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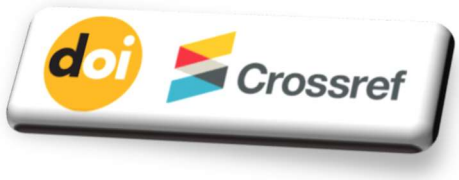

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Mobile Based Student Attendance System Using Geo-Fencing With Timing and Face Recognition

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ABSTRACT

Developing an effective attendance management system has always been a difficult issue for any company, ranging from schools to universities. Smartphones have been used for attendance with technologies such as face recognition, fingerprint-based attendance, and other types. The attendance management system (AMS) and its problems are discussed in this study. The study presents a student attendance system for schools and colleges combining Geo Fencing using the geofencing API from Google Play services and Google location services dependencies along with Firebase and Geofire dependencies and Face Recognition functionality. This is performed by acquiring live location of students and a geo-fence of the class area, the system also performs a face recognition for pre-registered student and attendance is automatically taken when a student has spent over 90% of the time within the set geo-fence (Classroom). This system was developed using Android Studio Integrated Development Environment (IDE) which is being used for the development of native android applications. A questionnaire was however designed and results gotten to further explain how well the functionalities work. The responses derived were subjected to statistical examination using SPSS. Discoveries showed that attendance system was able to improve identification, verification and accuracy of student attendance.

Keywords: Attendance, Geo-fence, Face Detection, Global Position System, Barcode, Database

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1. INTRODUCTION

Attendance plays a pivotal role in determining the academic performance of children and youth in schools and colleges. The regularity of attendance shows that the students are less likely to engage in delinquent or destructive behavior (Bhattacharya et al., 2018). Chronic absence increases the risk of school failure and early dropout. Attendance is a state of being present at a place, especially an institution. Attendance is very important in an institution as it represents how punctual a student is. Manual maintenance of attendance is inefficient due to attendance by proxies or impersonations. Class attendance has a significant effect on academic scores (Ayodele, 2017). Therefore, most institutions of learning require students to have a certain percentage of attendance to be eligible for examination. This is due to the belief that an above-average attendance will enhance student academic performance (Ayodele, 2017).

Before the advent of computers and mobile devices, the most common method of taking attendance in classrooms in our Institutions employs the use of pen and paper. The attendance system usually involves calling out the names of students in a classroom or by passing an attendance sheet around the class where each student is expected to sign the sheet to confirm their physical presence. Furthermore, this very current popular method of attendance signing for example in Nigeria is a challenge especially for large population classes of students as maintaining the records for these students is one very significant and fundamental task by Lecturers (Sultana et al., 2015). Also, the likelihood of having incorrect attendance records, altered data, attendance fraud etc. is very high with this attendance monitoring system (Dankar & Kundapur, 2019).

To resolve this problem of attendance, many mobile based attendance management systems have been proposed and introduced in recent years (Sai, 2021; Bhattacharya et al., 2018) though approaches to solving this problem could be classified into RFID/NFC-based and visual-based methods. Smartphones have been used for student attendance with technologies such as face recognition, fingerprint-based attendance, Bluetooth based attendance and so on. The use of smartphones as an attendance and monitoring device is prone to fraud by students such as attendance records not at the specified location, recording of attendance by others, or student who leave the campus after recording its presence (Shahab & Sarno, 2020). The combination of fingerprint, Secure user ID, and GPS location as authentication factors can be used to secure and improve the process of recording attendance. Additionally, securing the attendance application against emulators and fake location module would improve the security of the Mobile Attendance System (Utomo & Hendradjaya, 2018).

However, the electronic attendance management system with example in all available biometric system (such as the eye, face, finger etc.) being introduced and used by some universities and educational institutions in Nigeria and beyond (Bhattacharya et al., 2018) engrosses more extended time with unusual subsistence of their design (Jabez et al., 2020). For example, Classroom attendance using RF cards, causes problems such as recognition distance and the need for a check process in which students have to read the card each time with a reader for attendance (Syed, 2021). Also, it is not possible to respond in real time to the situation of midterm (early leave, absence from the second lecture time, etc.) because it is used in the lecture time of one subject with the record checked once (Sultana et al., 2015).

