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LOW COST APPROACH TO SECURED STUDENT ATTENDANCE MANAGEMENT SYSTEM DEVELOPMENT

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*Abstract***— In every setting where attendance is important, a system for managing attendance is a crucial tool. Several works exist in automated attendance management systems however, most of the approaches come with a lot of weakness and relatively high operational costs. These include additional hardware installations, less secure, and most critical, not efficient in handling large target/classroom populations. This paper identifies some weaknesses of the most popular approach used in developing student attendance management systems. Hence, develop a low-cost and secured student attendance management system using face recognition and GPS location that can be provisioned as a cloud application and accessible using any internet-enabled mobile device. Using this approach, the student can only clock-in attendance within the stipulated lecture time using their face and must be within the lecture venue coordinates. The proposed system was developed with python using the Django framework. It uses Viola-Jones Algorithm and face recognition API for face detection and recognition respectively. The system was deployed and tested on AWS EC2. The results showed that the system could be adopted by institutions or organisations having large classroom populations that desire to take attendance more efficiently with less cost.**

Keywords— **Attendance Management System, Face Recognition, Low Cost Solution, Viola-Jones Algorithm, of Global Positioning System.**

I. INTRODUCTION

Attendance is the measure of the presence of an individual in a place. It is a term that applies to a variety of daily activities and functions because it is an inescapable aspect of many environments [1]. It is a very significant criterion in many institutions or organisations and it is used for different reasons ranging from tracking individual presence to assessing grades. In every setting where attendance is important, a system for managing attendance is a crucial tool [2]. Several works exist in automated attendance management systems however, most of the approaches comes with a lot of weakness and operational cost which includes additional hardware installations, operating system dependents, and most critical, not efficient in handling large target/classroom population.

One method of keeping track of students' presence is to use attendance marking in classes to ensure students participate in the lectures and any class activities to improve their academic performance and reduce the number of absences without any reasonable causes. With the advancement of technology, several approaches have been applied to the automated attendance system. The biometrics method is one of the most popular with the use of fingerprint or face recognition. Others methods include the use of a Global Positioning System (GPS), Near Field Communication (NFC), Radio Frequency Identification (RFID), Smart Card, etc.

To achieve a more effective solution, a combination of some of the above approaches plays a very significant role. In this paper, we combine biometric-face recognition with GPS in developing our proposed system. The facial recognition technology is used to determine the identity of the student and the location is determined using the mobile device GPS.

A face recognition attendance system uses the camera on a mobile phone to mark students' attendance without requiring an extra device. It eliminates the need for specific software to be installed because mobile phones may be used directly with the help of an internet connection and a built-in camera to verify the presence of students [3].

Our proposed solution harnesses the digital era of mobile education which takes hold of the proliferation of mobile-enabled devices and the cloud computing paradigm which was suggested by [4] as a cost-saving measure for educational institutions. The approach leverages the inbuilt mobile device camera and GPS facility as one of the ways to achieve a low-cost solution.

In this paper, our focus is to develop a low-cost, secured, and more efficient automated student attendance system using face recognition and GPS location that can be provisioned as a cloud application and accessible using any internet-enabled mobile device. The proposed system will enable any institution or organisation to use a student attendance management system with no cost of hardware installation, enable students to clock-in attendance independently using any mobile device only when in the classroom, and also allows instructors to generate attendance lists per course in real-time.

The rest of the paper is organised as follows. Related works are discussed in section II. The research methodology is presented in section III. The implementation and evaluation are presented in section IV and the Conclusion is in section V.

II. RELATED WORKS

Several works have been done on the student attendance management system. Table 1 shows some unique approach that was reviewed and a summary of their weakness were presented. These weaknesses are mostly likely applicable to other works that use a similar approach. To mitigate most of their weakness, we suggest that a solution that minimises operational cost by leveraging existing hardware and provision on the cloud be adopted. In addition, the solution must be able to independently identify students using their biometric traits and ascertain their present location to avoid proxy attendance to guarantee a secured system.

Table 1: Related Works Summary

Author	Approach	Usage	Strength	Weakness
[5]	GPS and NFC	Mobile phone	Better than the manual method. Low cost and without hardware installation. Suitable for large classroom population.	Less secure as students can have a dedicated phone for this purpose which can be given to their friends to clock-in on their behalf. Software dependent because only android phone users can use the application.
[6]	Biometric fingerprint and RFID	Fingerprint scanner	Better than the manual method. Very secured.	Not suitable for large classroom populations because students may have to queue for fingerprint scanning. High cost of installing hardware installations such as the RFID readers, purchasing scanners, etc.
[7]	ATmega AVR32 Microcontrollers and RFID	Smart card	Better than the manual method.	Less secure as students can give out their smart cards to friends to clock-in on their behalf. Not suitable for large classroom populations because students will have to queue to scan their smart cards hence, consumes time. High cost of installing hardware installations such as the RFID readers.
[8]	Bluetooth Low Energy Positioning Technology	Mobile device	Better than the manual method. Suitable for large classroom population.	Less secure as students can have a dedicated device for this purpose which can be given to their friends to clock-in on their behalf. High cost of installing and maintaining the Bluetooth low energy indoor positioning technology.
[9]	Biometric fingerprint and	Mobile phone	Better than the manual method. Very Secured.	Software dependent because only android phone users can use the

