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A Review of Students Attendance Management Systems

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Abstract: The utilization of paper and pen for recording student attendance is a conventional method which is prevalent across a plethora of educational institutions. However, this technique is fraught with various challenges and inefficiencies, primarily owing to the extensive duration required in its execution. Additionally, it necessitates a secondary phase of data entry for report generation. This method is also susceptible to malpractices such as proxy attendance, where students may sign on behalf of their peers. Consequently, this mode of attendance documentation lacks security and is less favored. Scholars have, over a substantial time span, presented an assortment of alternative paradigms for managing student attendance. The pertinent academic literature on automated attendance systems can be dichotomized into two broad categories: those that employ biometric technologies and those that do not. Biometric systems are contingent on physiological attributes for authentication, by juxtaposing the captured data with pre-existing records. The incorporation of biometric verification in affirming identity and authorizing access to automated systems has gained traction and is now ubiquitous. Conversely, a segment of the academic community has explored non-biometric attendance systems, employing an eclectic mix of techniques. This manuscript undertakes an exhaustive analysis of over forty empirical studies and proffers a new taxonomy for student attendance management systems.

Keywords: *Students Attendance Management System; Fingerprint, Face Recognition; Class Attendance; QR Code; Mobile Attendance; Taxonomy of Attendance.*

1. Introduction

In academic institutions, the act of tracking student attendance is a paramount consideration to foster optimal operational efficiency. Ensuring a consistent level of student presence is crucial, given the various disruptions to regular attendance such as sickness or holidays. Traditional methods for marking attendance, involving individual roll calls, present time-consuming challenges due to the often large student cohorts. Therefore, these mechanisms need a revaluation in their efficacy[1]. There are two primary categories for student attendance validation based on the media used for authentication. Firstly, biometric systems rely on predetermined physiological attributes unique to each student, eliminating the need for additional equipment. Alternatively, other techniques encompass media that simplify user authentication, including technologies such as RFID tags, barcodes, QR codes, smartphones, access points, and beacons [2]. Various systems are utilized within the context of educational institutions, including Student Information Systems, Laboratory Registration Systems, Courses Registration Systems, Student Financial Information Systems, and Library Systems among others. These diverse methodologies enable universities to exert control over student activities to ensure adherence to institutional policies and legal requirements, thus aligning student behavior with the strategic goals of the institution [3]. Consistent student attendance is a fundamental criterion within the educational process. If student attendance falls below the minimum threshold, exam eligibility is compromised. Moreover, a low attendance average might lead to students failing their courses due to

inability to partake in final examinations. Notwithstanding, the current mechanisms in place have demonstrated susceptibility to errors [4].

Technology advancements in attendance taking have revolutionized the educational landscape. The transformation towards digital solutions has streamlined attendance processes and management [5]. Traditional methods of attendance taking, usually manually recorded, are labor-intensive for educators, particularly with large class sizes. Efforts have been made to integrate technological solutions, including software-based systems for student management [6, 7] as well as hardware-based options like RFID technologies [8], biometric systems [9-11] or a hybrid of both [12, 13]. These innovative solutions have been demonstrated to facilitate educators in monitoring student attendance, hence boosting their academic performance. However, challenges persist. In software-based solutions, educators must manually confirm student attendance before logging it into the system. Meanwhile, hardware-based solutions, utilizing either RFIDs or biometrics, necessitate a significant additional investment by the institution, especially considering the infrastructure required for RFID tracking. Biometric systems, in particular, are associated with reliability concerns, in addition to the need for supplementary equipment [14].

In this paper, we introduce a new taxonomy elucidating various types and patterns of student attendance management systems. The research incorporates a review of the most recent studies proposed by researchers, thereby classifying these management systems according to the techniques implemented. Section 2 of the paper provides a taxonomy of attendance management systems, offering an overview of all methods utilized to establish class attendance systems. Sections 3 and 4 detail biometric and non-biometric attendance systems respectively. The paper concludes in Section 5 with a summary of the key findings from the study.

2. Taxonomy of Attendance Management Systems

In scholarly investigations, a multitude of attendance management systems based on distinct techniques have been presented. The current study conducts a comprehensive review of over forty research studies, proposing a new taxonomy for these attendance management systems. Such systems can be bifurcated into two primary categories: biometric and non-biometric systems.

Biometric attendance systems employ specific physiological attributes, such as facial features or fingerprints, to recognize individuals. A salient benefit of these systems is the elimination of the need for individuals to carry additional items for authentication purposes, thereby streamlining the process. Conversely, non-biometric attendance systems utilize alternative mechanisms for attendance verification. These methods range from smartphone applications and QR code scanning cameras to networking technologies like wireless or Bluetooth systems.

