Review

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A Comprehensive Survey on Classroom Engagement Tracker: RFID and Facial Recognition for Enhanced Learning

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Abstract: The Classroom Engagement Tracker System is an educational technology that assists teachers with management tasks and boost engagement in class by recording attendance and performing behavioral scanning of students. By utilizing RFID technology, each student and teacher is issued an NFC card, allowing quick access to attendance through an RFID reader located at the classroom entrance. After the instructor comes into the classroom, there is a period of two minutes before the system recognizes the students for facial recognition of in-class monitoring to allow students to get organized. In class, the AI-enabled system remains active and can identify movements such as careless actions and mobile phone usage. When instances are detected, they are documented, given a date and time stamp, and sent to the specified instructor for reporting on the degree of engagement in the classroom. Students are engaged in a wider and faster interaction, through portals designed for attendance and behavior analytics while the teachers and administrators assign classes and take attendance respectively, without being exposed to student's behaviors in detail. In more detail, this prototype helps with proper supervision within the classroom and helps focus attention on active class participation.

Keywords: RFID reader; NFC card; OpenCV; ESP32

I. Introduction

In the evolving landscape of education, the integration of technology into classrooms has become imperative to ensure effective learning experiences. One critical aspect of class-room management involves monitoring student attendance and engagement, as these are directly linked to academic performance and participation. Traditional methods, such as manual roll calls and periodic teacher observations, are time-consuming, prone to errors, and provide limited insights into student behavior. To address these challenges, the Classroom Engagement Tracker System offers a robust, technology-driven solution that combines RFID-based attendance tracking, facial recognition, and behavioral analysis to enhance classroom efficiency and engagement.

The Classroom Engagement Tracker System leverages mod-ern technologies like RFID, facial recognition, and behav-ioral analysis to enhance classroom management. The sys-tem focuses on automating attendance tracking, monitoring student behavior, and providing real-time reports to improve the learning environment. By using an ESP32-CAM module integrated with an RFID scanner, the system offers seamless attendance tracking by linking each student's unique NFC card ID with their facial image. This ensures accurate identification of students for both attendance and behavioral monitoring.

In the registration process, students' NFC card IDs are captured and associated with their facial images. The ESP32 captures these images using the ESP32-CAM module and sends the image data along with the NFC card ID to a Flask server. The server stores the image in a folder and saves the image path in the SQLite database along with the corresponding NFC ID. This allows for easy

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retrieval of student images during subsequent sessions. The system is designed to be both efficient and secure, with all data stored locally on the server.

The system also integrates behavioral analysis through OpenCV to detect student activities such as inattentiveness, sleeping, or using mobile phones. This is done through contin-uous surveillance after the teacher's entry into the classroom, allowing for automatic tracking and identification of inactive students. Reports of such behaviors are generated and sent to the respective teachers, ensuring prompt action. Additionally, Flask serves as the backend server, managing both attendance records and behavioral data in a simple, user-friendly interface.

By incorporating a combination of hardware and software technologies such as ESP32, Python Flask, OpenCV, and SQLite, this project aims to automate classroom management, reduce manual intervention, and provide teachers with valuable insights into student engagement, ensuring a more efficient and productive learning environment.

II. Literature Survey

The integration of advanced technology into the educational environment has paved the way for new and innovative solu-tions which primarily aims at increasing student engagement and improving existing attendance tracking methods. Many methods show how different technological approaches can address these challenges and can provide valuable insights for development of a classroom engagement tracking system.

M. Yu et al. [1] proposed a behavioural recognition system utilizing Kinect sensors. These sensors capture depth images and skeletal data to identify specific student actions, such as sitting, standing, or raising a hand. The strength of this method lies in its ability to categorize meaningful behaviors. This gives educators important insights into student engagement. Classroom engagement tracking systems share the same goal of leveraging real-time data to monitor and increase student engagement. By combining the same depth and behavior detection capabilities, Classroom Engagement Monitor can provide a clearer understanding of engagement. Therefore, it promotes an interactive learning environment that encourages students to actively participate.