	GPS		Low cost and without hardware installation. Suitable for large classroom population.	application. High cost of installing and maintaining the Bluetooth low energy indoor positioning technology.
[2]	Biometric face recognition	IP camera	Better than the manual method. Very Secured.	Not suitable for large classroom populations due to limited camera coverage and students' faces appearing blurred hence, may fail to recognise every student in the classroom. High cost of installing and maintaining IP cameras.
[10]	Biometric face recognition	IP camera	Better than the manual method. Very Secured.	Not suitable for large classroom populations due to limited camera coverage. Students need to queue to scan their faces when entering classrooms hence, this consumes time. High cost of installing and maintaining IP cameras.
Our approach	Biometric face recognition and GPS	Mobile device	Better than the manual method. Very Secured. Low cost and without hardware installation. Suitable for large classroom populations.	Vulnerable to face spoofing.

III. RESEARCH METHODOLOGY

A. Software Development Process

This paper used the agile model as the software development process. Agile approaches are incremental development methods in which the increments are small. New system releases are typically developed quickly and made accessible to clients. By including users in the development process, this strategy allows for quick input on evolving requirements.

Using this approach, we break the entire attendance system into smaller iterations. Each iteration was developed within a specific period. We started by developing the user account Sign Up and Sign In. After that, we created the Course Registration module and then the Attendance module, which includes the Face Detection and Recognition module. The last part of the iteration was the integration of location-based service.

B. System Architecture

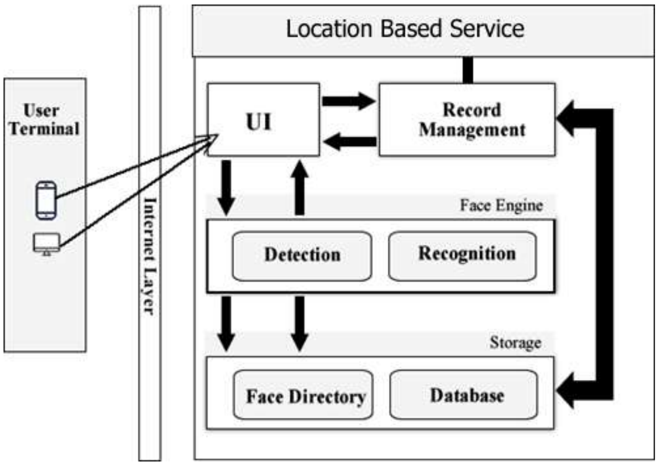


Figure 1. Architecture of the Proposed System

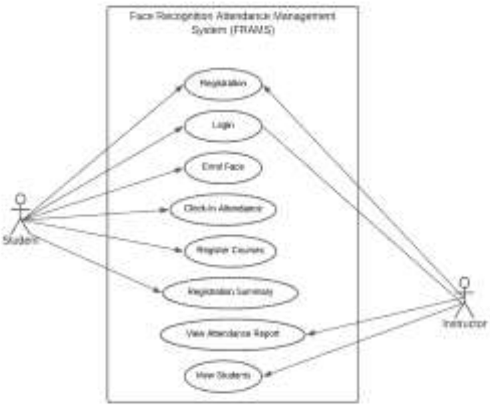
The proposed system is a cloud-based application that can be accessed through any internet-enabled mobile device. The user launches the application using a browser and interacts with it through its interface (UI). The user can create an account and log in to the application for further activities like course registration, updating profile pictures, and clock-in attendance through the UI using only their face. The record management module manages all user records, which are directly synchronised with the database to store and retrieve data.

The architecture also includes a face engine that performs face detection and recognition. The user can acquire a live stream image using the in-built camera of the mobile device. The face engine module takes the image, processes it, and checks for the presence of a human face on the image. If there exist, the face is cropped into 128 x 128 dimensions, and it is stored in the face directory.
The face recognition part of the face engine is triggered when the user (student) attempts to clock in attendance to a course. This part first leverages the output of the face detection part of the engine, which does the image acquisition and processing. The output is then compared with the stored face in the face directory. This comparison is a one-to-one matching. That means the face image acquired is not compared with all the images that exist in the directory to recognise the face. This approach makes the face recognition process very fast.

The lecture timetable component is also integrated to enable the student to clock-in only at the stipulated time for the various courses. The mobile device location service has to be on when clock-in attendance otherwise the process will not be successful. This helps the system determine the location the of student.

