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A Face Recognition System for Attendance Record in a Nigerian University

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Abstract
The classroom attendance of students is one of the important criteria for a student to participate in a course examination in the University. A manual record of attendance during lectures generally consumes the productive time of both the lecturer and the student in the class. In this work, we propose a solution that would automate the attendance system through face recognition. The facial recognition approach had proven to be the primary and most important of all biometrical sources of identification for any human beings. This work describes the method of detecting and recognizing the face in real-time with the use of the Faster Region Convolutional Neural Network (FRCNN) algorithm. The algorithm is applied through a four (4) stage module of face features extraction, face detection, face recognition and attendance record database. The model is designed and implemented in Google Colab to recognize the face of students in a Nigerian University which is used as a case study of this work, and create an attendance record for each course. The new system called "DLFacer" is user friendly and has an advantage of reliability, efficiency, and accuracy of about 97 - 99% over the existing systems. It is a significant contribution to solving the problem of attendance recording in African Universities.

Keywords: Student Attendance, Face detection, Face recognition, FRCNN, Google Colab

Introduction

A good maintenance of attendance is essential in checking the performance of students. In fact, in most Nigerian Universities, it is a rule that students must make up to 75% attendance to qualify them for a participation in the final course examination. This practice is also applied in other countries (Riya *et al.,* 2015). This good practice adds to the quality assurance index of raising graduates in both character and learning. This is because a physical presence to a lecture helps students to gain mastery of the arts and science of the subject taught in the classroom.

The existing traditional way of recording attendance in Nigerian Universities had proven to be inaccurate, time-consuming, and requiring manual intervention such that students who are absent in the classes get their attendance marked for them by their classmates. We refer to this as ghost attendance marking. To curb this, some lecturers had devised means of calling students' names and marking their attendance by themselves, but this in itself becomes

very difficult to mark the presence or absence of each student for a very large class population. Apart from the challenge of wasting of precious time, this approach is laden with the difficulties of finding and calculating the average of the attendance of each enrolled student to meet up with the examination criteria. It has, therefore, become paramount to seek easy and improved ways of recording and maintaining an accurate attendance (Jing, 2018).

A readily available approach is to exploit the face recognition technology. Although this approach faces a lot of problems such as the illumination, occlusion, and pose, it is still one of the few biometric methods that possess the merit of both accuracy and low intrusiveness (Mathana *et al.*, 2015). Even though other means of identification (such as fingerprint, or iris scans) can be more accurate, face recognition has always remained a significant focus of research because of its non-invasive nature and because it is a primary method of personal identification. Face recognition technology is gradually evolving to the universal biometric solution since it requires virtually zero effort from the user end while compared with other biometric options (Nirmalya *et al.*, 2012). Biometric face recognition is used in four (4) main domains which are time attendance system, employee management system, visitor management systems, and authorization and access control system (Nirmalya *et al.*, 2012). There are many other ways of managing attendance system which had been introduced to the market such as RFID system, punch card system, swipe card, and biometric system (fingerprint analysis, iris analysis, etc.). Apart from the biometric systems, these systems are not always applicable to students in an institution (colleges and universities) due to the salient and personal features needed in educational institutions. A system that would mark attendance for both the students and the lecturers needs to receive and link to their personal details in the enrolment database. The face recognition system generally consists of image acquisition, database development, face detection, pre-processing, feature extraction, and classification stages followed by the post-processing stage (Nirmalya *et al.*, 2012). The system would record the exact time the students and the lecturer came into the class without any human intervention with the aid of a camera mounted in the lecture hall.

The aim of this work is to provide an Attendance Record System using Face Recognition in a Nigerian University. This work is set to achieve three (3) objectives which are (1) to curate a local dataset of students in a selected Nigerian University for attendance management; (2) to develop a real-time face recognition model using FRCNN and (3) to deploy the model in a dynamic Web Attendance System. This work is useful and relevant to Universities in Africa where traditional means of attendance record is prevalent. It will reduce the drawbacks of the traditional way of recording attendance and help to prevent the menace of ghost attendance marking. While other methods of automated attendance record may be rampant in the technology industry, this work is limited to the application of deep learning algorithm to recognize faces of students in the classroom and record their attendance.

