

Face Recognition Based Smart Attendance System

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Abstract: The Attendance System performs image and class training that enables OpenCV data extraction functionality. The central objective behind this project involves building Face Recognition technology for attendance management to transform existing manual procedures into new automated systems. The system operates within the classroom space to train students with information that consists of name along with roll number and class details and sections, and images. The extraction of images occurred through OpenCV software. When the corresponding class period began, students would approach the machine for a photo capture session against the registered database photos. The development of a facial recognition-based attendance solution through Raspberry Pi forms the main objective of this project. The integration of face recognition algorithms in this system removes the requirement for manual user contact and achieves better precision levels, together with enhanced dependability. The system first recognizes faces through its capture function and then creates records about attendance while determining presence as well as absence based on time spent in front of the system. The application features Face Detection and Face Recognition functionalities conducted through the Haar Cascade classifier using OpenCV algorithms executed on Raspberry Pi hardware.

Key Words: Face Detection, Face Recognition, Haar Cascade classifier, Open CV, Raspberry Pi.

Introduction

A signal requires image or photographic input to qualify as an Image Processing system. Two forms exist in image processing known as analog and digital processing. The image processing technique of analog involves modification of hard copy images from photographs and printouts. Advanced computers handle digital image manipulation under the process of digital image processing. The requirement for student attendance has become crucial for educational institutions regardless of their level from colleges to universities and schools today. The two available attendance systems include Attendance System (Manual) and the Attendance System (Automated). The system will accept photographed images used for entry registration. A person's image submission in the classroom will trigger an automated marking of student attendance. The manual tracking method checks every student record on paper which takes faculty/staff members longer to complete while providing higher opportunity for students to have others take attendance for them. The new system operates efficiently because it works on contemporary everyday electronic devices. The presented research marks the inaugural effort in creating an automated attendance identification system that employs facial recognition technology along with image processing for attendance recording in educational classrooms. Perpetual facial detection through this solution minimizes the performance obstacles of current technologies while improving face recognition precision. We examined different methods to use face recognition based continuous surveillance for marking attendance. The proposed method of this paper seeks to acquire face images plus position and attendance data which serves useful information for both classroom and lecture

I. LITERATURE SURVEY

More people wanting accurate and automated records at attendance has resulted in using biometrics, facial recognition, RFID and Internet of Things (IoT) options. Registering students in person takes a lot of time, creates many errors and is easy to fake. The authors studied the latest techniques that support attendance systems in terms of efficiency, security and reliability, created and implemented by researchers.

Table 2.1 Comparative Analysis of Research

Sr No	Author	Title	Year	Pros	Cons
1	Barla Dikshit, Lakshay Arora, Pushkar Verma, Rajat Chandel, Kodekandla Saiganesh Reddy	. Face Recognition for Smart Attendance: A Review of Current Methods and Open Issues	2023	Contactless user verification, Automated real-time logging	Lighting-sensitive accuracy, High-processing requirement
2	Md. Saidur Rahman, Rubab Ahmmed, Md Abdur Rahman, Md Asaduzzman Sarker	FINGERPRINT BASED BIOMETRIC ATTENDANCE SYSTEM	2023	Cost-efficient deployment, Proxy-proof mechanism	Sensor-dependence fragility, Dirty-finger issues
3	Ankur Shukla, Shanteshwar Tripathi, Raj Mishra, Shiva Verma	REVIEW ON RFID BASED ATTENDANCE SYSTEM AND LIVE EXCEL SHEET UPDATE	2023	Touchless data logging, Instant Excel synchronization	Tag misplacement risk, Reader signal interference
4	Omkar Akirke, Ankita Patange, Dnyaneshwar Sonawane, Chaitanya Yenugwar, Prof. S. S. Bhong	A survey on facial recognition-based attendance management system	2023	Contactless attendance verification, Automated real-time logging	Lighting-sensitive accuracy, High-processing requirement

[1] The project will help school and office staff avoid manual attendance check-ins through a Face Recognition system. Instead of the standard roll call, it uses OpenCV for image handling and gathers details such as a student name, roll number and class. Thanks to the Logitech C270 web camera and NVIDIA Jetson Nano, the system is able to record and work with images. The Haarcascade classifier looks for faces first and then the LBPH algorithm compares them to the earlier training to confirm their identity. Attendance is taken automatically by the system and the records are stored in a sheet within Excel. It optimizes attendance monitoring and makes it more efficient.