The taxonomy proposed herein serves as a framework to categorize all student attendance management systems introduced in scholarly research according to their methodologies. Figure 1 delineates this taxonomy for attendance management systems, with subsequent sections elaborating on each category in isolation.

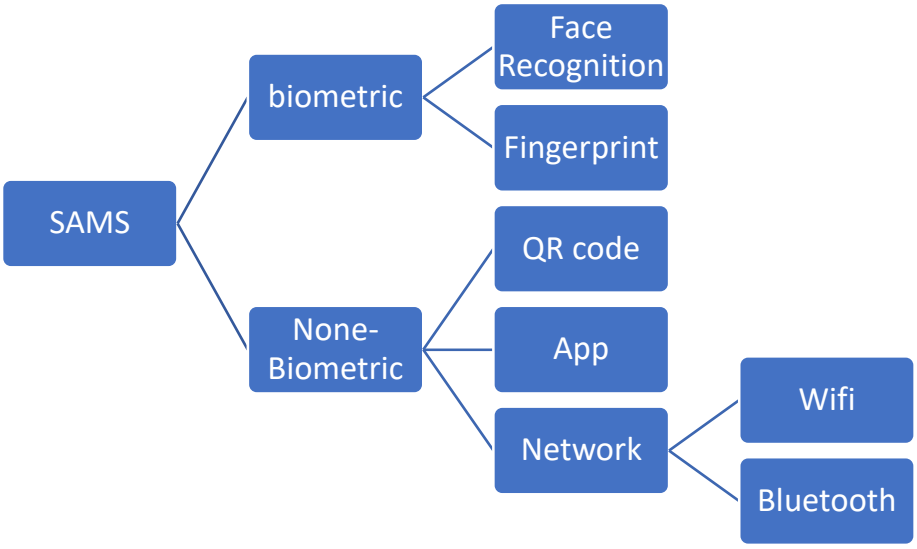

Figure 1: Taxonomy of Attendance Management Systems

3. Biometric attendance systems

3.1 Face Recognition Biometric Techniques

Face Recognition technology has garnered recognition as a predominant physiological biometric methodology, owing to its increased reliability and reduced susceptibility to fraudulent data. This system's enhanced security outperforms other physiological biometrics such as Fingerprint Recognition and Iris Recognition, as well as behavioral biometrics like Signature Recognition, Voice Recognition, and Keystroke Recognition[15]. The growth of face recognition as a security technology in the computing world has been notable, especially against the backdrop of prevalent global terrorist activities. Its significance is underscored in this context. The application of face recognition spans multiple sectors, including public safety, civil economy, and home entertainment, among others. [16, 17]. Within the framework of general business operations, the recording of staff attendance is a necessity. However, inadvertent errors frequently arise. For instance, in the prevalent fingerprint attendance system, studies have identified an approximate error rate of 5%. Such a significant error rate negatively impacts the efficiency of attendance systems, particularly in large settings prone to overcrowding[18].

The Personal Component Analysis (PCA) method is widely applied in face recognition systems. PCA is a recognized technique for data typology identification, leveraging eigenvectors to emphasize the commonalities and discrepancies between distinct data sets [19]. Convolutional Neural Networks (CNNs) have been pivotal in numerous applications, revolutionizing approaches to solving problems related to Computer Vision and Image Processing. As a result, they provide efficient solutions. Recently, Face Recognition has been frequently employed in various systems, such as university automation and smart entry management systems [15, 20, 21].

Certain studies have implemented a sensor-fusion methodology for recording attendance, positional data, and face images within a classroom setting, a technique referred to as the Active Student Detecting (ASD) method. This approach deploys an observational camera fitted with a fisheye lens, centrally positioned on the classroom ceiling, providing a vertical view of the student area. The ASD method utilizes background subtraction and inter-frame subtraction techniques to ascertain student presence[22, 23].

In their research, Sawhney et al. [24] integrated face recognition techniques, such as Eigenface values, Principle Component Analysis (PCA), and Convolutional Neural Networks (CNN), to construct a model for an automated student attendance monitoring system. The development process of this face recognition system entailed several key advancements. First, to register attendance, images of the students' faces are captured using a classroom-based camera, positioned to encompass the entire room. These images serve as the system's input. Image processing techniques like grayscale conversion and histogram equalization are employed to enhance the image quality, thereby facilitating more accurate face recognition. Following this enhancement process, the image undergoes face detection. Subsequently, face recognition is performed. This process could be facilitated using a variety of techniques including Eigenface, Principal Component Analysis, and Linear Discriminant Analysis. Priyanka et al. [25] developed an attendance system based on Face Recognition using Eigenface and PCA Algorithms. Another study [18] proposed a Face Recognition Attendance System, which employs real-time video processing and Linear Discriminant Analysis. Recently Asha et.al [26] introduced the Face Sync-Smart Attendance Marking System, which utilizes deep learning algorithms for face identification and analysis. The system automates attendance tracking by recognizing faces and transmitting the data via email for further processing, significantly improving efficiency and reliability compared to traditional methods.

