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An Intelligent Automated Attendance System using RetinaFace and ArcFace

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Abstract: *The shortcomings of existing facial recognition systems leads to the numerous operational challenges that afflict conventional attendance tracking systems in educational establishments. These methods create a backlog of students during peak times, disrupting class time and increasing the workload for administrative staff due to complex verification procedures. These ongoing issues emphasize the deficiencies of the existing frameworks and the need for more robust attendance monitoring systems.*

Consequently, technological innovation is essential to enhance accuracy, reliability, and administrative efficiency in attendance management systems.

AttendAI addresses these issues with a specially designed mobile device that combines artificial intelligence and edge computing. Its unique design goes beyond conventional limitations and ensures safe, dependable operation through a proprietary structure, allowing this small hardware solution to revolutionize attendance verification with advanced recognition algorithms. Experiments demonstrate that AttendAI works better than traditional systems, surpassing them in accuracy and efficiency.

Keywords: Face Recognition, AI, Attendance Management

I. INTRODUCTION

In the real-time system, the attendance tracking method has transformed into a challenging, engaging, and accurate process. Because of the large class size and high student turnout, it is difficult to track attendance for every student. The present research has included automated method for managing attendance.

AttendAI aims to overcomes these challenges by utilizing a specifically developed mobile device that integrates artificial intelligence and edge computing. Its innovative design goes beyond typical constraints and offers dependable, secure performance via a patented framework, allowing this compact hardware solution to redefine attendance verification with advanced identification algorithms.

Nonetheless, the attendance management system that relies on facial recognition continues to face issues, providing researchers with opportunities to advance their efforts and ensure the system operates effectively. This paper will perform a literature review of prior research articles by different scholars.

Managing attendance records remains a key administrative challenge in educational institutions, especially in large classrooms with high student enrollment. Traditional attendance methods, such as manual paper logs and early biometric systems, often prove inefficient, taking 5-10 minutes per session and reducing instructional time by 3-5% annually (Johnson & Patel, 2021). These systems can also lead to verification errors and delays, highlighting the need for a more streamlined and reliable solution.

AttendAI offers an innovative solution by integrating artificial intelligence and edge computing into a mobile-based system. Unlike traditional biometric scanners, which require dedicated hardware, AttendAI processes facial recognition directly on mobile devices, reducing infrastructure costs while ensuring real-time verification. This approach also enhances data privacy by minimizing dependence on cloud-based storage, addressing security and regulatory concerns commonly associated with facial recognition technology.

Despite its advantages, facial recognition for attendance tracking faces ongoing challenges related to privacy, ethics, and technical constraints. Regulations such as GDPR in Europe and CCPA in the United States set strict guidelines for

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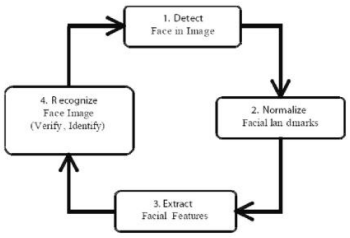
implementation, while concerns about algorithmic bias and informed consent continue to be debated. Addressing these issues is crucial for widespread adoption in educational settings.

This paper examines the development, implementation, and effectiveness of facial recognition-based attendance systems. By exploring current capabilities, practical challenges, and ethical considerations, this research positions AttendAI within the broader landscape of attendance tracking solutions while identifying opportunities for further innovation.

The face recognition process typically involves four key steps:

- **Detect** – The system identifies and locates a face within the image or video frame.
- **Normalize** – The detected face is preprocessed, adjusting for lighting, orientation, and scaling to ensure consistency.
- **Extract** – Key facial features are extracted, converting the image into a numerical representation.
- **Recognize** – The extracted features are compared against stored templates to verify or identify the individual.



II. LITERATURE SURVEY

The primary purpose of this review paper is to analyze existing solutions proposed by other researchers, identify their limitations, and explore potential improvements to develop a more effective attendance management system.

