British Journal of Mathematics & Computer Science
5(6): 735-747, 2015, Article no.BJMCS.2015.053
ISSN: 2231-0851

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Fingerprint-Based Authentication System for Time and Attendance Management

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Article Information

DOI: 10.9734/BJMCS/2015/8731
Editor(s):
(1) Chin-Chen Chang, Department of Information Engineering and Computer Science, Feng Chia University, Taiwan.
Reviewers:
(1) Anonymous, Bangladesh.
(2) Shoewu Oluwagbemiga, Electronic and Computer Engineering, Lagos State University, Nigeria.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=730&id=6&aid=7166

Original Research Article

Received: 26 December 2013
Accepted: 18 February 2014
Published: 09 December 2014

Abstract

Aims: Taking student attendance manually and maintaining it for a long time is a difficult task as well as wastes a lot of time. In this paper an Educational Time and Attendance Management System (EduTAMS) that will record and manage the time and attendance of students in a university community was developed.
Study Design: The system was implemented using C# and Microsoft SQL Server 2008, and was tested using electronic fingerprint scanner which was interfaced to the digital computer system for verifying student identity.
Place and Duration of Study: The students of University of Agriculture Abeokuta, Nigeria fingerprint attendance were captured during the 2012 academic session.
Methodology: The system comprises of four main modules namely; fingerprint capture, fingerprint processing, fingerprint matching and database while the deployment structure of the system also consists of four major segments; Fingerprint Terminals, Database Server, Access Workstations and Network Service. EduTAMS uses fingerprint technology to authenticate every student. A fingerprint recognition system uses the distinctive and persistent characteristics from the ridges, also referred to as fingerprint features, to distinguish one person from another.
Results: When eduTAM was compared with the manual method, the result shows that the average time taken per student using fingerprint based attendance and manual attendance register are 6.65 and 23.66 seconds respectively.
Conclusion: The performance of the eduTAM system shows that it provides robust, secured and automatic time and attendance management system for Students.

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Keywords: Attendance, authentication, biometric, fingerprint, time.

1 Introduction

Managing people is a difficult task for most of the organizations and maintaining the attendance record is an important factor in people management. When considering academic institutes, taking the attendance of students on daily basis and maintaining the records is a major task. Every academic institution has certain criteria for students regarding their attendance in class. In most Institutions of higher learning, eligibility for examinations is based on fulfillment of a minimum lecture attendance requirement. It is therefore very important to keep accurate records of student attendance.

However, this academic policy has not been fully functional due to limitations posed by the classical attendance method currently in use. The usual practice is that students are given sheets of paper to write down their names, matriculation number and signature. This manual method of taking attendance is obviously not effective. The use of attendance sheets becomes cumbersome and untidy as the population of students increases, is time consuming and a waste of human and material resources. The stress associated with manual calculation of student attendance rate has made it impossible to fully implement the use of percentage attendance in lecture as a factor in authenticating student access into examination venues. Also, high level of impersonation has been known to characterize this method of attendance as students can cheat by asking their friends to write attendance for them.

Consequently, it is very difficult to manage the attendance and determine whether each student meets up with the required lecture attendance. As a result of the flaws in the classical method of taking attendance, there is need for faster, easier, more accurate and effective method for managing attendance.

Technological improvements have been useful tools in the development of new methods such as the use of Barcode readers, Radio Frequency Identification (RFID), Bluetooth Systems, etc. These tools were however expensive and had limited use.

Fingerprint recognition is the most popular and mature biometric system used today. In addition to meeting the criteria for a good biometric system, fingerprint recognition systems perform well (that is, they are accurate, fast, and robust), they are publicly acceptable and they are hard to circumvent [1]. Among biometric traits, fingerprint is widely accepted by people because of its uniqueness and immutability [2].

Fingerprint verification is a very convenient and reliable way to verify the person's identity. It is believed that no two people have identical fingerprint in this world, so, the fingerprint verification and identification is the most popular way to verify the authenticity or identity of a person. Out of all the variety of the biometric technologies for the information security solutions the best appropriate seems to be the use of the systems based on fingerprints scanning and recognition. This method, in comparison with others is cheaper, more convenient in day to day use, and is known to have very low false acceptance rate [3].

