

Development of Face Recognition-Based Attendance System

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Abstract

Lecture attendance management is usually tedious, and time-consuming and may be prone to errors or manipulations when done manually. Hence, in this work, a web application called RollCall was developed and tested, for use by both students and lecturers in the Faculty of Engineering at the University of Ilorin as a model to manage attendance. The system manages attendance by allowing the lecturers to create courses, and take and retrieve attendance records for the courses created. Student functionalities include uploading their face data, enrolling for courses, and retrieving attendance records for the courses in which they enrolled. Attendance is marked through face recognition technology implemented with Python, OpenCV and Sci-kit Learn. The web interface was implemented using HTML5, Twitter Bootstrap CSS framework and JavaScript. The findings revealed that RollCall effectively streamlined attendance management, making it easier for both students and lecturers to keep track of attendance records. The web application is user-friendly and enhances the overall academic experience by improving the accuracy and efficiency of attendance management.

Keywords: Face Recognition, Class Attendance, OpenCV, Python

1. Introduction

The marking of attendance is regarded as one of the most important aspects of a lesson. This would guarantee that the students take part in class activities and absorb the knowledge of their tutors. According to the students' information and regulations handbook of the University of Ilorin, students must attend 75% of classes to be eligible for exams in any course. The majority of attendances are currently recorded using traditional techniques like name-calling or signing attendance papers. Unfortunately, a huge class cannot use these methods with accuracy and ease. Calling out students' names is time-wasting for the lecturers and students. Also, passing around the attendance forms during class for the students to indicate presence can be a source of distraction to learning and prone to manipulations by students with ill intent. Systems using biometrics are a viable alternative for tracking attendance because each person's biometrics are unique. Thus, students cannot fake attendance. Furthermore, since attendance is automatically recorded, it increases efficiency and lessens the stress on teachers (Gheisari et al., 2022; Memane et al., 2022).

Biometric identification is a growing field of technology. Several of a person's primary physiological and behavioral traits are used to identify them. It is based on hardware data acquisition systems that integrate software components using mathematical algorithms to analyze data, reconstruct identities, and identify people. Among the biometric technologies are those that recognize fingerprints, eye iris, voice, and facial recognition (Ghosh, Sharma & Kesharwani, 2022; Ramírez-Mendoza et al., 2022).

In this study, students are identified only using face recognition technologies. Face recognition technology uses patterns based on a person's facial features and forms to identify them from a digital image, a video frame taken from a video recording could also be used. There are numerous ways to accomplish this, but they all generally involve matching

up specific facial characteristics from an image with faces in a database. Although face recognition is not as accurate as iris or fingerprint identification as biometric technology, it is nonetheless commonly used because it is non-intrusive and contactless. Additional uses for face recognition technology include tracking down people who have disappeared, detecting diseases, confirming identity at Automated Teller Machines (ATMs), and restricting access to sensitive places for security reasons (Smith & Miller, 2022; Ramya et al., 2022).

2. Related Works

Several works with various approaches have been done towards automating and tracking class attendance. Fingerprint and Radio Frequency Identification (RFID) techniques were explored by (Huang et al., 2022; Kumar et al., 2021). The system uses RFID tags and readers to initialize the attendance tracking process and uses the fingerprint of the user to authenticate the user and the record is stored in a Secure Digital (SD) card. A real-time clock is also incorporated to know the exact time each student marked his/her attendance. Jadhav et al., (2023) described how a fingerprint-based student attendance system was created using biometrics. The study offered assertions on the staff and student general attendance systems. Fingerprints were utilised as a system entry sign. The creation of an IOT-based biometric attendance system that can track attendance and gather information for daily use was the main objective. An OLED display and fingerprint sensor were connected to an ESP32 to construct the optimal framework. Although Vinay et al. (2023) noted that fingerprint-based systems are more reliable than conventional attendance management systems, their use has been opposed by some as may be seen in (Abdullah, 2023).

