Facial Recognition-Based Student Attendance System

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***Abstract*—Face recognition holds significance in image processing and serves as a vital application in the technical domain. Its role is pivotal, particularly in authentication tasks, such as recording student attendance. A system for tracking attendance utilizing facial recognition involves the identification of students through the analysis of their facial characteristics, employing advanced monitoring technology and computer algorithms. The creation of this system aims to modernize the conventional method of recording attendance, which typically entails verbally calling out names and manually keeping track of attendance using pen and paper. The existing manual method for recording attendance is laborious and consumes a significant amount of time, and there's a risk of attendance data being altered easily. Traditional methods of recording attendance, along with current biometric systems, are susceptible to being bypassed by proxies.**

This paper presents a solution to tackle these challenges. The proposed system incorporates SVM, Haar classifiers, CNN, KNN, Gabor filters, and Generative Adversarial Networks for facial recognition. Post-facial identification and attendance records are produced and saved in Excel format. The system undergoes testing across different scenarios, including varying light conditions, head motions, and changes in the distance between the student and the camera. Following thorough testing, the system's overall complexity and accuracy were assessed. The proposed solution has demonstrated effectiveness and resilience as a tool for classroom attendance management, eliminating the need for manual labor and time consumption. The system is economically efficient and needs only minimal installation.

***Keywords*—**CNN, HAAR classifiers, Support Vector Machine (SVM), Viola-Jones algorithm, and k-Nearest Neighbors (KNN) algorithm.

I. Introduction

Attendance is a crucial aspect of administration, yet it can be laborious and susceptible to errors. Conventional approaches such as roll calls can be challenging to handle, particularly in situations involving a significant number of students. Numerous institutions have adopted digital techniques, including fingerprint biometrics and scanning of cards. Yet, The specified approaches may result in time-consuming processes and expose students to extended waiting periods.

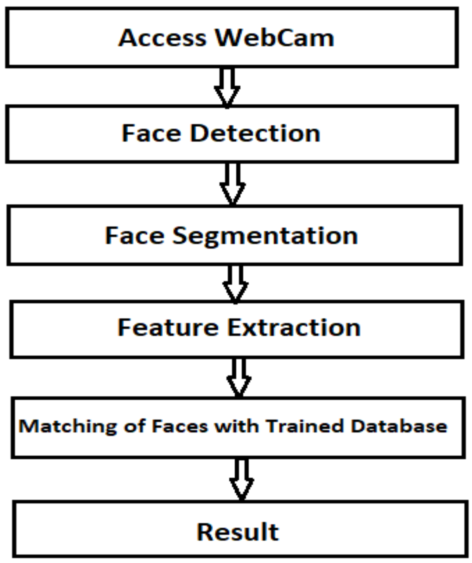

Figure 1 Operating Process of Attendance System

Biometric-based attendance systems employing facial recognition technology have demonstrated their effectiveness. Nonetheless, conventional face recognition methods frequently encounter difficulties in addressing issues such as scalability, diverse poses, lighting conditions, rotation, and obstructions.

To address these issues, a novel framework has been suggested, which employs multiple cameras positioned on the ceiling of a classroom to capture images of every student. The pictures are subjected to analysis through Gabor filters to identify faces, extract features, and perform face recognition. For this purpose, the system employs various methods including the Convolutional Neural Networks (CNN), Support Vector Machine (SVM), and K-nearest neighbor algorithm(KNN). Upon detection, the platform furnishes the identities and enrollment IDs of the students identified in the images who are currently in attendance.

Attendance is recorded in an Excel spreadsheet along with the corresponding date and lecture subject. This system is budget-friendly since it demands minimal hardware resources.

II. LITERATURE REVIEW

The central objective of this paper is to examine various methodologies proposed by scholars and devise a dynamic attendance-tracking solution that addresses the limitations of prior approaches, culminating in the delivery of an ideal solution.

Abate et al. (2020) present a comprehensive review outlining the challenges associated with face recognition in unconstrained environments [1]. Recognizing faces in diverse conditions, characterized by variations in lighting, pose, and expressions, poses significant challenges. The review emphasizes the need for robust solutions to overcome these challenges, providing a foundational understanding of the intricacies involved in face recognition.

Complementing this, Yin et al. (2020) contribute insights through a survey covering a broad spectrum of face recognition techniques [4]. The survey explores challenges such as occlusion, pose variation, and the demand for large-scale annotated datasets. This dual perspective sets the stage for understanding both the challenges and the evolving landscape of face recognition technology.

