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Real-Time Student Attendance Tracking Using YuNet Face Detection and SFace Recognition Models in Smart Campus Environments

[1]Rutuja R. Dakare, [2]Sangram T. Patil

[1]P G Scholar, [2]Professor
[1]Department of Computer Science and Engineering,
[1]D.Y. Patil Agriculture and Technical University, Kolhapur, India

Abstract : With the growing need for automation in educational institutes, intelligent attendance management systems have been developed. Manual registers, RFID cards, biometric devices are just a few traditional attendance systems that are prone to problems like proxy attendance, human error, data inconsistencies and the added burden of administration. To overcome these problems, this study suggests a smart attendance system to monitor the students in campus environment using face recognition system. A set of faces is created using a custom dataset of multiple images of faces taken from students at various lighting conditions and viewing angles. The images captured are then processed to enhance data quality and model performance, including resizing, normalization, noise reduction, and color conversion. The face detection uses the YuNet deep learning model, which has a lightweight architecture, high processing speed, and is suitable for real-time applications. After the faces are identified, key facial attributes are captured, and converted into numerical embeddings. The SFace recognition model is then generated and compared in terms of similarity measure like cosine similarity, Euclidean distance and so on. If a match is detected, the attendance module automatically logs the student's attendance and will not allow adding the same student again within a set time period. A second, administrative interface also allows students to be registered, attendance to be tracked and reports to be generated. The experimental results validate the accuracy, reliability and timeliness of the proposed system in terms of attendance recording and minimize manual workloads and fraudulent attendance practices. By combining with YuNet and SFace, the recognition performance is also improved, which is applicable to the current smart campus application and teaching scene.

Keywords—Face Recognition, Smart Attendance System, Deep Learning, YuNet, SFace, Face Detection, Image Preprocessing, Machine Learning, Real-Time Recognition

INTRODUCTION

Student attendance is one of the key management functions in the educational enterprise. Good attendance data enables tracking of student participation, promote good academic discipline and contribute to institutional decision making. The usual methods of attendance are manual registers, RFID cards or biometric systems. These methods, however, come with a number of drawbacks, including proxy attendance, data manipulation, device dependence and time consuming. Manual attendance system also demands a lot of efforts from the faculty and can lead to errors while maintaining the attendance records. With the educational institutions transitioning to Digital transformation, there is an increasing demand for Automated and intelligent Attendance systems that can be accurate, efficient and reliable.

Face recognition systems have been developed using recent advancements in artificial intelligence, machine learning and computer vision, which can automatically identify a person through their facial image. A computer-based system that identifies and verifies individuals by their unique facial features, without their having to interact with a person.A computer based system that recognizes and authenticates people based on their unique facial features without a person touching them. Face recognition can be performed remotely using the camera which is installed in the classrooms or campus premises without needing the physical presence of the user in the system. The technology has received considerable attention due to its potential of eliminating attendance fraud and boosting operational efficiency. Moreover, the recognition accuracy has been greatly improved even under various environments, with the use of the modern deep learning models.

The aim of the proposed Smart Attendance System is to provide an efficient attendance monitoring solution for the campus environment by implementing the face detection and face recognition algorithms of YuNet and SFace respectively. Students' facial images are captured and stored with personal information during the registration process. The images are then preprocessed to enhance quality and consistency prior to training and recognition. The facial region detection system, YuNet, accurately detects facial regions in real time, and the facial embedding system, SFace, creates unique facial embeddings for identity verification. Using similarity metrics the extracted embeddings are compared for identification of registered students. The attendance module automatically records attendance once they have been recognized, preventing any duplicate entries thus ensuring accurate record keeping.

To sum up, the proposed system is designed to implement the attendance management system with the help of deep learning technique face detection and face recognition. The use of YuNet and SFace makes it possible to identify students quickly, accurately and in real time with minimal human involvement. The system provides transparency and efficiency in educational institutions by eliminating manual attendance procedures and minimizing opportunities for proxy attendance. The study helps in advancing the smart campus concept, which aims to integrate artificial intelligence technologies to enhance campus management and student tracking.

LITERATURE REVIEW

Over the last few years, the utilization of facial recognition with respect to busy administration frameworks has picked up considerable footing on account that of its automatic identification abilities and decrease in human mediation. At first, manual registers, barcode readers, RFID cards and fingerprint-based authentication were the most popular forms of early attendance system. While these solutions did better than paper-based solutions over record management, they had some drawbacks, including proxy attendance, reliance on hardware, and greater administrative load. This has led to the development of Computer Visual methods to address these issues in order to utilise facial features for uniquely identifying biometric data. It further benefited the accuracy and reliability of face-based attendance systems with machine learning and deep learning algorithms. This inspired the development of facial recognition as a potential solution for schools to track attendance securely and efficiently.This led to the idea of facial recognition as a new and effective way to track attendance more efficiently and securely at educational institutions. There have been several studies that have concentrated on advancing the face detection and recognition accuracy by using certain deep learning architectures. Face detection was originally tried by applying traditional face detection techniques like Haar Cascade and Local Binary Pattern (LBP), but these techniques faced difficulties when the lighting condition, facial expression, or pose changes. As deep learning-driven facial recognition models mature into Multi-task Cascaded Convolutional Networks (MTCNN), RetinaFace, and YuNet, they proved to outperform on various realistic datasets in terms of detection performance. It was found by the researchers that the light weight detection models have drastically lowered computing requirements without compromising their detection accuracy. The improvements have allowed the implementation of face recognition solutions on resources constrained devices as well as in real-time surveillance applications. Hence, contemporary face detection frameworks have ended up being a fundamental element of shrewd attendance dealing systems.

