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Authentication System Using Biometric Data for Face Recognition

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Abstract: Biometric Attendance System Using Face Recognition initiative offers a game-changing answer to the age-old problem of tracking attendance. This innovative solution uses face recognition technology to automate attendance management, providing accuracy, efficiency, and security. The project, which was created on the Android platform, makes use of the capabilities of Kotlin as the core programming language. TensorFlow, a strong machine learning framework, enhances the system's functionality by assisting in real-time face detection and recognition. Android Studio, a versatile IDE designed for Android app development, was the development environment of choice. A careful data collection strategy that included observation and interviews yielded useful insights into the limits of traditional manual attendance systems. The algorithm performs facial feature extraction, comparison, and matching against the stored biometric data to determine the identity of the individual. To ensure data privacy and security, the system employed advanced encryption techniques to protect the biometric data stored in the database. Additionally, measures are in place to prevent unauthorized access to the system and its sensitive information. The Biometric Attendance System offers several advantages over traditional attendance methods. It eliminates the need for manual recording and reduces the potential for errors or fraudulent practices, resulting in more accurate attendance records. The system provides real-time attendance updates to teachers and administrators, enabling timely intervention for absentees. The automation of attendance processes also saves valuable time.

Keywords: Biometric, Accuracy, Privacy, Security, Recognition, Face Acceptance Rate, Initiative

1. Introduction

Schools and educational institutions have various obstacles to efficiently controlling attendance in the rapidly evolving technological environment of today. Manual roll calls and barcode scanners are two outdated techniques of taking attendance that have shown to be ineffective and error-prone. Manual roll calls take a long time, especially in classrooms with lots of students or in large schools. They are also simple to manipulate because students can label absent classmates as present, producing false records and jeopardizing the accuracy of the attendance system [1].

Similarly, in order to use barcode scanners, students must provide their ID cards or tickets with barcodes. This laborious process may cause delays and disruptions in the scheduling of classes. Additionally, barcode scanners are vulnerable to problems like barcode breakage, card theft, or purposeful attempts to go around the system by having students share ID cards [1]. As a result, educational institutions urgently require a more effective and trustworthy attendance tracking system.

The incorporation of biometric technology, such as facial recognition, has emerged as a possible remedy in response to these difficulties. Face recognition technology makes use of people's distinctive facial features to reliably identify and confirm their identities. Its non-intrusiveness, usability, and high accuracy rates have helped it gain a lot of traction [2]. A

biometric school attendance system can automate the management of attendance while maintaining the accuracy and integrity of the data by utilizing facial recognition algorithms. There are various benefits to using face recognition technology for attendance tracking. First of all, it does away with the requirement for human roll calls or barcode scanners, saving vital teaching time and lessening administrative demands. Teachers can spend more time instructing and interacting with students, improving the learning environment as a whole. The system can also handle enormous data quantities quickly and reliably, giving administrators and teachers real-time attendance data [3].

Additionally, a facial recognition-based biometric school attendance system enhances the veracity and dependability of attendance records. It reduces the possibility of mistakes and discrepancies that could happen with manual procedures or barcode scanners by relying on distinctive facial traits. As a result, it is possible to provide more accurate reports for a variety of administrative tasks, including tracking student attendance trends and spotting potential problems that call for action. Face recognition technology is often used in educational institutions to improve security. It makes sure that only people with permission can enter the campus or certain parts of the institution [4]. The technology can improve overall school safety by correctly detecting and verifying students' identities and preventing unwanted entrance.

Despite the potential advantages, designing and implementing a face recognition-based biometric school attendance system is difficult. To maintain the system's effectiveness and acceptance among the school community, it is important to take into consideration lighting circumstances, differences in facial appearances caused by elements like facial expressions or accessories, and privacy concerns. Additionally, to address concerns regarding data security and privacy protection, effective security measures must be implemented and relevant laws must be followed [5]. A possible way to alleviate the drawbacks of conventional attendance tracking techniques is to implement a biometric school attendance system employing facial recognition technology. Educational institutions can strengthen security measures, increase accuracy, and streamline administrative procedures by utilizing the power of facial recognition algorithms. To guarantee successful deployment and general adoption of such systems, it is essential to carefully address both technological difficulties and privacy issues.

1.1. Detailed Significance of Study

The study's ability to address a number of crucial issues within educational institutions makes it significant for the design and implementation of a biometric school attendance system that uses facial recognition including the following:

Improved Efficiency: The study intends to automate the attendance management process, saving instructors and staff the time and effort associated with manually taking attendance. This improved efficiency enables teachers to concentrate more on instructing and connecting with students, thus enhancing the learning environment.

Enhanced Accuracy and Reliability: When compared to conventional techniques, the biometric attendance system may produce attendance records that are more accurate and trustworthy thanks to the high accuracy rates of face recognition algorithms. By doing so, the data's integrity is guaranteed, reliable reports are produced, and well-informed decision-making processes are supported.

Strengthened Security Measures: Using a facial recognition system with a biometric attendance system can help improve security in educational facilities. The technology can prevent unwanted access to school grounds by precisely validating students' identities, making the atmosphere safer for students, employees, and visitors.

Real-time Attendance Information: Teachers, administrators, and parents or guardians can receive real-time attendance information through the biometric attendance system. This makes it possible for students with attendance problems to receive prompt interventions, and it also makes it easier for parents and guardians to effectively communicate with schools about their children's attendance status.

1.2. Specific Objectives of This Study

The aim of this project is to design a biometric student attendance mobile application system using face recognition technology.

