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Raspberry Pi-based wireless automatic assistance control system used by health center staff

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ABSTRACT

The ongoing COVID-19 pandemic has severely strained healthcare systems worldwide, necessitating the implementation of various biosecurity measures by governments to mitigate further virus transmission. Consequently, researchers have increasingly focused on developing automation technologies to minimize direct human contact. However, within healthcare centers, some work assistance processes still rely on inefficient methods wherein each worker fills out an assistance form in the presence of a supervisor. This outdated approach not only leads to time wastage but also introduces errors in the records. To address this issue, we propose the development of a wireless automatic attendance control system utilizing a Raspberry Pi device. This system will be implemented for the staff of healthcare centers, enabling them to record their entry and exit times using either a mobile device or a fingerprint reader. The recorded data will be accessible through a user interface and securely stored in the cloud. By adopting this system, it will be possible to monitor and enforce labor discipline among workers automatically. Through the implementation of the attendance control system, we have observed its optimal functionality, achieving an efficiency rate of 97.16% in registering and storing the entry and exit times of all workers in the database. This level of efficiency is deemed acceptable, given the swift and secure nature of the process.

1. Introduction

The emergence of the SARS-CoV-2 pandemic has set an unprecedented milestone in human history (Maguiña Vargas and Palacios-Celi, 2020). This rapidly spreading virus revealed the unpreparedness of healthcare systems worldwide to confront a pathogen of such magnitude. Its gradual dissemination across countries resulted in a high mortality rate and significant global economic losses, leading to a healthcare crisis (Maguiña Vargas, 2020). COVID-19 transmission primarily occurs through direct contact between individuals, prompting governments to mandate the use of face masks and enforce physical distancing of more than 1 meter as preventive measures (Shereen et al., 2020; Chicaiza Moncayo and Cordero Cerezo, 2021).

Physical distancing plays a crucial role in mitigating the current pandemic since individuals infected with COVID-19 may remain asymptomatic while transmitting the virus, thereby facilitating its continued spread (Cedeño et al., 2020). Consequently, there has been a significant surge in the development of various automated systems (Quiroz Carrillo et al., 2020) aimed at minimizing direct contact and preventing further COVID-19 infections (Perez et al., 2021). The significance of these automated systems lies in their ability to replace manual processes, which require human intervention (Román et al., 2020). By automating these processes, individuals can avoid unnecessary direct contact.

The implementation of an automated attendance system contributes greatly to the accurate documentation of healthcare center workers' attendance records. Monitoring the working hours and punctuality of each worker is crucial for the effective functioning of healthcare centers (De La Espriella-Babiloni, 2019). However, it has been observed that traditional methods still persist in healthcare centers, where attendance cards are manually completed under the supervision of an individual responsible for record-keeping. This

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approach is inefficient, prone to errors, and unreliable. Attendance records may be lost over time, and sometimes supervisors fail to complete the forms, creating problems for workers. Additionally, retrieving attendance sheets from storage files within medical centers is a time-consuming process (Bastidas Gavilanes, 2019). Moreover, considering the ongoing COVID-19 pandemic, it is imperative to minimize physical contact, a goal that cannot be achieved with the traditional method requiring direct interaction between supervisors and workers. This interaction poses a risk of contagion and the potential creation of a transmission hotspot, particularly given the presence of numerous patients in medical centers awaiting treatment (Bastidas Gavilanes, 2019).

Therefore, an automated system that reduces the manual efforts of supervisors and ensures the authenticity of each worker's identity is necessary. Our proposed system aims to address these challenges by enabling supervisors to monitor the presence of each worker within the healthcare center through a user interface. The system utilizes a Raspberry Pi configured as a wireless access point (WAP), allowing workers to connect to the network using their mobile devices. Once connected to the WAP, the system displays the MAC addresses of the workers' mobile devices, automatically recording their attendance without physical contact. Additionally, a fingerprint reader will be incorporated into the system for workers without mobile devices, enabling attendance registration by scanning their fingerprints.

The objective of this research is to develop a wireless automatic attendance control system based on a Raspberry Pi for healthcare center staff to record their entry and exit times using their mobile devices or fingerprint reader. The recorded data will be accessible through a user interface, facilitating monitoring of worker punctuality. The recorded data will be securely stored in the cloud and regularly updated. The system implementation involves configuring a Raspberry Pi as a WAP, creating a user interface to display connected devices, and employing a MySQL database to store worker data, including entry and exit times and MAC addresses of their mobile.

