Enhancing Attendance Management in Firms and Industries Using Fingerprint Biometric Recognition Technique.

Chinedu Innocent Nwoye

Department of Computer Science, University of Nigeria, Nsukka

Abstract*: The biometric verification technique has come to stay in the authentication and authorization of access in automated systems. Traditional way of handling attendance in firms and organizations by using hand written signatures on attendance sheets or booklets has proven to be very inefficient due to its challenging instances of falsifications, impersonations and miscalculations. This paper focused on studying the use of unique human biological anatomy or physiological feature, fingerprints, in recognizing, managing and monitoring the attendance of employees in firms and industries. Both quantitative and qualitative methodologies were adopted in the research whereas Object Oriented Analysis and Design Methodology (OOADM) was used in the development of a platform for a fingerprint enabled attendance management system using cross platform development technologies. The result of this research formed a backbone to the development of a generic system that saves time, eliminates the crude manual method of signing in/out each day at work and also eliminates the problem of impersonations and falsifications in the management of employee attendance to work.*

Keyword*: fingerprint, attendance management, employee attendance, biometric verification, authentication.*

I.   Introduction

Over the years, research has been taken into the industries for the purpose of enhancing productivity. A lot of factors has been highlighted as the cankerworm to efficient and increase productivity of various industries. These factors were classified as human, technological, economic, administrative and environmental factors [1]. The major cause of the human factors has been detected as fraud and laziness. An important aspect of this lapse is the records of attendance in terms of punctuality, regularity to duty and useful hours put to work. Many staff have been over or under paid due to inaccurate record keeping of their inputs (in terms of time and labour) to the industries. By this regards, attendance in virtually all organizations is a very important factor. According to [2], attendance is second to throughput as one of the most important criteria for the measurement and evaluation of the performance of employee in an organization. In time past, attendance recording has been done manually with employees having to sign in and out daily, providing details like name, employee ID, date, time, signature, etc., especially where enumeration of staff is based on number of days and hours put to work. This manual system takes little or no considerations on impersonation, falsification and the risk of loss of information in event of misplacement of attendance records, theft or disasters such as fire outbreak or flood [2], [3]. Another weakness of the manual system is error in the computation of the appropriate bonuses and deductions in the salary of employees [3]. Also to maintain the attendance records in this manual approach is a very inconvenient task [4].

This research main target is to provide a solution to firm's attendance problems through the use of attendance management software that is interfaced with a finger print device. The employee bio data and finger print is first enrolled to the database and then the fingerprint would be captured using a fingerprint device or scanner. The design will give room for the interfacing of any automated system in the collection and collation of attendance information which can be used to monitor the attendance of employees in an organization.

The significance of this research and development is to make personnel management in an organization easier and this is achieved through the automation of the process. This positively affects the economy of the organization and also the smooth running of the organizations daily operations. Also, findings and research from this work would assist future researches on fingerprint biometrics. The system would reduce administrative workload and increase staff productivity, and also serve as a means to promote computer literacy as it would expose staff, skilled and unskilled, to the computer systems.

II.   Review Of Related Literature

The campaign for the increase in industrial productivity has invited, over the years, institutional researchers for efficient research-development partnership. In the course of this research, lots of factors have been identified as the hindrances to productivity and were broadly classified as human, technological, economic, administrative and environmental factors [1]. Sidelining this work to the human factor, fraud and laziness has major role in limiting the performance of labour.

The most recommended means of checking this problem is by attendance and monitoring mechanisms. Attendance will help to check punctuality and regularity to duty while monitoring will supervise the amount of useful hours put to work. In many institution and organization, the attendance is a very important factor for various purposes particularly as an important criterion for checking the performance of employee [4]. Attendance taking started with the manual approach of using paper called register [5]. In queuing and delaying systems, this paper-based attendance management according to [4] is such an inconvenient task especially in the event of large population, whereas [5] sees it as a very lengthy process and time consuming task. Recording attendance using paper register is done with employees having to sign in and out daily, providing details like name, employee ID, date, time, signature etc., especially where enumeration of staff is based on the number of hours put to work. Some organizations also keep detailed records of attendance issues such as who calls in sick, who comes in late or who took permission [4], [7]. Unfortunately, the traditional manual paper based system takes little or no considerations on impersonation, falsification and the risk of loss of information in event of misplacement of attendance records, theft or disasters such as fire outbreak or flood [2], [4]. Another weakness of the manual system is error in the computation of the appropriate bonuses and deductions in the employees' salary[2].

