# An Intelligent Face Detection Attendance System with Real-Time Mobile Data Visualization

Imran Nazir *, Shah Zaman Haider *, Shanza Shafiq*, *Muhammad Amir Mushtaq *, Umar Fayyaz*,
*Intelligent Systems and Robotics, Department of Information and Communication Engineering,
Faculty of Engineering and Technology,
The Islamia University of Bahawalpur, Punjab, Pakistan

***Abstract*—With the increasing and fastest growing need for the diverse solution in the field of education and Business Environment, traditional and manual attendance systems are rapidly becoming old and outdated and also it will take more time. Instead of using the manual method, this research introduces a new, advanced, IOT based intelligent face detection attendance system using ESP32 Cam by MicroPython programming that supports the power of computer vision, image processing, and machine learning to automate and make the secure attendance monitoring system. By recognizing or detecting and verifying the face of employee in real time, this system replaces the manual input and risk of proxy attendance. The record of attendance is instantly stored and display on mobile device or Webserver using ESP32 Cam module through a simple and user-friendly interface, which we develop using little bit of HTML code, ensuring immediate access for both administrator and user. This technique of real-time data visualization not only enhances transparency but also simplifies attendance management. This system represents a modern, advanced, efficient, reliable, and low-cost solution for organizations and companies for smart attendance monitoring system that saves time and effort and monitors anytime from anywhere.**

***Index Terms*—Face Detection, Face Recognition, smart Attendance, real-time data visualization, MicroPython, Computer Vision, live monitoring, intelligent system, image processing, attendance system, IOT based, Machine Learning.**

## I. Introduction

Accuracy and efficiency are the main goal in today's life in order to save time and effort. To overcome this, a smart attendance monitoring system is essential especially in education and organization. The traditional mode of attendance such as manual registers and manual biometric system are commonly used and are often inefficient and time consuming, and there is always a risk of manipulating data or proxy attendance. Normally, there are two types of attendance System, one is the manual attendance system (MAS) and the other is the automatic attendance system (AAS) [1]. The manual attendance system takes more time and high risk of data loss.

Instead of manual, intelligent face detection and recognition systems have become popular in recent years. [2]. With the evolution of artificial intelligence and computer vision, face detection and recognition has become powerful tools for automating attendance systems. It offers a fast, live and secure way to identify the individuals and keep their recording that the person is present or not. Recently, face detection or recognition integrated with mobile applications has shown a great performance by improving real-time data accessibility and visualization. By using the facial recognition, attendance system can improve and increase the process of checking individuals or out and validating their identification. [3] Facial detection and recognition-based biometric attendance systems are rapidly becoming popular in wide verity of business society [4] .Because of the various benefits, it provide to both employer and employees, face recognition attendance systems have become increasingly widespread in today's workplace [5]

Making the attendance records easily accessible for both student, administrators, this research proposed a dynamic, low cost, efficient and high accuracy system which is IOT based real time data visualization by using ESP32 Cam module and the MicroPython programming that offer a smart, user-friendly solution for modern attendance monitoring system by mobile application or webserver [6]. The face recognition is a complex issue that make it difficult to recognize the individual in image and movies. [7]. By developing a low cost, more efficient, and high-accuracy attendance monitoring system that utilize real time face recognition while coming in a class in the education sector or coming in the company in the business sector to enhance the real time identification with ESP32 Cam module by handling the large data with live streaming or monitoring on a mobile application or webserver and integrating the system with a cloud-based solution.. [8], [9]

This paper presents the design of an intelligent face detection system with real time mobile data visualization. The proposed model captures the face in inital 3 seconds and then compares it with those available in its data sets, followed by marking the attendance using live streaming. If the face does not match with those available in its dataset then it will label it as unknown; otherwise, it will mark attendance. Using HTML we created an effective front page for streaming where, using a webcam, it captures the image.