Chen & Sun (2022) and Sandhya et al. (2022) recognized that speech may be used as a signal to swiftly gather and carry a range of information, making it useful for tracking student attendance in classes. The foundation of voice speaker recognition research is the speaker recognition corpus. The performance of the speaker recognition system is significantly improved by the use of a diverse, expansive, and high-quality speaker recognition corpus. From Chen & Sun (2022), there are currently few corpora for student attendance scenes, although there are many standardized corpora available. To construct the speaker's corpus, the authors analyzed the parameters of the speaker's speech and chooses the relevant expressions for Chinese students. On the other hand, the system proposed by Sandhya et al. (2022) keeps track of attendance by recording voice input using an app created using Kivy, and it offers a user interface to learn the specific status of the students/employees. According to Mary Meeker's annual Internet Trends Report, which is also the human threshold, a fully functional and equipped is 95% accurate because there is no way for the error to occur other than with the Google Speech Recognition API.

By combining discrete wavelet transforms (DWT) and discrete cosine transforms (DCT) to extract the features of the student's face and then employing the Radial Basis Function (RBF) to classify the facial objects, Mitra et al., (2017) suggested a way for a student attendance system in the classroom. In contrast, Narendar Singh et al., (2019) created a system that makes use of a Raspberry Pi 3 Model B, a USB camera, an ESP8266, an RFID reader and tag, and an Organic Light Emitting Diode (OLED). The Raspberry Pi's USB connector was used to attach the USB camera to take pictures of the students. Using the AWS Rekognition service, the collected images are then compared to those that were previously saved in the AWS Cloud database. A web application then receives the outcome. RFID was used in this study to track instructor attendance. Each faculty member is given an individual RFID card. The faculty member's presence must be registered by swiping the card against an RFID reader. The ESP8266 will use the OLED to display the date and time of such attendance. A technique that Alhanaee et al., (2021) and Gowda et al., (2020) invented uses a live video broadcast to record attendance. OpenCV is used to extract the frames from the video. Dlib is used by the system to identify and recognize faces. In a like manner, Das et al., (2019) use the face recognizer library to store attendance and recognize faces. An android phone's system camera takes a picture and sends it to a server, where an algorithm is used to identify faces in the input image, encode them, and recognize them in a database. Based on this information, attendance is determined.

3. Materials and Methodologies

The implementation of this research work is divided into three sections: web application, face recognition and attendance marking sections.

3.1 Web Application Section

This section includes the design and implementation of a user-friendly web application interface where users (students and lecturers) can sign up and log in. It also includes designing interfaces where lecturers can create a course, a dashboard to view all courses created by the lecturer and a dashboard for each course, which shows a list of students registered for the course with the number and percentage of class attendance for each student presented in a table. An interface to take and submit an image of students in class is also implemented. Interfaces for students to take and submit images containing their faces to the system, check available courses, enrol for a course, and view all courses enrolled by such a student with the number and percentage of attendance are also designed. This is achieved by using the following technologies: Python programming language, Flask Web Framework, JavaScript programming language, Hypertext Markup Language (HTML), Cascading Style Sheets (CSS), and SQLite Database Engine.

3.2 Face Recognition Section

This section involves designing and implementing the subsystem to process images and detect and recognize faces from the processed images. Images submitted by the students via the web interface will be processed to remove noise, and face detection carried out to ensure the presence of a single face in such images before storing them in the database. Fig.1 shows the block diagram of the student image acquisition process.

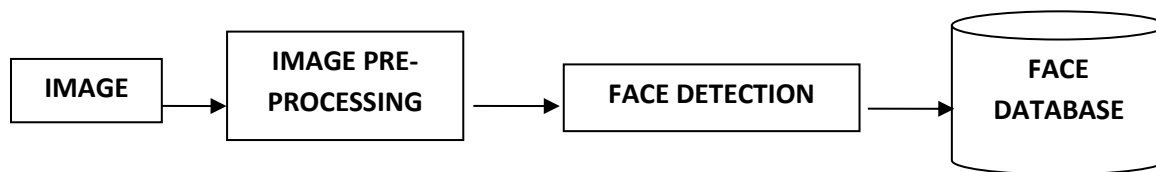


Figure 1. Block diagram of the student face image template acquisition

The image of students in a class submitted by the lecturer during the attendance process is processed to remove noise, before the detection and localization of each face in the image. After which the identity of each face will be determined and the data collected stored in the database. Technologies used in this section include Python programming language, OpenCV, and Scikit-Learn.