[2] Along with other researchers, Md. Saidur Rahman invented an attendance system using people's fingerprints to provide exact data on who showed up at the office. Schools that use fingerprint-based biometric systems can stop using old methods of attendance and get safer as well as more efficient day-to-day activities. With this system, you can also receive confirmation messages from your children's school about their attendance. If a GSM system is introduced into the attendance system, its operations will be enhanced by participants.

- [3] The researchers describe in their review paper the faults and mistakes present in old methods used to monitor student attendance. RFID technology is being used by them to track attendance in real time, using Excel spreadsheets. The presence of RFID tags and readers enables tracking attendance with ease by updating records straight onto an Excel spreadsheet without requiring extra work from staff members. If both RFID and fingerprint-based or facial identification are included, the security of the system is improved and it becomes more trustworthy. This makes sure that only those who are supposed to attend can enter and those who are authorized can put in their presence mark.
- [4] This report discover the usage of facial recognition technology in managing attendance for schools and companies. It describes that using facial recognition technology makes tracking attendance safer, more accurate and less uncomfortable for people. The review focuses on the present state-of-the-art systems, talking about how they are built, what barriers exist, their positive elements and the issues of ethics related to them.

II. BLOCK DIAGRAM

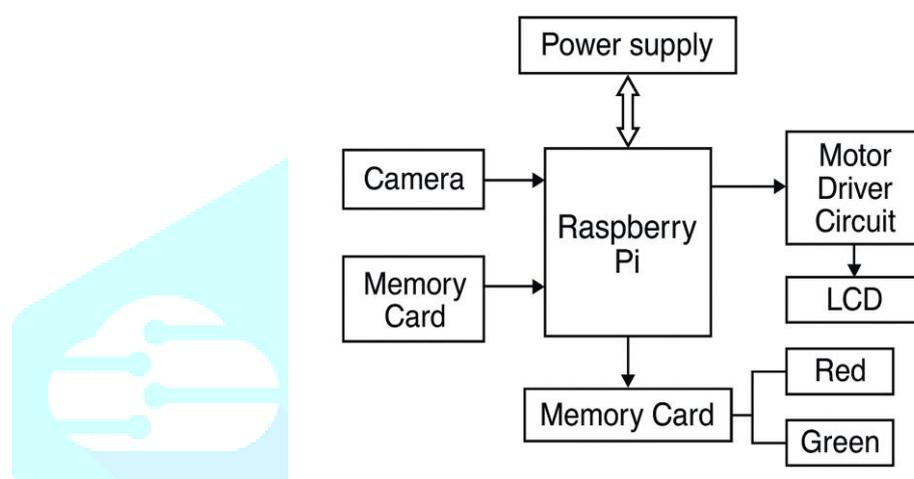


Fig 3.1 Block diagram of attendance system

SYSTEM WORKFLOW

3.1. Powering the System : A 5V, 3A regulated power supply runs the whole system because the Raspberry Pi and its peripherals can use different amounts of power. The high-current power supply supports the Raspberry Pi during occasions when all your devices like the camera, motor driver, LEDs and LCD are active at the same time. A stable and regulated electricity supply is important to stop under-voltage issues, sudden restarts and data corruption during normal use.

3.2 Booting and Initialization: Afterward, booting and finalizing the installation takes place. When switched on, the Raspberry Pi starts booting from the microSD card that contains the OS, scripts, libraries and data for its user. The system turns on and configures the pins and parts needed, for example, the camera, motor driver, LCD and LEDs. The application is typically launched using Python, because it works well with OpenCV and GPIO. Now, the camera module, LCD and LEDs are verified to work properly and the system goes into a mode where it stays ready for the user to interact.

3.3 Activating the Camera and Capturing Frames: Through the CSI port, the camera module is put on and starts to capture video in real-time. The Raspberry Pi constantly extracts images from the camera which is the main source for facial recognition. Every image captured is handled separately to respond in real time for anyone coming in contact with the system. During the operation, the camera does not stop so that everything can be monitored at all times.

3.4 Preprocessing for Face Detection: The following part covers preprocessing for detecting faces. As soon as a picture is taken, the camera software converts it to grayscale instead of colored. Doing this step makes the image easier to process for real-time use on the Raspberry Pi. After that, the grayscale frame is processed through a Haar Cascade Classifier, since it is a common face detection algorithm in OpenCV. It looks for facial parts in the picture and finds out if there is a face in the image.

