Web Enabled AI Based Facial Attendance Marking Platform

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***Abstract*— The creation of an automated facial recognition technology system for monitoring student attendance in the classroom is the aim of the proposed project. The issues with conventional attendance management will be resolved by this method, particularly in big classes where proxy attendance is frequently observed. The system aims to provide a state-of- the-art, practical, and scalable attendance-tracking solution. Some of its main benefits include the use of facial recogni- tion to track attendance, continuous observation to increase accuracy, and integration with security cameras to decrease proxy attendance. The automation of the system's attendance tracking reduces human labor and boosts dependability and efficiency as compared to conventional methods.**

It employs a methodical process that includes actions like taking webcam pictures, identifying faces, comparing, and identifying them, as well as keeping track of attendance. A validation experiment is conducted to assess the effectiveness of the system.

I. INTRODUCTION

Keeping track of student attendance is crucial for academic advancement and accountability in educational institutions, making it a vital component of organizational administration. Especially in big courses or hectic situations, traditional means of maintaining attendance, including manual roll calls or paper-based systems, sometimes prove to be laborious and error-prone.

Organizations have looked into a variety of technologies to automate the process of managing attendance, seeing the need for more dependable and effective solutions. Among the strategies used to expedite attendance recording are biometric techniques like fingerprinting and iris scanning. Even though these techniques have benefits like personalized identification and less dependence on tangible tokens, user acceptability and implementation remain issues.

Facial recognition technology [1] has become a viable substitute for attendance management in recent times. Facial recognition technology has various benefits over conventional biometric techniques, such as non-intrusiveness, user-friendliness, and scalability. Without the need for specialized hardware or direct physical touch, facial recognition systems can effectively identify people by evaluating distinctive facial traits like the position of the lips, nose, and eyes.

However, there are obstacles relating to both technical difficulties and ethical issues that prevent facial recognition from being widely used for attendance management. The performance of facial recognition algorithms can be impacted by variations in illumination, facial expressions, and occlusions, which can result in errors or incorrect identifications. Furthermore, the use of facial recognition systems requires careful thought and mitigation techniques due to privacy, data security, and algorithmic bias problems.

II. LITERATURE SURVEY

A. Literature

Advances in facial recognition systems have been made by combining several techniques to increase resilience and accuracy. A key component of system development is training models to identify faces in a variety of scenarios using a variety of datasets. To tackle the problem of face identification behind masks, scientists gather two datasets: one with real-world face photos and another that has been artificially enhanced with virtual masks. This increases system adaptability by allowing the model to detect whether authorized people are logging

Researchers experiment with preprocessing approaches including contrast adjustment and filter application to improve recognition accuracy. Contrast adjustment modifies pixel intensities to improve image quality, whilst filters such as Gaussian Blur, Median, and Bilateral filters work to lessen noise and improve the clarity of features. Researchers establish ideal parameters for these techniques by empirical testing, assuring improved detection and recognition accuracy.

Improvements in face detection algorithms also have a major impact on system performance. Algorithms for facial recognition enhance the precision and effectiveness of later procedures by separating distinct facial areas from intricate backgrounds. When compared to traditional procedures, evaluation findings show that the suggested detection methods are effective in achieving high detection accuracy rates.

B. Background

The research paper by [17] methodology comprises background subtraction to isolate faces, enhancing detection accuracy. After subtraction, faces are detected and marked, with emphasis on accuracy post-subtraction.

TABLE I
PERFORMANCE OF VARIOUS RESEARCH PAPERS

Literature	Data Set size	Highest Accuracy
[17]	<200 images	87% (Recognition)
[18]	40 images	80%
[20]	200 images	92% (With different expressions)

Detected faces are then cropped from the original image for individual processing. Finally, eigenvalue-based face recognition is employed for identification due to its speed and suitability. This method analyzes facial features extracted from cropped images to recognize individuals. By combining background subtraction, precise face detection, cropping, and eigenvalue-based recognition, the methodology ensures efficient and accurate identification of faces, particularly beneficial for applications like security systems and surveillance where reliable face recognition is crucial.

