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PORTABLE ANTI FORGERY RECOGNITION FOR ATTENDANCE SYSTEM USING FINGERPRINT BASED BIOMETRIC

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ABSTRACT

In this paper, a portable anti forgery recognition for attendance system using fingerprint based biometric is presented. Portability and security are the main purpose of applying biometric characteristics in a portable attendance system. An independent energy source and its miniature design make the system more efficient in terms of the portability criterion. This study introduces a system which overcomes the limitations of existing paper based attendance method and queuing delays due to fixed fingerprint reader installed in front of class entrances. Furthermore, in terms of security, encryption has been implemented to preserve data integrity. Results of the study include several analysis which among others involved student perceptions, average time taken and classification accuracy of biometric recognition. Moreover, a comparison study was done using the proposed and paper based methods.

Keywords: biometric, fingerprint, security, portable, encryption.

INTRODUCTION

In believing the fact that attendance may influence the students' performance, a lot of method was introduced to develop a beneficial attendance recording system. This fact brings the idea to the authorities to register the attendees using commonly documented method which is by pen and paper. Before the digital age, most of documents were recorded in a paper form. Unfortunately, there are some factors for rejecting paper documents over digital documents which is cost diminution, efficiency, productivity, flexibility and security [1]. Due to the drawbacks of the traditional methods, people change their documenting style by recording the information in digital form. Liu in [2] stated that there are several reasons why people need to have a digital copy where electronic documents are easier to distribute, edit, reorganize, locate, recreate and reuse. Therefore, digital format has the capability to preserve the data in case of destruction or loss. Hence, this study introduces a method of recording attendance digitally in supporting the solution for all predicament stated previously.

In order to build a huge business empire, recording the actual and accurate incoming and outgoing timing of the workers is a must [3]. Attendance is a trust that exists between the employer and their employees. It is a symbolic representation that could be a benchmark to the higher authority to assess their staffs' commitment toward their job. This scenario is similar to any organization such as the educational system. In this case, an educational instructor will play a role as the higher authority whereas the students will be his/her subordinates. Most universities have attendance systems that can be easily manipulated. As a proof to this fact, imagine if in each class, an educational instructor has to pass the attendance list which is printed in a paper for the students to record their presence. In this situation, the students only need to fill the attendance sheet with their signature. However, some of the students might imitate their absence friends' signatures. One of the key strategies to combat identity forgery is by implementing biometric. Thus, we will propose a fingerprint based biometric system in our research.

Biometrics is defined as an automatic recognition of individuals based on their physiological and/or behavioural characteristics [4]. The pillars of biometric system operation consist of identification and verification mode. Both modes have different functionality depending on which application the biometric system operation is used. In identification mode, the system will distinguished an individual fingerprint by searching the templates of all the users in the database for a match. In verification mode, the system will authenticate a person's fingerprint by comparing captured biometric data with his or her biometric templates stored in the system database [4]. It is important for us to understand the type of modes involved in the biometric system operation in order to recognize which mode is suitable for this research. Thus, based on the aforementioned explanation, we decided to use the verification mode in our biometric system operation as shown in Figure-1.

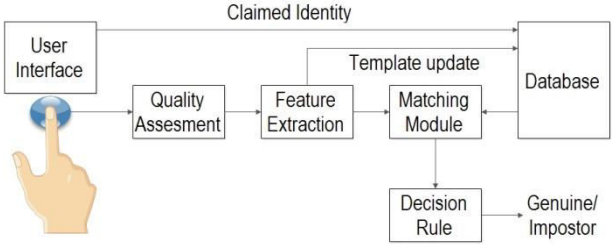


Figure-1. Verification model.

There are a number of biometric modalities such as face, iris, palm, keystroke, gait, voice and fingerprint. In our study, we will focus on fingerprint based biometric recognition which is a pattern of valleys and ridges on the surface of the fingertip as a biometric recognition [4]. The main reason of choosing fingerprint is due to the fact that this type of biometric recognition has been established for decades as an identification mechanism. A study by Heckle *et al*. in [5] shows positive results of people's perception and acceptance of fingerprint biometric technology. Among 24 respondents who were involved in this research, 88% agreed that fingerprint system for personal use is very convenient.

