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Development of Staff Attendance Management System using Fingerprint Biometric Identification Technique

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ABSTRACT

Attendance management is the act of managing attendance or presence in a work setting. Considering an academic institute, the conventional method of taking staff attendance is by signing on paper is very time consuming and insecure, hence inefficient. Maintaining these records for a long time adds to the difficulty of the task.

In lieu of this, an efficient system is proposed to solve the problem of manual attendance. In this research work, staff attendance is taken electronically with the help of a fingerprint Biometric system, and all the records are saved for subsequent operations. Fingerprints are considered to be the best and fastest method for biometric identification because they are secure to use, unique for every person and do not change in one's lifetime.

Staff attendance management system using fingerprint biometric identification technique employs an automated system to calculate staff attendance in lecture rooms in an institution and do further calculations of daily and monthly attendance summary in order to reduce human errors during calculations. In essence, this system can be employed in curbing the problems of tardiness or lateness of lecturers to lecture rooms, impersonation and missing lecture periods in any institution. The system will also improve the productivity of any institution if properly implemented.

Keywords: Biometric, Attendance Management System, Fingerprints, Software, Database, Authentication, Microsoft SQL server, .Net Framework.

List of Abbreviations: ACU: Ajayi Crowther University
FBI: Federal Bureau of Investigation
NBS: National Bureau of Standards
NIST: National Institute of Standards and Technology
AFIS: Automated Fingerprint Identification Systems
UML: Unified Modeling Language
CLR: Common language runtime
WAMP: Windows, Apache, MySQL, and PHP
AMS: Attendance Management System
FCL: Framework Class Library
XML: Extensible Mark-Up Language

INTRODUCTION

Attendance management is the act of managing attendance or presence in a work setting to minimize loss due to employee downtime. Attendance control has traditionally been approached using time clocks and timesheets, but attendance management goes beyond this to provide a working environment which maximizes and motivates employee attendance (Md. Shakil and RabindraNath Nandi, 2013). Attendance Management System (AMS) is the easiest way to keep track of attendance for organizations such as industrial organization, business organizations and volunteer groups. AMS is useful in terms of manpower analysis, day-to-day monitoring of attendance, maintaining statutory registers, leave records, calculation of overtime and transferring information to the payroll system.

The existing conventional staff attendance system requires the lecturers to manually sign the attendance sheet every time they attend a class. As common as it seems, such system lacks automation, where a number of problems may arise. These problems include the time unnecessarily consumed by the lecturer to find and sign their

name on the attendance sheet and the fact that the attendance sheet may get misplaced. As for system development and implementation, it should be able to help the institution to manage their staff attendance systematically. The system must have a database that contains lecturer's information and it must be able to help the admin to manipulate data, update database, alert lecturers accordingly, and also a good user interface to make it easier to use.

It is expected today that an individual who wants to authenticate himself for a service must have a token and/or password for example identity card, ATM card, driving license, health card and so on. Carrying different cards and remembering passwords for different services is a significant issue for individuals and organizations. A secure and effective identity management system plays an important role in the successful deployment of an attendance management system. To make the identity management system more secure and reliable for authentication, biometrics data are integrated in the attendance management systems. The move towards the digital era is being accelerated every hour. Biometrics technologies verify identity through characteristics such as fingerprints, faces, irises, retinal patterns, palm prints, voice, and hand-written signatures and so on. These techniques which use physical data are receiving attention as a personal authentication method that is more convenient than conventional methods.

In these technologies, fingerprint becomes the most mature and popular biometrics technology used in automatic personal identification. The reason for the popularity of fingerprint verification is that fingerprints satisfy uniqueness, stability, permanence and ease of capturing. Therefore, this research adopts the use of fingerprint biometric for staff attendance management system in order to make lecturers attendance easier and effective using the Faculty of Natural Science, Ajayi Crowther University (ACU).