In order to rectify these systematic failings in the traditional methods of taking attendance, this work seeks to shift paradigm from these referred methods by formulating and implementing a

simplified and cost effective model of fingerprint-based method for managing time and attendance of students. It has been proved over the years that fingerprints of each and every person are unique [4]. So it helps to uniquely identify the students. Before entering classrooms, student identities are verified through electronic fingerprint scanners that will read student fingerprint and send the data to a PC. The PC, in turn, sends data in form of student information and attendance record (course, time etc.) to the server immediately. This means no class time will be wasted.

1.1 Literature Review

A number of related works exist in literature on application of different information technology tools to student attendance management problem.

[5] proposed a system of automated attendance monitoring using Identity Card and Barcode Scanners. The authors tried to solve the problem of manual computation of attendance records by providing a system that uses barcode readers to scan Student ID embedded as barcodes on plastic ID cards. The proposed system minimizes the stress involved in manual computation of attendance and the system is easy to deploy and operate but the system does not eliminate the risk of impersonation. Students can circumvent the system simply by giving their ID card to their friends to help record attendance. Also, extra cost is incurred in the long run as the plastic ID cards would have to be replaced periodically as the barcode imprint fades off over time. The card reader used was also known to have a very high failure rate, thereby reducing the effectiveness of the developed solution.

[6] proposed a mobile system for maintaining time and attendance in schools. The author seeks to ensure effective monitoring of student attendance records by making such records available via the mobile phone. A system based on WAP (Wireless Access Protocol) was developed for monitoring student attendance. While the developed system enjoyed the portability of the mobile phone, and was noted to provide ease of navigation between modules and provision for feedback, thereby making the end-user great. The developed solution still depend on the instructor (lecturer) to mark the attendance of each student from his/her mobile phone. Use of this system is therefore time consuming and stressful to the instructors.

According to [7], technology methods developed to solve the problem of identity management includes; Possession of physical authorization (such as keycards), Possession of knowledge (password, PIN etc.), and Biometrics. While possession of physical authorization and knowledge rely on the assumption that the authorized person is present, biometrics is based on confirming the identity of an individual beyond reasonable doubt.

"RFID-based Systematic Student Attendance Management System" proposed by [8], tracks students using Radio Frequency Identification System (RFID). The proposed system embedded integrated Radio Frequency circuits in Student Identity Cards for the purpose of automated tracking. The system developed also provides real time access to attendance reports via the internet. The use of embedded chips on identity card ensures that each student is authenticated and marked for attendance securely and genuinely. The system is therefore not suitable for implementation in remote areas where there is limited access to internet. Also, the cost of internet service is high, thus increasing the cost of implementation. Radio Frequency interference can also considerably affect the accuracy of attendance record saved by the developed solution.

[9] proposed the use of electronic fingerprint scanner to solve student attendance monitoring problem of Bells University of Technology, Ota, Nigeria. The proposed solution ensures that only valid students are allowed access into lecture venues by capturing student fingerprint and comparing it with a database of stored fingerprint templates. The system ensured that only students registered for a particular course are allowed access into lecture venues. The system failed to cater for the recording of student attendance and thus could not provide a means of authenticating students for examination based on lecture attendance. Also, the application software of the proposed system lacks report generation and audit trail system and is thus as good as manually operated attendance management system.

[10], proposed a solution to lecture attendance problem through coordinated hardware and software design synergy that exists between an improvised electronic card and the card reader serially interfaced to a digital computer system. The electronic card proposed is a model of Smart Card containing the student identity (Name, Matriculation Number, and five PIN encrypted code). The student is granted/denied specific lecture attendance based on the result of authentication by the card reader which performs comparison using the backend software running on the PC to which the card reader is interfaced. The system eliminates the stress of manually computing student attendance records by providing a printable report of student attendance in form of percentage attendance but authentication into the examination venues still need to be done manually by the examination officials or supervisor.