Literature Review

There are many novel face recognition techniques which had been applied in the attendance management domain. Some of them include the eigenface, fisher face, neural network, elastic bunch method, graph matching, and so on (Riddhi and Shruti, 2013). Face Recognition is a challenging problem in the field of image processing and computer vision, and research currently seeks to improve the efficiency and performance of the algorithms.

Following a proposal to reduce the errors that occur in the traditional attendance system using face recognition, Anushka *et al.* (2018) presented a model using deep learning algorithms with the accuracy of 98.3% in recognizing the user. The system also tackles the problem of face recognition in a biometric system that is subjected to real-time scenarios such as illumination, rotation, and scaling. The model makes use of a camera to capture the input images and applies the linear support vector machine to detect a face from the input image and mark the attendance in a spreadsheet and later convert it into a PDF file. Riya *et al.* (2015) developed an Attendance Management System using the standard Bluetooth technology in Mumbai

University which ensures a 75% course attendance by a student before writing an examination. The system uses electronic tags (serial numbers) to facilitate automatic wireless identification via a Bluetooth smart based device which is programmed and configured such that it works in connection with Android application and records attendance as the lecturer moves around the class to detect the tags. In the same vein, an android based course attendance system using face recognition had also been developed by Sunaryono *et al.* (2019). The limitation of this approach is an overly dependence on the ownership and use of a Bluetooth compliant android phone thereby shortchanging lecturers and student without it.

The Principal Component Analysis algorithm (PCA) algorithm was applied by Kewalramani (2018) for face recognition. The resultant system is portable and can be easily accessed and used on any mobile phone or computer. The system is robust enough to maintain different attendance records for different classes and subjects. Another work that applied PCA was done by Pooja *et al.* (2017). The system marks the attendance by following these steps: First, a video clip of the classroom is taken and is stored in the database. Second, the video is converted to images and the face detection techniques are applied to detect the faces. The features extraction is done by Histogram of Oriented Gradients and Local Binary Pattern algorithm (LBPA). Face recognition is achieved by projecting a new image in the eigenface subspace in which a person is classified by comparing its position in eigenface space with the position of known individuals — extracting the image using PCA algorithm. The system sends the report both to the faculty and the parents. Likewise, Sbeha *et al.* (2017) applied PCA to build an Automatic Attendance System using the same extraction of the characteristic features known as eigenfaces. This method is secure enough, reliable, and needs no specialized hardware; it is constructed with the help of a camera, a computer, and some algorithms that recognize the face. The system is used for various applications such as security purposes, industry, education, and most of all, face recognition. Even though the systems developed with PCA are efficient, the time it takes to extract the principal components is long unless a specialized algorithm is used in addition.

Syafeeza *et al.* (2014) proposed a robust 4-layer convolutional neural network architecture for face recognition problem in a way that is capable of handling a facial image that has occlusion, posses, facial expression, and varying illumination. The model was applied in two databases (AR and FERET) and it could complete the facial recognition process in less than 0.01 seconds with 99.5% accuracy on the AR database and 85.15% accuracy on the FERET database. In the same vein, Ozmen and Yurtkan (2015) proposed a new automated class attendance system based on illumination and invariant face recognition system. The system consists of three distinct stages which are face detection through the Viola and Jones algorithms, face feature extraction through the Non-subsample contourlet transform, and face classification where an unknown face is being classified with a known face on the class database. The system was tested on the Yale and BU 3D face databases. In the University system, a similar work was done by Yamini *et al.* (2019) using Viola-Jones algorithm (Haar's Cascade) for face detection and linear binary pattern histograms for face authentication. First students' images were captured through the use of a camera and stored in a database in its original form (RGB) and then turned to GRAYSCALE image. Second, using the OpenCV framework, attendance is recorded by matching an input face with the ones in the database. Third, the output is printed on a Notepad at the last hour of the day and the system updates attendance of the student and sends message to the Head of the Department. Speed is an advantage in these systems; however, the usage of a database system that can't deliver the needed speed due to the variant face inputs may hinder the desired outcome.