In order to solve these problems, the various mobile attendance systems proposed are also unable to fundamentally solve problems such as interim and proxy attendance because they check attendance using only the application of a smartphone (Utomo & Hendradjaya, 2018).

This paper focuses on the use geofencing technology, which is a positioning-based technology that detects the entry and exit of people, objects, etc. in areas separated by virtual boundaries (Eldho & Joseph, 2021; Ozdemir & Tugrul, 2019). The proposed system solves the problem of intermediate attendance and alternate attendance by setting the student to automatically record the access record when entering and leaving the classroom set as a geofence with a smartphone. Geofencing is a sophisticated time management system with geofencing capability that helps track student attendance in real-time (Shahab & Sarno, 2020). It enables organizations to record the attendance of staffs and institutions to manage the attendance of students from any location (Ozdemir & Tugrul, 2019). The use of Geofencing in the system is intended to provide a location boundary where student can make presence and face recognition for their validation to minimize the occurrence of fraud in absenteeism. In the proposed system, every student is required to have a student ID, logon password and register a face photo before being able to use attendance through an existing mobile application.

This paper is structured as follows. Section one contains an introductory part of the paper. Section two reports the existing literature. In Section three, our proposed mobile based attendance system methodology was described. Section four contains description of the system testing and validation. Finally, section five concludes the paper and highlights feasible future directions for the work.

2. LITERATURE REVIEW

A number of related work exist on the application of different methods and principles to effectively monitor the attendance of students in Tertiary Institutions. The issue of poor class attendance rate in higher institutions of learning has been and is still a major concern for educators and educational researchers all over the world (Aderounmu & Tawa, 2017, Ayodele, 2017). In recent years, several researchers have dedicated a lot of their effort to the development of attendance monitoring systems, this has made possible the availability of several attendance monitoring systems based on current technologies lately (Baharin et al., 2020). There were many studies aiming at building automated attendance tracking systems, and many of them have been implemented in the real-world environment successfully. Normally, approaches solving this problem could be classified into RFID/NFC-based and visual-based methods.

RFID technology was widely used in many scenes in our daily life from apartment security tags to payment card etc. (Adukkathayar et al., 2015). Students using RFID/NFC-based systems would be equipped with a RFID tag containing unique registration code, or directly write the code into their cellphones using NFC technology. By hovering tags or cellphones upon the RFID reader placed in every classroom, students' appearance in a class would be recorded instantly. Saparkhojayev et al., (2012) and Chang (2011) introduced the method of applying RFID technology into classes. They have utilized RFID readers connected to the Internet and attendance records would be transmitted to a backend server.

Zhi et al., (2015) on the other hand employed NFC modules inside modern cellphones integrated with secret code for authentication whereas Srinidhi & Roy (2015) provided a web-based platform collecting and analyzing records in real time, along with SMS and email notification functionalities, which was distributed into real environment and indicated its efficiency. However, using RFID technologies involves installations of specific readers in the classroom leading to expenses on hardware and engineering works. Besides, these methods also have less or no considerations for student with multiple RFID cards or card losing situations, which cannot accurately authorize student's identity. Summarily, the major drawback of most RFID system is not being able to ascertain whether the user detected is the owner of the actual card (Chen & Tsai, 2011). Nowadays, the use of smartphones both Android and IOS is growing rapidly. At least, almost every University student talk less of working class people can afford to use a smartphone to communicate.

Based on that, the use of an application on a smartphone can be a solution to help the attendance process in the School and at work, hence, the Visual-based systems can come into play. This system is being believed to possess mechanisms to help minimize student fraud in case of absences. Oktavianto et al. (2012) proposed a real time video analysis system for logging attendance which could run at 16 frames per second. Instead of using single camera, Park et al. (2013) implemented a system using three Kinects to track students' appearance, providing much higher accuracy in real environment test. However, face recognition algorithms are far from perfect at present and engineers have to deal with the so many issues. Bad light conditions, different facing angles and poses by the students might cause serious decrease in accuracy of the result. In real world applications, such inaccuracy means even more manual work than to check and correct the records (Yang et al., 2016).

