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BIOMETRIC AUTHENTICATION SYSTEM FOR STAFF ATTENDANCE MANAGEMENT: COLLEGE WORKERS TRUANCY CHECKMATING APPLICATION

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ABSTRACT
Introduction*: The goal of any organization, company or institution is to increase its productivity and profitability. Achieving this goal requires monitoring and managing the activities of the workers. The attendance management system is very vital in tracking the attendance of workers, curb truancy and enhance reliability and profitability of the organization.* ***Aim****: This research is aimed at the development of Biometric Authentication System for Staff attendance (fingerprint) to checkmate Truancy among workers of Abia State College of Education (Technical), Arochukwu.* ***Methodology****: This research work adopted both primary and secondary methods for gathering data through observation of attendance register, personal interview with some staff of the institution as well as journals, electronic books (e-books) and online articles on Biometric authentication system. Waterfall Model was adopted as system development methodology; Unified Modelling Language was used for the design of the proposed system.* ***Tools****: The system was developed using Visual Basic Studio 2015 with other tools which include Hamster Plus SecuGen Fingerprint scanner, Standard Development Kit (SDK) for Visual Basic DotNet Framework, Crystal Report, VB.net as programming language and SQLite Relational database for data storage.* ***Result****: After the proposed system has been tested and evaluated, it showed that the system helped in monitoring and maintaining daily (morning and evening) attendance of staff in the college by capturing and verifying workers' fingerprints. It thwarted intruders' access to administrator's login details and captured exception cases of workers who are sick or had accidents. The system thwarts impersonations, manipulation and forgery of attendance register, enforces punctuality, ensures higher productivity and eliminate ghost workers in the institution.*

Keywords: Institution, Attendance, Truancy, Biometric, Fingerprint

1. INTRODUCTION

The goal of any organization, company or institution is to increase its productivity and profitability. According to Kusumanchi, (2019), tracking the attendance of employees is essential for the reliability and profitability of any institution, company or organization. There are various methods employed by some organizations to track workers' work hours, which ranges from traditional punch card systems, timesheets to a Biometric system. The main aim of this process is to keep track of employees' work hours by daily recording their clock-in and clock-out time. Employees usually have to fill the attendance sheet when they arrive workplace and after work hours or before leaving the office for that particular day. Manual filling of attendance sheets can give room to truancy, which can also encourage various issues like manipulation, tampering, inaccuracy, errors, and forgery of attendance registers.

With biometric attendance system, various organizations and institutions canavoid such situations.According to Jaiswal, Bhadauria, and Jadon (2011) biometrics are automated methods of identifying a person or verifying the identity of a person based on a physiological or behavioral characteristic. Examples of physiological characteristics include hand or finger images, facial characteristics, and iris recognition. Behavioral characteristics are traits that are learned or acquired; and it includes: Dynamic signature verification, speaker verification, and keystroke dynamics. Biometric authentication requires comparing a registered or enrolled biometric sample

(biometric template or identifier) against a newly captured biometric sample (for example, a fingerprint captured during a login). During Enrollment, a sample of the biometric trait is captured, processed by a computer, and stored for later comparison. Biometric recognition can be used in Identification mode, where the biometric system identifies a person from the entire enrolled population by searching a database for a match based solely on the biometric.All biometric systems consist of three basic elements (Jaiswal et al., 2011):

a. Enrollment or the process of collecting biometric samples from an individual, known as the enrollee, and the subsequent generation of his template.
b. Templates or the data representing the enrollee's biometric.
c. Matching or the process of comparing a live biometric sample against one or many templates in the system's database.

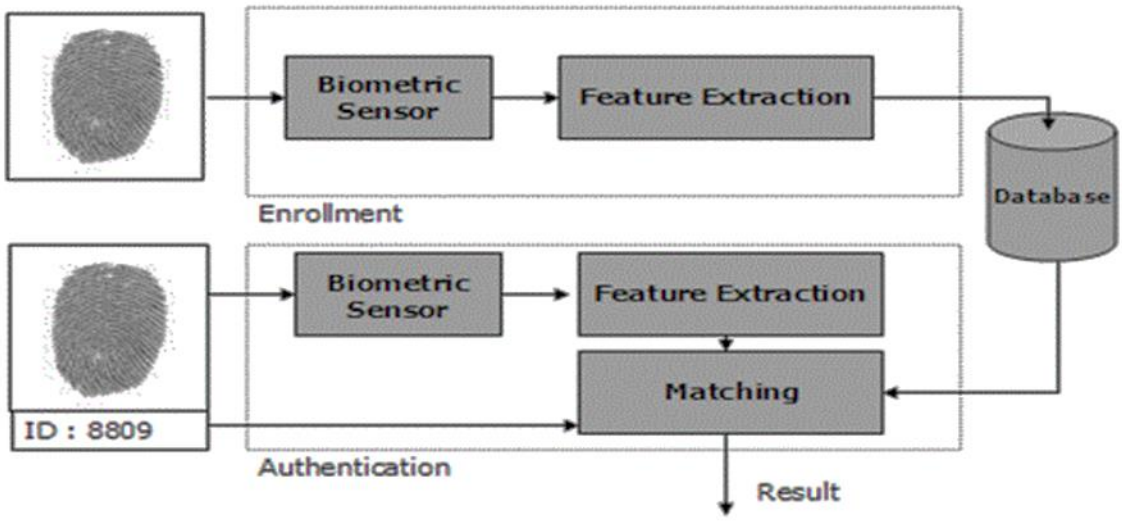

Figure 1: General Architecture of Biometric System (Sareen, 2014)

Biometric attendance measures and verifies the biological characteristics of a staff. It helps to keep track of the schedule of workers. It can accurately record the entry and exit times of the individual. So the employer/authority will have clarity and there will be no dispute between who is in and out of duty. This system not only helps to monitor the working hours of the employees, but also enhances the efficiencies of leave and payroll management. Based on fingerprints, the probability of finding two identical prints is one in sixty-four billion, even with twins. This makes biometric attendance system a more reliable in terms of security, authenticity and consistency. Fingerprint recognition describes the process of obtaining a digital representation of a fingerprint and comparing it to a stored digital version of a fingerprint. Electronic fingerprint scanners capture digital 'pictures' of fingerprints, either based on light reflections of the finger's ridges and valleys, ultra-Sonics, or the electrical properties of the finger's ridges and valleys. These pictures are then processed into digital templates that contain the unique extracted features of a finger. These digital fingerprint templates can be stored in databases and used in place of traditional passwords for secure access. Instead of typing a password, users place a finger on an electronic scanner. The scanner, or reader, compares the subsist fingerprint to the fingerprint template stored in a database to resolve the identity and validity of the person requesting access. (Mudholkar, et al., 2012)

This proposed system uses fingerprint identification and verification approaches to automate the attendance of academic and non-academic workers in Abia State College of Education (Technical), Arochukwu.

2. RELATED WORKS

Shoewu et al., (2016) designed and developed an employee monitoring system. The employee monitoring system was an android application used to monitor the call logs, sent and receive messages and the GPS location of an employee. The application was implemented using Java script, the application interface was designed with XML and PHP for the automatic mailing system.

Şahinbaş, K. (2022) proposed a prediction model for employee promotion using machine learning algorithm. A decision support system designed for a Human Resource (HR) departments about eligibility of employees' promotion. Synthetic Monitoring Oversampling Technique (SMOTE) and Random Oversampling (ROS) imbalanced techniques are used; then, classification algorithms are applied to predict employee promotion such as Support Vector Machine, Artificial Neural Network and Random Forest. RF outperformed the other algorithms with 98% accuracy, 96% precision, 1.0 recall and 98% f1-score rate obtained among SVM and ANN.

