

Automation Attendance Systems Approaches: A Practical Review

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Abstract. Accounting for people is the first step of every manpower-based organization in today's world. Hence, it takes up a significant amount of energy and value in the form of money from respective organizations for both implementing a suitable system for manpower management as well as maintaining that same system. Although this amount of expenditure for big organizations is near to nothing, rather just a formality, it does not hold as much truth for small organizations such as schools, colleges, and even universities to a certain degree. This is the first point. The second point for discussion is that much work has been done to solve this issue. Various technologies like biometrics, radio-frequency identification, Bluetooth, global positioning system, quick response code, etc., have been used to tackle the issues of attendance collection. This study paves the path for researchers by reviewing practical methods and technologies used for existing attendance systems.

Keywords: Biometric, attendance systems, QR code, RFID, face recognition, software system.

INTRODUCTION

Student attendance collection and management is one of the most time-consuming tasks in any school, university, or education system. In fact, gathering attendance is a time-consuming job that takes lecture time and takes the teacher's energy. But if the teacher does not do so, the school and family will not know if the students are pursuing the right of education. This problem has been attempted to be solved using various approaches and technologies currently available. The previous record on the research paper and product shows biometrics, including palm, iris, facial recognition, radio-frequency identification (RFID), near-field communication (NFC), Bluetooth, barcode, and quick response (QR), which are more demanding to make the system as automated as possible. In the next section, various types of these technologies used are described. This paper divides them into five subsections – biometric attendance system, facial recognition

based attendance system, RFID based attendance system, QR code based attendance system, and finally embedded system based attendance system. Following this review of existing attendance systems, the paper concludes with a summary of the types and a short excerpt about the importance of attendance management systems and integrating existing technologies to solve modern problems.

VARIOUS ATTENDANCE SYSTEMS

Biometric Attendance System

The word biometric comes from the word biometry, which means the process by which a person's unique biological or physical traits are accounted for identification. Palmprint, fingerprint, face, and iris are the most common biometrics used today. And the biometric attendance system uses one or more of these traits in conjunction to confirm the identity of the personnel attending lectures. A few existing

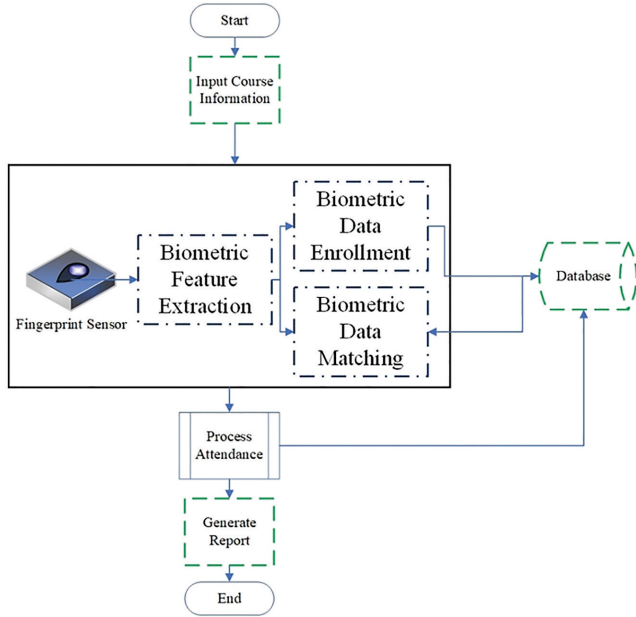


Figure 1. System design of Shoewu et al. [2].

research projects are surveyed to showcase existing work in the sector. In their review paper, Tsai-Cheng Li et al. [1] studied biometrics technology applied in the attendance management system. Their aim was based on some pertinent literature reviews through which they concluded that attendance management is an important measure and means for discipline as it dictates the productivity of an organization and its sustainability. Biometric data is a measurable biological trait that is unique to every person on the planet and can be automatically verified to confirm a person's identity. Most of the studies have shown that either hand geometry or fingerprint recognition is a very suitable means for the attendance management system. Even on the topic of improving efficiency and service quality, most of the respondents gave a reply of "agree" or "no comment." The paper also states that the biometric recognition system has the least controversy as it is exceedingly difficult to crack, and employees and respondents feel safe and fair that it should be the way to manage public attendance. In their paper, Shoewu et al. [2] talked about developing a biometric-based attendance management system and comparing it with a traditional manual attendance system (Figure 1).

