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A COMPREHENSIVE REVIEW OF DIGITALIZED ATTENDANCE SYSTEMS FOR VARIOUS INSTITUTIONS

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Abstract-- **With Technological and Digital change, it has become mandatory to keep an eye on attendance in educational and workplace settings. This change brings more novel digitalized methods of attending. The reasons behind adapting this are ways that reduce the time consumed in attendance as time wasted on attendance through the traditional pen-and-paper method. Overcoming all these limitations and to give more convenience, the development of the digitalized attendance system has come into being. These technologies use RFID sensors, Bluetooth devices, Wi-fi networks, Facial recognition, and Fingerprint decentralizing sensors that make the whole process close to error-free and very much accurate attendance tracking methods.**

This paper reviews the recent developments which have taken place in digitalized attendance systems by applying and incorporating relevant technology for efficiency. This presentation forms the very basis for a comprehensive analytical evaluation through an in-depth exploration of technology, implementable domains, and key discoveries.

Keywords–-**Technology, Digitalization, Attendance system, RFID sensor, Bluetooth devices, Wi-Fi networks, Facial recognition, Fingerprint Scanning.**

I. INTRODUCTION

In any Institution, attendance tracking is important to organizational efficiency and accountability. Traditionally, maintenance in students' attendance has been based on tedious and less reliable pen-and-paper methods. Digitalized attendance systems, however, bring about a transformative way of ensuring that attendance monitoring is both accurate and efficient. Traditional systems using pen and paper often face problems like proxy roll calls, enrolment discrepancies, wastage of papers, and the risk of manual entry of data errors. Now-a-days, various technological methods are now available to record, in computers, people's attendances of students or employees digitally. There are certain peculiar characteristics that uniquely determine a person, which include fingerprints, facial details and non-biological trait of a mobile phone. As the uses of these features have become more frequent, some new methods for attendance marking developed, which also involve fingerprint scanners, facial recognition models, mobile Bluetooth tethering and Wi-Fi-based connection with RFID validation.

These concepts provide high level of reliability and efficiency by minimizing human effort whereby the solutions are effective. The processing approaches used here essentially become very and cost-effective, excluding the usage of biometrics [2] and individual use of RFIDs tags. Exploring current techniques and the significance of digitalized attendance systems, this review provides insights of attendance management.

II. RELATED WORKS

Recent research has taken into consideration a shift from the traditional pen-and-paper attendance recording systems to online systems. Biometric authentication systems such as fingerprint and iris recognition have been discussed by Pratama et al. [3] and Patil et al. [4], which efficiently recognize individuals.

Furthermore, facial recognition technology is also gaining momentum, as observed by Shrikhande et al. [5]. Also, the other innovative solutions requiring less hardware are also studied, like Bluetooth, RFID-based systems. Bhalla et al. [6] combined these two technologies to reduce false readings by the RFID reader. Hameed et al. [7] described a simple RFID system combined with GSM, showing its viability and efficiency.

Among the various methods, Wi-Fi-based attendance systems, that is 802.11x, has proved the least expensive. Choi and Park [8] give authentication and attendance marking using tokens, a very efficient and economical solution. Abdalkarim et al. [9] discussed various techniques which include QR code/barcode scanning systems, Android-based ID password authentication, and all the above-mentioned techniques. The research conducted and major results are discussed in brief in the following section pertaining to those techniques.

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III. LITERATURE REVIEW

A. Fingerprint Scanning Technology

Many researchers agree that biometric solutions, especially fingerprint scanning, are very effective and reliable compared to other methods. Patil et al. [4] found that using fingerprint scanners instead of passwords and identity cards can greatly reduce cases of proxy attendance. Walia and Jain [10] have researched the technologies that can be integrated into Fingerprint scanning, such as, IoT, GSM with Zigbee, and RFID with Android through microcontrollers and backend services that handle the management process.

In general, there are three main parts of a fingerprint scanning system, as explained by Akinduyite et al. [11]: the Enrolment Module, the Authentication Module, and a Database. With the help of the Enrolment Module, a new user is registered. The Authentication Module is responsible for the extraction of the fingerprint features when one uses the scanner and comparing the data to the ones in the database. Finally, the Database stores details of authorized users. However, this is a quite cumbersome method and not cost-effective, since scanning mechanisms and additional hardware are required.

