its transparency and usability. This entire automated process not only enhances efficiency but also contributes to a more secure and tamper-proof attendance management solution, ideal for modern institutions and workplaces.

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# CHAPTER 4

# HARDWARE AND SOFTWARE IMPLEMENTATIONS

## 4.1 HARDWARE IMPLEMENTATION

In the hardware implementation, the components are assembled to ensure smooth system functionality. The ESP32-CAM is powered and connected to the Raspberry Pi via Wi-Fi for image transmission. The FTDI module is used for programming the ESP32-CAM. The Raspberry Pi processes the images using OpenCV and manages attendance records stored in a CSV file. A display unit (LCD/LED screen) is connected to show real-time attendance updates. Proper wiring and connections ensure stable communication between all components for efficient system performance.

### 4.1.1 RASPBERRY PI

The Raspberry Pi Figure 4.1.1 is the central processing unit of the system, responsible for handling image processing and attendance management. It receives images from the ESP32-CAM via Wi-Fi and uses OpenCV for face detection and recognition. If a match is found in the stored database, the attendance is recorded in a CSV file. The Raspberry Pi also controls the display unit (LCD/LED screen) to show real-time attendance updates. Its compact size, processing power, and built-in connectivity make it ideal for running the face recognition algorithm efficiently in this automated system

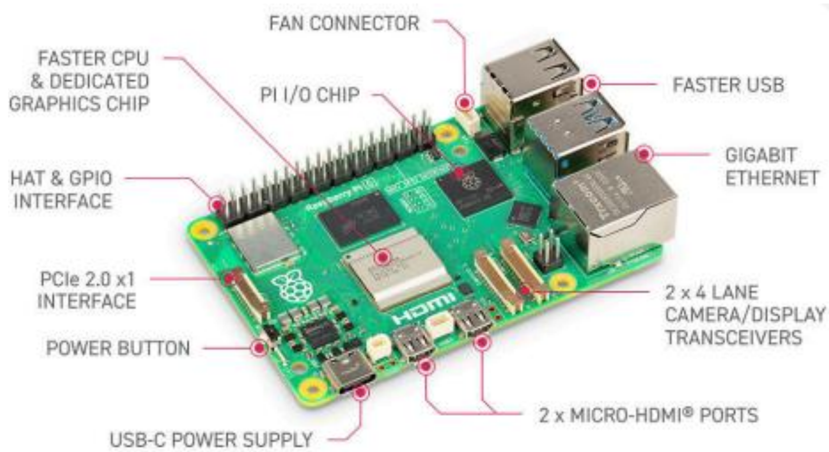


Figure 4.1.1 Raspberry pi

The Raspberry Pi is widely used in various applications due to its compact size, affordability, and versatility. It is commonly used in IoT projects, home automation, and robotics for controlling and processing data. In education, it serves as a powerful tool for learning programming and embedded systems. It is also used in computer vision applications, such as face recognition, object detection, and security surveillance. Additionally, Raspberry Pi is popular in media centres, weather monitoring systems, AI-based projects, and even as a mini web server. Its ability to run Linux-based operating systems and support multiple programming languages makes it a preferred choice for developers and hobbyists worldwide.

### 4.1.1.a RASPBERRY PI PIN CONFIGURATION

The pin configuration of Raspberry Pi is shown in Figure 4.1.1.a

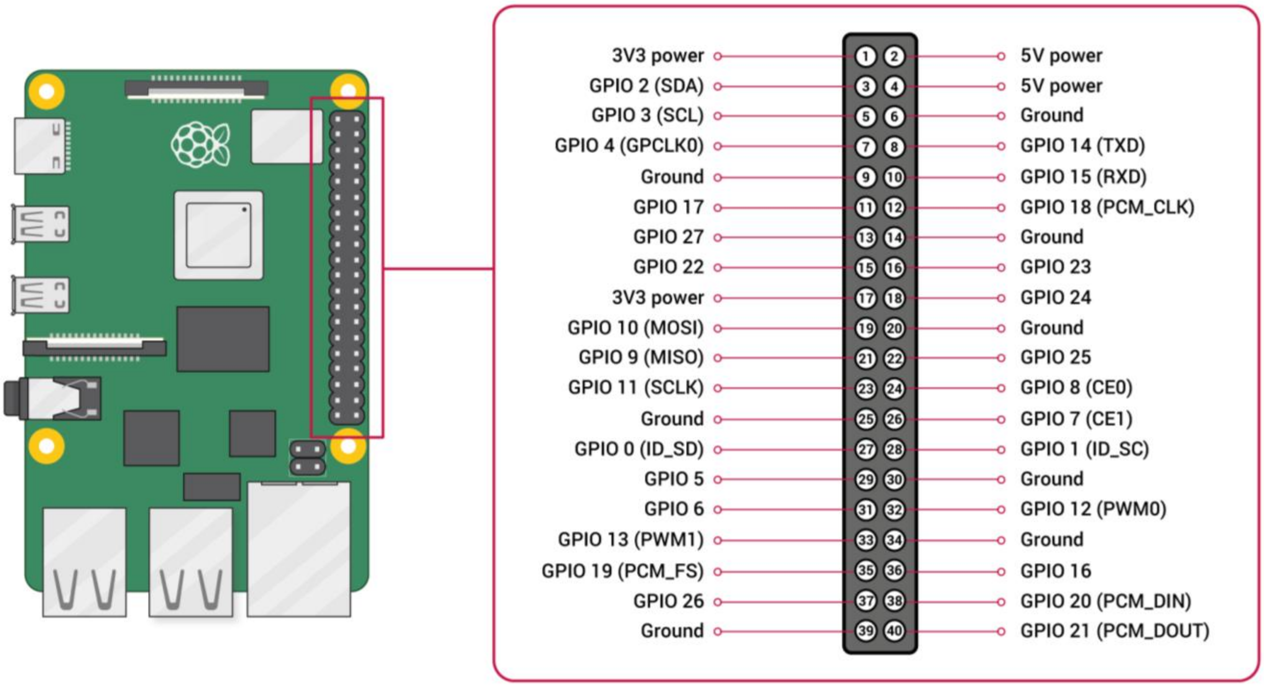


Figure 4.1.1.a Raspberry pi pin configuration

The Raspberry Pi has a 40-pin GPIO (General Purpose Input/Output) header, which includes power, digital, analog (via ADC), and communication pins.