Sundari and Venkatesan (2020) Analyzed the use of E-monitoring from the employee point of view as a technology that helps in improving his or her behaviour during the work and increase his or her productivity using a questionnaire. They revealed that the employees have a high desire to be monitored to improve their behaviour in the work and to improve the relationship between the employees themselves to make the work environment more peaceful and more welcome environment. However, the employees do not care about the organization performance. Hence, the results showed that the percentage of the people that favour E-monitoring is not higher than that for those who do not favour and that is justified as high percentage of people who accept the E-monitoring as a scientific method that improve their behaviour and can be useful for the organization but they don't like to be monitored.

3. METHODOLOGY

The proposed system is a Desktop-based biometric authentication system that maintains daily attendance of staff in Abia State College of Education, Arochukwo through the use fingerprint authencation. The application captures the fingerprint of the workers and uses that for verification and identification of staff during sign-in (morning) between 7:00 am and 9:30 am and sign-out (evening) between 3:00 pm and 5:00 pm thereafter saves the staffs' details into the attendance list for that working day. The application has a user-friendly interface and itencrypts the administrator's login details with Secure Hash Algorithm (SHA-3) at the database level to thwart intruders from having access to administrator's login details. The application also captures details regarding exceptions from staff. This means that staff that are sick, have accidents or have any vital incidents and have written officially to the school authority can be captured into the list of staff with exceptions cases. The system allows the administrators to view list of all enrolled staff, attendance of staff, exception cases and attendance summary, which shall be used for processing ofsalary and allowances. SQLite connector for Visual Basic DotNet will be used to link the system with the database. Standard Development Kit (SDK) for Visual Basic DotNetwill be used in connecting the biometric system with the Hamster Plus SecuGen fingerprint scanner device. The fingerprint image captured will be the thumb and index fingers of both hands.

3.1 Advantages of the Proposed system

The advantages of the proposed system are:

i. The system thwarts the activity of impersonations.
ii. The system prevents the activity of manipulation and forgery of attendance list.
iii. The system aids in ensuring that justices are done during payment as one receives salary based on the number of days attended work.

iv. The system enforces punctuality with the staff and also ensuring that the staff remain at their duty post until the close of work.
v. The system aids in ensuring higher economic productivity in the college
vi. The system aids in eliminating ghost working in the institution.

3.2 Proposed System Model

The following steps were taken into consideration for effective development of the system.

- The Administrator captures his/her data and registers into the system
- The Administrator captures other staff data and registers them into the system.
- The registered staff will have their fingerprint enrolled into the attendance system by the administrator using the staff Identity number as the reference.
- The administrator logins to the biometric system.
- During Sign-in period in the morning, the staff will be verified if their biometric had been captured and after verification, staff details are sent to the database.
- During Sign-out period in the evening, the staff will be verified if their biometric had been captured and after verification, staff details are sent to the database.
- If there is any exception, the staff details would be captured and stored into the exception table for review and reference.

The system is developed using waterfall model as its system development methodology. Waterfall Model illustrates the software development process in a linear sequential flow. This means that any phase in the development process begins only if the previous phase is complete. Requirements are constant and not changed regularly and the biometric technology is consistent. It is simple and easy to understand and use, easy to manage due to the rigidity of the model. Each phase in this model has specific deliverables and a review process and the phases are processed and completed one at a time.

3.2.1 The Functional Model of the Proposed System

The Unified Modelling Language (UML) Use Case diagram for Biometric Authentication System for Staff Attendance management (BASSAM App) is shown in Figure 2. The Use case diagram illustrates how the users interact with the system. It also describes the graphic diction of the interaction among the element of the system and the methodology used in system analysis to clarify and organize system requirement. It shows how functionalities relate between the internal/external actors. The following are actors are the participants of the system:

Actors: System administrator, Staff (academic and non-academic staff)

Staff (academic and non-academic): The staff get enrolled, sign-in, sign-out and give exception case.

System administrator: The system administrator registers, logins into the system, enroll staff, keep track of staff daily attendance during sign-in and sign-out periods, enters exception cases into the system, view and print reports of registered staff, staff attendance, exception case and generate monthly attendance summary.

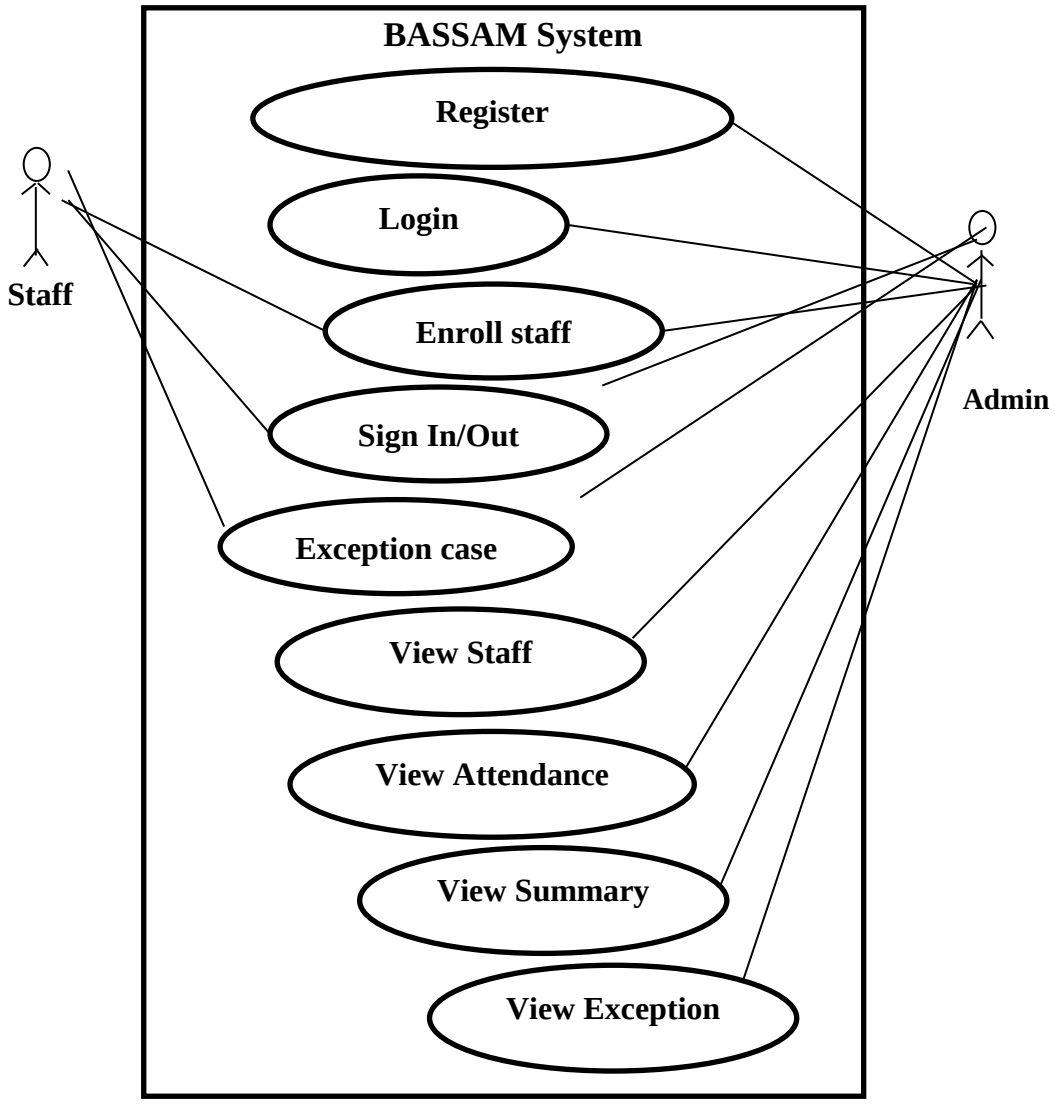

Figure 2: Use case diagram of the proposed system

3.2.2 Activity Diagram of the Proposed system

The activity diagram illustrates the behavior of the proposed system with regards to various activities. These activities are modelling elements that depicts the execution of a set of operations. However, the execution of these activities can betriggered by the completion of other activities, by the availability of objects, or by internal/external events. Figure 3 shows different activities for Biometric Authentication System for Staff Attendance Management (BASSAM), with rounded rectangles representing activities; arrows between activities representing control flow and thick bars representing the synchronization of control flow.