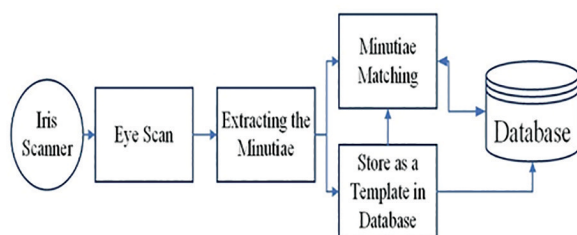


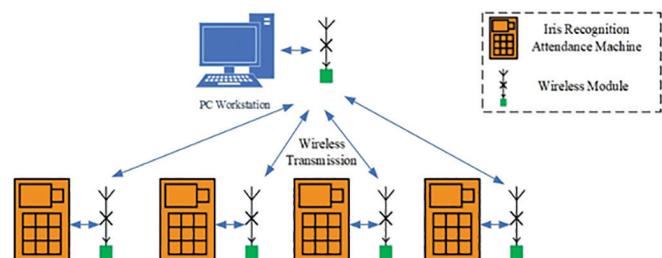
Figure 2. (A): Iris scan procedure of the system [3]. (B): System design of Kadry et al. [3].

According to Figure 1, their system uses two steps to both enrol and authenticate the users. First, all biometric data is scanned securely through biometric devices; then, their software executes a program for feature extraction from the scanned data and stores it with the biometric owner ID. Although the authentication only performs the same steps once, it matches the data stored in the structured query language (SQL) database. The system also produces an attendance summary report and flags mismatch attempts. The researchers concluded that the system was particularly useful because of its short implementation time and high success rate. However, one of the most secure forms of biometric recognition is iris recognition. In fact, it is more secure than traditional fingerprint recognition or palm recognition. Seifedine Kadry et al. [3], in their paper, have described a wireless attendance management system based on this very technology (Figure 2).

Figure 2(A) shows the iris scan procedure of the system. And Figure 2(B) shows how the iris recognition module connects to the workstation and completes the system. The system follows three basic modules: image acquisition and preprocessing; texture extraction and signature encoding; and iris signature matching for authentication. The researchers have established a cheaper way to perform the task by taking advantage of offline iris recognition and pairing it with a management computer via a PTR2000+ wireless communication module [22–30]. Their tests resulted in a 98.3% success rate. Hence, they concluded that implementing such a technique with iris recognition can prove easy access in attendance management systems.

Facial Recognition Based Attendance System

Facial Recognition is a part of biometrics but again, not quite so. Because facial recognition can be fooled, whereas biometrics defines uniqueness, meaning that identifying traits must be unique. Facial recognition is common in every face because no two faces are the same in most cases. And it is easy to implement because any camera with appropriate software can do the task. In their research, Naveed Khan Balcoh et al. [4] introduced face detection as an accurate and efficient replacement for the old school manual attendance system (Figure 3). Their system, as shown in Figure 3, used the EigenFace method to verify



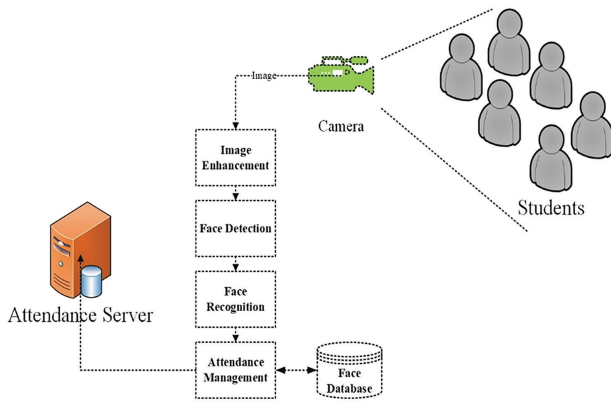


Figure 3. System design of Balcoh et al. [4].

