Fingerprint-Based Attendance Management System

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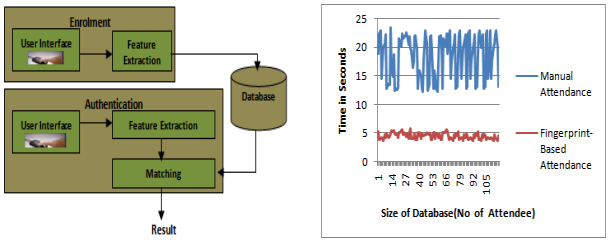
Abstract

In recent time, there has been high level of impersonation experienced on a daily basis in both private and public sectors, the ghost worker syndrome which has become a menace across all tiers of government, employers concerns over the levels of employee absence in their workforce and the difficulty in managing student attendance during lecture periods. Fingerprints are a form of biometric identification which is unique and does not change in one's entire lifetime. This paper presents the attendance management system using fingerprint technology in a university environment. It consists of two processes namely; enrolment and authentication. During enrolment, the fingerprint of the user is captured and its unique features extracted and stored in a database along with the users identity as a template for the subject. The unique features called minutiae points were extracted using the Crossing Number (CN) method which extracts the ridge endings and bifurcations from the skeleton image by examining the local neighborhoods of each ridge pixel using a 3 x 3 window. During authentication, the fingerprint of the user is captured again and the extracted features compared with the template in the database to determine a match before attendance is made. The fingerprint-based attendance management system was implemented with Microsoft's C# on the. NET framework and Microsoft's Structured Query Language (SQL) Server 2005 as the backend. The experimental result shows that the developed system is highly efficient in the verification of users fingerprint with an accuracy level of 97.4%. The average execution time for the developed system was 4.29 seconds as against 18.48 seconds for the existing system. Moreover, the result shows a well secured and reliable system capable of preventing impersonation.

At a glance: Figures



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1. Introduction

It is expected today that an individual who wants to authenticate himself for a service must ha password for example identity card, ATM card, driving license, health card and so on. Carrying d remembering passwords for different services is a significant issue for individuals and organizati effective identity management system plays an important role in the successful deployment management system. To make the identity management system more secure and reliable f biometrics data are integrated in the attendance management systems [1].

Biometrics technologies verify identity through characteristics such as fingerprints, faces, irises palm prints, voice, hand-written signatures, and so on. These techniques, which use physical d attention as a personal authentication method that is more convenient than conventional m password or ID cards because it uses data taken from measurements and such data is unique and remains so throughout one's lifetime [2].

In these technologies, fingerprint becomes the most mature and popular biometrics technology personal identification. The reason for the popularity of fingerprint verification is that fi uniqueness, stability, permanency and easily taking [3].

In this paper, an attempt was made to look at the prevalence in the high level of impersonation daily basis in both private and public sectors, the ghost worker syndrome which has become a tiers of government, employers concerns over the levels of absence in their workforce and diffi student attendance during lecture periods. Sequel to this, a fingerprint-based Attendance Mar was developed to provide a faster, more secure, and more convenient method of user verificatio and tokens can provide for a reliable personal identification.

2. Attendance Management

Attendance management is the act of managing attendance or presence in a work setting to mi employee downtime. Attendance control has traditionally been approached using time clocks an attendance management goes beyond this to provide a working environment which maximiz employee attendance [4].

Attendance management is a major part of today's human resource systems; take organizati human resource practice, systems and excellence, hence regular attendance and punctuality a employees or candidates in a work setting. Unsatisfactory attendance caused by unschedul tardiness cause a disruption in work, affects productivity, and creates morale problems wh shifted to other employees [5].

Moreover, in many institutions, and academic organizations, attendance is also a very importar used for various purposes. These purposes include record keeping, assessment of students,

present method of taking attendance presents. This traditional method involves the use of si
books in taking student attendance. This method could easily allow for impersonation and the
could be stolen or lost. Taking of attendance is time consuming and it is difficult to ascerta
students that have made the minimum percentage and thus eligible for exam. Thus, there is a r
that would eliminate all of these trouble spots.

