DESIGN AND İMPLEMENTATİON OF FACE ATTENDANCE RECOGNITION SYSTEM USING ESP 32 CAM

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Abstract: Face based attendance system captures and recognizes the faces of the individuals, for recording or marking of an attendance by using face biometrics based on high definition monitor video and other information technology. Currently, needs for an accurate and efficient methods of tracking attendance without relying on traditional manual systems, which are time-consuming, error-prone, and susceptible to manipulation have been improved recently. Different existing works have been carried out on the recognition of distinct sets of face features, but this work validate the face features detected and compared with the stored face features that can operate in lighting conditions and log data in real time to a cloud-based Google Sheets. The method employed ESP32-CAM for capturing images and performing face detection and recognition using a model trained with Edge Impulse. The system successfully sent the recognized face's identities, along with the timestamp, to the pre-configured Google Sheet. This automated process ensured real-time attendance tracking. It was observed that 100% of the recognized faces were correctly logged into the Google Sheet and with, average time taken of 20 seconds with minimal variation. The system achieved detection accuracy of 83% in well-light conditions and 58% at low-light conditions. The results indicate that the ESP32-CAM, combined with Edge Impulse, is effective for face recognition in most environments. However, the drop-in accuracy under low-light conditions suggests the need for further model training or hardware enhancements, such as adding infrared sensors for better performance in low-light environments.

Keywords: Attendance System, ESP 32 CAM, Face Recognition, Edge Impulse

Introduction

Face based attendance system captures and recognizes the faces of the individuals for recording attendance by using face biometrics based on high-definition monitor video and other information technology. In a face-based attendance system, the computer system will be able to find and recognize human faces fast and precisely in images or videos that are being captured through a surveillance camera (Al-amoudi *et al*., 2022; Alhanaee et al., 2021). It helps in the conversion of the frames of the video into images so that the face of the individuals can be easily recognized for their attendance (Damale & Bageshree., 2018.). The database of the attendance can be easily reflected automatically with the continuous development of technology, the demand for safety and security (Chandu *et al.*,2016; Dhanasekaran *et al.*, 2020). Face recognition is considered to be one of the most successful applications of image analysis and processing (Wu *et al.,* 2021; Adetunji *et al*., 2023; Adetunji *et al.,* 2021; Olaniyan *et al*.,2023; Ibitoye *et al.,* 2023). Maintaining the attendance is very important in all the institutes for checking the presence of student. The face recognition approach is for the automatic attendance of students in the classroom environment without student's intervention. This attendance is recorded by using a camera attached in the classroom which captures images of students, detect the faces in images and compare the detected faces with the student database and mark the attendance (Rahaman *et al*., 2021; Al-amoudi *et al*., 2022; Karuna *et al*., 2023). The facial recognition process can be divided into two main stages: processing before detection where face detection and alignment take place (localization and normalization), and afterwards recognition occur through feature extraction and matching steps (Soundrapandiyan *et al*., 2016; Singh *et al*., 2022). Every institute has its own method to keep record of attendance of students. Some are taking attendance manually using the traditional pen and paper or file-based approach but marking attendance a lengthy process and demand more time and effort. These afore mentioned inefficiencies result to errors, especially for lecture with huge number of students. Different steps are involved in face recognition system, the first case is to acquire and detect the face of real time environment followed by the face recognition. The first method is achieved by using Camera to acquire the images of the students, then the acquired face is extracted using Principal Component Analysis (PCA) and compared with the stored data of every student. In this way faces of students are verified one by one with the face database, find out the result and attendance are marked. Different approaches have been engaged for the facial attendance recognition and detection. Three different Machine learning Algorithms namely Support Vector Machine (SVM), Multilayer Perception (MLP) and Convolutional Neural Network were adopted for the face attendance recognition system by (Al-amoudi; 2022). Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) were first applied for the extraction (algorithms) of facial features. Convolutional Neural Network (CNN) outperformed other algorithms (SVM & MLP) with testing accuracy on self-generated data. Support Vector Machine and Multilayer Perception have testing accuracy of 87% and 86.5% respectively. Deep Learning Model was adopted by (Damale *et al*., 2018; Alhanaee *et al*., 2021) for the vision face attendance monitoring system and smart attendance face recognition system. Recognition accuracy of 74% while compared with real time surveillance system (Alhanaee et al., 2021). Three networks Convolutional Neural Networks employed, which are AlexNet, SqueezeNet and GoogleNet generated validation accuracy of 100%, 98.33% and 93.33% respectively (Alhanaee et al., 2021). Deep Learning approach was also adopted by (Al-amoudi et al.,