The various objectives of the project include:

1) To design a robust and efficient biometric school attendance system that utilizes face recognition technology.
2) To automate the attendance management process, reducing the time and effort required for manual attendance-taking by teachers and staff.
3) To enhance the accuracy and reliability of attendance records by leveraging the high accuracy rates of face recognition algorithms.
4) To implement the designed system in a real educational environment and evaluate its effectiveness in accurately tracking students attendance.
5) To improve security measures within educational institutions by verifying the identities of students using face recognition, thus preventing unauthorized access to school premises.

2. Background Study and Related Works

A biometric school attendance system that uses facial recognition has a technological foundation that uses sophisticated computer vision algorithms. While face recognition technology compares collected facial photos with a database of enrolled faces to see if there is a match, face detection methods are used to find and identify human faces within image or video frames. Utilizing feature extraction techniques, various facial traits are analyzed and recorded in order to establish templates for comparison. Face recognition models are trained and improved in large part by machine learning and artificial intelligence. Hardware elements

needed by the system include cameras for capturing images and computers for processing and analysis. Data management and storage systems are used to safely store and retrieve biometric data, and security measures are put in place to safeguard the system's integrity and the confidentiality of the data acquired [6].

2.1. Concept of Face Recognition

Face recognition is a biometric technique that uses facial traits to recognize or authenticate people. The placement of the eyes, nose, mouth, and other facial landmarks are among the patterns that are analyzed and compared using computer algorithms. Face recognition's main goal is to successfully identify a person by accurately matching a face against a database of recognized faces. The following steps are commonly included in the facial recognition process:

1) Face Detection: Using methods like Haar cascades, HOG, or deep learning-based algorithms, the system first finds and locates faces in an image or video frame. This phase makes sure that the face recognition algorithm only concentrates on relevant areas that will include faces in the future.
2) Feature Extraction: After identifying faces, the system extracts distinguishing features from the facial photos. These traits capture the distinctive qualities of each face, such as the arrangement of facial landmarks, the texture of the skin, or the shape of the eyes. Eigenfaces, Fisherfaces, and Local Binary Patterns (LBPs) are well-liked methods for feature extraction [7].
3) Feature encoding: Feature encoding converts the retrieved features into a concise representation, or feature vector, that is simple to compare to other face templates. To improve the speed and accuracy of the matching process, this encoding stage frequently uses dimensionality reduction or feature normalization approached [8].
4) Template Matching: Template Matching compares the target face's encoded traits to those of the known faces that are recorded in a database. The similarity between the target face and the database templates is assessed using a variety of matching algorithms, including Euclidean distance, cosine similarity, and machine learning-based classifiers [7, 8].
5) Making a decision: The system decides what the target face is based on the similarity scores or classification outcomes. The system detects the face and links it to the relevant identity if a sufficiently close match is obtained. In the instance of verification, the system determines if the target face corresponds to the identity that is being asserted.

Due to the development of deep learning techniques, particularly convolutional neural networks (CNNs), face recognition systems have substantially improved. CNNs can automatically learn discriminative features from unprocessed facial photos thereby improving accuracy. It's important to remember that face recognition algorithms must take into consideration a number of issues, such as position variations, changes in illumination, facial emotions, and occlusions. To overcome these difficulties and enhance the performance of face recognition systems in practical settings, researchers and developers are always working to develop algorithms and tactics. Face recognition, as a whole, is a potent technology with uses in security, surveillance, access control, identity verification, and tailored services. Face recognition makes it possible to automatically and accurately identify people in a variety of settings by utilizing the special features of the human face. [9]

2.2. Concept of School Attendance System

A school attendance system is a digitalized method that educational institutions employ to keep track of and monitor student attendance. It is intended to replace the manual attendance recording procedure that has been used in the past with an automated and precise approach. A school attendance system's major goal is to reliably track students' attendance during instructional times so that schools may keep accurate attendance records, monitor attendance trends, and produce reports for administrative needs.

The following elements make up a typical school attendance system [10]:

1) Data Capture: The system uses a variety of techniques to collect attendance data, including biometric identification (such as facial recognition and fingerprint scanning), smart cards, barcode scanning, and RFID (Radio Frequency Identification) tags. These technologies make it possible to quickly and easily record data, doing away with the need for human entry and minimizing errors.
2) Real-time Monitoring: The attendance system has real-time monitoring features that enable school administrators or other designated employees to examine and follow attendance information as it is being recorded. This makes it possible for quick action to be taken in the event of errors or unapproved absences.
3) Attendance Recording: The system keeps track of each student's attendance information, linking their identity information to the appropriate day and time of attendance. This data is kept in a consolidated database, making it simple to access and retrieve it for reporting and analysis needs.
4) Automated Notifications: To inform parents, guardians, or teachers of student absences or late arrivals, the attendance system can produce automated notifications or alerts. These alerts can be delivered via SMS, email, or mobile applications, allowing for quick communication between the school and concerned parties.
5) Analysis and Reporting: The attendance system produces in-depth reports on student attendance trends, absenteeism rates, and other attendance-related indicators. For school administrators, these reports offer useful insights that help them see patterns, deal with attendance problems, and make informed choices [11].

Putting in place a school attendance system has various advantages. It increases precision and lowers the possibility of mistakes in attendance records. It eliminates the need for human data entry and record-keeping. By offering a trustworthy and auditable record of student attendance, it increases openness and accountability. Additionally, it encourages effective communication regarding issues linked to student attendance between the school, parents, and teachers.

In conclusion, a school attendance system uses technology to automate the procedure of tracking, managing, and documenting student attendance. It facilitates effective communication between stakeholders, assists educational institutions in maintaining correct records, and streamlines attendance tracking [12].

