

AI-Powered Student Monitoring & Smart Attendance System

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Abstract: Proctor Nova is a computer vision based, AI powered automated attendance management system that aims to deliver precise, real time, and touchless student presence tracking in academic settings. Conventional methods of attendance tracking, including roll calls and RFID, may take a considerable amount of time and may also involve integrity problems. In this paper, we propose a computer vision based intelligent attendance management system called Proctor Nova, which uses deep learning techniques to accurately detect and record student attendance.

The full stack tech development of the Proctor Nova system allows for seamless and simple communication between the front end and back end, hence facilitating real-time attendance monitoring, storage, and retrieval. Furthermore, the optimized recognition process of the Proctor Nova system is capable of detecting and recognizing multiple students simultaneously, even under varying illumination and position conditions.

The experimental test results of the Proctor Nova system showcase high accuracy, reliability and efficiency in real world scenarios, significantly reducing human intervention, false detections and proxy problems. The proposed Proctor Nova system is scalable, easy to deploy, and highly adaptable to various academic settings.

Proctor Nova is a reliable, smart and intelligent alternative to conventional attendance tracking systems, contributing to the development of smart classrooms.

1. Introduction:

The rapid advancement of digital technology has greatly changed the face of traditional educational environments, creating a platform for smart classrooms and automatic administrative systems. One of the most important aspects of any educational system is attendance tracking. The traditional method of tracking students attendance is often inefficient and prone to errors. The current technological solutions, including RFID and biometric solutions, are also often limited by their costs and constraints.

Computer vision and deep learning have gained significant attention in recent years as a solution for many identification

and monitoring tasks. The recent advancements in computer vision have provided a new platform for face recognition-based solutions. The efficiency of face recognition-based solutions can be greatly improved by leveraging recent advancements in computer vision. Some of the challenges faced by face recognition-based solutions include different lighting conditions, occlusions, and pose variations.

This paper proposes Proctor Nova, a system based on an automated attendance system, using artificial intelligence, where advanced object detection and facial recognition technologies have been employed to efficiently and accurately track student attendance. This has been made possible by incorporating latest and most advanced face detection system, using the YOLO algorithm and facial recognition system using embedding based techniques such as InsightFace.

The primary contributions of this work are summarized as follows:

- 1. Design of an Efficient Real-Time Attendance Pipeline:** A streamlined pipeline is developed to capture, process, and record attendance in real time, ensuring minimal latency and smooth operation in live classroom environments.
- 2. Integration of Robust Facial Recognition Techniques:** The system combines advanced face detection and recognition models, to maintain high accuracy and reliability under practical constraints such as varying lighting conditions, pose variations, and partial occlusions.
- 3. Development of a Scalable System Architecture:** A full-stack, modular architecture is implemented to support multiple subjects, sessions, and users, enabling easy deployment across different institutional settings.
- 4. Reduction of Manual Intervention:** The automation of attendance tracking eliminates the need for traditional roll calls and manual record-keeping, saving time and reducing human errors and administrative workload.
- 5. Mitigation of Fraudulent Attendance (Proxy Prevention):** By leveraging identity verification through facial recognition, the system significantly reduces the possibility of proxy attendance and ensures authenticity.

6. Enhancement of Operational Efficiency and Data Reliability: The combined effect of automation and accurate recognition leads to improved efficiency in attendance management while maintaining consistent and reliable data records.

The contributions of the proposed work include the design and implementation of an efficient real-time attendance system, the integration of advanced facial recognition technology, and the design and implementation of a robust system that can handle multiple subjects and attendance sessions. This has not only improved the efficiency of the system but also reduced the chances of fraud.

2. RELATED WORK:

[1] J. Joshan Athanesious, Vanitha, S. Adithya, Anirudh Bhardwaj, "Deep Learning Based Automated Attendance System", Science Direct, Procedia Computer Science, 2019
Focus: Developing a deep learning-based automated attendance system (DPAAS) that minimizes manual effort and classroom disruption.