2022) for the automatic face attendance system. The system generated 87.03% for face recognition and 100% face detection. Haar Cascade classifier and Convolutional Neural Network (CNN) was applied for face detection and features extraction respectively by (Joshi et al., 2023). Ten different faces were tested with an accuracy of 85% and 95% for Local Binary Pattern Histogram (LBPH) algorithm and Convolutional Neural Networks respectively (Joshi et al., 2023). This current work validates the performance of the developed neural network for face recognition, by deploying into the ESP 32 Camera for real life assessment. Haar Cascade Classifier and the Local Binary Pattern Histogram Technique are employed for the face recognition system by (Joshi et al., 2024).The system has approximately 80% when three to five students were presented. Facial recognition attendance base system was developed by (Ajayi et al., 2025). The developed system was evaluated using False Acceptance Rate (FAR) and False Rejection Rate (FRR) of 0% and 5% respectively.

Materials and Method

This work is based on the validation of the comparison of the stored facial attendance of the set of samples with respect to the facial recognition attendance through the use of ESP 32- CAM module under well light and low light conditions. The methodology provides a detailed description of the research design, data collection, system design, and the procedures followed during the execution of the work. The developed system compared the facial features detected and

validated facial features recognized as depicted in the Fig. 2. The system architecture involves the
Google Sheets for storing attendance records. The ESP32-CAM is the core component responsible for capturing facial images. It is equipped with a
camera and Wi-Fi connectivity, making it suitable for IoT applications. The first step where the system scans the environment to locate and detect.
faces within a given frame (such as from a camera feed). The system uses algorithms to identify areas in an image or video that likely contain a face. Once a face is detected, the system analyses the facial features. This involves extracting and processing key facial characteristics, such as the distance between the eyes, the shape of the cheekbones, the contour of the lips, and the length of the jawline. integration of the ESP32-CAM module, a microcontroller, a face recognition algorithm, and processing key facial characteristics, such as the distance between the eyes, the shape of the cheekbones, the contour of the lips, and the length of the jawline.The analysed data is converted into a digital format, often as a unique facial signature or template that can be used for matching. In this step, the system compares the analysed facial data against a list of stored facial templates to identify or verify the individual. If the system finds a match, it identifies the person by cross-referencing the facial data with the corresponding identity stored in a Google Sheet. After identifying the person, the system automatically records their attendance. The system logs the time and date, along with the person's identity, into a Google Sheet. This sheet acts as the attendance record and can be accessed later for reporting and tracking purposes.

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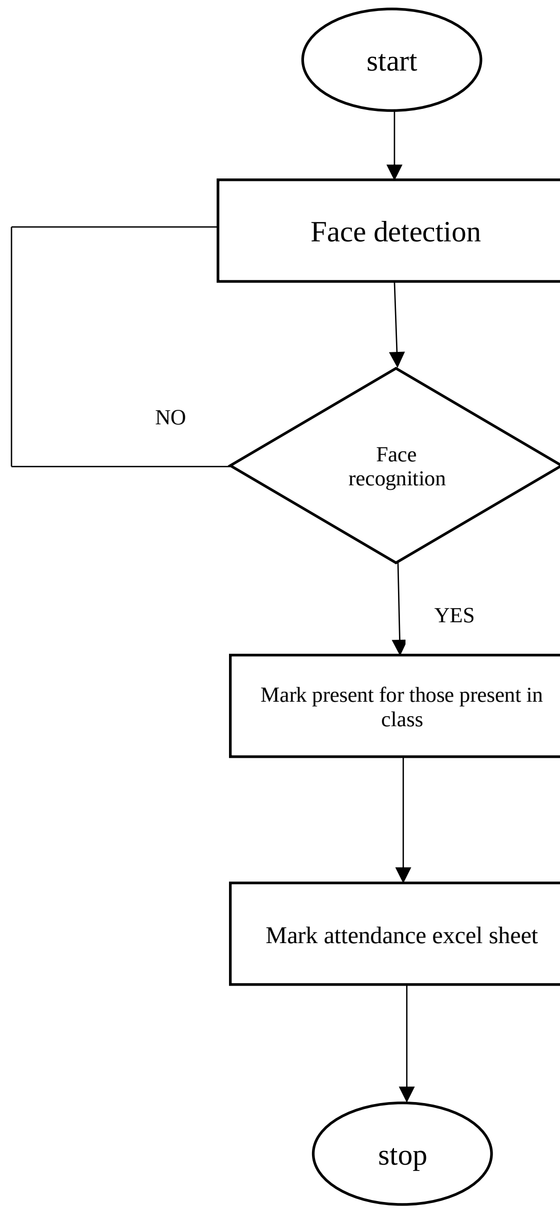