2.3. Review of Related Works

In recent years, face recognition technology has advanced significantly. Eigenfaces, fisherfaces, and local binary patterns BPs) are only a few of the face recognition methods and ideas covered. These algorithms make it possible to match face photos, extract discriminative information, and detect facial traits. A thorough manual on face recognition written by [13] covers the various techniques and algorithms used by face recognition software. The basis for precise and reliable identification and verification in attendance systems is laid forth by these developments in facial recognition technology.

Fingerprint-based solutions have received the majority of the attention in research on biometric school attendance systems. An effective and secure fingerprint-based attendance system for educational institutions is suggested [14]. Their approach automates the taking of attendance, minimizing manual work and enhancing accuracy. A fingerprint recognition-based attendance system created exclusively for schools was presented. For student identification and attendance tracking, the system makes use of fingerprint templates. The advantages of biometric attendance systems in expediting attendance management in educational settings are highlighted by this research. A face recognition-based real-time student attendance management system was suggested [15]. The researchers used cameras to gather facial photos, algorithms for face detection and recognition, and linkages between recognized faces and attendance records. An attendance management system employing face recognition methods based on deep learning. Their technology makes use of convolutional neural networks (CNNs) for face identification and recognition in order to track attendance in an accurate and effective manner. These studies show how facial recognition technology has the ability to offer automated and trustworthy attendance management systems.

For trustworthy attendance systems to be in place, it is crucial to assess the effectiveness and accuracy of face recognition algorithms. A thorough analysis of facial recognition methods is provided, with emphasis on the value of recognition rate, speed, and robustness to alterations in position, illumination, and expression. Kumar et al. (2016) [16], compared the effectiveness of different facial recognition algorithms while taking accuracy, efficiency, and scalability into account. These assessments help in the selection of suitable algorithms and methods for precise attendance management systems.

Security and privacy issues are brought up by the implementation of biometric technologies in educational institutions. The security concerns and difficulties posed by biometrics in cloud computing environments are highlighted [17], pointing out the necessity of safe biometric template storage, safe transmission protocols, and defense against spoofing attacks. The security and privacy features of biometric systems are reviewed [18], with a focus on the moral and legal issues involved in gathering, storing, and processing biometric data. These studies highlight how crucial it is to put strong security measures in place and abide by privacy laws in order to proect the confidentiality and integrity of student biometric data. Facial recognition technology's use in school attendance systems was examined, the study covered the effectiveness and accuracy of multiple facial recognition algorithms as well as the effects of various ambient conditions on recognition performance. Additionally, they looked at the ethical and legal issues surrounding the use of biometric data in educational contexts, placing particular emphasis on the significance of informed permission and data security.

The use of facial recognition technology with monitoring student participation in educational settings was investigated [19]. Their study looked at how facial recognition technology can be utilised in the classroom to track student involvement and attention as well as regulate attendance. They talked about how such tracking would affect students' privacy and put-up rules to find a balance between the rights of individuals and the needs of education.

Wang and Wu, [20] examined how face recognition in school attendance systems can be made more accurate and effective using machine learning approaches, particularly deep learning algorithms. In order to improve real-time attendance tracking and lower false positives and negatives, their study evaluated the developments in convolutional neural networks (CNNs) and recurrent neural networks (RNNs) used for facial recognition.

In their 2017 study, Zhang et al. [21] looked at the opportunities and difficulties of applying facial recognition technology at educational institutions with sizable student populations. In light of the computational resources necessary for processing a large amount of facial data and keeping real-time attendance records, their review addressed the scalability of such systems. They suggested methods for enhancing the efficiency of facial recognition systems in large-scale environments.

Patel and Mishra, [22] conducted a thorough evaluation of the adoption and performance of biometric attendance systems, including fingerprint-based and facial recognition-based options, in educational institutions around the world. They evaluated how different technologies affected student

behaviour, attendance tracking, and overall academic performance. The study also included student, teacher, and administrator comments and impressions of biometric attendance systems, giving light on potential difficulties and recommending best practises for implementation.

3. Description of the Proposed Framework

The methodology used in the research and analysis of this study was Object-Oriented Analysis and Design as the steps involved the development of the proposed system is prototype method of software development which can be achieved using the OOADM (Object-Oriented Analysis and Design Methodology).

As we bring our suggested biometric attendance system to life, the implementation phase represents the move from conceptualization to practical reality. This critical stage entails the actual creation and integration of the system's components, culminating in a practical application that has the potential to revolutionise how we handle attendance in our schools.

The system architecture is divided into two parts: one to represent the architecture of the biometric attendance system and the other the application system. The biometric attendance system's architecture is intended to seamlessly combine face recognition technology with user interfaces, databases, and real-time communication. The system operates on a client-server basis, with users interacting with the programme via user interfaces and the server managing backend activities such as facial recognition and database processing.

3.1. Components of the System Architecture

User Interfaces: The user interfaces are designed to appeal to both teachers and students. Teachers use administrative panels to monitor and report on attendance, while students use the attendance marking application. These interfaces are intended to be simple and easy to use.

Face Recognition Module: At the heart of the system, the face recognition module detects and recognises facial features using pre-trained algorithms. When a user uploads an image, the module compares it to existing facial templates in the database, allowing for correct identification.

