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Facial Recognition System for Efficient Attendance Monitoring using LBPH Classifier Algorithm

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Abstract:

A clever and dependable solution for real-time attendance tracking in educational institutions is offered by the proposed project, "Facial Recognition System for Efficient Attendance Monitoring using LBPH Classifier Algorithm." With role-based access, administrators and students can both log in to this system. Through face recognition, students can easily check in and out and register their facial data, guaranteeing a contactless and secure way to record attendance. Features that let administrators create thorough attendance reports based on particular date ranges or student names are available to them. They can also register student faces. Through the use of an interactive Power BI Dashboard, students can also examine their own attendance records by choosing a custom time frame and use a graphical representation to assess their presence at the school. In addition, the system is set up to notify students via email as soon as they check in or out, giving them real-time information. Along with removing manual errors and fostering digital transformation in educational settings, the system enhances the precision, security, and effectiveness of attendance tracking by fusing facial recognition technology with data visualization and notification capabilities.

Keywords **— LBPH Classifier, Attendance Monitoring, Facial Recognition, Email notifications, Proxy Attendance Prevention, Power BI Dashboard.**

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I. INTRODUCTION

Keeping safe and accurate attendance records remains a major challenge in educational institutions. The accuracy of attendance data is jeopardized by traditional methods such as manual roll calls and RFID-based systems, which are prone to mistakes, inefficiencies, and proxy attendance fraud [9]. In order to overcome these constraints, this project suggests an automated Face Recognition Attendance System that makes use of the Local Binary Pattern Histogram (LBPH) Classifier Algorithm for accurate and instantaneous facial recognition. LBPH is appropriate for real-time institutional settings because of its reputation for resilience in the face of changing lighting and facial expressions [10].

The system improves speed and accuracy in student identification by combining LBPH for recognition and Haar Cascade for face detection [10]. Only registered students are marked present thanks to this automated method, which also removes the need for human intervention. Attendance tracking is made safe and easy with real-time face recognition technology, which also greatly reduces administrative workload and increases operational efficiency [3], [5].

For graphical data representation, the system also integrates with Power BI, providing insightful information about patterns and trends in student attendance [2]. Instant email notifications at check-in and check-out improve system-student communication and transparency even more. These features facilitate efficient attendance monitoring for both students and administrators, encouraging accountability and streamlining institutional management procedures [3], [9].

II. OBJECTIVES

A vital component of academic administration, attendance monitoring is essential for upholding order, guaranteeing student participation, and meeting institutional requirements. However, traditional methods of attendance, like RFID cards or manual roll calls, are frequently laborious, prone to human error, and susceptible to abuse through proxy attendance. The Facial Recognition System for Efficient Attendance Monitoring using LBPH Classifier Algorithm, which uses real-time facial recognition to automate and improve the accuracy of attendance management, is created in this project to get around these restrictions.

This project's main goal is to create and put into place a safe, automated system for tracking attendance that makes things easier for administrators and students alike while maintaining accountability and transparency. The system's scope is delineated by the following specific objectives:

A. Real-Time Face Recognition :

Utilize the Local Binary Pattern Histogram (LBPH) classifier algorithm to precisely identify and detect student faces in real-time. Without the need for human intervention, the system enables check-in and check-out by comparing the captured face with registered data.

B. Admin and Student Role-Based Access :

Offer a safe login process that accommodates administrator and student roles. While administrators can manage attendance entries, register student faces, and keep an eye on system operations, students can register their facial data and view their attendance history.

C. Attendance Report Generation by Date and Name :

Give administrators the resources they need to create attendance reports that are filtered by names of students or by particular time periods. This makes data analysis, auditing, and monitoring simpler.

D. Student Attendance View with Graphical Visualization :

Give students the ability to check their own attendance records for specific time periods. Use interactive charts and graphs to improve user comprehension by integrating a Power BI Dashboard to graphically depict the amount of time spent in the organization.

E. Automated Email Notification System :

Install a system that automatically notifies students via email when they successfully check in and out. This guarantees that students are constantly informed of real-time attendance updates.