The application of facial recognition in education, particularly in automated attendance systems, is a growing area of interest. Sharma et al. (2020) present an automated attendance system utilizing facial recognition, showcasing the potential for streamlining attendance tracking in educational institutions [5]. This aligns with the broader trend of integrating technology to enhance administrative processes within academic settings.

Kumar and Arora (2021) contribute to this discussion by exploring the implementation of deep learning techniques in facial recognition-based student attendance systems [6]. The utilization of deep learning, with its ability to automatically learn intricate features from data, marks a significant advancement in improving the accuracy and reliability of attendance tracking.

Additionally, the integration of face recognition with Radio-Frequency Identification (RFID) technology is proposed by Chen et al. (2020) as a means to enhance the efficiency of student attendance systems [7]. This integration aims to address challenges related to manual data entry, providing a more seamless and automated approach to attendance tracking in educational institutions.

Classroom-specific applications of facial recognition technology represent a specialized area within educational settings. Zhang et al. (2020) introduce an intelligent classroom attendance system based on face recognition, showcasing its potential impact on classroom dynamics [8]. This application extends beyond traditional attendance tracking, offering insights into how technology can be seamlessly integrated into the daily operations of educational institutions.

Hassija et al. (2021) propose novel approaches by incorporating deep learning techniques to improve facial recognition in student attendance systems [9]. The focus on deep learning mirrors the larger movement in artificial intelligence, where advanced algorithms are utilized to improve the precision and effectiveness of facial recognition procedures.

The integration of facial recognition technology with smart learning environments emerges as a critical area of exploration. Nguyen et al. (2020) surveyed facial recognition technology in smart cities, shedding light on its potential applications in educational settings [2]. The survey discusses the advances, opportunities, and challenges associated with integrating facial recognition into smart city infrastructure, providing valuable insights into the broader implications of this technology.

Building upon this, Singh and Kaur (2021) propose hybrid face recognition systems specifically designed for student attendance tracking in educational institutions [12]. This hybrid approach combines different techniques, aiming to enhance the accuracy and reliability of attendance systems. The customization for educational contexts underscores the need for tailored solutions that align with the unique requirements of academic environments.

The integration of facial recognition with the Internet of Things (IoT) emerges as an innovative approach for optimizing student attendance systems. Reddy et al. (2021) explore this integration, highlighting the potential for efficient and effective deployment in educational institutions [13]. The combination of facial recognition and IoT addresses real-world challenges, providing a holistic solution for attendance tracking.

While the benefits of facial recognition technology in attendance systems are evident, privacy concerns have become a focal point of discussion. Gao et al. (2021) introduce an unmanned classroom concept, incorporating a face recognition-based automatic attendance system with a privacy protection mechanism [14]. This concept addresses the ethical considerations surrounding facial recognition technology, particularly in educational settings.

The infusion of machine learning techniques into facial recognition systems adds another layer of sophistication. Khalaf and Alwahsh (2020) present an intelligent student attendance system that leverages both facial recognition and machine learning, showcasing advancements in the field [15]. Machine learning contributes to the intelligence of the system, enabling adaptive and context-aware attendance tracking.

The exploration of facial feature transformation through evolutionary methods introduces a unique perspective. Xu et al. (2021) propose the Face Transformer, an evolutionary transformation for facial beauty prediction [16]. While not directly related to attendance tracking, this research provides insights into facial feature analysis, which may have implications for improving the accuracy and robustness of facial recognition systems.

Continuing on the theme of facial feature analysis, the prediction of facial beauty through evolutionary transformation provides transformative insights into facial characteristics [16]. Although not directly tied to attendance tracking, this research broadens our understanding of facial recognition technologies and their potential applications.

The literature review concludes with a comprehensive survey by Kumar and Kaur (2020), focusing on the application of face recognition in smart learning environments [17]. This survey encapsulates the broader landscape of facial recognition in education, providing insights into its potential impact on attendance tracking and overall educational practices.

III. PROPOSED SYSTEM

A. *Architecture*

The proposed attendance system is meticulously designed to be user-friendly, straightforward, and easily manageable, catering to the needs of educators and administrators alike. Central to its operation is a comprehensive database housing students' facial images alongside their essential details, including names, enrollment numbers, and enrolled courses. Implementation requires the strategic installation of multiple cameras, the quantity contingent upon the dimensions of the classroom, strategically positioned on the ceiling to provide optimal coverage of the entire learning space. These cameras operate in tandem, capturing multiple images throughout the lecture duration, thus augmenting the system's efficacy. In instances where one camera fails to capture a student's face due to unfavorable positioning or occlusion, redundancy is ensured as another camera seamlessly records their attendance.