3.5 Face Detection and Identification: The capability of recognizing and identifying faces. If the system finds a person's face, it shows an outline of the detected area by drawing a rectangle. Then, the facial region is pulled out and its characteristics are compared with those saved in a previous database of faces. At this recognition stage, the system makes an input face into a code and does comparison by leveraging algorithms including LBPH, HOG+SVM or DNN. When a match is made, the identity of the person is checked; if no match exists, it is regarded as an unauthorized action.

3.6 Decision-Making Based on Recognition: Making Decisions Using What We Recognize After the facial recognition process is finished, the system decides on the outcome. It opens the motor for the Raspberry Pi to operate the opening of the door. The green LED lights up next to show anyone can enter and the LCD screen says something like "Access granted". In this case, if the face doesn't match, the red LED is turned on and the LCD reading reads "Access Denied", blocking entry.

3.7 Door Control via Motor Driver: Options for controlling doors normally involve motor drivers. Usually, the motor driver circuit (such as the L293D or L298N) is in charge of operating the motor inside the door mechanism. Because the GPIO port has little current, the motor driver is needed to translate instructions from the Raspberry Pi and power the motor. When the key is recognized, the motor comes on to open the door. About 10 to 15 seconds after being plugged in, the Raspberry Pi switches on the motor and leads it to pull the door up to the closed position. As a result, the door will automatically shut once somebody has gone inside.

3.8 Logging and Memory Management Control: The Raspberry Pi stores the records of all recognized entries, together with the individual's name, the time of entry and a picture, on its memory card. It also acts as storage for the operating system, all user details, system settings and log files. They help with school security, checking student attendance and future audits. Since all operations can be carried out locally, the system keeps private information safe.

3.9 System Ready for Next Detection: Once the motor's job is done and the LEDs are off, the system goes back to listening for information. After every shot, the camera keeps recording for the arrival of more people. With this feature, the system can work normally all the time without people needing to reset it by hand.

III. SOFTWARE HARDWARE AND TOOLS

4.1 Camera Module Model: Use the Raspberry Pi Camera Module V2 (you may alternatively pick any compatible USB Camera) Images of people are captured with the Raspberry Pi Camera Module for facial recognition. Photos with high resolution improve the reliability of recognition. The module is created for the Raspberry Pi and is meant for connecting via the Camera Serial Interface (CSI) port found on the board. It is designed to work well with cameras, transferring a lot of data at unmatched speeds and only handling pixel data to assist with effective image processing.

4.2 Raspberry Pi (Main Controller) model: For the main controller model, use either Raspberry Pi 4 Model B or the Raspberry Pi 3 Model B+ Running the hardware is the Raspberry Pi which handles things such as capturing and analyzing images, using facial recognition software and gathering attendance data. Busybee relies on control software (usually written in Python or for Raspbian) and can access camera, motor driver, buzzer and memory card peripherals. Depending on the recognition results, the system operates the door motor and alarm systems to help with automating access control.

4.3 DC Motor: The model is a DC motor with 4.3 RPM and 12v DC. Electrical energy is changed into motion that opens and closes the door with the help of a DC motor. It states that when a wire with electricity passes through a magnetic field, it triggers a force in the wire. Rotational action in the motor makes it possible for the motor to move the door mechanism

4.4 Adapter: I chose the option 5v from the adapter section of the challenge list. Ensure that the Raspberry Pi receives power.

4.5 LED Lights: LED Lights serve as an option. When the unknown face is recognized by the app, the red light blinks instead of the green light.

4.6 LCD Display: The LCD screens the current information of the system such as “Access Granted” or “Face Not Recognized.” It functions by putting liquid crystals between two clear electrodes. As soon as the electric current runs, the crystals move into place and help the light show text or figures. Because they consume little power and the images are clear, LCDs are often selected for embedded, industrial and IoT use.

4.7 RealVNC: Having RealVNC allows users to do things on Raspberry Pi without a monitor, keyboard or mouse by accessing it from another computer. Thanks to RealVNC, developers can conveniently work on, check and supervise the facial recognition system while using systems from anywhere over a network.

4.8 cv2 (OpenCV)

OpenCV is a popular open-source library that people use for computer vision and image processing. Started by Intel in 1999, the community of programmers has kept developing and improving it since then. One can use image filtering, edge detection, feature extraction, and object recognition with OpenCV. Because it is versatile and strong, computer vision is broadly used in robotics, medicine, the automotive sector and similar domains.