**1. Power Pins**

- 5V (Pins 2, 4) – Provides 5V power output.
- 3.3V (Pin 1, 17) – Provides 3.3V power output.

- GND (Pins 6, 9, 14, 20, 25, 30, 34, 39) – Ground connections.

**2. Digital & Analog Pins**

- GPIO2 to GPIO27 – General-purpose digital input/output pins.

Raspberry Pi does not have built-in analog input, but you can use an external ADC (like MCP3008) to read analog signals.

**3. Communication Pins**

- UART (Serial Communication)
- TX (GPIO14, Pin 8) – UART Transmit.
- RX (GPIO15, Pin 10) – UART Receive.
- I2C (Inter-Integrated Circuit Communication)
- SDA (GPIO2, Pin 3) – Data line.
- SCL (GPIO3, Pin 5) – Clock line.
- SPI (Serial Peripheral Interface Communication)
- MOSI (GPIO10, Pin 19) – Master Out, Slave In.
- MISO (GPIO9, Pin 21) – Master In, Slave Out.
- SCK (GPIO11, Pin 23) – Clock.
- CE0 (GPIO8, Pin 24) – Chip Enable 0.
- CE1 (GPIO7, Pin 26) – Chip Enable 1

### 4.1.2 ESP32 CAMERA MODULE

The ESP32-CAM module is a compact and affordable camera module that integrates an ESP32 microcontroller with a built-in WIFI and Bluetooth module. It is widely used in image processing, video streaming, and IoT applications due to its low power consumption and wireless connectivity. In this project, the ESP32-CAM captures images of individuals and transmits them to the Raspberry Pi via WIFI for face recognition. It supports various resolutions and comes with an OV2640 camera sensor, making it suitable for tasks like face detection, surveillance, and remote monitoring. Additionally, it can be programmed using the Arduino IDE and configured through an FTDI module, making it an excellent choice for embedded vision applications.


Figure 4.1.2 ESP32 Camera Module

The ESP32-CAM module is widely used in various IoT and computer vision applications due to its compact size, wireless connectivity, and image processing capabilities. It is commonly used in face recognition-based attendance systems, home security and surveillance, and smart doorbells for real-time monitoring. In IoT-based monitoring systems, it helps track agricultural conditions, traffic, and industrial automation. It is also used in AI vision projects for object detection, QR code scanning, and barcode recognition. Additionally, it enables wireless video streaming for robotics, drones, and wildlife monitoring. Its affordability and versatility make it a powerful tool for embedded vision applications.

Its compact design and wireless features make it ideal for implementing portable and remote face recognition systems, allowing efficient and contactless attendance tracking. It plays a crucial role by continuously capturing facial images and transmitting them to the processing unit without the need for external storage or complex hardware.

### 4.1.2.a ESP32 CAMERA MODULE PIN CONFIGURATION

The pin configuration of ESP32 Camera Module is shown in Figure 3.3.1.a

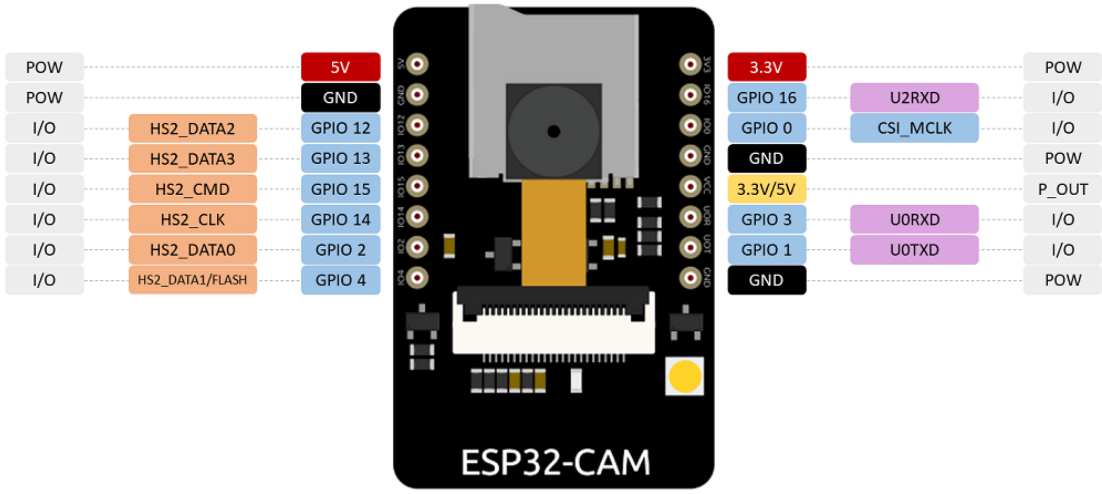


Figure 4.1.2.a Pin Configuration

**ESP32-CAM Pin Configuration**

**1. Power Pins**

- 3.3V – Provides 3.3V power input.
- 5V – Provides 5V power input (recommended for stable operation).
- GND – Ground connection.

**2. Digital & Analog Pins**

- GPIO0 – Used for flashing mode selection (LOW for programming, HIGH for normal operation).
- GPIO4 – Controls the onboard LED flash.
- GPIO12, GPIO13, GPIO14, GPIO15, GPIO16, GPIO17 – Used for the camera module.
- GPIO25, GPIO26 – Used for camera power and reset.
- GPIO33 – Used as Chip Select (CS) for the microSD card.
- GPIO34, GPIO35, GPIO36, GPIO39 – Can be used as ADC (Analog-to-Digital Converter) input pins.