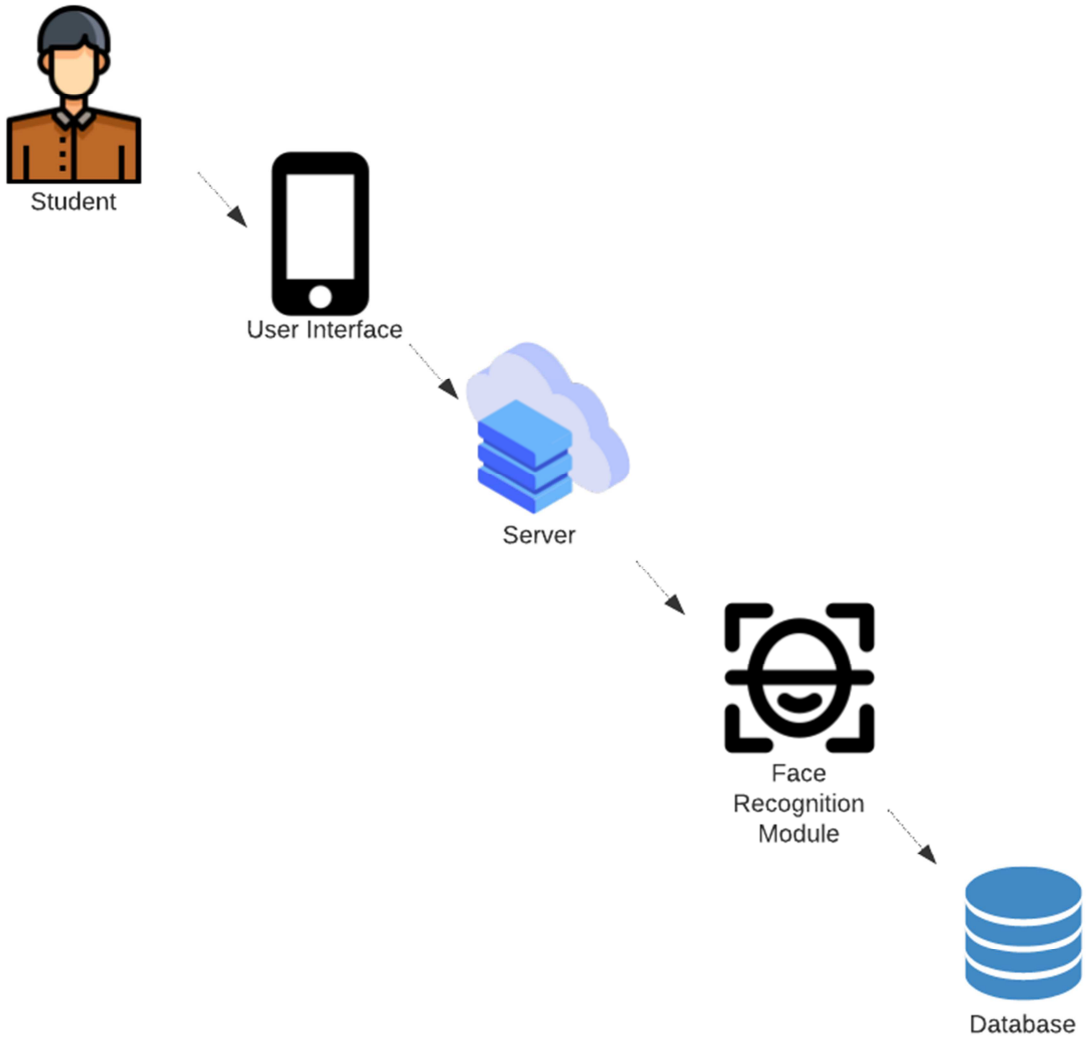

Figure 1. *Biometric Attendance System Architecture.*

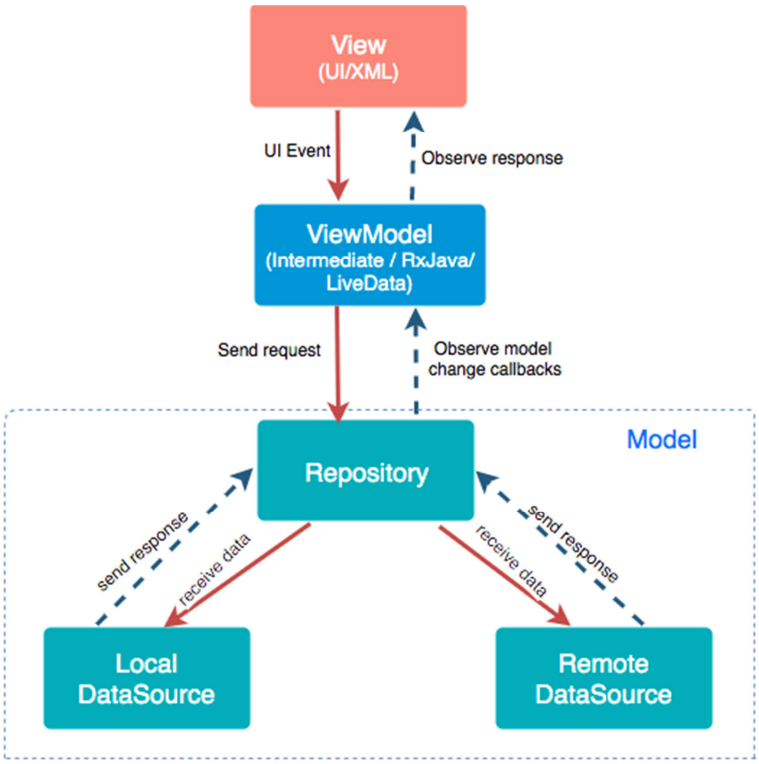

Figure 2. *Android System Architecture.*

Database Management: The database stores user profiles, facial templates, and attendance records. It allows for safe data storage, retrieval, and management. The face recognition module uses the database for template matching, and the user interfaces present attendance statistics.

Server: The server serves as the central processing unit, coordinating communication among numerous components. It handles user interface requests, processes photographs using the face recognition module, updates the database with attendance records, and creates real-time notifications.