In a similar context, many projects have been carried out one such project is " Online attendance system based on facial recognition with face mask detection" [18] has a prime focus on recognizing faces with and without masks, enabling both identity recognition and mask detection. A Python program manages the training process, creating embeddings from face images and training an SVM model. The trained model is then applied to input images for facial recognition. Additionally, two methods for mask detection are explored: employing a separate "face mask detector" program and augmenting the facial recognition program to detect masks using a synthetic dataset. Comparative analysis focuses on the efficiency of recognition and detection processes. Overall, the methodology integrates face recognition and mask detection, enhancing security and usability in scenarios requiring both functionalities.

"An improved face recognition algorithm and its application in attendance management system" [19] simplifies tracking by utilizing a student database containing names, enrollment numbers, and course details, alongside captured facial images. Multiple ceiling-mounted cameras cover the classroom, capturing images during lectures to ensure comprehensive coverage. Image processing involves blur reduction using Generative Adversarial Networks (GANs) and face detection using Haar classifiers. Garbo filters extract facial features for recognition, with methods like K-nearest neighbor, convolutions neural networks (CNN), and support vector machine (SVM). Redundant faces from multiple camera instances are removed, ensuring accurate attendance. Reports are generated in Excel format, marking students' presence based on recognized faces. The system's lucid operations make it efficient for real-time attendance management, enhancing classroom management effortlessly.

The methodology in "Student Attendance System using Face Recognition" [20] focuses on enhancing face recognition accuracy through two main approaches. Firstly, contrast adjustment optimizes input face images, while the comparison of Gaussian Blur, Median, and Bilateral filters reveals the bilateral filter as the most effective. A function is devised to reduce noise and control contrast, followed by histogram equalization to address lighting issues. The improved images undergo a Local Binary Pattern (LBP) algorithm aided by advanced processing techniques. Evaluation metrics include False Negatives, Unknown Faces, and False Recognition. Performance evaluation demonstrates significantly improved face recognition rates compared to original methods, validating the effectiveness of the proposed enhancements in real-life scenarios. The methodology's novelty lies in combining the LBP algorithm with advanced image processing techniques, such as contrast adjustment, bilateral filtering, histogram equalization, and image blending, to incrementally improve recognition accuracy.

The performance of these literature have been compared in Table 1. Table shows that all these research papers have small datasets and thus are not suitable for developing industry purpose attendance marking system, keeping this in mind we have used LFW[**?**] dataset which is a large publicly available dataset suitable for training model also preventing overfitting.

III. PROPOSED METHODOLOGY

With a focus on integrating Histogram of Oriented Gradients (HOG) technology for improved face recognition capabilities, the research paper's proposed methodology aims to develop an automated attendance management system that makes use of cutting-edge technologies, such as React with Next.js[4], Python FastAPI[2], TypeScript, NextAuth[6].js, MongoDB[5], OpenCV[7], and dlib. Through the system, users will be able to safely record their attendance, mark their attendance under the names of their teachers, and log in to a web application. Furthermore, the system will use HOG technology to extract distinguishing characteristics from webcam-captured facial photos, enhancing attendance monitoring accuracy and dependability.

The web application's front end will be designed and implemented using React with Next.js[4] Node.js and TypeScript as the first step in the development process.

The dashboard, attendance marking, and login user interfaces will all be part of the front end. React provides a strong framework for developing server-rendered React

apps with Next.js[4], and TypeScript improves the readability and maintainability of the code.

The backend will be created concurrently with Python FastAPI, an efficient and quick framework for developing APIs. FastAPI is a good fit for real-time applications such as attendance management because of its asynchronous features. The backend will manage business logic, API queries, and database communication.

NextAuth[6].js will be used to implement authorization and authentication, enabling users to authenticate via a variety of sources. Users who have verified their identity can indicate their attendance on the dashboard.

OpenCV[7] and dlib libraries will be used by the attendance management system's core for face recognition, and HOG technology will be added for feature extraction. A popular computer vision package, OpenCV[7], has many uses, and dlib is well known for its face recognition powers. Together, these libraries will use the webcam capability to record students in real-time and scan their photographs for facial recognition.

By removing edges and shapes from facial photos, HOG technology is essential to the face recognition process. Because this data is represented as gradient orientation histograms, the algorithm can accurately distinguish between various individuals. For applications like face detection and recognition, HOG is a good fit because of its resilience to changes in lighting, image noise, and background clutter.