3.2.1 OpenCV's Deep Learning Face Detector

The deep learning face detector in the OpenCV package is used in this work. This detector uses a ResNet-based network and is based on the Single Shot Detector (SSD) framework, unlike other OpenCV SSDs that typically use MobileNet as the fundamental network.

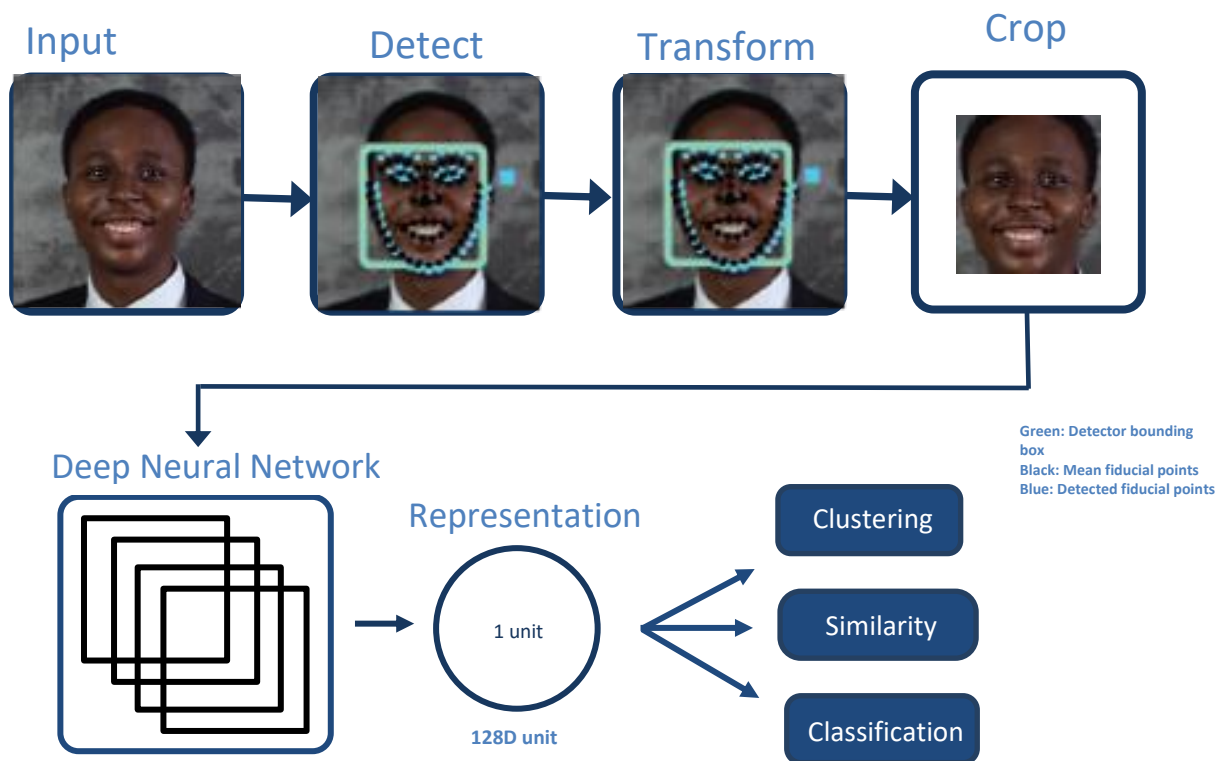


Figure 2. An overview of the OpenCV face recognition pipeline (Amos et al, 2016)

3.2.2 Face Recognition with OpenCV and scikit-learn

Although OpenCV was employed to aid in face recognition, faces were not identified by OpenCV. Figure 2 displays the face recognition pipeline for OpenCV. A CNN feature extractor that creates 128-d facial embeddings is a crucial step. The steps described below are used to achieve face recognition:

1. Face Detection: The OpenCV face detector described in section 3.2.1 performs this step.
2. Computation and Training for Embeddings: The OpenFace project, a Python and Torch implementation of deep learning for face identification, provided the model for quantifying each face in an image. This implementation was taken from FaceNet.