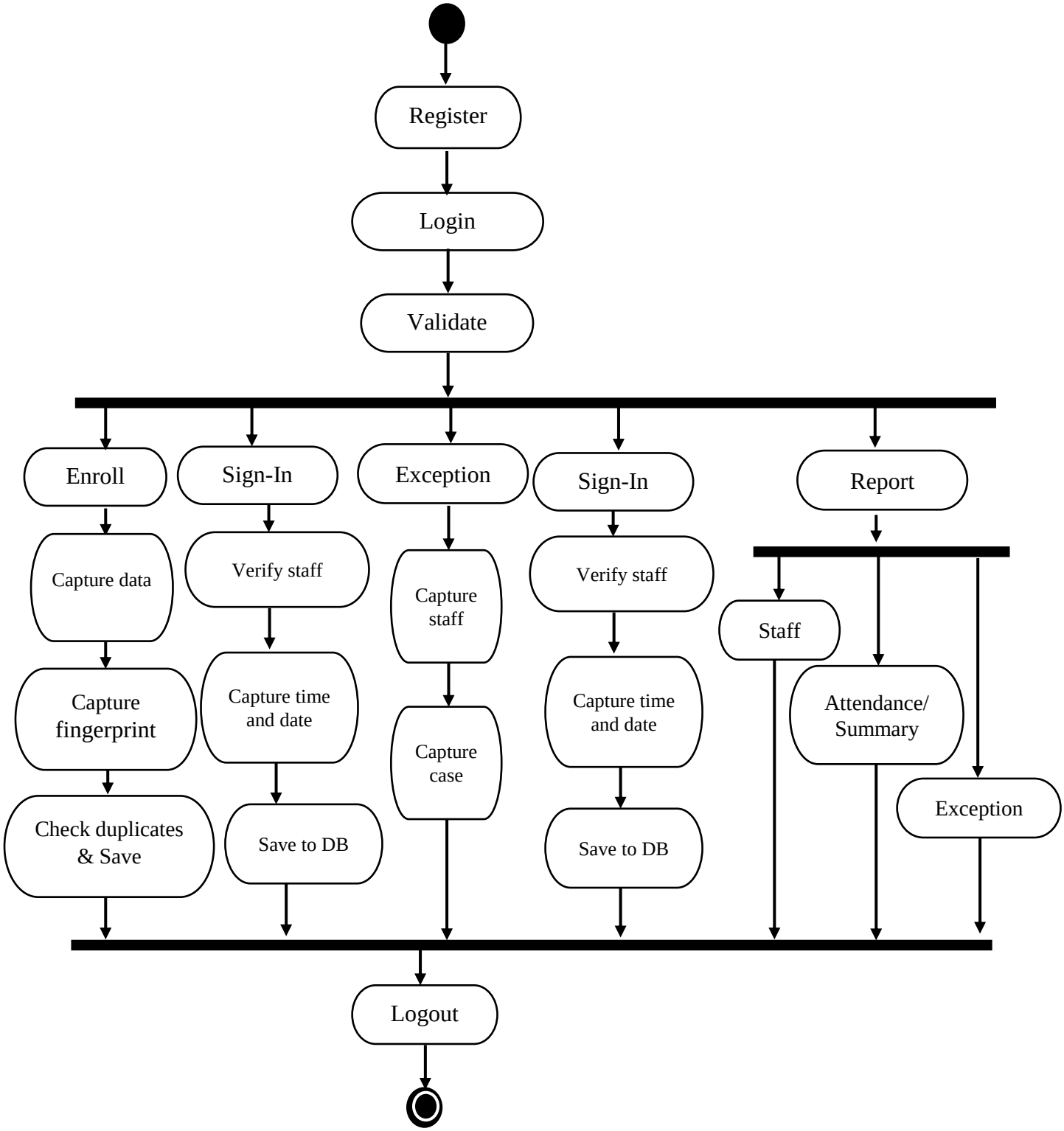
Register
Login
Validate
Enroll
Sign-In
Exception
Sign-In
Report
Capture data
Verify staff
Capture staff
Verify staff
Staff
Capture fingerprint
Capture time and date
Capture case
Capture time and date
Attendance/ Summary
Exception
Check duplicates & Save
Save to DB
Save to DB
Logout

Figure 3: Activity Diagram of the proposed system

3.2.3 Architecture of the Proposed system

Theillustrative representation of the proposed system architecture is shown in figure 4. System architecture depicts the various key components of the proposed system. Data capture component is responsible for the enrollment of staff with their fingerprints (left and right thumb and index fingers) samples extracted using scanner and stored into the database. Data verification component is responsible for authentication of staff during their sign-in and sign-out periods with their fingerprints (left and right thumb and index fingers) samples matched with that stored in the database using scanner. Data report component is responsible for displaying reports of registered staff, staff attendance and summary and exception cases.

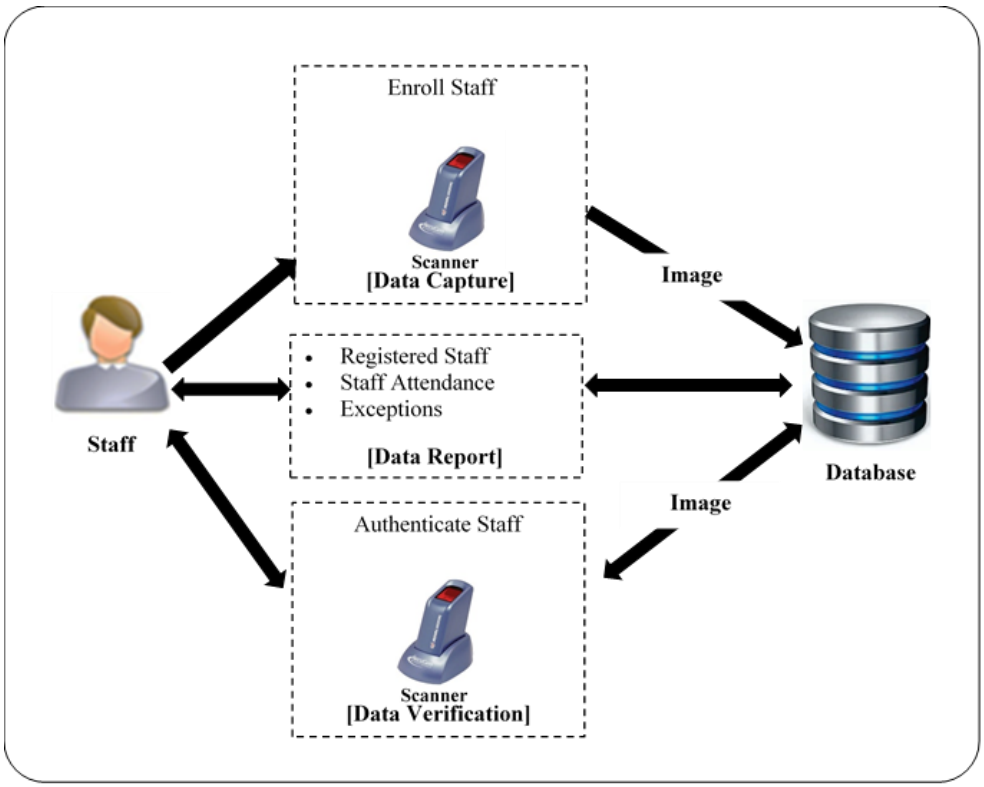

Figure 4: System Architecture of the proposed system

3.2.4 Database Structure of the Proposed system

The database was designed using SQLite relational database. The main table of users was linked with other tables on a one-one or one-to-many relationship. Figure 5 shows different tables such as admin, staff, attendance, exception and their relationships.