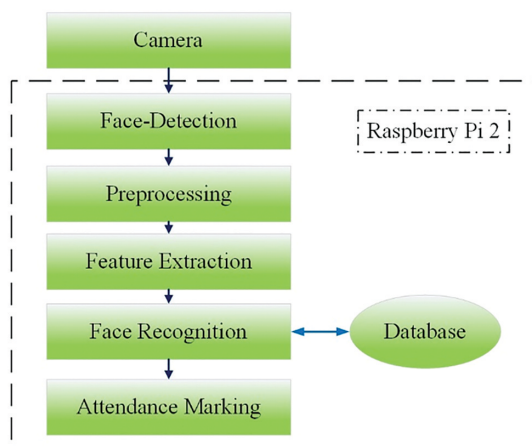


Figure 4. System design of Mehta et al. [5].

faces one by one, match them with their face database, and perform the attendance task. Their face database was populated with face data through a series of image processing techniques, including image histogram normalization, noise gratification, skin classification, and finally, face detection by selecting the region of interest.

The same process goes for attendance by face recognition. In their research, Preeti Mahita et al. [5] show a facial recognition-based attendance management system on the Raspberry Pi 2 with the included Raspberry Pi camera (Figure 4).

They used the Viola–Jones algorithm and local binary pattern in conjunction to identify the faces of the people in a photo. The faces will be stored in the database with the personal identification, which will then be used to identify the personnel present. They concluded that their system had a 92% accuracy. This accuracy is unacceptable when it comes to class attendance, as it is very vital. Priya Pasurmati et al. [6] show a much more advanced version of the facial recognition-based attendance management system. Their research uses an open-source facial recognition framework called OpenCV and uses Python as their main environment of work (Figure 5).

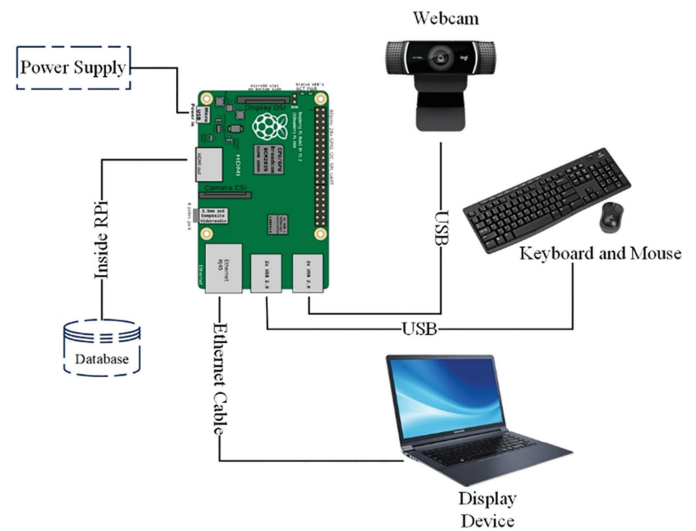


Figure 5. System design of Pasurmati et al. [6].

In Figure 5, their system design shows the components used. They used a physical webcam to accomplish the task. But the paper concludes with no real-world application proof of the system but only the results of an efficient facial recognition system using Python.

RFID/NFC Attendance System

RFID is an abbreviation for “radio-frequency identification,” which basically means that the communication is done through radio frequencies. In this system, information is digitally stored inside a tag or card, which can be read through radio frequencies. Near-field communication (NFC) is an RFID-based technology that can act as both a tag and a reader. This technology is cheap to manufacture now and can be readily used in the work sector. A small number of research papers on RFID-based attendance systems have been reviewed here, some of which work in conjunction with other technologies such as Bluetooth. In their paper, Vishal Bhalla et al. [7] described a system based on Bluetooth technology and an RFID reader application. Their proposed system is very novel because they have used RFID matrix cards to gather students’ attendance and then used Bluetooth for the teacher or professor to confirm the attendance before the data gets permanently sent to the main database (Figure 6).