The 128-d embedding created by the FaceNet deep learning algorithm quantifies the face itself. Figure 3 demonstrates how to do this.

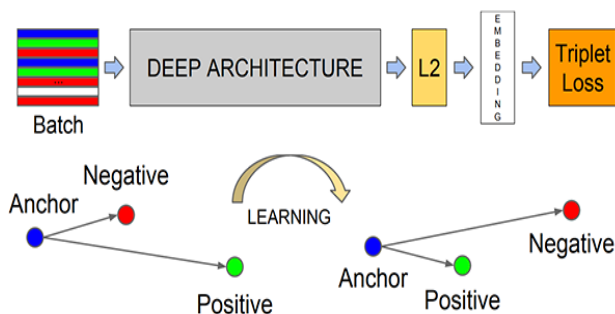


Figure 3. How the deep learning face recognition model computes the face embedding

Each input batch of data contains three images: the anchor, the positive image, and the negative image. These images are used to train a face recognition model with deep learning. The anchor has identification A and is regarded as the present face. The second image is tagged the optimistic one; it includes the face of person A. On the other hand, the

negative image does not share the same identity and could come from an individual tagged B, C, or even Y! The neural network calculates the 128-d embeddings for the individual face and then modifies the network weights (using the triplet loss function) so that the anchor and positive image embeddings are pushed closer together while the embeddings for the negative image are pushed farther apart. By quantifying faces using this method, the network can eventually produce highly reliable and discriminating embeddings that are appropriate for face recognition.

The deep learning model being employed will still be able to compute embeddings for individual faces even though it has (likely) no knowledge of the faces that will be run through it. Fundamentally, these face embeddings will be satisfactorily different so that the operator can train a "standard" machine learning classifier (SVM, SGD classifier, Random Forest, etc.) on top of the face embeddings and thereby obtain the OpenCV face recognition pipeline. For categorization, a Support Vector Machine (SVM) was employed.

3.3 Attendance Marking Section

This section involves the design and implementation of the subsystem to collect, organize, store and retrieve the attendance data generated from the face recognition subsystem. Technologies used are Python programming language, Flask Web Framework, and SQLite Database Engine. Figure 4 shows the block diagram of the face recognition and attendance marking process.

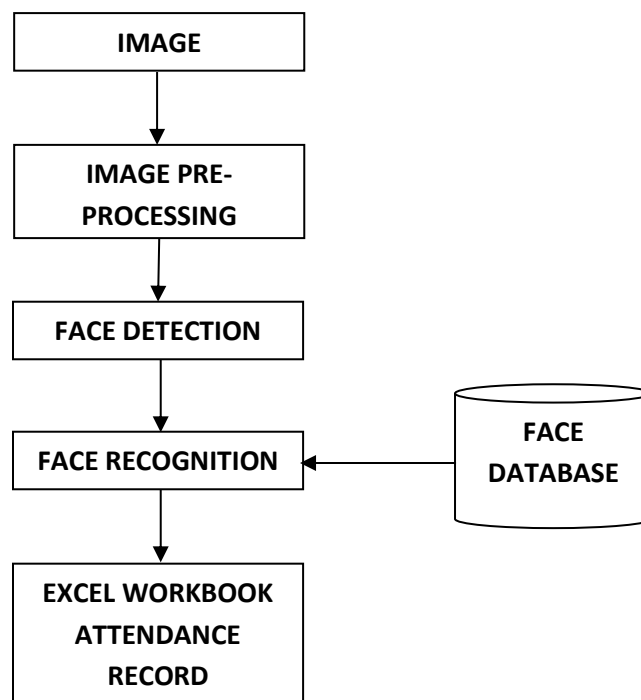


Figure 4. Block diagram of the face recognition and attendance marking process.