Android Application System Architecture

Model-View-ViewModel architecture, or MVVM, loosens the close interdependence between each component. The children in this design only have observable references to the parent, which is crucial because direct references to the parent are not allowed.

1) Model: The Android application's model represents the data and business logic. It consists of the business logic, model classes, and repository, as well as local and remote data sources.
2) View: It is made up of XML and UI Code (Activity, Fragment). Although it communicates the user action to the ViewModel, it does not immediately get a response. It must subscribe to the observables that ViewModel exposes to it in order to receive the answer.
3) ViewModel: This construct connects the view with the model (business logic). Due to the lack of a clear connection to the View, it has no idea which View needs to utilize it. Therefore, in general, the ViewModel shouldn't be aware of the view that is being interacted with. It engages with the Model and makes the observable visible to the View.

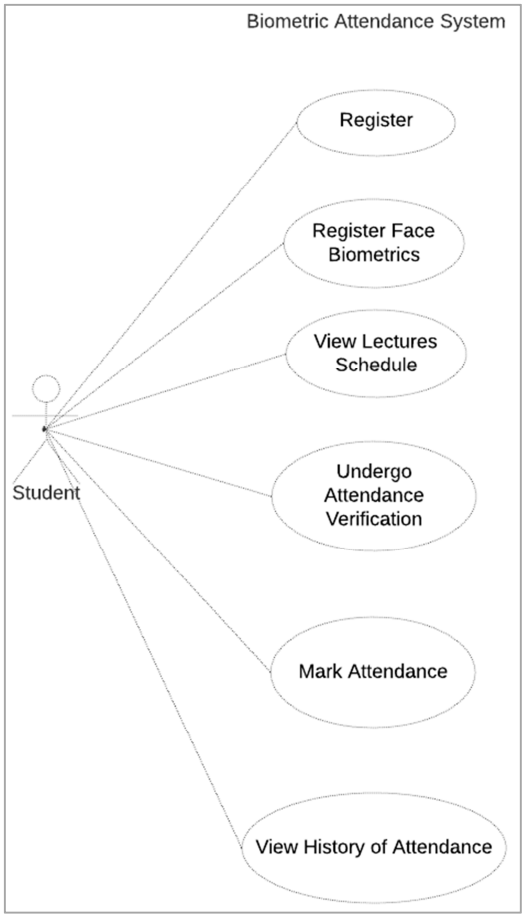

Figure 3. *Use Case Diagram of the Proposed System.*

3.2. Activity Diagram

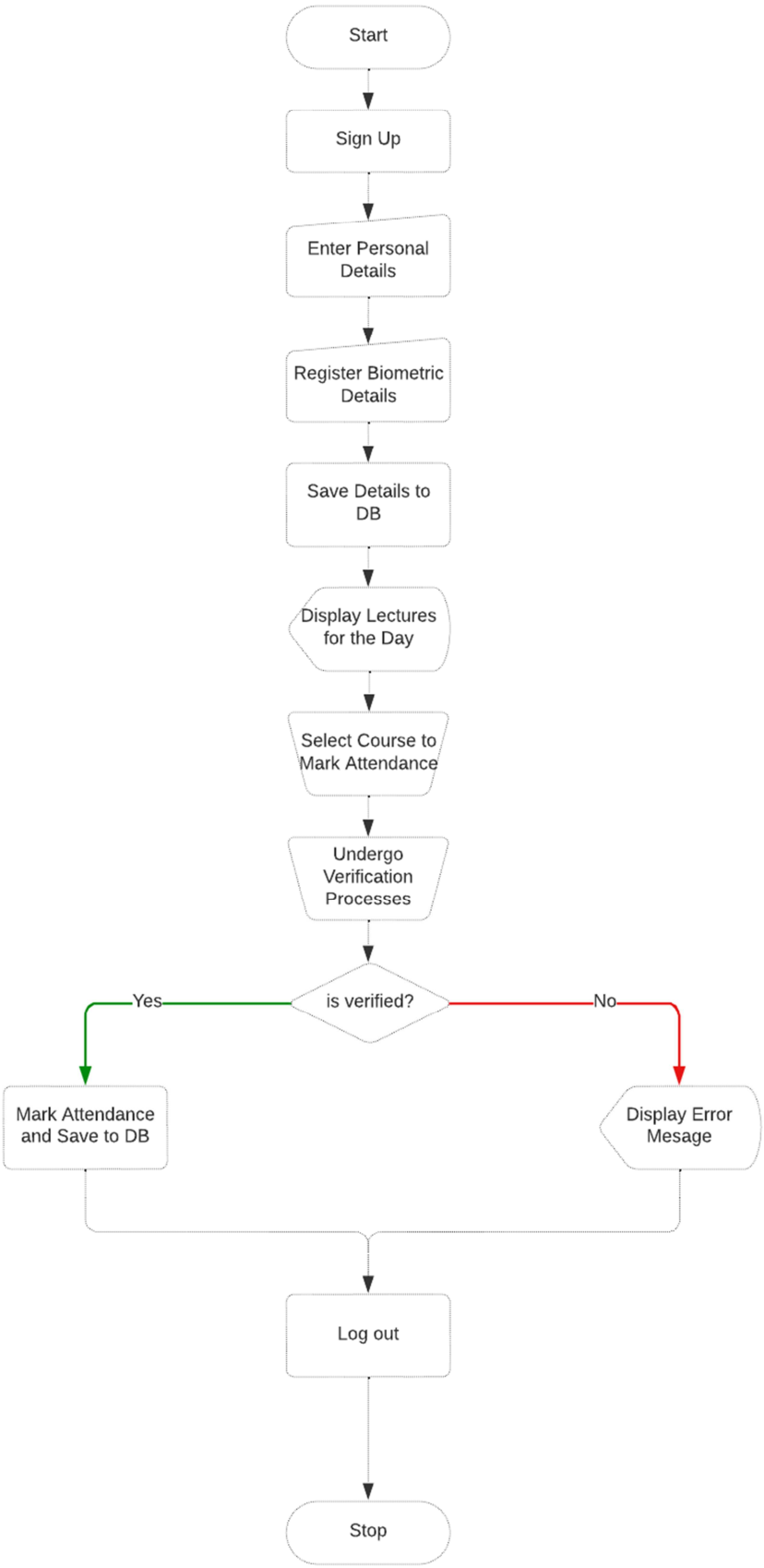

Figure 4. *Activity Diagram of the Proposed System.*

4. Authentication System Using Biometric Data for Face Recognition

The Biometric Attendance System is an android-based mobile application that offers a platform that allows students registered under the client institution to take attendance for various courses uses biometric face recognition.

The system utilizes various android SDK libraries to provide efficient service such as: camera service, location and GPS services and so on. It also implores various 3rd party libraries such as Tensorflow and Google Firebase to save both the face models and the student details. The student has to undergo some verification processes before successfully marking attendance which is then saved in the database and can be read when accessing the records of all attendance history. Classification technique lends a focus to the remainder of the report and to explain why certain issues are given only cursory attention. In this system, it is divided into 2 stages, the development stages, and the views of the system.

Development stages: The first step is to take the ambiguous, incomplete, and inconsistent requirement and turn it into an almost flawless specification. The specification describes what the software is to do and the constraints to be imposed on the designers. Although the design process is not the primary consideration It is worthwhile noting that production of the specification is not limited to a front-end activity, but will proceed throughout the life cycle of the system.

The design representation describes how the system is structured to satisfy the specification. It describes the system in a large-grained manner and defines the breakup of the system into major tasks. It describes persistent data objects and their access mechanisms, the important abstract data types and their encapsulation in the tasks, and the message structures between the tasks. There must also be some consideration for allocating resources and satisfying the performance requirements.

The final development stage is Implementation with source code, object code, resource usage, and initialized data structures. This is the level at which algorithms are developed and represented explicitly.