**3. Communication Pins**

- UART (Serial Communication)
- GPIO1 (TX0) – UART Transmit (TX).
- GPIO3 (RX0) – UART Receive (RX).
- SPI (Used for microSD card communication)
- GPIO33 – Chip Select (CS).
- GPIO34, GPIO35, GPIO36, GPIO39 – Data pins for SD card.
- Camera Interface (OV2640 Camera Module Pins)
- GPIO4, GPIO12-GPIO17, GPIO18-GPIO23 – Dedicated for the camera module

### 4.1.3 FTDI MODULE

The FTDI module (Future Technology Devices International) is a USB-to-serial converter that allows communication between a computer and a microcontroller or other serial-based devices.

Figure 4.1.3. FTDI module

Many microcontrollers, such as the ESP32-CAM and ESP8266, do not have a built-in USB interface, making it difficult to program or communicate with them directly. The FTDI module acts as a bridge, converting USB signals from the computer into TTL (Transistor-Transistor Logic) serial signals that the microcontroller can understand.

When a microcontroller needs to be programmed or debugged, the FTDI module is connected between the computer's USB port and the microcontroller's RX (Receive) and TX (Transmit) pins. It converts the USB data signals into serial UART communication, allowing the microcontroller to receive firmware uploads and send debugging messages back to the computer. The module supports both 3.3V and 5V logic levels, making it compatible with a wide range of devices.

Apart from flashing firmware, the FTDI module is essential for serial debugging. Developers can open a serial monitor on their computer to view real-time logs from the microcontroller, helping them detect errors, monitor sensor outputs, and analyse system behaviour. This makes the FTDI module a crucial tool in embedded development and troubleshooting.

### 4.1.3.a FTDI MODULE PINOUT

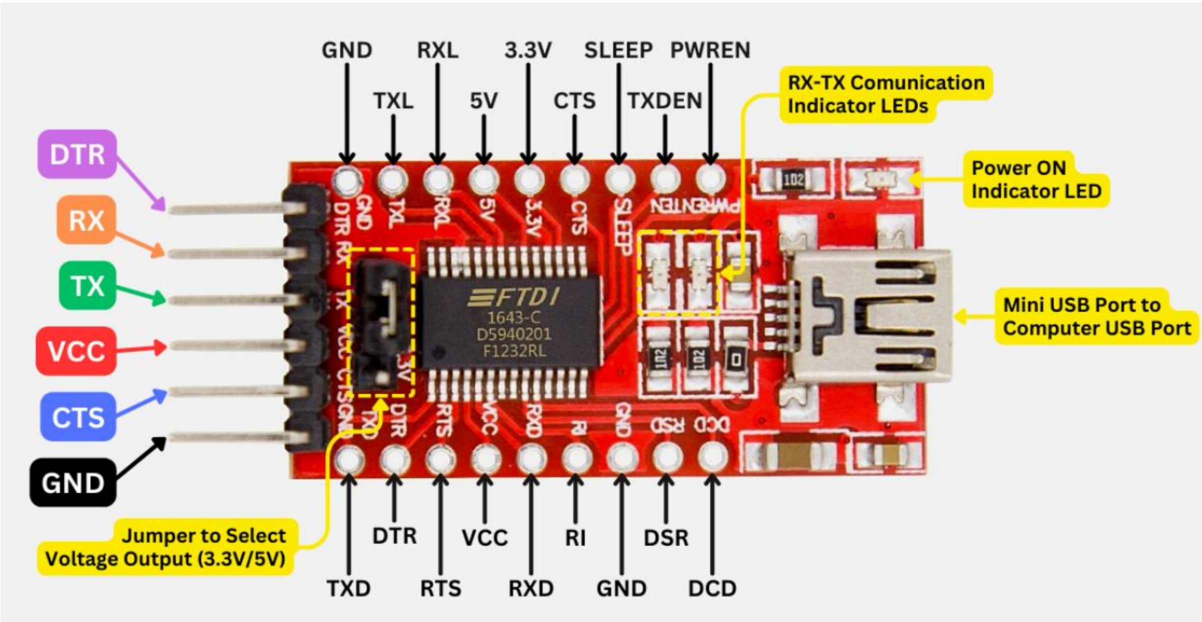


Figure 4.1.3.a Pin Configuration

The FTDI module (FTDI232 or FTDI FT232RL) is a USB-to-serial converter used to program microcontrollers like the ESP32-CAM. It has six main pins, which are:

**1. Power Pins**

- VCC – Provides power output (can be 3.3V or 5V, depending on jumper settings).

- GND – Ground connection.

**2. Communication Pins**

- TX (Transmit) – Sends serial data from the FTDI module to the microcontroller (Connect to RX of the ESP32-CAM).
- RX (Receive) – Receives serial data from the microcontroller (Connect to TX of the ESP32-CAM).

**3. Control Pins**

- DTR (Data Terminal Ready) – Used for auto-reset while uploading code (Not always required but useful in some cases).
- CTS (Clear to Send) – Usually not used for basic ESP32-CAM programming.

### 4.1.4 JUMPER WIRES

Jumper wires are essential components in electronics, used to establish temporary connections between different parts of a circuit without soldering. They are commonly used in prototyping, testing, and developing electronic projects, making them a fundamental tool for hobbyists, students, and engineers. These wires are designed for easy insertion and removal, allowing users to modify circuits quickly without permanent changes.

There are three main types of jumper wires: male-to-male (M-M), male-to-female (M-F), and female-to-female (F-F). Male-to-male jumper wires have pins on both ends and are typically used to connect two female connectors, such as those on a breadboard or microcontroller. Male-to-female jumper wires have a pin on one end and a socket on the other, making them useful for connecting sensors or modules to microcontrollers. Female-to-female jumper wires have sockets on both ends and are often used to link components with male header pins.