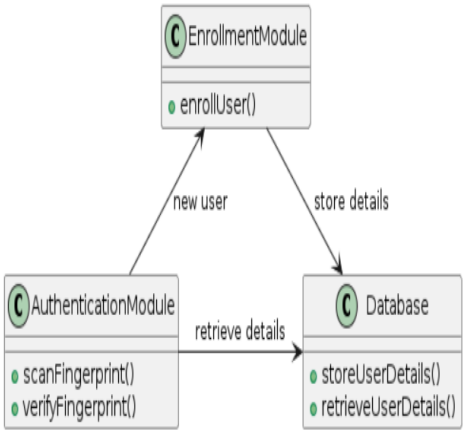

Figure 1. Basic Components Fingerprint Scanning Attendance System

B. Facial Recognition Systems

The Facial recognition systems, which use human facial features for authentication, are commonly used in offices and industries and can also be implemented for student attendance in educational institutions. The system captures student's photo or video, and, on the recognition of facial features, it marks their attendance. Although simple algorithms of facial recognition can perform with accuracy up to 96%, as demonstrated by Mekala V et al. [12], the quality and resolution of the images is a big factor affecting the accuracy. Convolutional Neural Networks correspond to neural networks that operate on data with grid-like structure, such as images.

The facial recognition system combined with machine learning techniques can improvise the system processing in a much better way. In the practical study taken by Shrikhande S et al. [5], considering various ML algorithms in the assessment, such as Support Vector Machine (SVM) and Random Forest (RF). Their results showed that the CNN method outperformed other methods, achieving a maximum accuracy of 98.4% with SVM and 97.7% with RF.

According to Balcoh et al. [13], this method of facial recognition can be performed following these steps: Image Acquisition, Histogram Normalization, Noise Removal, Skin Classification, Face Detection, Face Recognition, and Attendance Marking. Their approach requires minimal hardware—just a camera and a computer—making it practical and cost-effective for many institutions.

C. Bluetooth-Enabled Attendance Systems

Bluetooth is a form of technology that enables communication without the use of either cables or wires; communication is based on short-range radio frequencies; every device featuring Bluetooth can communicate with another within the right range. According to Bhalla V et al. [6], the Bluetooth range is extendable up to 100 meters by use of specific configurations and would have a growing pertinence if it is integrated with technology such as RFID. Their finding showed that Bluetooth based systems consume less power and can support voice, data, and audio connections, which enhances the accuracy of attendance marking. Although the issue of proxy attendance remains, this solution is reliable for record management.

In the research conducted by Puckdeevongs et al. [14], a novel architecture was suggested for classroom sizes varying from one to another. They installed Bluetooth stations, uses Raspberry Pi with BLE, inside each classroom. The BLE broadcast a signal to identify the position of every student receiving the MAC address of the student's device. These people used RSSI technology and ANN for better position calculation and hence provided higher accuracy in location tracking. It has the capability to find the location of a student within less than one meter deviation 72.56% of the time, so the system is very quick and very accurate for all types of Bluetooth-enabled attendance systems.

D. IoT and RFID-Based Solutions

RFID, or Radio Frequency Identification, is a technology often compared to barcode systems. Zaman et al. [15] showed many advantages of RFID over barcodes, including no need for line-of-sight scanning, enhanced security, and faster processing. An RFID system will have RFID cards or tags containing specified information about the student, and RFID readers that scan the tags, thereby logging the attendance of them. However, sharing RFID tags is one way

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to manipulate this style of taking attendance for proxy attendance.

Researchers have explored combining RFID with Android applications. Hameed et al. [7] developed a system where an Arduino microcontroller, programmed in C/C++, receives commands from an Android app via a Wi-Fi module. App which acts as control panel reads data from RFID tags used to identify the user and then transmits the information for processing and storage. It is also compatible with nearly all versions of the Android operating system, which makes this solution most ideal for student attendance management.

Additionally, Near Field Communication (NFC) can be used for attendance tracking. Chew et al. [16] presented a system in which students tap a matric card containing details against their NFC-enabled smartphones. The data is then stored on a server, and this offers a very simple and efficient attendance solution given that students have NFC-enabled devices.

Shah and Abuzneid [17] proposed an IoT-based RFID attendance system. The components used were an Atmega328P microcontroller alongside the MFRC522 RFID reader to read the RFID tags. The concept of IoT is used for the data logging on a server or cloud, making it accessible anytime. This integration of IoT enhances the functionality and convenience of RFID-based attendance systems.

E. Wi-Fi-Driven Attendance Systems

Wi-Fi is a wireless technology basically to connect devices like computers, tablets, and smartphones to the internet. It works by sending a radio signal transmitted through the connected wireless router and then transmitting the same to the devices nearby, which then translate them as data on the respective connected device.

Choi et al. [8] implemented a system that uses Wi-Fi for attendance tracking. In their research, managers use AP mode Wi-Fi to check attendance. A "token" is generated to the users who are near the manager, and their smart app logs into the server marking their attendance. If a user doesn't have a token, then the app marks him absent. This method is really simple and user-friendly, and hence proxied attendance problems can be reduced.