C. System Modelling
The system was modelled using the Unified Modeling Language (UML). The UML was developed to help system and software engineers in specifying, visualising, building, and documenting software system artifacts as well as business modeling and other non-software systems. UML is made up of an integrated set of diagrams. There are several types of UML diagrams available for different uses, but for this paper, only a few will be used. They include the following: Use case diagram, Activity diagram, Class diagram, and Sequence diagram.

I. Use Case Diagram
This is a behavioural diagram that shows the dynamic behaviour of the objects in a system. It describes a system's functional requirements in terms of use cases. It's a representation of the system's planned functionality (use cases) as well as its surroundings (actors). Use cases make it easier to connect what a system is supposed to do with what it's supposed to do. Figure 2 shows the use case diagram of the proposed system.



II. Sequence Diagram
The collaboration of objects based on a time sequence is represented by a sequence diagram. It depicts how the objects interact with one another in a use case scenario. Figure 3 shows the sequence diagram of the proposed system.

Figure 2. Use Case Diagram of the Proposed System

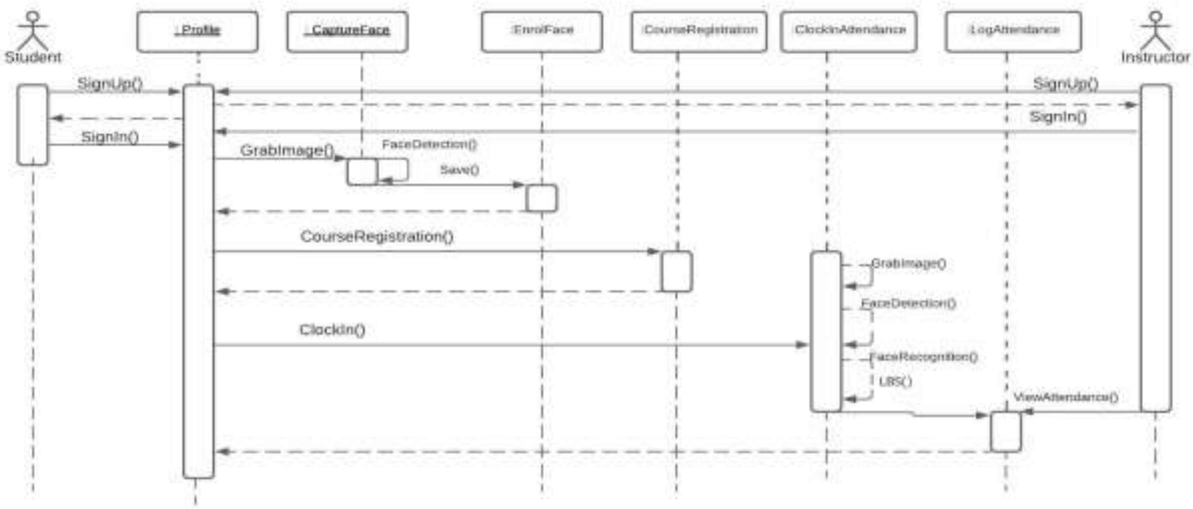


Figure 3. Sequence Diagram of the Proposed System

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III. Class Diagram

The class diagram is used to describe program classes and their relationships. It depicts the names and attributes of the classes, connections/relationships between the classes, and sometimes the methods of the classes. It can also be used to visualize, describe, and document different aspects of a system and construct executable code of the software application. In this whole idea, it means the classes in the source code must correspond with the classes in the diagram. Figure 4 shows the class diagram of the proposed system.

