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AI Based Attendance System using Haar-Cascade classifier and Local Binary Pattern Histogram

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Abstract: In today's digital age, face recognition systems have become increasingly important across various sectors. As one of the most commonly used biometric technologies, face recognition serves multiple purposes including security, authentication, and identification. Although its accuracy may not match that of iris or fingerprint recognition, it remains widely adopted due to its contactless and non-intrusive nature. At the end of each session, attendance records will be automatically sent to the respective faculty members via email.

Keywords: Attendance Report, AI, Face Recognition, Haar-Cascade classifier, Local Binary Pattern Histogram.

I. INTRODUCTION

Face recognition has set an important biometric feature, which can be easily acquirable and is non-intrusive. Face recognition based systems are relatively oblivious to various facial expression. Face recognition system consists of two categories: verification and face identification. Face verification is an 1:1 matching process, it compares face image against the template face images and whereas is an 1:N problems is compares a query face images.

Face recognition is crucial in daily life in order to identify family, friends, or someone familiar. Several steps are actually taken in order to identify human faces, though not always consciously perceived. Human intelligence allows information to be received and interpreted during the recognition process.[1] Information is received through the image projected into the eyes, specifically the retina, in the form of light. Light is a form of electromagnetic waves radiated from a source onto an object and projected to human vision. After visual processing is completed by the human visual system, shape, size, contour, and texture of the object are classified to analyze the information. The analyzed information is then compared to other representations of objects or faces stored in memory for recognition.

Motivation is it automates and simplifies the way attendance is marked. The innovative system captures the unique facial features of an individual and eliminates the need SSBT's College of Engineering and Technology, Bambhori, Jalgaon (MS) 3 for ID cards, biometrics, or passwords.[1] To execute business operations seamlessly, various organizations prefer facial recognition attendance system. The system is so advanced it can even scan blurred images and verify the real identity of a person. Let's explore what is facial attendance management system and how it is beneficial for field workers busy fulfilling service requests.

II. LITERATURE REVIEW

Face recognition-based attendance systems have gained significant attention due to potential to automate and streamline attendance management processes. Early approaches primarily utilized classical computer vision techniques, such as the work by Wagh et al. [5], who implemented an Eigenface and PCA-based system. Method provided a foundational understanding of feature extraction and recognition, though it faced limitations in handling real-world variations such as lighting and facial orientation.

Progressing from traditional methods, researchers have integrated machine learning algorithms to enhance recognition accuracy. Damale and Pathak [3] proposed a system leveraging intelligent computing and control systems to improve the robustness of face recognition in dynamic environments.

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Similarly, Raj et al. [4] introduced a smart attendance system that incorporated IoT for real-time tracking, highlighting the importance of connectivity and data management in institutional applications.

The emergence of mobile-based solutions was explored by Samet and Tanriverdi [6], who developed a face recognition attendance system deployable via mobile devices. Approach emphasized portability and user convenience, making it suitable for decentralized or outdoor classroom environments.

More recently, modern libraries such as OpenCV and face recognition APIs in Python have enabled faster and more accessible development of such systems. Sirivarshitha et al. [1] demonstrated an approach using these tools to build a functional attendance model, which is particularly useful for academic prototypes and small-scale implementations. Lee et al. [2] focused on the architectural design of a multi-user recognition system, aiming for efficiency and scalability in group settings. Deep learning has further pushed the capabilities of recognition systems. Painuly et al. [7] introduced an efficient real-time attendance system using deep learning algorithms, significantly improving accuracy and responsiveness under varied conditions. Their work addresses many of the limitations seen in earlier models and sets a precedent for future enhancements in this domain.

Overall, the evolution from classical techniques to deep learning and mobile-based platforms demonstrates the continuous advancement in face recognition-based attendance systems. Building upon these developments, the proposed work, AI Based Attendance System using Haar-Cascade Classifier and Local Binary Pattern Histogram, aims to provide an efficient and lightweight solution by combining Haar-Cascade for face detection and LBPH for face recognition. This approach ensures a balance between computational efficiency and recognition accuracy, making it suitable for real-time applications in educational institutions and beyond.