[2] Pinaki Ranjan Sarkar, Deepak Mishra, Gorthi Rama Krishna Sai Subrahmanyam, "Automatic Attendance System Using Deep Learning Framework", Advances in Intelligent Systems and Computing ((AISC, volume 748)), 2018
Focus: Designing an efficient deep learning-based attendance system using face detection and recognition, optimized for real classroom conditions.

[3] Seng Chun Hoo, Haidi Ibrahim, "Biometric-Based Attendance Tracking System for Education Sectors: A Literature Survey on Hardware Requirements", Journal of Sensors, 2019
Focus: Analyzing the hardware components of biometric-based attendance systems, emphasizing microcontrollers, sensors, communication channels, and data storage.

[4] Prabhjot Kaur, Mridul Namboori, Aditi Pandey, Keshav Tyagi, "Deep Learning Based Smart Attendance System", Proceedings of World Conference on Artificial Intelligence: Advances and Applications (pp.485-495), 2023
Focus: Developing a cost-effective smart attendance system using face detection and recognition techniques like MTCNN and ArcFace.

[5] Ahmad S. Lateef, Mohammed Y. Kamil, "Facial Recognition Technology-Based Attendance Management System Application in Smart Classroom", Iraqi Journal for Computer Science and Mathematics, 2023
Focus: Developing a real-time AI-based attendance system using face detection and feature extraction, integrated with a user-friendly interface, emphasizing high accuracy and scalability in classroom environments.

[6] Angelo Garangau Menezes, Joao M. D. da C. Sa, Eduardo Llapa, Carlos Estombelo-Montesco, "Automatic

Attendance Management System based on Deep One-Shot Learning", 2020 International Conference on Systems, Signals and Image Processing, 2020

Focus: Developing a face recognition-based attendance system using deep one-shot learning, optimized for real-world conditions.

3. MOTIVATION AND PROBLEM STATEMENT:

3.1 Inefficiencies in Traditional Attendance Systems:

Attendance tracking is at the heart of the administrative system in any educational institution. It is a vital tool in measuring student performance, instilling discipline, and monitoring academic compliance. Despite its significance, many educational institutions remain stuck in their conventional attendance tracking system, which includes manual roll calls and the use of paper-based records.

Manual roll calls waste precious class time, especially in a classroom full of students. Moreover, it is also a very error-prone system. These conventional attendance tracking methods are also vulnerable to human error, which can lead to misinterpretation, incomplete, and inconsistent records. Furthermore, the use of paper-based records also creates a problem in record storage, accessibility, and maintenance in the long run. These problems only prove the necessity of a more streamlined and efficient attendance tracking system.

In many schools, even the electronic versions of conventional attendance tracking systems do not provide real-time accessibility and integration. The lack of an automated system also proves to be a problem in itself, as it does not provide instant feedback and can cause more work in the long run.

3.2 Limitations of Existing Automated Systems and Proxy Attendance Issues:

In order to overcome the drawbacks of the manual method, institutions have adopted automated methods such as the use of RFID-based attendance systems. However, it has been observed that even these methods have their own share of problems.

In the case of the RFID-based method, cards are issued to students, which can be shared by many students. This results in proxy marking, which affects the authenticity of the attendance records. Another method that has been adopted by institutions is the use of biometric-based systems. This method may be more reliable compared to the use of RFID cards. However, this method requires students to touch the device, which may result in hygiene problems, especially after the pandemic. Another drawback of this method is that it may cause wear and tear of the device over time.

Both the RFID-based method and the biometric-based method are expensive. This shows that even though there are automated methods, they are neither reliable nor efficient.

3.3 Need for a Contactless and Intelligent Attendance Solution:

With the rapid evolution of smart classrooms and digital transformation in education, there is a growing need for a seamless and intelligent attendance system. Modern technologies, especially in the areas of computer vision and deep learning, have enabled accurate identification of human faces.

Face recognition technology offers a viable solution that avoids the need for human interaction and additional equipment. A camera-based face recognition system can automatically detect individuals and record their attendance without interrupting the natural flow of the class. This not only increases efficiency but also reduces the possibility of proxy attendance.

