Design and Develop an Attendance System Based on Fingerprint and Arduino Board

Ekhas Ghaleb Abdulkadhim
Collage of Tourism Sciences, University of Kerbel, Iraq
E-mail: ekhlassghaleb@gmail.com

Abstract. The academic attendance of students largely influences their acquired knowledge, grades, and skills and is of paramount importance. The present study aimed to reinforce a fingerprint identification system to be applied in a database. Fingerprinting is an efficient and rapid technique for attendance checks as it represents the uniqueness of humans and is easily available. Fingerprint sensors have benefited from this exclusivity for the automatic identification or recognition of individuals. To this end, we designed and developed an attendance system, the main components of which were a Fingerprint reader and Arduino board (microcontroller) for the insertion of the records into the database. As a result, the performance evaluation of students was facilitated by the recorded attendance in an accurate, efficient manner with the least possible error, as the results of testing this system was with an average of 98.833 %, as well as the improved academic performance of students as they must attend all the sessions and cannot avoid classes.

Keywords: Attendance System, Fingerprint, Arduino Board.

1. Introduction
The present study was focused on a student attendance system based on fingerprint matching, and the main objective of the research was to develop a hybrid student attendance system with a desktop-based application, which allowed the confirmation of students' attendance based on their fingerprints and posting or reviewing their attendance results in a web-based manner. One of the limitations of these sensors is that they currently operate on only one machine for fingerprint identification. Therefore, researchers have been attempting to devise new approaches to identify individuals by various fingerprint sensors. It is common knowledge that every individual has a unique fingerprint that cannot be duplicated. As such, fingerprint attendance systems could optimally authenticate the attendance records of students. Today, checking the attendance of students based on their fingerprints is not uncommon, and professors could assure the attendance of students. Furthermore, students must personally announce their presence in the class and cannot ask others to do so for them as the system only confirms their presence based on their registered fingerprint.
The key modules of the fingerprint attendance system are the attendance module, report module, fingerprint module, schedule module, lecturer module, and student module. These modules ensure the improved attendance of students based on the authentic data in this regard. Therefore, the use of an electronic technique for this purpose is preferred over conventional methods (pen and paper) for the collection, processing, storage, and production of attendance results and their long-term analysis [1].

A fingerprint-based student attendance management system aimed to address the problems associated with the attendance of college and university students and improve the conventional methods in this regard, which are commonly used by different educational institutions for the management of student attendance. Based on our observations, the use of conventional methods is a barrier to the proper management of student attendance in higher education systems, such as colleges and universities.

With this background, a fingerprint-based student attendance management system was developed to enhance the management of college and university student attendance. Presumably, the problems in educational institutions are due to the use of conventional attendance management systems. One of the key advantages of the designed systems for professors is that there would be no need for these academics to register the names of students for attendance every session as the system performs this task accurately and authentically throughout the semester, providing the professors with the results at the end of each semester. Considering the significant tuition payment of higher education systems, such systems could ensure the constant presence of students in classes and their proper knowledge acquisition for their future career, which is the main duty of the institutions in return for the payments of the registered classes by the students [2,3].

To address the objectives of the current research, the study was performed in several stages, including data collection and circuit and coding development. Before the initiation of the other phases, the previous related products were assessed to assure the development of a novel, user-friendly product. Considering that an attendance system should be portable, it had to be small and efficient, and the recorded attendance data were preserved in a memory card. After obtaining the components, the circuit was constructed, and troubleshooting was carried out on each component to ensure its function. When the proper status of all the components was confirmed, the codes were uploaded using Arduino. Notably, we used the fingerprints of 30 students for the experimental purposes [2].

2. Proposed System

The current experiment required hardware and software to be implemented. Figure 1 depicts the designed block diagram in the portable attendance system. In the hardware implementation, Arduino Mega was attached to the SD card, and the Fingerprint scanner. As for the software, the code was compiled using the Arduino compiler IDE.

![Figure 1. Overall Block Diagram](image)

2.1. Hardware

Arduino Mega is a microcontroller board (Figure 2 shows Arduino microcontroller), which operates based on ATmega1280 at the voltage of 5V, providing four hardware UARTs for the serial communication of TTL (5V). Furthermore, the microcontroller encompasses a serial monitor for the transfer of simple textual data to or from the Arduino board. RX and TX flash-up is obtained with the transfer of data through the USB connection and FTDI chip [2]. In addition, a library set (SoftwareSerial)
allows serial communication on the digital pins of the Mega. The microcontroller is primarily applied for fingerprint enrollment and searching; in the former, the template is read by the microcontroller based on the fingerprint sensor, and the ID number is enrolled and displayed on the serial monitor. Following that, the fingerprint is assessed by the controller in accordance with the stored template obtained in the searching stage. In case of a correct fingerprint, MySQL displays the values; otherwise, no output is provided by the controller.