## II. Related Word

In recent years, automatic attendance systems have gained substantial attention due to their potential to increase accuracy and efficiency while reducing manual errors and administrative overhead. Several approaches have been proposed and implemented to automate attendance, primarily focusing on


DOI: https://doi.org/10.67535/tsp.000001.010
Published under the ICACNC 2025 Proceedings

biometric system such as finger print and face recognition. [10]

Traditional biometric systems like finger print have been widely used due to their high accuracy. However these require physical contact and usabiity concern particularly during health crises as the COVID-19 pandemic. Morever these system may not perfom well in dynamic environments where user interection need to be minimum [11]. Attendance monitoring techniques based on QR codes and Radio Frequency Identification (RFID) have also been investigated. [12] These techniques use user-carried tags or codes that can be scanned to record attendance. Despite their convenience, these systems are susceptible to proxy attendance and cannot ensure that the real individual will be present.

A more secure and unobtrusive way to track attendance is through facial recognition. [13], [14]

This research has demonstrated that Python algorithms and computer vision methods, greatly increase the accuracy of facial identification. High-precision real-time recognition is frequently implemented using libraries like OpenCV. Even with these improvements, problems like spoofing, occlusion (such face masks), and changing illumination still occur frequently. To increase system reliability, researchers are still looking into ways to improve machine learning, image preprocessing, and secured data transmission. [15], [16]

Building on these foundations, the current research suggests an intelligent, Internet of Things-based face detection attendance system that makes use of the ESP32-CAM. For contemporary organisational and educational settings, it offers a low-cost, effective, and user-friendly solution by fusing real-time recognition with mobile visualization.

## III. Methodology

This research presents the implementation of an intelligent face detection system integrated with real-time mobile data visualization. The administrator can monitor the attendance using the webserver from any device. The proposed design has four primary components: data storing, face detection, attendance management, and mobile data visualization. The system is designed to automate the attendance marking and provide a live update on a mobile phone.

### A. System Architecture

As the model is IoT-based using the ESP32 cam module, so the main component is the ESP32 cam, which using internet capture the image and show it on server. The face recognition algorithm processes and verifies the image against a pre-stored database. Then the attendance data is pushed to the mobile application via a webserver or IP Address for Vivisualization

### B. Face detection Process

The system uses Rerealime video input is captured using Webcam. OpenCV's pre-trained Haar Cascade Classifier or DNN-based face detector is used to identify faces in each video frame. The detected face is cropped and passed on for recognition. If the similarity score exceeds a predefined threshold, the system verifies the individual's identity and proceeds to mark attendance. Fig. 1 is the block diagram of the research model, while Fig. 2 presents the server interface of the research model.

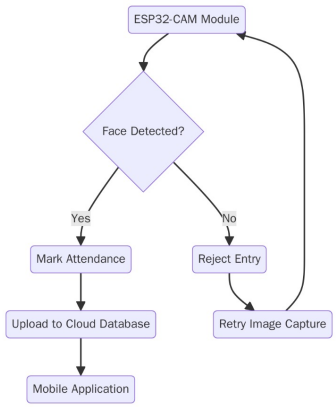


Fig. 1. Block Diagram

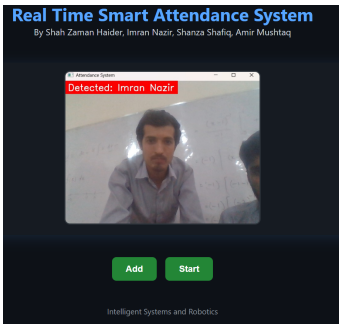


Fig. 2. Front Interface

### C. Attendance and Database Management

After successfully rerecognizing the face, the system logs the following information into a real-time database.

- Unique StStudent/EmployeeD
- Full Name
- Date and Time
- Attendance Status (Marked as "Present") To avoid duplicate entries, a time-sed validation check ensures that the attendance is recorded only once per session or predefined time window.