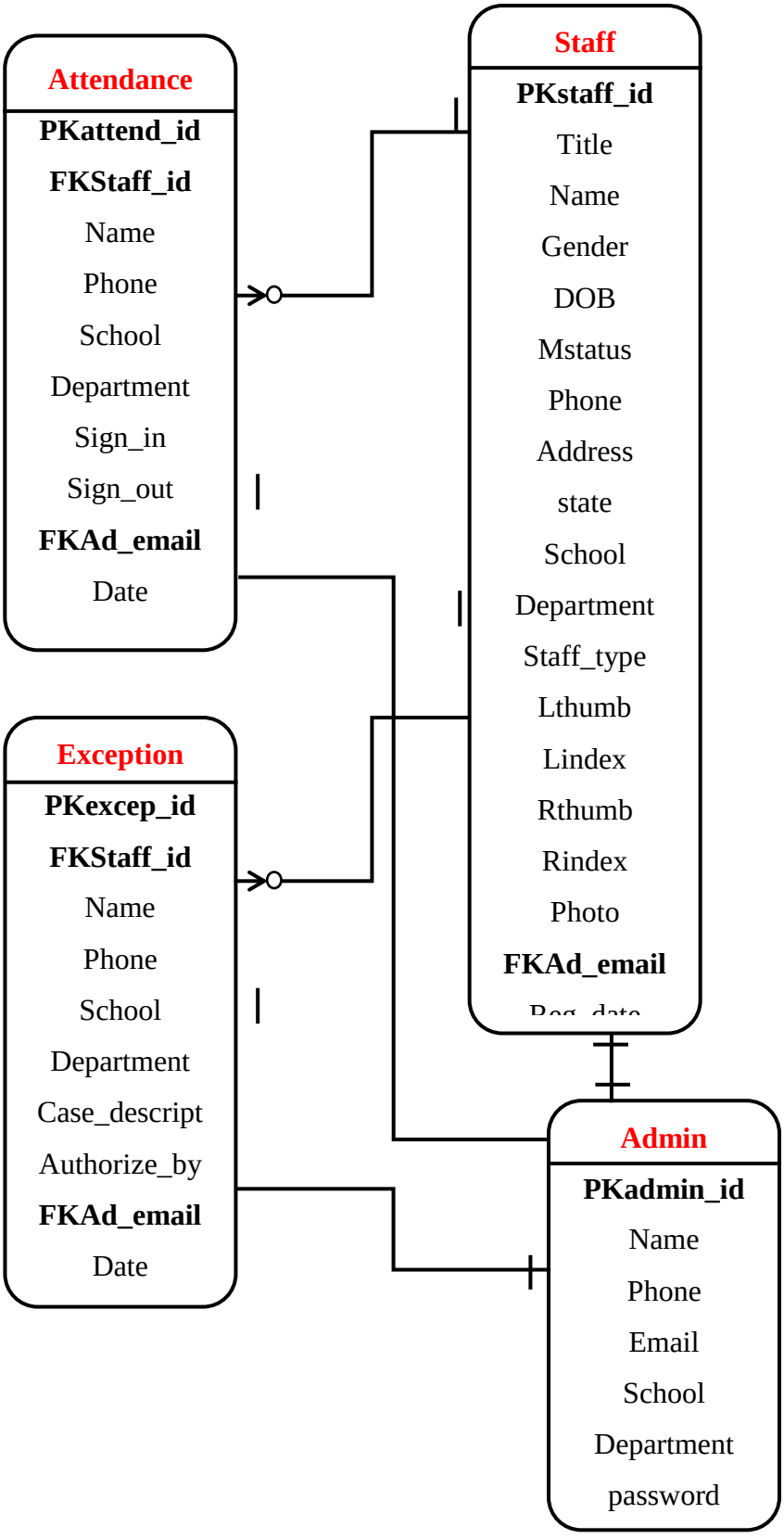
Attendance
PKattend_id
FKStaff_id
Name
Phone
School
Department
Sign_in
Sign_out
FKAd_email
Date
Staff
PKstaff_id
Title
Name
Gender
DOB
Mstatus
Phone
Address
state
School
Department
Staff_type
Lthumb
Lindex
Rthumb
Rindex
Photo
FKAd_email
Exception
PKexcep_id
FKStaff_id
Name
Phone
School
Department
Case_descript
Authorize_by
FKAd_email
Date
Admin
PKadmin_id
Name
Phone
Email
School
Department
password

Figure 5: Database Structure

3.2.5 Experimental Design of the Proposed System

While verifying the biometric images, the system was tested for its accuracy on positively identified users or lack thereof.

The experiment was measured using the following performance metrics:

The false positives or False Acceptance Rate (FAR): This is where an impersonator is incorrectly matched to a genuine user template stored within the biometric system. This reflects the ability of non-authorized users i.e. employee or supervisors to access the biometric system through no effort or using spoofing methods.

The False Reject Rate (FRR)/False Negatives: this is where a genuine user is incorrectly rejected from a biometric system. This may occur as a result of user presentation error or corruption of previously enrolled authentication templates.

Weighted Error Rate (WER): Weighted Error Rate is the sum between the False Acceptance Rate and the False Rejection Rate. In equation form, Weight Error Rate is expressed as follows:

$$WER = FAR + FRR$$

True Acceptance Rate (TAR): Probability that the system correctly matches a genuine user. A measure of accuracy defined as follows:

$$TAR = 1 - FRR$$

Failure to Capture Rate: Within automatic systems, the probability that the system fails to detect a biometric input when presented correctly.

Crossover Error Rate (CER): Percentage rating of FRR versus FAR. A lower CER indicates better matching accuracy. The non-cooperative users were those from the population but refused to participate in the exercise for one reason or another.

The unidentifiable users are those whose fingerprints cannot be captured because they are not present or the fingers are not in a good state.

4. RESULTS AND DISCUSSIONS

The proposed system of biometric authentication system for staff attendance management captures workers' attendance electronically. The system was developed using Microsoft Visual Basic Studio 2015 with other tools, which include Hamster Plus SecuGen Fingerprint scanner, Standard Development Kit (SDK) for Visual Basic DotNet Framework, Crystal Report, VB.net programming language and SQLite Relational database for data storage. It involves the enrollment of staff with their fingerprints (left and right thumb and index fingers) samples extracted using scanner and stored into the database, the authentication of staff during their sign-in and sign-out periods with their fingerprints (left and right thumb and index fingers) samples matched with that stored in the database using scanner andthe displaying of reports of registered staff, staff attendance and summary and exception cases.

The eligible workers of the college were the only ones that was allowed to be enrolled into the system and take daily attendance. The records of the registered staff and attendance with monthly summary can be retrieved and printed. The sign-in period start from 7:00 am and ends at 9:30 am in the morning with 30 minutes period of grace. The sign-out period starts from 3:00 pm and ends at 5:30 pm in the evening. The design requirement and system requirements were met and desirable results were achieved, some of which are discussed in this section.