2. Literature review

The process of recording worker attendance using unreliable and inefficient methods poses various risks, including the loss of data and erroneous entries, leading to conflicts between workers and their workplaces. Therefore, it is imperative to adopt automated systems that can ensure the safety and efficiency of this process. For instance, Hegade et al. (2021) addressed the issue of increased COVID-19 infections among workers during attendance registration due to direct contact with supervisors and the shared use of attendance cards. To mitigate this, the authors proposed an alternative system based on fingerprint and facial recognition techniques to eliminate physical contact and enhance infection control. Their method employed the HOG algorithm for facial recognition, body temperature detection, and face mask verification. A fingerprint reader was used in cases where workers did not have mobile devices. The proposed system achieved an efficiency rate of 96.89%, demonstrating its effectiveness in combating COVID-19 in workplace settings.

Ahmed et al. (2019) highlighted the limitations of current attendance registration systems, which rely on unreliable and irregular methods, leading to data loss and time wastage during the search process. To address these issues and enhance workflow within companies, the authors proposed a web-based work assistance management system. Their methodology utilized the Model-View-Controller framework, Java Server Faces Framework for visualization and attendance calculation, and HTML and JavaScript for client-side web interface implementation. The MySQL database was employed for storing worker attendance records. The system achieved an efficiency rate of 90.79% and effectively organized attendance data.

Chen and Li (2021) emphasized the importance of accurate attendance records for workers and students, highlighting the inefficiencies and problems associated with the current systems used in their workplace and educational institution. In response, the authors proposed an attendance management system based on facial recognition and RFID technology for the Albert Einstein Institute. Their methodology involved the use of Microsoft Visual Studio 2017, C# language for creating the user interface, and SQL Server database for data storage and retrieval. The system achieved an efficiency rate of 91.92%, effectively addressing the drawbacks of traditional attendance systems.

Oo et al. (2018) stressed the significance of efficient worker attendance management in improving corporate performance. However, existing attendance control systems suffer from cost and monitoring limitations, diminishing their suitability for companies. Additionally, these systems generate little confidence in the market and exhibit low efficiency, resulting in long queues and potential COVID-19 outbreaks. To overcome these challenges, the authors proposed an employee attendance management system with a cloud-based web application utilizing NFC technology. The methodology included attendance recording through NFC, automatic calculations of working hours, leave verification, and overtime management. The system provided online access and generated comprehensive reports, achieving an efficiency rate of 93.14%.

In a study by Hapani et al. (2018), the authors highlighted the importance of biometric recognition, particularly facial detection, in ensuring contactless worker attendance management during the COVID-19 pandemic. They proposed an automated assistance system based on image processing for biometric recognition. The methodology involved

training data to detect and distinguish faces from background environments, thereby recording attendance in a database without manual intervention. The system achieved a face detection accuracy of 45% using the Viola-Jones algorithm and a facial recognition accuracy of 50% using the Fisher Face algorithm. The study concluded that the traditional attendance method resulted in time and paper wastage, highlighting the need for more efficient solutions.

3. Methodology

The methodology encompasses the design of the attendance control system, as depicted in Fig. 1. This design provides a comprehensive overview of all the components involved, ensuring the efficient, accurate, and timely operation of the system. The primary objective is to enable the healthcare center's workers to perform their duties effectively.

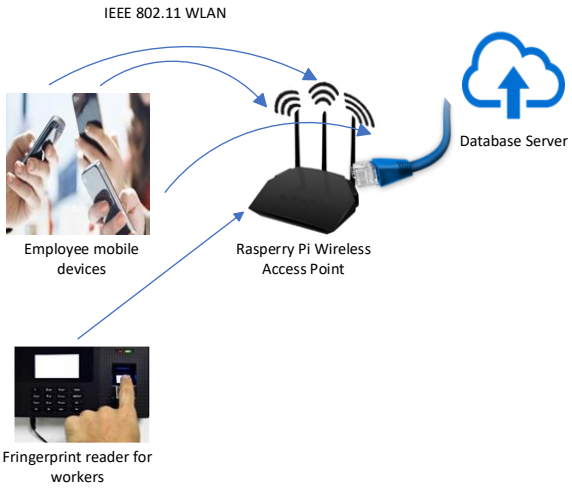

Fig. 1: Design of the attendance control system

The central concept of the attendance control system revolves around employing a Raspberry Pi as a WAP to facilitate the connection of health center workers' mobile devices, creating a wireless local area network (WLAN). To achieve this, workers register their mobile devices in the system's database, utilizing their unique MAC addresses for identification purposes upon connecting to the wireless network. In cases where workers do not possess a mobile device, an alternative option is provided through the utilization of a fingerprint reader. In this scenario, the system will still recognize the worker and accurately record their attendance within the health center, ensuring a seamless process.

