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Deep Learning And Facial Recognition Based Multi-User Attendance System.

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A B S T R A C T :

This project presents a deep learning & facial recognition based multi-user attendance system designed for mass face detection and automated attendance logging. The system leverages deep learning-based face recognition models to detect and identify multiple individuals simultaneously, ensuring an efficient and contactless attendance process. The hardware setup includes a Raspberry Pi 5, Hailo 8L AI accelerator, HP HD webcam, and a 3.5-inch touchscreen display, enabling real-time processing and user interaction.

The system employs RetinaFace MobileNet for face detection and ArcFace MobileFaceNet for face recognition, utilizing a LanceDB vector database to store facial embeddings for quick retrieval. Additionally, FAISS (Facebook AI Similarity Search) is integrated for high-speed nearest-neighbour search in large-scale face embeddings, significantly improving retrieval efficiency and scalability. The system uses cosine similarity-based matching with an adaptive threshold to enhance accuracy and robustness in varied lighting conditions.

Attendance records are automatically updated in a cloud-based Laravel application, enabling real-time data synchronization, report generation, and remote monitoring. By eliminating manual attendance methods, this AI-driven system enhances efficiency, reduces errors, and prevents proxy attendance, making it ideal for educational institutions, corporate environments, and large-scale events requiring fast, automated, and secure attendance tracking.

Keywords: Face Recognition, AI-Based Attendance System, Mass Face Detection, Automated Attendance, Deep Learning, Raspberry Pi 5, Hailo 8L AI Accelerator, RetinaFace, ArcFace, LanceDB, FAISS, Cosine Similarity, Biometric Authentication, Cloud-Based Attendance, Laravel, Real-Time Attendance Tracking,etc.

Introduction

The personnel staff should have a suitable procedure for approving and regularly updating the student attendance record in order to validate it. Automated Attendance System (AAS) and Manual Attendance System (MAS) are the two main types of student attendance frameworks. Practically speaking, MAS staff members may find it challenging to approve and continuously monitor each student's progress in a classroom [1]. Physically recording each student's attendance and cumulative attendance becomes a very dismal and time-consuming task in a classroom with a high teacher-to-student ratio. As a result, we can implement a workable system that uses facial recognition to automatically record students' attendance. AAS may reduce its employees' managing workload. In particular, when an attendance system uses Human Face Recognition (HFR), it often uses a picture of the student's face taken as they enter the classroom or when everyone is seated in order to record attendance [1]. In general, there are two established approaches to handling HFR: the brightness-based approach and the feature-based approach. The feature-based methodology makes use of landmarks, which are important facial features, such as the mouth, nose, eyes, edges, or other distinctive characteristics. In this manner, only a portion of the previously extracted image is covered during the computation process. On the other hand, the brightness-based approach combines and calculates every aspect of the provided image [1]. Another name for it is image-based methodology or holistic-based methodology. The brightness-based approach is more complex and requires more processing time because the whole image must be taken into account [1]. Face detection and recognition are the fundamental elements in this face recognition framework, while there are further advancements made throughout the process. First, pictures of the kids' faces will be needed to record attendance. The camera that will be placed in the classroom at a point that allows for a view of the entire space can take this picture. This picture will be regarded as a system input. The image should be improved using image processing techniques like grayscale conversion and histogram equalisation for effective face recognition. Following an improvement in image quality, the picture will be sent to a face detection programme. The face recognition procedure comes after the face identification step. A variety of facial recognition techniques are available, including Eigen face, PCA, and the LDA hybrid algorithm. Faces that are recognised in the Eigen face are removed from the image [2]. Various facial highlights are extracted with the element extractor's help. The student is identified using these faces as Eigen characteristics, and their attendance is recorded by integrating with the face database [2]. For the purpose of comparison, the face database must be developed. Using cutting-edge face detection and recognition algorithms tailored for AI hardware, this research focuses on creating a mass facial recognition system for attendance monitoring.

2. REVIEW OF LITERATURE

Two databases are connected to a model as described by Naveed et al. [4]. One is used to indicate attendance, and the other is utilised for the faces. The camera is used to take a picture of the student's face and remove background and noise before the detection and recognition stage.