4.1 Staff Enrollment

This phase is responsible for the registration of workers of the institution. This is important in order to uniquely identify each worker of the system. Some personal details and academic information such as staff Id, title, name, gender, date of birth, marital status, phone, address, state of origin, school, department, fingerprints and photo were required and captured from

the staff, which is later stored into the database. Figure 6, shows the staff enrollment implementation.

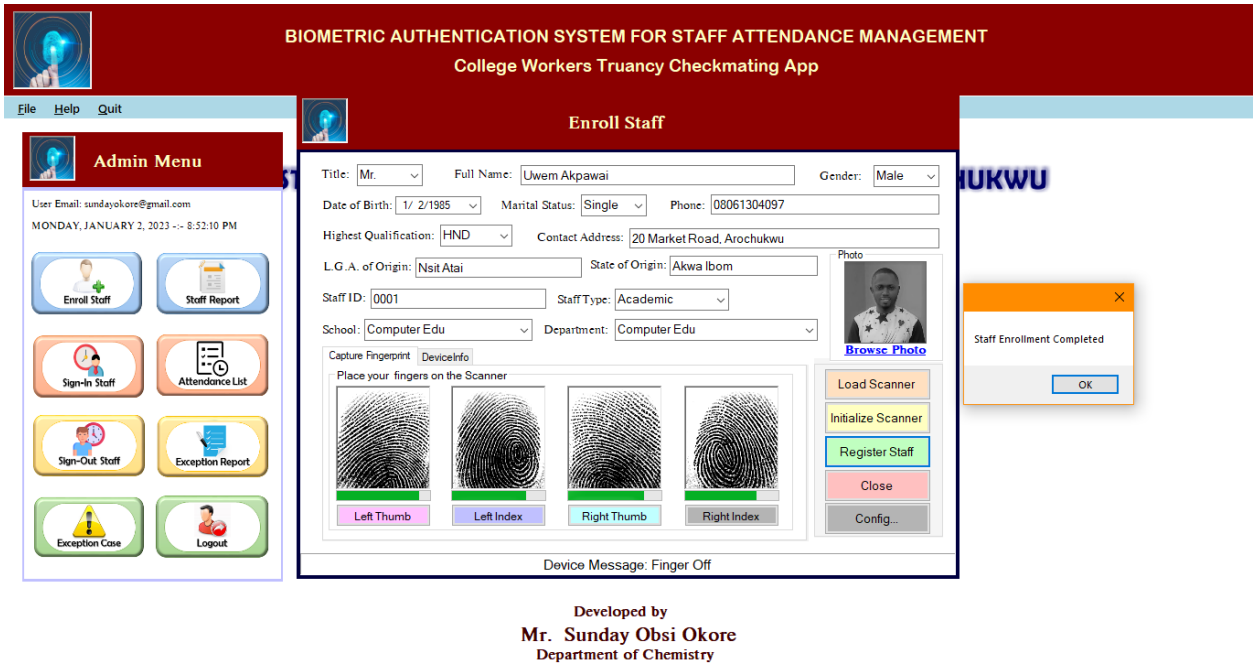

Figure 6. Staff Enrollment (personal and academic information)

4.2 Staff Authentication

This phase is responsible for taking staffs' attendance information in the morning period as well as in the evening period. During Sign-in period, the fingerprint scanner is captures and extracts the fingerprint sample of the staff, match it with that of the database, if the match is successful, the staff's data and time (after successful synchronization with Internet time) is captured and stored into the attendance list. The process is repeated during the Sign-out period but only the staff that signed-in (verified) in the morning can complete the daily attendance. This approach hinders truancy, manipulation of attendance list and impersonation as only staff verified is sent to the attendance list. Figure 7, 8, 9 and 10 show the staff authentication's implementation.

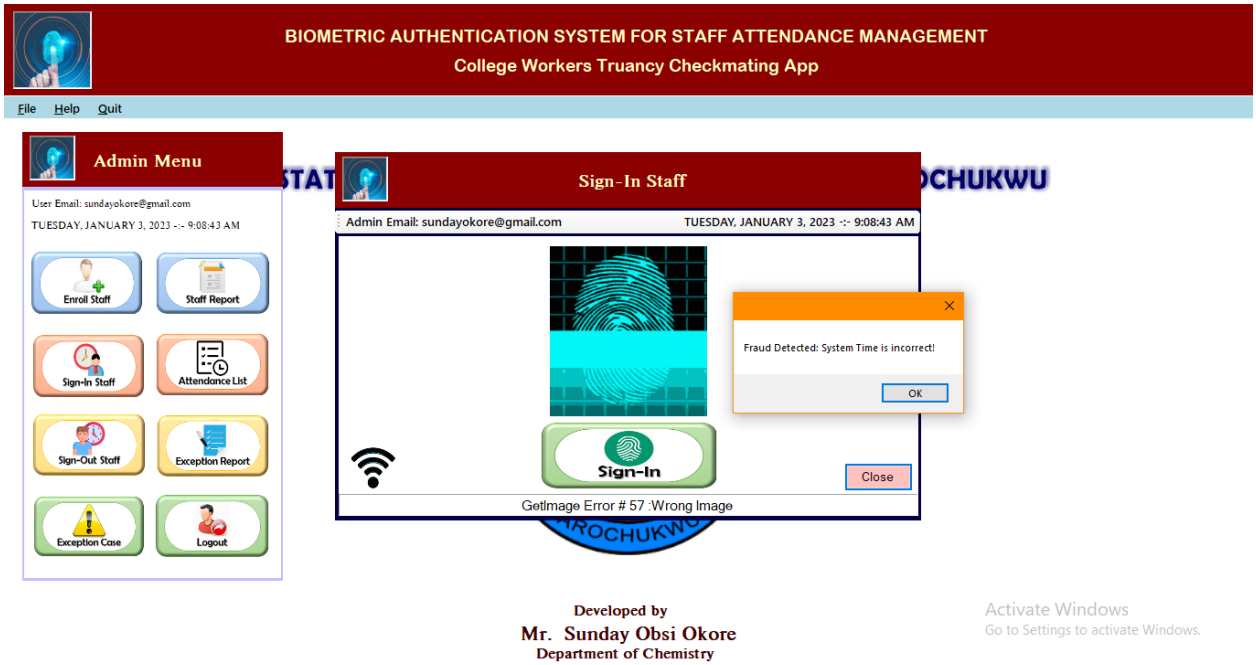

Figure 7. Staff Sign-In Authentication (Fraud detection: incorrect time)