These related works had demonstrated applications of different algorithms and methods in achieving the attendance record system. Almost all the systems to the best of our knowledge had been designed with their prevailing local datasets; none of the works had been done in the African context in a Nigerian University. Again, most of the works tend to provide vendor hardware for its implementation which is

costly to maintain. This proposed system is designed to be cost-effective with no specific vendor hardware and software for deployment.

The rest of the paper is organized as follows: Section 2.0 provided a detailed description of the materials/methods employed in the design and development of the system. The results were discussed in the section 3.0 outlining the achievements from the research. Conclusions, recommendations and future work were provided in section 4.0.

Materials and Methods

This study was carried out with students' record at the Department of Computer Science in Federal University Lokoja (FUL) and validated at the Department of Mathematics and Computer Science, Benue State University, Makurdi (BSU). FUL is one of the nine newly established Federal Universities in Nigeria in 2011 while BSU is a state owned University established in 1992. The two Universities have good research thrust in data mining and seek to develop solutions that would drive innovations in education, agriculture and governance.

The methodology chosen for this work is a hybrid method of the Cross-Industry Standard Process for Data Mining (CRISP-DM) and the modular programming approach of the Object-oriented design methods (OODM). The CRISP-DM is employed in the development of the model and its deployment phase uses the OODM to implement the web application system. It is chosen for this work because of its iterative and standardized data science approach and the systematic development and delivery process it employs.

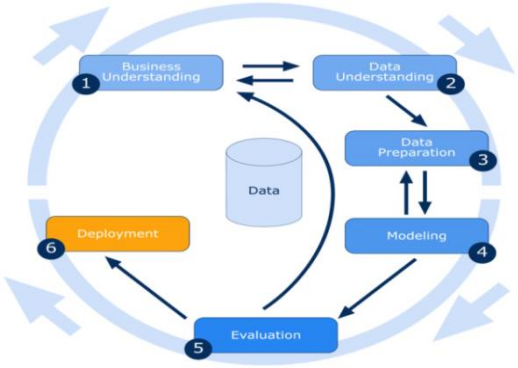


Figure 1: Cross-Industry Standard Process for Data Mining (Source: Petersen, 2018)

The steps of the CRISP-DM are shown in Figure 1 and the descriptions as applied in this work are provided as follows:

Business Understanding: The works seeks to achieve the aim/objectives as outlined in the Introduction section. It is applied in the University domain to detect, recognize, classify and record attendance of students to lectures.

Data Understanding: The dataset is a collection of twenty (20) pictures of nine (9) faces of students captured through the use of a camera. This built a local dataset of students registered in the course. The dataset were labelled to store the features of the images in an XML format such that each image has its own features stored thereby creating a total of 20x9x2 (360 files). This is shown in Figure 2.

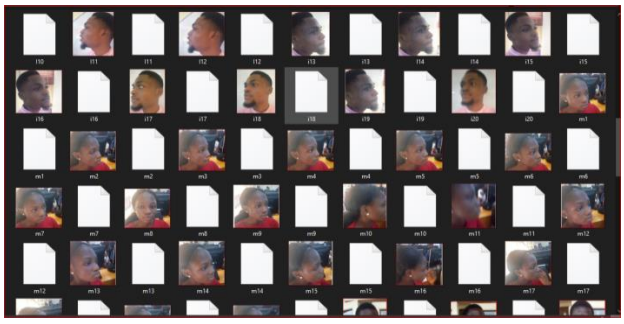
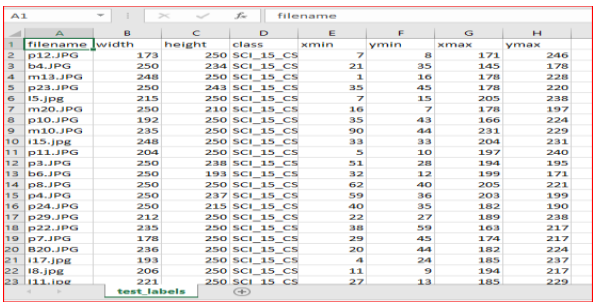