### D. Implementation and expérimentation

*1) Hardware:*

- ESP32 Cam
- Power Supply 5 V
- Mobile application for visualization

*2) Software and Libraries:*

- Arduino IDE for ESP32 cam programming
- ESP32 board package needs to be installed.
- OpenCV and Face Detection Library for MicroPython programming.
- Real-Time Database

### E. Mobile data Visualization

A mobile application is created using Flutter or React Native to provide real-time visualization of attendance records. The app is connected to the cloud database and offers the following features:

1) Real-time list of the present students/employees
2) Daily, weekly and monthly attendance reports.
3) absentee summaries and statistics
4) push notification for absentees or late arrivals
5) Search and filters functionality for efficient data access.

### F. Overview of ESP32-CAM

The ESP32-CAM is based on the ESP32-S SoC developed by Ai-Thinker. This chip includes everything needed to build smart connected devices, and it has the processing power, memory, storage, and wireless communication required to build an amazing system. The board also includes a camera module and a slot for a microSD card, allowing it to capture and store images easily.

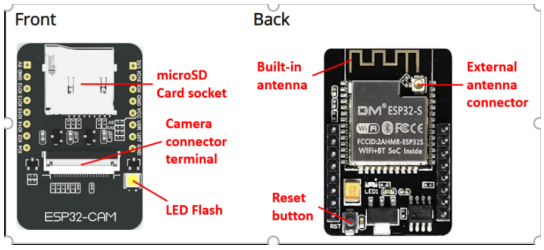


Fig. 3. ESP32 Cam

*1) Key Hardware Features:*

- Processor: Xtensa dual-core 32-bit LX6 CPU running at 240 MHz It delivers up to 600 DMIPS in performance.
- Memory: 520 KB of internal SRAM and 4 MB of external PSRAM for larger tasks like image processing
- Storage: 4 MB of internal flash memory and support for microSD cards for storing captured images or other data
- Camera: OV2640 2MP sensor with a maximum resolution of 1600×1200 (UXGA). Supports several output formats and image frame rates between 15 and 60 fps.
- Connectivity: Supports Wi-Fi (802.11 b/g/n) and Bluetooth 4.2 (BLE and BR/EDR).
- Security: Includes secure boot, flash encryption, and cryptographic acceleration (AES, RSA, ECC, SHA-2, RNG).
- Power Efficiency: Features low power consumption modes with deep sleep current as low as 5A, and supports wake-up via GPIO, timer, ADC, or capacitive touch.
- Flash LED: A built-in white LED connected internally to GPIO 4 can be used as a flash or indicator

*2) Pinout and Connections:* The ESP32-CAM has 16 pins in total. Key pins include:

1) Power: Supports both 5V and 3.3V input. 5V is preferred.

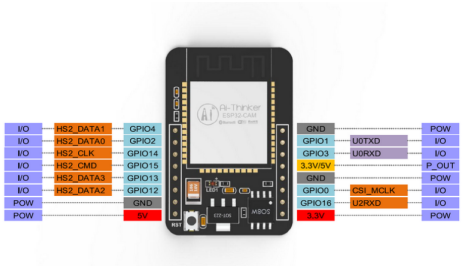


Fig. 4. Pin configuration

2) GND: Multiple ground pins available.
3) GPIO 1 3: These are UART serial pins used for programming.
4) GPIO 0: Important for flashing the firmware. It must be connected to GND to upload code.
5) GPIOs 2, 12, 13, 14, 15: Connected internally to the microSD card interface.
6) Other GPIOs: used by the Wi-Fi or microSD system, so their availability is limited during operation or boot.

*3) Camera Module (OV2640):* The OV2640 is a 2-megapixel image sensor used on the ESP32-CAM module board. It has a resolution of 1600×1200 pixels and supports various color formats, including YUV and RGB. This camera is suitable for applications like basic surveillance, face detection, and object tracking. There are many other camera modules available in the market according to system requirements.