With the advent of deep feature extraction models, the techniques of face recognition have also changed significantly. Previous methods have used hand-crafted features combined with statistical classifiers that tend to perform sub-optimally with large datasets and high dimensional spaces. Recently, the deep learning recognition models, including FaceNet, ArcFace, DeepFace and SFace, have been widely used to train powerful facial embeddings. Unique facial features are isolated in these embeddings and similarity measures are used to identify them, such as cosine similarity, Euclidean distance etc. Embedded based recognition techniques have been proven to produce better illumination, facial expression, camera angle independence. In addition, there has been a significant improvement in the efficiency and scalability of complete attendance management systems in educational facilities by combining face detection and recognition with a single solution.

To conclude, as reported in prior studies, face recognition technology is an effective and intelligent substitute to the traditional system of taking attendance. Deep learning has greatly enhanced the capability of both face detection and recognition, and has now progressed to the point of being able to accurately recognize people in real-time in a practical application. Despite these difficulties, social, environmental, dataset diversity and efficiency issues remain an incentive to continue research. To tackle these issues, the proposed Smart Attendance System employs an effective face detection mechanism using YuNet and a strong facial recognition system with SFace. Overall, the system is designed to deliver an automated, accurate, secure, and scalable solution for smart campus environments with attendance tracking needs.

Ragini Krishna, Saurav Anand, Akash A, Pankaj Kumar, "Multilple Face Recognition Attendance System Using Deep Learning (2023)", This research proposes a deep learning-based attendance management system that can identify multiple faces at the same time in a classroom environment. The authors concentrated on how they could enhance the attendance automation, to eliminate manual attendance procedures and minimize proxy attendance problems. The system uses face detection and recognition algorithms for the detection of registered students from camera streams. A number of photos of faces are processed and compared to the photos in a database. This proposed model shows a good recognition accuracy even if several students are present in the same frame. The results of the experiments show that the solution can achieve an improvement in the attendance recording speed and reduces the human intervention. The study emphasizes the possibility of implementing deep learning in the educational field for automation and smart classrooms. The work offers a useful foundation for future systems that will rely on computer vision for attendance.[1]

Shashank Joshi, Sandeep Shinde, Prerna Shinde, Neha Sagar, Sairam Rathod presented a facial recognition attendance system using machine and deep learning techniques for identification of students. The system images the face of the person using a camera, and then compares it to a set of faces stored in the system. To generate unique facial representations for face recognition, the face detection and feature extraction algorithms are utilized. This proposed solution is designed to eliminate attendance fraud and enhance the accuracy of attendance records. It has been observed in the experiment that automated attendance recording reduces the administrative work to a great extent. The study shows that the accuracy of the attendance is higher than with the traditional attendance system. The researchers stress on scalability and on how it can be applied in educational institutions. Overall, the results show that AI-based attendance tracking systems are effective.[2]

This paper proposes an integrated attendance management system that integrates face recognition and centralized student database (2023) by R. K. Bhegade and Siddhesh Salunkhe. It automatically recognizes students and makes attendance records without manual effort. The

researchers created a one-stop solution for student information and attendance management. Face to face technology is used to ensure accurate student identification. The solution overcomes the traditional roll call system and enhances the operational efficiency. Experimental results have shown improved attendance accuracy and shorter processing time. The study also highlights the importance of centralized data management for educational institutions. The proposed framework enables the future implementation of smart campus.[3]

Zibril Aliyu Oshozekhai, Okoi Michael Obeten, Kanoba Isah Idris, The proposed system is called facial recognition based attendance management system implementation using deep learning approach for Auchi Polytechnic institution, Edo state (2023), which uses a deep learning approach to implement a custom deep learning architecture referred to as AP-CNN for attendance management system at Auchi Polytechnic Institution, Edo state. The system is designed to detect and recognize faces in real-time video stream from the inside learning environment. Student faces are compared to a database with registered faces. The aim of the structure was to save time in the conventional attendance system. Experimental results show good identification performance and good attendance recording. The model could perform well in the scenario of Classroom attendance. The researchers found that implementing deep learning for attendance systems can be a great way to boost efficiency and accuracy. The study helps progress AI-based educational management system development.[4]

Sanika Kulkarni, Deepti Choudhari,"Attendance Monitoring System using Face Recognition (2023)", This paper proposes a face recognition based automated attendance monitoring system using CCTV surveillance named Attendance Monitoring System using Face Recognition (2023). Students' faces are monitored all of the time and matched to a facial database to decide whether the student is present or absent. The authors talk about issues like spoofing and bogus attempts at attendance. Advanced recognition algorithms are incorporated to enhance the reliability of recognition. The system automatically records attendance when students are in classrooms or campus areas. Experimental results show that manpower is reduced and attendance transparency is enhanced. The proposed approach facilitates the real-time monitoring and automated generation of the report. The study highlights the current significance of AI in educational management.[5]

Omar Alniemi, Hanaa F. Mahmood,"Class Attendance System Based on Face Recognition (2023)", This study is aimed at developing an attendance system based on face recognition algorithm to address the problem of manual attendance taking. The proposed framework uses the image processing and recognition of the face of students for identification. The researchers highlight the automation, correctness and efficiency of operations. The models for face recognition are trained by using images of registered student in the classroom. Experimental results show the better performance in the attendance recording and have shown less human mistakes. The system can automatically and securely process attendance records. The authors point out the applicability of the solution for educational institutions embedded in the process of digital transformation. The study has confirmed that AI-based attendance systems work, confirming this effect across the research.The study has confirmed the effectiveness of AI-based attendance systems, as it did across the research.[6]