Digital age is the age in which the consumption and consequences of digitization are visible in all level of the society. Nevertheless, security becomes a major topic in the cyber-world. Most systems are interconnected within a network. How secure is our data in a public domain system? In 1988, Robert Tappan Morris created a program which infected 10% out of all the computers in the Internet causing denial of service attack. Only after 1988, the first juvenile for computer crime is imprisoned and accused by the US federal government [6]. Therefore, in this study, we introduce a data protection method by using a basic encryption technique.

Although a biometric attendance system has already been implemented in some institutions, we offer extra criterion which are portability and security. These criterions make it suitable to be implemented in universities as lectures have multiple subjects which sometimes are conducted in different venues. Thus, we will introduce a portable anti forgery recognition for attendance system using fingerprint biometric to solve the aforementioned issues.

LITERATURE REVIEW

In this section, we will briefly describe related literatures pertaining to portable attendance system.

Xiang *et al*. in [7] had conducted a research on a prototype biometric security authentication system based on fingerprint recognition where the focus of this research is mainly on analyzing the fingerprint to test its effectiveness. They proposed a simple efficient algorithm to identify and eliminate false minutia in order to convalesce the performance of the system. The percentage of FAR (False Acceptance Rate) and FRR (False Reject Rate) that is evaluated from the result were ranging from 5.0 to 9.1% (for FAR) and 6.5 to 9.9% (for FRR). This result noticeably shows the high accuracy of the developed fingerprint recognition system.

Heckle *et al.* in [5] performed a research on the perception and acceptance of fingerprint biometric technology in order to obtain people's opinions about the biometric system. In the research, each participant needs to complete several tasks that use the fingerprint biometric scanner. The result shows that 88% of the participants though the usage of fingerprint system for personal use is very beneficial. A total of 67% of the participants agreed that the usage of it in purchasing for their employer is moderately beneficial and 46 % of them are in the comfort zone when using the fingerprint biometric in personal credit card for personal purchases.

Coli *et al.* in [8] had performed a research on vitality detection from fingerprint images. The research tested the vitality recognition on fingerprint verification systems for personal identity recognition. The idea of bringing up this issue is due to the fact that the biometric system can be deciphered using fake fingerprint. The study implemented several methods to detect the fingerprint vitality such as neural network, threshold and linear discriminant analysis. Based on the experimentation result, it showed that capacitive sensor have 6% error rate, electro-optical sensor have 3% error rate while optical sensor have 2% error rate.

In a different research, Gafurov *et al*. in [9] focused on the fusion in the fingerprint authentication experimented on two different fingers and scanners. A total of three different situations were examined which were two fingerprints scanned by the same scanner, a fingerprint scanned by two different scanners and two fingerprints both scanned by two different scanners. The purpose of this study was to find any differences among fingerprints in a fusion mode. The result shows that in terms of EER, the mean improvement for the three stated fusion sets were 61.6%, 72.5% and 75.8% respectively. On the other hand, the mean value for these three fusion sets is 0.6%, 0.5% and 0.3%.

Another research was done by Kawaguchi *et al* in [10] developed an attendance system based on face recognition. The research proposed a method for estimating the attendance accurately by referring all the result of face recognition. Observation was made by comparing the outcome from one cycle detection and continuous observation. The results show that the face detection rate is 37.5% in one cycle detection and 80.0% in 79 minutes continuous observation which consist of eight cycles.

Despite these previous works, none of them were implementing the encryption technique parallel with the biometric application in their project. Hypothetically, if a security mechanism is implemented in an attendance system; biometric fingerprint is the best alternative choice due to its low market cost as compared to face recognition and its capability in recognizing an authentic identification. However, this matter becomes more intense as the general public worries that the information hidden beneath the prevailing devices can be hacked. Therefore, in prolonging this issue, we design a maze cipher circling our raw data which contains the information about the students' attendance to protect it from any fallacious demeanor by the third party. We propose a systematic scheme device to refute all the drawbacks, which is to design and develop a portable anti forgery attendance system using fingerprint based biometric.

METHODOLOGY

The research will be based on the following methodology; Analytical Study, Development, Design, Implementation and Evaluation as shown in Figure-2.

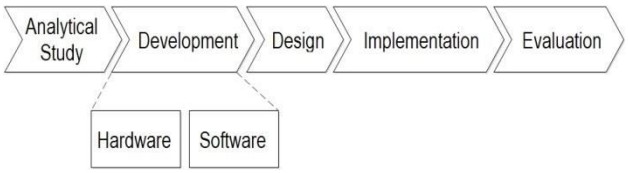


Figure-2. Proposed methodology.