III. PROBLEM STATEMENT

The concept of face recognition is to give a computer system the ability of finding and recognizing human faces fast and precisely in images or videos. Numerous algorithms and techniques have been developed for improving the performance of face recognition. [3]Recently Deep learning has been highly explored for computer vision applications. Human brain can automatically and instantly detect and recognize multiple faces. But when it comes to computer, it is very difficult to do all the challenging tasks on the level of human brain. [3]The face recognition is an integral part of biometrics. In biometrics, basic traits of human are matched to the existing data. Facial features are extracted and implemented through algorithms, which are efficient and some modifications are done to improve the existing algorithm models.

Attendance system Educational Institutions Automating attendance tracking in schools, colleges, and universities. Reducing manual errors and saving time in large classrooms. Integrating with Learning Management Systems (LMS) to monitor attendance patterns. Offering seamless integration with existing biometric systems. Also integrate with Healthcare Monitoring staff attendance in hospitals and clinics to ensure optimal patient care. Tracking shift changes and compliance with work hours. Minimizing physical contact during attendance, aligning with hygiene protocols. Streamlining attendee registration and monitoring at conferences, trade shows, and events. Ensuring secure access to restricted areas. Providing organizers with real-time analytics on participation. Monitoring workforce attendance in large-scale government offices. Ensuring accountability and compliance with working hours in public services. Reducing absenteeism and fraudulent attendance claims. Using facial recognition to monitor attendance at training programs and operational briefings.

IV. SYSTEM ARCHITECTURE

Systems Architecture is a generic discipline to handle objects (existing or to be created) called ”systems”, in a way supports reasoning about the structural properties of these objects. The system architecture is the conceptual model defines a system’s structure, beh-avior, and views. An architecture description is a formal description and representation of a system. It provides a broad understanding of the portal. In the system, the architecture database provides functionality like getting information, selecting criteria, etc. Figure shows System Architecture diagram of project. Figure 1. shows System Architecture diagram of AI based Attendance System using Face Recognition query.

The system initiates with face capturing via webcam, which acquires live images of individuals for further processing. The architecture is divided into two main paths. One path directly contributes to creating and updating the attendance dataset, while the other focuses on preprocessing the captured face images.

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The preprocessing stage includes grayscaling, which simplifies image data by reducing color complexity, and thresholding, which enhances image contrast for easier detection. This is followed by face detection using the Haar-cascade classifier, a fast and efficient object detection method based on machine learning.

Once faces are detected, histogram-based recognition is applied to generate and store face image training data. In the parallel recognition module, Local Binary Pattern Histogram (LBPH) is used for feature extraction, leveraging texture based features that are robust to illumination changes. These extracted features undergo a matching process, where they are compared against trained data for identity verification.

Successful identification proceeds to the face recognition module, which confirms the individual's identity. The recognized data is then passed to the attendance recording process, where attendance is marked and stored in the attendance dataset. The system generates a result that reflects the outcome of recognition and attendance recording, completing the cycle. Fig.1 shows the system architecture diagram of the system.

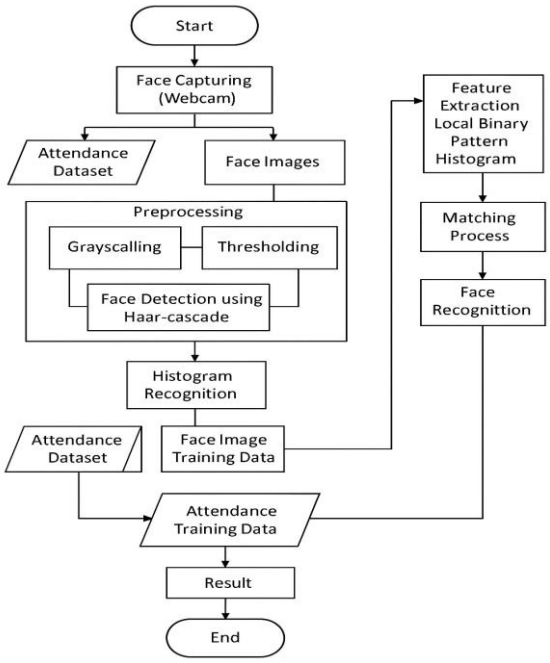

Fig. 1 System Architecture Diagram

V. METHODOLOGY

The steps involved in AI based Attendance System using Face Recognition are as follows:

1. Dataset Preparation: Initially, a dataset comprising facial images of all registered students is collected or loaded. These images are organized into directories, with each folder labeled using the corresponding student's ID or name. Ensuring variety in facial expressions, lighting conditions, and angles enhances the accuracy of recognition during realtime testing.
2. Import Required Libraries Python libraries as: OpenCV for face detection and recognition, numpy for numerical operations, os for file handling, datetime for recording attendance timestamps, pandas or csv for attendance logging.
3. Face Detection using Haar Cascade Classifier: To identify faces in the dataset images, the Haar Cascade Classifier provided by OpenCV is employed. Method uses trained data on positive and negative images to detect key facial features efficiently. It offers real-time detection with minimal computational overhead, making it ideal for live video applications.
4. Image Preprocessing: The detected face regions are extracted and subjected to preprocessing to standardize input for the recognition phase. Images are first converted to grayscale to support the requirements of the LBPH algorithm. They are then resized to uniform dimensions to maintain consistency across the dataset. Optional noise reduction techniques can also be applied to improve feature clarity.
5. Training Using LBPH Face Recognizer : The Local Binary Pattern Histogram (LBPH) algorithm is used for face recognition.

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6. This method segments grayscale images into grids and computes binary patterns for each region, generating a histogram of features. These histograms are then used to distinguish between individuals. The model is trained using the labeled dataset and optimized for future predictions.
7. Model Persistence: The trained LBPH model is saved in a file, typically in XML format, to preserve the learned parameters. The model can be directly loaded during the recognition phase without needing to retrain it every time the system is started.
8. Real-Time Face Recognition: In the deployment phase, the system captures live video feed through a webcam. Each frame undergoes face detection and preprocessing as described earlier. The extracted face is then passed to the trained LBPH model for identification. A confidence threshold is applied to validate the prediction and ensure reliable recognition.
9. Mark Attendance: A face is recognized with acceptable confidence, the system logs the student's name, ID, and the corresponding date and time. This information is recorded in a CSV or Excel sheet. Mechanisms are implemented to avoid multiple entries for the same individual within a single session, thus ensuring the integrity of attendance records.

VI. IMPLEMENTATION

The proposed AI-based attendance system was implemented using Python due to its high-level syntax, cross-platform compatibility, and rich ecosystem of libraries suited for computer vision, GUI development, and machine learning. Python's dynamic typing and rapid prototyping capabilities also facilitated fast iterations during development.

Face detection was implemented using OpenCV's Haar Cascade Classifier, a machine learning-based approach where a cascade function is trained from a large number of positive and negative images. Technique is built upon the Viola-Jones object detection framework, which uses Haarlike features, integral images for rapid computation, and the AdaBoost learning algorithm to improve accuracy. Its low computational complexity made it ideal for real-time execution on standard consumer-grade hardware such as laptops or embedded systems with moderate CPU resources. The system uses a pre-trained frontal face Haar classifier (haarcascade_frontalface_default.xml) for locating faces in each frame captured via webcam. Upon detection, the face region is extracted and sent for preprocessing.

The captured face images are first converted into grayscale to reduce computational complexity and to meet the input format requirements of the recognition algorithm. The grayscale image is then normalized and resized to a standard resolution to maintain consistency across all training and test samples. Feature extraction is carried out using the Local Binary Pattern Histogram (LBPH) technique. LBPH is a texture-based descriptor that is robust against changes in illumination and facial expressions. The algorithm divides the image into small grids and computes the local binary pattern by thresholding surrounding pixels with the center pixel. The histograms of all grids are concatenated to form a feature vector, which is then used for training and recognition.

During the training phase, multiple images of each student are collected to account for slight variations in facial orientation and lighting. Each image is labeled with a unique identifier corresponding to the student's ID or name. The OpenCV LBPH Face Recognizer is trained on these labeled images, and the learned model is serialized into an XML file (classifier.xml). This file allows the system to load pretrained data instantly without requiring retraining each time the application runs. To ensure scalability, the training dataset is organized in a structured directory hierarchy, enabling efficient addition of new entries and periodic retraining.

Once the model is trained, the system continuously captures frames from the webcam. Detected faces are passed through the LBPH recognizer for identification. If a match is found above a defined confidence threshold, the system logs the student's name, ID, recognition confidence score, and a timestamp into a CSV-based attendance log. Confidence values typically ranged between 90–95%, ensuring reliable recognition in most classroom environments. To avoid duplicate entries, the system maintains a session-based record that prevents marking the same student multiple times within a predefined time interval.