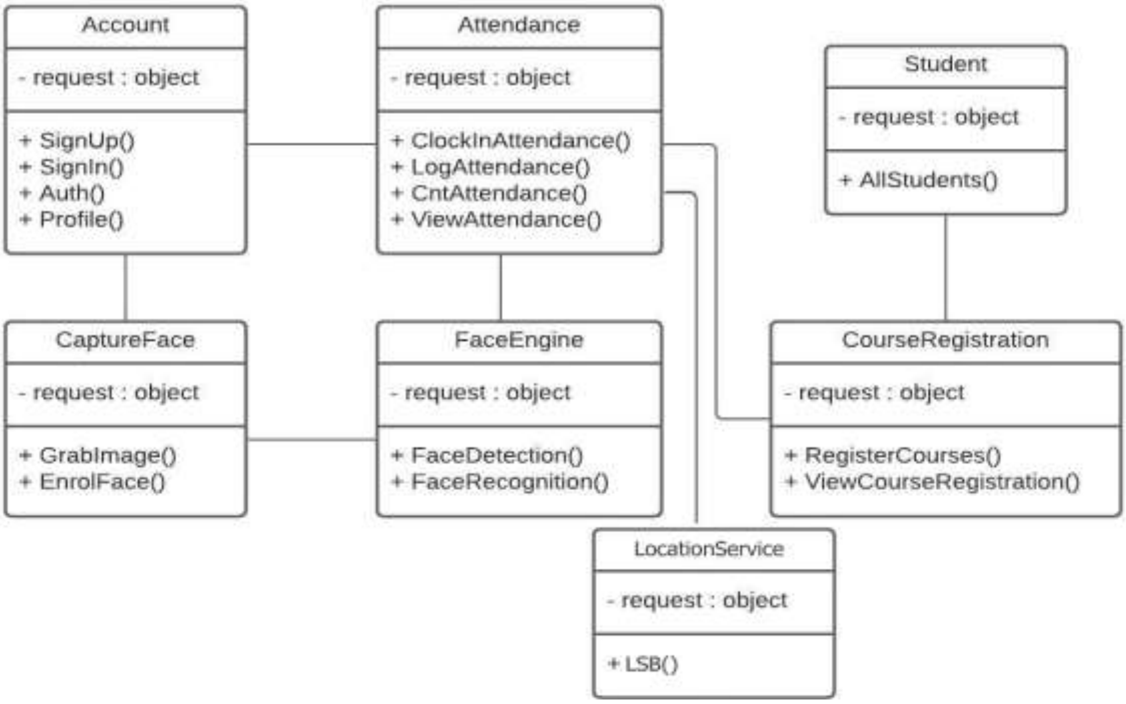

Figure 4. Class Diagram of the Proposed System

IV.Activity Diagram

The activity diagram visually presents a series of actions or flow of control in a system similar to a flowchart or a data flow diagram. It shows the activities performed by a system. Figure 5 shows the activity diagram of the proposed system.

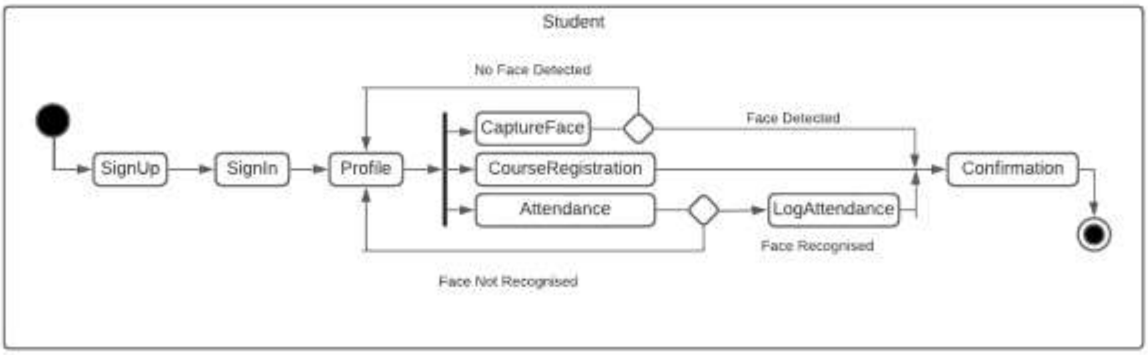

Figure 5. Activity Diagram of the Proposed System

D. Face Recognition Model

The face recognition task is divided into two parts: Face Detection and Face Recognition. In this paper, we used the Viola-Jones algorithm in OpenCV to perform face detection and face_recognition Application Programming Interface (API) presented by [11] to perform face recognition. The Viola-Jones algorithm is a machine learning system for object detection that can recognize things in pictures and movies [12]. The pre-trained classifier for faces and grins stored as Extensible Markup Language (XML) files with several feature sets is part of the OpenCV implementation of this approach that we used. A cascade function in the method is taught using numerous positive and negative images. The training is then used to detect a face in any other images. The algorithm uses four concepts to detect a human face in an image.

1. Selecting Haar Features: Basically, all human faces share similar properties like the eyes and nose bridge regions. These regularities may be matched using Haar Features. Calculations are carried out on neighboring rectangular sections at a predetermined position within a detection window in order to produce what is known as a Haar feature. In order to complete the calculation, you will first need to add up the pixel intensities in each region, and then you will need to calculate the differences between the amounts. The calculation results in the formation of a rectangle, which can be seen in Figure 6, which surrounds the detected face, which can be seen in Figure 7.

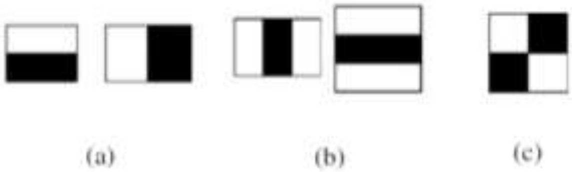

Figure 6. Haar Rectangular Feature: (a) Edge, (b) Line, (c) Four rectangle. Source [13].