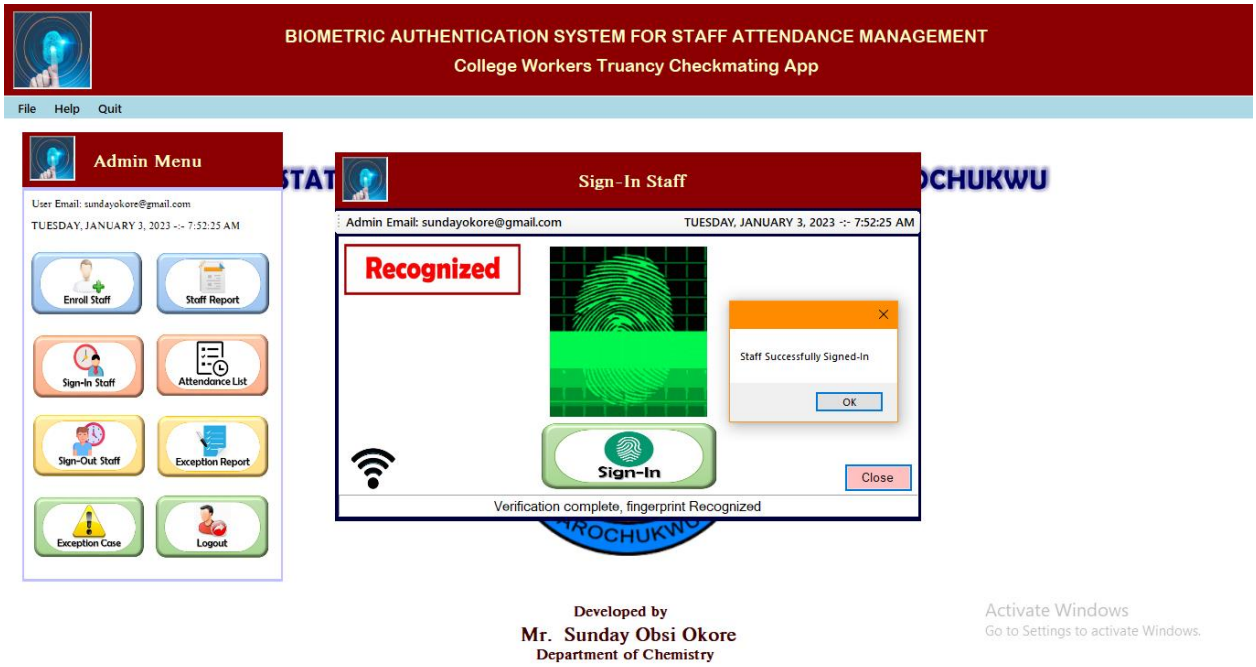

Figure 8. Staff Sign-In Authentication (Fingerprint recognized)

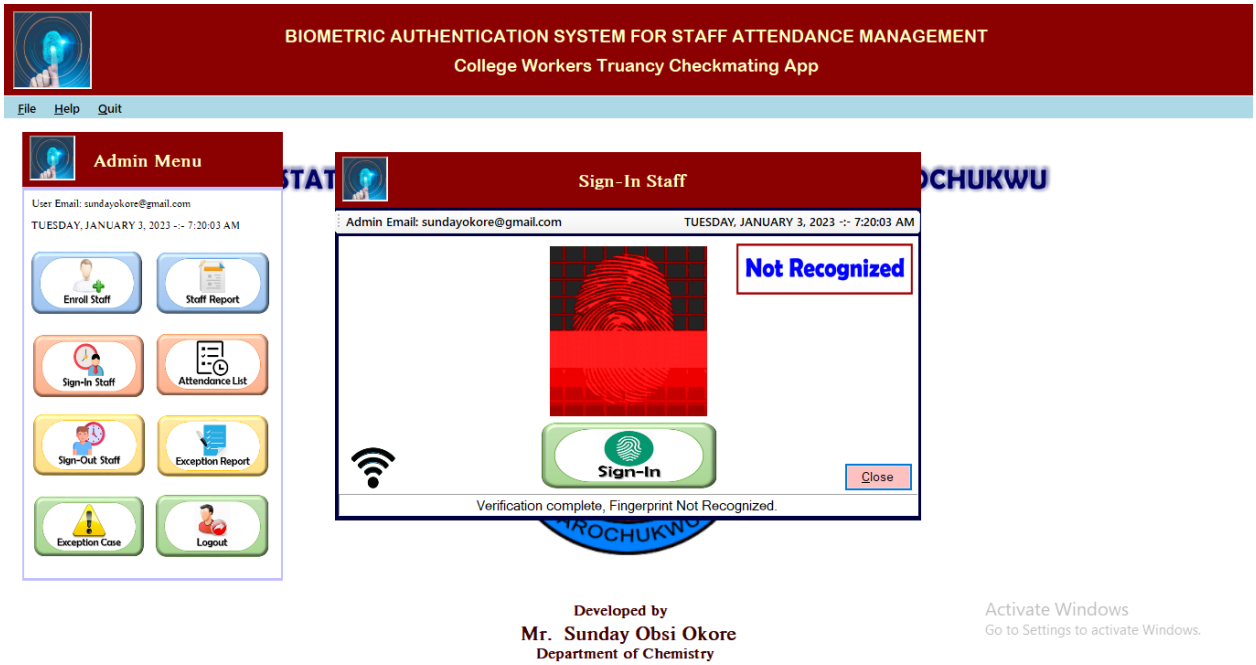

Figure 9. Staff Sign-In Authentication (Fingerprint Not recognized)

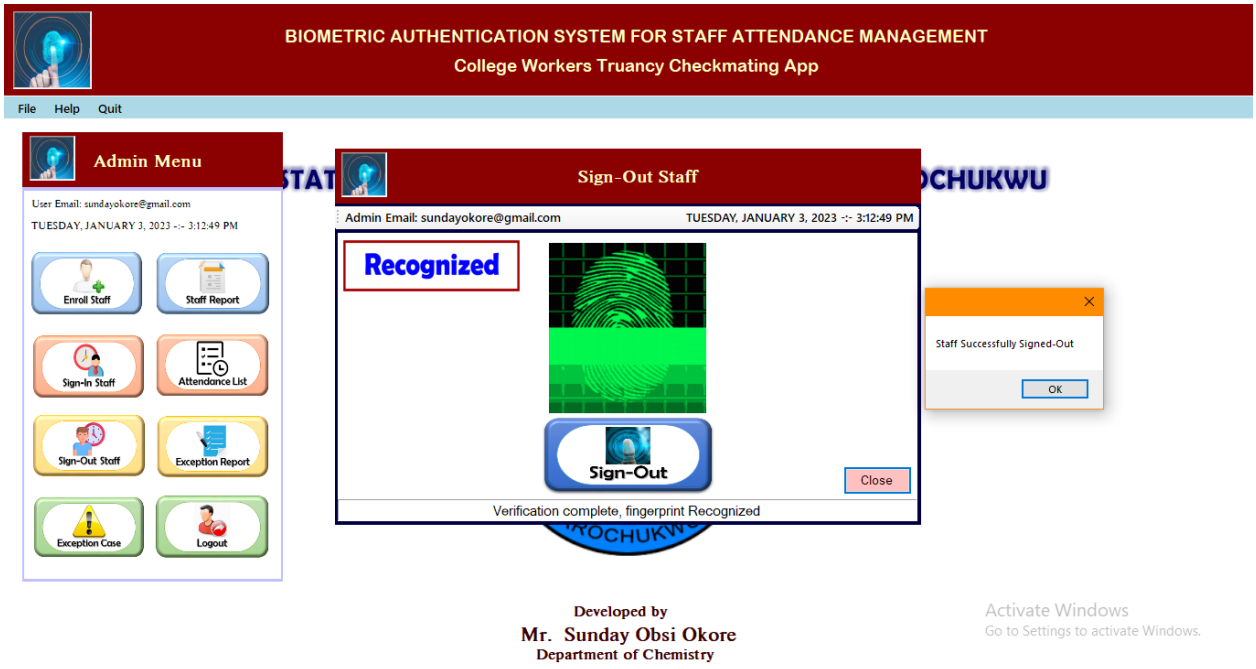

Figure 10. Staff Sign-Out Authentication (Fingerprint recognized)

4.3 Staff Exception Case

This phase is responsible for lodging some information regarding staff that are having some cases such as accidents, health issues, etc., and are being captured alongside the name of head

of department that authorizes such information to be captured. Figure 11 shows the staff exception case implementation.

