(CIJST) 3007-3847 (Online) Vol. 1(1)

CAVENDISH INTERNATIONAL JOURNAL OF SCIENCE AND TECHNOLOGY (CIJST)

RESEARCH ARTICLE

ENHANCING CLASS ATTENDANCE WITH AI: A STUDENT FACE RECOGNITION SYSTEM USING OPENCV

Open Access

Vol. 1(1):
https://journals.cavendish.ac.ug/index.php/cjst/article/view/12/9

August, 2024

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Abstract

Background: With the rapid advancement of technology, there is an increasing need to incorporate these innovations into education, particularly in attendance tracking. Traditional methods, such as roll calls, are inefficient, error-prone, and unsuitable for large classes. Computer vision, a subset of artificial intelligence (AI), utilizes machine learning and neural networks to extract valuable information from digital images and videos, aiding in well-informed decision-making.
Methods: This study employs computer vision, a subset of AI, using the OpenCV library to develop a Student Facial Recognition system. The system captures and analyzes students' images during class sessions, automatically recording their attendance. Actual classroom experiments were conducted to evaluate the system's effectiveness and accuracy.
Results: The Student Facial Recognition system has demonstrated its value by achieving a 92% accuracy rate in identifying students, with an average processing time of 10 seconds per student. This level of efficiency and accuracy can significantly enhance the attendance tracking process in educational institutions.
Conclusion: In conclusion, the facial recognition system holds promise for improving attendance tracking, but it also raises significant data privacy and ethical concerns that require careful consideration. Despite these challenges, the system's potential to transform attendance tracking in education is reason for optimism. Future research should address these issues and explore the technology's broader potential in education.

Keywords: *Artificial Intelligence, OpenCV, Facial recognition, Class attendance tracking, Computer Vision.*

INTRODUCTION

Background

It is essential to monitor attendance to identify absenteeism patterns and ensure student participation. Traditional methods, such as roll calls and sign-in sheets, are time-consuming, prone to human error, and challenging to scale in large classes. Facial recognition technology provides a promising alternative by utilizing unique biometric identifiers to automate the process, offering significant advantages over manual methods. Traditional methods, while familiar, present inherent challenges, such as the time-intensive nature of conducting roll calls and susceptibility to human errors, including mispronunciation of student names. Addressing scalability challenges within large class settings has been an ongoing struggle. The need for innovative and efficient solutions has arisen, leading to the consideration of automated attendance systems utilizing advanced technologies. Facial recognition, with its unique biometric identifiers derived from facial features, stands out as a promising technology for addressing the limitations of traditional attendance tracking methods. Implementing a student facial recognition attendance system addresses the shortcomings

associated with traditional recording methods (Uddin et al., 2021). The system in question is designed to assign a unique identification to each student, accurately record their attendance, and seamlessly function in educational settings with many students. Additionally, it facilitates real-time tracking of attendance records through its dynamic database. (Uddin et al. 2021 Facial recognition, a rapidly advancing technology, is gaining popularity due to its high accuracy and speed in analyzing unique facial features. This technology, which is difficult to replicate or alter, significantly reduces the chances of erroneous attendance records. When students arrive in class, their image is captured and verified against their facial information in the database. This process automates attendance-taking, eliminating the need for manual intervention. The efficiency of this system is particularly valuable in large classes, where manual attendance tracking can be challenging to implement.

This study aims to deploy this technology to achieve accuracy and automate the process of attendance taking by employing the capabilities of OpenCV, an open-source system. The implementation of the technology of recognizing faces has become popular because of its significant progress. Higher accuracy and efficiency in analyzing an individual's facial attributes render them difficult to replicate or alter. This technology has the potential to revolutionize the attendance tracking process in educational institutions by automating the verification of students' identities upon their arrival in class. This initiative aims to leverage the capabilities of OpenCV, an open-source computer vision library, to develop a robust Student Face Recognition System. By integrating this technology into educational institutions, such as Cavendish University Uganda, manual attendance processes can be replaced with a streamlined, efficient, and accurate system. Facial recognition technology is expected to enhance student attendance management, instill accountability, and optimize classroom engagement.