Jumper wires are available in different lengths and colours, which help in organizing and differentiating connections in a circuit. They are flexible and reusable, making them ideal for rapid prototyping. Additionally, their low resistance ensures minimal signal loss, which is crucial for maintaining the integrity of electronic signals.

Figure 4.1.4. Jumper Wires

In your attendance system project, jumper wires play a crucial role in connecting various components such as the ESP32-CAM, Raspberry Pi, FTDI module, and display. They enable seamless communication between these parts, ensuring the proper functioning of the system without the need for permanent soldering.

### 4.1.5 HDMI CABLE

An HDMI (High-Definition Multimedia Interface) cable is a widely used digital connection standard that transmits high-quality audio and video signals between devices such as TVs, computers, gaming consoles, projectors, and more. Unlike older analog cables, HDMI supports high-definition (HD), Full HD (1080p), 4K, and even 8K resolutions while also carrying high-fidelity audio, including formats like Dolby Atmos and DTS:X. It eliminates the need for separate audio cables and offers features like CEC (Consumer Electronics Control), which allows devices to communicate and control each other, and ARC (Audio Return Channel) for sending audio back to soundbars or receivers without extra wiring. There are different types of HDMI cables, including Standard HDMI for basic HD content, High-Speed HDMI for 4K and 3D video, and Ultra High-Speed HDMI for 8K and high refresh rates. Additionally, compact versions like Mini and Micro HDMI are used in smaller devices such as cameras and Raspberry Pi boards. With its low latency and high bandwidth, HDMI is the preferred choice for modern multimedia connectivity, ensuring smooth and immersive audio-visual experiences.

Figure 4.1.5. HDMI Cable

### 4.1.6 LCD MONITOR

An LCD (Liquid Crystal Display) monitor is a flat-panel display that uses liquid crystal technology to produce images. Unlike older CRT monitors, LCD monitors are thin, lightweight, and energy-efficient, making them the standard choice for computers, TVs, and portable devices.

Figure 4.1.6. LCD Monitor

They work by blocking or allowing light to pass through liquid crystal molecules, which are illuminated by a backlight, usually LED, LCD monitors offer sharp visuals, high resolutions (HD, Full HD, 4K, and beyond), and better colour accuracy compared to traditional displays.

## 4.2 SOFTWARE IMPLEMENTATION

This project utilizes two main software tools: Arduino IDE and a Python IDE. The Arduino IDE is used to program the ESP32-CAM, enabling it to connect to Wi-Fi and stream live camera footage. The Python IDE is used to run face recognition scripts on a Raspberry Pi, using libraries like OpenCV and face recognition to detect faces and mark attendance in real-time. Together, these tools ensure smooth communication between hardware and software, enabling a contactless, automated attendance system.

### 4.2.1 ARDUINO IDE

The Arduino IDE (Integrated Development Environment) is an essential and powerful tool used in the development of this Modern Face Recognition Attendance System based on ESP32-CAM, OpenCV, and Raspberry Pi. In this project, the Arduino IDE serves as the main platform where the program logic for the ESP32-CAM module is written, compiled, and uploaded.


Figure 4.2.1 Arduino IDE

The code written in the Arduino IDE is responsible for initializing the ESP32-CAM hardware, setting up the camera resolution, establishing a Wi-Fi connection, capturing real-time images, and hosting a web server that streams the live camera feed. This makes the ESP32-CAM act as a standalone IoT camera device that can be accessed wirelessly over a local network.

The process begins with writing the code using Arduino-supported C/C++ syntax, which includes necessary libraries like <WiFi.h>, <WebServer.h>, and <esp32cam.h>. These libraries provide pre-built functions that simplify communication with the Wi-Fi network, setting up the web server, and handling camera configurations. Once the code is ready, the Arduino IDE allows the user to select the appropriate board settings, such as ESP32 Wrover Module, and choose the correct communication port through which the ESP32-CAM is connected via a USB-to-Serial converter (commonly using an FTDI programmer or CP2102 module). After successful configuration, the Arduino IDE compiles the code into machine-readable binary files and uploads it to the ESP32-CAM's microcontroller.

Another key feature of the Arduino IDE that plays a critical role in this project is the Serial Monitor, which is used for real-time debugging and status monitoring. When the ESP32-CAM is powered on, the serial monitor can display messages such as whether the camera has initialized correctly, if it is connected to Wi-Fi, or if image capture has failed or succeeded. This helps the developer quickly identify and troubleshoot any issues during the setup or runtime.

Once the ESP32-CAM is successfully programmed using the Arduino IDE, it begins operating independently. It connects to the configured Wi-Fi network and waits for incoming HTTP requests on specific endpoints such as /cam-lo.jpg, /cam-mid.jpg, or /cam-hi.jpg, which are mapped to different camera resolutions. When these endpoints are accessed from a browser or another device like a Raspberry Pi, the ESP32-CAM captures a live image, processes it, and sends it back as a JPEG stream through the web server. The Raspberry Pi, which runs OpenCV, receives these images and performs face detection and recognition algorithms, comparing the faces in the live stream with stored faces in its database. If a match is found, the system marks the attendance of the identified person, stores their details with a timestamp, and updates the attendance record in a CSV file.

In summary, the Arduino IDE is the development backbone that enables the ESP32-CAM to become a smart, camera-enabled IoT device. It allows for writing, debugging, compiling, and uploading the required code that enables wireless communication, live image capturing, and web server functionality. Without the Arduino IDE, setting up and programming the ESP32-CAM for this face recognition system would be highly complex. Therefore, it plays a crucial role in enabling real-time, contactless, and automated attendance tracking, forming the foundation of this modern, intelligent attendance system.