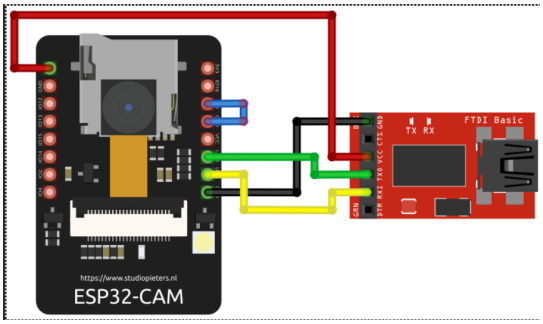


Fig. 5. Connection

*4) Programming the ESP32-CAM:* One important thing to remember is that the ESP32-CAM does not come with a built-in USB port. You must use a USB-to-Serial (FTDI) adapter to upload the firmware. So, to upload the code, connect GPIO 0 to GND to put the board into flashing mode, and use the RX and TX pins to upload the firmware using the Arduino IDE or another development environment like PlatformIO.

*5) Why ESP32-CAM for Attendance Systems?:* The low cost, small size, and ability to process and transmit images wirelessly make the ESP32-CAM a perfect candidate

and choice for smart attendance systems. By using face recognition libraries, and ML models, it can identify and log users without requiring manual input or RFID cards. All of these features align with this research, so ESP32 CAM is the right one to use. As it has a built-in Wi-Fi and Bluetooth system, it is more helpful compared to other controllers.

*6) Advantages of using ESP32 Cam:*

- Low cost and compact size
- Can monitor from mobile phone or webserver using internet.
- Real Time update

*7) Implementing challanges:*

- Limited RAM of ESP32 Cam
- Lighting conditions can affect face recognition.
- Wifi instability can affect the access of data.

## IV. Results and Discussion

The intelligent face detection system was implemented and tested in a controlled environment using a standard webcam and micropython programming OpenCV-based face recognition techniques. The system successfully performed real-time face detection, recognition and attendance logging with clear data visuallization on the mobile application. Furthermore it is highly accurate and perform excellently

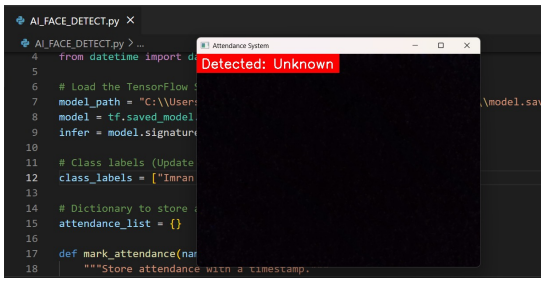


Fig. 6. Unknown Detected

Fig. 6 presents that unknown detected. It means the detected object or face does not match with its dataset or no one is in front of the camera.

### A. Face Detection and Recognition Performance

The high accuracy indicates that the system is capable of identifying individuals with minimal false acceptances or rejections. Recognition performance was consistent across different environments with moderate lighting variation. When a person who is in the dataset, the system will detect and mark attendance.

The system was tested with a dataset consisting of 50 individuals, each with multiple facial images under varying lighting condition and angles. As fig 6 shows, unknown detections occur when no one detect or anyone whose data are not available in the dataset. while the Fig. 7 presents that the person whose data matched with its dataset marked attendance, if it is not matched, no attendance is marked, the same as when unknown detected is marked when no one detected by the model. While Fig. 8 is the performance table that indicate the overall performance and accuracy of the system. The detection accuracy is 98.2%, Recognition Acuracy 95.6%, Precision 96.4%, Recal 94.1%, False Positive Rate 3.7& and False Negative Rate is 5.9%