Figure 2: The Image of the Dataset

Data Preparation: The collected images were further converted to CSV format and stored in the system with their different dimensions as shown in Figure 3. This is to prepare the dataset for the modeling task ahead with the FRCNN. This phase performs some operations on the image to get an enhanced image or to extract some useful information from it.



	filename	width	height	class	xmin	ymin	xmax	ymax
2	p12.JPG	173	250	SCI_15_CS	7	8	171	246
3	b4.JPG	250	234	SCI_15_CS	21	35	145	178
4	m13.JPG	248	250	SCI_15_CS	1	16	178	228
5	p23.JPG	250	243	SCI_15_CS	35	45	178	220
6	l5.jpg	215	250	SCI_15_CS	7	15	205	238
7	m20.JPG	250	210	SCI_15_CS	16	7	178	197
8	p10.JPG	192	250	SCI_15_CS	35	43	166	224
9	m10.JPG	235	250	SCI_15_CS	90	44	231	229
10	l15.jpg	248	250	SCI_15_CS	33	33	204	231
11	p11.JPG	204	250	SCI_15_CS	5	10	197	240
12	p3.JPG	250	238	SCI_15_CS	51	28	194	195
13	b6.JPG	250	193	SCI_15_CS	32	12	199	171
14	p8.JPG	250	250	SCI_15_CS	62	40	205	221
15	p4.JPG	250	237	SCI_15_CS	59	36	203	199
16	p24.JPG	250	215	SCI_15_CS	40	35	182	190
17	p29.JPG	212	250	SCI_15_CS	22	27	189	238
18	p22.JPG	235	250	SCI_15_CS	38	59	163	217
19	p7.JPG	178	250	SCI_15_CS	29	45	174	217
20	B20.JPG	236	250	SCI_15_CS	20	44	182	224
21	l17.jpg	193	250	SCI_15_CS	4	24	185	237
22	l8.jpg	206	250	SCI_15_CS	11	9	194	217
23	l11.jpg	221	250	SCI_15_CS	27	13	185	229

Figure 3: The CSV file of the Dataset

The dataset consists of seven (7) features: image name, width, height, xmin, ymin, xmax, ymax which are the annotation box and the class. The class

consists of nine (9) instances of student matriculation numbers like SCI_15_CSC_005, SCI_15_CSC_004, SCI_15_CSC_043, etc. Finally, the dataset was split into train and test sets with the ratio 80%:20% respectively.

Modelling: Using the trained dataset, the face recognition model was built with FRCNN. The model convolves over an image looking for patterns such as distance between eyebrows to the eye, eyebrow to the top nose, nose top to mouth, eye to mouth. In the first few layers of the FRCNN, the network can identify lines and corners, and then pass down through the neural net and start recognizing more complex features as it gets deeper. The FRCNN does this by going through the image and applying a filter to find some patterns. It moves over a section of the images and effectively checks for a pattern in that section. The filters are a stack of weights represented as a vector which are multiplied by the values outputted by the convolution. When training an image, these weights change and return high values if it thinks it is seeing a pattern it has seen before. The combinations of weights from various filters let the network predict the content of an image. The inconsistencies in making these predictions are handled by the loss function. The loss function is used to measure the inconsistency between the predicted values ($y\hat{}$) and the actual value. It is a non-negative value where the robustness of the model increases along with the decrease of the values of the loss function. The loss function helps to optimize the parameters of the neural networks. Our objective is to minimize the loss function of our training model by optimizing its weights. The loss is calculated using loss function by matching the target (actual) value and the predicted value. Figure 4 shows the loss during the training phase.

Figure 4: Loss function

Over fitting occurs when complex machine learning models (i.e. one with a lot of parameters) is being trained on a fairly small dataset (i.e. few samples) thereby giving the model the capability of memorizing those samples. This means that it will learn a set of weights where for every single one of the input samples it will predict its train labels with higher accuracy but would not perform better on the test data. This is apparent because the model reaches a training loss of zero. To avoid our model memorizing its train label, we are using a relatively large number of samples with different backgrounds.

The work was implemented on Google Colab because it requires high graphics, good computational power (NVIDIA) and makes use of Matplotlib and OpenCV libraries for visualization.