Analytical study

This step requires the analysis of the existing methods and attendance recording techniques. It allows us to evaluate the most suitable mechanism that can be applied to our situation.

Development

This step consists of two sections which are hardware and software development.

i. Hardware

This stage requires the list of the electronic components needed to develop the attendance device. The main components consist of Arduino microcontroller, fingerprint scanner, SD card module, TFT touch screen and RTC.

ii. Software

The development of the device is constructed based on the flowchart in Figure-3. The flowchart of the attendance device proposed the idea on how the device works in a real life situation.

The information in the device used will be scrambled and encrypted using a cryptography method to increase the security features. The method is based on shifting numerical positions. Although, this method is considered as the basic encryption method, the security can be further enhanced by using more secure techniques in future research. The main point here is that security mechanism for the data stored has never been applied for attendance recording system and the proof-of-concept has been implemented in this study.

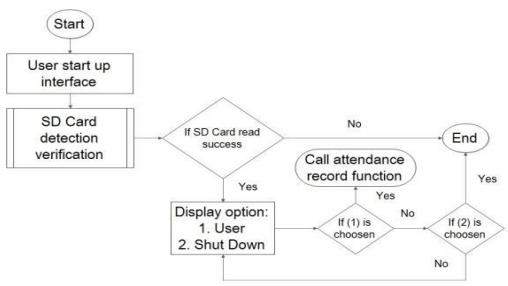


Figure-3. Software development flowchart.

In order to decrypt the data, a Graphical User Interface (GUI) has been developed called Attendance Software Analysis Application using MATLAB. The decryption application will be exclusively given to the respective lecturer. The development of the application is to ease the lecturer in obtaining the file saved in the SD card. Figure-4 shows the display of the Attendance Software Analysis Application. The functions of all the buttons are listed in Table-1.

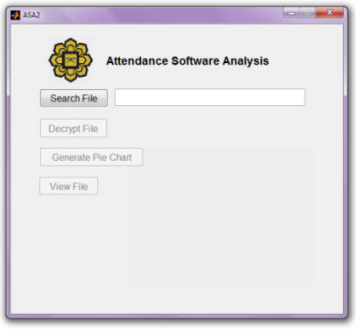


Figure-4. The attendance software analysis application.

Table-1. Function of buttons in the attendance software analysis.

Button list	Functions
Search File	To allow the user to search file from the directory. Once a file is chosen, the 'Decrypt File' and 'Generate Pie Chart' buttons will be enabled.
Decrypt File	To decrypt the encrypted file. (Note that the decrypted information is automatically saved in the file name, NewFile.csv). After this button is clicked, 'View File' buttons will be enabled
Generate Pie Chart	To generate the percentage of absentees and presenters in the class.
View File	To enable the user to view file such as the new file that had been created after decryption button is clicked.

The final display when a lecturer uses this software is shown in Figure-5. The software helps for the lecturer to perform several functions such as decrypting the file, generating a pie chart and viewing the files.

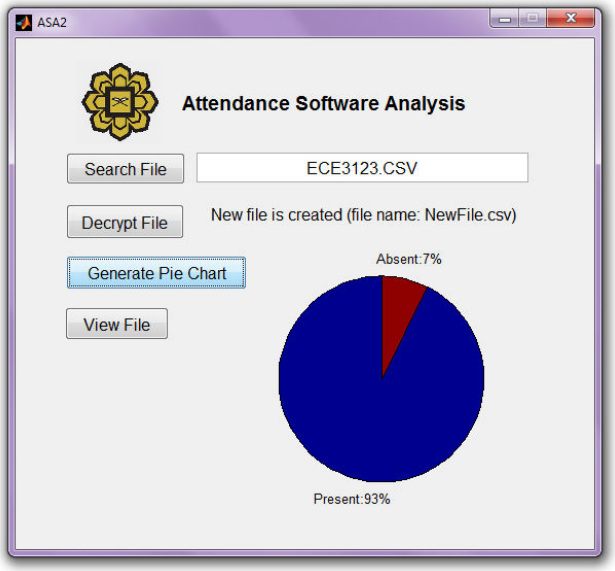


Figure-5. Final result of using the Attendance software analysis.