A fingerprint scanner (Figure 3 shows the fingerprint module) could provide the ridge and valley images of human fingers. In the present study, the scanner was employed for the functions of scanning and retrieving the students' data, as well as the matching of their IDs with their fingerprints [4]. For this purpose, we used the ZFM20 fingerprint scanner with a memory and processor, so that the identification process could be carried out using the same device without overloading the main processor (Arduino Mega). In addition, the SD card module acted as the interface between the Arduino microcontroller and SD card and consisted of an SD card for the storage of the records of the students.

2.2. Software

The attendance of the students was recorded by saving their ID in the fingerprint scanner. Initially, new IDs were enrolled by the uploading of the program code into the Arduino compiler, and the serial monitor was used to key the IDs. Notably, fingerprint authentication was employed to secure the device against unauthorized access, so that only authorized individuals would be granted access to the device. The user should initially setup the device and select the attendance marking batch, and following that, the reset and power switch would be inserted into the device cabinet to restrict the access of the students.

Database management systems are the software packages applied for database development and management, which are classified into several types based on the management of the database structure. In the present study, we used MySQL for this purpose, which is an oracle-backed open-source relational database management system (RDBMS) based on the structured query language (SQL), and could be virtually run on all platforms (Linux, Mac OS, and Windows). Despite the wide-range applicability of MySQL, it is more commonly proper for online publications and web applications. Furthermore, MySQL is considered to be an inherent element of an open-source enterprise stack known as XAMP, which is a web development platform that functions by the Linux operating system, Apache web server, MySQL relational database management system, and PHP object-oriented scripting language, while Perl or Python is occasionally used instead of PHP [3,5].

3. Experimentation Setup

The proposed system was composed of three segments of enrollment, search, and attendance display. The device had a simple design and functioned by attaching the fingerprint sensor and Arduino to the computer for enrollment. As for the search segment, the user's fingerprint would be read immediately.
after pressing the fingerprint sensor by the user, and the user data would be displayed on the computer based on the provided instructions. The displayed data on the computer included the scanning time, date, and user's name and ID number, and the information were shown by the MySQL.

3.1. Enrollment
At this stage, the fingerprint module was initially attached to the controller, and the user's ID number was enrolled by the serial monitor. If the process continued smoothly, the fingerprint would be scanned by the sensor. Afterwards, the fingerprint would be converted into templates and saved in EEPROM (Figure 5 and Figure 6 illustrate this process), and another fingerprint would be recorded and stored for another user ID number, Figure 4 illustrates the flow chart of the enrollment stage. This process continues for another fingerprint of another user's ID number.

Figure 4. Flow Chart of Enrolling

3.1. Enrollment
At this stage, the fingerprint module was initially attached to the controller, and the user's ID number was enrolled by the serial monitor. If the process continued smoothly, the fingerprint would be scanned by the sensor. Afterwards, the fingerprint would be converted into templates and saved in EEPROM (Figure 5 and Figure 6 illustrate this process), and another fingerprint would be recorded and stored for another user ID number, Figure 4 illustrates the flow chart of the enrollment stage. This process continues for another fingerprint of another user's ID number.
Yes
Start

If fingerprint

Yes
Scan the finger image

No
Fingerprint matched

Yes
Display the current date, time, name, ID Number in mysql

End

Figure 7. Flow Chart of Scanning and Displaying Attendance

Figure 5. Enrolling ID Number

Figure 6. Saving Fingerprint
3.2. Search and Fingerprint Display
The controller initially examines the presence of the fingerprint, and after its detection, compared the template with the saved value in EEPROM. In case of a match, the user's ID number and name are shown in MySQL, as well as the scanning time and date. It is notable that the fingerprint of the user is extracted in triplicate by the fingerprint sensor. In addition, changes in the fingerprint yields outcomes in the form of data with the volume of up to eight bytes. Following that, the fingerprint data collection would be converted into the hexadecimal form, and the fingerprint extraction results would be transferred to Arduino, which eventually forwards the results to the server. The stored data would be displayed in the form of monitoring and could be viewed on the interface. Figure 7 shows the flowchart of search and attendance display. In the experimentation, the results could be observed by pressing a finger on the fingerprint sensor [6,7].