HOG features taken from photographed faces will be compared with reference features kept in the database of the system to assess attendance. The system will be able to precisely match each detected face with the matching student identity thanks to this comparison. After validation is successful, the system will update the teacher's class attendance record in MongoDB[5], a NoSQL database renowned for its scalability and flexibility. To enable effective data management and retrieval, MongoDB[5] will store user information, attendance logs, and other pertinent data in an organized fashion.

A. Dataset used

The "face recognition" module utilized in your research paper is a versatile tool trained on the Labeled Faces in the Wild (LFW) dataset.[21] This dataset, renowned in the field of face recognition, encompasses over 13,000 images collected from the internet, portraying various individuals under diverse conditions like pose, lighting, and expression. Each image is labeled with the respective person's identity, enabling supervised learning and evaluation of recognition algorithms. Leveraging the LFW dataset, the "face recognition" module demonstrates proficiency in accurately identifying faces across a broad spectrum of real-world scenarios, making it a valuable asset in your research endeavors.

B. Flow Chart

The dashboard will show the user's attendance status and act as a single point of contact for tracking academic progress and attendance-related data. Teachers will also be able to get daily attendance data for every student from their dashboard to monitor academic progress effectively.(Figure 3)

Fig. 1. Sample Data

Fig. 2. Sample Data

To summarize, the suggested approach entails utilizing React with Next.js[4], Node,js[15] Python FastAPI, TypeScript, NextAuth[6].js, MongoDB[5], OpenCV[7], and dlib libraries to create an all-inclusive attendance management system. By combining these technologies with HOG technology for improved facial recognition capabilities, classroom attendance management will be more accurate and efficient thanks to a user-friendly interface, secure authentication, and real-time attendance tracking.

The suggested methodology creates an automated attendance management system by combining cutting-

TABLE II

PERFORMANCE METRICS AND OCCURRENCE COUNT

Label	Description	Occurrence count
TP	Predicts accurately and matches with the correct label	38
FN	Unable to match the captured image with the stored images	4
FP	Determines unauthorized people	2
TN	Rejects unauthorized people	6