Although the face recognition technology is a viable solution for student attendance, there are some limitations to the system. For instance, changes in lighting conditions, variations in face orientation, face occlusion due to masks or accessories, and crowd densities may affect the overall recognition efficiency of the system.

Despite these limitations, the benefits of using face recognition technology for student attendance outweigh the disadvantages.

3.4 Problem Definition and Proposed Direction:

In light of the aforementioned, it can be established that there is a dire need for a unified, reliable, and scalable attendance system. The current attendance systems lack integration, real-time accessibility, and efficient data management. There is a need for a system that not only provides accurate attendance records but also efficient storage, visualization, and analysis of attendance data.

The problem being addressed in the proposed project is the designing and implementation of an automated attendance system that can guarantee:

1. Real-time attendance tracking
2. Elimination of proxy attendance
3. Minimum human intervention
4. High accuracy in real-world environments
5. Scalability up to a high number of users

The proposed system, Proctor Nova, intends to use AI-based facial recognition technology to develop a completely automated attendance system. By using advanced computer vision algorithms in combination with an optimized system architecture, it is intended to develop a robust and efficient system that can be implemented in real-world environments. In a nutshell, the project intends to address the gap between inefficiencies and technology, transforming attendance tracking into a seamless, reliable, and intelligent system.

4. PROPOSED SYSTEM/ METHODOLOGY:

4.1 Overview of Proctor Nova:

Proctor Nova is an AI based, automated attendance management system designed to provide a seamless experience to the modern educational environment. The

system uses the technological advancements in computer vision and deep learning to detect and recognize faces in real-time, eliminating the need to interact with the system physically.

The basic intention behind Proctor Nova is to provide accurate attendance tracking, solve problems like proxy attendance, address the inefficiency in existing systems, and scale up to accommodate a large number of students in classrooms. The system uses face detection and recognition models with back end infrastructure to support real-time processing, storage, and visualization.

At a high level, Proctor Nova consists of three key components:

1. **Input Layer:** Captures real-time videos or images from a camera.
2. **Processing Layer:** – Employs face detection and recognition models.
3. **Application Layer:** – Manages attendance, storage, and application interface.

This three layered architecture is intended to be flexible, scalable, and easy to integrate with existing institutional infrastructure.

4.2 Workflow Pipeline:

The workflow of Proctor Nova is based on a sequential process that takes images as input and transforms them into attendance records. This process happens sequentially as follows:

1. **Image Acquisition:** A stream of still images are acquired using a camera placed within a classroom setting.
2. **Preprocessing:** The acquired images are analyzed and processed to fit the required dimensions to be compatible with the face detection algorithm, enhancing efficiency.
3. **Face Detection:** The images are passed to a face detection algorithm that uses deep learning techniques to detect faces within images.
4. **Face Recognition:** The detected face is passed to a face recognition algorithm that generates unique face embeddings to compare them with existing ones within a database.
5. **Identity Matching:** The detected face is matched to existing identities using similarity metrics to establish the identity of the person.
6. **Attendance Marking:** Upon confirmation of identity, attendance is marked accordingly.
7. **Data Storage and Visualization:** The marked attendance is stored within a database and visualized using a dashboard. This process ensures a seamless flow of images that is efficient for real-time attendance tracking.

4.3 Face Detection using YOLO:

The face detection in Proctor Nova employs a YOLO (You Only Look Once) object detection algorithm.

The YOLO algorithm is chosen because it is both fast and accurate.

The YOLO algorithm is different from other face detection algorithms because it does not involve multiple stages in face detection. Instead, it involves a single forward pass in the neural network. In this algorithm, the image is divided into a grid and then bounding boxes are predicted along with the confidence levels of objects in an image. This helps in detecting multiple faces in an image.

The benefits associated with using the YOLO algorithm in face detection are:

1. The algorithm can be used in real-time face detection.
2. The algorithm is very accurate in face detection.
3. The algorithm can detect multiple faces in an image.

The algorithm is also robust to changes in face positions and sizes because these are common in classroom settings. However, it can be affected in extreme lighting conditions.

4.4 Face Recognition using InsightFace:

Proctor Nova makes use of the InsightFace framework, for face recognition, which uses deep metric learning and produces face embeddings that are extremely discriminative.