J. H. Lim et al. [2] developed an automated classroom monitoring system capable of performing facial recognition, movement analysis, and behavioral assessment. This system utilizes cameras installed in classrooms to capture real-time images, which are then processed through dedicated modules. It showcases the potential of a comprehensive verification system that not only tracks student attendance but also eval-uates their level of interest and overall participation. The foundational methods employed in this system can be directly applied to classroom participation monitoring, particularly to enhance facial recognition and behavioral analysis capabilities. By adopting a multi-faceted tracking method, Classroom En-gagement Trackers can provide a more holistic understanding of student engagement. It allows educators to proactively intervene when disengagement is detected.

W. Zeng et al. [3] explored the concept of an Intelligent Classroom Attendance system whose basis lies on facial recog-nition technology. This innovative application of AlexNet's ad-vanced neural network for face recognition highlights the value of advanced biometric solutions in education. The system captures a student's face as they swipe the RFID card, making the attendance verification process smooth. The classroom participation tracker aims to incorporate RFID technology for recording attendance. This reflects the effectiveness of this method. And integrating facial recognition features and cross-referencing attendance data with biometric verification can greatly improve accuracy and accountability, ensuring that educators and students will recognize this as well. This biometric method not only improves attendance verification but also promotes a sense of security among students regarding accurate recording of class attendance.

k. Sanath et al. [4] discussed a multilayered security atten-dance system that combines RFID, facial recognition, and tem-perature monitoring. It is a holistic approach to student safety and well-being. Using neural networks to track emotions, this system guarantees students' physical health and ensures high attendance accuracy. This is especially relevant in today's educational context where

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one may need additional emotional or psychological support, thereby promoting a healthier educational environment.

E. Sawall et al. [5] promoted a contactless zero interaction attendance system through integration of Wi-Fi-based devices to classroom environment. Student attendance can be deter-mined through a three-part technique based on received signal strength indicator (RSSI) measurement which is a non-invasive attendance verification method. This system enables efficient attendance marking without the need for physical interaction and is especially relevant in today's educational environment. Classroom participation monitoring systems can draw insights from this method to improve the user experience and enhance the attendance verification process. In the end, it contributes to making the attendance management system more efficient and effective by using such non-invasive techniques, providing a seamless tracking tool for students and educators that can facilitate experiences encouraging higher participation rates.

Y. Shen et al. [6] developed a behavior recognition sys-tem using deep learning for teachers and students in smart classrooms. The system employs the ByteTrack multi-target detection model for activity tracking and the VideoMAE action recognition model for analyzing key student actions. ByteTrack utilizes YOLOX-X to ensure continuous tracking in dense classroom environments, while VideoMAE enhances recognition accuracy by focusing on significant student move-ments in video clips. This system effectively monitors engage-ment and classroom dynamics, improving teaching quality and learning experiences.

V. Bhalla et al. [7] presented a Bluetooth- based attendance management system to track student attendance. The struc-tured Bluetooth-based attendance management system offers an alternative approach to modern attendance recording by using unique MAC addresses for student identification. When entering class, student devices will be recognized by the teacher's mobile app, which will record attendance in real-time. This approach emphasizes user-friendly interfaces and immediate feedback. This could inspire similar functionality to monitor classroom participation. By ensuring ease of use and quick access to information for teachers, the tracker can enhance attendance management allowing for better data tracking and reporting capabilities. Using mobile apps can empower educators by providing timely information about student attendance and engagement levels.

B. K. P. Mohamed et al. [8] proposed the development of portable fingerprint attendance devices, which demonstrates the potential of biometric technology in automated attendance. The system allows students to record their attendance by simply placing their finger on the sensor, making the pro-cess more streamlined and ensuring accuracy. Meanwhile, classroom engagement monitors focus on RFID technology and facial recognition. Incorporating principles from biometric attendance systems increases its robustness to provide an additional layer of verification and security. The fusion of multiple biometric methods can also increase student trust in the system.