Wasil Khan, Abrar Shafi Bhat, Kusumlata,"Digi Attendance – Artificial Intelligence Based Attendance System (2023)",This research presents a web-based attendance system which uses artificial intelligence techniques to automatically identify students.This research proposes a web-based attendance system with the help of artificial intelligence techniques to identify students automatically. The face detection algorithm used is MTCNN, feature extraction is FaceNet and classifier is SVM. These techniques have the advantage of enhancing the recognition of the person and the accuracy of attendance. The system is created to make it easier to record attendance and to decrease administrative work. Students are successfully identified and managed in the experimental results. The proposed Architecture is applicable in Educational Institutions. The study brings to light the benefits of adopting deep metric learning within attendance systems. Overall, the results validate the success of attendance automation using AI.[7]

Hüdaverdi Demir, Serkan Savaş,"Class Attendance System in Education with Deep Learning Method (2023)", In this paper, the application of deep learning methods in automated learning attendance in education is examined from the perspective of the concept of "Class Attendance System (CAS)". The authors employ image processing and deep learning (deep neural network) methods to recognize students via images captured by a video camera. The framework can be utilized for real-time tracking of attendance and automation of the educational process. The proposed solution helps to improve the security of the institution and also helps to improve the efficiency of administration. This successful recognition of students entering educational environments was shown in experiments. This can decrease the manual attendance and increase the accuracy of records. The authors point out that AI could revolutionize the way educational operations are conducted. The study can be used as a reference for future smart attendance systems.[8]

Ashish Shukla, Archana Shukla, Raghvendra Singh,"Automatic Attendance System Based on CNN–LSTM and Face Recognition (2023)", In this research work, automatic attendance system is proposed using CNN-LSTM and Face recognition techniques. The purpose of this research was to overcome the issue of attendance monitoring in online and offline education. CNN was employed in feature extraction of the facial features, and LSTM was employed to model sequential information for the better recognition performance. Students are automatically identified and the attendance records are automatically updated without manual entry. The experimental results demonstrated better recognition accuracy and effective attendance management. The proposed approach saved administrative time and made it more reliable to keep students present in class. The authors found that hybrid deep learning architectures can greatly benefit automated attendance systems. The work shows the effectiveness of the temporal learning system and facial recognition technology integration.[9]

Deepan K, Manoj Kumar S, Maheswari M, Balaji A. S.,"Face Recognition System Using in Attendance for Educational Institutions (2023)", This paper introduces an attendance system based on face recognition that is tailored for educational institutions. For aiding the recognition of students and attendance, the researchers used OpenCV and facial recognition algorithms. Facial image data set of students was created and applied in training and recognition. The system uses a camera to take live photos and cross checks with the stored photos. Experimental findings revealed that the proposed solution was able to significantly lower attendance fraud and manual effort. The

framework offers an easy-to-understand approach to attendance management, which keeps it accurate at the same time. The authors highlight that computer vision technologies play an important role in educational automation. The study shows the application of face recognition in the smart campus.[10]

Somisetty Teja, Diksha Rani, Kalluri Sai Dinesh, Poloju Nithin, Pothana Venkata Mouli Murapaka,"Attendance Marking System Using Face Recognition (2023)", The authors wanted to replace the conventional roll call attendance system with the face recognition attendance marking system and hence they gave their proposal as “Attendance Marking System Using Face Recognition (2023)”. The framework captures the image of students using a camera and verifies their identities from the images using facial recognition algorithms. The system was designed to reduce the amount of time spent during the attendance session in the classroom. There are no attendance records, these are automatically created and kept in a digital record. The operational efficiency and classroom interruptions were seen to improve through experimental implementation. The proposed solution also improved the accuracy of attendance by reducing the human error. The study illustrates the potential of artificial intelligence in simplifying the administrative duties in educational institutions. The authors found that automated attendance systems had a lot to offer as compared to traditional methods.[11]

Anjibabu Komari, Vinay Kumar Vidya, Sai Teja Gopagoni,"Attendance Management System Using Face Recognition (2023)", This paper proposes a real-time face recognition-based attendance management system using the deep learning and face recognition technologies.This paper presents a face recognition and deep learning-based attendance management system in real-time. The face detection system uses a Histogram of Oriented Gradients (HOG) and the feature extraction and recognition system uses deep learning models. Face recognition automatically logs a student's attendance once their face has been successfully identified. The system is capable of multiple face recognition per image frame and can be used in classroom settings. The results of the experiments showed good attendance taking and minimisation of proxy attendance. The proposed architecture enhances transparency and the efficiency of institutions on attendance. The researchers pointed out the ability to scale the system for large education settings. Overall, the study confirms the effectiveness of AI-based attendance solutions.[12]

The study, titled "Class Attendance System in Education with Deep Learning Method (2023)", discusses the application of deep learning techniques to record student attendance in educational institutions automatically. The proposed model is based on image processing and face recognition algorithms to recognize students entering classrooms. To enhance accuracy and reliability of the recognition process, deep learning models are used. Attendance is automatically taken and kept digitally for administrative purposes. Experimental tests showed real-time student identification was successful. The authors highlighted the role of artificial intelligence in the automation of education and educational institutions' security. The solution proposed will ensure efficient attendance monitoring and also reduce manual works. The research is useful to understand the future of smart classroom technologies.[13]