Unlike traditional face classification, InsightFace converts each detected face into a numerical form called an embedding. This embedding contains unique facial features, which are not affected by changes like lighting, pose, or expressions up to a certain extent.

The face recognition process works as follows:

1. Extracting the embedding of each detected face
2. Comparing the extracted embedding with the pre-stored embedding
3. Calculating the similarity score using distance measurements like cosine similarity
4. Identifying the face based on the maximum similarity score

The embedding-based face recognition process allows the system to scale up efficiently, as new users can be added without retraining the entire model. This increases accuracy as well as robustness.

4.5 Multi face Handling Strategy:

In a classroom scenario, where several students are present, multiple individuals are identified in a single frame, and hence it is important for the system to process simultaneous recognitions and detections, to ensure every student is marked present.

The Proctor Nova system processes individual frames separately, where all faces are detected and then embeddings are created for individual faces.

For ensuring reliability:

1. The system processes individual faces with a unique bounding box assigned to each face.

2. Temporal consistency is maintained to handle duplicate faces in successive frames

3. Recognition is validated for multiple frames to avoid false recognitions

The process ensures that all individuals in a frame are recognized without any interference or confusion.

4.6 Attendance Marking:

The attendance marking mechanism is built to ensure accuracy, prevent duplication, and eliminate fraudulent entries.

After face recognition, the system checks whether attendance for that face has already been marked in a certain period of time. If not, it marks attendance along with the timestamp.

This ensures that the attendance is scalable, without congesting the system, with continuous updates.

The important parts of the attendance logic are:

1. Duplicate Prevention: The student is marked as present only once in a session
2. Threshold-based Validation: The attendance is marked only if the face recognition confidence is above a certain threshold
3. Temporal Filtering: Multiple face recognitions in different frames are filtered to mark attendance only once
4. Real-time Updates: The attendance is updated in real-time in the database

4.7 Database Design and Management:

An efficient and structured database plays a vital role in ensuring the reliability and scalability of the Proctor Nova system. The database is required to store the student information, facial embeddings, and attendance records in a manner that supports fast real time access and efficient querying.

The system employs a structured database approach, which includes the following main entities:

1. **Student Records:** This database stores the basic information of the students, including their student ID, name, roll number, class, and section. Each student is uniquely identified in the system. It also stores attendance, class sessions, and overviews for quick access. The database is normalized to ensure robustness and scalability.

2. **Face Embeddings:** Facial embeddings, calculated using the facial recognition model, are stored in the database as a vector representation. Each student has a unique facial embedding, which acts as their identifier. The facial embedding is used as a unique identifier in the system. During the system execution, the facial recognition module queries the facial embedding database, comparing the input facial embedding with the existing facial embeddings. Efficient querying is employed in the system, which supports real-time querying and minimizes latency in the facial embedding comparison process.

The database is designed to accommodate real-time updates, ensuring that the attendance records are reflected in real time in the system dashboard. Furthermore, the design of the system is expandable to accommodate additional attributes or connect to other external academic management systems

4.8 System Optimization and Performance Considerations:

Due to the real time nature of Proctor Nova, optimization of performance is an important factor of the system design. The system has to maintain a balance between accuracy and speed, enabling the processing of multiple faces at a time without a considerable delay.

One of the important considerations of the system design is the use of a lightweight detection model, which allows for efficient processing of real time video feeds. The system has been designed to process images at a certain pace, thus preventing computational overload, which might occur especially if the system has limited processing power.

To improve efficiency, preprocessing of images, including resizing and normalization, has been done, which reduces the processing cost of the model. In cases of high frame rates, frame processing or skipping might be used, which allows for real-time efficiency without a compromise in accuracy.

Another important factor of the system design is the balance between accuracy and efficiency. While a higher accuracy model might have a higher processing cost, the system has been designed to operate at an optimal pace, which allows for efficient recognition without a considerable delay.

Scalability is also taken care of by designing a system that can support more than one face in a single frame. Memory management and parallel processing techniques can be implemented in the system.