An electronic attendance management system provides a secure and easy way of monitoring the attendance of employees in an organization, minimizing or even eliminating impersonation and falsification of days and time of reporting to duties by employees. Attendance management has also been carried out using attendance software that uses passwords for authentication too. In [4] an attendance management system was implemented to authenticates the user based on passwords, this type of system allows impersonation since the passwords can be shared or tampered with or even forgotten at times thereby preventing the user from accessing the system. There were also some other attendance solutions such as RFID (Radio Frequency Identification)-based student attendance system and GSM-GPRS based student systems which are all device-based solutions. While GSM-GPRS based systems use position of the class for attendance marking which is not dynamic and if schedule or location of the classes changes, wrong attendance might be marked. in [5] the major problem with RFID based systems is that the students would be required to carry RFID cards and also RFID detectors are needed to be installed on the system.

In [7] another technique for attendance management was proposed which enables each user logs into the system and has to mark his/her attendance manually. The user selects the particular date and courses attended on that particular day and it is automatically saved to the database. In this event of developing a comprehensive attendance management system, [11] developed a simple payroll calculator. The software was developed using Visual Basic and runs on computers with installed .NET framework. It accepts employee number of hours worked, computes net pay and records all payroll data for subsequent processing then prepares pay-cheques and payroll ledgers and maintains data on a sequential payroll file. OOP was used in its development and the system was divided into five modules: employee data, payroll records, rates, ledgers and help. Just like our proposed system this was also aimed at automating daily operations in an organization and minimizing human prone errors.

In 2013, an attendance system which can take attendance using Bluetooth was proposed [6]. Here, attendance is being taken using the instructor's mobile phone. Application software which is installed on the instructor's mobile telephone enables it to query student's mobile telephone via Bluetooth connection and through transfer of student's mobile telephone Media Access Control (MAC) addresses to the instructor's mobile telephone, presence of the student can be confirmed. The problem of this system is that the student's phone is required for attendance. In case of a students' absence, if his mobile is given to his friend then he/she is still seen as been present. So the presence of a student is not necessary but only the phone should be in coverage area for an attendance to be recorded.

In [2] an embedded computer based lecture attendance management system was proposed. The system provides an improved electronic card and card reader serially interfaced to the digital computer system. In another work [9], a web base attendance management system was developed still hinged on the many problems associated with the manual system. The PIID methodology which is a combination of Prototyping model and Iterative and Incremental Development was used. The system has three modules namely; the Student Attendance Module which the admin uses to manage the attendance of the students, the Repot Module which is used to generate the attendance report of students and the Discipline Module which sends SMS messages to parents of students who are absent from school and a notification to the disciplining officer of the institution. A web base leave management system which was aimed at solving the many problems associated with the manual leave system was also proposed in [10]. The system developed with certain constraints using web technologies after an in-depth analysis of the existing system and identification of the underlying problems hence providing better data reliability, more automation and less effort, efficient real time data and up-to-date report generation among others.

Another researcher [3] used a wireless attendance management system that authenticates using the iris of the individual. The system was an off-line iris recognition management system that can finish all process including capturing the image of the iris, extracting minutiae, sorting and matching.

Finally in [8] an attendance management system using fingerprint biometric was proposed. The standalone system comprising of an enrollment and identification phase was developed because of the need to move from the traditional manual way of marking attendance to an automated way. According to [1] biometrics identify people by measuring some aspect of individual anatomy or physiology (such as your hand geometry or fingerprint), some deeply ingrained skills or other behavioral characteristics (such as hand written signatures) or something that comprises of both (such as voice). In [1] a biometric system is essentially a pattern recognition system that operates by acquiring biometric data from an individual, extracting a feature set from the acquired data and comparing the feature set against the template set in the database. A fingerprint is comprised of ridges which are the dark area of the fingerprint and valleys which are the white area that exists between the ridges. It is unique to each individual and cannot be shared. When a fingerprint pattern is captured with a fingerprint device, the captured fingerprint is enrolled into the database through the process of registration. Subsequently, prints captured by the fingerprint device at every point of signing in/out are being compared with those already enrolled into the database to validate that particular users was registered ab-initio, verify the owner of the prints through features extractions and pattern matching as against the stored prints in the database then allow access to a system. At the point, date and time are being captured as parameters for attendance management.