Fig. 1: Block Diagram of the Proposed System

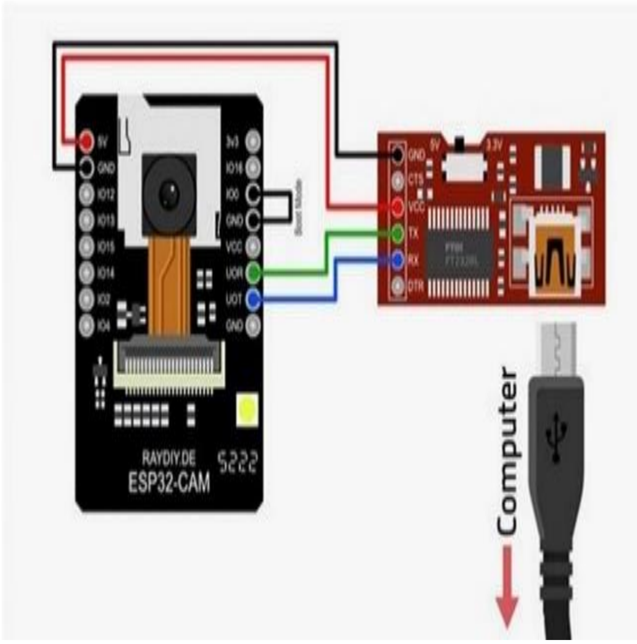

Fig. 2: Diagrammatical Representation of connection between ESP32-CAM and FTDI module

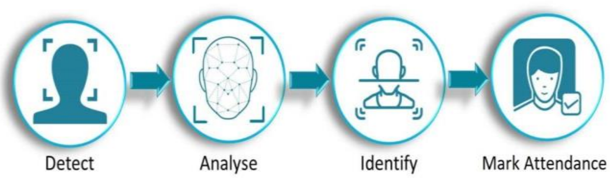

Fig. 3: Operations going on ESP 32 CAM (For Marking Attendance)