III. MODULES AND ALGORITHMS

The Face Recognition Attendance System is a machine learning-based system made for educational institutions. It uses the Local Binary Patterns Histograms (LBPH) classifier to enable real-time face recognition for effective attendance tracking. The system facilitates date-wise attendance analysis, check-in/check-out functionality, and face registration by allowing both administrators and students to log in. While automated email notifications are sent out during student check-in and check-out events, the integrated Power BI dashboard visually represents attendance statistics, increasing the system's transparency.

A. Modules

1) Face Registration and Database Management Module :

Through the user interface, administrators and students can both register student facial data with this module. Face images are captured, processed, and safely stored in a structured dataset using OpenCV's Haar Cascade for face detection. A distinct ID and name are mapped to each enrolled student. The admin panel guards against tampering and unauthorized access by ensuring that only authorized personnel can add or manage facial data.

2) Real-Time Face Detection and Recognition Module :

The LBPH-powered real-time face recognition module is the brains behind the system. This module compares faces in a live camera feed with faces that have already been registered using Haar Cascade classifiers. The LBPH model is a good fit for real-time classroom applications because of its low computational overhead and resilience to different lighting conditions. When a match is discovered, the system records the time spent checking in or out in relation to the profile of the corresponding student.

3) Attendance Logging and Reporting Module :

The precise timestamps of each student's check-in and check-out are recorded by this module. For convenience of storage and retrieval, attendance records are kept in an Excel-compatible format. Using specified date ranges or student names, administrators can create attendance reports. These reports aid in tracking both the overall number of hours spent on campus and individual attendance trends.

4) Visualization and Analytics Module (Power BI) :

This module incorporates Power BI dashboards to improve transparency and give students insightful feedback. Students can compare their presence over days or weeks, see trends, and view their attendance data as graphs over time. With dynamic dashboards, administrators can also keep an eye on overall attendance data and trends across the entire institution.

5) Notification and Email Alert Module :

An automated email notification is delivered to the student's registered email address upon successful check-in or check-out. Students can stay updated on their attendance status thanks to this instant alert, which guarantees accountability and transparency. If an unidentified or unauthorized person tries to access the system, the email system also alerts administrators or faculty.

6) Admin and Student Portal Module :

For secure access, separate interfaces are offered for administrators and students. Students can only view their own attendance records and visualization dashboard, but administrators can register students, manage attendance data, and view analytics. Role-based access control guarantees system integrity and data privacy.

B. Algorithms

1) Local Binary Patterns Histograms (LBPH) Classifier :

In this project, the primary algorithm for face recognition is LBPH. By comparing every pixel in a 3x3 grid with its neighbours, it transforms the input grayscale image into a local binary pattern. The neighbour pixel value is indicated as 1 if it is greater than or equal to the central pixel, and as 0 otherwise. The binary number created by combining these binary values is then transformed into a decimal and used to represent that specific face region. After that, the image is separated into grids, and each grid is given its own histogram. One feature vector that represents the face is created by concatenating the histograms that are produced from each grid. The feature vector of the recorded face is compared to vectors in the database during recognition. The identity is verified and the attendance is noted if a match is discovered within a predetermined range.

*2) **Haar Cascade Classifier :***

The system detects faces in real time using the Haar Cascade Classifier to start the facial recognition process. In order to identify facial structures, this machine learning-based method was trained using a large number of both positive and negative images. To determine whether a face is present in a frame, it makes use of characteristics like the mouth, nose, and eyes. Applying rectangular windows over the image and calculating the contrast differences between regions allows for the extraction of Haar features. To guarantee accurate detection of faces of varying sizes, the classifier scans the input frame in multiple scales. Following face detection, the area is cropped and moved on to the recognition stage.

C. Functional Modules

*1) **Attendance Marking Logic :***

This module is in charge of documenting a student's attendance status following a successful facial recognition test. After identifying a face with the LBPH classifier, the system verifies the date and time. The system indicates the current check-in time if the student has not checked in for the day. An additional detection made later in the day will be noted as the Check-Out time if the student has already been marked as checked in. By ensuring that the entry and exit times are precisely recorded, this logic makes it possible to determine how long a student will be enrolled in the school. Additionally, the reasoning guarantees that a student cannot unnecessarily check in or out more than once on the same day.