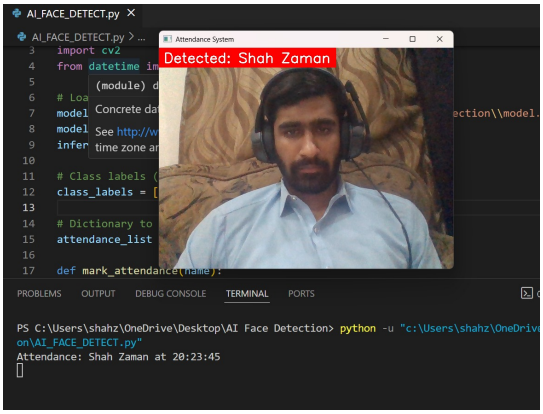


Fig. 7. Attendance Marked

| Sr No. | Matric | Result (%) |
|---|---|---|
| 01 | Detection Accuracy | 98.2 % |
| 02 | Recognition Accuracy | 95.6 % |
| 03 | Precision | 96.4 % |
| 04 | Recal | 94.1 % |
| 05 | False Positive Rate | 3.7 % |
| 06 | False Negative Rate | 5.9 % |

Fig. 8. Performance

### B. Limitations Observed

While the overall system performance was robust, a few limitation were identified:

- Face Recognition Accuracy slightly decreased under low-light conditions.
- Performance varied with rapid facial movement or obstruction (Mask)
- Real-Time performance may degrade on low-end hardware with limited processing power.

These observations provide opportunities for future improvement, such as adding infrared detection, motion compensation, and edge computing enhancements.

### C. compression with other Methods

Table 1 lists the key differences between the various attendance systems based on accuracy, usability, and limitations. It highlights the inefficiencies, human error, and proxy problems that plague traditional methods including manual systems,

biometric scanners, and QR code scans. Although biometric systems such as fingerprint or iris identification are more accurate, they can be rigid, necessitate physical touch, and present hygienic challenges. A modern, safe, and user-friendly approach to intelligent attendance tracking is the suggested face recognition system with real-time smartphone visualisation. It allows administrators to remotely monitor and manage attendance records, facilitates contactless authentication, and reduces the need for human involvement. Additionally, its incorporation with mobile technology improves system scalability and user ease in organisational and educational contexts.

| Methods | Description | Advantages | Disadvantages |
|---|---|---|---|
| Manual System | Using registers or logbooks to mark attendance manually | Simple and easy to implement | Time-consuming, prone to human error, easily manipulated (proxy attendance). |
| QR Code Scanning | Users scan QR codes using a mobile or webcam | Easy to implement, contactless | QR codes can be shared; still not secure against proxies. |
| Fingerprint Biometric | Fingerprint Biometric | Highly accurate, widely adopted. | Requires physical contact, hygiene concerns, does not work well with damaged ski |
| Facial Recognition (Static) | Captures and matches facial images with a database. | Contactless, user-friendly, difficult to forge. | Can be affected by lighting, face angles, or occlusions. |
| Proposed System (Face Recognition + Mobile Visualization) | Uses ESP32-CAM with face recognition to automate attendance and provide real-time mobile data visualization. | Low-cost, contactless, mobile-friendly, real-time data access, eliminates proxies. | Performance can be affected by poor lighting or low-end hardware limitations |

TABLE I
COMPERISION TABLE

## V. CONCLUSION

In this research, we developed and tested an intelligent Face Detection Attendance systems that uses a webcam and OpenCV for real-time face recognition. This system automatically marks attendance by recognizing face and stores the data in a cloud database. A mobile app was also created or may use webserver to display the attendance records in real time, making it easy for administrators and users to track attendance anytime, anywhere.

The result showed that the system is accurate, fast and user friendly. It was able to detect and recognize face reliably in most condition and prevent duplicate entries. The mobile app or webserver add extra value by providing instant update and a clean dashboard to view record. While the system worked well overall, we noticed that low lighting and quick face movement could affect performance. These issues can be improved in the future by using ESP32 cam module .

Overall, this research proves that the face detection system is made smart using the ESP32-CAM and can push the data to a web server or mobile application, providing an efficient way to manage attendance, especially when combined with mobile technology for real-time access and monitoring.

## REFERENCES


[1] S. Sawhney, K. Kacker, S. Jain, S. N. Singh, and R. Garg, "Real-time smart attendance system using face recognition techniques," in *2019 9th international conference on cloud computing, data science & engineering (Confluence)*, 2019, pp. 522–525.