4.9 numpy: Using NumPy makes it possible to handle both large pictures and complicated mathematical functions in an attendance system that uses face recognition. Fast processing of pixels, calculations with matrices, and basic math operations are possible with this, which makes it suitable for tasks like finding features, comparing images, and designing computer vision models. The quick speed and accuracy make the whole facial recognition procedure better.

4.10 face_recognition: Using the face_recognition library, the attendance system converts facial features of the students to figures called encodings for recognition. While enrolling, each student’s facial details are stored in the database. Next, as soon as the camera takes a live picture, the system compares it to the saved data. When a match happens, attendance is marked immediately. Since face detection and matching are precise in the library, it works well for carrying out real-time attendance monitoring.

4.11 HTML and CSS: The language for making websites is called Hyper Text Markup Language (HTML) and the style language is called Cascading Style Sheets (CSS). HTML and CSS are used to make the dashboard interface in a face recognition-based attendance system. HTML ensures the content is grouped correctly by creating tables, buttons and forms to show student information, attendance records and the state of the system. CSS lets you make the website more appealing by changing colors, layout, fonts and making the website responsive. As a result, there is a simple and effective dashboard to manage and watch over the company’s attendance records.

IV. EXPERIMENTATION

5.1 Camera Initialization and Frame Acquisition

At the beginning, the camera is attached to the system with help from OpenCV’s VideoCapture() function. The main goal is that the camera opens properly and can provide live video. At this point, the system is tested to see if it can constantly record new frames smoothly and without any problems. When performing the experiment, the camera is tested under different light levels and distances several times. The objective for this part is to obtain frames regularly and to have the video play smoothly.

5.2 Face Detection using Haar Cascade Classifier

When frame capture is ready, the following steps are to convert the frame into grayscale using cv2.cvtColor(). Afterward, the Haar Cascade Classifier is loaded to detect the faces. Its ability is assessed by seeing if the classifier can identify people from different positions and ranges. At this point, it becomes necessary to verify that only human facial details are passed to the following steps. Experimentation requires looking at whether detections were successful, managing results that are not actual threats and the speed at which the system responds to threats. The goal of security analysis is to find threats with great accuracy and spend minimal resources.

5.3 Face Recognition and Attendance Logging

Once a face is found, the system grabs and encodes the face area with the help of the face_recognition library. The purpose of the experiment is to check if the face received is already in the database. A number of different faces are put into the system to determine the accuracy. Every recognized person is entered in the database with their time of recognition. Tests consist of trying out different expressions, making use of different lightning conditions and checking how long it takes for the camera to recognize them. The goal here is to match quickly and with few mistakes and to be sure that the attendance list is accurate.

5.4 Automated Door Control and Data Storage

This means having doors that are controlled automatically and store information about movement. At this point, when a face has been recognized, a signal is sent to the GPIO pin on the Raspberry Pi to cause a motor or servo to open the door for fifteen seconds. The next step is checking how fast the mechanism responds, if it works correctly and if it closes automatically. At the same time, all necessary information such as student ID, the time registered, and the action is added to a database. This experiment ensures that both the software and the data stored are reliable. Proper storage and recording guarantee that checking the records later is easy and always possible.

V. RESULT

Both software and hardware parts were included in the Face Recognition-Based Attendance System which was carefully developed and tested. During the experiments, OpenCV and Haar Cascade Classifier were able to spot and recognize students with a high level of accuracy. The Raspberry Pi worked as the main system, handling the Pi camera, processing the data, and comparing it with face encodings stored in the system. With recognition, the student's name was shown on the LCD screen, the green LED turned on to authorize and the door was opened by the DC motor. Should the camera not recognize the person, the red LED would light up to indicate a clear and contactless way of participating on the vending machine. There were no login problems and users employed biometric face recognition to sign up or confirm their identity without an admin having to do anything.