A. Employee mobile devices: Each worker in a health center possesses a mobile device, enabling them to connect to a wireless network for communication with colleagues, and relatives, or browsing social networks. Each mobile device is associated with a unique identifier known as a MAC address, a 48-bit value displayed upon connecting to a wireless network. This MAC address serves to identify individual workers based on their registered device addresses.

When workers' mobile devices establish a connection with the wireless network, the system records their entry and exit times. In the input phase, the system logs all employees who connect to the health center's wireless network, allowing for efficient management of worker information and the recording of entry times. Conversely, in the output phase, the system generates a report for each worker, displaying their departure time and storing this information in the database.

B. Fingerprint reader for workers: The fingerprint reader serves as a crucial device for workers who lack a mobile device to connect to the wireless network. This electronic device enables workers to record their data through fingerprint recognition, ensuring the authenticity and physical presence of the worker within the health center. Using a small touch monitor adjacent to the fingerprint reader, workers can confirm their data to record their entry and exit times. These recorded data hold significance as they facilitate supervisor oversight and detailed report generation.

C. Raspberry Pi WAP: The Raspberry Pi WAP continuously measures information pertaining to mobile devices that successfully connect to the network. The WAP gauges the strength of received signals, influenced by factors such as operating frequency, utilized IEEE 802.11 standard, the distance between workers and the WAP, and potential obstacles obstructing the signal's path. Consequently, the strength value of a received signal will be higher for a worker's mobile device located in close proximity to the WAP compared to another device positioned outside the health center due to distance or intervening walls. Thus, to ascertain a worker's presence within their workplace, the system employs the reference of received signal strength in association with the WAP.

For WLAN configuration, the Raspberry Pi-based WAP employs the parameters outlined in Table 1, enabling all health center workers to connect their mobile devices using the specified authentication details.

Table 1: Parameters used in the WLAN

Frequency	2.4 GHz
Transmission power	31 dBm
Standard	IEEE802.11g
Authentication	WPA2

The utilization of Raspberry Pi as a WAP is grounded in its diverse features that are well-suited for our attendance control system. The configuration process involves installing specific software and setting up the Dynamic Host Configuration Protocol (DHCP) server to dynamically allocate IP addresses to mobile devices, enabling communication with other networks. Additionally, the Secure Shell protocol (SSH) is configured to facilitate remote access to the server (Sudibyo et al., 2018). Once these configurations are implemented, workers can

connect their mobile devices to the WAP, which will employ WPA2 as the wireless security mode.

To accurately assess the signal strength of received signals, it is essential to establish a threshold value that facilitates measurements. Determining the appropriate threshold value for each area within the health center necessitates separate assessments due to variations in radiofrequency wave propagation, influenced by area dimensions, internal medical equipment, and potential interferences. These factors will inevitably impact the threshold value. Fig. 2 illustrates the designated entry point of the health center, denoted as "s," where measurements are taken from mobile devices. The outer section of the entry point is represented by "x" and delineates an area inaccessible to workers, while "AP" signifies the location of the WAP.

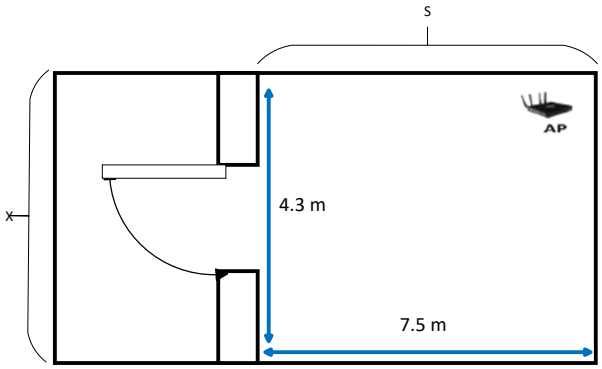

Fig. 2: Specified area of the medical center

Based on signal strength measurements, any mobile device located within the health center's admission area will be identified as having a minimum value, as it will obtain a good signal strength represented in negative relative decibels (dB). Consequently, if a signal has a value significantly distant from 0, it indicates a weaker signal.