In view of the limitations observed in the use of identification methods based on possession of authorization or knowledge, there is need to develop an automated system for managing time and attendance. Fingerprint technology is therefore a veritable tool that can be explored in this respect.

The model developed in this work seeks to eliminate the challenges faced in the implementation attendance management system. The model is a simplified and cost effective model of fingerprint-based automated attendance system that monitors student attendance and uses student fingerprint attendance records for automated authentication into examination venues based on attendance criteria set by the lecturer. The proposed system also provides solution for keeping track of lecturer's attendance in lectures. The proposed system does not only speed up the process of taking attendance but reduces error and allows for faster verification of student attendance, all with minimal human interaction.

2 Methodology

2.1 Architecture of eduTAMS

Educational Time and Attendance Management System (eduTAMS) is a fingerprint-based comprehensive attendance management system for universities and colleges. It provides robust, secure and automatic attendance management system for Students. The system employs the use of electronic fingerprint scanner interfaced to the digital computer system for verifying student identity.

The student Identity is authenticated by the fingerprint-based biometric system which compares the captured fingerprint image with fingerprint templates stored in a database. The student is granted or denied specific lecture attendance based on the result of the comparison by the backend software system running on the PC to which the fingerprint scanner is interfaced as shown in Fig. 1.

The main purpose of this system is to take attendance of the students for lectures, calculate the attendance rate of each student and use this record with specified percentage requirement to perform authentication for access into examination venues. The technologies used for this purpose are electronic fingerprint scanners and computers (notebook or desktop) as workstations, a desktop computer as a server, a database management system and network connection for workstation/server interconnectivity.

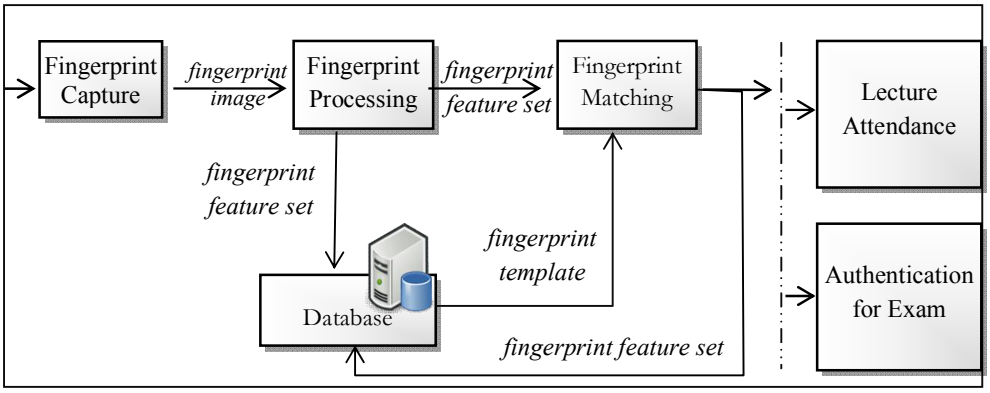

Fig. 1. Architecture of eduTAMS

Fingerprint Capture: This module interfaces with the fingerprint scanner to capture the fingerprint of the individual to be enrolled or authenticated.

Fingerprint Processing: This module accepts the fingerprint image taken by the sensor and extracts the unique features of the fingerprint (minutiae points) to be used for matching with features saved for the templates in the database.

Fingerprint Matching: This module compares the features extracted from the taken fingerprint sample with features of fingerprint templates stored in the database. This is done by performing comparison on a one-to-one basis.

Database: The database stores student fingerprint templates as well as fingerprint history. It also provides data storage for daily lecture attendance records.

2.1.1 Deployment structure of eduTAMS

Fig. 2 shows the deployed structure of eduTAMS. The System consists of four major segments; Fingerprint Terminals, Database Server, Access Workstations and Network Service.