On the whole, the optimization strategies guarantee a high level of performance from Proctor Nova under changing working circumstances.

5. System Architecture and Design:

5.1 High-Level Architecture:

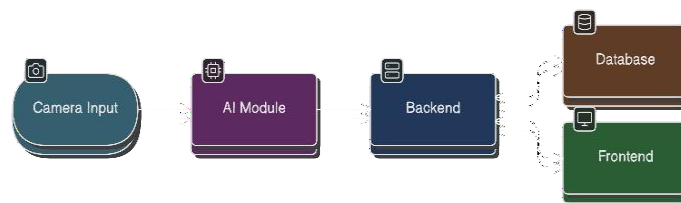
The Proctor Nova system is designed with a modular architecture, which is comprised of computer vision models and a full-stack application framework.

At a high level, the Proctor Nova system is comprised of three major layers:

- 1. Frontend Layer:** This layer is comprised of the user interface, which is utilized by the administrator or the instructor to monitor attendance.
- 2. Back end Layer:** This layer is comprised of business logic, which is utilized to interact with the API and the database. The back end layer acts as an intermediary between the frontend layer and the AI processing layer.

3. AI Processing Layer: This layer is comprised of face detection and recognition. The AI processing layer is utilized to process the input frame, perform identity matching, etc.

4. Database Layer: This layer is comprised of the database, which is utilized to store student information, facial embeddings, attendance, etc. All these components are utilized in a cohesive manner to enable seamless flow between image capture and attendance visualization.

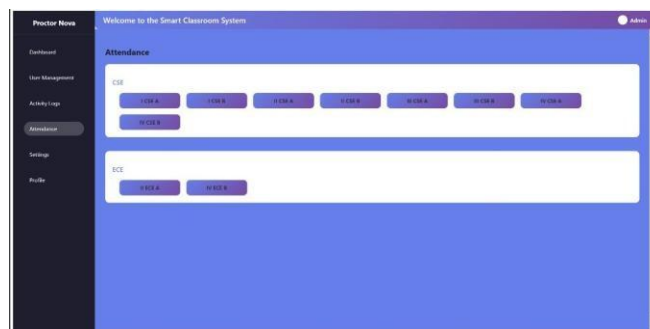


5.2 Frontend Design (Dashboard and User Interface):

The frontend of Proctor Nova is intended to be user-friendly and interactive, allowing users to interact with the system effectively. The frontend allows real-time monitoring and management of attendance information.

Key Features of the Frontend:

1. Dashboard View: This feature shows the real-time attendance status, showing the list of students identified and the timestamps.



2. Student Management Interface: This feature allows administrators to add, modify, or delete student information, along with their facial information.

3. Attendance Visualization: This feature offers a structured way to visualize attendance information, possibly in the form of a table or chart.

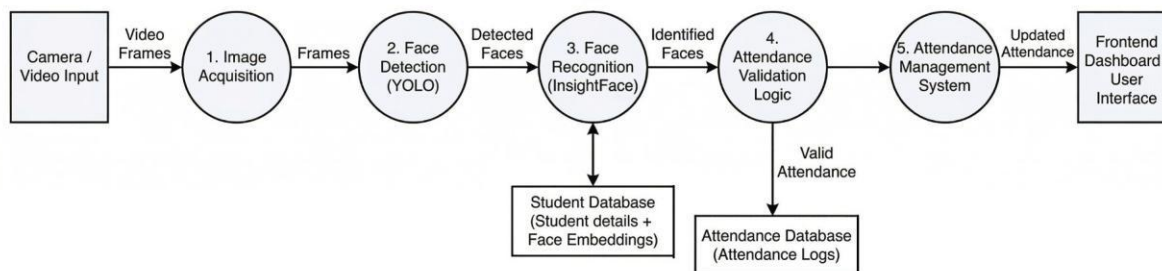
4. User Experience Considerations: The design is minimal and clean, ensuring ease of use even for non-technical users. Responsiveness is achieved across various devices.

5. Communication with Back end: The frontend uses RESTful APIs to communicate with the back end, ensuring real-time updating without the need to manually refresh.