The Graphical User Interface (GUI) was developed using Python's Tkinter library, which provided tools for rapid interface design and event-driven programming. The interface is divided into distinct functional modules including student registration, model training, recognition, and attendance viewing. The student registration module allows the administrator to capture face images and store labeled datasets. The training module enables on-demand model training from new data. The recognition module initiates the real-time face recognition process, and the attendance viewer displays the CSV-based attendance log in a tabular format. Error handling and realtime feedback were incorporated into the GUI to guide users through each operation and to ensure robustness.

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The system follows a modular architecture with separate scripts for dataset generation, model training, recognition, and GUI. This modular design ensures ease of debugging, scalability, and code reuse. All components communicate through shared directories and configuration files. The application can be deployed as a standalone executable using tools like PyInstaller, making it platform-independent and eliminating the need for installing Python separately on deployment machines.

VII. RESULT

The AI-Based Attendance System using Face Recognition captures real-time student images, detects faces, recognizes them using the LBPH algorithm, and automatically marks attendance in the MySQL database. The system efficiently identifies registered students and maintains attendance logs without manual intervention. Table 1 shows the AI-based attendance system along with the corresponding actions and generated outputs. The system begins with the user interface (UI), which is implemented using the Tkinter library. This component provides a visual interaction point for users, allowing access to features such as student registration and attendance monitoring.

The Data Collection operation is responsible for capturing facial images of students through a webcam. These images are stored in a structured directory, forming the foundational dataset for subsequent stages. The Detection phase utilizes OpenCV's Haar Cascade Classifier to identify and extract faces from the collected images, resulting in cropped facial images that are suitable for training.

The Training stage involves the application of the Local Binary Pattern Histogram (LBPH) algorithm. During this process, the face images are processed and used to train the facial recognition model. The trained model is then saved as a serialized XML file (classifier.xml) which can be reused for real-time recognition.

In the Recognition phase, the system compares live facial input with the trained model to identify students, outputting the corresponding student name or identification number. Lastly, the Attendance module logs the recognized student's presence, appending their details along with a timestamp to a CSV file, effectively maintaining a digital attendance log. This structured, modular workflow ensures a robust and real-time facial recognition attendance system suitable for educational environments.

TABLE I RESULT TABLE1

Module	**Action**	**Output**
UI	Show Interface	Tkinter Window
Data Collection	Capture Faces	Image Dataset
Detection	Detect Faces	Cropped Face Images
Training	Train LBPH Model	classifier.xml File
Recognition	Recognize Face	Student Name/ID
Attendance	Mark Entry	CSV Attendance Log

Table II shows the performance evaluation of the face recognition-based attendance system in terms of accuracy and identification reliability. The table compares the test IDs (assigned during the real-time recognition phase) with the actual IDs from the training dataset to verify the correctness of the match. Each row represents a unique subject tested using the system.

The Name column lists the individuals who participated in the testing process. The Test ID corresponds to the identifier predicted by the system during real-time recognition, while the Actual ID reflects the identifier assigned during the training phase. The Match column indicates whether the system correctly identified the individual by comparing the test and actual IDs. As shown, the system achieved 100% match accuracy for the tested individuals.

The Confidence values, which measure the certainty of the recognition, demonstrate the effectiveness of the LBPH (Local Binary Pattern Histogram) algorithm. For instance, Vaishali was identified with a high confidence level of 94.55%, while Unnati and Hitesh were recognized with 92.45% and 90.67% respectively. These results affirm the reliability of the system under normal conditions, reflecting its suitability for real-time deployment in attendance management applications.

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TABLE II RESULT TABLE2

Name	Test ID	Actual ID	Match	Confidence%
Unnati	1	1	Yes	92.45%
Hitesh	2	2	Yes	90.67%
Vaishali	3	3	Yes	94.55%

VIII. CONCLUSION

The AI-Based Attendance System using Face Recognition effectively automates the attendance process by leveraging the LBPH algorithm for accurate student identification. It eliminates manual attendance tracking, ensuring efficiency, accuracy, and security. The system successfully captures and recognizes faces, marking attendance in the MySQL database with real-time feedback through a Tkinter interface. Solution offers educational institutions a streamlined, low-cost method for attendance management, with potential for future improvements in scalability and robustness under varying conditions.

The system can further enhanced by incorporating multicamera support to improve face detection accuracy.

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