*2) **Email Notification System using SMTP :***

By providing students with real-time email notifications whenever they check in or out, this module guarantees open communication. An email message with the student's name, the date, and the time of the event (check-in or check-out) is automatically generated by the system following a successful attendance mark. The system connects securely to an SMTP server using Python's smtplib library, authenticates using the sender's credentials, and then sends the email to the student's registered email address. In addition to informing students, this gives the attendance system an extra degree of security and accountability.

IV. METHODOLOGIES

A. Data Acquisition and Face Registration :

Students' facial information is first gathered during registration. A webcam is used to take a picture of each student via the system interface. To guarantee accurate recognition, several photos are captured from various viewpoints and facial expressions. Grayscale conversion and uniform resizing are applied to these facial samples. The data is saved for training after being label with the student's unique ID. This step guarantees that the facial dataset is ready for precise model recognition and training.

B. Feature Extraction using LBPH Algorithm :

After the image dataset is prepared, facial features are extracted using the Local Binary Pattern Histogram (LBPH) algorithm. In order to effectively convey the distinctive qualities of every face, LBPH analyses the local patterns of pixels and transforms them into histograms. Because of its resilience to changing lighting, this technique can be used for real-time recognition in educational settings. During live recognition, the system stores the extracted features for comparison.

C. Model Training and Real-Time Recognition :

The stored face dataset is used to train the LBPH algorithm, which links each histogram to its corresponding student ID. The system takes a real-time picture of the student at check-in or check-out, extracts facial features, and compares them with the trained data. A successful recognition is defined as the best match above a predetermined confidence threshold. Depending on the recognition result, the system immediately logs the time spent checking in or out. This module guarantees fast, precise attendance recording and supports real-time operation.

D. Attendance Marking and Notification System :

Following a successful face recognition attempt, the system uses the student's daily attendance record to determine whether they are checking in or out. In the attendance database, it logs the relevant time. Using the SMTP protocol, the system simultaneously notifies the student via email of the timestamp and attendance event status (check-in or check-out). This encourages openness and guarantees that students are notified instantly of their recorded attendance.

E. Attendance Analysis and Power BI Integration :

The system uses a Power BI Dashboard to give administrators and students visual insights. Pupils can see a graphical depiction of their time spent in the school and view their attendance based on a chosen date range. Admins have the ability to view attendance reports by student name or by specific date range. By providing interactive and lucid attendance record visualizations, this module facilitates decision-making and facilitates analysis.

V. EXISTING SYSTEM

A. Manual Attendance Systems :

The majority of institutions continue to use manual attendance procedures like roll calls and paper registers. Inaccurate records or missed entries are examples of human error that can occur with these time-consuming systems. Additionally, manual systems lack appropriate verification mechanisms, which permits proxy attendance and lower student accountability, and they make it challenging to track real-time attendance or generate cumulative reports.

B. Biometric Fingerprint-Based Systems :

In order to track attendance, many organizations have implemented biometric systems, such as fingerprint scanners. Although these systems are quicker and more secure than manual methods, they are not completely effective in high-traffic settings, like educational institutions; physical contact with the scanner may raise hygienic concerns, particularly in the event of a pandemic; and wear and tear, wet fingers, or sensor malfunctions can result in authentication failures, which can cause inconvenience and inaccurate attendance.

C. RFID and Smart Card Systems :

Smart cards and radio frequency identification, or RFID, are frequently used to track attendance by swiping the cards close to sensors. By giving these cards to their peers for proxy attendance, students can easily abuse them. Cards may be lost, copied, or damaged, and the system does not confirm the cardholder's identity. In addition, these systems are not well suited to intelligent, contactless environments and need constant hardware maintenance.

D. QR Code-Based Attendance Tools :

Scanning QR codes produced by the system is one of the more recent solutions. Despite being fast and contactless, QR-based systems rely significantly on smartphones or cameras. If the QR code is shared, they are susceptible to unauthorized access, screenshot sharing, and phony logins. These techniques provide very little security and are unable to verify the student's identity or real presence at check-in or check-out.

E. Basic Face Recognition Systems without Learning Algorithms :

Using simple OpenCV modules without incorporating learning algorithms, some institutions have tried facial recognition for attendance. Frequently, these systems are unable to identify faces in various lighting scenarios, from various perspectives, or with various expressions. They don't have strong training, so they frequently make mistakes or can't tell one face from another. Lack of adaptive algorithms leads to poor accuracy and dependability.