This paper presents an innovative online attendance system that integrates facial recognition with face mask detection. It is designed for a browser-based interface, allowing users to record attendance without installing special software. The system leverages Python and OpenCV for image processing, while PHP and MySQL are used for the web interface and database. Users can capture their selfies to be processed for identity and mask-wearing status, and this information is then stored in an online database. The authors aimed to address attendance management challenges in educational institutions while ensuring safety compliance in a post-COVID world. Initial testing indicated an accuracy of around 81.8% for facial recognition and 80% for mask detection, providing a streamlined, contact-free solution to attendance logging.[1]

This study proposes a contactless, camera-based attendance monitoring system enhanced with anti-spoofing technology to address security concerns. In response to COVID-19's social distancing requirements, traditional biometric systems were limited, prompting the authors to develop a scalable and cost-effective solution for schools and workplaces. The system employs facial recognition alongside an anti-spoofing module that verifies liveliness, effectively preventing fake attendance logging. Data management is facilitated by Firebase, which enhances data exchange efficiency and reduces storage costs by 33.52%. Their approach showed 95.85% accuracy, proving superior to conventional methods in both security and scalability. This system demonstrates potential for broad adaptation in environments requiring contactless attendance management[2]

In this paper, the authors developed a smart attendance system based on facial recognition using deep transfer learning and convolutional neural networks (CNNs). The system addresses the need for automated attendance management in schools and organizations, offering a reliable alternative to traditional methods. Three pre-trained CNN models (AlexNet, GoogleNet, and SqueezeNet) were trained on a custom dataset, each achieving high prediction accuracy and efficient processing time. The system can classify individual identities with impressive precision, reducing time and complexity in attendance tracking. By implementing transfer learning, the model benefits from pre-trained networks that adapt quickly to smaller datasets, making it a robust and resource-efficient solution for accurate attendance logging in diverse settings. [3]

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The study presents a portable attendance system that leverages face recognition technology with integrated liveness detection to mitigate spoofing threats. By employing MobileNetV2 on a Raspberry Pi, the system achieves a processing time of less than 0.6 seconds per recognition, making it suitable for real-time applications. The results indicate a high accuracy rate of 96% for recognizing live subjects, while the system demonstrates varying effectiveness against spoofing attacks, achieving 79% accuracy for level A, 83.7% for level B, and 70% for level C attacks. This innovative approach not only enhances security in attendance tracking but also ensures efficiency, making it a viable solution for educational institutions and workplaces seeking reliable attendance management systems. The authors emphasize the importance of balancing security and performance in the development of biometric authentication systems. [4]

The paper presents an innovative attendance system that leverages face recognition technology on Android smartphones to streamline the attendance process in educational settings. The system requires students to capture their facial image alongside a QR code displayed during class, which is then transmitted to a server for verification. The implementation achieved a remarkable accuracy rate of 97.29% using Linear Discriminant Analysis (LDA) and demonstrated an impressive recognition time of just 0.000096 seconds. This approach significantly reduces the potential for fraud and eliminates long queues associated with traditional attendance methods. Additionally, the system capitalizes on the widespread availability of smartphones, making it accessible for most students. Future enhancements may include the integration of Bluetooth technology to further ensure student presence and minimize cheating opportunities. Overall, this system represents a modern solution to attendance tracking in educational institutions. [5]

The paper presents a Facial Recognition Attendance Monitoring System aimed at automating the attendance process in educational institutions. By leveraging advanced facial recognition technologies, including OpenCV and various algorithms such as Haarcascade, Eigenfaces, Fisherfaces, and LBPH, the system enhances the accuracy and efficiency of attendance tracking. The proposed solution addresses common issues associated with manual attendance methods, such as human error and time consumption, while also improving data management. However, the implementation of such a system faces challenges, including high costs, potential accuracy issues, privacy concerns, and reliance on technology. Future work is suggested to focus on refining algorithms to adapt to different lighting conditions and creating an online database for attendance records, ultimately aiming to streamline the attendance process further and ensure a more reliable system. [6]

The research project aimed at creating an RFID-based attendance tracking system for students. A simulation was conducted in a controlled environment using an Arduino Uno Board, an RFID reader, passive RFID tags, and a laptop server connected via LAN. During the simulation, the RFID reader collected data from the tags, which was then compared to a database to verify student identities. If a student was confirmed to be in the class, their check-in time was recorded, and positive feedback was sent back to the reader module. The results of the simulation indicated that the system was reliable, efficient, and convenient for managing attendance, fulfilling the project's objectives of collecting, validating, and storing quality data for consultation and reporting. [7]

This document presents a proposal for a smart mobile application designed to automate student attendance at Taif University through RFID technology. The traditional methods of taking attendance are often inefficient and time-consuming, leading to disruptions in the learning process. The proposed system allows lecturers to use their mobile devices to automatically detect student ID cards, streamlining the attendance process without interrupting lectures. This innovative approach not only reduces the workload for educators but also enhances the accuracy of attendance records. The application generates comprehensive reports categorizing students as present, late, or absent, thereby providing valuable insights into attendance patterns. Overall, the implementation of this smart attendance system aims to improve the educational experience for both students and faculty. [8]