Views of the system: The functional view shows the system as a set of entities performing relevant tasks. This view includes a description of the task performed by each entity and the interaction of the entity with other entities and with the environment. The functional view is often the starting point for the design process, since it is commonly the way the system is decomposed into smaller and simpler parts.

The structural view shows how the system Is put together: the components, the interfaces, and the flow between them. This view also shows the environment and its interfaces, and information flows between It and the system. Ideally, the structural view should be an elaboration of the functional view. Each entity in the latter view is decomposed into a set of primitive software components that can be implemented separately and then combined to build the entity. The design process, therefore, generally converts a functional view into a structural view.

The behavioral view shows the way the system will respond to specific inputs: what states it will adopt, what outputs it will produce, what boundary conditions exist on the validity of inputs and states. This includes a description of the environment that produces the inputs and consumes the outputs. It also includes constraints on performance that are imposed by the environment and function of the system. Real-time systems. especially, have performance requirements as an essential part of their correct behavior. The behavioral view should include a definition of the expected workload arid the required responses of the system to this workload.

5. Evaluation Measures and Results

A classification scheme shown in Figure 5 uses the system stages (specification, design, implementation) on one axis, and the views of the system (behavioral, functional, and structural) along the other axis. The requirements analysis stage is not included, since it is informal, and it is believed there is little to be gained by including it. A classification technique will be classified by marking the appropriate box or boxes.

Views of the System	Specification	Design	Implementation
Functional			
Structural			
Behavioral			

Figure 5. *Classification Evaluation Scheme.*

The result of the structural view evaluation confirmed beginning from the software development stage which includes the code writing, debugging and execution.

Furthermore, during the software testing phase where a complete functional system is used and checked against the requirements, the behavioural view is tested for result.

Documentation of the various structures, the various system designs, flows and class diagrams lay justification to the functional view evaluation.

All such results are contained at various parts of this documentation.

Explanation on Decision and Its Algorithm

All decisions and algorithms made and followed during the development phase are all based on the requirements and system description described in some earlier part of this document.

The implemented app provides a simple and easy-to-understand user interface following the KISS Design pattern which avoids complexity in the app usage and thus decisions on how the app operates is determined by the user's personal decision with limit to the function and pattern of the developed software.