As explained in the system design in Figure 6, once the data is sent to the central database, it can be edited later, and reports can be generated via emails. By approaching this double-layer model, the error rate in their system is extremely low, and almost only human error remains. Their system significantly reduces time consumption in the whole system too. In their paper, the researchers also mention that this project model can be further secured by introducing a fingerprint when authenticating the use of a terminal. They have used Bluetooth rather than Wi-Fi

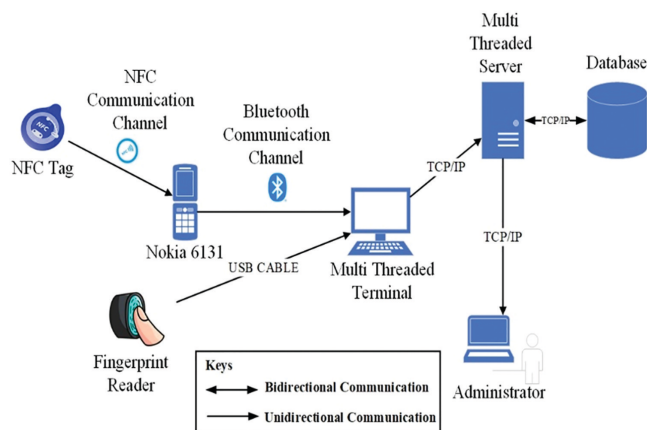


Figure 6. System design of Bhallah et al. [7].

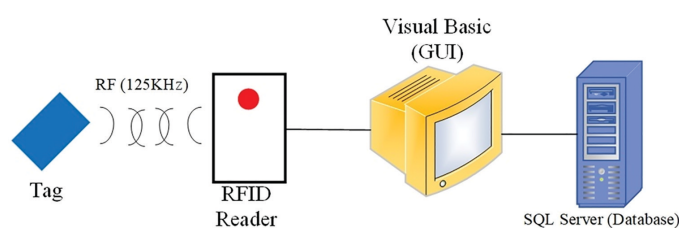


Figure 7. System design of Arulogun et al. [8].

and other long-range solutions because of range, power consumption, and ease of availability as they are using the Bluetooth devices embedded in the cell phones of the teachers to take the attendance where the teachers will use their very own cell phones to confirm the RFID attendance. In their paper, Arulogun et al. [8], present an intelligent RFID based student attendance control and management system. Their simple system is illustrated in Figure 7.

In their project, they used passive tags due to the cost and implementation flexibility. Upon bringing those tags close to the designated reader, the reader captures the card's data and sends it to the system, recording the time of arrival and departure. Their software for handling the data is made with Visual C# with a Visual Basic graphical user interface (GUI) incorporated with Microsoft's SQL server to store the data. The researchers conclude that incorporating a facial recognition application would further enhance security.

Nikhil P. Shegokar et al. [9] compare existing technologies in the scope of an automated attendance system based on the Raspberry Pi and prefer NFC as the better path. They compared the various biometrics technologies, facial recognition, iris recognition, and NFC. Their paper does not quite show any active system being implemented, though.

QR Code Attendance System

The letters QR stand for quick response in the term QR code. It belongs to the two-dimensional (2D) code family

whose predecessor is actually barcodes. But barcodes have many limitations, hence QR codes have superseded them. One of the main reasons why QR code is better is that it can store a huge amount of information in any orientation with much more damage tolerance than all other 2D code technologies out there. At the same time, it is industrially cheap to implement. A small survey on the existing applications of QR code technology proves useful to make the reasons why QR code is much more efficient a bit clearer.