Notwithstanding its current limitations, including high processing power requirements, privacy concerns, and operational speed on standard computers, this technology significantly advances attendance tracking. It promises to improve education management practices worldwide, especially in academic institutions in Uganda. Computer vision library. OpenCV provides solid face detection, recognition, and tracking tools, making it a proper platform for developing a Student Face Recognition System.

By integrating an OpenCV-based attendance system into educational institutions such as Cavendish University Uganda, tedious and error-prone manual attendance processes can be replaced with a streamlined, efficient, and accurate system. This project, using facial recognition technology, aims to significantly improve the overall management of student attendance, promote accountability, and optimize classroom engagement.

All in all, though this system needs improvements in its operation, colossal processing power use, privacy concerns, and its slowness on regular computers, the gaps in traditional attendance tracking methods through implementing an innovative and technology-driven solution. It aims to pave the way for improved attendance management practices and contribute to advancing education technology in academic institutions in Uganda and across the world.

The article is structured as follows: Section 2 provides a review of the pertinent literature, while Section 3 outlines the methodology. Section 4 presents the results derived from the sample. The paper concludes by offering a comprehensive summary and delineating future work in Section 5.

REVIEW OF LITERATURE

The utilization of facial recognition technology is undoubtedly increasing on a global scale within the realm of biometric technology (Al-Nayyef, 2024). In the realm of education, a substantial demand exists for biometric authentication owing to its dependability and longevity as a means of verification (Shabaneh et al., 2023). Of particular interest is its utilization in overseeing and monitoring class attendance. Facial recognition, harnessing distinct facial attributes unique to individuals, has demonstrated exemption from misidentification, robust security, and immunity to errors (Sain et al., 2023; Udaya Varshini et al., 2023). Our research introduces an autonomous system designed to validate students' class attendance and maintain relevant data in a secure database accessible to lecturers and school management. Traditional attendance tracking systems are often inefficient, inconsistent, and susceptible to fraud, highlighting the necessity for a more reliable and efficient solution. The proposed system addresses these shortcomings by offering accurate and trustworthy class attendance tracking suitable for small and large classrooms.

Nguyen et al. (2024) developed a cost-effective and user-friendly machine learning-based system for attendance tracking, utilizing Haar Cascade, OpenCV2, and the NVIDIA Jetson Nano. This system has the potential to revolutionize attendance management practices by offering high accuracy, efficiency, and adaptability across various educational and workplace settings.

Bussa et al. (2020) proposed an OpenCV-based face recognition system for marking attendance. The system integrates a camera, face detection algorithm, face encoding, and identification of faces, as well as attendance logging and conversion to a PDF file. The system utilizes a training database created from authorized students' faces, with features extracted using the Local Binary Pattern Histogram (LBPH) algorithm.

Muhammad et al. (2020) presented a generic face detection and recognition system designed to automate school attendance collection by identifying students' frontal faces in classroom photographs. The system utilizes principal component analysis for face detection, OpenCV for face recognition, and Python programming language for system development.

Furthermore, Deng (2023) developed a dynamic sequence facial expression recognition system using big data technology and innovative methodologies. It addresses critical shortcomings in current facial expression recognition methods through a personalized learning algorithm combined with an optical flow technique.

Reddy (2019) proposed a facial biometric technology to continuously recognize students, mark their attendance, and monitor their performance by comparing their faces with a database. This technology has potential future applications in artificial intelligence for motion picture analysis of students in class.

METHODS

Implementing technologies such as OpenCV for real-time image processing has enabled efficient face detection and recognition in our system. We have employed the face_recognition library to compare student faces with a database, ensuring precise and dependable attendance tracking. Additionally, preprocessing

techniques and data augmentation have enhanced the model's performance across diverse conditions. The system also possesses real-time video processing capabilities and seamless integration with Firebase services, augmenting authentication, database management, and cloud storage functionality.