2.1. Types of Attendance Management System

Attendance Management falls into two categories namely; Conventional and Automated methods

Conventional methods include time sheet, attendance register and time clock. Time sheets
electronic or otherwise that record what time was spent by the employee on what tasks. Attenda
official list of people who are present at an institution or organisation. Time clock which is
electronic) time piece used to assist in tracking the hour worked by an employee of a company.

Automated methods include Barcode system attendance system, magnetic stripe attendanc
Frequency Identification (RFID) and the biometric attendance system [6].

The barcode attendance system requires that every employee is issued a badge/card in which tl
In order to check into or out of the company, the badge/card is swapped on the time clock
captured by the clock. In the magnetic stripe attendance system, data is encoded in the magı
employee card. When the card, is swiped through the employee time clock, the information in th
stripe is recorded by the time clock. This system reads one card at a time and also requires
reader. Radio-frequency identification (RFID) is a technology that uses radio waves to trans
electronic tag, called RFID tag or label, attached to an object, through a reader for the purpose
tracking the object. The ID cards of the employees is embedded with RFID tag which is read
RFID system is interfaced to a database through a computer. Each employee uses an RFID ca
records the data when the employee enters or exits. In biometric Attendance system, the
software that is paired with a time clock for employees which uses biometric technology f
purposes. When these systems are in use, the employees can use their biometric data such a
clocking in and clocking out. This method has the great benefit that the entire process is easy
Other advantages include elimination of the cost previously incurred in getting the employees ca

3. Related Works

[7] proposed an embedded computer-based lecture attendance management system whe
computer based subsystems (an improvised electronic card and the card reader) were interfac
serial port of the digital computer. The electronic card is a model of a smart card containing th
(ID-Name, Matriculation Number and five pin encrypted code). The student ID is authenticated b
which compares the entrance code with the encrypted code on the card swiped through the
student is granted and/or denies specific lecture attendance based on the result of the cc
backend software system running on the PC to which the card reader is serially interfaced. Th
provided a simplified, low cost embedded computer based system solution to the manag
attendance problem in developing countries but does not eliminate the risk of impersonatio
devise-based in which students have to carry RFID cards and also the RFID detectors are needec

[8] proposed a real time computer vision algorithms in automatic attendance managemer
Computer vision and face recognition algorithms and integrating both into the proces
management. The system eliminates classical student identification such as calling student na
respective identification cards, but still lacks the ability to identify each student present in class
a lower recognition rate because facial images are subject to change between the time of enrol
verification and also poses a bigger financial burden during installation and does not offer any pr

In [2], a wireless attendance management system based on iris recognition was proposed
algorithm. The system uses an off-line iris recognition management system that can finisl
including capturing the image of iris recognition, extracting minutiae, storing and matching but i
the transmission lines where topography is bad.

This proposed system introduces a new automatic attendance management system, which inte authentication into the process of attendance management for both staff and student. It is processes namely; enrolment and authentication.

During enrolment, the biometrics of the user is captured and the minutiae data are extracte database as a template for the subject along with the user's ID. The objective of the enrolm admit a user using his/her ID and fingerprints into a database after feature extraction. These template that is used to determine the identity of the user, formulating the process of au enrolment process is carried out by an administrator of the attendance management authentication, the biometrics of the user is captured again and the extracted features are c ones already existing in the database to determine a match. After a successful match, atter against the user's id used in matching the templates.

The work utilized a fingerprint reader as the input to acquire images, developed program th recognition and identification system as well as database to store user's information. The databa fingerprint templates and other bio-data of the users together with the attendance records ma Figure 1 shows the architecture of the proposed attendance management system.

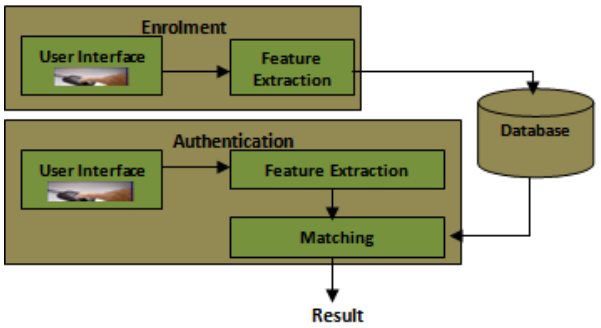

Figure 1. Architecture of the proposed fingerprint-based attendance management system

5. System Architecture

The design of the fingerprint-based attendance management system is made up of the following

i. Enrolment module

ii. Authentication Module

iii. System database.