Tin Jin Soon [10] surveyed and explained the fundamentals of QR code in his journal and also showed various widespread implementations of the QR code technology. He reviewed the technologies used in the fields of industry and transport, from the identification of different products to banknotes. Online and local ordering system, food freshness control systems, betting ticket management systems, patient management systems, livestock tracking, jewelry certification systems, agriculture, telecommunications, payments and other fields – all use QR codes widely. And the merits of using QR codes in all these sectors are the same, i.e., efficiency and profitability. Masahiro Hara [11] presents a similar picture to Tin Jin Soon, but from a more historical perspective. He stated in his paper that before QR code was there, barcodes were widely used. But it came with some limitations, like reading directions and information capacity. So QR code, or quick response code, was developed, which removed these limitations and even allowed alphanumeric characters in different languages to be encoded and represented through it. Compared to the previous generation of 2D codes like barcodes, QR codes have an error correction capability of up to 30%, whereas the other technology has zero. A QR code, which is five times a barcode, can be read in around 30 ms with a bare minimum RISC processor (MIPS: 18) in any orientation. And because of its versatility, high speed reading, and miniaturization capability, it is widely used in industrial sectors. Two-layered QR codes are used to expand security and avoid copying confidential QR codes. For these reasons and the added facility of cheap implementation, QR code technology was chosen for this project.

The following are some existing works related to QR code-based attendance systems.

Hsin-Chih Lai et al. [12] in their research show a broad implementation of the QR code technology. They show the implementation of mobile learning in outdoor education through the implication of QR codes. In their study, they developed an outdoor education information system that combines natural and cultural environment GMs, or Green Maps, using QR codes. The implementation had QR codes printed on a GM, and then students on site for exploration of the outdoor environment were asked to scan the QR codes to find relevant information from the internet. The idea being that having static QR codes on GMs can easily be scanned by a cell phone to retrieve information about the place and the place's elements. A rough sketch of their

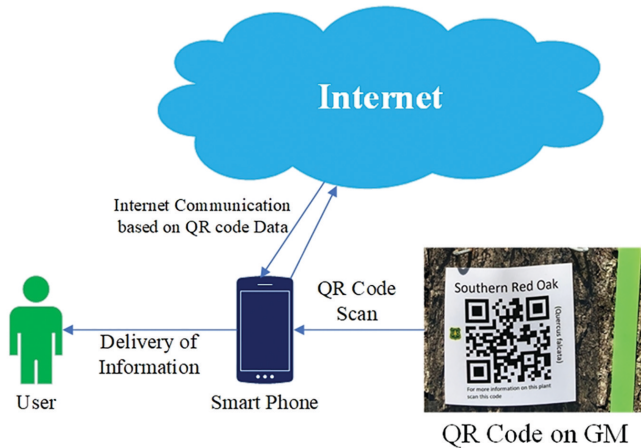


Figure 8. Implementation of QR codes on GMs [12].

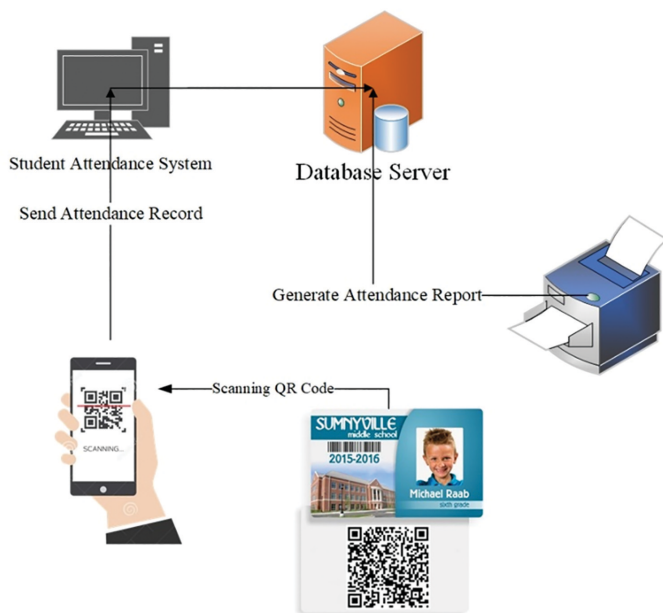


Figure 9. System design of Hendry et al. [13].

implementation of QR codes on Green Maps is shown in Figure 8.

