Biometric Attendance System using Fingerprint for Smartphones

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***Abstract*—Educational institutions have implemented various modern technologies to improve the quality of education such as smart class, e-learning and so on but one of the traditional methods still followed at many institutions is the manual attendance system. A faculty member must call out every student of a class, for every hour, for every single day to take attendance. This not only utilizes a considerate amount of time and energy but also leads to many confusions since it is done manually. This paper explains about the Biometric Attendance System which could automate the attendance process using fingerprints. With a one-time registration, students can mark themselves present as they enter the class without having to involve the faculty. This list can be sent as a document to the faculties through the mail. As fingerprints uniquely identify every individual, the process cannot be faked. This application provides an efficient yet secure method to simplify attendance and can be implemented at any institution.**

***Keywords*—biometric attendance, fingerprint, minutiae extraction, minutiae comparison, cloud storage, smartphone application, android**

I. INTRODUCTION

Keeping track of the student's presence in a class helps to monitor their academic activities. Be it school or university, it is essential to have an attendance system to keep records of every attendee. The concept of attendance emerged in the late 1800s and was used in factories to monitor employees. Machines were used to print out time stamps which the employees lined up and collected one by one. This was later replaced by a much smaller electrical time clock [1]. But these instruments were installed in sophisticated factories by wealthy owners. These were not used in educational institutions as marking attendance for students was not the primary concern at that time. In the present scenario, especially in highly populated countries, it is mandatory for the management to maintain records of student activities within the premises. The major problem here is the current method followed to take attendance. A few institutions follow the signed sheet mechanism where the students can sign against their name or this sheet could be passed on [2]. Here, there is no time wasted by the faculty member, but the students can sign for others too (proxy attendance). The other widely followed method is a person calling out all students of a class. This comparatively has fewer chances of proxy attendance but wastes a considerable amount of time for every class and moreover leads to a lot of confusion since done manually. Also, both these methods are paper-based and result in a huge amount of paper consumption when practised on a larger scale.

In this paper, a mechanism is proposed to overcome the drawbacks of both manual attendance and proxy attendance. Technology has made the use of biometrics such as fingerprints easy and convenient to most development frameworks. Fingerprint provides two features, namely identification which is a one-to-many process and verification, a one-to-one process [3]. It is the simplest and cost-efficient biometrics which provides a combination of both security and efficiency where multiple data can be processed at once. A mobile application is developed which reads fingerprints from a fingerprint scanner and identifies every registered member uniquely. This process involves its users to complete a process of one-time registration after which every time a student needs to mark attendance, he or she could use the application through a smartphone directly and mark themselves present on their own without having to directly involve the faculty member. There are a few other methods proposed for an improved attendance system which is discussed in the literature review segment of this paper.

II. LITERATURE REVIEW

There are several proposed methodologies to improve the attendance system. The most important one was the implementation of mobile application-based attendance [2]. This system breaks the idea of paper-based attendance marking and allows users to use a mobile application where the attendance could be marked and updated to the server. This brings the whole concept of efficiency and automation, but this still involved a faculty member to do the process. The process does not involve any self-validation mechanism for the students to directly mark their attendance. Another paper involves the idea of NFC tags embedded in ID cards and installing an NFC reader in every class to detect these ID cards [4]. This method is a convenient way for students to mark their attendance on their own and a few institutions have already embedded NFC tags in the student's ID cards but this does not ensure validation security as these ID cards can be passed on to a fellow student and still mark proxy attendance. The same drawbacks apply while implementing barcodes in ID cards which is also a slower process than NFC.

QR code is the fastest way to authenticate digital data. Implementing this in an attendance system would allow the students to scan QR code on their mobile to mark attendance

[5]. The major disadvantage is that this code must be generated for every class and should be displayed to students. Also, the students can exchange the credentials and scan the QR code for another student. The QR code itself can also be shared and be misused.

Face recognition is a modern technology used in various fields. This technique, when implemented in an attendance system, allows users to scan their face one by one to enrol attendance [6]. The problem in this method is the execution, if the students are made to scan their face one by one, it takes a lot of time to complete the process for the whole class. Whereas if this is implemented in a CCTV camera installed in every class, it would be a highly expensive method in terms of hardware, server and process time to be implemented by the management. The registration phase requires a minimum of thousand images of input for a single person to be identified which may not be practically possible in an institution and the system fails to differentiate identical twins.

Fingerprints are the most simple and unique identity available to all human beings. It is so unique that using it we can accurately identify an individual using appropriate technology. The registration process is simple, and the execution time is less [7]. Also, the students can directly validate themselves. The process is false proof, and chances of proxy are almost zero. The important factor is the method of implementation.