5.1. Enrolment Module

The task of enrollment module is to enroll users and their fingerprints into the system enrolment, the fingerprint and other bio-data of the user is captured and the unique features a the fingerprint image and stored in a database as a template for the subject along with the u data to be captured includes: employee number, surname, other names, sex, position, staff typ email, department and passport photograph. Student bio data includes: matriculation number, names, sex, department, level, studentship, phone number and passport photograph. To improv captured image during enrolment/registration, two image samples per fingerprint used are cap degree of accuracy.

When the fingerprint images and the user name of a person to be enrolled are fed to the enro minutiae extraction algorithm is first applied to the fingerprint images and the minutiae patte

management system. The enrolment and registration phase is an administrative phase. The u
well as other bio-data is stored for the first time into the database for registration. The courses
lecturers and exams are also registered at this phase. All data and information required for the
of attendance are enrolled in this module.

The most commonly employed method of minutiae extraction is the Crossing Number (CN) [9
research is based. It involves the use of the skeleton image where the ridge flow pattern is eigh
minutiae are extracted by scanning the local neighbourhood of each ridge pixel in the imag
window. The CN value is then computed, which is defined as half the sum of the differences
adjacent pixels in the eight-connectivity neighbourhood. The CN for a ridge pixel P is given by

$$CN = 0.5\sum_{i-1}^{8}\left|P_i - P_{i+1}\right| \quad P_9 = P_1$$

where P_i is the pixel value in the neighbourhood of P.

5.2. Authentication Module

The task of the authentication module is to validate the identity of the person who intends to a
The person to be authenticated indicates his/her identity and places his/her finger on the fingerp
fingerprint images captured is enhanced and thinned at the image processing stage, and at t
stage, the biometric template is extracted. It is then fed to a matching algorithm, which matc
person's biometric template stored in the system database to establish the identity. During a
staff attendance, a staff supply his/her department and name, then places his/her finger ov
reader, the fingerprint recognition unit compares the fingerprint features with those stored in th
a successful match, the staff's employee number is sent to the database alongside the time o
attendance and update the status (either present/absent) of user's attendance for the day. S
captured twice a day for both arrival and departure time.

For student attendance, the lecturer (or a designated personnel as the case may be) selects his
level, course code, attendance type (for example lecture, practicals etc) and the attendance ID,
places his/her fingerprint on the fingerprint reader; the fingerprint recognition unit compare
features with those stored in the database, after a successful match, the student's matriculatio
to the database alongside the time of making such attendance and update the status (either p
student's attendance for the class. Student attendance is captured only once for each attendance

Fingerprint matching approaches includes minutiae-based matching, ridge-based matching ar
matching approaches. However, it is believed that minutiae-based matching approach, upon w
based facilitates the design of a robust, simple, and fast verification algorithm while maintaining
size. Minutiae-based representation is commonly used, primarily because forensic examiners
relied on minutiae to match fingerprints for more than a century, minutiae-based represer
efficient, and expert testimony about suspect identity based on mated minutiae is admissible in c

Most common minutiae matching algorithms consider each minutiae as a triplet m = {x, y, θ}
(x, y) minutiae location coordinates and the minutiae angle θ [11]. Extracted minutiae from t
together forming a point pattern in plane. Therefore matching two minutiae point patterns wi
considered as a 2D point pattern problem. The point patterns are constructed only on positions
in the plane. Since point patterns are based on positions of minutiae in fingerprint they form dis
With enough points in each pattern the positions (x, y) of the minutiae are the only information
good matching results.

Let T and I be the representation of the template and input fingerprint, respectively. Let the mi
template be given as:

$$T = \{m_1, m_2, \ldots m_m\} \quad m_i = \{x_i, y_i, \theta_i\} \quad i = 1 \ldots m$$

and the minutiae sets of the input fingerprint be given as:

are within specified thresholds r_o and θ_o. For efficient matching process, the extracted data is st

format [12] as follows.