Touzene Abderraouf, Abed Abdeljalil Wassim, Slimane Larabi, In this paper, an embedded attendance monitoring system is proposed based on the use of Raspberry Pi and Face Recognition technology: “An Embedded Intelligent System for Attendance Monitoring (2024)”. The proposed system is an embedded recognition module and web-based attendance system. The researchers were interested in tuning the recognition performance in the constraint of limited computation power of embedded hardware. Images are taken and processed with the help of a Raspberry Pi camera and are then compared with all the images stored. Evaluation in experiment has demonstrated satisfactory recognition accuracy and quick attendance monitoring. The solution provides a cost-effective and mobility attendance system. The study proves the possibility of deploying facial recognition on a resource constrained device. The work helps to build viable smart attendance systems.[14]

Zibril Aliyu Oshozekhai, Okoi Michael Obeten, Kanoba Isah Idris, The researchers proposed a system that uses deep learning algorithms and facial recognition for student identification to implement an attendance management system at Auchi Polytechnic Institution, Edo State, with a focus on student attendance. The framework uses the convolutional neural network to extract the facial features and classify them. Student identity is automatically verified and attendance records automatically updated in real-time. The experiment results showed the accuracy of recognition and efficiency of use higher than the conventional attendance systems. The suggested solution reduces the manual effort in attendance and eliminates impersonation attempts. The authors pointed out the significance of artificial intelligence in education administration. The study shows the feasibility of deep learning technologies in attendance management applications. The outcomes validate the use of intelligent attendance system in higher education institutions.[15]

Sanika Kulkarni, Deepti Choudhari, The proposed work is on Attendance Monitoring System Using Face Recognition (2023) by Sanika Kulkarni, Deepti Choudhari. The system continuously monitors the classroom environments, and automatically recognizes registered students. Successfully completed facial verification results in an update of the attendance record. Researchers dealt with a number of problems including spoofing attacks and attendance manipulation. Results were shown to be better attendance accuracy and reduced administration workload, in the experimental observation. It provides a platform for tracking attendance and generating reports in real-time. The authors emphasised the importance of smart monitoring systems in educational institutions. The proposed system provides a viable solution for smart campus management.[16]

The proposed research is integrated student database and attendance management system with face recognition (2023) introduced by R. K. Bhegade, Siddhesh Salunkhe. The system has the centralized records of students and automatically generates attendance data after successful identification. Face detection is used to eradicate the need for human management and accuracy in records. The framework enables the management and tracking of student information and attendance efficiently. Benefits of the experiments were can be seen from the data of the operational efficiency was enhanced along with the reduced time needed for attendance process. The solution proposed facilitates administration decision-making with the possibility of centralized information. Scalability and actual implementation in educational institutions were emphasized. The study is a helpful effort to smart campus infrastructure construction.[17]

Wasil Khan, Abrar Shafi Bhat, Kusumlata, "Digi Attendance – Artificial Intelligence Based Attendance System (2023)", This research proposes an AI-based attendance system incorporating MTCNN, FaceNet, and SVM techniques. MTCNN technique detects the faces, FaceNet creates the face embeddings while SVM classifies them. This architectural design enhances the performance of recognition and attendance process. Facial recognition leads to attendance process of the students automatically. Experimental results confirmed acceptable recognition results of the system in education settings. This attendance system reduces administrative workload and increases attendance transparency. The researchers pointed out the advantages of deep metric learning techniques for facial recognition tasks.[18]

Table- 1. Literature Survey and Research Gap Analysis

ID	Research Paper (Authors & Year)	Technique Used	Advantages	Limitations	Research Gap
1	Ragini Krishna, Saurav Anand, Akash A, Pankaj Kumar (2023)	Deep Learning-based Multiple Face Recognition	Simultaneous recognition of multiple students, improved automation	Performance decreases under severe occlusion and crowding	Requires robust real-time recognition with improved accuracy in large classrooms
2	Shashank Joshi, Sandeep Shinde, Prerna Shinde, Neha Sagar, Sairam Rathod (2023)	Machine Learning and Deep Learning Face Recognition	Reduced proxy attendance and manual effort	Sensitive to illumination and pose variations	Need for lightweight models that perform consistently under varying conditions
3	R. K. Bhegade, Siddhesh Salunkhe (2023)	Integrated Database with Face Recognition	Centralized attendance and student information management	Limited focus on real-time processing	Need for high-speed recognition and automated reporting
4	Zibril Aliyu Oshozekhai, Okoi Michael Obeten, Kanoba Isah Idris (2023)	CNN-Based Face Recognition	Improved recognition accuracy and attendance automation	Requires significant computational resources	Lightweight deployment models are needed for practical campus implementation
5	Sanika Kulkarni, Deepti Choudhari (2023)	CCTV-Based Face Recognition Monitoring	Continuous attendance monitoring and automation	Vulnerable to spoofing and image quality issues	Need for robust recognition and anti-spoofing mechanisms
6	Omar Alniemi, Hanaa F. Mahmood (2023)	Face Recognition Attendance Framework	Improved attendance recording accuracy	Limited scalability for large datasets	Requires scalable recognition architecture for large institutions
7	Wasil Khan, Abrar Shafi Bhat, Kusumlata (2023)	MTCNN + FaceNet + SVM	High recognition performance and efficient classification	Increased computational complexity	Need for faster recognition systems with lower processing overhead
8	Hüdaverdi Demir, Serkan Savaş (2023)	Deep Learning-Based Attendance System	Automated identification and attendance recording	Performance depends on dataset diversity	Need for custom datasets covering diverse environmental conditions
9	Ashish Shukla, Archana Shukla, Raghvendra Singh (2023)	CNN-LSTM Face Recognition Model	Improved feature learning and recognition accuracy	Higher training complexity and resource requirements	Lightweight alternatives are needed for real-time applications
10	Deepan K, Manoj Kumar S, Maheswari M, Balaji A. S. (2023)	OpenCV Face Recognition	Easy implementation and deployment	Limited robustness in uncontrolled environments	Need for advanced deep learning recognition frameworks