Fingerprint Terminals: Consist of electronic fingerprint scanners interfaced to a computer system running the developed application software. These terminals are placed at the entrance of each lecture/examination venue to verify student identity and use the result of verification (plus attendance requirement verification in case of examination) to grant/deny access.

Database Server: Stores the bio-data of every student and lecturer, and also maintains their fingerprint templates. The database also stores the record of student attendance, as well as fingerprint sample history.

Access Workstations: Are PCs running a version of the application software but with reduced functionalities just for the purpose of reporting. Access workstations would be located in offices of HODs, Deans etc.

Network Service: This segment of the system ensures interconnection between the different fingerprint terminals and the database server. It comprises of resources meant to ensure network connectivity for the different terminals such as switches, routers, etc.

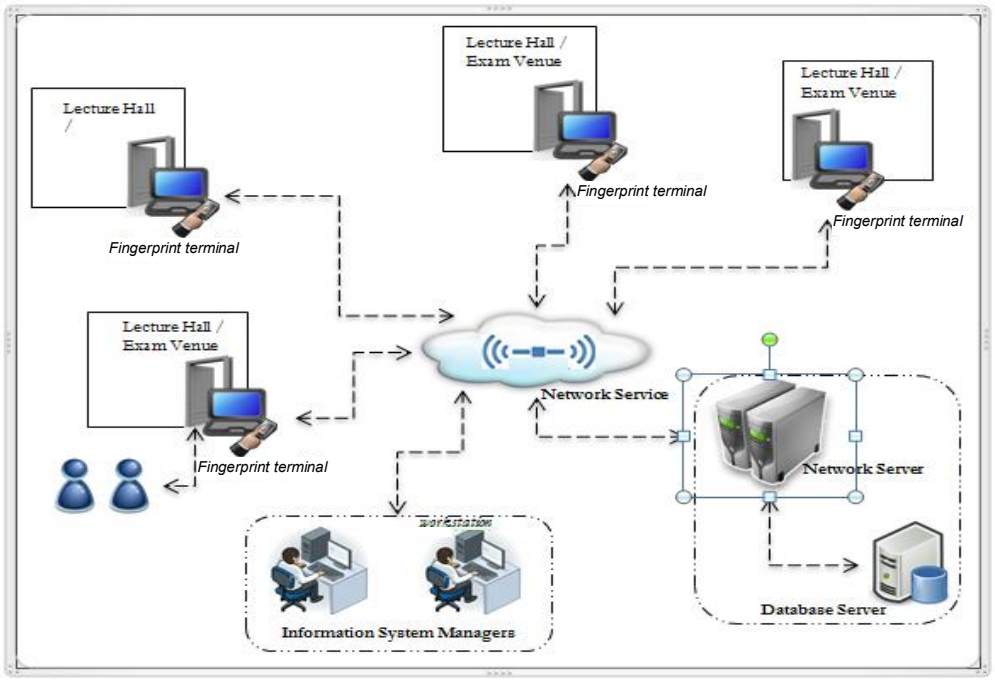

Fig. 2. Deployment structure of eduTAMS

2.1.2 System flow structure

Figs. 3 and 4 shows the flowcharts representing how the modules are linked to perform different operations of the developed system.

3. Results

3.1 Implementation of eduTAM

eduTAM was implemented with C# and Microsoft SQL Server 2008. Fig. 5 shows the attendance register for a specific course. This interface enables student's to mark attendance register using their fingerprint before entry into the lecture and/or examination venue.