Sultana et al., (2015) developed smart location-based time and attendance monitoring system. This is implemented on a smart-phone with Android as its operating system. Any organization has a specific location that can be determined via GPS service of the phone. This application is made specifically for corporate organizations without many privileges given to the user. It is based on GPS location services only and is therefore not very accurate. Raghuwanshi & Swami, (2017) proposed an attendance system using video and face recognition. The system used a camera placed in various classrooms in order to detect student's presence in class automatically. This system simplified the attendance process but it required a high cost to operate. If it is used in a company which has various locations, the companies must provide a large number of cameras and thus very expensive to acquire and maintain.

Varadharajan et al. (2017) suggested a face recognition-based method for automatic attendance system. There were four stages during the device usage, the first is background subtraction, in which the background of the image is removed. The image is subtracted, leaving only the face in the image. Face detection and cropping is the second component. Only the faces are cropped and stored in the images. The third step involves using the Eigenvalue method to recognize images. Eigen vectors are determined using formulae in this system, and images are recognized. Between the stored and testing images, the Euclidean distance is determined. After that, attendance is registered. Face recognition is difficult with this approach as the Eigen vector used in work has an accuracy of between 60-70%. However, the Haar features which yields a better result other than the Eigen vector can be used to improve on the accuracy solution.

Bhattacharya et al., (2018) proposed a scheme that avoids the pitfalls of the conventional manual attendance system. The research explained how real-time face detection and recognition can be used to track student's attendance. The work presented an automated attendance device that consists of a camera mounted in the classroom to capture photographs, accompanied by multiple face detections. Students' Face Database Development, HOG features, Face Detection and Eye Detection, SVM Classifier, Comparison/Recognition, and Attendance Marking are just a few of the steps in this method. To achieve the desired results, Viola-Jones and HOG functionality as well as an SVM classifier were used.

Dankar & Kundapur, (2019) presented a simple user-friendly mobile application called "Automated Mobile Attendance System" (AMAS). AMAS is interfaced with a website in the backend for data entry and report generation. The application is able to track students using GPS and Bluetooth beacons to confirm and verify their presence in classrooms. The application maintains a record of the absentees that is synchronized with tables in a remote database server regularly. This application reduces the time required to take attendance, prevents the loss of data as well as provisions to edit incorrect responses. AMAS is developed using Android Studio 3.0.1 and is compatible with 4.4 (KitKat version). Son et al., (2019) introduced an automatic attendance system based on the combination of facial recognition technology and interaction with the existing academic portal.

They conducted a review of several modern methods to select the most suitable open framework for individual tasks, this led to this proposed design which is flexible and allowed applicability to large-scale set of students without compromising predictive accuracy. They tested their system on more than 2200 freshmen at FPT University in Hanoi, Vietnam and initial numerical results shows the effectiveness in both aspects of the accuracy and performance of the prototype. Shanthi et al., (2020) showcased the ability of using facial recognition in attendance management by combining the LBPH and Haar cascading algorithms, this produces a facial map of the individual which helps in improving the post image processing of the individual image taken during attendance.

The result of this method showed a 92% efficiency compared to traditional methods, it also showed some drawbacks that can be easily addressed by improving the environment and using artificial intelligence techniques. Sunaryono et al., (2021) proposed a biometric (face) recognition system which uses with it a QR code on Android phones for attendance management. The QR code was used so that students could be present in available classes, the code which is made up of the course information was placed in each available class and displayed on a raspberry pi screen. All each student needed was to capture his/her face and the code displayed on their smartphone. These two (2) images are their sent to the server for further processing. The results obtained shows a 97% accuracy in terms of face recognition but the computational time is very high. Also, students tend to leave the class after capturing their attendance.

However, after a thorough and critical review of the literature, it is clear that a timing Geo-fence application for attendance monitoring which can provide a major solution to this menace of attendance monitoring has not been developed, hence the need for the development of the proposed system. The proposed system as earlier discussed will use a technique (a geofence algorithm) alongside a face recognition system such that student fraud during absence and leaving of lecture rooms after taking attendance is drastically minimized.

3. METHODOLOGY

Description and Algorithms

In this section, a detailed description of the design and development of the automated mobile based student attendance system will be discussed. A hybrid approach is being employed in this proposed system, the face recognition technique which is an Android based software development framework for real-time face detection and recognition using OpenCV library applicable in several mobile applications (Sai, 2021; Shahab & Sarno, 2020) alongside a location based monitoring system using geo-fencing. The approach suggested in this research is to use a facial recognition technology for authentication and geofence technology to monitor presence of the student for attendance using real time presence within the set perimeter for as much as 90% of the total period of time the Lecturer stays in the class.