D. Database Server: To implement the database on the Raspberry Pi, the MySQL open-source web platform was primarily utilized as a database management system for storing the registered data of each worker. As shown in Table 2, the database includes the following columns: "N" representing the worker's list number, "ID" indicating the worker's name, "ADD" denoting the MAC address of their mobile device, "DT" representing the date, "IN" recording the worker's entry time when they connect to the WAP, and "OUT" indicating the departure time. Once workers are registered in the system, their data can be easily accessed by searching their ID, which is stored in the MySQL database. The database is continually updated and generates a text file that allows the supervisor to view the data through the user interface.

The data that were visualized in Table 2 are specific information about the assistance of each worker since the system must be understood by any person in charge of evaluating the assistance of the workers without presenting any difficulty to understand it. It should be noted that those workers who used the fingerprint reader to record their attendance, will be displayed in the part of the MAC address as "none," in such a way that the person in charge of the assistance has knowledge about the way to register or of each worker at the time of entering the health center.

Table 2: Registered data of workers

N.	ID	ADD	DT	IN	OUT
1.	W. Perez	00-14-22-01-23-45	May 12, 2022	09:00 AM	05:00 PM
2.	B. Lopez	00-14-17-04-29-78	May 12, 2022	09:05 AM	05:01 PM
3.	L. Gormez	None	May 12, 2022	08:59 AM	05:00 PM
4.	.....	.....	.....	.....	.....

4. Operation of the user interface

The user interface facilitates the retrieval of worker data via a platform. This platform presents a comprehensive record of each worker who successfully establishes a connection between their mobile device and the WAP based on Raspberry Pi, or utilizes the fingerprint reader to register their attendance. The displayed information includes the worker's name, the MAC address of their mobile device, and the corresponding strength value of the received signal. This data representation is illustrated in Fig. 3. The user interface is developed using the JavaScript programming language, enabling efficient management of the database and seamless display of attendance records.

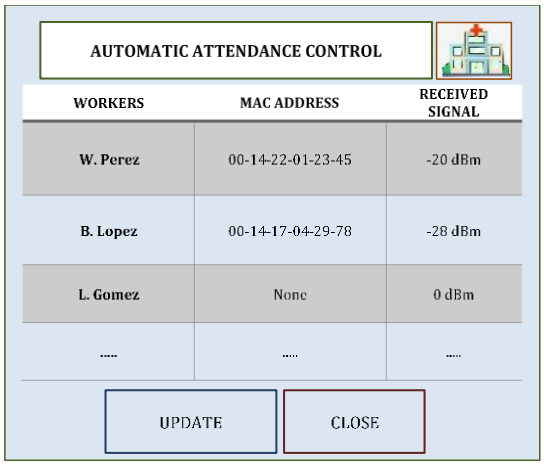

Fig. 3: User interface

The system incorporates automatic updates, ensuring that it consistently records and stores all information related to workers who connect to the wireless network or utilize the fingerprint reader. By establishing a connection with the MySQL database, this platform facilitates access to the records of each worker for any given day, as all the information is securely stored in the cloud. This feature significantly simplifies the supervisor's task of retrieving past records. Moreover, the system automatically transmits the daily recorded data to the supervisor, who can conveniently review the

workers' working hours in the form of a text file report.

5. Result

The implementation of the wireless automatic attendance control system, utilizing Raspberry Pi technology for the healthcare center staff, successfully achieves the objective of recording employees' working hours and providing a user interface for data visualization. This system enables effective monitoring of workers' punctuality and commitment to their workplace.

Table 3 outlines the key features of the wireless automatic attendance control system. As previously discussed, the system fulfills each parameter necessary for its proper functioning. It serves as a valuable tool for tracking the entry and exit times of each worker, thereby assessing their dedication to the health center. In cases where workers experience delays or fail to fulfill their required hours, the supervisor can take appropriate measures based on the information stored in the system. The system accurately records each worker's activity, whether it be through the use of a fingerprint reader or by connecting their mobile device to the Wireless Access Point (WAP), which also logs disconnections from the wireless network.

In addition to the utilization of a fingerprint reader, this system enables individuals without a mobile device to register effortlessly. By placing their finger on the reader, the system automatically records their entry time. Similarly, when a worker intends to leave, they must place their finger on the fingerprint reader once again to ensure the accurate recording of their departure time. This functionality demonstrates the comprehensive and dependable nature of the proposed system.

Table 3: Characteristics of the attendance control system

Power supply	Raspberry Pi: 5.1v DC; Fingerprint reader: 220v AC
Place of control	Entrance door
WAP distance range	20 meters
Wireless network access time	2 seconds
Total connection time	10 hours

To develop the automated attendance control system, the algorithm shown in Table 4 was used, where each step carried out by the system internally is specified, allowing us to obtain an efficiency of 97. 16% in its operation to control the time of entry and exit of each worker, is an accepted value since it performs the entire process quickly unlike the traditional way.