III. Fingerprint Biometric Computational Science

There are a lot of bio-information that can be generated from individuals using fingerprint biometrics data. The act of deriving such information is known as fingerprint biometric computations. The input data extracted from the fingerprint are known as features extracted and they include:

i.   Ridges
ii. Ridge endings
iii. Dots
iv. Minutia
v.   Bifurcations,
vi. Patterns and textures
vii. Fast seen symbols
viii. Intersections or crossovers
ix. spurs
x.   islands and lakes

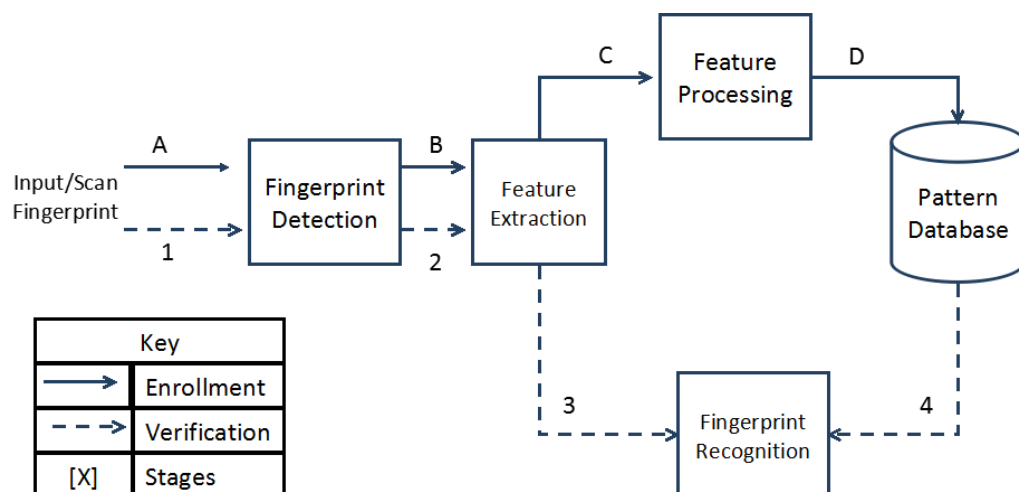Below is a sketch of how finger features are extracted and processed in a fingerprint biometric system.

Figure 1: Sketch of the Conceptual Model of the Fingerprint Recognition Approach

The sketch diagram (figure 1) for fingerprint recognition technology consists of four phases. The first phase is the Fingerprint Detection, the second phase is feature extraction, and the third phase has the distinguishing elements for first time enrollment and time to time verification. While the enrollment exercise needs the Feature Processing block to process the minutia and bifurcations before transferring the final result

(pattern templates) to the Database in the last phase, the verification exercise employs Fingerprint Recognition by comparing patterns from the second phase with the retrieved patterns from database.

The fingerprint system can extract and compute the following information from a particular fingerprint:

    i.   unique patterns
    ii.   binary digits
    iii.   stretchable angles
    iv.   non-stretchable angles
    v.   eigenvalues
    vi.   eigenvectors

The fingerprint biometric computation can then be use in analysis, derivation and processing in realizing the following information about a particular user:

    i.   Authenticated user
    ii.   Date and time
    iii.   Pressure or mood
    iv.   Status
    v.   Cleanliness

These information, especially (i) and (ii) above are most essential in the attendance registration of a user and they are the most needed derivatives in the design and implementation of any attendance management system that works on the principle of fingerprint biometrics. When a finger impression is made on a scanner, the fingerprint features are extracted, analyzed and processed. The unique patterns are compared with the existing templates of the registered users in the database in a process known as pattern matching. If the pattern matching algorithm returns true meaning a user is authenticated and ascertained to be the real representation of the intended user, the date and time of the finger impression activity is recorded against the user's information in the database as attendance. Pressure or mood are useful for crime detection and access regulation systems. The status detection are useful in detecting level of activeness in some mechanical systems where the blood circulation in the veins and ridge ending are analyzed too. The cleanliness parameter can also serve same purpose but more useful in tasks that change the neatness of the fingers when carried out. It is also a factor in acceptance or rejection of many finger impressions in the exercise of fingerprint recognition.

IV. Research Objectives

The major objectives of the research is to:
1. Find out the level of incompetence in non-biometric attendance identification
2. Find out the need for a biometric attendance system which forms the motivating factor.
3. Find out the areas that biometric recognition will be needed in firms and industries.
4. Evaluate the enhancing power of fingerprint biometrics in the effective and efficient attendance management.
5. To extract the important aspect of attendance for effective throughput.
6. To recommend the right techniques in attendance management system development.