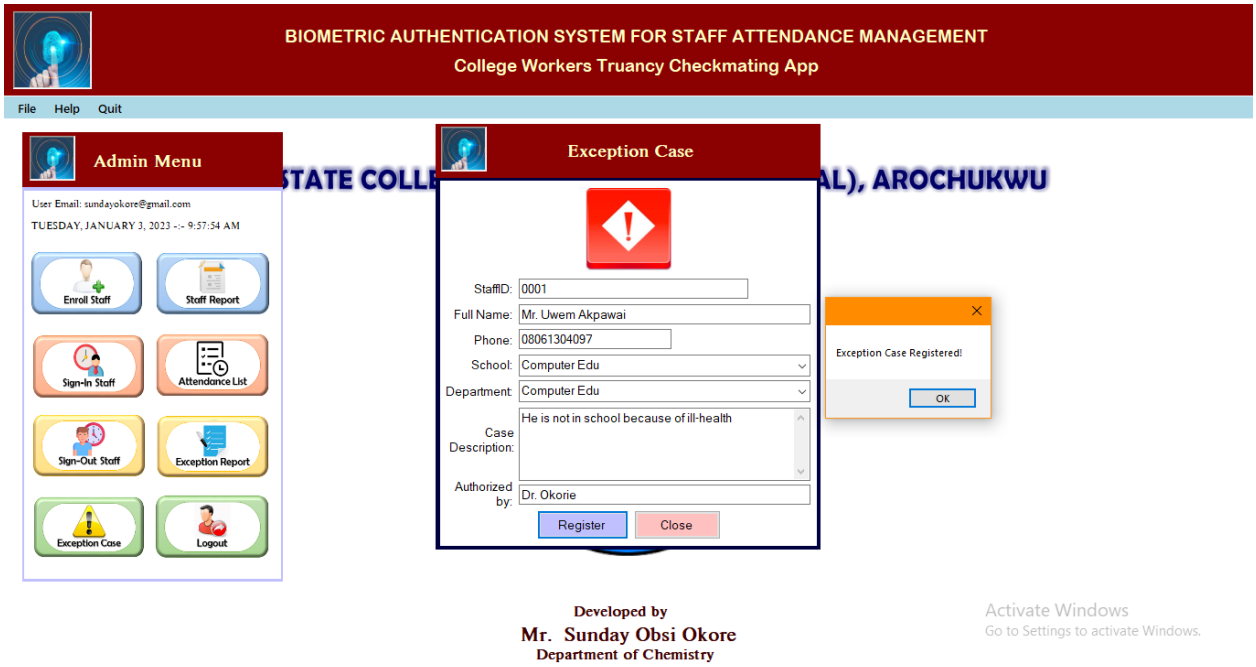

Figure 11. Staff Exception Case (Registration)

4.4 Staff and Exception Case Report

These registered staff and exception report interfaces can be accessed from administrator's menu, where the information of registered or enrolled staff and all the staff that had different cases and were exempted from signing in and out in the department are retrieved and displayed. The system is designed such that the administrator can delete any staff from the database as well as view and print the reports. The interfacesare shown in figure 12 and 13.

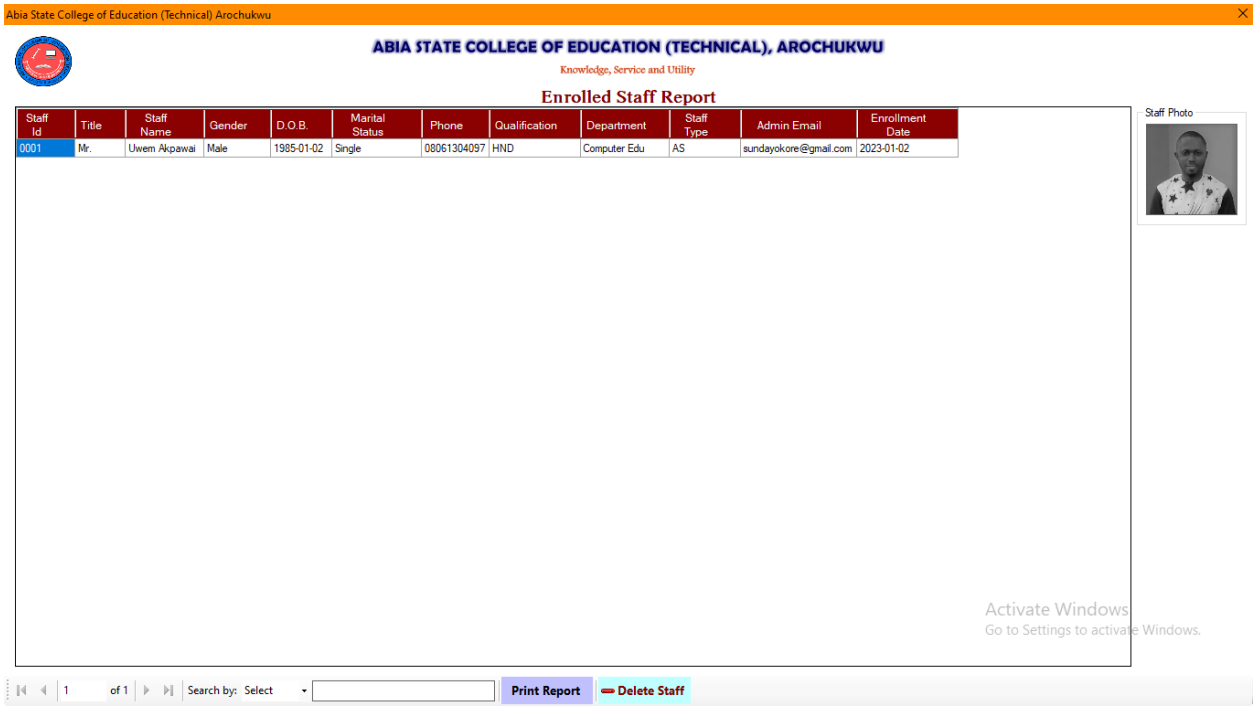

Figure 12. Enrolled Staff Report

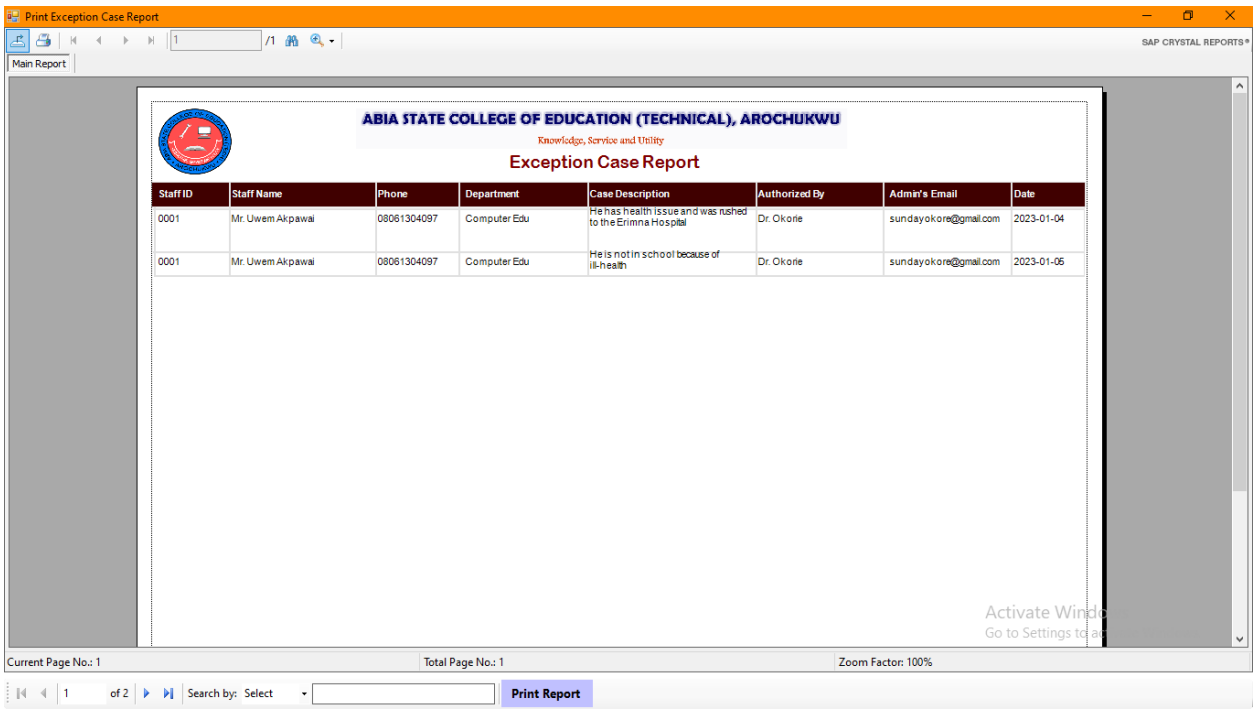

Figure 13. Exception Case Report

4.5 Attendance and Summary Report

TheAttendance and attendance summary report interfaces can be accessed from administrator's menu, where the information of staff that had signed in and signed out successfully in the department are retrieved and displayed. The system is designed such that the administrator can generate the summary of attendance of staff on monthly basis, which canviewed and printed. The interfaces are shown in figure 14 and 15.