Biometric is an authentication method. It identifies people by recognizing one or several physical characteristics. It is one of the future main solutions for providing authentication" (SrideviBonthu, 2014). Biometrics is the combination of biological statistical analysis, computer science and engineering to get the physiological or behavioral characteristics of an individual (Ikuomola Aderonke Justina, 2014). However from different definitions of biometrics, it still boils down to the fact that biometrics must include measurement, distinctiveness, and robustness. Measurable means that the characters or traits can be easily presented to a sensor located by it and converted into a quantifiable digital format. The measurability allows for matching to occur in matter of seconds and makes it an automated process. The robustness of biometrics refers to the extent to which the characteristics or trait is subject to significant traces over time. These occur as a result of age, injury, illness, occupational uses and or chemical response. A high robust does not change significantly over time while a less biometric will change. For instance, the iris of a person changes a little over a person's life time is more robust than voice. Distinctiveness is a measure of the variation of differences in the pattern among the general population. The higher the degree of distinctiveness, the more the individual is the identifier. A low degree of distinctiveness indicates a biometric pattern found frequently in the general population. The iris and retina has high degrees of distinctiveness than hand or finger geometry (Maltoni D. and Cappelli R, 2008).

Biometrics are of advantage in the sense that it authenticates only people, and the unique characteristics (e.g Iris) for authentication resides permanently with the person alone (security), It is practical enough, no need of stressing on usage of password which is easy for hackers to violate and finally biometrics makes it possible to know exactly who has been authenticated and where. A password or an access card can have been borrowed by someone and used illegally but with a biometric authentication system, this cannot happen.

FINGERPRINTS

The practice of using fingerprints as a method of identifying individuals has been in use since the late nineteenth century when Sir Francis Galton defined some of the points or characteristics from which fingerprints can be identified. These "Galton Points" are the foundation for the science of fingerprint identification, which has expanded and transitioned over the past century. Fingerprint identification began its transition to automation in the late 1960's along with the emergence of computing technologies. With the advent of computers, a subset of the Galton Points, referred to as minutiae, has been utilized to develop automated finger print technology.

In 1969, there was a major push from the Federal Bureau of Investigation (FBI) to develop a system to automate its fingerprint identification process, which had quickly become overwhelming and required many man-hours for the manual process. The FBI contracted the National Bureau of Standards (NBS), now the National Institute of Standards and Technology (NIST), to study the process of automating fingerprint classification, searching, and matching.

NIST identified two key challenges:

- Scanning fingerprint cards and extracting minutiae against large repositories of fingerprints.
- Searching, comparing, and matching lists of minutiae against large repositories of fingerprints.

In 1975, the FBI funded the development of fingerprint scanners for automated classifiers and minutiae extraction technology, which led to the development of a prototype reader. This early reader used capacitive techniques to collect the fingerprint minutiae. At that time, only the individual's biographical data, fingerprint classification data, and minutiae were stored because the cost of storage for the digital images of the fingerprint was prohibitive. (Ravi et al 2009a). Over the next few decades, NIST focused on and led developments in automatic methods of digitizing inked fingerprints and the effects of image compression on image quality, classification, extraction of minutiae, and matching.

The work at NIST led to the development of the M40 algorithm, the first operational matching algorithm used at the FBI for narrowing the human search. The results produced by the M40 algorithm were provided to trained and specialized human technicians who evaluated the significantly smaller set of candidate images. The available fingerprint technology continued to improve and by 1981, five Automated Fingerprint Identification Systems (AFIS) had been deployed (Ravi et al 2009b).

There are two different techniques to capture fingerprints. The first is by scanning optically the finger. The other method is by using electrical charges, that determines which parts of the finger are directly in contact with the sensor and which are not. Each fingerprint has some characteristics such as curves, bifurcations, deltas. One set of these characteristics is unique for each person. Moreover, if your finger is little dirty, or injured, it will work as well, because the main characteristics of your fingerprint are not changed. A vulnerability of this method is reproducing a fingerprint for example with silicon. For the optical devices, even a picture of a fingerprint can fool the device. Fingerprints are commonly used in a lot of organization. Also you can find fingerprints readers easily.

MATERIALS AND METHODS

This is the design phase of the Biometric based Staff Attendance Register Software. It involved decomposing the whole system into modules and defining the relationship among the constituent modules. Top down design approach was employed which involved dividing the system into subsystems or modules and each subsystem being further divided into even smaller subs. This process of division is repeated until each module is sufficiently small enough to be conveniently coded (implemented) as an independent entity that performs a clearly defined operation.