F. Lack of Real-Time Notifications and Reporting :

Data analytics dashboards and integrated notification systems are uncommon features of

current attendance systems. There is uncertainty among students because they are not promptly notified of their check-in or check-out status. Additionally, the lack of graphical analysis tools and real-time monitoring capabilities makes it difficult for administrative staff to glean valuable insights from raw data. Consequently, these systems provide limited usability and poor transparency for administrators and students alike.

VI. PROPOSED SYSTEM

To improve attendance tracking, the suggested Face Recognition Attendance System combines real-time camera input, automated reporting, user authentication, and the Local Binary Patterns Histogram (LBPH) algorithm. The system offers a safe, contactless, and effective way to manage student attendance by doing away with manual labor and increasing accuracy. Identity verification is ensured by the use of face recognition, and the system is dependable and easy to use thanks to extra modules like email notifications and graphical analysis.

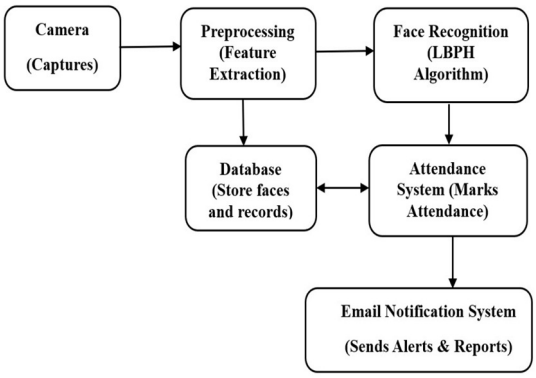

Fig. 1 Architecture of Face Recognition Attendance System

A. LBPH-Based Face Recognition Engine :

The system's LBPH face recognition algorithm, which is well-known for its ability to handle a variety of lighting conditions and facial expressions, is at its heart. It converts facial images into histograms using localized pixel intensity comparisons, enabling effective and precise face classification. The system takes multiple samples of each student's face during registration to increase recognition accuracy, and during attendance logging, the model verifies identity by comparing real-time camera input with trained facial data. This ensures accurate attendance capture without physical contact.

B. Dual Role Access with Secure Login System :

Administrators and students can access different login modules on the platform. Admins have the ability to view comprehensive reports, manage attendance records, and register new users. In addition to receiving real-time notifications, students can view their attendance history. Role-based access guards against unwanted changes and guarantees system security. Credentials are used for authentication, and future multi-level verification can be achieved by integrating additional security features.

C. Real-Time Attendance Logging and Notifications :

The system automatically logs check-in and check-out times and marks attendance once a student's face has been successfully identified. Transparency is increased by an integrated email notification system that notifies students when they successfully enter or exit. Confusion is decreased and appropriate attendance discipline is maintained thanks to this instant feedback loop. To ensure dependability, the system marks the entry for admin review if recognition attempts are unsuccessful several times.

D. Robust Data Handling and Excel Integration :

Every day's attendance information is automatically saved in structured Excel sheets, arranged by student ID and date. This makes it simple to filter, sort, and export records for institutional reporting or audits. Duplicate entries are avoided and error-free recording is guaranteed by the data handling module. It is simple to generate daily summaries and monthly reports, which ensures accountability and lessens the administrative load.

E. Power BI-Based Graphical Visualization :

The system is integrated with a Power BI dashboard to offer insights into attendance trends. The dashboard shows trends in attendance, absenteeism, and punctuality over time through graphical visualizations like pie charts, line charts, and bar graphs. To examine attendance patterns and take prompt action when necessary, administrators can apply filters based on date ranges or particular students.

F. Web-Based Interface :

The Flask framework was utilized to create the system's responsive and easily navigable web interface. It does away with the need for local installations by enabling administrators and students to interact with the system via a web browser. For face recognition, user authentication, and smooth navigation between modules like face registration, attendance logs, and report generation, the interface allows real-time camera access. Fast execution, modular design, and simple integration with external components such as Power BI dashboards, Excel reports, and email services are all guaranteed by Flask. This web-based strategy improves user convenience and platform independence.