5.3 Back end Services (API and Database Integration):

The back end acts as the core control part of the system. It manages communication between frontend, database and AI modules.

Data Flow Diagram of Proctor Nova



The back end exposes a list of APIs to perform the following operations:

- 1. Student Data Management:** The back end exposes APIs to perform operations like adding, updating, and retrieving student data and embeddings.
- 2. Attendance Processing:** The back end receives the results from the attendance recognition process and performs validation operations to mark attendance.
- 3. Data Retrieval:** The back end provides attendance data to the frontend to visualize it.

The back end is built to process requests concurrently to ensure efficient working with multiple faces detected at any given point in time. Additionally, it ensures data consistency by enforcing validation rules and storage.

The integration with the AI module is done using well-defined interfaces to process and store detection and recognition results.

5.4 Data Flow Design:

The flow of data within the Proctor Nova system demonstrates how the flow of information occurs within the system.

The process starts with the acquisition of images from the camera. Then, the images are processed through the AI processing module. The image is processed for face detection through the detection model. Then, the image is processed through the recognition model.

The identified identities are processed through the back end system. Then, the validation of the attendance is processed through the validation logic. Then, the attendance is recorded through the database.

The recorded data is processed through the frontend system to be shown to the user in real time.

5.5 Database Schema Design:

The database schema of Proctor Nova is intended for efficient data organization and management of system information, which supports real-time processing.

SectionID	INTEGER	DepartmentID	INTEGER NOT NULL	AcademicYear	YEAR NOT NULL	SectionName
PRIMARY KEY	REFERENCES	Departments (DepartmentID)	UNIQUE	NULL UNIQUE		VARCHAR(10) NOT NULL +
AUTOINCREMENT						UNIQUE
1	1	1	DepartmentName: 'CSE'	1		A
2	2	1	DepartmentName: 'CSE'	1		B
3	3	2	DepartmentName: 'ECE'	2		A
4	4	1	DepartmentName: 'CSE'	4		B
5	5	1	DepartmentName: 'CSE'	4		A
6	6	1	DepartmentName: 'CSE'	2		B
7	7	1	DepartmentName: 'CSE'	2		A
8	8	1	DepartmentName: 'CSE'	3		B
9	9	1	DepartmentName: 'CSE'	3		A
10	15	2	DepartmentName: 'ECE'	4		B

The schema comprises the following entities:

- 1. Accounts:** This contains account information regarding users
- 2. User_profiles:** This table contains profile information of users.
- 3. Sessions:** This table contains session information during an active session.
- 4. Attendance_logs:** This table contains attendance information that was processed.
- 5. Departments:** This table contains academic department information.
- 6. Sections:** This table contains academic department sections information.
- 7. Periods:** This table contains academic period information.
- 8. Students:** This contains information on the students
- 9. Attendance_records:** This table contains condensed attendance information.

6. Implementation Details:

6.1 Technology Stack:

The implementation of Proctor Nova utilizes a variety of modern web technologies, as well as deep learning libraries, to provide scalability, efficiency, and ease of integration.

- 1. Frontend:** The user interface of Proctor Nova will be built using React. This will help to create a dynamic user interface to display the dashboard.

React will help to create a dynamic user interface to display the attendance data.

2. **Back end:** The back end of Proctor Nova will be built using a lightweight back end framework Flask. This will help to create a seamless interface between the front end and the back end of the system. RESTful APIs will be used to create seamless interactions between the front end and the back end.

3. **Database:** Proctor Nova will utilize sqlite3 database system to create an interface to store student data, facial data, and attendance records. This will help to create fast read and write operations to support real-time functionality.

4. **AI/Deep Learning Frameworks:** Proctor Nova will utilize pre-trained models to create a seamless interface for face detection and recognition. This will be done using Python-based libraries. This will help to create an efficient interface to process the data.

6.2 Model Integration:

The integration of face detection and face recognition models is a critical component of the system implementation. The models are incorporated into the back end pipeline to enable seamless processing of input frames.

The detection model (YOLO) is responsible for identifying face regions within each frame. Once faces are detected, the corresponding image segments are extracted and passed to the recognition model (InsightFace).