One of the proposed ideas using fingerprint is to build a separate device using IoT. A combination of the fingerprint sensor, a WIFI module, a keypad and an LCD display connected to a raspberry pi which acts as a processor [8]. This acts as a stand-alone device and must be carried to every class with which attendance can be taken. The paper states that fingerprint matching has not resulted in 100% success. Also, the students must be properly trained to use the device and failure of even a single component would lead to failure of the whole system. This device requires to be paired up via WIFI with a computer or mobile to send the collected data which results in carrying both the device and its pair everywhere which may not be practically convenient.

Finally, a method proposed to link a fingerprint validation module directly to the university server to take records of people present [9]. This module is practically feasible as the registration process is simple and the validation time is less. Also, this process does not require any faculty member and can be done directly by the students. One drawback is that linking an external module to a large-scale server such as the university server is not the best idea as any downtime and maintenance to the server affects the attendance process and the data during that period are lost.

Considering both advantages and disadvantages of all the above-discussed papers, a biometric attendance application using fingerprint is developed which composes of potential upsides and minimal drawbacks. The methodology of the proposed system is explained below.

A. Abbreviations and Acronyms

BAS - Biometric Attendance System

NFC - Near Field Communication

ID - Identity Document

QR - Quick Response

CCTV - Closed Circuit Television

IoT - Internet of Things

WIFI - Wireless Fidelity

LCD - Liquid-crystal-display

USB - Universal Serial Bus

OTG - On the Go

III. METHODOLOGY

In this section, the working of Biometric Attendance System (BAS) using fingerprints is explained. BAS is an android application designed and developed to make the process of marking attendance simple and efficient. This application is designed to execute on any android mobile, running operating system lollipop or higher. It requires an external USB fingerprint scanner to be attached to the mobile to retrieve the fingerprint input form the user. This fingerprint sensor can be attached to any android device using an OTG cable. This external device only functions as a fingerprint scanner which provides the application with a high-quality image of the fingerprint. The main advantage of BAS is that it does not entirely rely on the devices including the android device and the fingerprint scanner which implies that the device is completely replaceable.

A. Architecture Description

The system mainly comprises two roles namely, faculty and student. Fig. 1 shows the architectural workflow of the application. The faculty is required to login with credentials into BAS only after which the application is usable by the students. This makes sure that the students do not misuse the application outside the campus. Fig. 2 represents the use case diagram where various activities of the actors are depicted.