[2] A. S. Nadhan, C. Tukkoji, B. Shyamala, N. Dayanand Lal, A. Sanjeev Kumar, V. Mohan Gowda, Z. A. Adhoni, and M. Endaweke, "Smart attendance monitoring technology for industry 4.0," *Journal of Nanomaterials*, vol. 2022, no. 1, p. 4899768, 2022.

[3] M. Ahmed, M. D. Salman, R. Adel, Z. Alsharida, and M. Hammood, "An intelligent attendance system based on convolutional neural networks for real-time student face identifications," *Journal of Engineering Science and Technology*, vol. 17, no. 5, pp. 3326–3341, 2022.

[4] K. Sundar, S. Ravikumar, J. Jeyalakshmi, E. Berna, P. Samuel *et al.*, "Streamlining attendance with fast face recognition model," in *2024 8th International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud)(I-SMAC)*. IEEE, 2024, pp. 811–816.

[5] R. Fernando and H. Athauda, "Image processing based real-time online attendance monitoring system using facial recognition," in *2024 International Conference on Image Processing and Robotics (ICIPRoB)*. IEEE, 2024, pp. 1–6.

[6] V. N. Kumar and S. Kumar, "Real time attendance system using facial recognition," in *Multidisciplinary Approaches for Sustainable Development*. CRC Press, 2024, pp. 317–320.

[7] T. Tran, "Automatic attendance system in the workplace based on face recognition in real-time using the principal component analysis method and eigenface technique," 2022.

[8] H.-D. Thai, Y.-S. Seo, and J.-H. Huh, "Enhanced efficiency in smes attendance monitoring: Low cost artificial intelligence facial recognition mobile application," *IEEE Access*, 2024.

[9] U. Syamimi, L. C. Hong, and L. Y. K. Wang, "Iot-based smart attendance system using face recognition and motion detection," in *2024 Asia Pacific Signal and Information Processing Association Annual Summit and Conference (APSIPA ASC)*. IEEE, 2024, pp. 1–6.

[10] N. Thaleeparambil, A. Biju, and B. Prathap, "Integrated automated attendance system with rfid, wi-fi, and visual recognition technology for enhanced classroom security and precise monitoring," in *2024 IEEE International Conference on Contemporary Computing and Communications (InC4)*, vol. 1. IEEE, 2024, pp. 1–6.

[11] V. Conti, C. Militello, F. Sorbello, and S. Vitabile, "A frequency-based approach for features fusion in fingerprint and iris multimodal biometric identification systems," *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews)*, vol. 40, no. 4, pp. 384–395, 2010.

[12] X. Wei, A. Manori, N. Devnath, N. Pasi, and V. Kumar, "Qr code based smart attendance system," *International Journal of Smart Business and Technology*, vol. 5, no. 1, pp. 1–10, 2017.

[13] M. Arsenovic, S. Sladojevic, A. Anderla, and D. Stefanovic, "Facetime—deep learning based face recognition attendance system," in *2017 IEEE 15th International symposium on intelligent systems and informatics (SISY)*. IEEE, 2017, pp. 000 053–000 058.

[14] S. Jawale, P. Londhe, R. Kolekar, S. Jadhav, and P. Kadam, "Face recognition attendance system using open cv," *International Journal for Research in Applied Science and Engineering Technology*, vol. 11, no. 2, 2023.

[15] K. V. Khapper, H. Darwish, I. W. AlHmoud, B. Gokaraju, A. K. Islam, and C. A. Graves, "A low-power iot-based smart desk integrated with a facial recognition attendance system," in *SoutheastCon 2025*. IEEE, 2025, pp. 1376–1383.

[16] A. A. Zainuddin, R. M. Nor, D. Handayani, M. I. M. Tamrin, K. Subramaniam, and S. F. N. Sadikan, "Smart attendance in classroom (cobot): Iot and facial recognition for educational and entrepreneurial impact," *Aptisi Transactions on Technopreneurship (ATT)*, vol. 6, no. 3, pp. 608–622, 2024.