Procedure used in Fingerprint Processing

❖ Fingerprint Acquisition

At the enrolment phase, the fingerprints would be acquired such that the print of the texture of the first finger (that is the pointing finger) is obtained twice and analyzed for processing. The fingerprint samples would be stored in a Microsoft SQL Server database with the aid of an interfaced fingerprint reader/scanner. The fingerprints are then to be saved inside a database to cater for subsequent need for the various fingerprint analysis during matching.

❖ Fingerprint Feature Extraction

In any fingerprint image, there are dark lines which are called ridges, whereas the spaces in between those dark lines are called valleys. Ridges and valleys often run in parallel but there are two things that happen to any print. It is either, the ridges and the valleys terminate or they bifurcate. Termination of a fingerprint is simply the situation in which a particular ridge ends abruptly while bifurcation is the situation by which the line splits into two. In the analysis of the fingerprint images during matching (authentication), the pattern of the fingerprint exhibits one or more regions where the ridge lines assume distinctive shapes; which are: loop, delta and whorl. If the fingerprint scan matches any one stored in the database at the enrolment phase, the staff with the fingerprint will be updated as present for the lecture.

❖ Minutiae Extraction

Each fingerprint images in the database after enrolment will be processed in order to extract a unique feature called minutiae. It is this unique feature that will be compared at the (authentication) matching phase. This requires the fingerprint grey-scale image to be converted into a binary image. The binary images obtained by the process are submitted to a thinning stage which allows for the ridge line thickness to be reduced to one pixel. Finally, a simple image scans allows the detection of pixels that correspond to minutiae through the pixel-wise computation of crossing number.

System Design

The biometric staff attendance system was designed using classes that perform specific functions. The classes are; 'class AttendanceView' which presents the date, time and status of the user, 'class Admin' which presents the list of all registered users and the attendance record. 'class RegPage' which deals with collecting data of the fingerprint and other bio-data, 'class AttendForm' displays the scanned fingerprint, 'class FormDefault' is the default form displaying module, and 'class DataAccessLayer' manages the data flow between all the classes. The system design can be best explained by the schematic hierarchical diagram of the Unified Modelling Language (UML) as shown in figure i

The System Module

The system consists of two main modules (phases); the enrolment module and the authentication (the attendance taking) module. The enrolment module can be referred to as the registration module. It starts with the taking of fingerprint using the scanner, the fingerprint key features are extracted and the template gotten is then checked to verify if it has been taken before or not. If the fingerprint template is identified, the execution process will go back to the line of code where fingerprint is being extracted, informing the user that 'fingerprint template has been collected before'. If the fingerprint template is not found, then it will be saved. This ensures that no single user can be enrolled (registered) more than once. Every successful fingerprint template is enrolled, and user's details are saved alongside with the template. Figure ii depicts the enrollment flow process.

The authentication module verifies a registered (enrolled) user and allows the attendance to be taken. It starts with the taking of the finger print; the template of the finger print taken is extracted. The system goes ahead to verify the template to check if it has been pre stored (registered), so that it can match it with an existing template taken. If no finger print template has been pre-stored (matching unsuccessful), the system displays "Please Register". But if the matching is successful, the attendance status for the day is checked. If the fingerprint has already been matched for the lecture period, it displays. "Attendance Already Taken for period" and if not it goes ahead to take the Staff's Attendance. This ensures that the attendance cannot be taken more than once by the same staff for the same lecture. The Admin views and generates reports of the staff using the attendance register of every user according to the time table. Figure iii depicts the authentication flow process.

User Flow Diagram

The user flow diagram shows the sequence and pages of the attendance system. It also shows the inter relationships between the pages. It starts with the initialization page which introduces the user to the application. The next page is the registration page (figure iv); where a new user is enrolled, user details as well as fingerprint are taken here. The registration page links directly with the admin page, the admin has the privilege of seeing the details of every registered user and the page displaying attendance information of all users. The use case diagram (figure v) fully describes the interactions between the entities of the application software, the staff gets registered, and takes attendance for each lecture, and the admin generates necessary reports and feed the necessary authorities with proper information deduced from the reports.