VI. OUTPUT

A. Face Recognition Attendance System Outcomes :

By identifying students' faces when they check in and out, the suggested Face Recognition Attendance System tracks attendance accurately and in real time. The name of the student, the time, date, and visual confirmation are recorded with every accepted entry. Email notifications are sent automatically for each successful entry and exit, and administrators and students can view their attendance records via a Flask-based web interface. In order to visually depict attendance trends and facilitate more efficient and transparent monitoring and decision-making, the system also incorporates Power BI dashboards and allows data export to Excel.

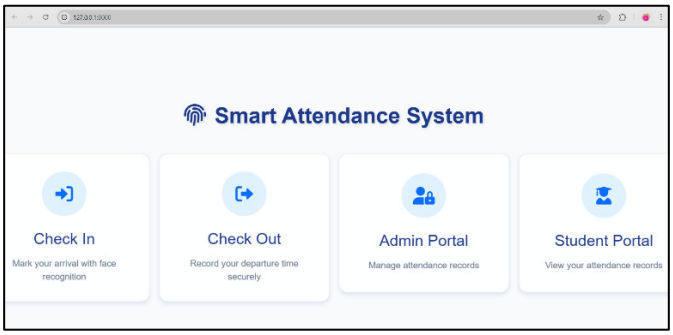

Fig. 2 Home Dashboard of Smart Attendance System

1) Home Dashboard Overview :

Users can easily navigate the Face Recognition Attendance System's home dashboard thanks to its clear and well-organized layout. Check-in, Check-out, Admin Portal, and Student Portal are its four main modules. Every module has a clear label and an easy-to-understand icon to help users navigate their tasks with ease. In addition to administrators being able to manage attendance records, students can check in and out in real time face-to-face. By enabling users to examine their own attendance records, the student portal encourages openness and system participation.

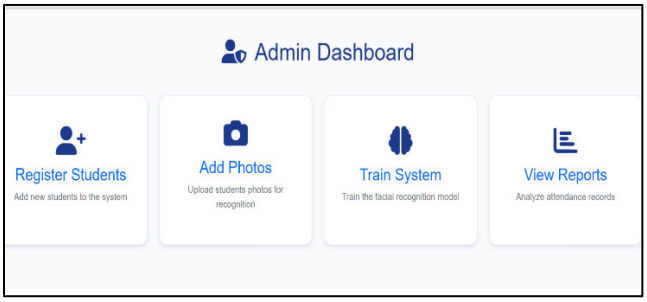

Fig. 3 Admin Dashboard of Smart Attendance System

2) Admin Dashboard Overview :

The four main features of the Admin Dashboard—Register Students, Add Photos, Train System, and View Reports—give administrators complete control over student attendance management. By entering new students' information, uploading facial images to train the recognition model, and starting the model training process straight from the interface,

administrators can quickly onboard new students. Furthermore, the View Reports module facilitates effective attendance data analysis, providing instant access to individual records and trends. Because of the layout's intuitive design, administrators can complete tasks quickly and efficiently.

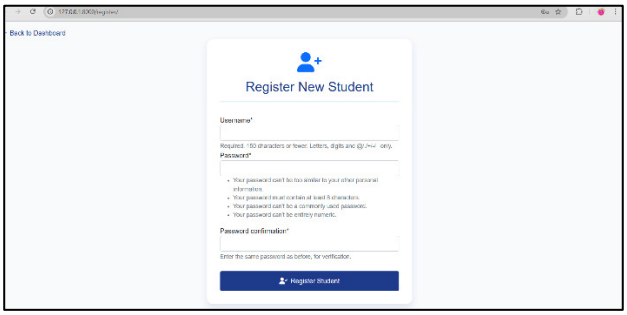

Fig. 4 Student Registration Interface

*3) **Student Registration Module :***

Administrators can safely add new students to the system using this interface. The form asks for basic information like username and password, and it has built-in validation to make sure the passwords are strong and distinct. By reducing input errors, the password confirmation field provides an additional degree of security. The administrator is guided through each step with clear instructions, guaranteeing accurate data entry. Enabling face recognition functionality connected to each student's identity requires completing this module.