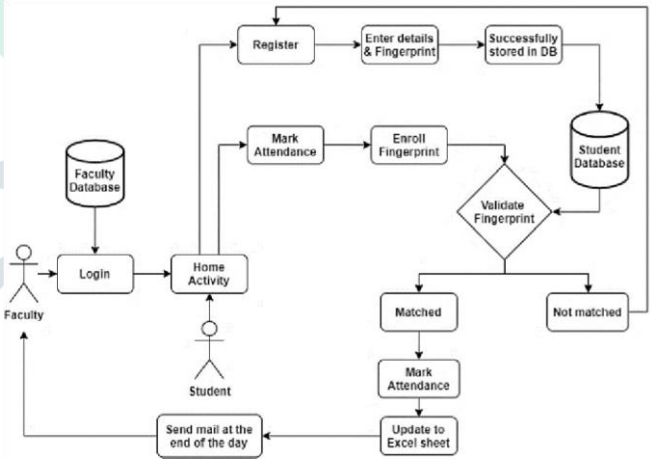

Fig. 1. Architecture Diagram of BAS

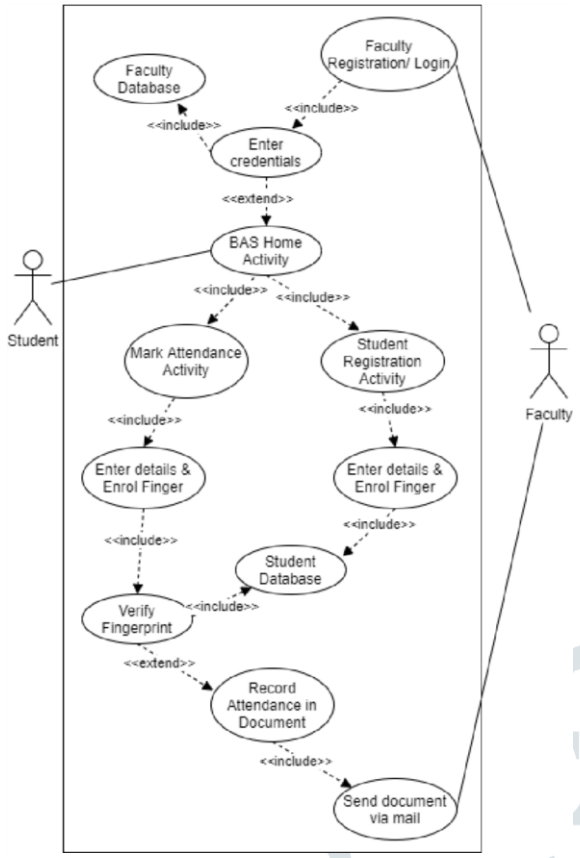

Fig. 2. Use case diagram of BAS

The application opens into a mark attendance activity and registration activity. The student needs to register themselves by entering their details and enrolling their desired fingerprint. This is a one-time registration which would be valid for the entire duration of study at the institute. After the registration, the student can mark themselves present by just enrolling their fingerprint. This does not require any direct involvement of the faculty member and there is no chance of proxy attendance. Whenever a student is required to mark attendance, they can simply enrol their finger in the BAS and mark themselves present. This information is being appended to a document which could be mailed to the respective faculty member by just a button click.

B. Minutiae Extraction and Comparison Algorithm

The working of the algorithm comprises five steps namely, fingerprint acquisition, fingerprint pre-processing, fingerprint enhancement, feature extraction and minutiae matching [3].

Fingerprint acquisition: It is the process where BAS retrieves the fingerprint input from the user through the fingerprint scanner. The scanner captures an image of the fingerprint placed on its surface. BAS communicates with the scanner using device drivers and retrieves the image of the fingerprint into the application for further processing.

Fingerprint pre-processing: In pre-processing, the acquired image is converted to pure grayscale. i.e., black and white. This makes sure that the ridges, ridge endings, bifurcations, valleys and whorls are made distinct which are shown in Fig. 3.

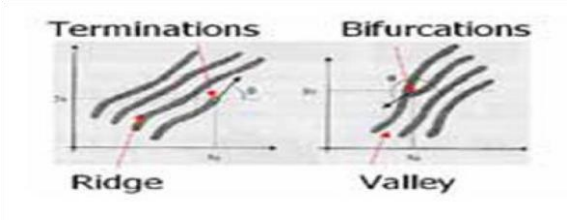

Fig. 3. Diagrammatic representation of fingerprint minutiae

Fingerprint enhancement: At this stage, the quality of the image is enhanced to the maximum to better differentiate between minutiae and white space. The image undergoes a quality check to ensure that it is adequate for the extraction process. Once passed, binarization occurs where every black ridge in the image is considered as 0 and the white space is considered as 1. This helps to identify the features of the fingerprint in the extraction process.

Feature extraction: The image is fully rooted for the binary bits with the value 0 to recognise the features. Every feature is determined by the value they hold in each pixel. These binary values and the pixel values are computed using (1) and stored in a byte array [3]. This byte array represents the whole fingerprint.

$$CN = 1/2 \sum_{i=1}^{8} \left| P_i - P_{i+1} \right| \quad (1)$$

where CN is Cross Number, Pi is the binary pixel value in the neighbourhood of P with Pi = (0 or1)

Minutiae matching: Since the byte array represents the whole fingerprint, the byte arrays of the desired two fingerprints are compared and a similarity index is generated. This similarity index is used to find whether the fingerprints match or not. If the generated result is above 100 then the fingerprints match else, they do not.

C. Module Description

BAS consists of two main modules namely, registration and mark attendance. In the registration module, the students are required to enter their basic details such as name, year of study, department, section, registration number, mail id along with their desired fingerprint. Fig. 4 shows the user interface of the registration module. This fingerprint is converted into a byte array using the above-explained minutiae extraction algorithm. Once the student submits the details, the data is collected and stored in a cloud database securely. The database schema is structured in such a way that every student can be easily identified by using their registration number. Moreover, a real-time database is implemented. So, any data change is quickly reflected and there is no need for a server. Also, as the fingerprints are stored as byte arrays, there would not be any leakage in privacy or sensitive data.

Fig. 4. Registration module of BAS application

In the mark attendance module, the students are not required to enter any details other than the last four digits of their registration number and their registered fingerprint and BAS ensures that the student is marked present for the specific hour. Fig. 5 shows the user interface of the mark attendance module. Since it is time-based and details such as year of study and department for a class is already available, it is not required to specify any details regarding the professor or the subject. When the student's input fingerprint matches with the existing fingerprint in the database, the student would be marked as present and the student's details along with timestamp would be recorded in a document which can be sent as a mail to the respective professor. A time constraint is also implemented which does not allow the students to use the application beyond a time limit for each period. The application would again accept attendance input from the starting of the next period to avoid latecomers.