The recognition model generates embeddings for each detected face, which are then compared with stored embeddings in the database. This integration is achieved through a well-defined processing pipeline within the back end, ensuring minimal latency between detection and recognition.

To maintain efficiency, model inference is optimized by:

1. Loading models into memory during system initialization
2. Avoiding repeated initialization for each frame
3. Using batch or sequential processing depending on system capacity.

The modular integration allows each component (detection and recognition) to function independently while contributing to a unified workflow.

6.3 Real Time Processing Strategy:

Proctor Nova is designed to operate in real time, requiring efficient handling of continuous video streams and rapid processing of multiple faces.

The system processes video input as a sequence of frames, with each frame undergoing detection and recognition. To maintain real-time performance, the processing rate is controlled to match system capabilities, ensuring that the system does not become overloaded.

Key strategies include:

1. **Frame Rate Control:** Instead of processing every frame, the system may selectively process frames at fixed intervals to reduce computational load.

2. **Asynchronous Processing:** Back end operations such as database updates and API responses are handled asynchronously to prevent blocking the main processing pipeline.

3. **Parallel Handling of Faces:** Multiple detected faces within a frame are processed independently, enabling simultaneous recognition.

4. **Latency Minimization:** By reducing preprocessing overhead and optimizing model execution, the system ensures minimal delay between detection and attendance marking. These strategies enable the system to deliver consistent performance in dynamic classroom environments.

6.4 Optimization Techniques (Speed and Accuracy):

To attain a balance between speed and accuracy, a number of optimizations have been employed as part of Proctor Nova.

1. **Image Resizing and Normalization:** Frames are resized to an optimal size prior to processing, which reduces complexity without losing important attributes.

2. **Efficient Model Selection:** YOLO has been selected for efficient detection, while Insight Face has been selected for its high accuracy recognition with robust embedding.

3. **Threshold Tuning:** Recognition confidence levels have been tuned to attain high accuracy with minimal false positives.

4. **Duplicate Filtering:** To mark attendance, validation has been employed, which prevents duplicate entries from consecutive frames.

5. **Resource Management:** Resources are efficiently utilized, enabling multiple detection without slowing down the system.

6. **Scalability:** To handle increased data sizes and number of users, database queries have been optimized.

All these optimizations have been made to ensure that the system performs efficiently regardless of the environment, thus attaining a balance between speed and accuracy.

7. RESULTS:

7.1 Accuracy of Face Recognition:

The performance of Proctor Nova was evaluated in real-time classroom environments with respect to detection accuracy, recognition reliability, and processing latency.

The system achieved 100% face detection accuracy across the tested scenarios, successfully identifying all visible faces within the camera frame under standard classroom conditions.

For face recognition, the system demonstrated an average accuracy ranging between 80% to 85%, depending on pose

variations and environmental factors. The embedding-based recognition approach effectively distinguished individuals based on subtle facial features, even in moderately dynamic conditions.

Additionally, the system maintained a low processing latency, with frame processing timestamps recorded as:

- 17:39:02.038188
- 17:39:02.535917
- 17:39:02.876126

This indicates an approximate processing interval of ~300–500 milliseconds per frame, enabling near real-time attendance marking.

Under controlled conditions with clear visibility, the system achieved consistent recognition performance. However, slight variations in accuracy were observed under challenging conditions, as discussed in the following sections.

7.2 Performance in Different Conditions:

To check the robustness, the system has been tested in various real-world scenarios.

1. **Lighting Conditions:** The system performed optimally under standard indoor lighting, maintaining near-perfect detection accuracy and stable recognition performance. In low-light or high backlit environments, recognition accuracy dropped slightly (within the 80–85% range), primarily due to reduced feature clarity. Preprocessing techniques such as normalization partially mitigated these effects.
2. **Variation in Angles and Pose:** The system demonstrated reliable performance for moderate pose variations, maintaining recognition accuracy within the observed range. However, in cases of extreme head tilt or side profiles, accuracy degradation was observed due to reduced feature visibility.
3. **Multiple Students in Frame:** Proctor Nova effectively handled multi-face scenarios, achieving 100% detection of multiple faces in a single frame. Recognition was performed independently for each detected face. While accuracy remained stable, processing time increased slightly in densely populated frames due to higher computational load.