The application sense faces in image format after it has been enrolled initially, uses identified landmarks of the faces such as the eyes and nose which is already linked to the student database. Attendance will thus be recorded if the GPS coordinate of the student lies within the geofence for up to 90% of the time for the lecture of a particular course. The use of Geofencing in the system is intended to provide a location boundary where student can make presence for their period of stay within the Geofence and face recognition for validation of student to minimize the occurrence of fraud when students are absent.

The proposed system which is intended to provide a better and possible breakthrough in the Attendance Monitoring System, proposes a Mobile-based Attendance Monitoring System using the Winding Number algorithm for the implementation of the Geofence. Basically, a geofence technology is a positioning-based technology that detects the entry and exit of people, objects, etc. in areas separated by virtual boundaries (Babatunde, et al., 2021; John & Joseph, 2021; Ozdemir & Tugrul, 2019). The Winding Number Algorithm is chosen because it can accurately determine if a point is inside a non-simple closed polygon. It does this by computing how many times the polygon winds around the point (Deshmukh et al., 2018). For identification, the system recognizes an individual by comparing his/her image with every record in the database, that is, every individual is recognized by comparing his/her image with the image stored in the database across his/her matric number. Image identification phase is made up of two (2) stages: Enrolment and Authentication. At the enrolment stage, students register his/her details comprehensively on the application to include capturing of the face and storing all the details while the authentication (detection) stage, faces are first captured using a camera and the detected image is then compared with the database for verification. Summarily, before a student will be able to use the proposed system, the student is required to have a student ID, login password and registered a face photo in the database.

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The proposed system is represented with the Architecture in figure 1 where the application takes in as input the geo-fence coordinates, the enrolled data (id, face and so on) with the information retrieved being stored at the backend. The face landmarks are extracted and compared with what is stored in the database. When the students are within the geo-fence as set by the lecturer, the face is matched with the data source and attendance is recorded successfully after taking due cognizance of the time spent within the geo-fence.

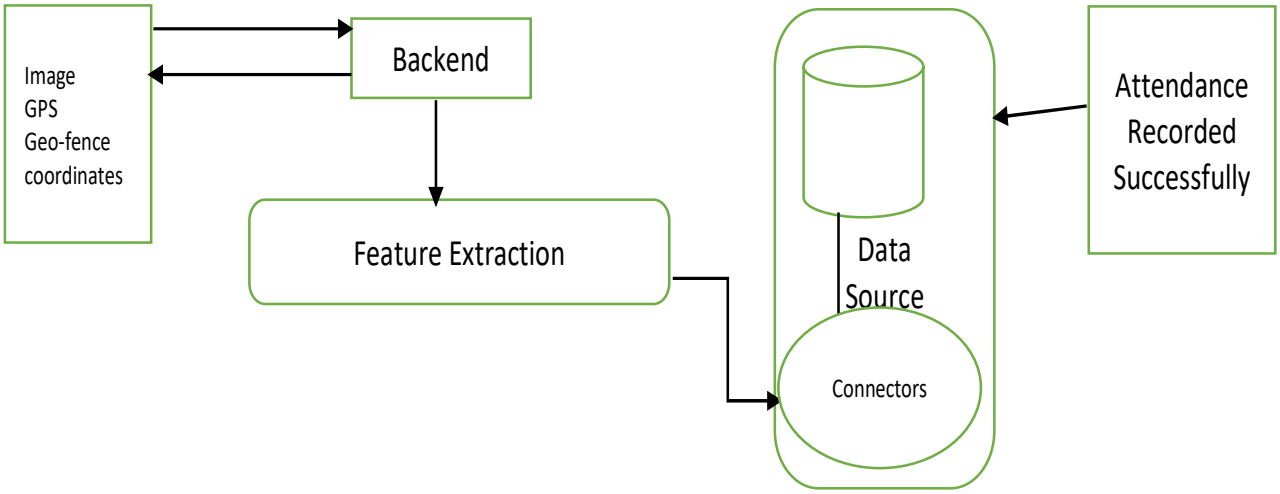

Figure 1: Proposed System Architecture Diagram

Module Description

Face Detection Phase

Detection is the process where the image, given as an input (picture) is searched to find any face, after finding the face the image processing cleans up the facial image for easier recognition of the face. Convolutional Neural Network algorithm implemented to detect the faces.