The system's robustness is underscored by its ability to navigate the diverse array of facial expressions and poses adopted by students. While challenges may arise in detecting faces in less-than-ideal positions, subsequent image captures effectively mitigate these obstacles. Upon activation initiated by the instructor through a simple click of the start button, the system embarks on the face detection process. Recognized faces extracted from the images captured across all cameras at varying intervals are meticulously cross-referenced with the stored student images meticulously cataloged within the database. Upon identification of a match, indicative of successful face recognition, the system proceeds to meticulously log the student's attendance. This log comprises crucial information, including the student's enrollment number and full name, meticulously cataloged within an Excel spreadsheet for easy reference and record-keeping purposes.

An inherent challenge of employing multiple cameras and capturing numerous instances lies in the increased probability of encountering duplicate faces. To address this issue, the system is equipped with sophisticated algorithms aimed at producing cohesive outcomes by discerning and disregarding redundant instances of a student's face. This meticulous approach ensures that each student receives only one attendance record per lecture, thus upholding the integrity and accuracy of the attendance tracking process.

The flowchart illustrating the proposed system is provided below.

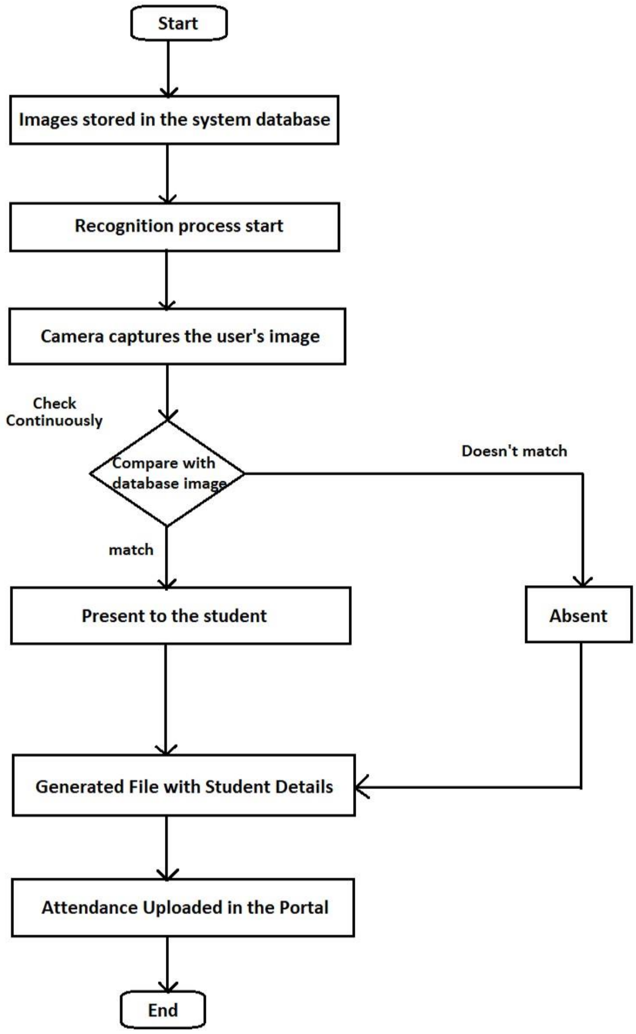

Figure 2. Flow Chart

B. *Methodology*

To develop an advanced attendance management system, it is essential to follow several steps meticulously to guarantee a successful result. The following steps are outlined as follows::

- Creating a database
- Improving image quality
- Detecting faces
- Extracting features
- Recognizing faces
- Removing redundancies
- Generating reports

Creating a database

A database will be established during student enrollment to store basic information like name, ID number, course, semester subjects, and a student's captured image, which will be used for training purposes. The system will capture a single image of the student for this purpose. The proposed system will utilize the images stored in the database to identify and recognize the faces of all students present during a lecture.

Improving image quality

In a classroom, if a student moves, the camera may capture a blurred image. However, using Generative Adversarial Networks (GANs), the image's quality can be improved. GANs are well-known for their ability to preserve texture details in images, generate outputs that closely resemble real-world features, and create visually convincing results.