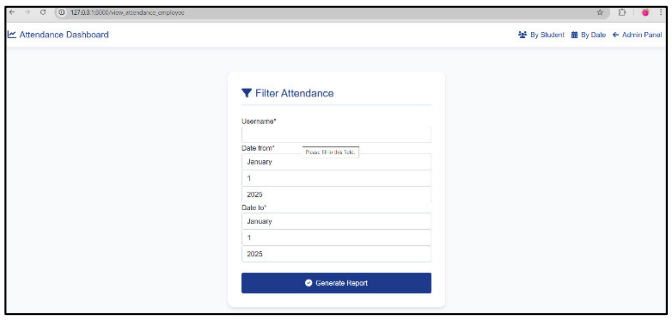

Fig. 5 Attendance Filtering Interface

*4) **Attendance Report Generation :***

By picking a particular student and specifying a range of dates, this module allows users to create personalized attendance reports. The filter allows for flexible attendance tracking over specified time periods by including inputs for both start and end dates. Following completion of the necessary fields, the "Generate Report" button gathers and presents the pertinent attendance information. This feature helps administrators and students keep an eye on attendance trends, guaranteeing openness and effective record-keeping.

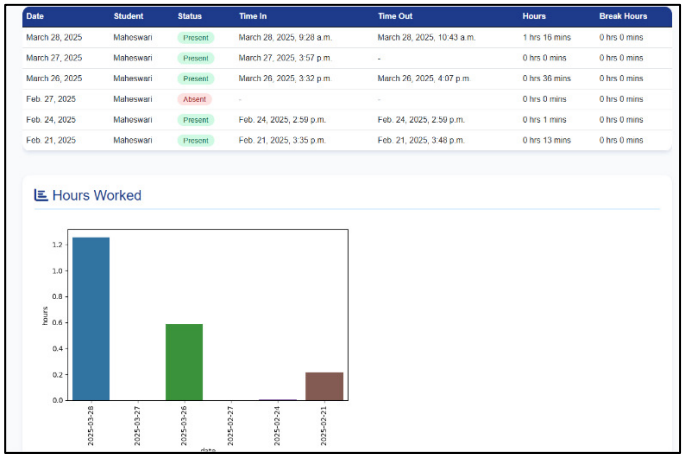

Fig. 6 Student Attendance Summary

*5) **Student Attendance Visualization :***

A comprehensive overview of each student's attendance is provided by this interface, which also includes daily check-in and check-out times, total hours worked, and break times. For a quick overview, the top panel shows the total number of days, present days, and absent days. The student's working hours are displayed in a dynamic bar chart below, which lets users quickly monitor engagement and punctuality. Clarity is improved and well-informed attendance analysis is supported by this visual representation.

VII. CONCLUSIONS

For automated attendance management in educational institutions, the Face Recognition

Attendance System offers a dependable and intuitive solution. In order to minimize human error and improve security, the system effectively logs student check-ins and check-outs using real-time facial recognition. A smooth and simple experience for all users is guaranteed by the integration of role-based access (admin and student portals), secure student registration, and graphical attendance analytics. The visual components, like filterable reports and dynamic charts, make it simple to track attendance trends and encourage responsibility.

A. Efficient Attendance Management :

The LBPH facial recognition algorithm is used by the system to automate the attendance process, guaranteeing precise and instantaneous identification. By minimizing manual intervention, administrative workload is decreased and reliability is increased.

B. Secure Student Registration :

Enrollment in the system is restricted to authorized users only thanks to a password-protected student registration module. System integrity is improved and unwanted access is avoided through validation checks performed during registration.

C. Role-Based Portals :

Administrators and students can access separate portals on the platform. Administrators are able to create attendance reports, train the recognition model, upload photos, and register students. Students can see thorough summaries of their own attendance records.

D. Graphical Attendance Insights :

Users can quickly comprehend participation trends with the aid of visual representations of working hours and attendance summaries. The system is easy to use and educational because it combines dynamic bar charts with tabular data.

E. Scalability and Adaptability :

The system, which was developed with Flask and Python, is very scalable and can be extended to accommodate bigger datasets, extra features like mobile alerts, and integration with other learning platforms. Future enhancements and institutional customization are supported by its modular architectures.

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