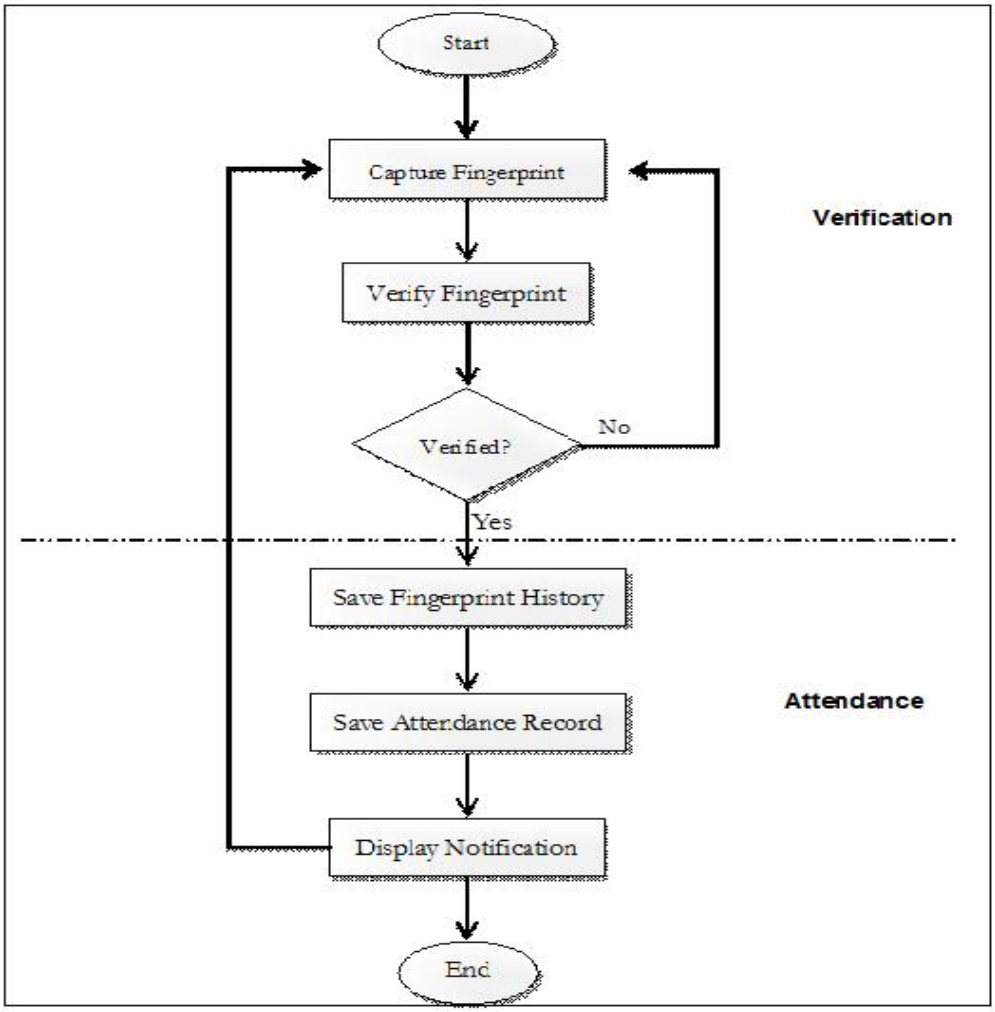

Fig. 3. Flowchart of lecture attendance process

Fig. 6 shows the summary of each student's attendance for a specific course in an academic session.

3.2 Testing and Evaluation

The model is evaluated using the fingerprint attendance capture after the lecture and before the examination period and a series of experiments were performed focusing on the effectiveness and its usability.

The system was evaluated using usability testing. The usability testing technique is a technique for ensuring that the intended users of the system can carry out the intended task efficiently,

effectively and satisfactorily. The following tests were carried out to evaluate the developed solution;

- Test of Biometric Efficiency
- Speed of Identification and Authentication
- Test of General Requirement