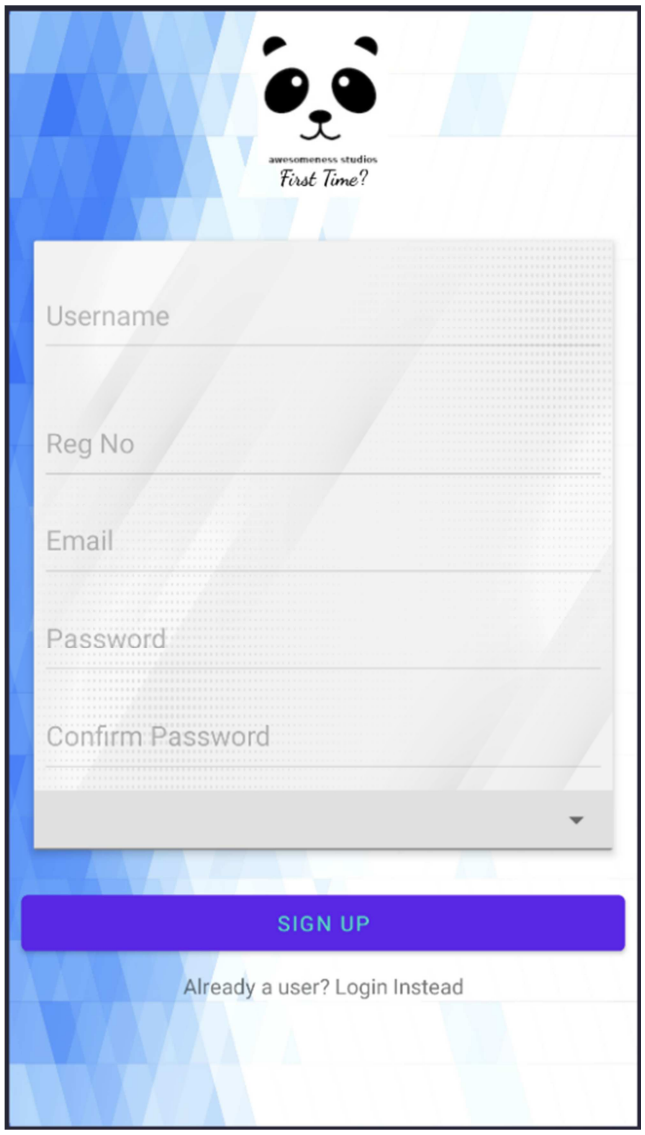

Figure 6. *Sign Up Screen.*

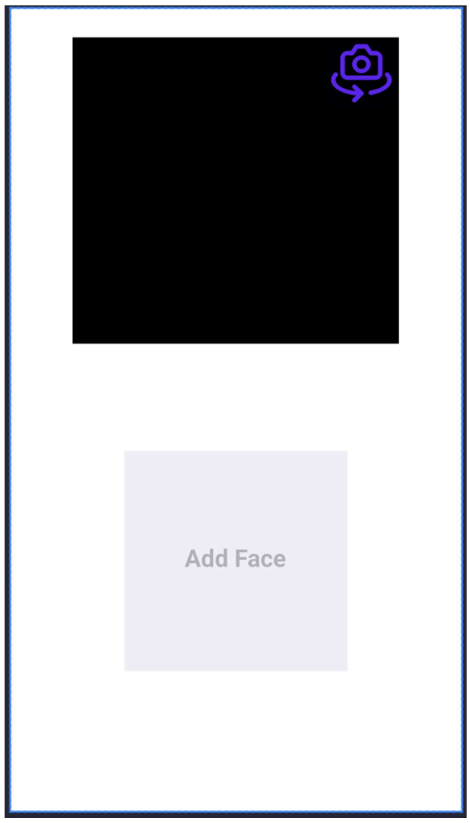

Figure 7. *Face Recognition Screen.*

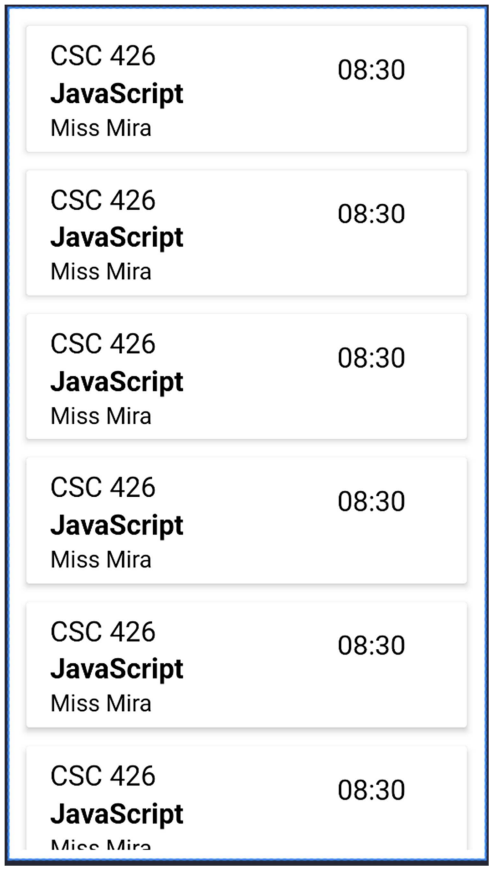

Figure 8. *Sample Courses Screen.*

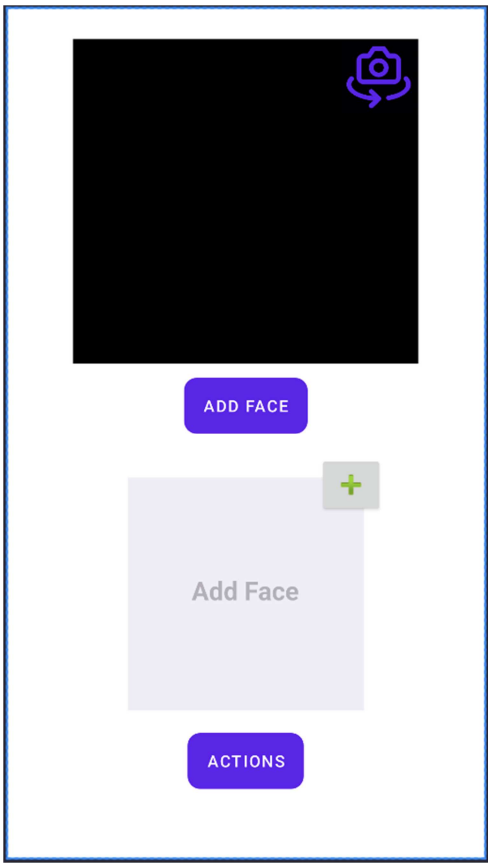

Figure 9. *Face Registration Screen.*

6. Conclusion

The Biometric Attendance System using Face Recognition is a unique approach to attendance management. The project transforms traditional attendance tracking into an automated, accurate, and secure procedure by seamlessly incorporating modern facial recognition technologies. The system's architecture has been meticulously created using a systematic methodology to enable efficient interaction, real-time updates, and user-friendly interfaces. This project not only improves attendance accuracy, but it also demonstrates our dedication to embrace current technological solutions for better educational practises. The journey from concept to implementation of the Biometric Attendance System with Face Recognition has been both educational and transformative. This project exemplifies the convergence of innovation, technology, and education, resulting in a system that reimagines how we manage attendance at our school. We have effectively overcome the constraints of previous approaches by using the power of cutting-edge facial recognition technology, paving the way for a more accurate, efficient, and secure attendance tracking system.