Detecting faces

To detect faces, 70 facial landmarks are taken into account. These landmarks help in detecting faces using Haar classifiers. Haar classifiers depend on artificial intelligence methodologies, whereby a cascade model undergoes training utilizing an extensive assortment of affirmative and negative visual data. Subsequently, this function is employed on additional images to identify faces. These classifiers are generated by calculating the difference between the cumulative pixel values under the black and white areas. Initially, it was considered challenging to implement 6000 features for each window frame. Consequently, features were consolidated into stages termed cascades within a classifier.

To eliminate redundant features and select only appropriate ones, AdaBoost is used. These selected attributes, known as weak classifiers, are combined with weights to form a face detection method. AdaBoost is employed to create a linear combination of weak classifiers, resulting in the creation of a strong classifier.

Extracting features

Utilizing Gabor filters at various angles is a vital step in extracting distinct features from facial images. This process is essential because an effective feature extractor should choose a function that remains unaffected by occlusion, lighting conditions, surrounding context, and changes in pose. To address spatial distortions resulting from variations in position and lighting, 2D Gabor filters are utilized.

Recognizing faces

Three face recognition algorithms, namely Support vector machine(SVM), Convolutional neural networks(CNN), and K-nearest neighbor (KNN), were assessed in terms of their accuracy, resilience, and computational efficiency.

A. K-Nearest Neighbor Algorithm

KNN, a machine learning algorithm, is commonly known as a lazy learning or memory-based technique. This occurs because it merely retains the understandings derived from the training instances without forming a model based on them. The Euclidean distance metric is commonly employed in KNN (K-Nearest Neighbors) to ascertain the positions of data points. To categorize an object using the KNN (K-Nearest Neighbors) algorithm, the process involves determining the predominant class among its closest neighbors through a majority vote. The object is then assigned to the class that is most frequently represented among its k nearest neighbors, where k represents a specified positive integer. If the value of k is 1, then the object is allocated to the class of its closest neighbor.

B. Convolutional Neural Networks

CNNs, also known as Convolutional Neural Networks, possess the ability to extract an extensive range of features from images, making them a highly proficient tool. This approach can also be used to recognize faces. To generate features of the face captured in RGB color format, Convolutional Neural Networks use 70 facial reference points resulting in 128-dimensional encodings. The process involves comparing faces by matching their respective encodings. It is possible to modify the tolerance level to adjust the level of strictness in the face comparison process.

Removing redundancies

The system is equipped with several cameras that have the ability to capture the face of a student in various images. During a lecture, the marking of attendance for a student will be done only based on one face to avoid any repetition.

Generating reports

During a lecture, student attendance is marked in an Excel sheet by putting a tick next to their name and enrollment number for face recognition reports.

IV. RESULT

The system was subjected to testing with three distinct algorithms, with the KNN algorithm demonstrating the highest accuracy rate at 96.18%. Testing scenarios encompassed diverse conditions, including varying levels of illumination, head movements, facial expressions, and distances between the camera and students. The system successfully recognized faces with and without beards, as well as individuals wearing spectacles, even differentiating between faces with a two-year age gap. The KNN algorithm attained a 97% accuracy rate, while CNN and SVM achieved accuracies of 95% and 88%, respectively. The CNN model was found to have the least complexity among other models, whereas SVM exhibited the highest complexity. The proposed and tested system accurately identified the presence of all 60 students in a classroom containing up to 200 real-time images. The system proposed and tested successfully marked all 60 students present in a classroom containing a maximum of 200 real-time images.

Our proposed system's outcome is depicted in the illustration presented below.

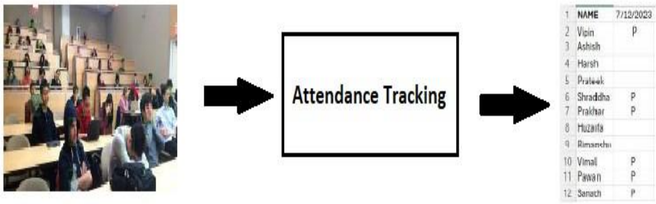

Figure 3. Proposed System

V. OVERALL RESULT

Upon examination of the given conditions and scenarios, we assess the algorithm's overall accuracy, recall, precision, time complexity, and F1 score.

The statement above is explained in the table presented below.