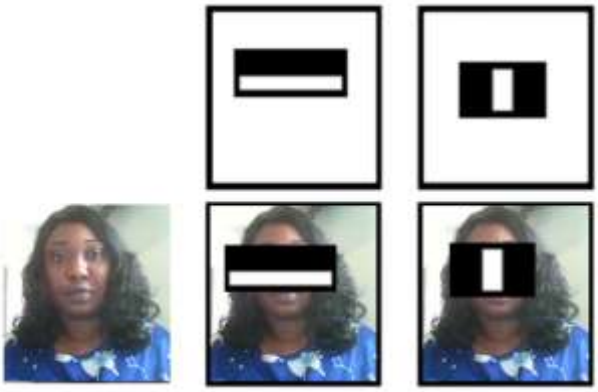

Figure 7. Haar Feature Result.

2. Creating an integral image: This is a rapid computation of a rectangle feature using an intermediate image representation. The total of the pixels to the right of and above x, y inclusive make up the integral image at position x, y [12].

$$ii(x,y) = \sum_{x' \leq x, y' \leq y} i(x', y'),$$

--- (1)

By starting the addition procedure, the top left of the image (original pixel) become the bottom right of the image (addition pixel result) shown in Figure 8.

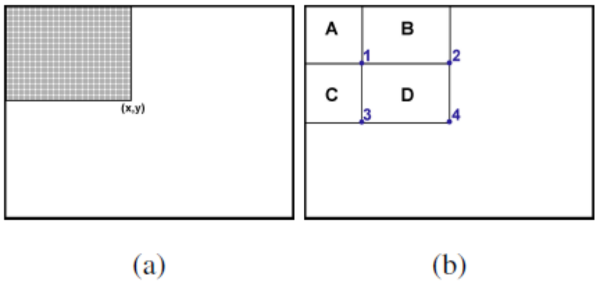

Figure 8. Integration Process, (b) Rectangle Divided into Multiple Segments. Source [13].

3. Running AdaBoost Training: Boosting is an ensemble modelling method that has gained popularity for solving binary classification issues. These algorithms improve the prediction power by combining many (thousands) of weak classifiers into a single strong classifier [14]. In Haar Cascade Classifier, each Haar-like feature represents a weak learner. AdaBoost evaluates the effectiveness of each of the provided classifiers in order to determine the kind and dimensions of a feature that will be incorporated into the final classifier. The effectiveness of the classifier can be determined by analysing each individual subregion that makes up the training image.
4. Creating classifier cascades: Cascade is a series of sequential tasks coming one after another. Here, a strong classifier is turned into a cascade where each stage represents a weak classifier. The cascade at this point discards non-faces quickly, and this avoids wasting time and computations.

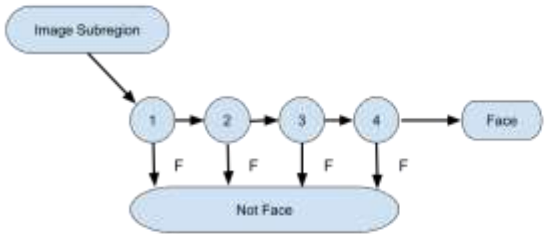

Figure 9. Cascade Classifier Illustration. Source [13].

Figure 9 is an illustration of a series of AdaBoost classifiers. The sequence of filters in the cascade is based on AdaBoost weighted results. The initial stage of the classifier will do an analysis on any image subregion that has progressed farther in the cascade. In the event that the stage evaluation returns a positive value, indicating that the classifier agrees that the object in question is a face, the stage output may be. This information is sent along to the subsequent level of the cascade. In the event that this step receives a positive evaluation, the result is yet another possibility. If the stage considers the subregion to be positive, which indicates that it believes the subregion to be a face, then the stage will produce the output maybe. During this procedure, the image will be replicated on each of the successive levels of the cascade.

If a certain subregion is given a maybe rating, then it is moved on to the subsequent step of the cascade. In the event that this one provides a favourable appraisal, then that's another maybe, and the image is passed on to the third stage. If the image passes all of the tests, then it is eventually identified as a human face and the status of the detection is changed to "face detected." If the evaluation at any level, including the first stage, determines that the image does not contain a face, then the image is immediately discarded, indicating that it does not contain a face.

A positive detection will result in the output of the word Yes, which indicates that the subregion in question possesses all of the characteristics that are characteristic of a human face. Each classifier in this system represents one of these characteristics. However, the entire subregion will be disqualified if even a single feature is absent. Because the eyes classifier and the nose bridge classifier are known to be the weak classifiers that perform the best in the Viola-Jones Algorithm, it makes sense to place them at the beginning of the cascade.

E. Global Positioning System (GPS)

Global Positioning System (GPS) is a space-based radio-positioning and time-transfer system that provides three-dimensional positioning of an object on the ground as well as navigation services for users [15]. It can deduce the exact position of an object on the Earth using a group of satellites. Integrating GPS will enable the system to obtain the current location the student is trying to clock-in from by obtaining the longitude and latitude coordinates. Since a student needs to be in class to be able to clock-in the attendance, any student outside the coordinate of the classroom is denied access and this prohibits remote clock-in.
The coordinates of each lecture venue were taken from the center of the venue and profiled on the lecture timetable. Any student location that is greater than 10 meters is assumed not to be in class hence, denied clock-in. We used the Haversine formula [16] to find the distance between where the student and the lecture venue are located. It uses their latitudes and longitudes measured along the surface. The Haversine formula is shown in equation 2.

$$d = 2r \arcsin\left(\sqrt{\sin^2\left(\frac{\phi_2-\phi_1}{2}\right) + \cos(\phi_1)\cos(\phi_2)\sin^2\left(\frac{\lambda_2-\lambda_1}{2}\right)}\right)$$

--- (2)

where φ is latitude, λ is longitude, r is earth's radius (mean radius = 6,371km), and d is distance.