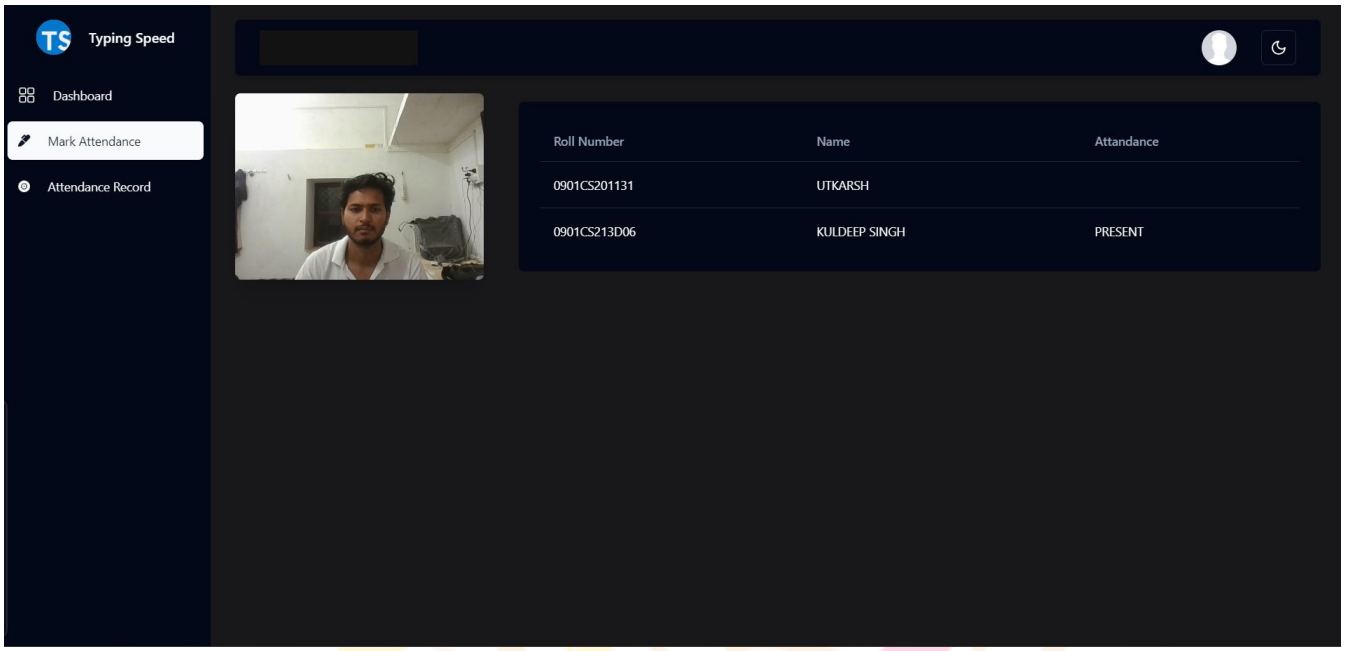

Fig. 3. Face Detected - Attendance Marked

edge technologies like React with Next.js [4], Node,js[15], Python FastAPI, TypeScript, NextAuth[6].js, MongoDB[5], OpenCV[7], and dlib libraries. By using HOG technology, facial recognition capabilities are improved, resulting in precise and effective attendance tracking (Figure 4). With its intuitive UI and real-time attendance tracking, the system provides a strong means of enhancing academic administration and classroom management.

IV. WORK DONE AND RESULTS ANALYSIS

Our main website has a simplified login process, making it easier for students to view their attendance history and course information. Students are automatically taken to the dashboard, where they can easily access their attendance records and course information, after completing the authentication process successfully. React, Next.js[4], Node,js[15], and TypeScript were used in the dashboard interface's design to provide a user-friendly, responsive, and easily navigable experience.

A. HOG Intuition used :

Firstly the image is captured by the camera and is sent for resizing. It is converted into a pixel vector format after resizing the input image to fit standard segment sizes such as 128x64 or others. Following this, the image gradients are calculated to capture directional intensity changes. The horizontal gradient $G_x(r, c)$ is computed by subtracting the intensity value of the pixel to the right from the intensity value of the pixel to the left:

$$G_x(r,c) = l(r,c+1) - l(r,c-1)$$

Similarly, the vertical gradient $G_y(r, c)$ is obtained by subtracting the intensity value of the pixel below from the intensity value of the pixel above:

$$G_y(r,c) = l(r+1,c) - l(r-1,c)$$

These gradient computations provide crucial insights into the intensity change rate and direction within the image, which are essential for subsequent processing steps in the Histogram of Oriented Gradients (HOG) approach. For each pixel, we calculated the gradient magnitude [Figure 3] (the strength of the change in intensity) and the gradient orientation (the direction of the change) using

Gradient Magnitude (Gradient Strength):

$$\text{Magnitude}(x,y) = \sqrt{G_x(x,y)^2 + G_y(x,y)^2}$$

Gradient Orientation (Gradient Direction):

$$\text{Angle}(\theta) = \tan^{-1}\left(\frac{G_y}{G_x}\right)$$

Histograms of gradient orientations are constructed for each cell, capturing the distribution of gradient angles within the cell. These histograms use bins covering a range of angles, often 0 to 180 degrees,[Figure 4] with contributions weighted by gradient magnitudes. Now normalization can be applied to the histograms to enhance robustness against variations in illumination and contrast.

Students can record their attendance conveniently thanks to the dashboard's seamless integration of the attendance marking procedure. The system takes pictures of the students and verifies their identities in real-time by using the web camera feature. Modern facial recognition tools like OpenCV[7] and dlib libraries, together with the accuracy-boosting Histogram of Oriented Gradients (HOG) technology, power this authentication process. To extract features from collected facial photos and enable

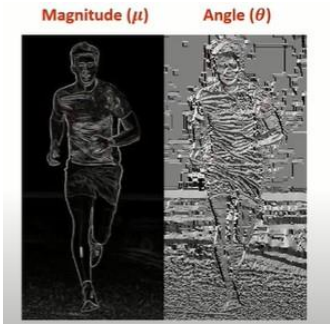

Fig. 4. magnitude and angle distribution

the system to identify students despite differences in lighting and facial looks correctly, HOG technology is essential. The robustness of this face recognition process guarantees the dependability and reliability of attendance tracking, which is essential for the operational efficiency of academic institutions.