Design

The integration of all devices will form a complete ready-to-test gadget for a portable attendance recording system based on fingerprint biometric. In the design stage, user friendliness, convenience, portability, and heat resistance are factors that are considered for the product in the design stage

Implementation

Our propose system is tested in the classroom of an undergraduate course in the Faculty of Engineering, International Islamic University Malaysia. The main criteria examined in this implementation are time, security, accuracy and efficiency.

Evaluation

The proposed system is analyzed and the results are compared with the previous attendance recording method.

EXPERIMENTATION AND RESULTS

The portable attendance can save each student's fingerprint, hence makes the system more robust. During enrolment, the student's fingerprint is assumed to be clean, not dry or damp, no scratches and not swollen. After the enrolment stage, the data will be saved in the fingerprint scanner and the verification system takes place by comparing the capture fingerprint characteristic with the previously enrolled data. Table-2 shows the types of issue that might occur when taking attendance system acquiring fingerprint for attendance purposes.

Table-2. Condition of biometric characteristic.

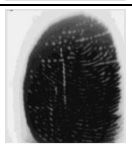
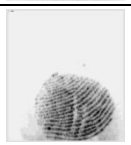
Problems	Fingerprint snapshots	Problems	Fingerprint snapshots
Finger misplacement		Dirty finger	
Wet finger		Skin problem	

Figure-6 shows our proposed portable classroom attendance system based on fingerprint biometric.

Figure-6. The portable classroom attendance device.

In the recent time, most organizations such as universities uses sheet of papers to record the students' attendance. Students need to sign on the attendance sheet as an evidence for them to show that they have attended the classes. When the attendance sheet is passed around in the class, each student needs to scan the name on the attendance sheet. The estimated time for each student to sign the attendance sheet is approximately around 1 to 2 minutes. If the total number of students in a single class is 40, then, the required time to sign the attendance is about 40 to 80 minutes.

Similarly, for the fixed attendance system placed near the entrance to the class, the registration time for each student is around 20 seconds to 30 seconds. If the total number of students in the class is 40, then the required time is about 13 to 20 minutes. Therefore, the last student to register will miss the class around 20 minutes.

The test sample of this experiment was taken from a class which consists of 27 students whom enrolled in ECE 3123 Digital Signal Processing course which is a third year undergraduate subject. There are 15 males and 12 females, with the age ranges from 21 to 24 years old registered in this course. This class was held in Engineering Block 2, Level 2, Room number 1, every Monday and Tuesday at 3.30 p.m. to 4.50 p.m. Figure-7 illustrates the situation in the class.

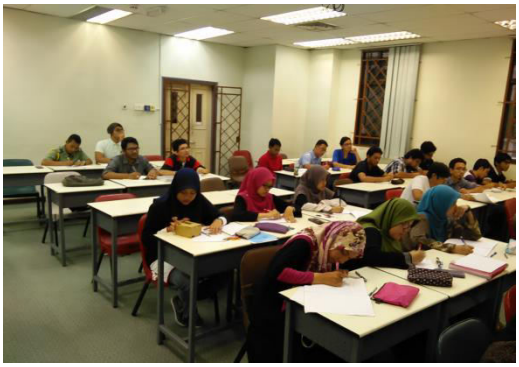


Figure-7. Students from digital signal processing course.

The analysis of the study have been categorized in three main parts which are (i) survey analysis, (ii) time analysis and (iii) classification accuracy analysis. Each of these categories will be elaborated further in the next sub-sections.

Survey analysis

This analysis has been exclusively prepared to present the findings from the students who are involved in the study. The survey question was distributed as soon as the data collection process has been completed which is after 1 month.

The main focus of this survey is to investigate student's opinion on this research. The survey questions concerned on the satisfaction level of the portable attendance device capability in three different aspects which are user-friendliness, portability and time saving. The students were given with five options which are Poor, Fair, Average, Good and Excellent.

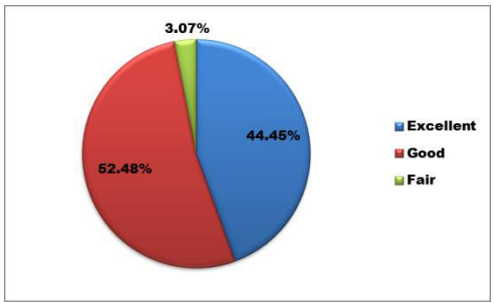


Figure-8. Percentage of student's opinion on the portable attendance device in term of user-friendliness.