3.2 Fingerprint Biometric Techniques

Fingerprint verification, one of the earliest biometric techniques, continues to be highly favored due to its simplicity and precision. Each individual possesses unique fingerprint patterns from birth, characteristics leveraged to differentiate individuals. The benefits of implementing this system within an institution or organization are manifold. By reducing time expenditure and mitigating the limitations associated with traditional attendance record-keeping, fingerprint identification and verification have been widely adopted as replacements for traditional methods. Students verify their attendance in classes or examinations by swiping their fingertips across a sensor. A fingerprint detection device is installed in each classroom or exam hall for this purpose. Student records are preserved in a database for subsequent verification. When a student swipes their finger across the scanner, the system performs a verification check [27]. Acharya proposed a wireless fingerprint-based student attendance system that extracts minutiae-based information from scanned fingerprint images, which are distinguished by unique ridge patterns. The data is then wirelessly transmitted to register the student's attendance [28].

The construction of an attendance management system using fingerprint recognition involves two key processes: fingerprint enrollment and fingerprint matching. During the enrollment phase, a user's fingerprint is captured, its unique attributes identified, and the user's identity is stored in a database, serving as a template. The Crossing Number technique is used to extract unique minutiae points from the skeleton image, examining the vicinity of each ridge pixel to identify ridge endings and bifurcations. Before attendance is recorded, the user's fingerprint is taken again, and the extracted features are compared to the database template to ascertain a match [29, 30]. These processes involved in a Fingerprint-based attendance system are illustrated in Figure 2.

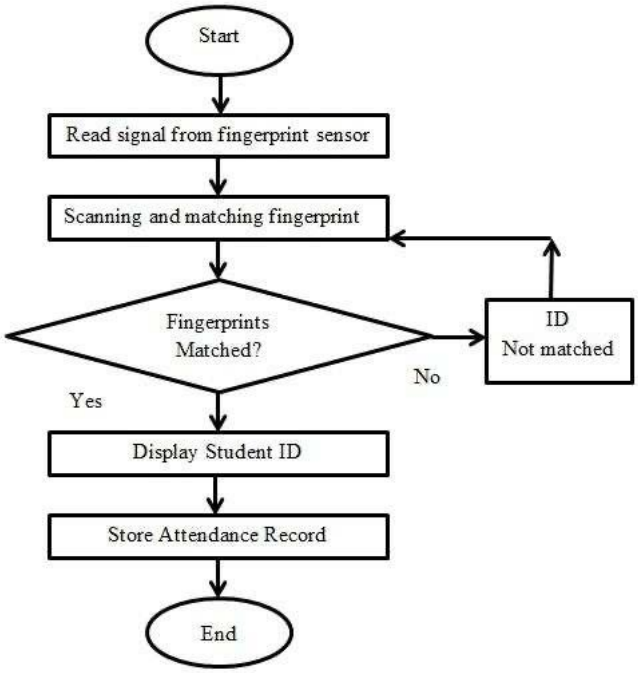

Figure 2: Working of Fingerprint based Attendance System [30]

Verma et al. [31] employed GSM technology to devise a Fingerprint-Based student attendance system. The system encompasses a terminal fingerprint acquisition module and an attendance module, capable of executing functions such as fingerprint data collection, processing, wireless transmission, fingerprint matching, and automated attendance reporting. After attendance is recorded, this technology transmits each student's attendance status to their parents' mobile phones via GSM.

Walia et al. [30] categorized Fingerprint-Based attendance systems based on the tools and techniques utilized in their implementation. For instance, Yadav et al. [32] employed a microcontroller and LabView in developing a Fingerprint-based attendance system. Wang and Jingli [33]. incorporated Internet of Things (IoT) technology in their attendance system design.

4. None-Biometric attendance systems

In this portion of the review, we will focus on the non-biometric techniques that have been utilized to construct student attendance management systems. A majority of these techniques have leveraged functionalities in mobile devices to facilitate attendance systems. For instance, certain systems utilize a camera to scan QR codes, employ Near Field Communication (NFC), or tap into WIFI networks. Additional studies have proposed the development of mobile applications to monitor attendance. These diverse methods have been classified into three distinct subcategories, each of which will be comprehensively addressed in the subsequent subsections.