Number of rows: Number of minutiae points.

Number of columns: 4

Column 1: Row index of each minutiae point.

Column 2: Column index of each minutiae point.

Column 3: Orientation angle of each minutiae point.

Column 4: Type of minutiae. (A value of '1' is assigned for termination, and '3' is assigned for bi

During the matching process, each input minutiae point is compared with template minutiae po template and input minutiae are selected as reference points for their respective data sets. The are used to convert the remaining data points to polar coordinates. The Equation 4 is use template minutiae from row and column indices to polar coordinates.

$$\begin{pmatrix} \gamma_k^T \\ \phi_k^T \\ \theta_k^T \end{pmatrix} = \begin{pmatrix} \sqrt{\left(row_k^T - row_{ref}^T\right)^2 + \left(col_k^T - col_{ref}^T\right)^2} \\ \tan^{-1}\left(\dfrac{row_k^T - row_{ref}^T}{col_k^T - col_{ref}^T}\right) \\ \theta_k^T - \theta_{ref}^T \end{pmatrix}$$

Where for a template image,

r_k^T= radial distance of kth minutiae.

ϕ_m^I= radial angle of kth minutiae.

θ_k^T = orientation angle of kth minutiae.

row_{ref}^T, col_{ref}^T = row index and column index of reference points currently being considered represents row index and the column index of the kth minutiae. Similarly the input matri converted to polar coordinates using the Equation 5.

$$\begin{pmatrix} \gamma_m^I \\ \phi_m^I \\ \theta_m^I \end{pmatrix} = \begin{pmatrix} \sqrt{\left(row_m^I - row_{ref}^I\right)^2 + \left(col_m^I - col_{ref}^I\right)^2} \\ \tan^{-1}\left(\dfrac{row_m^I - row_{ref}^I}{col_m^I - col_{ref}^T}\right) + rotatevalues(k,m) \\ \theta_k^T - \theta_{ref}^T \end{pmatrix}$$

Where for an input image,

r_m^I= radial distance of mth minutiae.

ϕ_m^I= radial angle of mth minutiae.

θ_m^I = orientation angle of mth minutiae.

the column index of the m[th] minutiae. T_k and I_m represent the extracted data in all the columns m in the template and input matrices, respectively.

5.3. The Database

The attendance management system database consists of tables that stores records, each of w to an authorized person that has access to the system. Each record may contain the minutiae person's fingerprint and user name of the person or other information such as pin no as an inde The database design for the system implements relational data model which is a collections c data are stored. The database was implemented in Microsoft SQLServer database (Sql Server, is fast and easy, it can store a very large record and requires little configuration.

6. System Performance and Evaluation

Given a fingerprint matcher, one would like to assess its accuracy and speed performance in a Unlike passwords and cryptographic keys, biometric templates have high uncertainty. Ther variation between biometric samples of the same user taken at different instances of time. There always done probabilistically. This is in contrast to exact match required by password a approaches. The inexact matching leads to two forms of errors namely: False (impostor) Accep and the False (genuine individual) Rejection Rate(FRR). The FAR/FRR ratios depend, among oth type of difficulty of the algorithms used in the fingerprint extraction. Usually, algorithms w complexity lead to acceptable low FRR/FAR [13].

False Accept: An impostor may sometime be accepted as a genuine user, if the similarity with within the intra-user variation of the genuine user. The FAR normally states, either in a percent the probability of someone else matching as you. FAR is defined by the formula:

$$FAR = \frac{FA}{N} * 100$$

Where FA is the number of false accept and N is the total number of verification.

False Reject: When the acquired biometric signal is of poor quality, even a genuine user may b authentication. This form of error is labelled as a 'false reject'. If you fail to match against yo then you have been falsely rejected. The probability of this happening is referred to as the false FRR. Thus, the higher the probability of false rejection, the greater the likelihood you will be defined by the formula:

$$FRR = \frac{FR}{N} * 100$$

Where FR is the number of false reject and N is the total number of verification.