The Student Attendance Monitoring System using Face Recognition aims to streamline the attendance process in educational institutions by automating it through advanced technology. The system employs a combination of Haarcascade classifier and Local Binary Pattern Histogram (LBPH) for effective face detection and recognition, implemented using Python and OpenCV libraries. The project successfully achieved a recognition accuracy of 91%, allowing for efficient attendance tracking, which is recorded in an Excel spreadsheet for easy access and management. Future enhancements are proposed, including the integration of high-resolution cameras and deep learning techniques

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to improve face detection accuracy, as well as the development of user-friendly applications for updating student images, ultimately aiming to create a more robust and efficient attendance monitoring system. [9]

The "Automated Student Attendance Management System Using Face Recognition" (FACECUBE) aims to streamline the attendance process in educational institutions by employing advanced face recognition technology. The system captures images of students in the classroom using IP cameras, detects their faces, and matches them against a pre-existing database to mark attendance automatically. By utilizing cloud computing for image processing, FACECUBE enhances scalability and minimizes the burden on local servers. The system is designed for multiple user roles, including students, instructors, and administrators, facilitating efficient account management and attendance tracking. Ultimately, this innovative approach significantly reduces the time and effort required for manual attendance recording, promoting a more efficient educational environment. [10]

This research paper discusses the development of an automated student attendance management system utilizing facial recognition techniques, which is considered more effective than traditional methods like fingerprint recognition. The authors highlight the use of Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT) in conjunction with facial recognition algorithms to improve attendance tracking in classrooms. The paper also reviews existing systems, noting that while some utilize personal devices for attendance, they lack detailed situational awareness of the classroom environment, emphasizing the need for a more comprehensive solution. [11]

The Face Recognition System is a critical technology that enables the identification of individuals by analyzing facial features. As computers advance, their ability to recognize faces is approaching that of humans. The system employs various methods, including geometric and photometric approaches, to process and analyze facial data. Key techniques such as 3D recognition, thermal imaging, Eigenfaces, and Principal Component Analysis (PCA) enhance the accuracy and efficiency of recognition. The process typically involves face detection, normalization, and recognition through eigenvector analysis. Despite its effectiveness, particularly with the Eigenface method, challenges remain, including variations in facial expressions and lighting conditions that can affect recognition accuracy. Overall, the system represents a significant advancement in biometric identification technology, with applications across security, surveillance, and personal device access. [12]

This study, published in Addiction Science & Clinical Practice, explores the effectiveness of Internet-based interventions for individuals struggling with substance use issues. The authors highlight significant improvements in both mental and physical well-being among participants who engaged in these online programs. The findings suggest that such digital interventions can be a viable option for addressing substance use problems, offering accessible support and resources to those in need. The article emphasizes the importance of further research to optimize these interventions and enhance their impact on public health.[13]

III. METHODOLOGY

The proposed mobile-based attendance tracking system, AttendAI, leverages deep learning-based face recognition to automate and enhance the accuracy of student identification. The system follows a structured pipeline consisting of four key steps: detection, normalization, feature extraction, and recognition. By integrating open-source frameworks—RetinaFace for face detection, ArcFace for feature extraction and recognition, and FAISS for efficient similarity search—AttendAI ensures real-time and scalable performance on mobile devices.

Face Detection using RetinaFace

The first step in the process is detecting faces in an image or video feed. RetinaFace is used for this purpose, as it provides a highly accurate face detection mechanism that works under varying lighting conditions, angles, and even when the face is partially occluded. Unlike traditional detection methods, RetinaFace not only locates the face but also identifies facial landmarks such as the position of the eyes, nose, and mouth. This helps in proper alignment of the face before further processing.

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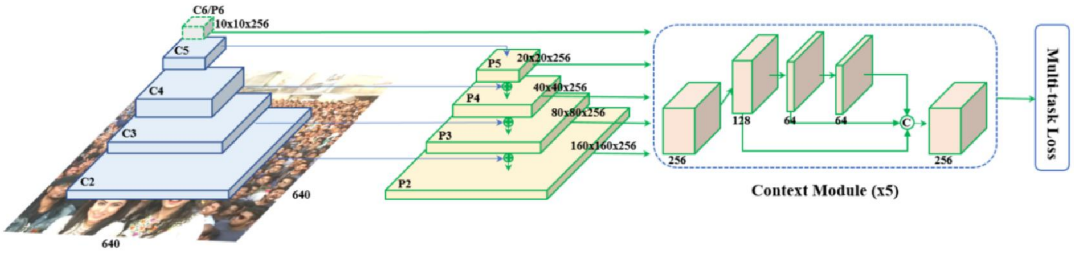


1. RetinaFace Model Structure

Feature pyramid: Its a feature extractor that takes a single image as input and outputs feature maps at multiple scales. It has been a crucial tool for object detection tasks in the last few years. It was proposed in the paper titled 'Feature Pyramid Networks for Object Detection'.