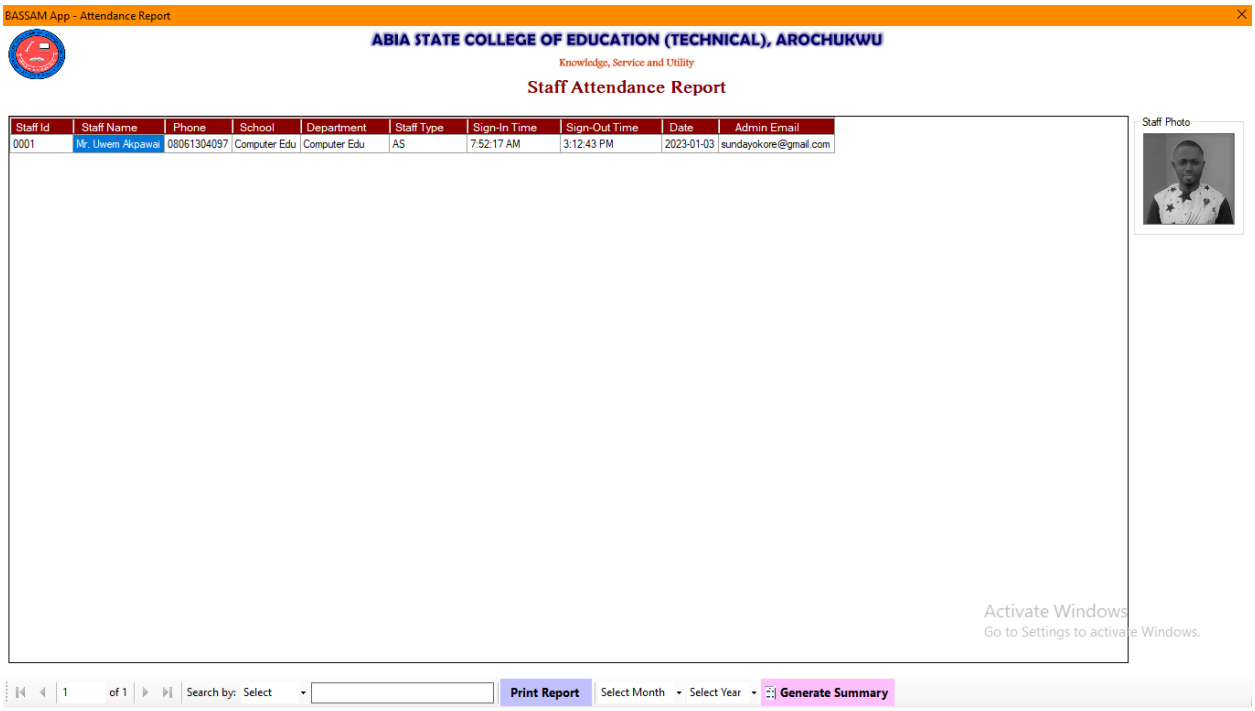

Figure 14. Staff AttendanceReport

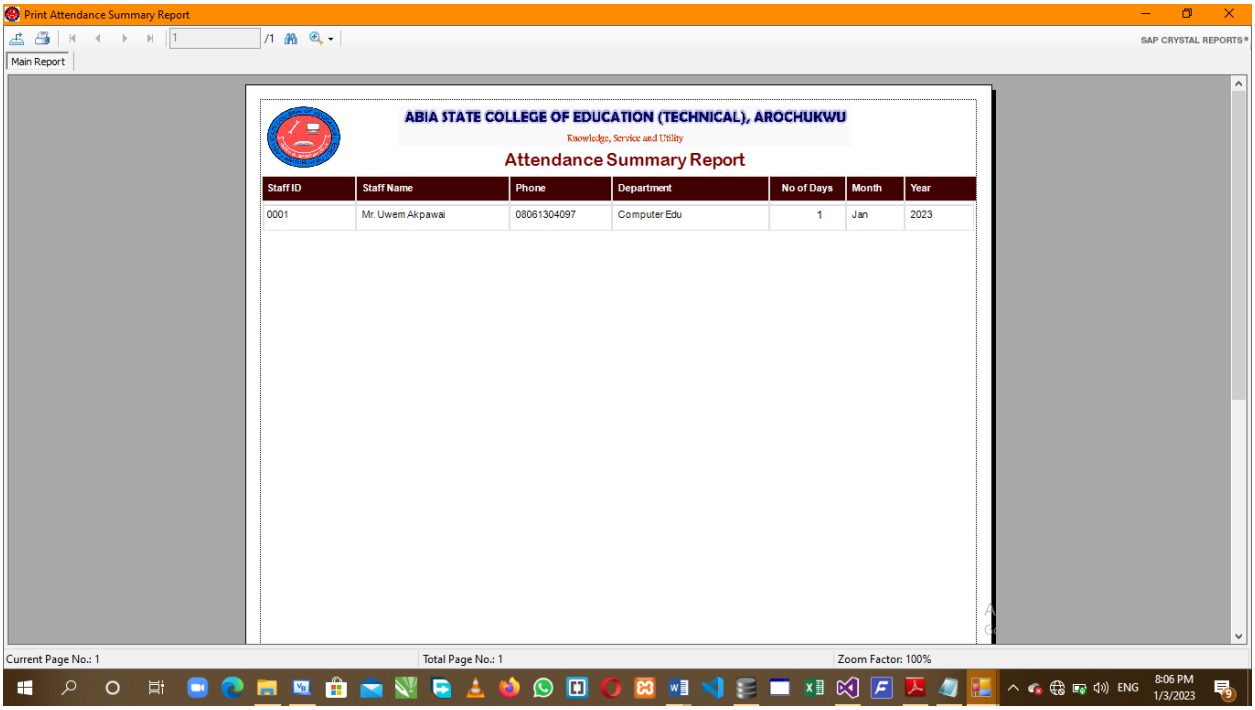

Figure 15. Staff Attendance SummaryReport

5. CONCLUSION

Truancy is a perennial and persistent problem in the institution. The school management has introduced some measures such as signing of signature at their various departments, deduction of money for those days one was absent from work and presently signing of signature at college gate to curb this menace. The implementation of biometric-based authentication system for attendance management will greatly assist the institution in mitigating and eliminating truancy. The developed system will help in monitoring and maintaining daily (morning and evening) attendance of staff in the college by capturing and verifying workers' fingerprints. It will thwart intruders' access to administrator's login details and capture exception cases of workers who are sick or having accidents. The system will help prevent impersonations, manipulation and forgery of attendance register, enforce punctuality, ensure higher productivity and eliminate ghost workers in the institution.

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