Geo-fence design Phase

Geofencing: Geofences are virtual perimeters or boundaries around actual geographic areas implemented with the help of software or hardware (Babatunde et al., 2021; Singh et al., 2020). The proposed application would implement geofencing as virtual boundaries around each lecture room that the lecturer would use and subsequently activate the lecture hall per lecture for a course and thereafter all registered students can mark attendance. The geofencing API uses the Google Play services and Google location services dependencies along with Firebase and Geofire dependencies. The location service uses the Geofire service of Google Firebase, a no-SQL real-time database to store the current location of the student which gets updated every time a new location is requested.

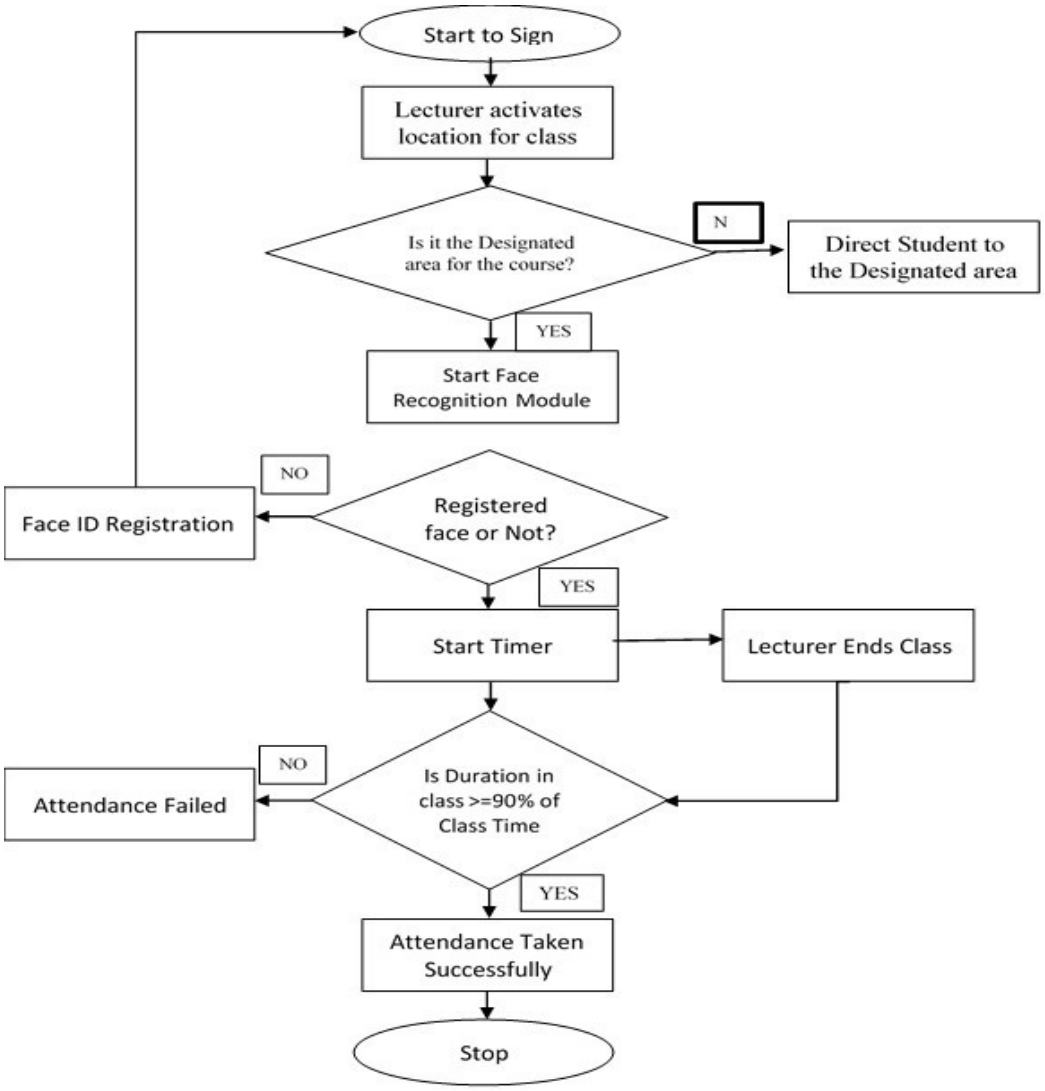

Figure 2: Flowchart for the attendance system

5. TESTING EVALUATION AND DISCUSSION OF FINDINGS

The designs exhibited and discussed in the previous section were created in this section using the Android Studio Integrated Development Environment (IDE), which is used to create native Android applications. To implement a mobile based student attendance system using geo fence and face recognition there are must-have tools of hardware and software. The proposed system was built to be a very robust, modular, scalable and secured. This was achieved using Android Studio, JAVA (Android), SQLite Database and XML. Android Studio makes it possible to create applications that work on the Android OS. JAVA was employed because of its powerful libraries.

Testing and Discussion