Single stage: Single stage methods, unlike two stage methods (eg: Faster R-CNN), only require one single iteration over the full network to generate the bounding boxes of the object to be detected. This makes it much more efficient and is more widely used in the recent papers.

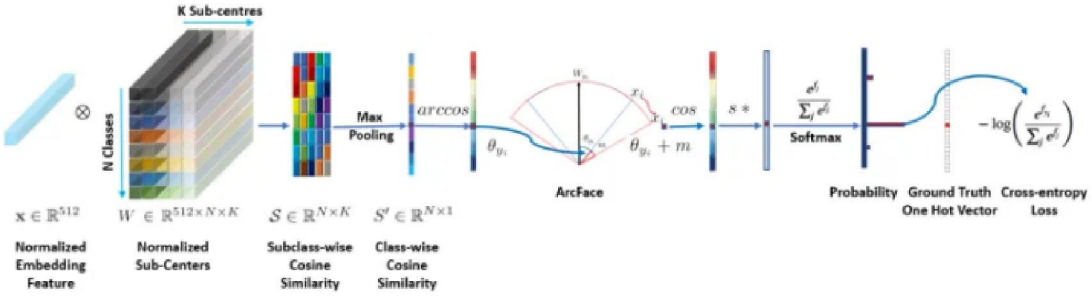
Context modelling: The idea is to learn contextual information from the images to aid the localisation task using DCN. DCN or deformable convolutional networks works much like convolutional blocks in CNN except that it doesn't have a strict kernel grid. Rather the grid points can be adjusted by a parameter that allows it to be more adaptive to the multiple feature scales of the object.

Face Normalization

Once the face is detected, it is aligned based on key facial landmarks to ensure consistency. This step is crucial as variations in head position or camera angles can affect recognition accuracy. Normalization ensures that all faces are processed in a standardized manner, improving the overall reliability of the system.

Feature Extraction using ArcFace

After normalization, the system extracts unique features from the face using ArcFace. Instead of storing raw images, ArcFace converts each detected face into a numerical representation (embedding). This embedding acts as a unique fingerprint for the individual, allowing the system to differentiate between different faces with high precision. ArcFace is designed to maximize the distance between embeddings of different people while keeping variations of the same person close together, improving recognition accuracy even under changes in appearance.



2. ArcFace Model Architecture

ArcFace, or **Additive Angular Margin Loss**, is a loss function used in face recognition tasks. The softmax is traditionally used in these tasks. However, the softmax loss function does not explicitly optimise the feature embedding to enforce higher similarity for intraclass samples and diversity for inter-class samples, which results in a performance gap for deep face recognition under large intra-class appearance variations.

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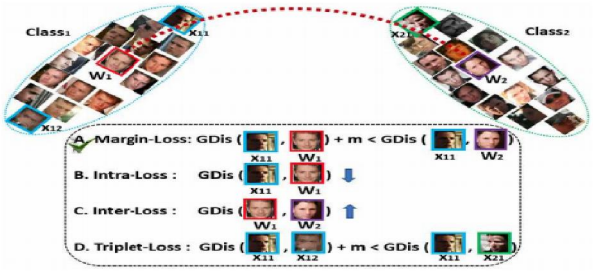

3. ArcFace Model Classification

It improves recognition accuracy by ensuring that embeddings of the same person remain close together while embeddings of different individuals are pushed further apart. This is achieved by modifying the traditional classification approach to enforce a larger angular margin between different face classes, making it more difficult for similar-looking faces to be misclassified. Instead of simply classifying an image, ArcFace maps each face to a high-dimensional space where the angles between embeddings represent identity differences. By applying this method, ArcFace enhances the system's ability to recognize individuals even when they appear in different lighting conditions, angles, or slight variations in expression.

Face Recognition using FAISS

The final step is face recognition, where the extracted embeddings are compared with a database of enrolled faces. FAISS (Facebook AI Similarity Search) is used to efficiently search and match the newly captured face against a large dataset. Instead of performing a direct one-by-one comparison, FAISS organizes the database in a way that allows rapid searches, significantly reducing processing time. This ensures that real-time attendance marking is possible, even in large classrooms with hundreds of students.

By integrating RetinaFace, ArcFace, and FAISS, the system achieves a balance between accuracy, speed, and scalability. This methodology allows for a seamless, automated attendance marking system that minimizes manual effort, enhances security, and reduces time consumption in educational institutions.