Figure-8 indicates the percentage of student's opinion on the portable attendance device in term of user-friendliness. Based on the survey, more than half of the students in the class consider that the portable attendance device is good in term of user-friendliness. A total of 44.5% of them rate this device as Excellent and rest of them rates it as Fair. Overall, in term of user-friendliness, the device gives quite satisfactory respond toward the user.

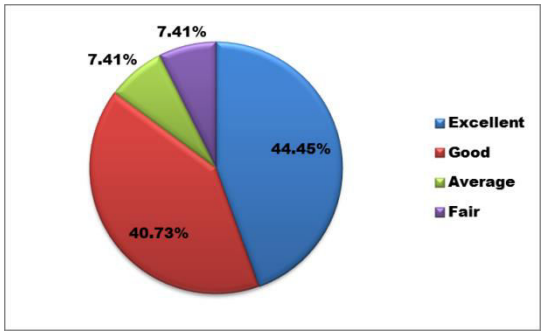


Figure-9. Percentage of student's opinion on the portable attendance device in term of portability.

In terms of the portability criterion as shown in Figure-9, 45% of the students agree that the portable attendance device is Excellent in term of portability. A total of 40.7% of them evaluate it as a Good portable device. In addition, the same percentage is obtained for Average and fair which is 7.4%. In brief, the device's score in term of portability is intermediate. This is due to the user's expectation of the size of the device to be as small as a smartphone whereas for our system, it is as large as CD-ROM driver.

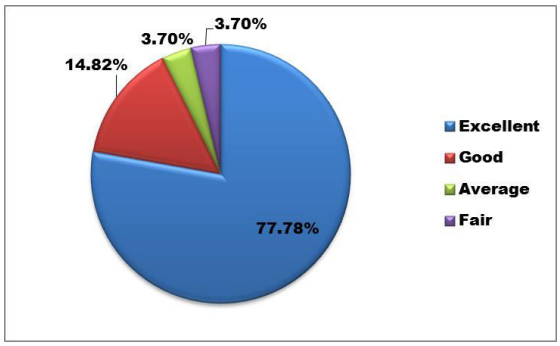


Figure-10. Percentage of student's opinion on the portable attendance device in term of time saving.

One of the significant aims of doing this research is to reduce the time taken for the lecturers to record the student's attendance. Therefore, based on Figure-10, 77.8% of students who join this survey find that this device is very time saving whereas 14.8% of them agreed that the device is moderately good. However, the result shows that the number of students who vote that this device is average and fair in time saving is similar which 3.7% is.

In brief, the portable attendance device gives a satisfactory outcome to the users. None of the users rated this device as poor in terms of all aspects which are user-friendliness, portability and time saving. Concisely, this device obtained the highest score in terms of time reduction. This fact is supported later by the time saving analysis.

Time saving analysis

Another aspect which we consider in evaluating our proposed system is the time saving analysis. In this evaluation, the attendances of the students were recorded in a one month period. This study compared two methods of recording the student's attendance which are by the paper based method and our proposed portable attendance system. The result of this experiment is presented in Table-3.

Table-3. The total time taken for paper based method and portable attendance device.

Date	**Time taken** (minutes)	
	Paper based method	**Portable attendance device**
1st April 2015	11	-
6th April 2015	11	9
8th April 2015	5	9
13th April 2015	14	6
15th April 2015	12	6
20th April 2015	12	8
22nd April 2015	10	8
27th April 2015	8	7
29th April 2015	11	8

Based on the outcome of Table-3, on 1st April, there was no record under the portable attendance device. During the test, the device had loose connection causing malfunction to the whole system. However, the connection had been repaired afterwards. Then, on 6th April, we can see that the time taken to record the attendance using paper based method is slightly higher than using the portable attendance device. Even though the portable attendance device is faster, there was a problem which occurred during the experiment which is incomplete data retrieval from the SD card. This data was supposedly holding the list of attendee's matric number. After troubleshooting, we discovered that there are some corrections which need to be modified in the algorithm. Later, the results taken from 13th April and afterwards are much more comparable to each other since the aforementioned problem had been improved. All the data collected suggest that the time taken to record the student's attendance using our proposed portable attendance device is quicker than using the paper based method except on 8th April. During that time, a test was held instead of lecturing session. There are few hypotheses that can be made from this result. Firstly, most of the students already had their pen in their hands. There is no need for them to waste their time searching for a pen to sign the attendance sheet. Secondly, all of the students were focusing in answering their test. This may be one of the factors that affect the speed of signing the attendance.