4. Results and Discussion
In the current research, the registration mode was manually selected in the designed fingerprint sensor model by pressing the button, and the sample outcomes of the sensor were displayed. Table 1 shows the experimental results in detail. According to the results of the matching process, a total of seven fingerprints remained unidentified, which were signified with an 'x'. This occurred due to the incorrect position of the fingerprints, wet/greasy fingerprints, and thin surface of the fingertips. On the other hand, the properly detected fingerprints were marked with '✓'. According to the matching fingerprint data in Table 1, the accuracy ratio of the developed system was 98.833 %, the value of which was gained using Equation 1 [8, 9].

\[
\text{Accuracy ratio} = \frac{\text{n. of successful fingerprint matches}}{\text{Total tests for fingerprints}} \times 100\% \quad \ldots \ldots \quad (1)
\]

\[
\text{Accuracy ratio} = \frac{593}{600} \times 100\%
\]

\[= 98.833\%\]

| User ID | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|-------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|
| 1     | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
| 2     | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
| 3     | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
| 4     | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
| 5     | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
| 6     | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
| 7     | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
| 8     | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
| 9     | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
| 10    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
| 11    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
| 12    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
| 13    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
| 14    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
| 15    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
| 16    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
| 17    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
| 18    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
| 19    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
| 20    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
5. Conclusion

In the modern era, there has been remarkable advancement in information systems and communications technologies. Fraud could be identified using several technologies, one of the most effective of which is the biometric technology. In this study, we proposed a fingerprint-based attendance system to improve detecting the fingerprints of students and employees. The proposed method has adequate efficacy and accuracy and could be employed in various settings. Furthermore, it is reliable and user-friendly as it benefits from the MySQL database to show the name, date, time, and ID number. The system could be utilized for checking the timely arrival of individuals, which saves time by providing the necessary reports in a timely manner.

In this study, fingerprint-based student attendance management system was accomplished, which able to address the following issues:

1) Fingerprint identification in the attendance system using Arduino was performed effectively with the success rate of 98.833 % as the centralized server recording;
2) No time waste by checking attendance during lectures without the involvement of the instructor;
3) Automated attendance management;
4) No opportunity of simulate attendance marking.

References

[1] Liew, K. N. (2015). Fingerprint Recognition Student Attendance Management System (Doctoral dissertation, UTAR).
[2] Zainal, N. I., Sidek, K. A., Gunawan, T. S., Manser, H., & Kartiwi, M. (2014, November). Design and development of portable classroom attendance system based on Arduino and fingerprint biometric. In The 5th International Conference on Information and Communication Technology for The Muslim World (ICT4M) (pp. 1-4). IEEE.
[3] Asabere, P., Sekyere, F., & Ofosu, W. K. (2020). Wireless Biometric Fingerprint Attendance System Using Arduino and MySQL Database. International Journal of Computer Science, Engineering and Applications (IJCSEA) Vol, 9.
[4] San Myint, K., & Nyein, C. M. M. (2018). Fingerprint Based Attendance System Using Arduino. 2018 International Journal of Scientific and Research Publications, 8(7).
[5] Mohamed, B. K., & Raghu, C. V. (2012, December). Fingerprint attendance system for classroom needs. In 2012 Annual IEEE India Conference (INDICON) (pp. 433-438). IEEE.
[6] Ezema, L. S., Joe-Uzuegbu, C. K. A., Eneh, J. N., & Amanze, I. (2015). Fingerprint Based Attendance Management System. International Journal of Scientific and Engineering Research, 6(7), 1623-1628.
[7] Pratama, N. P., Triayudi, A., & Hidayatulloh, D. (2019). Design-Based Fingerprint Time Attendance System Using IOT With MCU Node ESP8266. Jurnal Teknik Informatika CIT, 11(1, Maret), 15-21.
[8] Muchtar, M. A., Seniman, A. D., & Hasanah, S. (2018, March). Attendance fingerprint identification system using arduino and single board computer. In Journal of Physics: Conference Series (Vol. 978, p. 012060).
[9] Nora omran alkaam, Dr Mohammed Q. Mohammed, Ahmed J. Obaid, A Hybrid Technique for Object Detection and Recognition Using Local Features Algorithms, Journal of Advance
Research in Dynamical and Control Systems, vol.10, no.2, pp.2330-2343, 2018.