Hendry et al. [13] in their paper have proposed a smart attendance system by applying QR codes. Their system was built with PHP, MySQL, and Apache based on the WAMP Server. The application would prompt registration for the first time and then allow you to be logged in to take attendance by generating QR codes. The codes can be scanned with a mobile device and hence attendance can be taken, and then reports are generated via checklists and can be printed. Their system provides very minimal functionality yet gives one of the first ideas about implementing QR codes in an attendance management system, which is shown in Figure 9.

The enhanced version of Hendry et al.'s [13] research is the research by the next group of researchers. Xiong Wei et al. [14] in their research paper made a system for

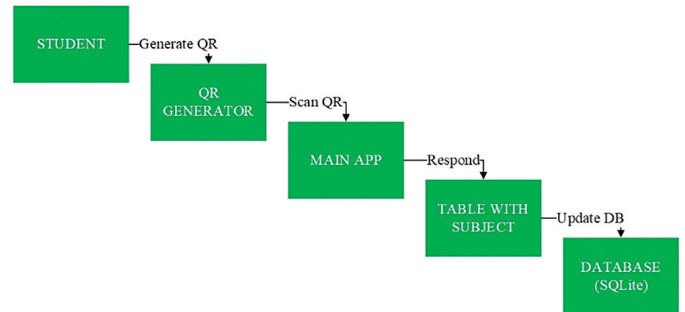


Figure 10. System sequence of Wei et al. [14].

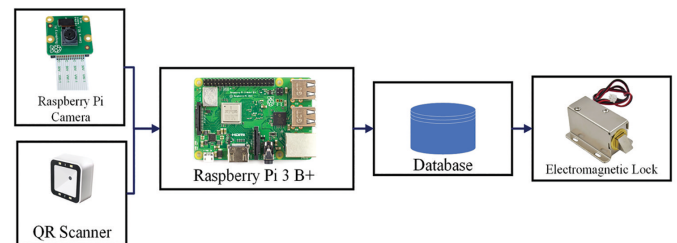


Figure 11. System design of Fauzi et al. [15].

smart attendance systems with QR codes with functionalities such as student details, subject details, and report export as csv. They have used the SQLite database as their primary data storage technology. And their whole system is based on Android applications. Both the teacher and student interact with the system through the app. This system is very suitable for small classrooms but not for big ones for this very reason. The researchers conclude that integration with facial recognition would make the system more secure. Their system's idea of sequence is presented in Figure 10.

Ahmad Fahmi Mohd Fauzi et al. [15] showcased a different kind of system which functions both as a web-based smart door lock system as well as an attendance management system, although the main focus is on the smart door itself. In fact, their system is one of the few projects out there that uses both a facial recognition system and a QR code system in conjunction. Their proposed system has the Raspberry Pi working with a camera that scans the static QR code on the student or staff's ID card and matches it with the QR code stored on the database. The researchers conclude that the efficiency of this method needs to be further evaluated in the future as this is only preliminary work. Their research's system design is portrayed in Figure 11.

Their proposed system, according to Figure 11, has the Raspberry Pi working with a camera that scans the static QR code on the student or staff's ID card and matches it with the QR code stored on the database. The researchers conclude that the efficiency of this method needs to be further evaluated in the future as this is only preliminary work.