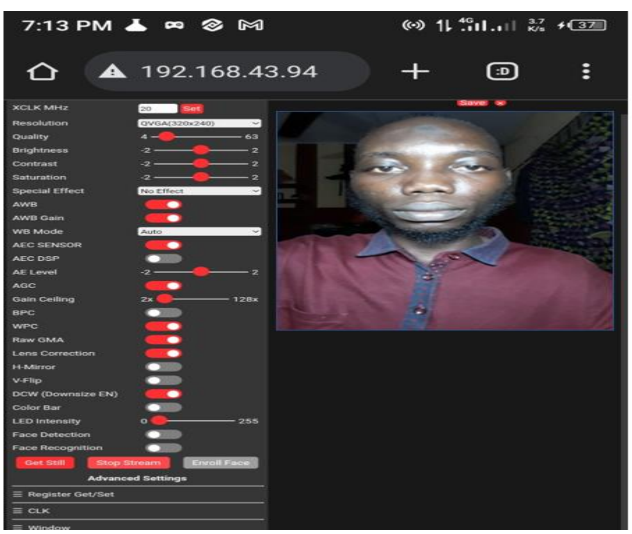

Fig. 4: Testing the ESP 32 CAM Module

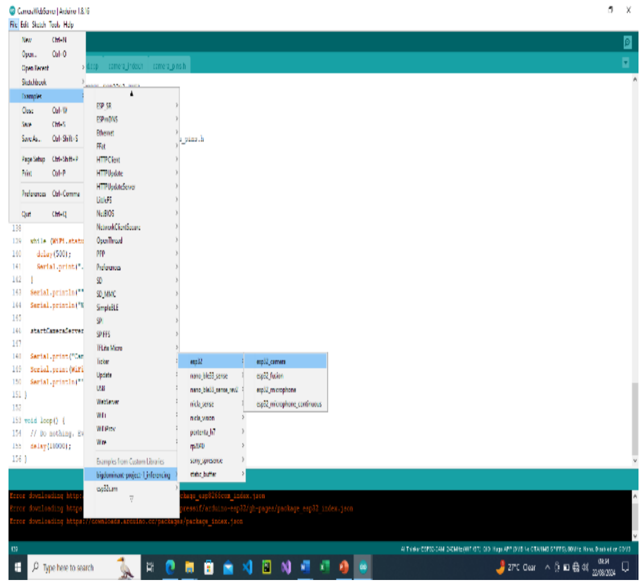

Fig 5: Importing the EDGE IMPULSE FILE ON Arduino IDE

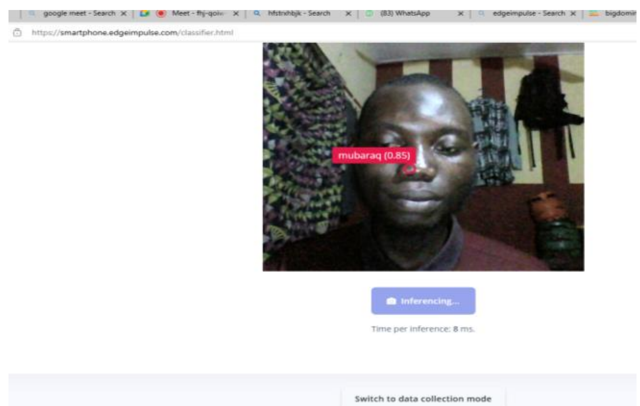

Fig. 6: Model Testing in Edge Impulse

After identifying the person, the system automatically records their attendance. the system logs the date, name and time, into an attendance record. this digital record can be accessed later for reporting and tracking purposes. The system is designed to be used by educational institutions. For testing purposes, a sample of 1 student was selected. The sample was chosen using purposive sampling, targeting individuals available during

the testing periods. Facial images of the sample population were collected using the ESP32-CAM module. student face was captured multiple times to create a robust dataset for training the face recognition model. The collected facial data was uploaded to Edge Impulse, where a machine learning model was trained for face recognition. The training process involved labelling the images with unique name and utilizing Edge Impulse's platform to optimize the model for deployment on the ESP32-CAM. The facial recognition model was trained on Edge Impulse, where various metrics like accuracy, precision, and recall were used to evaluate the model's performance. Once optimized, the model was deployed onto the ESP32-CAM for real-time face recognition. The ESP32-CAM was programmed and connected to a local Wi-Fi network.

The system was powered using a USB connection, and the module was configured to communicate with a remote server.

Results and Discussion

The system successfully sent the recognized face's identity, along with the timestamp, to the pre-configured Google Sheet. This automated process ensured real-time attendance tracking. It was observed that 100% of the recognized faces were correctly logged into the Google Sheet and with, average time taken of 20 seconds with minimal variation. The system achieved average detection accuracy of 83% in well light conditions and 58% at low-light conditions. The results indicate that the ESP32-CAM, combined with Edge Impulse, is effective for face recognition in most environments. However, the drop-in accuracy under low-light conditions suggests the need for further model training or hardware enhancements, such as adding infrared sensors for better performance in low-light environments.