3.4 Implementation

A stage-by-stage (modular) design and development method was followed while implementing the work. This ensured faster development, testing and troubleshooting. The entire system was fragmented into smaller parts that enhance easy designed and development with each segment tested before proceeding to the next. This implementation ensured higher reliability, reproducibility and maintainability.

Since all parts of the system were split into smaller functional units, integrated and made to interoperate, a fault in one fragment will not pose so many problems on the entire system. The repair or replacement will only be done on such part alone and any of the parts of the system can be easily upgraded without changing the other parts of the system. Figure 5 shows the system's interface navigation flow diagram.

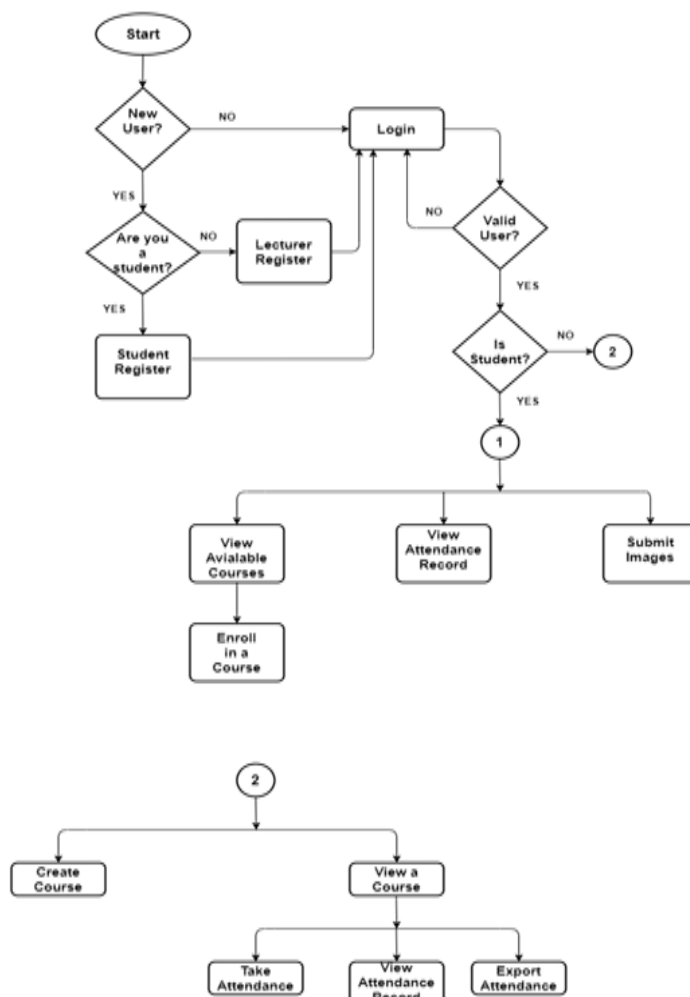


Figure 5. Interface Navigation Flow Diagram.

4. Results

The developed RollCall has the following features.

4.1 Login Page

This page as shown in Figure 6 is used to login into the web app if a user has previously registered either as a student or a lecturer. After logging in, the user is redirected to their respective dashboard.

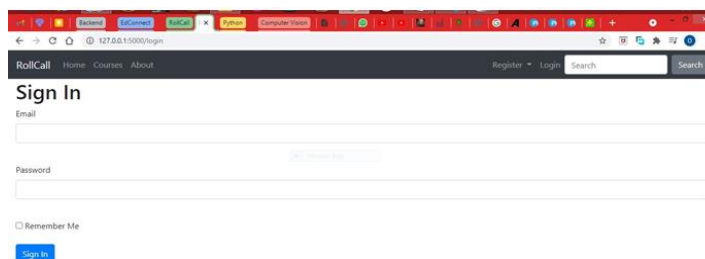


Figure 6. Login page.

4.2 Lecturer Registration Page

This page is used by a user who is a lecturer to register on the web app as depicted in Figure 7.