IV. IMPLEMENTATION AND EVALUATION

A. Implementation

The proposed system was developed as a web application and deployed to the cloud to enable accessibility using any internet-enabled mobile device. The development stack used in implementing the proposed system is Python programming languages, Django – a python based web application development framework, and Bootstrap - an open-source CSS framework aimed at front-end web development that is compatible with all devices. The system uses Viola-Jones Algorithm and face_recognition API for face detection and recognition respectively. The system was deployed and tested on AWS EC2.

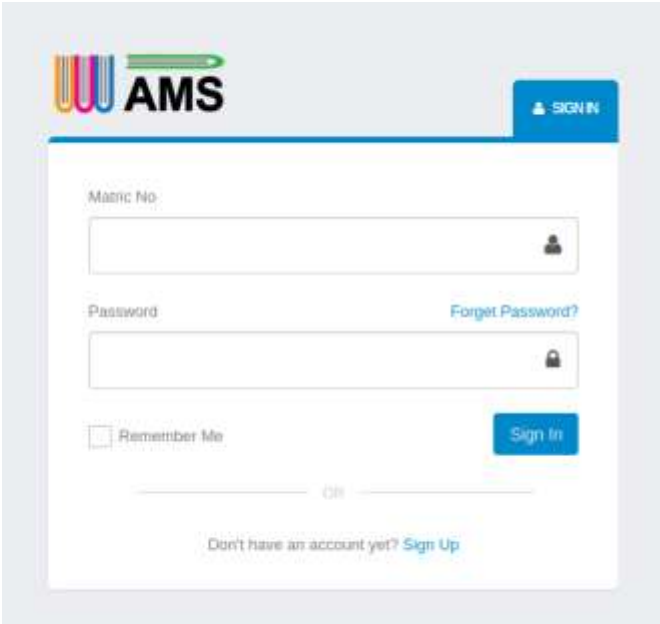

Figure 10. Student Login Page.

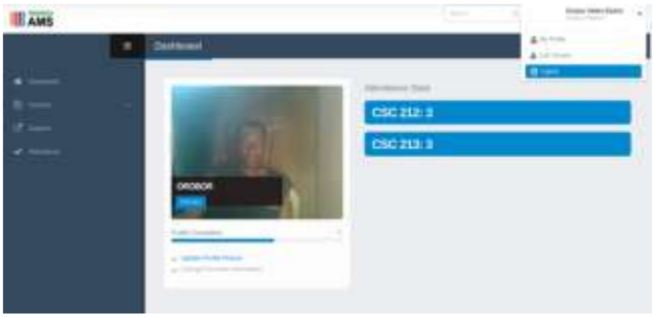

Figure 11. Student Profile Page.

Figure 12. Instructor Attendance Report Page.

B. Evaluation

To measure the success of the system, getting student feedback was a crucial step. We employed a questionnaire approach in other to determine end-user satisfaction with the system. Google form was used to create the questionnaire and distributed to a few persons who were granted access to the system. Figure 13 shows the online questionnaire.

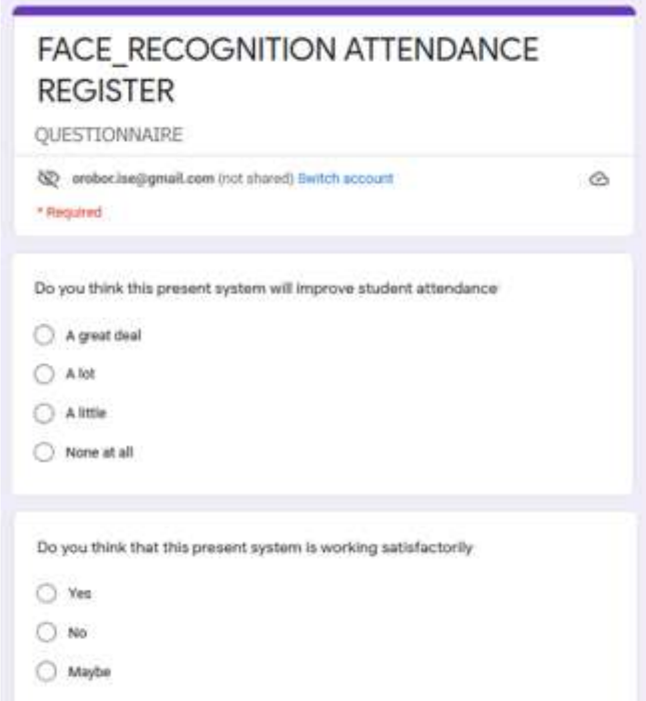

Figure 13. Evaluation Questionnaire.