In summary, we can conclude that when the portable attendance device is working properly, the time taken to record the student's attendance will be much faster than by using the paper based method. Moreover, there are some factors that affect why the time taken to record the student's attendance by paper based method is longer than the portable attendance device. Firstly, students need to search their name in the attendance list. Then, to sign their attendance, they need to look up for a pen which will definitely consume time to search for it. However, if we use portable attendance device, students just need to scan their fingerprint and then, pass it to another students. This fact without doubt, places the portable attendance device one step further than paper based method in terms of saving time.

Classification accuracy analysis

The final analysis focuses on the accuracy level of the device to recognize and identify individual based on the fingerprint database collected. In this subsection, our result depends on the observation that was made when the portable attendance device was used in the class. The observer monitors how many times the student needs to scan their fingerprint for the device to recognize it. From the data collected on the 20th April as shown in Table 4, we were able to know the accuracy of our proposed system applied in the class for each student. In this study, the True Positive Rate (*TPR*) is calculated based on Eqn. (1).

$$TPR = \frac{TP}{P} = \frac{\sum_{i=1}^{k} P(S_i)}{k} \quad (1)$$

where *TP* is true positive or correctly identified fingerprint, *P* is positive instances.

In this study, it is labelled as *k* which is the total number of students, $P(S_i)$ is the probability of each student's fingerprint identified where $i = 1, 2, 3, \ldots. k$.

Table-4. The true positive rate of the experimented subject.

Subject	Probability, x/y	Subject	Probability, x/y
S_1	1.00	S_{15}	1.00
S_2	1.00	S_{16}	1.00
S_3	0.20	S_{17}	1.00
S_4	1.00	S_{18}	1.00
S_5	1.00	S_{19}	1.00
S_6	1.00	S_{20}	0.50
S_7	1.00	S_{21}	1.00
S_8	1.00	S_{22}	1.00
S_9	0.50	S_{23}	0.25
S_{10}	1.00	S_{24}	1.00
S_{11}	1.00	S_{25}	1.00
S_{12}	1.00	S_{26}	0.25
S_{13}	1.00	S_{27}	1.00
S_{14}	0.25		

From Table-4, x is referred as the number of correctly identified fingerprint whereas y is the total number of times the students scanned their fingerprint. The *TPR* percentage is calculated in Equation (2).

$$TPR\% = \frac{\sum_{i=1}^{k} P(S_i)}{k}\% = \frac{22.95}{27}\% = \underline{\underline{85.0\%}} \qquad (2)$$

Overall, *TPR* of the proposed system is 85.0%. In comparison with a research done by Kawaguchi *et al* in [12] which focus on development of an attendance system based on face recognition, our proposed system obtained higher accuracy than their research which is 5.0% higher. Their research results indicate that the face detection rate for one cycle detection which is around 10 minutes is 37.5% and 80.0% in 79 minutes which consist of 8 cycles. There are a few reasons why the value of the accuracy is as it is. Firstly, the students' attention may be focused on the lecture. They might have scanned their fingerprint in the wrong position due to the concentration towards the lesson in the class. Secondly, the fingerprint might be clean due to dirt or wet fingers that probably affect the fingerprint scanner's capability to detect the thumbprint pattern. In a nutshell, the portable attendance device based on fingerprint biometric revealed to be more accurate. Morever, our propose system classification accuracy is 100% since it can detect all the student's fingerprints without failure.

In the case of Failure to Capture (*FTC*), which refers to the measure of the probability that the biometric system will incorrectly reject the true identity, the biometric system gives a result of 15.0%.

CONCLUSIONS

This paper has presented a portable anti forgery attendance system using fingerprint based biometric. The system helped to reduce many issues such as denying the possibilities of cheating in recording the attendance, helped to ease the lecturers to keep track of students' attendance, the crytography technique added more security so that there will be no anonymous fingerprint which is able to tamper with the recorded data, and the portability criteria which saves time in taking attendance instead of queuing in a line.

In our future work, some enhancements of the developed attendance system can be implemented, such as a battery life indicator as well as a security. A battery life indicator is a good way to display the remaining power for the device. When the battery is low, it will trigger a buzzer or light up an LED. In terms of security, the encryption technique could be upgraded by using a more secure method.

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