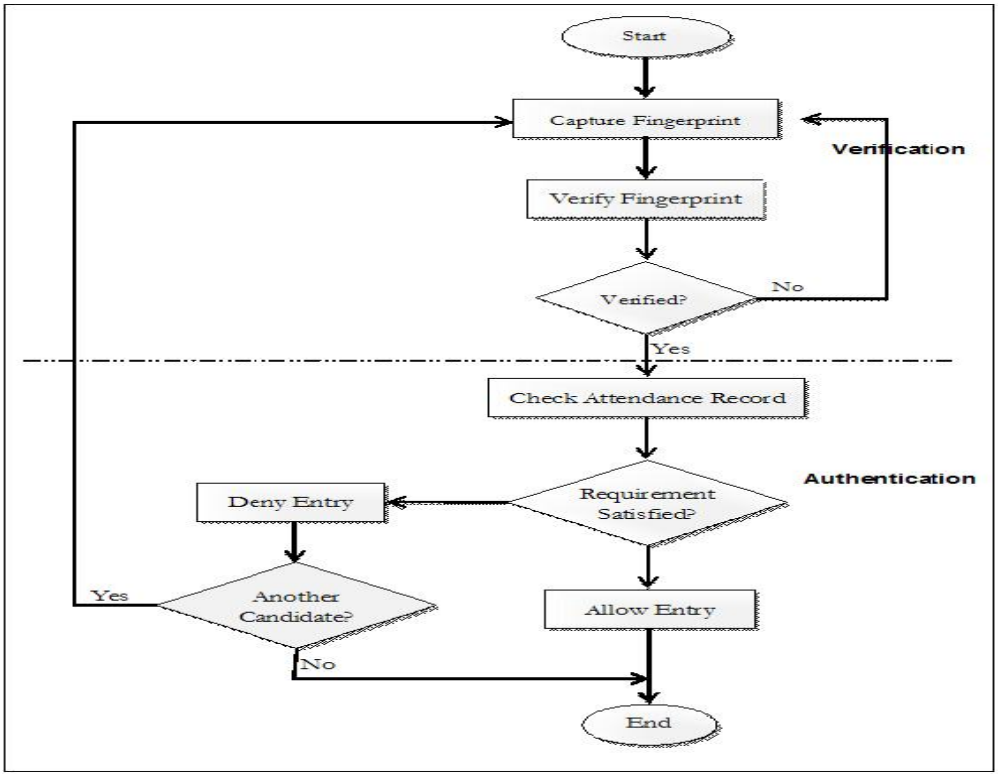

Fig. 4. Flowchart of exam authentication process

3.2.1 Test of biometric efficiency

False Accept Rate (FAR) and False Reject Rate (FRR) are the error rates which are used to express matching trustability. The parameters used to measure these error rates include;

False Accept: A situation, in which the wrong fingerprint is accepted as valid for an individual during verified.

False Reject: A situation in which the system fails to match the valid fingerprint of an individual.

True Accept: Is said to occur when a fingerprint matches with the fingerprint of same individual.

True Reject: Is said to occur when the system rejects a wrong fingerprint in the process of verifying an individual.