In a different implementation of a similar system, Kawaguchi et al. [5] suggested a concept where the fixed sitting positions and faces are compared to photographs in a database. This continuous assessment technique detects pupils' presence in the classroom using a video streaming camera. They even used a variety of computations to estimate the seating arrangements. It is a widely used design that is implemented using two distinct cameras, one for sensing and the other for taking pictures.

A different method was put up by Muthu Kalyani et al. [6], who used Android devices to complete this work. This was accomplished by connecting the Android phone to the security camera. Following camera capture, the image was subjected to 3D modelling, and the images were subjected to canonical procedures for comparison.

Utilising the most recent developments, the model put forth by Marko Arsenovic et al. [7] uses convolutional neural networks for face embeddings and convolutional neural networks for face identification. Applying these algorithms to tiny datasets was the main test because CNNs perform better on larger datasets, or, to put it another way, case underway condition. On a small dataset of the initial face photos of employees in the ongoing condition, the overall precision was 95.02%.

The facial detection model put forth by Kruti Goyal et al. [8] is constructed utilising a variety of techniques, including AdaBoost and Haar Cascades. MATLAB and OpenCV are used to implement this model. The process of extracting facial features involves localising the face through pattern recognition.

The Nusrat In their paper, Mubin Ara et al. [3] talked about the advancements in the technologies they used, including neural networks, face detection, normalisation, and identification. The authors also described the methodology that uses History of Oriented Gradients for face identification, Convolutional Neural Networks for feature extraction, Face Alignment based on face landmark estimation, and finally, embedding. Their accuracy was over 95%, despite the fact that their method detected some incorrect predictions. In their Student Attendance system, Samuel Lukas et al. [1] combined the recognition system with the corresponding mathematical formulae for the Discrete Wavelet Transform (DWT), Discrete Cosine Transforms (DCT), and Radial Basis Function Network (RBFN). Using a block diagram to illustrate the process flow, they have depicted the system design of their suggested framework. Based on the results of their experiment, they were able to identify some students as others, achieving an accuracy of 82%.

The success rate of several face recognition methods, including Principal Component Analysis (PCA), Eigenface, Support Vector Machines (SVM), and Neural Networks, was compared by Priyanka Wagh et al. [2]. The authors also provided step-by-step methodology, system architecture, and algorithmic support for their writings. Additionally, they have offered a mathematical model that makes use of mathematical terminology and notions.

By using statistical techniques PCA and LDA, as well as comparing the captured and stored images for attendance marking, Abhishek Jha et al. [10] advanced to a better system for the recognition process. They recommended the lengthy and error-prone process of participation making, which, if negotiated, may undoubtedly have an impact on the understudy. In order to make match scoring feasible, they suggested a framework for determining the images in a particular process. However, it might be possible to achieve this by using certain computations, such as colour detection, PCA, and LDA. They extracted numerous facial elements from the image, such as the eyes, nose, and face structure, among others. Eigen Values are used by the PDA and LDA to accurately mark students' attendance.