The system development process encompasses a comprehensive requirements analysis to align with stakeholder needs, followed by a detailed system design encompassing high-level architecture and specific components. The client-side application is constructed using React, while the server-side application is implemented using Flask, with integrated OpenCV for image capture and processing. The system's testing includes unit, integration, and system testing to ensure its functionality, performance, and security. The deployment process on the Google Cloud Platform is meticulously planned to ensure seamless accessibility and functionality in classroom settings.

The successful operation of this system is contingent upon the presence of robust computing equipment or a dedicated server along with a high-definition camera. The central processing unit (CPU) or graphics processing unit (GPU) of the computer must be capable of real-time video processing and accommodating facial recognition algorithms. The camera, possessing strong low-light performance, should be able to capture distinct facial images in diverse classroom lighting environments.

The hardware configuration is influenced by the deployment strategy. In a scenario where individual classrooms operate autonomously, each classroom necessitates a suitably equipped computer with camera connectivity. Alternatively, in a cloud-based system, a centralized server is employed for processing, requiring solely high-definition cameras connected to the network in each classroom.

RESULTS

Lecturer or Sys admin Login

For lecturers and administrators to access the system and assume their respective roles, they must use the login credentials provided to them beforehand. This involves selecting the "Admin" button on the homepage and subsequently entering their unique login. details, specifically their ID, email, and password.

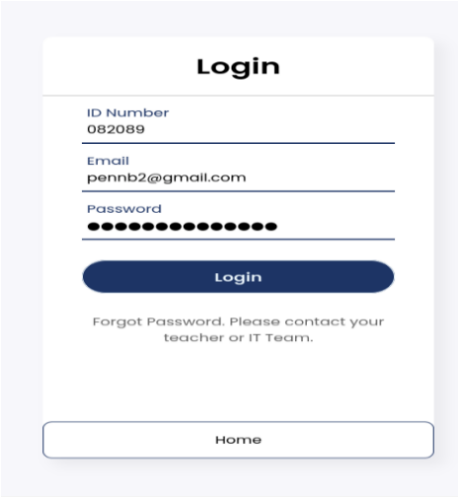

Figure 1: Login illustration

Following login, the lecturer or administrator will be presented with a window providing access to "View Enrolled Students," "Add Students," and "View Student Attendance Records," as depicted in Figure 2.

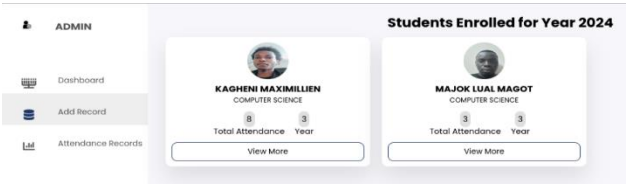

Figure 2: Viewing enrolled students

Adding Student Information to the System

The process can be initiated by the lecturer through the "Add Records" dashboard. This task involves the collection of student data including Student ID, Full name, Password, Email Address, Course, year of Entry, and current Year of Studies, as illustrated in Figure 3. Notably, the student picture, used for system training, is also uploaded through this form.

This pivotal step ensures the precise identification and authentication of students during attendance tracking.

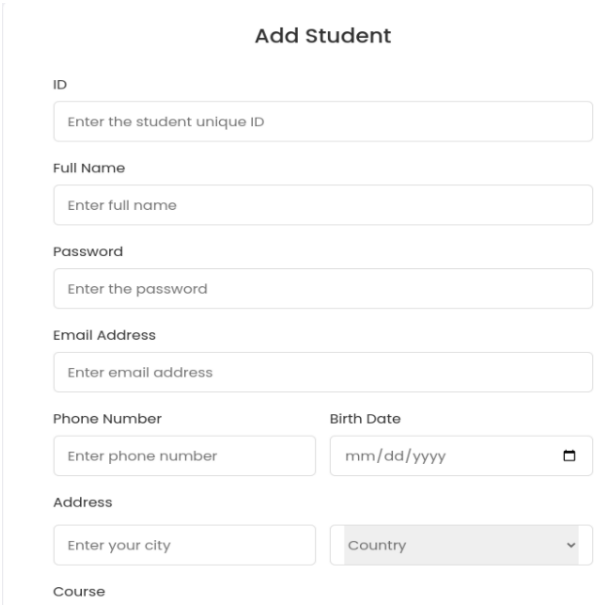

Figure 3: An illustration of adding students's information

Student Taking Attendance

During the attendance-taking process, the system requires students to scan their faces. It searches for and verifies their identity information. If the verification process is successful, the system indicates "Face Detected", displays the student's biodata, and then adds the student's attendance information to the attendance list, as shown in Figure 4.