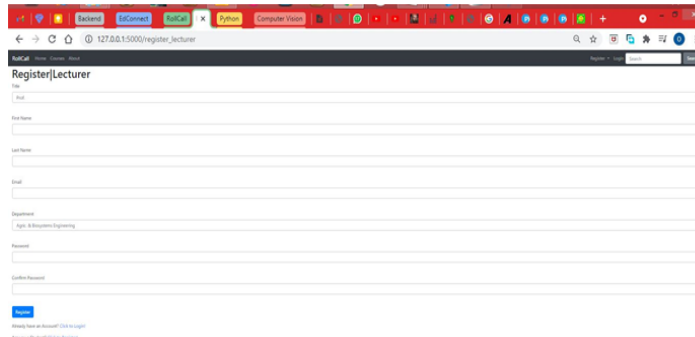


Figure 7. Lecturer Registration Page

4.3 Student Registration Page

The student registration page depicted in Figure 8 is used by a user who is a student to register on the web app.

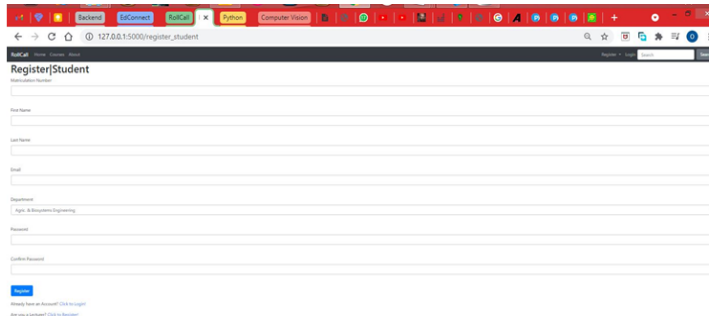


Figure 8. Student Registration Page

4.4 Student Dashboard

This page shows the list of courses enrolled by the student, the number of lectures that have been held for each course, the number of lectures the student has attended, and the percentage of attendance. It also contains an 'Upload Your Image' button that directs the student to a page where he/she can upload their image into the face recognition dataset. Figure 9 shows the student's dashboard.



Figure 9. Student Dashboard

4.5 Upload Image Page

Figure 10 shows an interface for students to upload their images into the face recognition database. Once the page loads, the student's device camera will be initialized and video streams of the camera will be shown in the left canvas. Once a good frontal image of the student is shown in this canvas, the button with the label 'Snap' can be clicked and the frame in the left canvas at the point of the click event will be shown on the right canvas. If the user is satisfied with the image on the right canvas, the 'submit' button can click to submit the image. A response from the server will be displayed

once the image has been processed. Three different responses can be shown depending on the result from the face detector, these are:

1. 'Image Upload successful': This will be the response if only a single face is detected in the uploaded image.
2. 'No faces detected in the image. Try again: This will be the response if the face detector is unable to detect a face in the image.
3. '{number_of_faces} faces Detected in the Image. Try Again': This is the response when two or more faces are detected in the image. The {number_of_faces} variable will be replaced with the actual number of faces detected in the image.

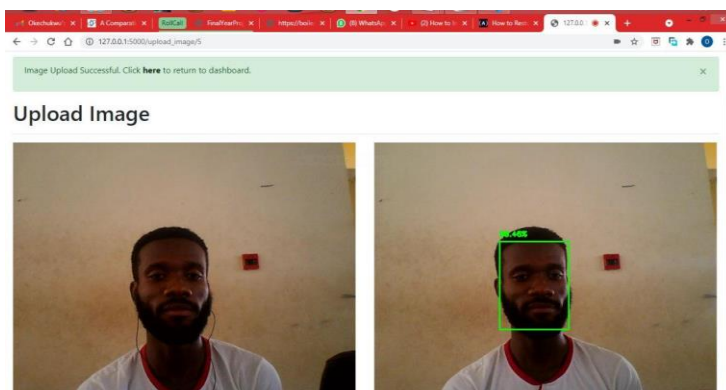


Figure 10. Upload Image Page

4.6 Available Courses Page

Figure 11 shows the interface that lists all the courses available on the web application. A student user can click on the individual course and will be redirected to a page where he/she can enroll in the course. This functionality is not available for the lecturer user (lecturers can only view this page and cannot perform any other action).