The interface as shown in figure .5 is being displayed once the software is successfully loaded. This interface contains all the basic functionalities of the app. The interface as shown in figure 3 is being displayed once the software is successfully loaded. This interface contains all the basic registration and login functionalities of the app. The Mobile Based Student Attendance System Using Geo Fencing and Face Recognition is designed with the interface where the user's image is captured from the camera and stored in the Firebase database. Additionally, from the image, the face of the user is being detected and saved. Figure 4 provides the interface for the student registration and course information as it is being displayed in the figure, the interface contains seven different text boxes for data input; and a button to proceed to image capturing from the camera. The interface of the mobile application is being section into three different phases in which this is one of them. The remaining two interfaces are the face detection and face recognition interface. This interface five distinct functionalities. The functionalities of all the buttons will be further discussed in the figures that follow.

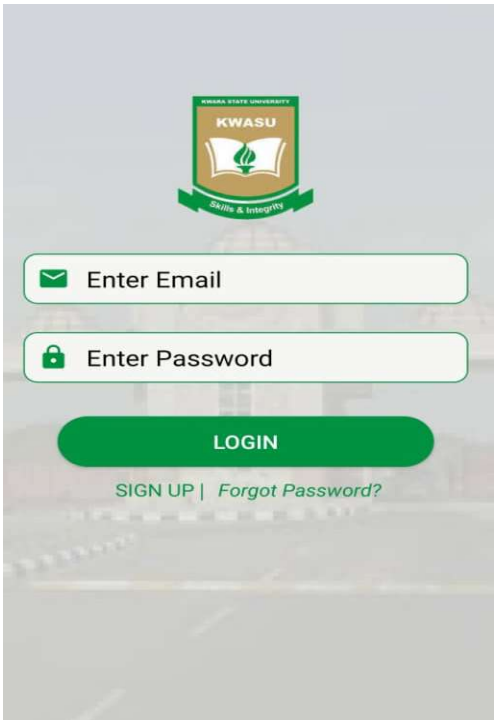

Figure 3: System Interface

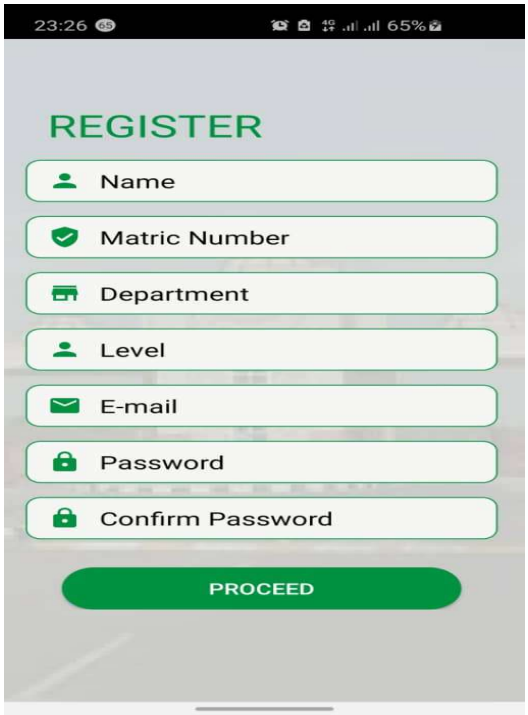

Figure 4: System Interface (Translation)

Figure 7 presents a sample face detection and registration for the student. The original sample comes with other DL model and it computes the results in one single step. For this application, we implemented several steps process. Most of the work consisted in splitting the detection, first the face detection and second to the face recognition. For the face detection step Google ML kit is used. The application defines two bitmaps (the rgbFrameBitmap where the preview frame is copied, and the cropped Bitmap which is originally used to feed the inference model as shown in figure 7).