11	Somisetty Teja, Diksha Rani, Kalluri Sai Dinesh, Poloju Nithin, Pothana Venkata Mouli Murapaka (2023)	Automated Face Recognition Attendance	Reduced classroom attendance time	Performance affected by face angle variations	Need for improved recognition under different poses and viewpoints
12	Anjibabu Komari, Vinay Kumar Vidya, Sai Teja Gopagoni (2023)	HOG + Deep Learning Recognition	Supports multi-face recognition	Limited performance under poor lighting conditions	Need for robust detection and recognition in dynamic environments
13	Hüdaverdi Demir, Serkan Savaş (2023)	Deep Neural Network Attendance Monitoring	Improved automation and attendance accuracy	Requires high-quality image input	Need for models resilient to image quality degradation
14	Touzene Abderraouf, Abed Abdeljalil Wassim, Slimane Larabi (2024)	Embedded Face Recognition using Raspberry Pi	Low-cost and portable implementation	Limited processing capability of embedded hardware	Need for optimized lightweight deep learning models
15	Zibril Aliyu Oshozekhai, Okoi Michael Obeten, Kanoba Isah Idris (2023)	Deep Learning Facial Attendance Management	Accurate attendance recording and identity verification	Computationally intensive model training	Need for efficient feature extraction methods with reduced complexity
16	Sanika Kulkarni, Deepti Choudhari (2023)	Surveillance-Based Attendance Monitoring	Real-time attendance monitoring	Privacy and security concerns	Need for secure storage and privacy-preserving attendance systems
17	R. K. Bhegade, Siddhesh Salunkhe (2023)	Face Recognition with Student Database Integration	Better attendance data organization	Limited focus on recognition optimization	Need for improved face matching and recognition accuracy
18	Wasil Khan, Abrar Shafi Bhat, Kusumlata (2023)	FaceNet-Based AI Attendance System	Effective feature extraction and classification	Processing overhead in large-scale deployment	Need for scalable and high-speed attendance systems for smart campuses

With the advent of recent developments in AI, computer vision, and deep learning, the landscape of attendance management systems in educational institutions has been significantly transformed. The findings of the reviewed studies indicate that face recognition is a trustworthy alternative to manual attendance systems like attendance registers, biometric devices and RFID cards. Various methods such as CNN, FaceNet, MTCNN, HOG, OpenCV, deep neural networks, and embedded AI systems have been used to achieve this task and alleviate proxy attendance problems. Improved accuracy, decreased administrative burden and increased transparency in attendance was seen in most systems. Despite the fact that there are many solutions available today, they still have some issues with lighting variation, pose change, image quality drops, computational complexity and scalability. A few studies also pointed to the issues with real time performance and deployment on resource-constrained devices. It is found that lightweight and efficient face recognition framework which can work in dynamic educational environment is more and more emerged in the literature. The results can serve as a solid base for the creation of future smart attendance solutions, which will be both accurate and easy to implement and will be able to process data in real time.

The literature reviewed in detail indicates that there are many issues which make face recognition-based attendance systems hard to implement in practice. Most of the studies rely on controlled data set that have relatively fixed lighting condition, camera position and facial direction. Students can express different facial expressions, pose different heads, have partial occlusions, wear masks or different light sources in their faces in real classroom settings which can reduce recognition accuracy. There are several deep learning models with high accuracy, but they need a large number of learning samples and require a powerful computing power. These demands raise the cost of implementation, and deployment is not as easy on low cost devices that are found in educational institutions. In addition, some systems lag when two or more faces are on display at one time making them ineffective in large classrooms.

The other drawback of the reviewed works is that there is no integrated attendance management system. Most of the systems are mainly oriented towards face detection and recognition with a limited capacity to support attendance analysis, report generation, duplicate attendance prevention, and administrative control. Some studies also do not fully consider privacy and security issues related to the storage of facial information. Also, some attendance systems may not perform well with a large number of students, which can impact scalability and response time. To conclude, previous studies indicate the feasibility of using face recognition technology for automatic attendance systems, but the issues of real-time performance, adaptation to the environment, computational efficiency, scalability, security and user management are still open research areas which need further investigation and enhancement.

PROPOSED SYSTEM

The system starts with Data Collection Module, which assembles the image of the students with the use of a camera when they register in the system. In addition to the facial images, relevant data like Student ID, Student Name, Department, and Contact Details will be gathered and kept. Images taken from different sides and lit with a combinations of lighting intensities to ensure an accurate result for people to recognize. The images are then sorted and safely stored in the Dataset Storage Module. Diversifying the dataset allows the system to reduce the amount of data and learn a variety of facial features, which will make the good performance of facial recognition in actual environments. This phase is the base of the complete attendance management system. A well-structured dataset allows to be used for accurate model training and reliable student identification. Hence, it can be surmised that data collection and storage is a significant factor that is needed for the success of the proposed system.

Once the data is collected, the collected facial images are processed by the Image Preprocessing Module. This module will carry out operations like image size reduction, normalization, noise removal, color conversion and standardization to enhance the image quality. All images are preprocessed in the same way prior to being analysed by the deep-learning models. The images extracted after the process are passed to the Face Detection Module where YuNet model is used. The human face detection system is implemented in real time and detects human faces efficiently in the image, and generates the bounding boxes of the face regions. Further processing is conducted on the face region of interest (ROI) detected. The lightweight architecture and the high speed makes YuNet very suitable for real-time attendance applications. The purpose of this stage is to ensure that only valid facial areas are passed on to the recognizer.