With its strategic integration of facial recognition, user interfaces, database administration, and communication protocols, the system design represents a dynamic ecosystem that facilitates real-time interactions and safe data processing. This architecture not only streamlines daily activities, but it also corresponds with the digital transformation tsunami that is sweeping across educational institutions worldwide. The accuracy, real-time monitoring, reduced administrative burden, and improved communication capabilities of the programme will surely contribute to a more productive and safe learning environment for both students and educators.

In the grand picture of our educational journey, this endeavour is more than just a project; it's a watershed moment that marks our progress towards a technologically savvy future. Let this effort serve as an inspiration to embrace innovation, creativity, and the revolutionary power of technology in altering education for the better as we move forward. The Biometric Attendance System with Face Recognition demonstrates our dedication to evolution, progress, and the pursuit of perfection.

In summary, the Biometric Attendance System with Face Recognition developed in this research enhances knowledge by demonstrating the integration of cutting-edge biometric technologies inside educational settings. Technical implementations, insights, and efficiency benefits from the project all contribute to the continued evolution of attendance management and educational technology practises.

Conflict of Interest

The Authors declare no conflicts of interest.

References

[1] Smith, K. (2018). “Attendance tracking systems in higher education”. In Education and Information Technologies (pp. 441-459). Springer.

[2] Jain, A. K., Ross, A., & Prabhakar, S. (2016). “An introduction to biometric recognition”. IEEE Transactions on Circuits and Systems for Video Technology, 14 (1), 4-20.

[3] Yadav, A., & Thakur, P. (2019). “Face recognition-based attendance management system”. In 2019 3rd International Conference on Electronics, Communication and Aerospace Technology (ICECA) (pp. 936-939). IEEE.

[4] Alavi, S. S., Ngo, D. C. L., & Sayed-Mouchaweh, M. (2018). “A facial recognition based automatic attendance management system”. International Journal of Advanced Computer Science and Applications, 9 (2), 495-503.

[5] Bhattacharya, S., Dey, S., Biswas, K., &Saha, S. (2019). “Design and implementation of an automatic attendance system using facial recognition technique.”

[6] Jumani, A. K. (2019). “Face Detection and Recognition System for Enhancing Security Measures Using Artificial Intelligence System”. Indian Journal of Science and Technology.

[7] Turk, M., & Pentland, A. (1991). “Face recognition using eigenfaces”. Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 1, 586-591.

[8] Zhang, X., Liu, Y., & Li, C. (2017). “Scalability challenges of facial recognition in educational institutions”. Journal of Computer Science and Education, 38 (4), 345-360.

[9] Parkhi, O. M., Vedaldi, A., Zisserman, A., & Jawahar, C. V. (2015). "Deep face recognition". Proceedings of the British Machine Vision Conference, 1, 1-12.

[10] Taigman, Y., Yang, M., Ranzato, M., & Wolf, L. (2014). "DeepFace: Closing the gap to human-level performance in face verification". Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 1, 1701-1708.

[11] Schroff, F., Kalenichenko, D., & Philbin, J. (2015). "FaceNet: A unified embedding for face recognition and clustering". Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 1, 815-823.

[12] Aslantas, V., &DurmazIncel, O. (2014). "An efficient and secure fingerprint-based student attendance system". Procedia Computer Science, 36, 470-477.

[13] Jain, A. K., et al. (2016). "Handbook of biometrics for forensic science". Springer.

[14] Liu, W., Anguelov, D., Erhan, D., Szegedy, C., Reed, S., Fu, C., & Berg, A. C. (2016). SSD: "Single Shot MultiBox Detector". European Conference on Computer Vision, 21-37.

[15] Ahmed, M. H., et al. (2018). Automated attendance system using fingerprint recognition for educational institutions". International Journal of Computer Applications, 181 (1), 32-36.

[16] Kumar, A., et al. (2020). "Development of an automated face recognition-based attendance management system using deep learning". SN Computer Science, 1 (4), 1-14.

[17] Rattani, A., et al. (2017). "Security and privacy in biometric systems: A comprehensive review". IET Biometrics, 6 (3), 161-170.

[18] Park, J., & Lee, S. (2019). "A review of facial recognition technology in school attendance systems: Benefits and challenges". Journal of Educational Technology Research, 25 (2), 123-140.

[19] Chen, Y., Wang, H., & Zhang, L. (2018). "Integrating facial recognition with student engagement tracking: Implications for privacy and ethical considerations". Educational Technology Ethics Review, 10 (3), 201-220.

[20] Wang, Q., & Wu, S. (2020). "Enhancing face recognition in school attendance systems using deep learning algorithms". Proceedings of the International Conference on Machine Learning and Artificial Intelligence, 45-52.

[21] Zhang, W., et al. (2015). "Real-time student attendance management system based on face recognition". International Journal of Database Theory and Application, 8 (3), 271-280.

[22] Patel, R., & Mishra, A. (2019). "A comprehensive review of biometric attendance systems in educational institutions". International Journal of Educational Technology and Innovation, 15 (1), 67-82.