When the student comes to retake the attendance for a second time at the same lecture time, the system will return an "Already Marked" message to indicate that the student has already been added to the attendance list.

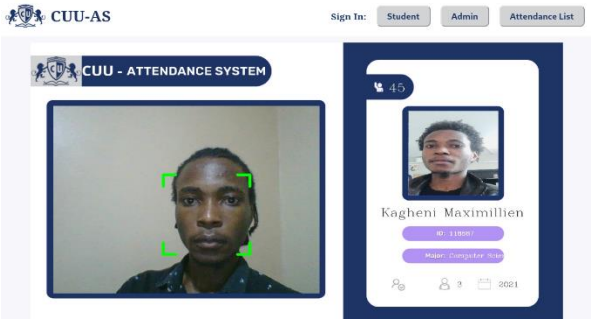

Figure 4: Sample student taking attendants

In cases where the system fails to authenticate the student's identity, it will present an error message stating "Face not found," along with pertinent details as depicted in figure 5. The student is then advised to reach out to their instructor or system administrator for the inclusion of their information in the system.

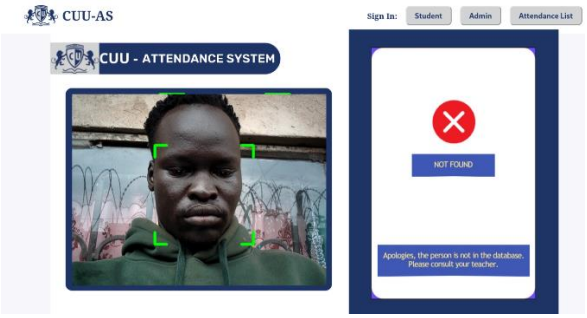

Figure 5: Illustration "Face not found"

False Pictures Detection

The system is equipped to thwart fraud attempts by detecting and rejecting images impersonating individuals rather than their authentic selves. For instance, a student may attempt to deceive the system by falsely using an image of another student to confirm their presence, as illustrated in Figure 7. This advanced system promptly identifies such deceit and rejects the fabricated image.

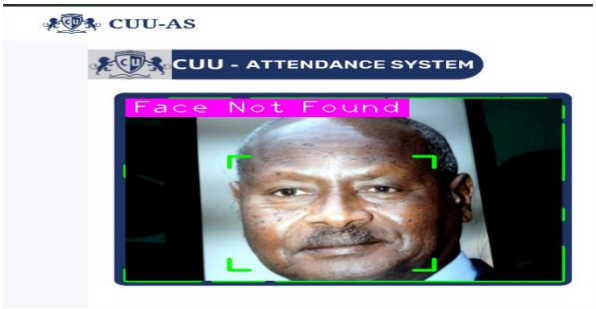

Figure 6: An illustration of the identification of fake identity

Attendance List and Information

Upon completing the student information verification process and attendance tracking, the attendance data is documented on a list accessible to students and lecturers. However, lecturers have the authority to modify or remove entries, while students have view-only access. The attendance list includes the total number of student attendances, their most recent attendance, and the time remaining until their following lecture.

Student Portal

The system allows students to view their biodata and read any "Notes" left for them by their lecturers. They need to click "Student" and use their login details to access attendance records and lecture history.