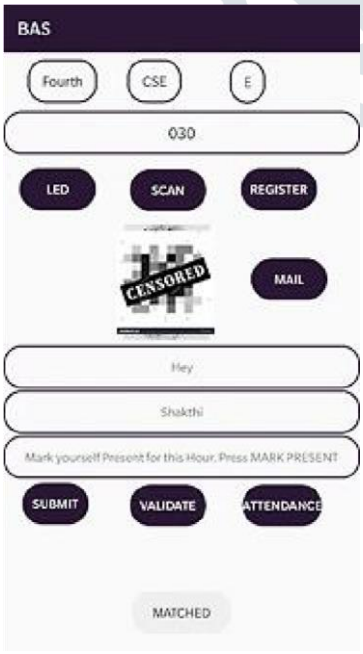

Fig. 5. Mark attendance module of BAS application

IV. RESULTS AND DISCUSSION

Thus, the Biometric Attendance System paves a way to overcome the traditional methods of manual, paper-based attendance. It also reduces the direct involvement of faculty members in the student's attendance which makes the system more efficient with fewer confusions. It provides the opportunity of self-attendance entry for students. The time mapped attendance entry makes the application to get less number of inputs from the user and speeds up the process. Also, time restrictions prevent students from coming late. The use of fingerprints makes it convenient to prevent proxy attendance as the only way to mark attendance is the presence of the student in the class. In terms of the minutiae matching algorithm accuracy, regression testing has been performed which resulted in 100% accuracy in matching fingerprints. In terms of the database, a real-time database is used which makes the process of data retrieval instant and does not require a server. This ensures zero server downtime. The sensitive data such as fingerprints are converted into bytes and stored as a byte array. So, in terms of data security, the application is safe to use, and no sensitive data will be lost. Finally, the main output of the attendance record is mailed as a document which makes it easier to upload it on the university website. Fig. 6 shows the contents of the document being attached as a mail and Fig. 7 shows the database schema of the real-time database.

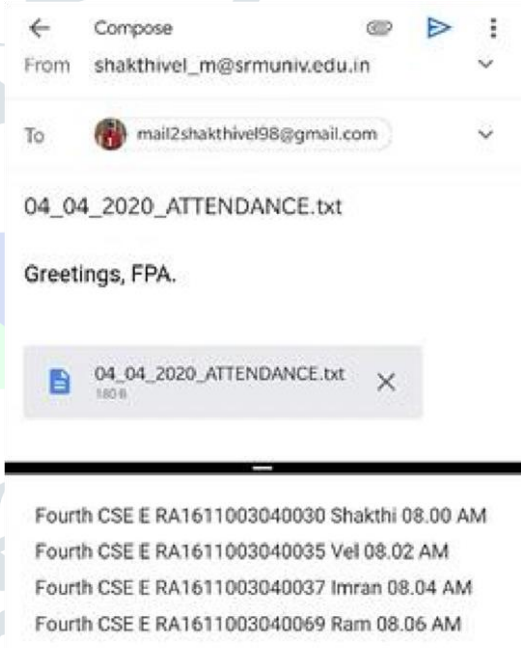

Fig. 6. Attendance record output of BAS application

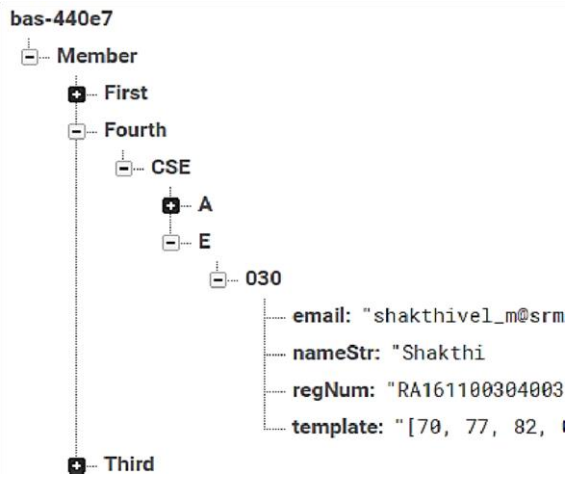

Fig. 7. Cloud database schema

V. CONCLUSION AND FUTURE SCOPE

In conclusion, the Biometric Attendance System using Fingerprint for Smartphones has been designed, developed and implemented successfully. It clearly provides a solution to the overcome problem discussed in the existing system. Also, the application combines all crucial upsides and eliminates most downsides of the related work discussed in the literature review. Moreover, the application not only solves the main problem by automation but also provides various other advantages which have been discussed in the result section of the paper. The overall user experience is made comfortable for both students and the faculty members. In further sprints, the following features could be released as updates:

- Registration of more than one fingerprint for every user.
- A backup method to mark attendance in case of any failure.
- A master login to update attendance for special circumstances.
- A student login to track their attendance and submit OnDuty forms.
- Report a problem feature to contact the management.
- A feedback feature to report bugs to the development team.

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