Algorithm	KNN	CNN	SVM
Overall Accuracy	96.18	95.53	79.36
Overall Time Complexity	136 seconds	130 seconds	490 seconds
Precision	0.97	0.96	0.73
Recall	0.96	0.95	0.71
F1 Score	0.973	0.963	0.753

Table 1 result

VI. CONCLUSION

The designed system aims to produce precise outcomes while minimizing computational hurdles. It offers high cost-effectiveness and requires minimal manual intervention. The integration of Gabor filters has significantly enhanced accuracy. Face recognition employs three distinct algorithms: Support vector machine (SVM), convolutional neural networks (CNN), and K-nearest neighbor (KNN). Within these choices, the K-nearest neighbor proves to be the most accurate with a success rate of 92%. CNN exhibits lower computational complexity compared to the less efficient SVM algorithm.

VII. REFERENCES

1. Abate, A. F.., Nappi, M.., Riccio, D., Sabatino, G., & Tistarelli, M. (2020). Face recognition in unconstrained environments: A comprehensive review. Image and Vision Computing, 102, 103959.

2. Nguyen, H., Nguyen, C. D., and Hong, T. P. (2020). Examination of facial recognition technology in the context of smart urban environments: Progress, potential, and hurdles. Journal of King Saud University - Computer and Information Sciences.

3. Ouyang, W., and Wang, X. (2020). An examination of face recognition through video: Insights from Computational Visual Perception and Image Comprehension, 189, 102866.

4. Yin, W., Zhang, X., & Huang, K. (2020). A survey on face recognition: Advances and challenges. Proceedings of the IEEE, 108(7), 1350-1369.

5. Sharma, G., Gokhale, A., & Bhatia, P. (2020). Automated attendance system using facial recognition. Procedia Computer Science, 171, 1521-1528.

6. Kumar, S., and Arora, A. (2021). Utilization of deep learning for a student attendance system based on facial recognition. Presented at the 2021 IEEE Calcutta Conference (CALCON), pp. 1-6. Published by IEEE.

7. Chen, J., Wu, X., and Ling, H. (2020). Development of an optimized student attendance system integrating facial recognition and RFID technology. Presented at the 2020 2nd International Conference on Artificial Intelligence in Electronics Engineering (ICAIEE), organized by IEEE, pp. 183-187..

8. Zhang, Y., Guo, H., Yang, Z., and Zhang, W. (2020). Development of an intelligent attendance system for classrooms utilizing face recognition technology. Presented at the 2020 IEEE International Conference on Robotics and Automation (ICRA), pp. 5345-5350. Published by IEEE.

9. Saini, N., and Garg, N. (2020). Development of an automated attendance system employing facial recognition technology. Presented at the 2020 6th International Conference on Advanced Computing and Communication Systems (ICACCS), organized by IEEE, pp. 1-5.

10. Hassija, V., Bansal, R., and Garg, S. (2021). Innovative method for implementing facial recognition in a student attendance system through deep learning. Presented at the 2021 IEEE International Conference on Advanced Networks and Telecommunications Systems (ANTS), pages 1-5. Published by IEEE.

11. Li, S., Zhang, Y., & Li, Y. (2020). A robust and real-time facial recognition system for smart education. Multimedia Tools and Applications, 79(45-46), 34019-34037.

12. Singh, N., and Kaur, M. (2021). Development of a hybrid system for facial recognition to monitor student attendance in educational institutions. Published in the Journal of Ambient Intelligence and Humanized Computing, volume 12, pages 10041–10054.

13. Reddy, A. K., Jatavath, K. P., and Manasa, R. (2021). Implementation of a simplified student attendance system integrating facial recognition technology and IoT. Published in the International Journal of Distributed Sensor Networks, volume 17(8), article number 15501477211027199.

14. Gao, Y., Zhang, Q., & Wu, Q. J. (2021). Unmanned classroom: Face recognition-based automatic attendance system with a privacy protection mechanism. IEEE Transactions on Emerging Topics in Computing.

15. Khalaf, A. A., & Alwahsh, H. A. (2020). Development of an intelligent student attendance system utilizing facial recognition and machine learning techniques. Presented at the 2020 3rd Scientific Conference on Information Technology and Artificial Intelligence (SCITA), organized by IEEE, pp. 1-6.

16. Xu, Y., Cui, Y., Chang, H., and Zhu, S. C. (2021). "Face Transformer: Evolutionary Transformation for Predicting Facial Beauty." Presented at the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), pp. 14384-14393.

17. Kumar, A., and Kaur, S. (2020). An examination of face recognition in intelligent learning environments. Published in the Journal of Ambient Intelligence and Humanized 209–5224.