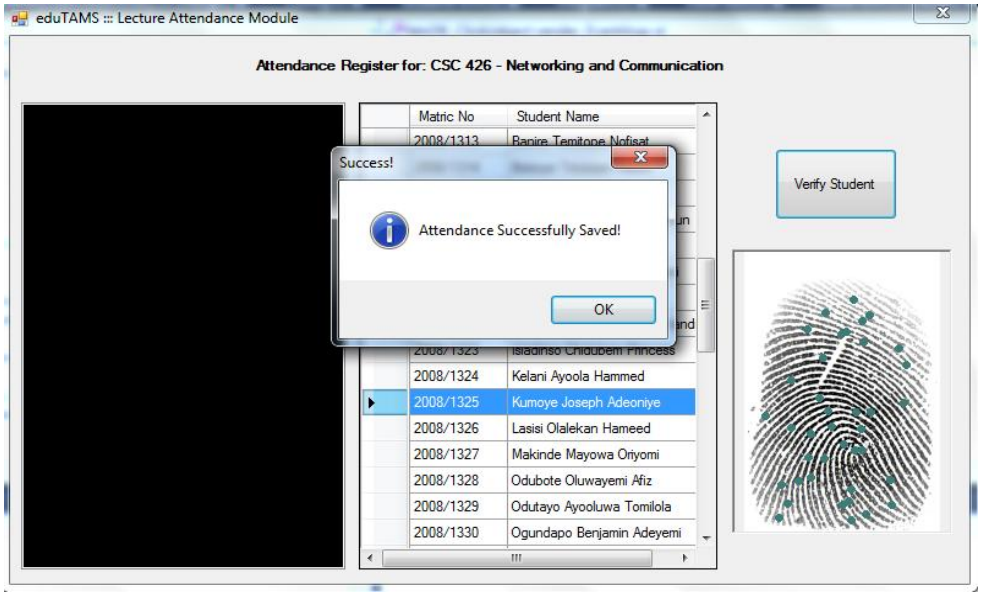

Fig. 5. Lecture attendance interface

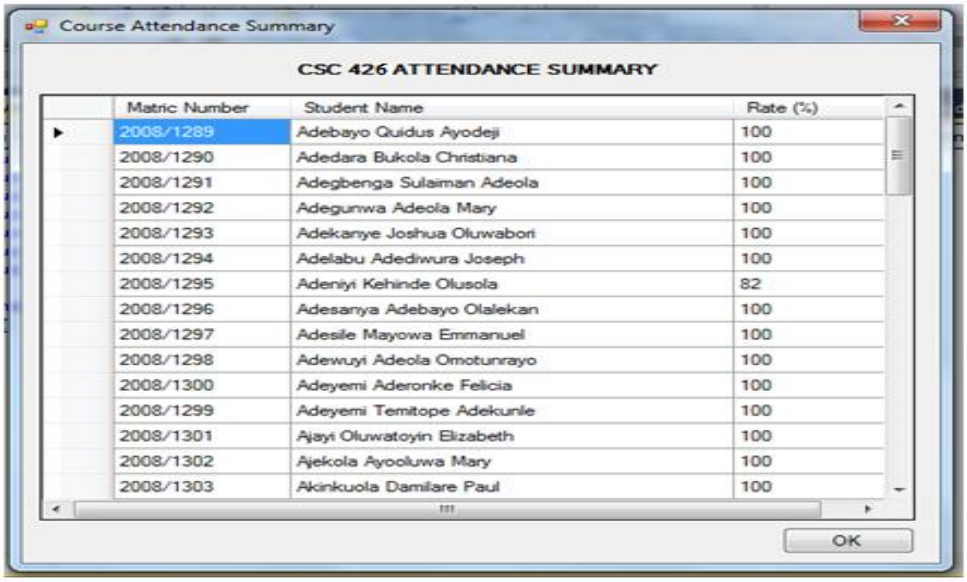

Fig. 6. Course attendance summary

FAR and FRR are defined by the formulae:

$$FAR = \frac{FA}{N} * 100,$$
$$FRR = \frac{FR}{N} * 100$$

where FA = Number of False Accepts,
FR = Number of False Rejects,
N = Number of Verifications

The Table 1 below shows record of verifications performed during lecture attendance.

Table 1. False accept and false reject in fingerprint verification

Date	No. of students	False accepts	False rejects	True accepts	True rejects	FAR	FRR
19-Apr-2012	48	0	0	48	7	0.00 %	0.00 %
26-Apr-2012	54	0	0	54	4	0.00 %	0.00 %
07-May-2012	52	0	0	52	1	0.00 %	0.00 %
14-May-2012	49	0	0	49	0	0.00 %	0.00 %
04-Jun-2012	55	0	0	55	1	0.00 %	0.00 %
07-Jun-2012	49	0	0	49	2	0.00 %	0.00 %
17-Jul-2012	46	0	0	46	1	0.00 %	0.00 %

From Table 1 above, we can deduce that the developed solution has the following error rate as a measure of efficiency / effectiveness;

False Accept Rate (FAR) = 0.00%,
False Reject Rate (FRR) = 0.00%.

Also, it can be observed that students' attempt at circumventing the system was foiled as shown in the records of True Rejects.

3.2.2 Speed of identification and authentication

This test was used to measure the average time it takes to record student attendance and also to authenticate student entrance into examination venue in comparison with manual system. This is shown in Table 2.