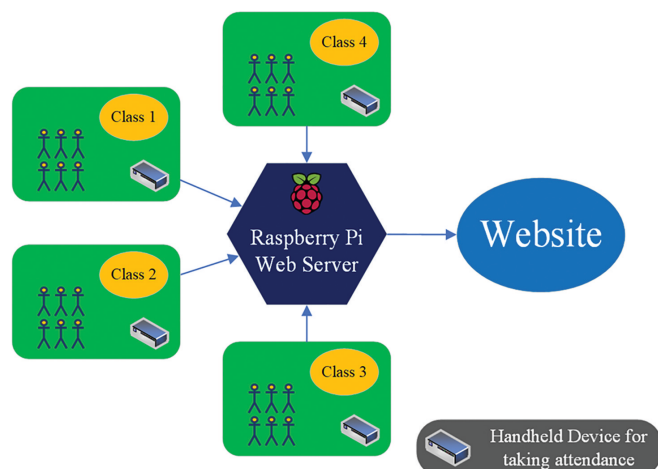


Figure 12. System architecture of Shailendra et al. [16].

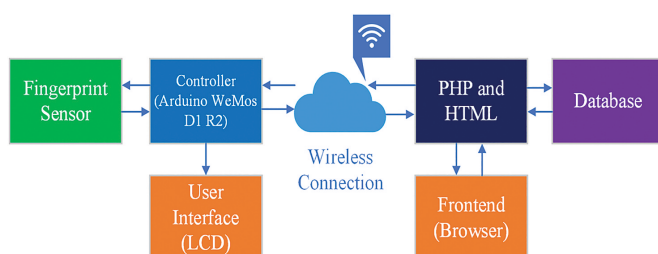


Figure 13. Overall design of Asabere et al. [21].

Embedded Systems-based Attendance Systems

An embed system is a combination of hardware and software designed and deployed for a specific function and is called an embed system. Such a system is also able to run inside larger systems. Usually, this system has a finite set of functions. And in terms of attendance management systems or attendance methods using technology, embedded systems along with various sensors are used. A design and framework for taking attendance in schools and colleges using AVR ATMEGA16 of ATMEL, a low-power CMOS 8-bit microcontroller as the handheld client and the Raspberry Pi as the server, was presented by Shailendra et al. [16]. The system architecture uses the Raspberry Pi as the main server while the ATMEGA powered handheld devices with Xbee in every class like a zonal model [17] (Figure 12).

The system design in Figure 12 shows an example of a single-board computer-based attendance system where the Raspberry Pi is connected by the ATMEGA powered handheld device – both are the backbones of the two-part system. Swarnendu Ghosh et al. [18] used biometric sensors with Arduino uno. This is an example of technologies being used in conjunction. The Arduino attendance module, which consisted of the Arduino UNO, fingerprint sensor, Bluetooth sensor, and an LCD, was named the

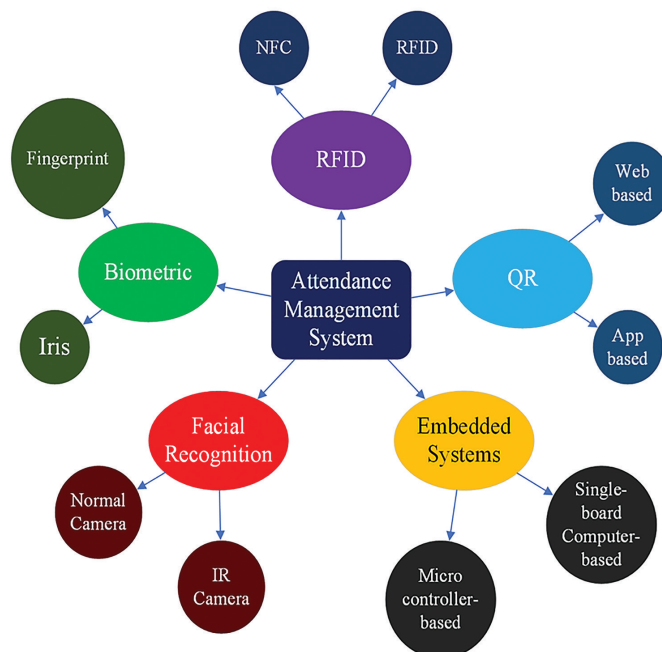


Figure 14. Various technologies used for attendance management system.