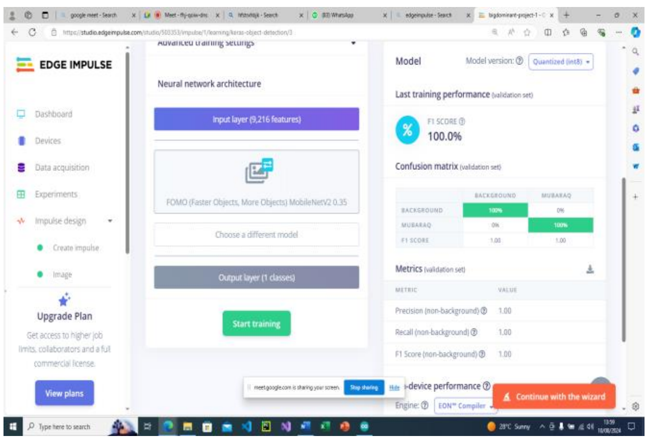

Fig. 7: Edge Impulse data visualisation

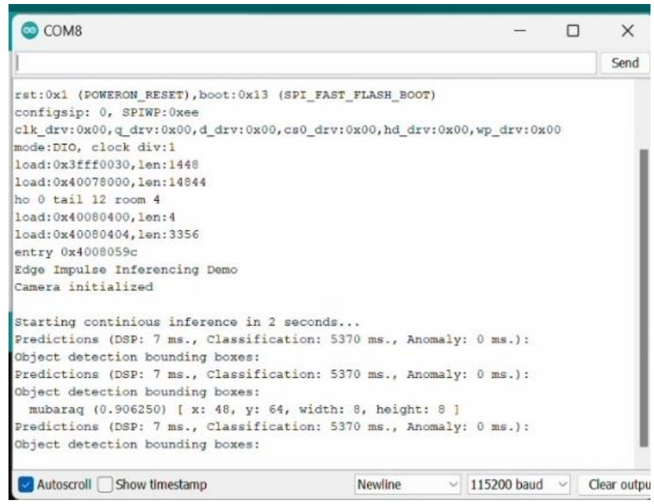

Fig. 8: Response from the Integrated GoogleSheet

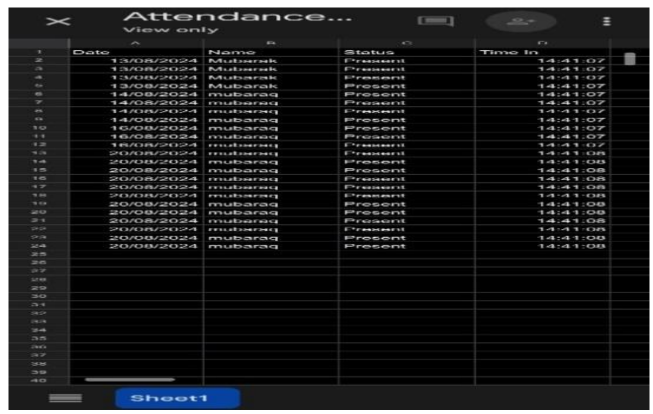

Fig. 9: Response from the integrated Google Sheet

Table 1: Performance Evaluation of the developed system

Attendance	Accuracy under well light conditions (%)	Accuracy under low light conditions (%)	Response Time (s)
A	85	54	20
B	87	50	16
C	86	65	19
D	80	56	22
E	81	61	25
F	88	60	21
G	85	59	18
H	83	54	17
I	83	63	21
J	79	62	23
K	82	60	21
L	81	57	24
M	84	61	18
N	85	58	17
O	85	51	18
P	80	58	21
Q	81	62	23
R	77	59	25
S	81	57	22
T	79	60	19

Conclusion

Traditional attendance management methods, such as manual record-keeping, biometric fingerprint systems, and RFID-based methods, are often tedious and less efficient. The developed system addresses these shortcomings by offering a more robust and effective solution for capturing and recording student attendance. the facial recognition process can accurately identify faces under varying lighting conditions. This face recognition-based attendance management system offers a precise and streamlined way to track student attendance, automatically uploading the data to a server via an Ethernet connection. The system is user-friendly, easy to operate, and provides enhanced security. It achieves an accuracy rate of 85%, though the accuracy may slightly decrease as the number of student faces increases. while the. system can currently detect faces at certain angles, there is potential for further improvement to recognize faces at more diverse angles and enhancing its overall efficiency.

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