### 4.2.2 PYTHON IDE

The Python IDE plays a central role in the development and execution of the face recognition and attendance logging component of this Modern Face Recognition Attendance System. In this project, the Python IDE is used to write and run the Python script responsible for handling facial recognition, matching, and attendance management. The script integrates several powerful libraries, including OpenCV for image processing, face recognition for facial encoding and comparison, pandas for handling CSV files, and urllib for fetching image data from the ESP32-CAM via a live URL. The IDE allows developers to write the logic in an organized and modular way, with features like syntax highlighting, error detection, auto-completion, and terminal access, all of which streamline development.

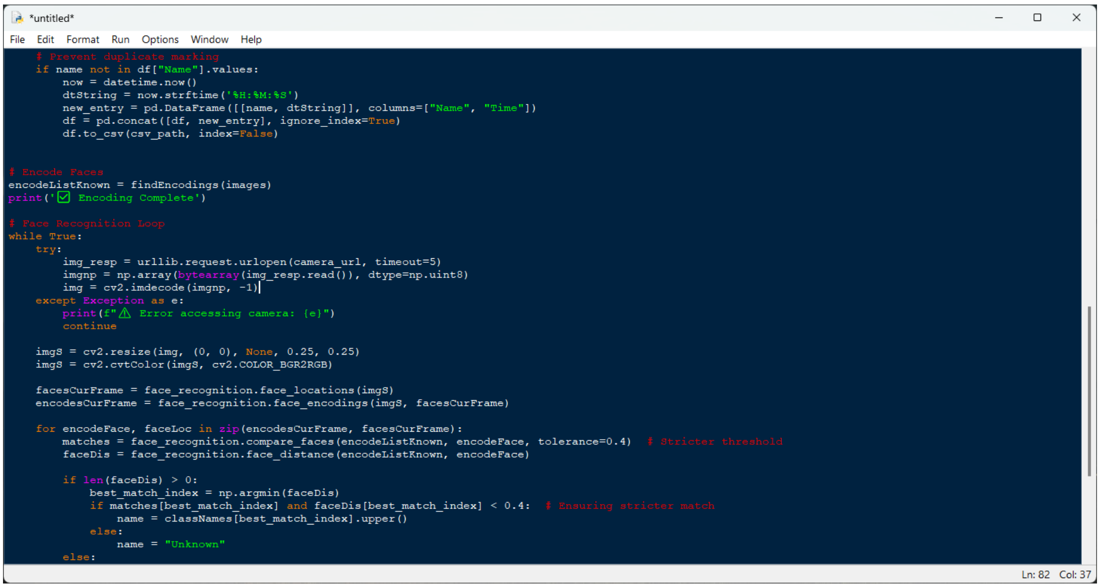


Figure 4.4.2 Python IDE

Once the ESP32-CAM is programmed and streaming a live camera feed over a local IP address, the Python program fetches this image stream continuously using the camera URL. Each image frame is processed by resizing and converting it to the RGB colour format, which is compatible with the face_recognition library. The Python code first loads and encodes pre-stored images from a dedicated folder, extracting unique facial features for each known individual. These encodings are stored in memory as reference data. During live operation, the Python program captures frames from the ESP32-CAM stream, detects faces in each frame, and compares them with the known encodings. If a match is found with high confidence (based on distance threshold), the system identifies the person and labels their face on the image in real-time using OpenCV’s drawing tools. The Python script then automatically logs the person’s name along with the exact time of recognition into a CSV file stored locally, ensuring that each individual is marked only once per session.

The Python IDE plays a pivotal role in the development and execution of this face recognition-based attendance system. It provides a robust and developer-friendly environment that supports real-time debugging, print logging, and seamless code editing, which are essential during the phases of testing, optimization, and troubleshooting. These features allow developers to fine-tune critical parameters such as face detection accuracy, recognition confidence thresholds, and ESP32-CAM connectivity settings with ease. The integrated terminal within the IDE enables direct execution of Python scripts, offering instant feedback in the form of logs, such as "Encoding Complete," verification of image folders, camera stream accessibility, and face match results.

In addition to real-time outputs, the Python program is equipped with comprehensive error handling mechanisms that gracefully manage unexpected issues like missing directories, corrupted CSV files, or interrupted camera streams. This minimizes the risk of system crashes and ensures reliable performance during both development and deployment stages. Moreover, Python’s simplicity and the modular structure of the code make it easy to iterate quickly—developers can test new features, update logic, or enhance recognition capabilities without the need to recompile firmware or reflash any hardware, significantly reducing development time.

In summary, the Python IDE acts as the central control hub for the entire face recognition and attendance logging process. It connects the hardware components with advanced AI-based facial recognition algorithms, processes real-time camera data from the ESP32-CAM, and ensures that attendance records are logged accurately and securely into a CSV file. This integration of hardware and software not only simplifies administrative tasks but also enhances reliability, scalability, and overall system intelligence. By enabling automation and real-time decision-making, the Python IDE contributes directly to the success of this smart, efficient, and contactless attendance system—showcasing the power of open-source tools in the development of modern AI and IoT-based applications.

# CHAPTER 5

## TIME AND COST ANALYSIS

### TIME ANALYSIS

| SL NO. | PROCESS | TIME (DAYS) |
|---|---|---|
| 1 | Idea Finalization | 15 Days |
| 2 | Component Selection | 6 Days |
| 3 | Hardware Assembly | 24 Days |
| 4 | Software Development | 6 Days |
| 5 | Testing and Debugging | 23 Days |
| 6 | Report Preparation | 21 Days |

Table 5.1 Time Analysis

## COST ANALYSIS

| SL NO. | COMPONENTS | COST (RS) |
|---|---|---|
| 1 | Raspberry Pi 3 Model B+ (x1) | ₹3,900 |
| 2 | ESP 32 CAMERA MODULE (x1) | ₹ 600 |
| 3 | FTDI MODULE (x1) | ₹ 150 |
| 4 | JUMPER CABLES (x20) | ₹ 25 |
| 5 | HDMI CABLE (x1) | ₹ 150 |
| TOTAL COST | | ₹ 4,825 |

Table 5.2 Cost Analysis

# CHAPTER 6

## ADVANTAGES

**1. Fully Automatic and Efficient:** This system automates attendance marking using face recognition, eliminating the need for manual entry or biometric scanning. The ESP32 camera continuously captures images, and the system identifies individuals in real time, ensuring a seamless and efficient process.