Additionally, Wi-Fi technology can be enhanced with location fingerprinting and RSSI (Received Signal Strength Indicator) acquisition. Anand et al. [18] presented the application of a k-NN algorithm to positioning that showed accuracy of 94% within the 1.5-meter threshold for determining if a device is inside or not inside a classroom. Since this approach makes use of machine learning to project the position of a student, this becomes a viable solution. Narzullaev et al. [19] proposed an AI-based system that automatically detects a student's presence using Wi-Fi signal information from their smartphone. Their solution is free from external devices and achieves an accuracy as high as 95% with a Logistic Regression algorithm. They trained the model on a dataset of wireless signals, extracting features like matching Access Point (AP) ratio, RSSI difference, and beacon RSSI difference. This dataset, with 8500 samples, was used to train a Machine Learning model in attendance detection.

In general, Wi-Fi-driven attendance systems are cost-effective, and along with Machine Learning, it turns out to be an accurate attendance system with reduced problems related to proxy attendance in the educational institutions.

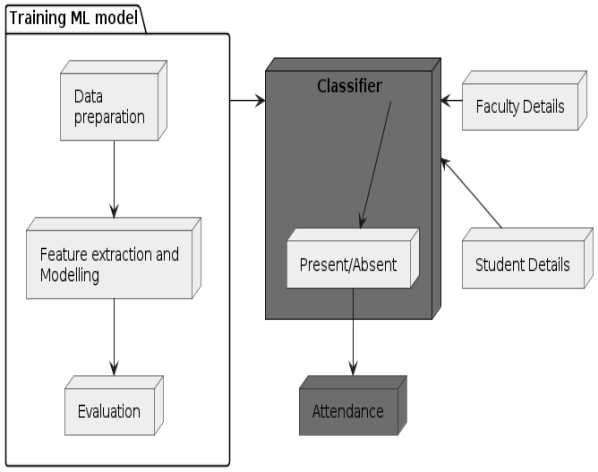

Figure 1. Framework of wi-fi based attendance system using ML [19]

IV. DISCUSSION

Many studies have been conducted on digitalized attendance systems, which bring out numerous techniques to make attendance management much easier compared to the pen-and-paper approach, whereby methods used to be generally tedious and prone to human error. Smart Attendance Systems present a more efficient way of managing, evaluating, maintaining, and analysing student records. The integration of IoT, AI, and ML technologies has significantly enhanced these systems. Classifiers by machine learning and deep learning, especially when combined with facial recognition and location-based attendance systems, make recording student attendance highly accurate and reliable. The advancement not only makes the process easier but brings down the possibilities of error and the proxy attendance which, hence, makes the management of the students' records effective.

Table 1. Recent Advances in Digitalized Attendance Systems

Authors & Publishing Year	Technology Used	Main Finding
Reddy and Chandrakanth (2024)	Facial Recognition with Machine Learning	Used high-quality cameras to capture images and authenticate students using ML algorithms, achieving accurate tracking.[20]
Samaddar et al. (2023)	IoT & Cloud using RFID	Developed a scalable and efficient attendance management system using IoT, AWS, RFID, Python, and Arduino. [21]
Ababaou et al. (2023)	Android and Wi-fi AP	Utilized an Android mobile app with offline wireless technology to detect the BSSID of access points, reducing the need for an Internet connection and using it as a tracking identifier for attendance. [22]
Chiang et al. (2022)	GPS, NFC and Android	Students enable NFC and get close to the NFC tag to mark their attendance, allowing the professor to monitor students' distance and attendance status through GPS. [23]
Narzullaev et al. (2021)	Wi-Fi AP and Logistic Regression Classification Algorithm	Achieved up to 94% accuracy in determining students' presence in the classroom using Wi-Fi tracking for attendance.[19]
Puckdeevongs et al. (2020)	Bluetooth, IoT and Deep Learning	Used Raspberry Pi with BLE to identify students' positions via MAC addresses, employing RSSI and ANN for higher accuracy.[14]

V. CONCLUSION

Ensuring accurate student attendance records remains a significant hurdle for educational institutions. This paper reviews recent evolutions in digitalizing attendance processes and provides brief overviews of the results. This digital attendance system provides an effective way of tracking and managing student records. Various techniques discussed by the researchers, such as IoT, facial recognition, biometric scanning, Bluetooth tethering, and Wi-Fi integration with AI and ML for precise location tracking, highlight advancements in attendance management. Such technologies would make attendance recording easier and be able to offer accuracy and reduce the administrative burden across different learning environments. With more institutions adopting the digital environment, such innovations are sure to transform attendance monitoring into ways that will become reliable and efficient in managing students.

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