IV. COMPARISON

Author/ Date	Theoretical/ Conceptual Framework	Research Question(s)/ Hypotheses	Methodology	Analysis & Results
Khawla Alhanaeea, Mitha Alhammadia , Nahla Almenhalia, Maad Shatnawia. (2021)	**Facial recognition attendance system based on deep learning convolutional neural network.**	Utilize transfer learning by using three pre-trained *convolutional neural networks.*	The proposed approach consists of several stages: **data collection, data pre-processing, data augmentation, CNN training and validation, and system testing.**	The three networks are **SqueezeNet, GoogleNet** and **AlexNet** where they achieved a validation accuracy of 98.33%, 93.33% and 100% respectively.
Dwi Sunaryono, Joko Siswantoro, Radityo Anggoro. **(2021)**	**An android based course attendance system using face recognition**.	Attendance fraud in a large class.	The student only needed to capture his/her face image and displayed **QR code** using his/her smartphone. The image	The proposed attendance system achieved face recognition **accuracy of 97.29%by using**

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			was then sent to server for attendance process.	**linear discriminant analysis** and only needed **0.000096s** to recognize a face image in the server.
Dr A Manjula, D. Kalpana, Sanjay Guguloth. **(2023)**	**Facial Recognition Attendance Monitoring System using Deep Learning Techniques**	Facial Recognition System can aid in identifying or verifying a *person's identity from a digital image.*	Involves utilizing a camera to capture input images, detecting faces using algorithms such as **Haarcascade, Eigen values, support vector machines**, or **the Fisher face algorithm**, verifying the faces against a database of student profiles, and marking attendance in an Excel sheet.	By utilizing face detection and recognition algorithms, this system saves **time** and **effort**, especially in classes with a large number of students.
Nico Surantha, Boy Sugijakko. **(2024)**	**Lightweight face recognition-based portable attendance system with liveness detection**	Face recognition systems that do not implement liveness detection are susceptible to *face spoofing Attacks.*	To develop a lightweight liveness detection method that can be run on a **Raspberry Pi**. Several pre-trained models were evaluated and **MobileNetV2** was chosen based on the results	The proposed attendance system achieved an **average processing time below 0.6 s and 96 % accuracy for live subjects**, **79 % accuracy for level A spoof attacks, 83.7 % accuracy for level B spoof attacks,** and **70 % accuracy for level C spoof attacks.**

V. CONCLUSION

Attendance tracking remains a crucial administrative task in educational institutions, yet traditional methods often fall short due to inefficiencies, verification challenges, and time constraints. The advancement of facial recognition technology has introduced a more streamlined and accurate alternative, reducing manual effort while enhancing reliability.

This review examined various facial recognition-based attendance management systems, analyzing their methodologies, strengths, and limitations. While existing solutions demonstrate significant progress, many still rely on extensive hardware infrastructure or lack real-time adaptability. AttendAI, leveraging a mobile-based approach with advanced face detection, normalization, feature extraction, and recognition through open-source frameworks like RetinaFace, ArcFace, and FAISS, offers a promising solution that eliminates the need for specialized biometric devices. Despite its potential, challenges such as privacy concerns, algorithmic bias, and regulatory compliance must be addressed to ensure ethical and secure deployment. Future research should focus on improving edge computing capabilities, minimizing computational overhead, and developing privacy-preserving mechanisms to enhance user trust.

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By integrating mobile-based AI-driven attendance tracking, educational institutions can achieve greater efficiency, security, and scalability, paving the way for more accessible and cost-effective attendance management systems.

The first study introduced a deep learning-based facial recognition system using three pre-trained networks (SqueezeNet, GoogleNet, and AlexNet). The system achieved high accuracy rates of 93.33% to 100% through comprehensive data processing and CNN training, establishing a strong foundation for automated attendance systems.

Advancing the technology, the next development created an Android-based system combining face recognition with QR code verification. Using Linear Discriminant Analysis, it achieved 97.29% accuracy with rapid processing time (0.000096 seconds), making it highly efficient for large classroom implementation.

The third study enhanced the system by integrating multiple algorithms (Haarcascade, Eigen values, SVM, Fisher face) into a comprehensive attendance solution. This automated approach excelled in face detection, database matching, and attendance recording, significantly reducing manual effort while maintaining accuracy.

The latest development focused on portability and security, creating a lightweight system for Raspberry Pi with liveness detection features. Processing faces in under 0.6 seconds with 96% accuracy, it addressed attendance fraud through multi-level anti-spoofing measures, achieving security accuracy rates between 70-83.7% for different attack levels.

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