**2. Eliminates Proxy Attendance:** Traditional attendance methods, such as manual registers and RFID cards, are prone to proxy attendance (buddy punching). With face recognition technology, each individual is uniquely identified, making it impossible to mark attendance for someone else.

**3. Time-Saving and Convenient:** Unlike conventional methods, which require physical interaction (signing a register, swiping an ID card, or fingerprint scanning), this system quickly records attendance as soon as a person’s face is detected. This reduces waiting times and speeds up the attendance-taking process, especially in large institutions or workplaces.

**4. Minimal Hardware Requirement:** The system primarily relies on an ESP32 camera and a Raspberry Pi for processing, making it a cost-effective solution. It eliminates the need for expensive biometric scanners or RFID systems, reducing overall costs while maintaining high accuracy.

**5. Remote Monitoring and Data Storage:** Attendance records are stored digitally, allowing easy access, analysis, and integration with existing databases. Administrators can monitor attendance remotely, ensuring transparency and reducing the risk of data loss compared to traditional paper-based methods.

**6. Scalability and Flexibility:** The system can be expanded to support multiple locations and large numbers of users. It can be integrated with existing school, office, or organizational management software, making it a versatile solution adaptable to various environments.

# CHAPTER 7

## RESULT AND DISCUSSION

The Face Recognition-Based Attendance System has been successfully developed and tested, proving to be a reliable and efficient solution for automating attendance tracking. The system seamlessly integrates hardware and software components, utilizing the ESP32-CAM for capturing live images, OpenCV for image processing, and face_recognition libraries in Python for accurate face detection and recognition. The attendance data is stored digitally in a CSV file, ensuring a structured and tamper-proof record of attendance. This digital approach minimizes human intervention, reducing errors, preventing proxy attendance, and enhancing security in attendance tracking.

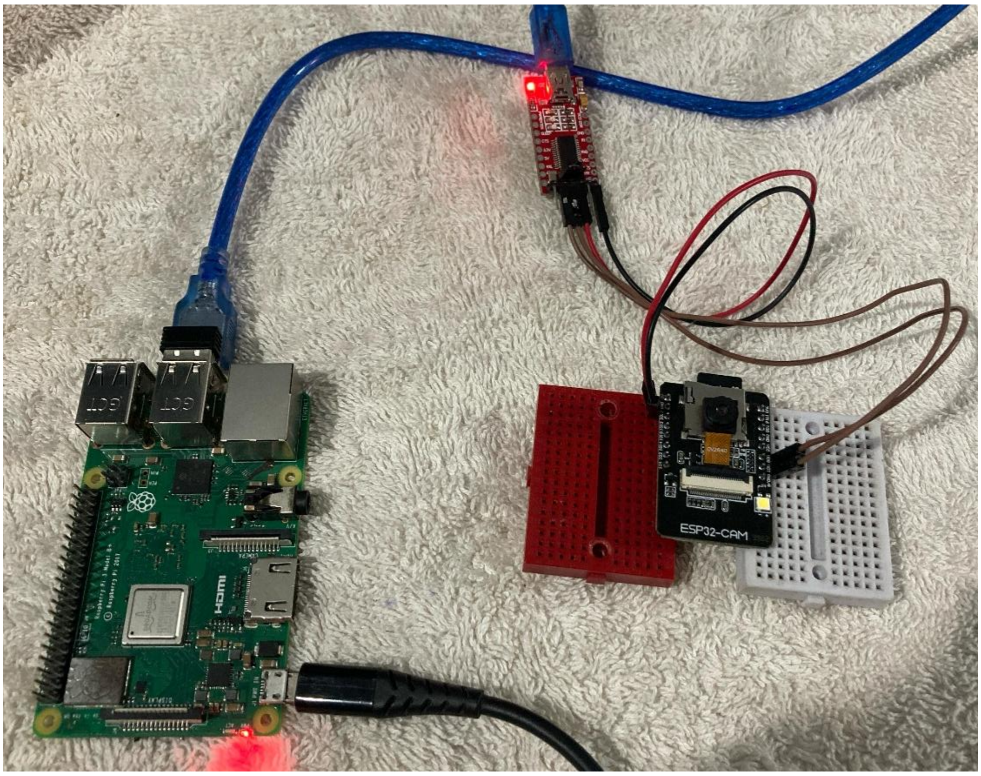


Figure 7.1 Image of Circuit

As demonstrated in the provided output image, the system effectively detects a person’s face in real time, processes it, and correctly identifies the individual by matching their facial features with a pre-stored dataset. The recognized individual’s name is displayed within a highlighted bounding box over their face, confirming successful identification. Simultaneously, the system records the attendance with a timestamp, ensuring that attendance is logged precisely without requiring manual input.