D. Mijic' et al. [9] proposed an RFID-based attendance management system using a PoE-enabled RFID reader, which demonstrates the interplay between hardware and software solutions for effective attendance tracking. The system ensures that attendance data is collected correctly and stored centrally for easy access by faculty. Similarly, the classroom partici-pation monitoring system aims to use RFID technology for recording attendance. This makes it possible to manage data in real time and create comprehensive attendance reports. Such data collection efficiencies parallel the streamlined process in the tracker that improves data access and management for edu-cators . This easy attendance data can improve administration's ability to track and respond to student engagement trends.

P. Tholeti et al. [10] proposed the use of YOLO algorithm for methods involved in acquiring the database, recording class attendance, and behavioral analysis, highlighting the importance of continuous monitoring in education. By pro-cessing high-definition video to detect student behavior such as inattention or mobile phone use, it aligns with the purpose of the Classroom Engagement Monitor. This effort focuses on providing monitoring of student engagement. Integrating advanced video analytics can facilitate timely intervention based on real-time engagement metrics to ensure

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that teaching strategies are tailored to meet the needs of diverse students. Continuous monitoring by educators allows for customizing each student's experience, promoting a more personalized learning environment.

The peer-reviewed approaches emphasizes comprehensive research and development aimed at improving classroom man-agement and student engagement through innovative tech-nologies. By synthesizing insights from these approaches, the Classroom Engagement Tracker System aims to adopt and refine best practices, ultimately promoting a more effective learning environment that supports better academic perfor-mance and improved student well-being . The intersection of these diverse methods not only informed the development of the Classroom Engagement Tracker but also paved the way for future advancements in educational technology.

III. Conclusion

The Classroom Engagement Tracker System represents an innovative solution for modern classroom management, com-bining RFID, facial recognition, and behavioral analysis to automate attendance and monitor student engagement. The system integrates multiple technologies such as ESP32, Python Flask, OpenCV, and SQLite, offering a unique approach by linking each student's NFC card ID with their facial image for precise identification and real-time monitoring. Unlike traditional systems that rely only on one technology, this project stands out by offering a more comprehensive solution that not only tracks attendance but also detects disengaged students by analyzing behaviors like sleeping or using mobile phones during class. When compared to existing methodolo-gies, the system provides an improvement in accuracy and reliability by combining both RFID and facial recognition and storing facial images on the server to overcome device storage limitations. Furthermore, the system's use of a backend server for managing data ensures scalability, enabling it to handle larger classrooms or institutions. The future scope of the sys-tem includes the integration of AI-driven behavioral analysis, cloud-based storage for greater scalability, and the addition of multi-modal biometric authentication, further enhancing its potential for widespread use in educational settings. Overall, this system offers a robust and flexible solution for improving classroom management, fostering student engagement, and providing teachers with valuable insights into student behavior and participation, ultimately contributing to more effective and personalized teaching strategies.

IV. Future Scope

The Classroom Engagement Tracker System can be further enhanced by integrating advanced AI models for more ac-curate behavioral analysis. While the current system tracks disengagement through basic actions like sleeping and phone usage, future versions could identify a wider range of student behaviors. Additionally, incorporating emotion recognition could offer deeper insights into students' mood and overall engagement during class.

The system can also be expanded for larger educational environments by integrating cloud storage and databases. This would allow the system to scale efficiently across multiple classrooms or institutions, enabling real-time data access and management. Moreover, advanced data analytics could provide personalized engagement reports, identify at-risk students, and predict academic performance, helping teachers adapt their strategies to improve learning outcomes.

Finally, the system could be integrated with other classroom management tools, such as Learning Management Systems (LMS) and Student Information Systems (SIS). This would streamline administrative tasks, offering a unified platform where teachers can manage attendance, engagement, and aca-demic performance, ultimately creating a more data-driven and personalized learning experience.

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