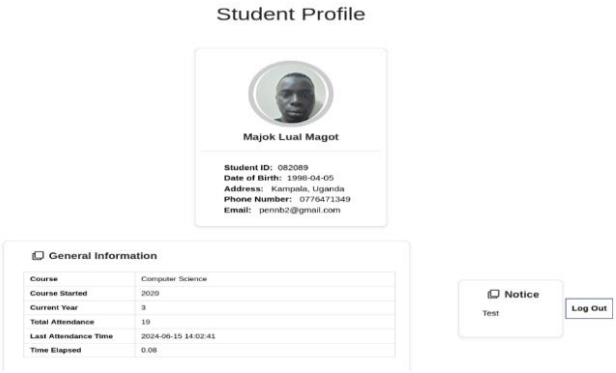

Figure 5: An illustration of student's portal

DISCUSSION

The integration of a facial recognition system for attendance tracking has produced encouraging outcomes, demonstrating its potential to significantly improve the efficiency and accuracy of attendance management in educational environments. This section deliberates on the implications of the findings, the encountered challenges, and potential areas for further enhancement and research.

Accuracy and Efficiency

The system's 92% accuracy rate in recognizing students and recording their attendance signifies a high level of dependability. This accuracy represents a substantial improvement over conventional methods, which are often susceptible to human errors. Moreover, the system's quick average processing time of 10 seconds per student emphasizes its efficiency, enabling seamless integration into the classroom setting without causing significant disruptions.

Automating the attendance process diminishes the administrative workload on teachers, liberating valuable time that can be redirected toward instructional activities. Furthermore, the system furnishes real-time data on student attendance, empowering educators and administrators to promptly identify and address absenteeism trends. This proactive approach can contribute to enhanced student engagement and academic performance.

Implementation Challenges

Despite the positive outcomes, the implementation of the facial recognition system unveiled several challenges. One notable issue is the system's reliance on high-quality images for accurate recognition. Factors such as poor lighting conditions, facial obstructions, and changes in students' appearances can adversely affect the system's performance. These limitations indicate a necessity for further refining the algorithm to bolster its robustness under diverse conditions.

Another challenge is the demand for substantial processing power. The requirement for a powerful processor and high-definition camera may pose financial constraints, particularly for institutions with limited resources. This reliance on hardware may impede the scalability of the system across different educational settings.

Ethical and Privacy Considerations

The adoption of facial recognition technology raises crucial ethical and privacy concerns. The collection and storage of biometric data necessitate stringent measures to safeguard students' privacy and ensure data security. It is imperative to establish clear guidelines on data usage, access, and retention to mitigate potential risks. Transparency in communicating how the data is collected, stored, and utilized is pivotal in gaining the trust of students, parents, and other stakeholders.

Potential Improvements and Future Research

To address the identified challenges, several improvements can be considered. Enhancing the system's algorithm to effectively handle variations in lighting, facial obstructions, and changes in appearance will be pivotal for enhancing accuracy. Additionally, exploring advanced preprocessing techniques and machine learning models can further refine the system's performance.

Future research could explore the integration of facial recognition technology with existing infrastructure, such as campus security cameras, to reduce implementation costs. Developing a user-friendly application for updating and managing student data can ensure the system remains accurate and up-to-date.

Moreover, expanding the application of facial recognition technology beyond attendance tracking to areas such as campus security, examination authentication, and administrative processes could yield additional benefits. Research into the ethical implications and development of best practices for the use of biometric data in educational settings will also be essential.

CONCLUSION

The study underscores the potential of facial recognition technology to revolutionize attendance tracking in educational institutions. While the results are promising, addressing the identified challenges and ethical considerations is crucial for the successful adoption and long-term sustainability of the system. By focusing on improving accuracy, reducing hardware dependencies, and ensuring robust data privacy measures, educational institutions can leverage this technology to enhance attendance management, student engagement, and overall educational outcomes. Future research and development should aim to further refine the system and explore its broader applications in the educational sector.

Acknowledgment

The authors acknowledge Cavendish University Uganda for the opportunity to sponsor the publication of this article at no cost.

Competing Interests

The author declares that there are no conflicts of interest related to this study.

Authors contribution

The authors contributed equally in every section of the manuscript

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