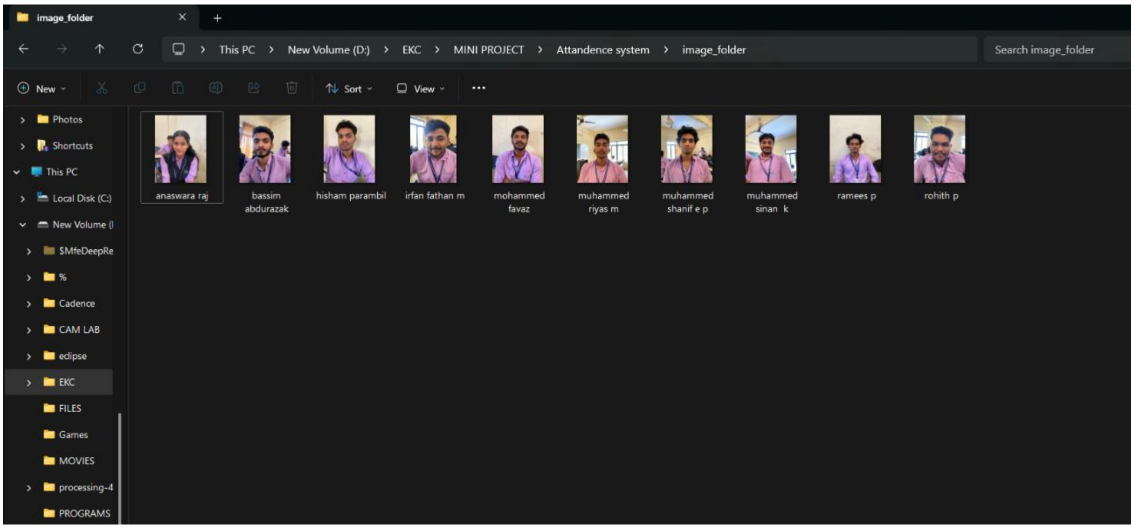


Figure 7.2 Face Enrollment

The recognized individual's name is displayed within a highlighted bounding box over their face, confirming successful identification. Simultaneously, the system records the attendance with a timestamp, ensuring that attendance is logged precisely without requiring manual input. The CSV file generated by the system maintains an accurate log of individuals present, which can be retrieved and analysed for future reference.

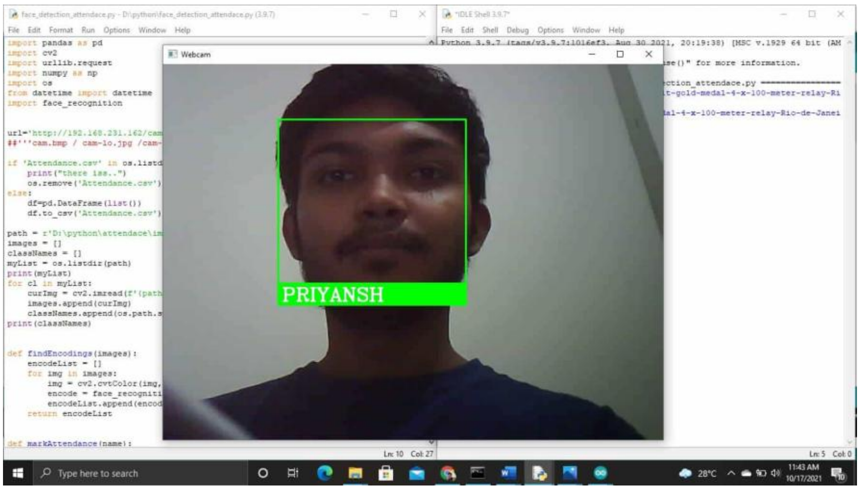


Figure 7.3 Output Window

The implementation has been thoroughly tested under different conditions, including varying lighting environments, different facial expressions, and minor changes in facial features The system has demonstrated a high level of reliability and accuracy, with minimal false positives or missed detections. Furthermore, to ensure robustness, error-handling mechanisms have been incorporated into the system. These include checks for corrupted or missing CSV files, validation of camera connectivity, and fallback methods in case of failures. Such features enhance the stability of the system, making it suitable for real-world applications in educational institutions, corporate offices, and secured environments.

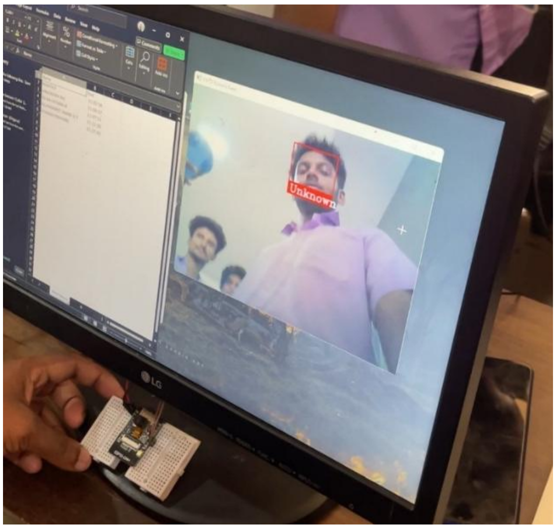


Figure 7.4 Detected Unknown


Figure 7.5 Recognizes Enrolled Identity

The Arduino IDE played a crucial role in configuring and programming the ESP32-CAM module, allowing seamless communication between the hardware and the software components. It facilitated easy code deployment, debugging, and real-time adjustments, ensuring the smooth operation of the camera module. Similarly, the Python IDE was instrumental in processing the captured images, performing facial recognition, and managing attendance records. The integrated terminal in Python allowed for real-time debugging, providing insights into the system’s performance, such as camera connection status, successful image processing, and recognition accuracy.

The successful execution of this project demonstrates the practical application of Artificial Intelligence (AI), Computer Vision, and IoT in automating daily administrative tasks. This contactless, real-time, and automated attendance system not only reduces human effort but also significantly improves efficiency and reliability. With the potential for further enhancements, such as cloud storage integration, mobile application support, and multi-face detection, this system can be scaled for large institutions, ensuring a more advanced and feature-rich attendance management system.

The visual output obtained during the testing phase of the Face Recognition-Based Attendance System effectively showcases its successful real-time performance and overall functionality. As illustrated in the provided image, the system captures a live video stream using the ESP32-CAM module and processes it with Python-based face recognition algorithms. The system accurately identifies the individual in front of the camera as their name by comparing the captured facial features with pre-stored images in the dataset. Upon successful recognition, it outlines the detected face with a green bounding box and overlays the name on the screen, providing a clear visual confirmation. At the same time, the system logs the name along with a timestamp in a CSV file, which acts as a digital attendance sheet. This ensures real-time, automatic attendance marking without any manual intervention, making the system both efficient and reliable.