Following our research and statistical evaluation of the outcome, we believe this system has fulfilled the research objectives as shown from the results in Figures 14 – 16.

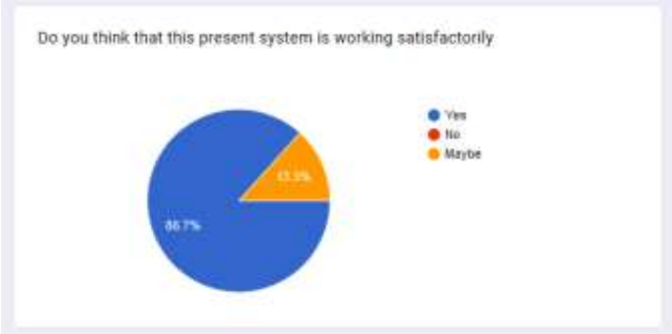

Figure 14. Student Satisfaction Response.

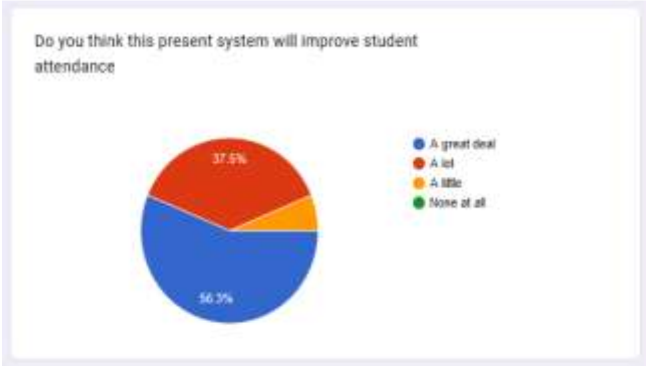

Figure 15. Student Attendance Response.

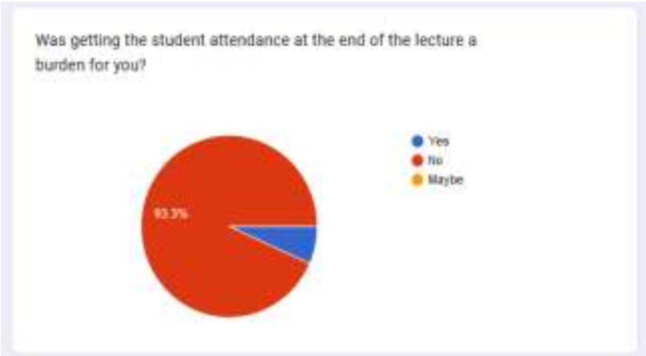

Figure 16. Staff Response.

Figure 14 responses from students showed that the system is working satisfactorily with 85.7% affirmation. 14.3% partially agreed. However, none disagreed. This showed that the students are willing to use the system if fully deployed.

We also got a response from faculty members. 56.3% strongly agreed that the proposed system will improve student attendance taking if deployed. 37.5% quite agreed and the remaining 6.2% slightly agreed. 7.1% responded that getting attendance at the end of the class was a burden. 92.9% did not agree.

The overall response showed that the proposed system was accepted. This shows that this innovation can be adopted as a

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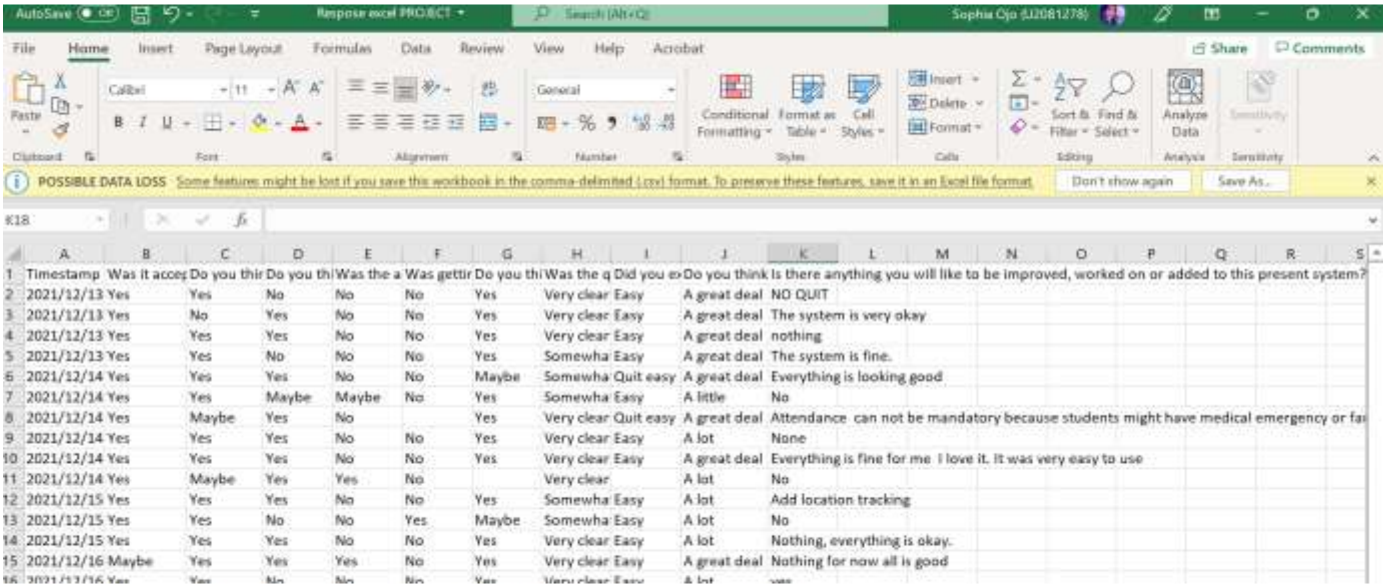
means of attendance monitoring in large class populations, organisations, and even conferences. The benefit of the proposed system will be highly evident in a large class population.