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Two additional bitmaps are defined for processing, the portraitBmp and the faceBmp. The first is simply to rotate the input frame in portrait mode for devices that have the sensor in landscape orientation. And the faceBmp bitmap is used to draw every detected face, cropping its detected location, and re-scaling to 112 x 112 px to be used as input for our *MobileFaceNet* model.

Figure 1.5: loading info

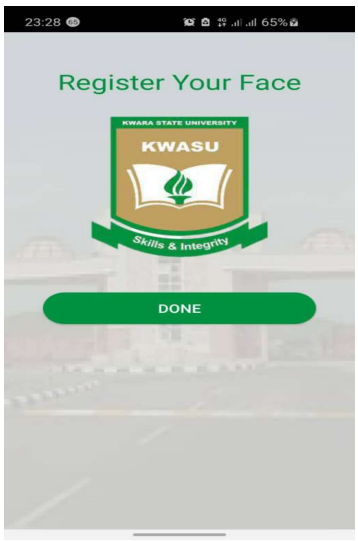

Fig 1.6: Image Registration

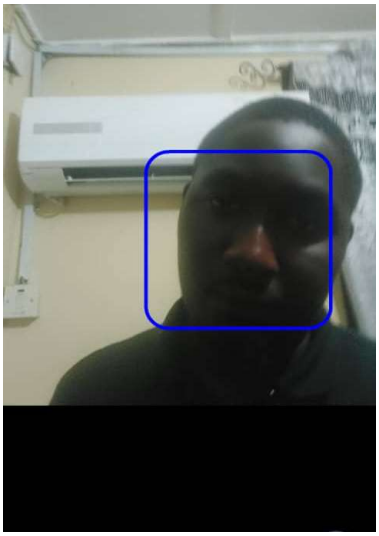

Fig 1.7: Face detection module

Figure 1.8: Selecting Subject

Figure 1.9: Activating a subject

Figure 2.0: Summary Report

Figures 5, 6 and 7 shows the image loading interface that activates the camera, the image registration phase with face detection and face detection module respectively. The image registration module accepts the image of the student from camera and uses the MLkit to detect user face and subsequently stores the face in the firebase database. The face recognition module takes the face that was detected on the input image. Additionally, the faces are compared by computing its Similarity, and then check it against some threshold. If lower we can say that both faces are from the same person. Once the similarity is computed and it returns a lower similarity as compared to the threshold, it means the face has been recognized and the student can take his/her attendance for that particular class and course.