B. Evaluation Metrics

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$
$$= \frac{44}{50} \times 100 = 0.88 \times 100$$
$$= 88\%$$

$$Precision = \frac{TP}{TP + FP} \times 100$$
$$= \frac{38}{38 + 2} \times 100$$
$$= \frac{38}{40} \times 100$$
$$= 0.95 \times 100$$
$$= 95\%$$

$$Sensitivity = \frac{TP}{TP + FN} \times 100$$
$$= \frac{38}{38 + 4} \times 100$$
$$= \frac{38}{42} \times 100$$
$$= 0.9048 \times 100$$
$$= 90.48\%$$

TABLE III

PERFORMANCE METRICS

Metric	Value
Accuracy	88%
Sensitivity	90.48%
Precision	95%

After authentication and attendance marking are completed successfully, the system updates attendance records in the NoSQL database MongoDB[5], which is adaptable and scalable. MongoDB[5] facilitates easy data retrieval

Fig. 5. Bins distribution

and management by effectively managing user details, attendance logs, and other relevant data.

Students can easily track their academic progress and receive attendance-related information via the dashboard, which acts as a central center. Furthermore, teachers gain access to thorough daily attendance records through their dashboard, which facilitates efficient tracking of attendance and academic progress.

V. CONCLUSION AND FUTURE SCOPE

The creation and effective deployment of an automated attendance management system, which achieved noteworthy precision, accuracy, and sensitivity findings, marks the conclusion of the study article. Reliable and trustworthy attendance records are ensured by the system's 95% precision rate, which successfully identifies actual positive attendance markers while limiting false positives. Utilizing cutting-edge tools such as Python FastAPI, TypeScript, NextAuth.js [6], MongoDB[5], OpenCV[7], dlib libraries, and React with Next.js[4][14], and the system achieves a remarkable 88% accuracy rate while tracking student attendance in real-time classroom situations. By incorporating Histogram of Oriented Gradients (HOG) technology, face recognition capabilities are greatly improved, guaranteeing accurate student identification even in difficult situations like changing lighting and facial appearances. Additionally, the system attains a remarkable sensitivity rate of 90.48 efficiently tracking and identifying student attendance. These outcomes highlight the system's effectiveness in precisely recording attendance and providing administrators and teachers with easy access to attendance data.

Future developments in the automated attendance management system can potentially improve its efficacy and utility even more. While implementing machine learning algorithms would enable predictive analysis to identify attendance patterns and facilitate early intervention strategies for students at risk of chronic absenteeism, the integration of additional biometric authentication methods, such as fingerprint or iris recognition, would strengthen security and accuracy in attendance tracking. The system's accessibility might be improved by creating a mobile application that would let users indicate attendance and access information from a distance. Expanding analytics capabilities to include trend analysis and predictive modeling could provide deeper insights into attendance patterns and student behavior. Furthermore, integrating IoT devices for automatic attendance tracking and Learning Management Systems for smooth data exchange will expedite procedures and offer real-time data insights, thereby improving attendance management techniques in educational settings. These developments can greatly increase student engagement, academic performance, and overall operational effectiveness in educational settings.

This automated attendance management system project could look into several ways to improve its efficacy and performance. First, adding more biometric verification

techniques, like iris or fingerprint recognition, could improve attendance tracking accuracy and security. Using machine learning algorithms would enable early intervention techniques for kids who are at risk of chronic absenteeism, as well as predictive analysis, attendance trends, and identification.

Creating a mobile application for the system would further improve accessibility by letting users indicate attendance and get records from a distance. Increasing the scope of analytics to include trend analysis and predictive modeling may shed more light on student behavior and attendance trends. Last but not least, real-time data insights and process streamlining might be achieved by combining the system with learning management systems for smooth data sharing and investigating IoT device connections for automated attendance tracking. These possible developments can improve attendance control procedures in learning settings, eventually leading to increased student participation and academic success.

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