V. Research Methodology

In order to back up the set of findings from the data collection in one method underpinned by different methodologies, quantitative and qualitative research methodologies were used together in analyzing the effect of fingerprint recognition in the attendance management of a firm. Questionnaires was constructed and distributed to target audience, the employee and employer. From the responses, the questionnaires were fine tuned and redistributed. The corresponding responses call for smaller group of the target audience to be reached out in interviews and field observations. The result of this direct observations were analyzed and following the research objectives, a larger number of employee were targeted online with mass distribution of the questionnaires on social networks and as website polls.

Research Findings and Derivatives

Facts emerged from the quantitative data measure variables and verifying theories and hypothesis. The statistics of the final results was sufficient enough for drawing conclusions on the research findings.

-Problems: The inherent problem in the current manual system were analyzed from the research data as presented in table 1 below:

High rate of falsification: It is evidence from the research findings that falsification which has no better means of validation is inherent in the manual staff attendance and nominal rolls. The falsified parameters are always the date and time. From the research findings in table 1 below, it can be deducted that more than 65% of the employee falsify their arrival time and up to 11% reported present even when they were actually absent to duty. Owing to the facts that certain amount are surcharged for lateness and irregularity to duty, the attendance roll is always compromised with such faked and over hyped data for favourable payment from the employee point of interest. This goes a long way to invalidate the use of such documentaries for research purpose.

High rate of impersonation: The result of the research shows that there is 28% possibility of an employee who is absent to duty being recorded as being present due to decaying favour from fellow employee in the name of impersonation.

Inaccurate calculation: In economics; land, capital, labour, entrepreneur and information are the factors of production. Days, time and number of available labour are the essential parameter of labour which is the direct interfacing factor of production. If as high as 65%, 11% and 28% levels of inaccuracy are experienced in the factors of time, days and labour respectively, the estimation and decision making of firms and industries will be badly affected. This can lead to purchase of excessive machines and extension of working days and hours and thereby increasing industrial expenditure and decreasing the life span of the sincere labour force.

Table 1: Research data for the staff attendance roll

Questions	NO Very Poor (0-20%)		Fair (21-30%)		Moderate (41-60%)		Good (61-80%)		YES Excellent (81-100%)		Total
How often do you report the exact time you came to work?	961	20.01%	2160	44.97%	1202	25.03%	384	8.00%	96	2.00%	4803
How often do you report only the exact days you came to work?	144	3.00%	432	8.99%	482	10.04%	1344	27.98%	2401	49.99%	4803
How often do you sign attendance for another person absent to work?	480	9.99%	864	17.99%	1056	21.99%	1920	39.98%	483	10.06%	4803
How offten do you think your employer miscalculated total number of days and hours you put to work?	482	10.04%	576	11.99%	1344	27.98%	960	19.99%	1441	30.00%	4803
Do you think a fingerprint attendance system will limit employee from signing in/out for wrong date and time?	0	0.00%	192	4.00%	243	5.06%	528	10.99%	3840	79.95%	4803
Do you think that a fingerprint attendance system will limit employee from signing for their colleagues?	0	0.00%	1	0.02%	77	1.60%	506	10.54%	4219	87.84%	4803
Do you think that a fingerprint attendance system will make your colleagues to come to work daily and early?	96	2.00%	192	4.00%	864	17.99%	962	20.03%	2689	55.99%	4803
Do you think that a fingerprint attendance system will reduce the rate of miscalculation of worker's salary?	576	11.99%	480	9.99%	964	20.07%	1536	31.98%	1247	25.96%	4803
Do you think that a fingerprint attendance system will improve the knowledge of the use of computer system in workplaces?	483	10.06%	336	7.00%	624	12.99%	1440	29.98%	1920	39.98%	4803
With fingerprint attendance system, do you think wrong persons can still sign attendance?	4656	96.94%	93	1.94%	48	1.00%	6	0.12%	0	0.00%	4803
With fingerprint attendance system, do you think wrong date and time can still be signed in attendance?	4411	91.84%	242	5.04%	145	3.02%	3	0.06%	2	0.04%	4803
With fingerprint attendance system, do you think wrong calculations can still be made in terms of hours worked?	2422	50.43%	912	18.99%	961	20.01%	432	8.99%	76	1.58%	4803
If wrong data is gotten from the system, how much can we hold the device responsible?	477	9.93%	579	12.05%	1344	27.98%	1445	30.09%	958	19.95%	4803
If wrong data is gotten from the system, how much can we hold the operators responsible?	2883	60.02%	1008	20.99%	387	8.06%	432	8.99%	93	1.94%	4803
If wrong data is gotten from the system, how much can we hold the instructors responsible?	381	7.93%	576	11.99%	528	10.99%	1157	24.09%	2161	44.99%	4803
How well do you think the system can	96	2.00%	0	0.00%	484	10.08%	575	11.97%	3648	75.95%	4803

perform in firms?										
How much do you think the system should be used in other sectors of economy?	306	6.37%	566	11.78%	432	8.99%	1573	32.75%	1926	40.10%	4803