Database Design

MySQL was used to create the database of this project. The backend of the biometric attendance system refers to the storage for keeping data (such as fingerprints, users' bio-data, passwords etc.) for future use. MySQL is secured and gives room for easy extraction and use of the stored data which is its core functionality. The database schema diagram as shown in the figure vi on the page is the outline of the dataflow between classes (objects) in the biometric attendance system. 'Class bioData' (with properties biodataID, Name, Age, Gender, Dept, Position, StaffID, prfPic, PhoneNumber and email) represents the data of a single user that are filed in during the registration. The 'class bioData' is linked to the other classes (attendance and template classes) by the primary key 'StaffID'.

The attendance class (with properties Date, Status, StaffID, AttID and time) represents the attendance taken each day, while the class Template refers to the fingerprint gotten from the scanner. Its properties include templateID, Buffer, Quality and StaffID. Each class (Template, Biodata and Attendance) has a screenshot each showing the variables and the data types. Figures vii and viii displays the users' biodata and the attendance screenshot respectively with the variables and the data types as well.

Development Tools Used

The implementation phase of this work was carried out using the Microsoft's Visual Studio's C Sharp Programming Language which is on the .NET platform, with MySQL in the WAMP (Windows, Apache, MySQL, and PHP) Server as the back end. The .NET Framework was chosen as the platform to develop this Biometric based Attendance and Punctuality Register software. The reason is that the .NET framework constitutes an ideal infrastructure in which windows based application may be developed and run. The .NET framework is the combination of layers Common language runtime (CLR), Framework class library (FCL) and Extensible Mark-Up Language (XML). Figure ix displays .NET framework layers

C-Sharp Programming Language

C# (pronounced C-Sharp) is the language of choice in the .Net environment. It is a whole new language free of backward compatibility with a whole bunch of new, exciting and promising features. It is an Object oriented programming language and has its core, many similarities to Java, C++ and VB. In fact C# combines the power and efficiency of C++ and it's the simple and clean object oriented design of Java and the language simplification of VB. Java and C# also does not allow multiple inheritance or the use of pointers (in safe /managed code), but does provide garbage memory collection at runtime, type and memory access checking.

However, contrary to java, C# maintains the unique operations of C++ such as; operators overloading, enumerations, pre-processor directives, pointers, function pointers and promises template in its versions. It also supports the context of properties (context sensitive fields). C# also include in its features; reflections, attributes, marshaling, remoting, threads, streams, data access and more.

SOFTWARE ARCHITECTURE

The major modules in this Biometric based Attendance and Punctuality Register application software are: home module, admin module (users' details, users' attendance and admin login), attendance module, students'/workers' registration module and the help module. Each module was coded on separate forms (pages). The index page is the starting point for the use of the Biometric based Attendance application software. It has three menus. The menus are: Admin, Attendance, Register menus and the Exit button. The Admin Menu contains the Admin login button which allows the admin to login and view some windows; like the daily attendance Window for example, which is inaccessible to non-admin users. The registration window allows the new user to register (enrol) by placing the thumb on the scanner for the finger print to be captured and stored in the database, and to supply biodata (name, level, department, gender, matric no, phone no and e mail). The Attendance window allows the registered users (ACU Lecturers) to register their presence for the lectures for the day, once the thumb is placed on the scanner, the registered user is authenticated, recorded present and the time is recorded too. The Exit button is used to quit the application once all workers' attendance and punctuality register is taken for the day. Figures x to Figure xv show the windows of the Biometric based Attendance and Punctuality Register application software.

RESULTS AND DISCUSSION

This research work has several advantages when compared with the conventional manual attendance control system. Some of its benefits are highlighted below

- **Improved security:** the developed software work was able to guide against unauthorized person gaining access to manipulate the system or impersonate.
- **Improve employee performance:** the implementation of this software system in an institution will curb tardiness of lecturer's to the lecture rooms and make them regular. This will equally help to improve the performance of the students and lecturers.

- **Fast and easy retrieval of data:** the system enhances fast retrieval of attendance data. The report can be generated at any point in time. It reduces loss of data since all data are saved in a database.
- **Easy monitoring:** staff attendance is monitored at a single point. The administrator does not need to go about staff data or attendance sheet; at a click of a button, all data will be made available.
- **Reduce paper work:** the conventional method of taking attendance involves the use of several papers which makes it more cumbersome. The automated system reduces paper work and makes the attendance system less cumbersome.
- **Avoidance of Impersonation:** the conventional method gives room for impersonation whereby a lecturer takes attendance for another lecturer. The automated process with the aid of fingerprint biometrics does not give room for impersonation. Once enrolled, it can't be verified by another person.