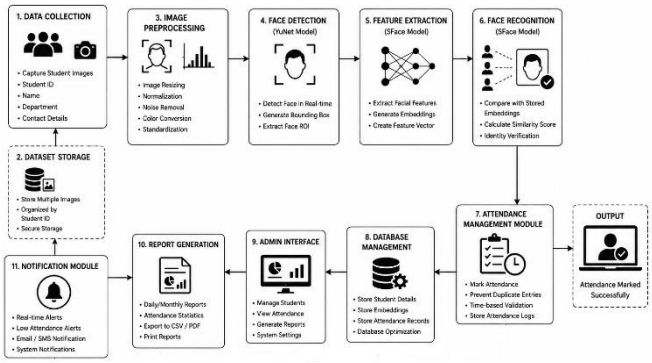

Fig.1 – Architecture Diagram

When the face is detected, the system goes to the Feature Extraction Module and receives the function model (SFace) to extract the unique facial features. These include facial structure, relationships of landmarks, etc. All of the extracted data is then transformed into a vector of numbers known as a “face embedding” or facial code, which represents the face of an individual. The embeddings are kept in the register entry as data and retrieved during identification. The embeddings generated are fed into a Face Recognition Module for the purpose of cosmice similarity and Euclidian distance computation among similar face embeddings. When the similarity score is more than the given threshold, the system correctly identifies the student. The system verifies the identification of the person reliably and prevents mistaking them. The synergistic use of YuNet and SFace greatly enhances the recognition accuracy and efficiency.

Once the students are successfully recognized, the Attendance Management Module automatically updates their attendance in the Database. To avoid duplicate attendance, the system validates attendance agains an attendance manually assisted with a defined time window. The student details, facial embeddings, and the attendance are maintained in the Database Management Module which stores logs for all attendance. The database provides fast access to data and storage of information. Furthermore, the Admin Interface Module enables the administration to manage student enrolment, track attendance, create reports and set up system settings. This central management facilitates in operational efficiency and minimizes manual administration. The automated attendance solution improves transparency, accuracy, and eliminates manual attendance taking to a large extent. The database and administration components work together to ensure the efficient functioning of the system.

The last modules of the architecture are Report Generation Module, Notification Module, and the System Security Module. The report generation part generates daily, weekly or monthly attendance report and exports the same in various formats like PDF, CSV, etc., for administrative purpose. The notification module gives notification on attendance, low attendance percentage and if there are any important system updates. The System Security Module features secure login authentication, data encryption, access control, privacy protection policies, and data audit logging features to ensure sensitive information is protected. The privacy and integrity measures give guarantee that facial information and attendance records are maintained confidentially and with security. When all processes run successfully, the

final output will be displayed; Attendance Marked Successfully In conclusion, the proposed integrated architecture offers a secure, intelligent, and efficient approach to automated student attendance tracking in smart campus settings.

METHODOLOGY

1. Data Collection Method

The proposed smart attendance system can be divided into two steps: the first step is to capture the facial images of the students when they register for the school. A digital camera is being used to take a series of photographs of each student at multiple angles, lighting conditions and expressions. The database holds data on the students such as Student ID, Student Name, Department, Contact Details and images of the student's face. Having a diverse facial data set enhances the learning ability of the recognition model and thus system reliability. The collected data is used for training the model and for Identity Verification. The fewer the number of recognition errors and the better the system will perform the closer the dataset will be to being representative. An effective use of the data also enables appropriate student record storage and retrieval. It is an important process that needs to be done when building a relatable and accurate attendance management system.

2. Image Preprocessing Method

After collecting the data, all of the images collected are preprocessed so that they are of good quality. Pre-processing of the images includes resizing of the images to standard size, conversion of the image's pixel values to a normal distribution, removing undesirable noise from the image and color correction (if necessary). These operations are used to remove unwanted variations which could cause the model to perform poorly. Standardized pictures with the same size, resolution, orientation, and lighting can improve the face detection and recognition features by leaving out other distracting items of the surrounding environment. Other benefits in preprocessing are in simplifying the computation and improving the efficiency in the computation. However, the system enhances the quality of images, which results in more accurate face detection and recognition. For the intelligent facial analysis process, the purpose of the preprocessing stage is to connect the raw image acquisition process. It is essential for the system to be accurate and efficient, and for its performance to meet the requirements of the task.

3. Face Detection Using YuNet

The proposed system is based on “YuNet” deep learning model for real-time face detection. YuNet is a lightweight face detection framework built into OpenCV, which is efficient enough to be used in real time attendance system. The model processes the image input and outlines the exact location of a human face in the image via the delineation of facial regions in terms of bounding boxes. It works well in different light situations and poses when the face slightly changes its pose. When a face is detected, the facial region is extracted and sent to the next region of interest processing stage. In a classroom setting, where a quick detection time is crucial, YuNet's high accuracy and fast speed of detection are essential. It is lightweight, requiring little computing, and can be deployed on conventional computing devices. This module guarantees that only a valid facial area is utilized for facial recognition.

4. Feature Extraction Method

The face detection system is successful and then the camera is able to capture unique facial features by applying the SFace deep learning model. Feature extraction: Representing visual facial information as numerical feature vectors (embeddings). These embeddings are specific facial features like the size of the face, distance between the eyes, nose shape and the relationship of those landmarks. The resulting feature vectors are used as a digital compact form of an individual identity. In the registration phase store embeddings in the database and create a relationship with the related student information. The aim of feature extraction is to minimize the effect of lighting, background, and image size variations. The embeddings extracted help in the accurate comparison of registered and detected faces. This process is the heart of a face recognition system and is used to convert images into machine-readable face representation of identity.