The importance of implementing this system in different health centers is that it will allow having the complete information of the labor registry of each worker to determine if he really complies with his work schedule. In addition to preventing people from having direct contact with other people, we are still in the middle of a pandemic. Also, this system is not very expensive, unlike other systems that exist in the market that have inefficiency in their operation.

Table 4: Attendance control system algorithm

Algorithm 1: Attendance control system
1. Adding the workers' personal data to the system.
2. Add the MAC address of each worker's mobile device.
3. While the mobile device connects to the wireless network
4. Register the time of the entry of the worker
5. Store the information in the database
6. End while
7. If the mobile device disconnects from the wireless network or puts back its fingerprint.
8. Register the worker's departure time
9. Store the information in the database
10. End if
11. Calculate the total time of working hours
12. Store the information in the database

6. Discussion

Various research studies have aimed to replace the traditional method of manual attendance taking, which requires direct contact with a supervising individual responsible for recording attendance. In this study, we developed an automated attendance control system to streamline the process of recording attendance. This work differs from previous research in several aspects. For instance, Hegade et al. (2021) proposed a registration and updating system for labor attendance using a fingerprint reader and facial recognition technique. They achieved an efficiency result of 96.89%. However, their system did not incorporate cloud storage for storing worker records, resulting in potential data loss. Ahmed et al. (2019) developed a labor assistance management system based on a web interface and cloud storage, attaining an efficiency result of 90.79%. However, their system did not focus on calculating working hours, making the recorded information susceptible to manipulation. Chen and Li (2021) proposed an attendance management system utilizing facial recognition and RFID technology for workers and students at the Albert Einstein Institute. They achieved an efficiency result of 91.92%. However, their system did not consider potential communication interferences, leading to instances where attendance was not recorded. Oo et al. (2018) designed an employee attendance management system with a cloud-based web application using NFC technology. They achieved an efficiency result of 93.14%. Nevertheless, their system did not track working hours outside the office for field workers, potentially resulting in non-attendance since the system would not register their presence. Hapani et al. (2018) proposed an automated assistance system using image processing for biometric recognition. Their system achieved an accuracy rate of 45% for face

detection and 50% for facial recognition. However, the system faced challenges when detecting faces covered by masks, impeding its functionality.

To provide a comparison, Table 5 presents a comparison between a common market-assistance system (a) and our wireless automatic attendance control system (b).

Table 5: Operation of attendance control systems

	to	b
How to register	Manual	Automatic
Electronic device	Touch monitor	Raspberry Pi and fingerprint reader
Registration time	2 minutes	2 seconds
Data storage	Excel file	Database
Efficiency	80.14%	97.16%

7. Conclusion and recommendation

In conclusion, the wireless automatic attendance control system demonstrates effective performance and immediate data recording. Workers can swiftly access the wireless network using their mobile devices, with a mere 2-second connection time, enabling seamless storage of information in the system database. This system greatly contributes to maintaining order and preventing overcrowding within the health center workforce. Furthermore, the system streamlines record retrieval by securely storing data in the cloud, eliminating the need for supervisors to sift through numerous documents as required in traditional methods. This significantly saves time and enhances efficiency in record management. The system, encompassing the specifications outlined in Table 3, effectively addresses the challenges encountered when workers attempt to register their entry time. It eliminates the potential conflicts arising from the supervisor's failure to record entries, thereby averting any associated workplace issues. With a remarkable efficiency rate of 97.16% in registering and storing workers' information, the implementation of this attendance control system ensures safety and reliability. It surpasses the inadequacies of other inefficient systems available in the market.

The automated nature of the attendance system obviates the need for human intervention, minimizing physical contact between workers and supervisors. This aspect plays a crucial role in mitigating the risk of COVID-19 transmission, considering the large number of patients present in medical centers. Moreover, the versatility of the system allows for its implementation in various settings such as medical centers, universities, hospitals, and shopping centers, as it operates seamlessly without limitations. It contributes significantly to workforce management, enabling scrutiny of workers' commitment to the health center through stored records. As a future endeavor, the addition of a mobile application to the attendance control system is recommended. This enhancement would facilitate the transmission of entry and exit time information to health center workers via a GSM module. To ensure optimal connectivity for workers, it is advisable to position the Raspberry Pi-based WAP strategically within the premises. This will expedite network detection and facilitate seamless connection, preventing unnecessary difficulties for workers in establishing wireless connections.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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