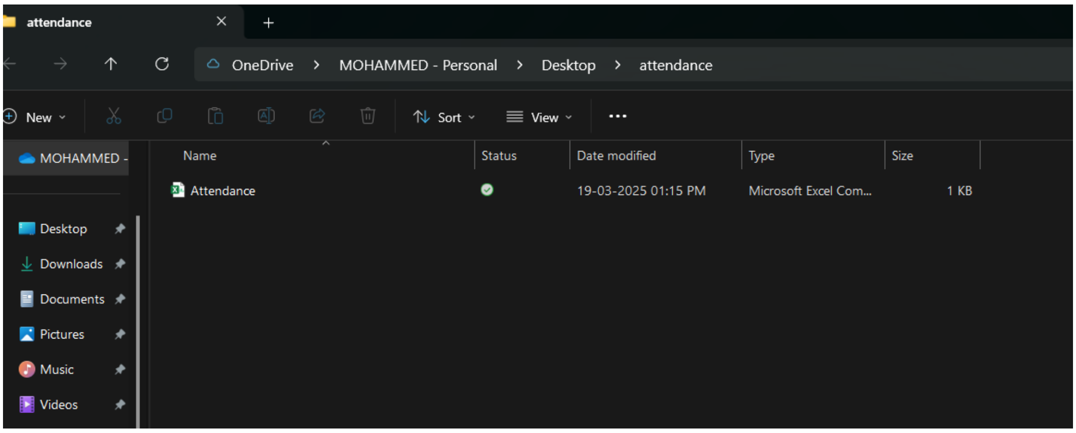


Figure 7.6 Generated CSV File

In addition to recognizing registered users, one of the system's standout features is its ability to detect and label unfamiliar faces as "Unknown." When a person who is not present in the image database appears before the camera, the system processes the face and, upon failing to find a match, displays the label "Unknown" with a red bounding box. This functionality adds a significant layer of security and ensures that no unauthorized or unregistered individuals can falsely be marked as present. It helps maintain the integrity of the attendance records and alerts administrators to potential anomalies.

This face recognition-based attendance system is designed to operate with high threshold values to ensure greater accuracy and reliability during the face matching process. By setting a stricter tolerance level in the face comparison algorithm, the system minimizes the chances of false positives and ensures that only closely matching facial features are accepted as valid. This approach is especially important in environments where precise identification is crucial, such as schools, offices, or secure facilities. Using high threshold values helps the system distinguish between similar-looking individuals and ensures that only authorized or pre-registered faces are marked present. While this may slightly reduce the flexibility in recognizing faces under extreme lighting or angle variations, it significantly enhances the overall security and integrity of the attendance data.

| A | B | C |
|---|---|---|
| NAME | TIME | |
| BASSIM ABDURAZAK | 13:09:37 | |
| MUHAMMED RIYAS M | 13:09:40 | |
| MUHAMMED SINAN K | 13:09:41 | |
| HISHAM PARAMBIL | 13:09:49 | |
| MUHAMMED SHANIF E P | 13:09:58 | |
| ANASWARA RAJ | 13:10:06 | |
| ROHITH P | 13:10:37 | |
| MOHAMMED FAVAZ | 13:15:02 | |
| | | |

Figure 7.7 Attendance & Time marked in CSV File

This output is a clear demonstration of the seamless integration of hardware (ESP32-CAM) and software (Python with OpenCV and face recognition libraries), proving that the system can perform under real-world conditions with both accuracy and speed. The generation of a time-stamped, tamper-proof CSV file as evidence of attendance further adds to the system's practicality and usefulness in institutional environments like schools, colleges, and offices. The intuitive interface, robust performance, and automated detection of both known and unknown individuals make this project a scalable and future-ready solution for contactless attendance monitoring.

# CHAPTER 8

## FUTURE SCOPE AND CONCLUSION

### FUTURE SCOPE

i. AI & Deep Learning:

Advanced face recognition models powered by deep learning can significantly improve accuracy by adapting to variations in lighting, angles, and facial changes over time. Implementing these models will enhance the system’s reliability.

i. Edge AI & IoT:

By leveraging on-device processing, the system can perform real-time face recognition without relying on external servers. This ensures faster processing, reduces latency, and allows offline functionality, making it more efficient and independent.

ii. Cloud Integration:

Integrating cloud services will enable remote access to attendance records and real-time data storage. This allows administrators to monitor attendance from anywhere and ensures secure, scalable data management.

iii. Enhanced Security:

Liveness detection techniques, such as motion analysis and depth sensing, can prevent spoofing attempts using photos or videos. This adds an extra layer of security, making the system more robust against fraudulent entries.

iv. Industry Applications:

The system can be widely implemented in offices, schools, factories, and smart cities for seamless and automated attendance tracking. Its adaptability makes it suitable for various industries, improving efficiency and security in workforce and access management.

## CONCLUSION

The Face Recognition-Based Attendance System is an innovative and efficient solution that modernizes traditional attendance tracking through the integration of cutting-edge technologies. By combining the ESP32-CAM module, OpenCV, and a Raspberry Pi, the system is capable of capturing, analysing, and identifying facial features in real-time, ensuring highly accurate and automated attendance logging. The use of the Arduino IDE for embedded programming and Python for face recognition and data handling brings versatility, ease of development, and powerful functionality to the overall system.

This smart attendance solution significantly reduces manual effort, eliminates the risk of proxy attendance, and enhances the security, accuracy, and transparency of attendance records. Furthermore, the system operates in a contactless manner, making it ideal for environments where hygiene and social distancing are important. Its low-cost components and modular design make it scalable and adaptable for various use cases, from schools and colleges to offices and institutions.

With the potential for future upgrades such as cloud integration, mobile app support, and multi-camera networking, this project demonstrates a practical and impactful application of IoT and computer vision technologies. It not only streamlines attendance processes but also showcases how modern technology can be leveraged to solve everyday problems in a smarter, more automated way.

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