Low throughput: The result of these irregularities in the attendance roll can affect the amount of useful work in a given time which can cause the firm and industries to work with wrong data in their analysis and decision making since the amount of useful work done will be a quotient of wrong time put to work.

Wrong use of payment parameters: Labour is rewarded as wages, salaries, bonus, surcharge and overtime. The payment parameters are the amount of time and number of days put to work for each employee. For the industries, it is a compliment of the number of available labour. From the analysis of the irregularities in the attendance management, most staff are overpaid. From the statistical report in table 1 below, 22% of respondents believed that their work pay were occasionally miscalculated. This is due to the use of manual system which an automated system design should put into considerations.

Inconsistency: This factor would have been the best parameter for tracing the irregularities in the system. Inconsistent paper signatures were meant to be a validating parameter against impersonations. The question is, what are the validating parameters against falsification of days and time to duty?. What is the efficiency of the manual signature validation technique? A fingerprint biometric recognition is hence the most appropriate technology in this regard.

Wrong industrial reports: An Industrial report cannot be comprehensive if it does not cover the financial report of the industrial operations. This financial reports is majorly divided along the income and expenditure. The total expenditure is a compendium of the fixed and recurrent expenditure. The amount spent on workers' wages and salary is the base aspect of the recurrent expenditure. From the discussion so far, it is inherent to produced inaccurate industrial reports owing to the fact that the parameters of determining the salaries and wages of worker are widely falsified..

Increase level of computer illiteracy: This is an adherent effect of the continual use of paper based staff attendance roll. The use of automated system natural improve the staff level of computer literacy.

VI. Analysis And Design Methodology

The Object Oriented Analysis and Design Methodology (OOADM) was used in requirement specification and conceptual solution definition. The Object Oriented Analysis (OOA) emphasizes on the findings and describing the objects (concepts) in the problem domain, Object Oriented Design (OOD) emphasizes on defining software objects and how they collaborate to fulfill the requirements dealing basically with objects, classes, relationships and instances. A prototype application formed from the framework was used to experiment the output of the work.

Design and Implementation Platforms

The design of the framework is presented in the use case diagram in figure 1 below and this represents the actors and actions performed by the actors. The use case diagram is a UML tool used in the identification of the main functionality or the processes in the system and the actors participating in the use of the system. It describes the system's functional requirements. In the use case diagram the admin as an actor enrolls the employee, submit feedback to the system and backup attendance records. He also uses the system to compute the staff payment which includes the computation of attendance statistics as compulsory action that must comes before the main computation is completed. There are other optional actions that can follow the computation tasks such as generate pay slip, email payment, etc. He can also generate industrial reports which includes attendance reports, payment reports, etc. Another actor of interest is the staff. The staff takes attendance by scanning the fingerprint impression on a fingerprint biometric scanner for the system to automatically on the staff based on the uniqueness of the print. He also submits feedback to the system and can view and print his/her pay slips.

The framework so developed is a cross platform framework which can use the technologies of Xamarin, Phonegap, or any other cross platform IDE, utilizing the technologies of develop-one-deploy-many, to actualize its ability to work in iOS, Android, Windows and Linux platforms. It can be used as a mobile, desktop and web based applications. Its screen resolution can fit in small to large screen size devices such as laptops, desktops, tablet PCs, PDAs, iPhones, iPad and mobile smart phones. It does not need a large database to function as it only stores an employee fingerprint pattern once and matches with subsequent patterns for authorizations, validations and processes. It does not need to store the staff records but can interface the firm's or organization's database or simply uses a staff identification number (staff_ID) as a foreign key to relate each staff fingerprints to their records in other database tables. Its technicalities and functionalities can work in