Figure 11. Available courses page

4.7 Lecturer Dashboard

Figure 12 shows a typical dashboard of the lecturer. The page shows the list of courses that are taught by the lecturer. At the far right hand of each list item is a button with the label 'View'. Clicking this button will direct the user to a page where the attendance information for the particular course is displayed. It also contains a 'Create Course' button that directs the lecturer to a page where he/she can create a course on which students can enroll to. Once created, such a course will be available on the 'Available Courses Page'.

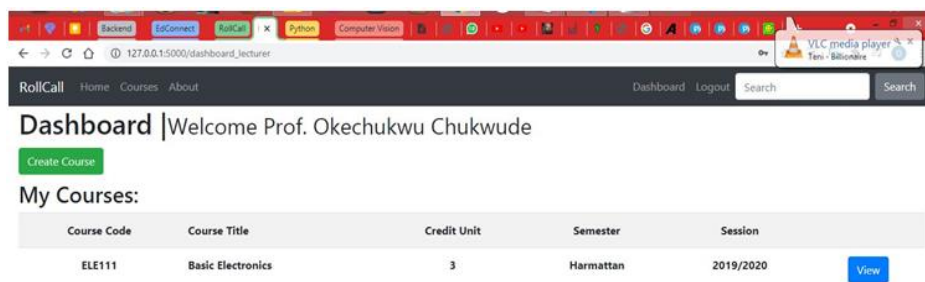


Figure 12. Lecturer Dashboard

4.8 Create Course Page

This page provides an interface for lecturers to create courses. The form on this page has a field where relevant information about the course can be collected. Information such as course title, course code, credit unit, session, and semester. Figure 13 shows the course creation page.

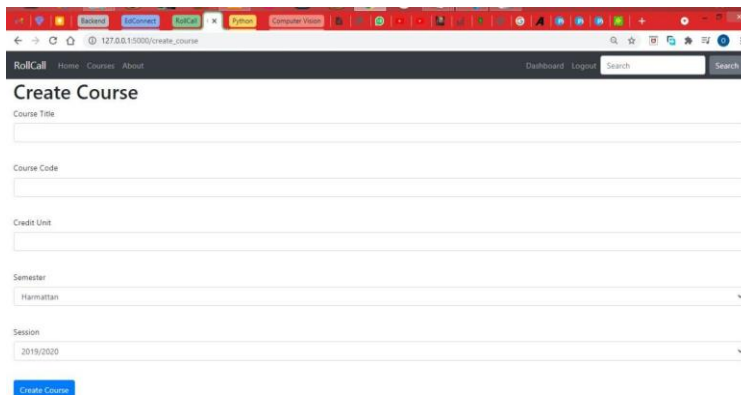


Figure 13. Create Course Page

4.9 Course Dashboard

The course dashboard page in Figure 14 shows the attendance information for a particular course. A list of all the students that have enrolled for the course is shown with their names, matriculation numbers, number of lectures attended and percentage of attendance. The total number of lectures conducted is displayed just above the list of students. The 'Take Attendance' button directs the lecturer to the page where attendance can be taken for the lecturer session. The 'Export Attendance' button compiles the attendance records into an Excel spreadsheet and downloads it to the user's computer.