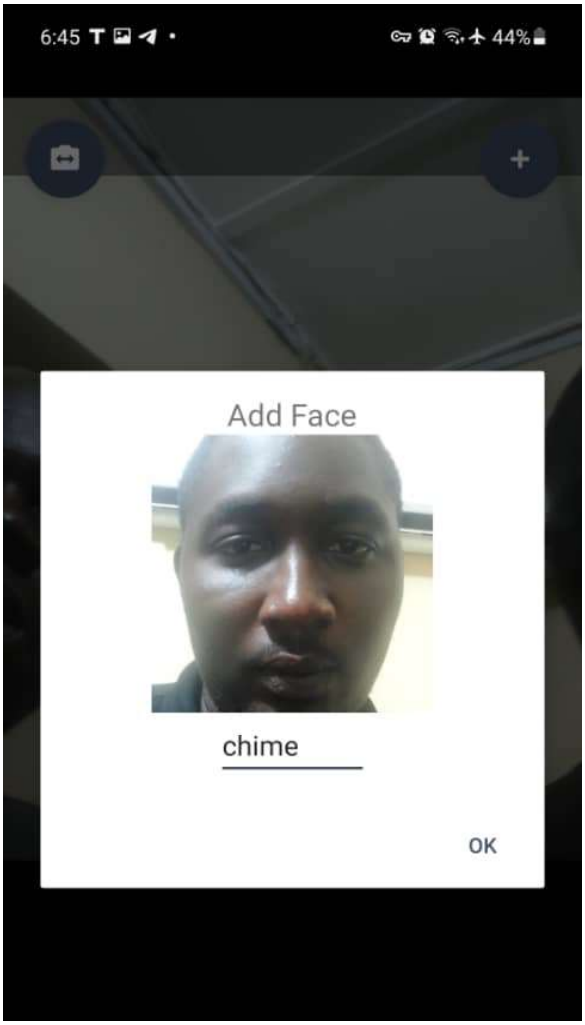

Figure 8: Samples of Screenshot from the Application

Figure 8 shows the registered face of the user, when the face is recognized with the registered face. It should however be noted that it is from the interface of the recognized face that activates the marking of attendance for a particular course. The student is able to take attendance which is submitted to the Firebase Database.

Evaluation

The evaluation process began with the compilation of a questionnaire that outlined the profiles of the subject respondents, who were largely university students. Respondents were asked to use the develop mobile application for attendance in a classroom of their choice in Section B of the questionnaire. On the requirements analysis phase, a survey questionnaire was constructed to determine the different challenges/problems encountered by the Computer Science Student in checking and monitoring of class attendance. The data gathered will be used to determine the important features and functionalities needed on the developed application to address the challenges/problems identified.

Table 1. Ranking of the Common Problems/Challenges Encountered in Manual Checking and Monitoring of Attendance

Method	Frequency	Rank
Checking of attendance is time consuming.	14	1
Attendance records being misplaced or lost.	3	5
Computation of attendance grade involves a lot of effort.	8	4
Attendance record is not that accurate.	5	3
Monitoring attendance is tedious task (tracking of number of absences and tardiness of students)	11	2

Table 1 displays the different problems encountered on the existing system of checking and monitoring of attendance. It shows that majority of the respondents agreed that manual way of checking attendance is time consuming, followed by monitoring attendance is a tedious task. On the last rank, attendance records are misplaced or lost.

Table 2. Level of Acceptability of Developed Application

Software Quality	Weighted Mean	Verbal Interpretation
Functionality	4.12	Moderately Acceptable
Reliability	4.10	Moderately Acceptable
Usability	4.10	Moderately Acceptable
Portability	4.27	Highly Acceptable

Based on Table 2, functionality, reliability, and usability was rated as Moderately Acceptable. On the other hand, portability is Highly Acceptable. With this high evaluation rating, the developed system was proved to be useful and meets the needs of the respondents.

Table 3. Significant Difference between the Manual System and the Developed Application

Groups	Weighted Mean	t_c (computed value of t-test)	$t_{0.05(22)}$ (table value of t-test)
Existing System's Mean on the Level of Acceptability	3.54		
Proposed System's Mean on the Level of Acceptability	4.17	7.58	1.52
		7.58	1.72

Table 3 shows the significant difference of the manual system and the developed system using T-test. Decision Rule: The negative sign of the computed value of t-test implies that the existing system's mean is less than the mean of the proposed system's mean. The tabular value of t for df(22) at 0.05 level is 1.72. Since the computed value of t-test does exceed the critical value, the researchers reject the null hypothesis. There is a significant difference between the level respondents' level of acceptability on the existing and the proposed system.

6. CONCLUSION

Automated Attendance System has been envisioned for the purpose of reducing the errors that occur in the traditional (manual) attendance taking system. The aim is to automate and make a system that is useful to the organization such as an institute. The efficient and accurate method of attendance in the office environment that can replace the old manual methods. This In the course of developing this system the android based mobile application for students" attendance at a university. In this study we developed a mobile application for taking students attendance at Kwara State University, Malete. The developed application has been proven to solve the problem of manually taking attendance and proposes to integrate keying in the attendance in the CMS portal after each class.

There are several improvements that can be suggested in enhancing the mobile applications. The attendance application can be improved by providing the notification from the lecturers to the administrator. This could be implemented upon further research development of the system for the administrator. Attendance App can also be improved by the graphical user interface by incorporating more icons, colours and menus. Furthermore, the attendance application can be improved by adding the function to alert the lecturers like notification in a smartphone status bar or setting alarm sound if the lecturer forgot to key in students" attendance. Although, the number of recorded sentences in the firebase database is limited the system was developed using android studio integrated development environment (IDE) which involves the use of XML for the frontend design and the Java programming language for the backend design.

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