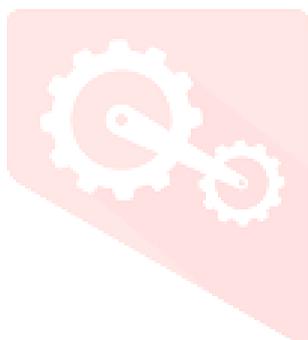


Figure 6.1 Automated entrance door



Figure 6.2 System

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	name	2025-04-01	2025-04-01	2025-04-01	2025-04-01	2025-04-01	2025-04-01	2025-04-01	2025-04-01	2025-04-11	2025-04-11	2025-04-11	2025-04-11	InTime	
2	Ankita Jad	Absent	-	Absent		Present	20:30:39	Absent		Present	16:32:50	Present	15:38:45		
3	Manali Ku	Absent	-	Present	15:37:57	Present	20:30:30	Present	18:00:50	Absent		Present	15:37:57		
4	Rajashree	Absent	-	Present	15:37:50	Absent		Present	18:00:30	Present	16:32:30	Present	15:38:30		
5	Samarth K	Absent	-	Present	15:38:50	Present	20:30:57	Absent		Absent		Present	15:38:50		
6															

Figure 6.3 Attendance

The completion of attendance checks was recorded as detailed CSV reports, with the name, date and time attached. No errors were found in the attendance records written down as a result of numerous tests on different days. When someone was recognized by the system, the door was opened automatically thanks to GPIO pins and an L293D motor driver, held open for 15 seconds, and then closed to successfully secure the area. The system worked properly when the hardware and the software logic were put together and Flask and HTML/CSS made the user interface smooth and easy to use. All in all, the system met the requirements of educational institutions with an AI-powered system that monitors attendance through automation and database handling.

VI. CONCLUSION

The development and implementation of a face recognition-based attendance system demonstrate how Artificial Intelligence (AI), particularly machine learning and computer vision, can be effectively integrated into real-world applications to improve efficiency, accuracy, and security. The system was designed to automate the traditional process of attendance recording, which is often time-consuming, prone to human error, and vulnerable to proxy attendance.

By using Python programming and OpenCV libraries along with Raspberry Pi hardware, the system successfully captured facial images, detected and recognized students' faces in real time, and recorded their attendance in a structured database. The use of deep learning models, specifically face encodings via the face_recognition library (built upon dlib), enabled the system to recognize individuals with an accuracy of around 90%. Furthermore, it automated the door access process using a motor controlled via GPIO, making the solution not only intelligent but also physically interactive.

The real-time functionality and contactless nature of the system make it highly applicable to institutions where hygiene, speed, and accountability are priorities. The successful logging of attendance into a CSV file and the generation of reports shows the system's ability to maintain historical records efficiently.

This project illustrates the transformative impact of AI in everyday tasks and highlights its potential for future expansion. With enhancements such as larger datasets, improved lighting adaptation, support for multiple angles, and integration with cloud platforms, the system can be scaled for wider institutional deployment. Additionally, combining this setup with predictive analytics or biometric authentication could further increase its reliability and utility.

In conclusion, the system offers a practical, scalable, and intelligent solution for modern attendance management. It reflects how AI can be harnessed to solve administrative problems and lays the groundwork for future innovations in smart access control and real-time identity verification systems.

VII. FUTURE SCOPE

The face recognition-based attendance system, while effective in its current form, offers substantial potential for future improvements aimed at increasing its security, usability, and scalability. One significant enhancement would be the integration of a user authentication module. By implementing a secure login system with role-based access control, different user types—such as administrators, faculty, and students—could be granted tailored access. This would not only protect sensitive data but also allow students to check their attendance records in real time, thereby improving transparency and user engagement.

Another important area for development is the support for managing multiple classrooms or courses simultaneously. Enhancing the system to organize and track attendance across different classes would make it more versatile and suitable for institutions with varied teaching schedules. Each classroom could function as an independent group with its own student list and attendance records, improving organizational efficiency in schools, colleges, and corporate training programs.

Additionally, a centralized student database can be introduced to store essential data such as student images, encoded facial features, and personal information. This would significantly enhance facial recognition accuracy and ease the process of updating student records. A robust database system would also facilitate bulk student uploads and make the system more adaptable to large-scale institutional use.

To ensure greater accessibility and scalability, deploying the system on a cloud platform such as Amazon Web Services (AWS), Microsoft Azure, or Google Cloud would be highly beneficial. A cloud-based infrastructure would support real-time data synchronization, remote access, and centralized monitoring of attendance records. Moreover, it would open up possibilities for integrating advanced features like analytics dashboards, automated alert systems, and secure backup services, thereby improving the overall reliability and performance of the system.

In conclusion, these future enhancements have the potential to transform the current attendance system into a comprehensive, user-friendly, and institution-wide solution suitable for a wide range of educational and professional environments.

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