In summary, the result and various benefits incurred from the implementation of this software is enough to entice all institutions and it will go a long way to improve the quality of education in institutions. It is therefore suitable for all institutions where high performance of lecturer's is of prime importance to achieve high academic productivity.

The biometric attendance system was duly tested and certified working perfectly. The system consist of the attendance software installed on an HP 630 Laptop with 64-bit Operating System (Windows 7 OS), 500 Gigabytes Hard disk, 4 Gigabytes RAM and 4 Gigahertz Processor Speed (Intel Pentium Dual Core) and a fingerprint scanner. The fingerprint's Software Development Kit (SDK) too was installed on the computer system as well for the scanner to communicate well with the application software. The developed system was tested over and over, and every bug detected was corrected over and over until the system worked perfectly.

SYSTEM MAINTENANCE

The system developed will stand the test of time if properly maintained. The most important maintenance is to make sure that the fingerprint scanner is kept in a very good condition; its USB cable must be kept well. The OS on the computer should be upgraded as at when due to avoid system crash. In case the school wants to use the developed system on the school's network, network maintenance will be very important to enhance communication between the networked computers; servers should be physically repaired or replaced when damaged, software for server too should be consistently updated. All these maintenance practices should be done on a regular or semi-regular schedule, often during non-peak usage hours, and keep servers running smoothly.

CONCLUSIONS

Traditionally, lecturer's attendance is taken using the manual method which involves pen and paper registers. This research mainly comprises of development of staff attendance management system using fingerprint biometric technique. Attendance management system is very helpful in saving valuable time of students and lecturers, saving paper and generating report at required time. This research has presented a framework in which attendance management has been made automated. Furthermore, it can curb tardiness of lecturers in the institution and make them regular if implemented.

It can be concluded from the above discussion that a reliable, secure, fast and efficient system has been developed replacing a manual and unreliable system. Results have shown that this system can be implemented in an institution for better results regarding the management of attendance. This system will save time, reduce the amount of work the administrator has to do and replace the stationery material with electronic devices. Hence, a system with expected results has been developed but there is still room for improvement.

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Fig 1: Unified Modelling Language Diagram for the Class

Fig 2: Flow Chart showing the Enrolment process

Fig 3: Flow Chart showing the Attendance (authentication) process

Fig 4: User Flow Diagram showing the sequence of pages

Figure 5: The use-case diagram for the software

Figure 6: Database Schema showing the classes and their variables

Fig 7: Screenshot showing Users Bio data

Fig 8: Screenshot showing the Attendance Table

Fig 9: Net framework layers

Reg

PERSONAL DATA

NAME:

SEX:

MARITAL STATUS:

PHONE NUMBER:

HOME ADDRESS:

EMAIL ADDRESS:

OCCUPATION:

STATE OF ORIGIN:

Capture Picture

Capture Finger

ACADEMIC INFORMATION

STAFF NO:

DESIGNATION:

DEPARTMENT:

DATE OF APPOINTMENT:

Register

Fig 10: The Enrolment/Registration Page

Reg

PERSONAL DATA

NAME:

SEX:

MARITAL STATUS:

PHONE NUMBER:

HOME ADDRESS:

EMAIL ADDRESS:

OCCUPATION:

STATE OF ORIGIN:

Capture Picture

Capture Finger

ACADEMIC INFORMATION

STAFF NO:

DESIGNATION:

DEPARTMENT:

DATE OF APPOINTMENT:

Register

Fig 11: Enrolment/Registration Page Showing the User's Data

Fig 12: The Screen when the Thumb is on the Scanner for Attendance

Fig 13: Window Showing Successful Attendance

Staff No	Date	Time In	Time Out
age234	5/25/2016 12:00:00 AM	10:48:30.0815993	10:51:38.7897933
Cse123	5/25/2016 12:00:00 AM	18:46:36.6446090	18:47:27.6834966
cse1234	5/25/2016 12:00:00 AM	19:36:43.8041026	00:00:00

Fig 14: The Admin Window showing the attendance list for the day

Fig 15: The Admin Page for Report Generation

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