METHODOLOGY

The Face Recognition-Based Attendance System follows a structured methodology to ensure efficient and accurate attendance tracking using AI-powered face recognition. The system operates in real-time by detecting and identifying multiple faces simultaneously and logging attendance automatically through a cloud-based application. The methodology consists of several key steps: The system is deployed on Raspberry Pi 5 with a Hailo 8L AI accelerator to perform AI inference efficiently. The following hardware components are integrated: HP HD Webcam captures real-time video for face detection, a 3.5-inch touchscreen display provides visual feedback to users on their recognition status, and an Edge AI Accelerator (Hailo 8L) enhances the speed and efficiency of AI model inference. This setup ensures that the system can process face recognition locally, reducing dependency on external cloud computing and enabling low-latency real-time processing. The RetinaFace MobileNet model is used to detect and locate faces in the captured video frames. The detection process includes identifying facial regions using bounding boxes, extracting landmarks (eyes, nose, mouth) for alignment, and aligning and cropping the face using transformation matrices to standardize input before recognition. The aligned face images are then passed to the face recognition model for identity verification. For recognition, the ArcFace MobileFaceNet model is used to generate 128-dimensional facial embeddings for each detected face. The workflow includes extracting deep facial features using ArcFace, storing and retrieving embeddings in LanceDB (a vector database for fast similarity searches), using FAISS (Facebook AI Similarity Search) to perform high-speed nearest-neighbor search, enabling quick identity retrieval even for large databases, and applying cosine similarity-based distance measurement with an adaptive threshold to determine the closest matching identity. If a match is found above the confidence threshold, the user's identity is verified, and attendance is logged. After recognition, attendance is marked in a Laravel-based cloud application. The process includes assigning a unique ID to each registered user, storing attendance logs with timestamps in a remote database, and time window-based validation, ensuring attendance is recorded only if the person is present at both the start and end of the session. If a user is detected only once (either at the start or end), their attendance is not marked, preventing fraudulent check-ins. The system ensures instant feedback and real-time monitoring through a 3.5-inch touchscreen display, showing user recognition details, remote access via the Laravel web application, allowing administrators to monitor, generate reports, and analyze attendance reports, and edge AI-based inference, ensuring fast processing without cloud dependency. The system follows a modular architecture, integrating edge AI processing, database management, and cloud-based reporting. The architecture is divided into the following layers: The Input Layer (Data Acquisition) includes a Camera (HP HD Webcam) that captures real-time video frames and Raspberry Pi 5 + Hailo 8L AI Accelerator that processes video input locally. The AI Processing Layer (Face Recognition) consists of Face Detection (RetinaFace MobileNet) to detect faces and extract key landmarks, Face Alignment & Preprocessing to normalize face images before recognition, Face Recognition (ArcFace MobileFaceNet) to generate 128-dimensional embeddings, and FAISS + LanceDB to perform fast nearest-neighbor search for identity matching. The Attendance Management Layer ensures Time Window-Based Verification to log attendance only during predefined lecture sessions and Attendance Logging in Laravel to store recognized user data in a cloud database. The Output Layer (User Interaction and Reporting) includes a Touchscreen Display for real-time attendance feedback and Cloud-Based Reporting, where attendance data is accessible through the Laravel web application for monitoring and generating reports.

OBJECTIVES

The main objective of the project is to develop a Facial recognition attendance management system. The objectives of the project are:

- Implement a face recognition-based automated attendance system for mass detection and real-time logging using deep learning.
- Utilize RetinaFace MobileNet for face detection, ArcFace MobileFaceNet for recognition, and FAISS for high-speed similarity search in large-scale face embeddings.
- Integrate with a cloud-based Laravel application to log attendance, manage records, and generate reports in real time.
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SUMMARY

The Face Recognition-Based Attendance System is an advanced AI-driven solution designed to automate and streamline attendance tracking in educational institutions and workplaces. By leveraging edge AI processing on Raspberry Pi 5 with a Hailo 8L AI accelerator, the system ensures real-time face detection and recognition without relying on external cloud services, reducing latency and improving efficiency. The system integrates RetinaFace MobileNet for accurate face detection, extracting key facial landmarks and aligning images for consistency. ArcFace MobileFaceNet is then utilized to generate unique 128-dimensional embeddings for each face, which are stored in LanceDB and retrieved using FAISS for high-speed similarity searches. The attendance logging process is managed through a Laravel-based cloud application, ensuring secure data storage and seamless accessibility for administrators. A time-window validation mechanism ensures that students or employees are marked present only if they are detected at both the start and end of the session, preventing fraudulent check-ins. Real-time feedback is displayed on a 3.5-inch touchscreen, providing users with immediate confirmation of their attendance status. The system architecture follows a structured approach, integrating multiple layers for efficient operation. The input layer includes a high-definition webcam for real-time video capture, while the AI processing layer handles face detection, preprocessing, and recognition. The attendance management layer ensures secure database handling, and the output layer provides real-time reporting and analytics through the web-based portal. The use of edge AI processing reduces dependency on external cloud infrastructure, ensuring data privacy and faster processing. With a modular and scalable design, the system can be expanded for larger organizations or adapted for different applications beyond attendance tracking, such as access control and workforce management. The combination of AI-driven accuracy, cloud integration, and real-time processing makes this system a highly effective and reliable solution for modern attendance management.

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