Table 2. Comparing lecture attendance using manual and automated system

Sample	No. of students	Manual attendance		Fingerprint-based attendance	
		Total time	Average time	Total time	Average time
1	48	18 minutes	22.50 seconds	5 minutes 41 seconds	7.11 seconds
2	52	19 minutes	21.92 seconds	6 minutes 5 seconds	7.01 seconds
3	58	24 minutes	24.83 seconds	6 minutes	6.22 seconds
4	55	23 minutes	25.09 seconds	5 minutes 50 seconds	6.40 seconds

From Table 2 above, we can deduce the following;

Average Time taken per student using manual attendance register: **23.66 seconds**
Average Time taken per student using Fingerprint based Attendance: **6.65 seconds.**

A histogram showing the comparison between the average time taken per student in recording attendance using the manual method and eduTAMS is shown in Fig. 7.

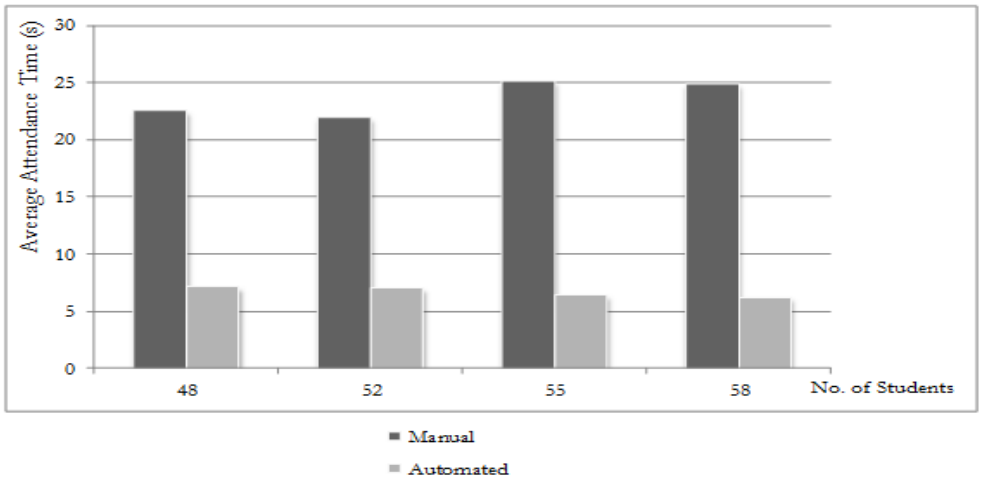

Fig. 7. Histogram comparing attendance time between manual method & eduTAMS

Also, authenticating student access into examination venue takes about 5 seconds compared to about 25 seconds when using manual checking of examination pass.

3.2.3 Test of general requirements

The software developed was also tested and evaluated based on the following criteria;

- Ease of Enrollment
- Adherence to Attendance Rules for Examination eligibility
- Ease of viewing attendance records of students

The software was found to satisfy the above criteria given the following observations;

- The developed system also ensures that only students who meet the required attendance score are allowed access into the examination venue.
- Student and course attendance report are available at the click of a button

Given the above observation, it can be concluded that the developed system effectively addresses the needs of the academic environment with regards to student attendance.

4 Conclusion

Managing attendance is a very important record-keeping activity in any organization. The lapses recorded in traditional methods of recording and managing attendance has therefore necessitated the development of an automated system (eduTAMS) for this task. To ensure the integrity of such records, biometrics is a tool that cannot be neglected. Fingerprint authentication has thus been tested and proven as a veritable tool in achieving the much needed automation. The result shows that the average time taken per student using eduTAM and manual attendance register are 6.65 and 23.66 seconds respectively.

The major strength of the developed system lies in its high scalability and flexibility. By careful examination, it can be inferred that eduTAMS could not only speed up the process of taking attendance but reduce the error rate and produce faster verification process of authenticating student lecture attendance policy required for writing examination in a campus environment. This work has presents a simplified, low cost fingerprint based system solution to the management of lecture attendance.

In future, it might also be necessary to investigate student attendance monitoring through hybridized biometric features like face and iris for better performance.

Competing Interests

Author has declared that no competing interests exist.

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