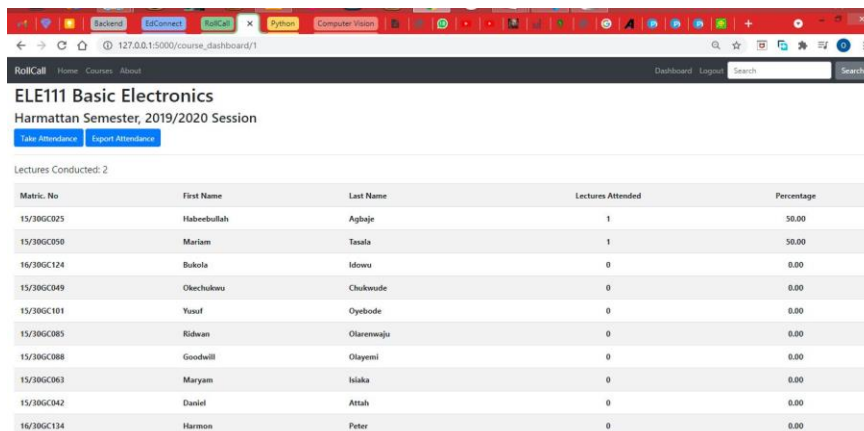


Figure 14. Course Dashboard

4.10 Take Attendance Page

This page is an interface where the image containing students in the class can be taken and sent to the server for processing and marking of attendance. Figure 15 shows the take attendance page.

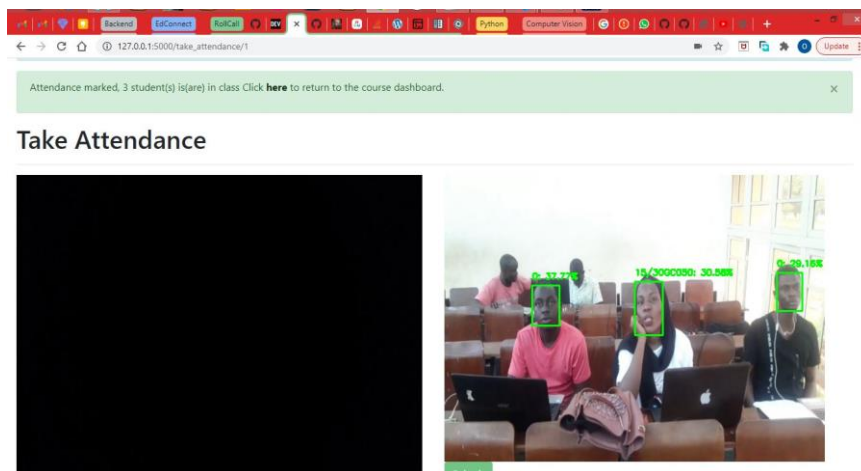


Figure 15. Take Attendance Page

The developed system was deployed and assessed, with the outcome summarized in Table 1. Here, RollCall was compared with the Name call approach and the passing around of attendance sheet system.

Table 1: Performance comparison of existing manual systems with *RollCall*

Attendance Systems	Performance Comparison Metrics			
	Ease of Use	Time Consumed	Efficiency	Accuracy
Name Call	Worst	More time consuming	Less efficient	More accurate
Attendance Sheet Passed Around	Better	Most time consuming	More efficient	Less accurate
<i>RollCall</i>	Best	Lesser time	Most efficient	Most accurate

Overall, the feedback from users of the system has been positive. Students reported that the system was easy to use. One student mentioned that the system was more efficient compared to the manual attendance method, which reduced waiting time during lecture sessions. Another student reported that the system helped them to be more accountable for their attendance, which motivated them to attend classes regularly. Lecturers also provided positive feedback, stating that the system was easy to set up and use. They appreciated the time-saving benefits of the system, particularly in terms of not having to manually record attendance. One lecturer mentioned that the system helped them to identify students who were struggling with attendance and follow up with them accordingly. However, some lecturers expressed concerns about the accuracy of the face recognition technology in cases where students wore face masks or when the lighting conditions in the classroom were poor. Overall, the feedback received from students and lecturers suggests that the web-based face recognition-based attendance management system is an efficient and effective tool for managing attendance in a tertiary institution. However, further improvements could be made to address concerns about accuracy under certain conditions.

5. Conclusion

The objective of this work is to present a streamlined design model for an efficient platform that manages class attendance. The system was designed to perform the following functions: registration of students and lecturers, uploading of facial images by students, creation of courses by lecturers, enrollment of courses by students, attendance-taking by lecturers, viewing attendance records, and exporting attendance records to an Excel file which was achieved. It provides an innovative solution to the problem of attendance management in tertiary institutions. The application's ability to integrate facial recognition technology makes it an effective and efficient tool for attendance management.

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