devices with or without built-in fingerprint recognition components. It can recognize a removable peripheral fingerprint device attached to a system. With all these functionalities, the platform proposed can effectively serve any firm and industry interested in the upgrade of its attendance management system to this recommended biometric technology.
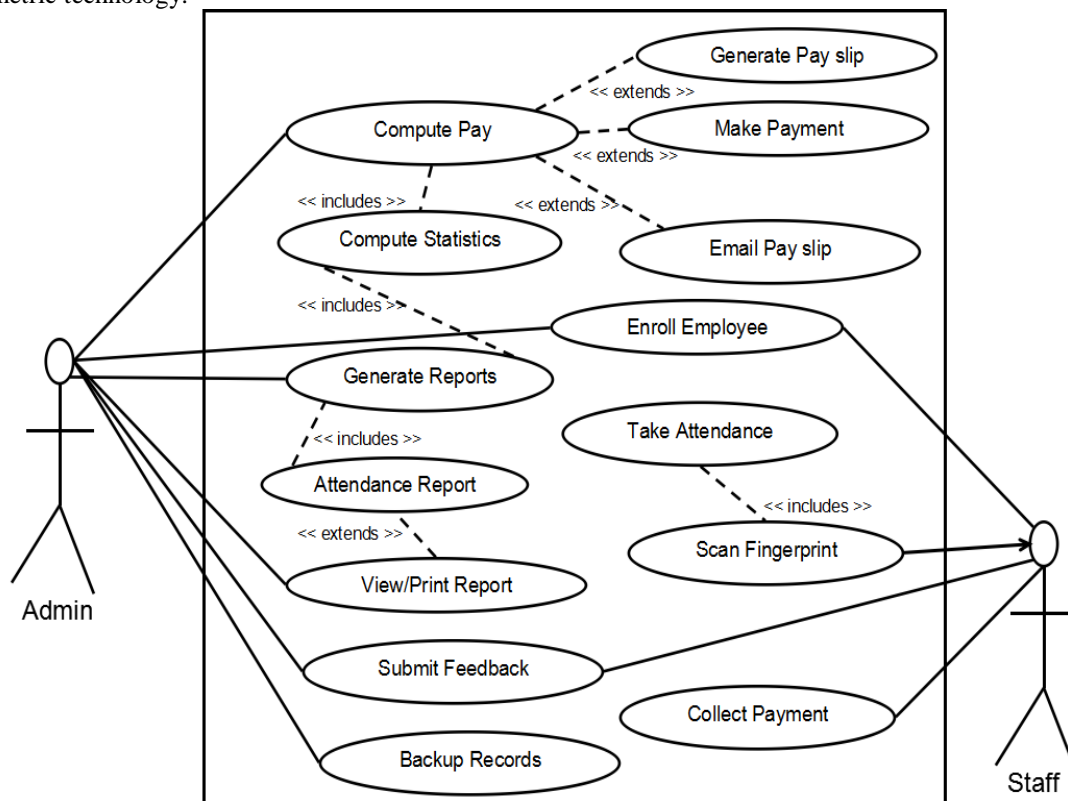

Figure 2: UML Use case diagram of the attendance management system

VII.   Result Evaluations

The research carried out in this paper revealed the level of incompetence in non-biometric attendance management systems in terms the rate and possibilities of work days and hours falsification, labour impersonation, work pay miscalculation and insincerity. The result of the research also spelt out the need for a biometric attendance system in firms and industries in order to utilize the real value of the number of working hours truly put to work, curb corruption, enhance computer literacy among employees and improve balance of payment. The research and development also evaluated the enhancing power of fingerprint biometrics in the effective and efficient attendance management in ensuring that only the right persons, right date and time, right payments circulate around the labour factor of production in industries. Finally, the resultant development recommended the right interfacing techniques to be used in attendance management and the need for accurate directives constraints (scope and shortfalls) to be put in place to improve output.

VIII.   Conclusion And Recommendation

This work has succeeded in providing a guide to a fingerprint biometric attendance management system framework which will go a long way to assist in development of any attendance monitoring and management application that can promote hard work, integrity, punctuality and regularity to duty among the employee owing to its efficient and non compromising capabilities in deciding the daily numerations. The system will also has the tendency of increasing computer literacy amongst its users as the knowledge of the use of computer is needed to effectively use the system. The research findings can be used in further evaluation of industrial activities for efficient economy. The limitation is that with the research carried out and findings made, an automated attendance system can only record the right time a right employee signed in and out to daily work but cannot monitor the idle time and the hours put to work except a human supervisor is delegate with such task. It is therefore important to recommend that similar technologies should be employ in devising a means of supervising actual job activities of employee/labour in firms and industries.

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