7.3 Comparison with Manual Attendance Systems:

If we compare this system with the existing method of manual attendance, it can be clearly stated that there are several advantages to the proposed system.

1. **Efficiency:** The existing method of manual roll call requires 3–5 minutes per session, depending on class size. On the other hand, Proctor Nova's system records the attendance immediately.
2. **Accuracy:** The chances of human error are eliminated. Moreover, the system does not allow

proxy attendance, which is one of the problems that exists with the existing method.

3. **Real-time Availability:** The data regarding the attendance of the students can be available immediately, unlike the existing method.

4. **Scalability:** The system can handle a number of students without increasing the complexity of the process.

The automated system far outperforms the existing method in terms of speed, reliability, and data management.

7.4 Limitations Observed:

Despite its benefits, Proctor Nova also has some limitations which were noticed while testing.

1. **Sensitivity to Extreme Lighting:** In conditions where lighting is very low or very high, accuracy in face detection and recognition can be affected.
 2. **Occlusion Issues:** In face recognition, masks or objects covering parts of the face can affect accuracy.
 3. **Pose Variations:** In conditions where faces are not directly in front of the camera, face recognition can be affected.
 4. **Hardware Dependency:** Real-time performance is influenced by system hardware. Lower-end systems may experience increased latency beyond the observed ~300–500 ms range.
 5. **Scalability Constraints in High-Density Scenes:** In conditions where a large number of faces are to be processed in a scene, delays can be experienced.
- The limitations show where Proctor Nova can be improved in the future.

8. Conclusion and Future Work:

8.1 Summary of Contributions:

In this paper, the authors introduced a system called Proctor Nova, which is based on artificial intelligence and uses automated attendance. This system was created to overcome the limitations of traditional attendance systems and existing electronic attendance systems.

The proposed system uses face detection and face recognition techniques to ensure efficient attendance. The system uses face detection based on a deep learning model to ensure accurate attendance. Face recognition is based on the embedding technique. This system also uses a structured workflow pipeline to ensure efficient attendance. The system design is also optimized to ensure efficient attendance. The system also uses face detection to ensure that there is no duplication of entries.

The system has shown that it is possible to ensure accurate attendance without any human intervention. The system has also shown that it is possible to minimize the chances of proxy attendance. The system has shown that it is possible to bridge the gap between traditional attendance systems and modern intelligent attendance systems.

8.2 Practical Impact:

Significant benefits can be derived from Proctor Nova in terms of its practical utility to an educational institution.

1. The system can eliminate the need to conduct physical roll calls. This can reduce administrative workload, allowing more time to be devoted to actual teaching.
2. The system can reduce human error in attendance recording while providing more accurate data.
3. The contactless nature of Proctor Nova can make it more user-friendly and hygienic compared to physical interaction-based systems.
4. The availability of attendance data in real-time can provide better monitoring, analysis, and decision-making in academic administration.
5. The system can be scaled to accommodate different sizes of institutions due to its modularity.

8.3 Future Work:

Although Proctor Nova has shown impressive performance, there are still areas that can be enhanced to make the system even more efficient.

1. **Mask Detection Integration:** The integration of mask detection will enable the system to show better recognition capabilities in situations where the face is partially covered.
2. **Mobile Application Integration:** The extension of the system to the mobile platform will enable the system to be more user-friendly. A mobile application interface will enable the instructor to access the attendance records from their mobile devices.
3. **Multi-Camera Tracking:** The integration of multiple cameras in a classroom setting will enable the system to cover more areas without blind spots. This will enable the system to show better performance in situations where there is a large number of people to be tracked.
4. **Improved Robustness and Scalability:** The system can be further enhanced to show better performance in situations of extreme lighting, occlusions, and large densities of people. The system can also be optimized for better scalability using multiple processing units. The above-mentioned improvements will enable the system to show better performance and will be more suitable for a wider range of applications.

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