SAS module, or Smart Attendance System Module. An Android application was also made and could connect to the module using Bluetooth for management. This kind of combination and application through the connection of Arduino with an application using Bluetooth or another medium is novel and very practical. Other applications, such as virtual reality and exergames [19], use this kind of communication. Arduino and RFID are also used in combination in many projects, such as Arbain et al.'s [20] LAS, which is a web-based laboratory attendance system. They used RFID tags inside ID cards as a medium of attendance for staff controlled by Arduino, which can connect to the system using a USB connection. In their paper, Asabere et al. [21] constructed an attendance system with a fingerprint module and an Arduino Wemos D1 ESP8266 (Figure 14).

From their overall system design in Figure 14, three technologies – namely, biometric, microcontroller, and Wi-Fi – are used in conjunction. The figure also shows an example of a microcontroller-based attendance system where the Arduino board is the main backbone of the system. Table 1 compares the different types of attendance systems based on the advantages and disadvantages of the technologies used in them.

According to Table 1, biometric attendance, RFID, facial recognition, and QR codes all require devices and maintenance. All the available technologies require server software and DBMS as a common requirement to operate. The embedded system and QR code-based attendance system are the cheapest and easiest to deploy due to their size. The QR code systems that are subautomatic require clients to scan the QR code themselves.

Table 1. Advantages & disadvantages of existing attendance management system technologies.

No.	Method	Hardware	Software	Advantage	Disadvantage
1	Biometric Attendance	Fingerprint Reader, Retina Scan Machine	Custom Software, Server Software, DBMS	Automatic	Cost of Machine & Maintenance
2	RFID	RFID Reader, RFID Tags	Custom Software, DBMS	Automatic	
4	Facial Recognition	Infrared Camera, Server	Facial Recognition software, Server Software, DBMS	Automatic	
4	QR Code	Camera, QR or Barcode Scanner, Server	DBMS, Server Software	Sub- Automatic, Cheap	
5	Embedded Systems	Microcontroller (Arduino / ATMEGA), Single Board Computer (SBC) e.g., Raspberry Pi + Other Detection Technology	Server Software, DBMS	Automatic, Easily Deployable	Needs Expert to Operate

CONCLUSION

Finally, based on the survey and discussion, the attendance management system uses four different techniques, at least one subclass of each technique, such as fingerprint reading under biometrics or NFC under RFID. These are shown in detail in Figure 13.

As shown in Figure 14, attendance management systems can be classified into four basic types based on the technologies used. The first type – biometrics – can be divided into two types: fingerprint and iris. The second type – RFID – can be divided into two types as well: NFC and RFID tag. The third type – facial recognition – can utilize two methods. The first is a normal camera, which is a camera we typically use to take photos, and the second is an IR-based camera. Examples of IR-based cameras can be night-vision cameras, CCTV cameras, etc. These are more accurate than normal cameras. The last and final category is QR. QR codes are typically application-based. On that basis of methodology, it can be divided into two more categories: web-based and app-based. Each of these technologies can be used in combination with another to make the system more secure. The last type – embedded systems – can be an example of this statement. The main divisions of this type are microcontroller-based and single-board computer (SBC)-based. In conclusion, there are different ways a problem can be solved. And for attendance management systems the most feasible design seems to be when cloud technologies [31–39] and service robots, deep learning, etc. [40–53] are used in conjunction. Attendance management systems are not just required for schools, colleges, or educational institutions. They are widely used for any place where labor is the main workforce. Software companies, movie studios, industries etc., require a lot of manpower to function. And there may be classified work going on even now. Keeping track of them is vital for the development of the said organization. In this paper, we list the various prominent types of technologies to do exactly that. As the world grows and

more and more people go toward work, better solutions are needed to integrate the most prominent technologies.

CONFLICT OF INTEREST

The authors declare that this article does not contain any conflict of interest.

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