	Timestamp	Was it acces	Do you thir	Do you thi	Was the a	Was gettir	Do you thi	Was the q	Did you ex	Do you think	Is there anything you will like to be improved, worked on or added to this present system?
2	2021/12/13	Yes	Yes	No	No	No	Yes	Very clear	Easy	A great deal	NO QUIT
3	2021/12/13	Yes	No	Yes	No	No	Yes	Very clear	Easy	A great deal	The system is very okay
4	2021/12/13	Yes	Yes	Yes	No	No	Yes	Very clear	Easy	A great deal	nothing
5	2021/12/13	Yes	Yes	No	No	No	Yes	Somewha	Easy	A great deal	The system is fine.
6	2021/12/14	Yes	Yes	Yes	No	No	Maybe	Somewha	Quit easy	A great deal	Everything is looking good
7	2021/12/14	Yes	Yes	Maybe	Maybe	No	Yes	Somewha	Easy	A little	No
8	2021/12/14	Yes	Maybe	Yes	No		Yes	Very clear	Quit easy	A great deal	Attendance can not be mandatory because students might have medical emergency or fa
9	2021/12/14	Yes	Yes	Yes	No	No	Yes	Very clear	Easy	A lot	None
10	2021/12/14	Yes	Yes	Yes	No	No	Yes	Very clear	Easy	A great deal	Everything is fine for me I love it. It was very easy to use
11	2021/12/14	Yes	Maybe	Yes	Yes	No		Very clear		A lot	No
12	2021/12/15	Yes	Yes	Yes	No	No	Yes	Somewha	Easy	A lot	Add location tracking
13	2021/12/15	Yes	Yes	No	No	Yes	Maybe	Somewha	Easy	A lot	No
14	2021/12/15	Yes	Yes	Yes	No	No	Yes	Very clear	Easy	A lot	Nothing, everything is okay.
15	2021/12/16	Maybe	Yes	Yes	Yes	No	Yes	Very clear	Easy	A great deal	Nothing for now all is good
16	2021/12/16	Yes	Yes	No	No	No	Yes	Very clear	Easy	A lot	yes

Figure 17: Surveys Responses.

V.CONCLUSION

With the advancement of technology, several approaches have been applied to the automated attendance system and the biometrics method is the most popular. However, to achieve a good level of security in the system, combining any of the approaches with some other techniques could greatly help. From our study, we affirmed that most of the existing work on attendance management systems requires additional hardware which makes them less cost-effective, or cannot adequately handle a large classroom population. This paper, therefore, attempts to eliminate these challenges by creating a face recognition-based attendance management system that leverages the user's mobile device camera as an input terminal for image capturing.

The proposed system provides a handy and independent means for students to clock-in attendance through face scanning using the mobile device's inbuilt camera and GPS hence, it does not require any specific hardware or software to operate making it cost-effective. Students can use any mobile device to perform attendance tasks simply by logging into the application.

The facial recognition technology is used to determine the identity of the student and the location is determined using the mobile device GPS to avoid remote clock-in. However, there is a major vulnerability with this system which has to do with face spoofing. Facial spoofing is the act of using a person's face and simulating their facial biometrics with the use of a photo or video to steal their identity. But with the integration of a liveness detection algorithm, the security of any face recognition-based system can reasonably be improved. Liveness detection for face recognition in biometrics is the ability of a computer system to detect if the person in front of the camera is alive and real.

The system was deployed and tested on AWS EC2 and the users' feedback showed that the system could be adopted by institutions or organisation that desires to take attendance efficiently with less cost.

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