The system may also have other less frequent form of error such as:

- **Failure to enroll(FTE)** It is estimated that nearly 4% of the population have illegible consists of senior population, laborers who use their hands a lot and injured individuals. Due structure present in such individuals, such users cannot be enrolled into the database and the subsequently authenticated. The FTE normally states, either in a percentage or a fraction, someone failing to enroll in a system.

$$FTE = \frac{FE}{N} * 100$$

Where FE is the total number of Failure Enrol and N is the total number of verification.

For performance analysis, the application developed was tested using the bio-data and fingerpri One hundred and seventeen (117) users out of which 30 were staff and 87 were students of t computer science, the Federal University of Technology, Akure, Nigeria using a live-scan metho were taken from any of the ten fingers of a respective member of the group in which e

for interest in the use of students and staff of the above mentioned department and school re accessibility and their readiness to provide their biometric data for research purposes.

The minutiae data were extracted from the fingerprint images and stored in a database as a subject along with the user's ID. During authentication, the biometric of the user is captured a data are also extracted forming the test template which is matched against the already store database. In each case, if the matching score is less than the threshold, the person is reject person is accepted. Using equation 6-8, Table 1 gives the respective values for the false Acce and False Rejection Rate (FRR) and for the test that was carried out.

In the test, the false acceptance rate was zero meaning that there were no cases of false accep person that was not pre-registered was not falsely enrolled for attendance. There were a fe (FRR) during the test in which the system failed to identify some pre-registered users. These c to improper placement of the finger on the scanner and fingers that have been slightly scarred d

Table 1. Values of the FAR and FRR from the Test

FAR	FRR
0.0%	2.56%

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The above values of FAR and FRR implies an accuracy of 97.4% considering the genuine accep 2a and 2b show the details.

Table 2a. Details of the evaluation

	Successful Verification	Unsuccessful Verification
Staff	30	0
Student	84	3
Total	114	3

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Table 2b. Details of the evaluation

No of Attendee	Successful Verification	Unsuccessful Verification	Accuracy
117	114	3	97.4%

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Type of system	No of attendee	Total time in seconds	Total time in minutes	Execution Time in seconds
Fingerprint-Based Attendance System	117	502.41	8.37	4.29
Manual Attendance System	117	2161.55	36.02	18.48

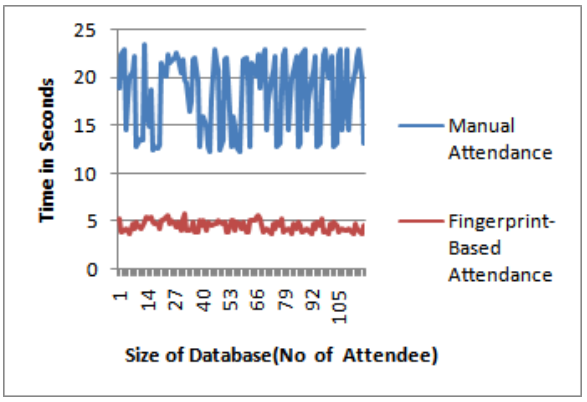

Figure 2. Comparison of the Manual Attendance System with the Fingerprint-based Attendar Management System.

The developed fingerprint-based attendance management system was compared with the attendance system (use of paper sheet/attendance register) and the time of taking both recorded. The manual attendance system average execution time for one hundred and attendees is approximately 18.48 seconds as against 4.29 seconds for the fingerprint-b management. Table 3 shows the time taken for verification. Figure 2 shows the comparison of th with the Fingerprint-based Attendance Management System.

7. Conclusion

In this paper, we have presented a fingerprint-based attendance management system. The de an embedded system that is part of a fingerprint recognition/authentication system based on The system extract the local characteristic of a fingerprint which is minutiae points in template are matched during both registration and verification processes. For improved quality co registration or verification process, a matching score was used to determine the success of th matching score was specified so that only sets of minutiae data that exceed the score will be a below the score will be rejected. Therefore, Fingerprint Recognition using Minutia Score Matc used for matching the minutia points before attendance is recorded.

The developed system is very helpful in saving valuable time of students and lecturers, pape report at required time. The system can record the clock in and clock out time of students and convenient manner using their fingerprint to prevent impersonation and reduce level of absence

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