4.1 QR code attendance systems

Smartphones are swiftly becoming the primary devices of choice for consumers, usurping the position traditionally held by laptops and notebooks. The ubiquitous use of smartphones and their accelerated adoption rate have transformed the ways in which individuals access information, especially in the realm of education. Numerous technologies exist that facilitate educators in streamlining their attendance recording procedures. Emerging technologies can be leveraged to enhance the efficacy of systems used to record student attendance. One such technology is the Quick Response (QR) Code, a machine-readable optical label that contains information about the item to which it is attached. The implementation of QR codes for logging student attendance has been explored and evaluated across

various studies. The findings have demonstrated that QR codes not only save time that would have otherwise been spent on manual attendance recording but also offer educational administrators the opportunity to collect in-person classroom statistics for accurate attendance score allocation and administrative decision-making.

Sarana et al. [34] developed a QR code-based Android application for recording student attendance, providing valuable data to students, academic administrators, and department managers. Additionally, Hendry proposed an alternative attendance recording method that involves scanning QR codes with a webcam connected to a computer [35]. Attendance can be tracked without relying on biometrics through the use of QR codes and barcodes. These codes can be scanned with either a barcode scanner [36] or a smartphone application employed by the instructor [14, 37]. By using smartphones for identification, students can add flexibility to attendance recording systems and mitigate delays associated with processing attendance via a reader or manually by the instructor [2].

4.2 WiFi-Based attendance systems

Wireless Local Area Network (WLAN) technology has permeated nearly every establishment today, facilitating the cost-effective tracking of mobile devices. Wi-Fi technology, though not specifically engineered for positioning, outperforms the Global System for Mobile Communications (GSM) indoor positioning system in precision, and also proves to be more accurate in certain outdoor situations as compared to the Global Positioning System (GPS). Wi-Fi Positioning Systems enable the tracking of virtually any Wi-Fi capable device without necessitating additional software or hardware modifications. Techniques that were originally devised for other tracking systems were later adapted for Wi-Fi positioning. With Wi-Fi positioning, indoor location-based services become feasible, thereby catering to an array of industrial applications.

Zheng et al. [38] conceived and realized a classroom attendance detection system based on a Wi-Fi position algorithm. Another smart attendance system was proposed by [39], built around wireless technology and the students' Media Access Control (MAC) addresses. This smart identification system examines the MAC address stored in the student's mobile device, potentially yielding efficiency superior to that of conventional connections. Chio et al. [40] proposed a novel attendance verification approach grounded on Wi-Fi 802.11x technology. This method uses Service Set Identifier (SSID) names along with an encrypted token generated exclusively for students in proximity to an instructor. Pambudi et al. [2] suggested an attendance management system integrating Wi-Fi Direct and Wi-Fi hotspot technologies. This system employs Wi-Fi Direct for the class broadcasting process and a temporary Wi-Fi hotspot for the verification process.

4.3 Bluetooth-Based attendance systems

Bluetooth beacons strategically positioned within the classroom can assist the system in pinpointing the student's location. Apoorv et al. [41] proposed an attendance management system grounded on Bluetooth Low Energy (BLE) interfaced with an Android application. This mobile application serves to gather data from the sensors and archive it chronologically, thus facilitating the instructor's task of recording and analyzing students' attendance. Azmi et al. [42] harnessed BLE alongside Beacon Sensor technology to devise a smart attendance system for University Tenaga Nasional. A separate attendance management system conceived by [43] integrated BLE, Beacon technology, and Android devices. In this system, students use their smartphones to scan for available beacons within the classroom and subsequently transmit data to the server. To enhance system security, the transmitted data can also contain secret codes. Another recent study [44] proposed a Smart Attendance System using Bluetooth technology, which leverages Bluetooth beacons and mobile devices to automate attendance tracking. The system emphasizes accuracy, ease of use, and real-time data access, providing a more efficient

alternative to traditional methods of attendance management in both educational and organizational settings.

5. Conclusion

This manuscript explores over forty scholarly articles on Student Attendance Management Systems (SAMS). Attendance monitoring represents a pervasive procedure instituted across educational establishments to scrutinize absenteeism and assess student adherence to institutional regulations. Traditional methods of attendance tracking—often involving pen and paper—have been identified as not only wasteful but also disruptive, with students losing focus during class as attendance sheets circulate. Our survey details various automated attendance management systems currently deployed in institutions worldwide. These systems can be broadly categorized into two types, each with its distinct characteristics and architecture. The first category, biometric management systems, relies on human physical attributes such as fingerprint, palm, or facial recognition. This system operates by automatically comparing the presented biometric data with previously uploaded data, looking for a degree of similarity. The second category, non-biometric systems, bases its operations on technological advancements and can be further divided into three subcategories: QR codes, mobile applications, and wireless-based systems. These systems are typically more expedient as they eliminate the need for time-consuming recognition of human physical attributes and instead directly process details from codes. Wireless systems, in particular, leverage signal sharing and IP addresses, allowing students to transmit their presence to the lecturer via their smartphones.

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7. Conflict of Interest:

There is no conflict of interest for this paper

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