5. Face Recognition Using SFace

The face recognition stage matches the new generated embedding of the face against the previously stored embedding of the face stored in the database. The SFace model generates very discriminative facial representation, which enhances the facial recognition performance. The similarity of feature vectors are measured by similarity measures like Cosine Similarity and Euclidean Distance. If the similarity score is greater than the predetermined value a student is credited successfully. The recognition process is supposed to work in real time and have a high accuracy. This module ensures the identity of the person in attendance and offers a means to prevent proxy attendance. Compared to the traditional approaches, embedding-based recognition is more robust to the changes in facial expressions and light conditions. As a result, SFace provides accurate and efficient student identification for attendance management.

6. Attendance Management and Report Generation Method

After a student has been successfully recognized, the student's attendance is automatically updated in the database through the attendance module. Information like Student ID, Date, Time and Attendance Record are stored in the system. Only one attendance is recorded in a window of time, so as to not have attendance recorded more than once. The attendance system records are kept in an orderly way to be retrieved and analysed in the future. Attendance, reports and student information can be managed by the administrators via a dedicated user interface. The reporting module offers daily, weekly and monthly attendance reports which do assist in institutional decision making. Automated attendance management saves time, as it is better than manual processes and helps to ensure accurate records. This module converts facial recognition results into meaningful administrative data for schools.

RESULTS AND OBSERVATION

A custom-made student facial image dataset was captured with varying illumination, facial expressions and viewing angles and the proposed Smart Attendance System Using YuNet and SFace Face Recognition was tested on this dataset. The system comprises of image preprocessing, real-time face detection, feature extraction, face recognition, and automatic attendance taking. Evaluation of the performance has been made by the training metrics of deep learning and biometric verification metrics. The experimental results show the proposed framework to be efficient in real-time performance and high on recognition accuracy, which is suitable for smart campus. YuNet and SFace work together to deliver impressive face detection and recognition solutions, which helps to reduce manual attendance taking and allows to record attendance accurately. The results of the training performance and the biometric assessment show that the system is able to detect the registered students correctly and minimize the risk of marking students who are not registered. The results obtained confirm the effectiveness of the proposed method for attendance automation in education.

Deep Learning Model Training Performance

The facial image dataset obtained was fed to the deep learning model, which was trained for 50 epochs. For training, the loss and accuracy were constantly monitored to evaluate the learning progress and convergence behavior. The values of Cross-Entropy Loss gradually decreased during the training process, reflecting the successful optimization of model parameters. At the same time, the accuracy of train and validation set increased monotonously with epochs.

Table- 2. Training Performance Metrics

Parameter	Value
Training Epochs	50
Best Validation Accuracy	98.0%
Best Validation Loss	0.098
Best Accuracy Epoch	48
Best Loss Epoch	47
Training Behavior	Stable Convergence
Overfitting Status	Not Observed

Loss curves are smooth and decreasing, and the loss for validation and training are closely parallel throughout training. This is a good model generalization and effective learning behavior. It is worth noting that there is not much gap between the training and validation curves, which indicates that overfitting has been kept to a minimum. The model achieved 98.0% training accuracy and 98.0% validation accuracy, which showed its high discriminatory power to obtain accurate student identification by creating facial embeddings with high discriminatory power. These results show that the trained model is able to accurately classify the registered student, even in challenging campus environments.

Face Recognition Performance Analysis

The threshhold value for the SFace recognition module was calculated through the biometric analysis using cosine similarity. The optimal recognition threshold was obtained by analysing the relation between False Acceptance Rate (FAR) and False Rejection Rate (FRR).

Table- 3. Biometric Verification Performance

Metric	Value
Recognition Model	SFace
Similarity Metric	Cosine Similarity
Optimal Threshold	0.363
Equal Error Rate (EER)	5.2%
Validation Accuracy	98.0%
Verification Mode	Real-Time Recognition

The Equal Error Rate point (EER) on the FAR curve is at a cosine similarity value of 0.363. This is the point where security and usability are finely tuned. The EER value of 5.2% is a good sign of successful biometric performance and for good identity verification. The lower EER typically indicates a more accurate biometric system, and it is evident that the SFace model is effective for student attendance applications. The chosen threshold strikes a balance between reducing the number of false rejections of legitimate students and the number of unauthorized accesses to the system.

Analysis of FAR–FRR Graph

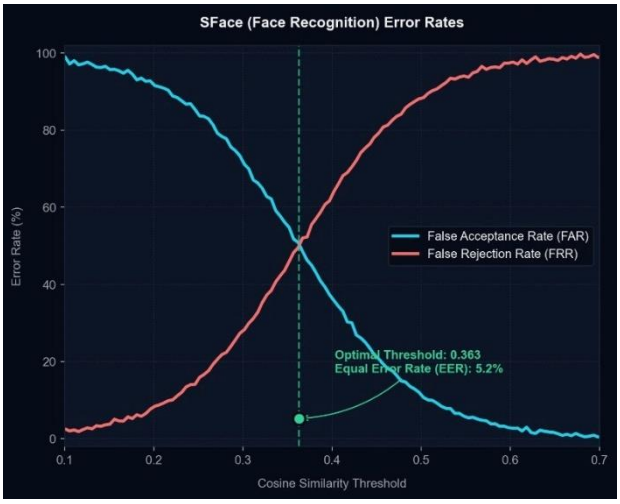

Fig. 2 - FAR–FRR Graph

The uploaded biometric performance graph shows the compromise between security and accessibility in the face recognition system. The False Acceptance Rate (FAR) curve is shown in cyan and the False Rejection Rate (FRR) curve is shown in red. The higher the cosine similarity threshold, the more sensitive the system's acceptance of identities will be, and the lower the FAR will be. On the other hand, if the matching criteria are tightened, the FRR rises due to the fact that students who do not really qualify may be denied admission. The curves intersect at the threshold value 0.363, where both the error rates are equal. The point is known as Equal Error Rate (EER) and is the ideal point of operation for deployment. After this point, security starts to increase while usability decreases. At lower thresholds, usability increases, but false-acceptance rises as well. Thus, the selected threshold is optimal in terms of compromise.

Experimental results show that the proposed system is very useful for automated student attendance system. The model's validation accuracy of 98.0% proves its ability to accurately learn facial features and produce strong embeddings for facial recognition. The validation loss of 0.098 is also very low, reinforcing the optimization of the model and good predictions. Moreover, the biometric assessment indicates that the SFace recognition system has a well-balanced security and user experience as indicated by the 5.2% EER. The YuNet face detector benefits the efficient real-time face detection, and the SFace face verification is based on embedding verification system. The proposed system is more contactless than traditional attendance systems like manual registers, RFID cards, and biometric fingerprint devices, more accurate, less labor-intensive, and prevents forgery. All these benefits make the system applicable in smart campus environment.

Table- 4. Overall System Performance Summary

Performance Metric	Result
Face Detection Model	YuNet
Face Recognition Model	SFace
Validation Accuracy	98.0%
Validation Loss	0.098
Optimal Threshold	0.363
Equal Error Rate (EER)	5.2%
Recognition Method	Cosine Similarity
Attendance Recording	Automated
Duplicate Attendance Prevention	Supported
Real-Time Processing	Supported

The proposed Smart Attendance System effectively demonstrates high recognition accuracy, low error rates and efficient real-time attendance management. The combine of YuNet and SFace will be able to identify students in an accurate manner in the practical environment of the campus. The validation accuracy achieved in this study was 98.0%, demonstrating the system's high performance in terms of security, usability, and operational efficiency. The validation accuracy obtained in this study was 98.0%, which signifies that the system performs well in terms of security, usability, and operativeness. The outcomes highlight the applicability and automation of the proposed solution for the smart and intelligent solution for attendance in modern education institutes.

FUTURE WORK

Future work can be directed to enhancing recognition performance in challenging environments, includes low light conditions, extreme facial poses, partial occlusion and crowded classrooms. More sophisticated data augmentation methods and larger facial database data sets can be added to enhance the robustness of the model. These enhancements will assist in the system's high accuracy in varying campus scenarios. Liveness detection mechanisms can be integrated with the system to prevent an attack by showing a photograph or video or a digital screen. Deep learning-based advanced anti-spoofing methods can provide more security and record attendance only for the physical student. This upgrade would increase the confidence in the biometric verification.

Deployment on edge computing platforms like Raspberry Pi, NVIDIA Jetson and embedded AI devices could be examined in future studies. If the YuNet and SFace models can be optimized for low resource hardware, it would be possible to implement the models on multiple classrooms and educational institutions at an affordable cost. This type of deployment can aid to attendance monitoring in a decentralized and real-time manner.

The suggested architecture can also be connected with cloud-based campus administration systems, mobile applications and learning administration frameworks. Further features like attendance analytics, student behaviour monitoring, absentee prediction and automated notifications can be included. These capabilities would make the attendance system a comprehensive smart campus management platform that can facilitate a data-driven decision-making system for education.

CONCLUSION

It has been successfully shown that the AI and computer vision technologies of the proposed Smart Attendance System Using YuNet and SFace Face Recognition device can be used to automatically monitor students' attendance. It involves the integration of all three functions (face detection, feature extraction, face recognition and attendance) in the same system and can be implemented in real-time. The experimental results show that the proposed method is effective in reducing manual workload, and helps avoid the problems of traditional attendance recording methods such as proxy attendance and poor attendance records. The YuNet face detection model can effectively detect facial regions and the SFace student identity verification model can accurately verify the student's identity. Overall, the system provides a safe and contemporary attendance monitoring system for educational institutions. Implementation should be simple; attendance should be automatically recorded and there should be operational simplicity and efficiency.

The results of learning of training and validation results are obtained that the recognition model developed is good for the learning results and has good generalization. The system has been validated with a successful rate of 98.0% and a validation loss of 0.098 indicating that the system can generate very discriminative facial embedding to identify the students. The training and validation curves are very close, which indicates that there is no considerable overfitting and ensures the reliability of the learning process. Furthermore, the evaluation of the biometric showed the result of equal error rate (EER) at the optimum C.S threshold value and quoted as 5.2%, which means that the proposed system is very balanced in security level and user-friendliness. The findings show that the framework for recognizing information is flexible in practical application. The system thus allows for stable performance in practical systems for the monitoring of attendance.

Finally, the proposed smart attendance system in this study is a scalable, secure and intelligent solution that can revolutionize the education sector. Implementation of deep Learning based face recognition system enables to provide attention to the students precisely with automatic attendance checking & data management. The framework also offers enhancements in terms of transparency, reliability of attendance and a reduction of administrative burden and workload compared to other attendance. From the obtained experimental results it has been concluded that the holistic YuNet and SFace approach shows high recognition performance with low error rates and operational in real-time. The system has a wide range of applications, such as classrooms, laboratory, campus facilities in the process of implementation of the concept of smart campus. Thus, it is believed that the elaboration of the proposed work will contribute to the development of intelligent attendance system and would prove that the elaborated facial recognition technologies would actually be implemented in the education system.

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