Evaluation: The test dataset is used at this phase to test the accuracy of the model. The result is presented in the results and discussion section.

Deployment: The model was applied in a Web Application for the attendance record system. The OODM approach is used to design four (4) modules of the web application which include verification, detection, recognition, and attendance marking as follows:

A. Verification module: This module is achieved by a password security authentication technique. Successful user authentication and verification on the system promotes easy retrieval of relevant data from the system. The module is also designed to deny access to a user who provides wrong username and password. The Mango web server database management system was used for housing and manipulating the database of the system. The database table stores the registration details that is been received from the user at the point of registration and then compares it with the user login details that are received at the point of login. This module is relevant to ensure that only the registered admin/lecturer is authenticated to use the system.

B. Real-time face detection module: This module performs an important aspect of the system. It detects the faces at real-time with the aid of a handheld device (android mobile

phone) or web-based application. The face features are extracted in this module to perform the detect action.

C. **Face recognition module:** This is saddled with the responsibility of identifying whether the face under investigation is present in class or absent. This module is very essential because we have numerous kinds of faces with different pose/occlusion. The model sits on this module.

D. **Attendance module:** This module employs the use of the MongoDB database to record or store the attendance of the student.

The architectural design is shown in Figure 5. The flow allows features to be extracted from an input image and use same features to detect and recognize (match) the faces for attendance marking onto the database.

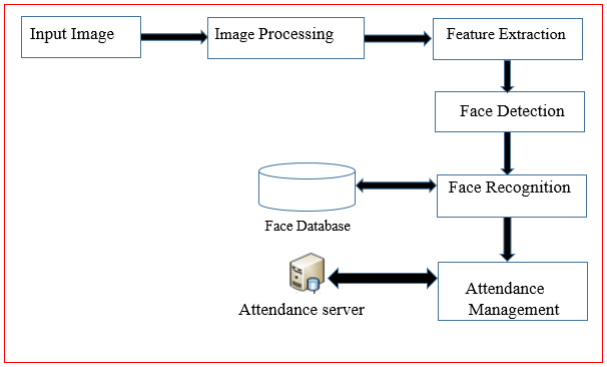


Figure 5: Architectural Design

Using the architecture, the system is designed as shown in Figure 6 and implemented as shown in Figure 9.

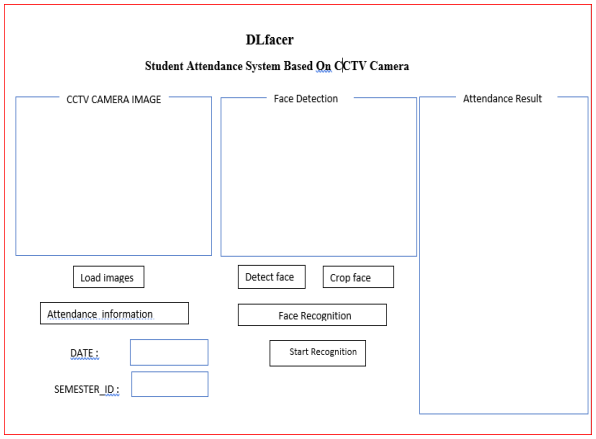


Figure 6: System Design

Results and Discussion

The result of this work is an attendance record system using face recognition known as "DLfacer" app. The application performs the task of processing of image (faces), detection of the faces and their recognition for attendance in real-time. The app registers users (admin/staff) and enables them to log onto the system. It allows images to be loaded into the system and further perform the detection/recognition tasks for attendance recording.

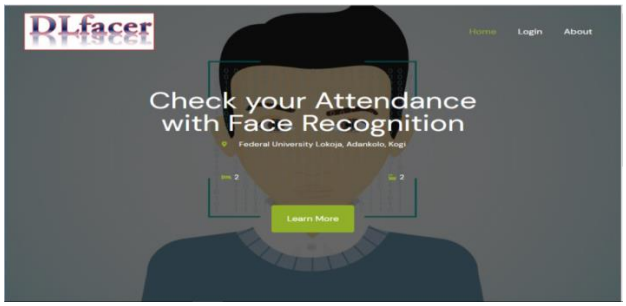


Figure 7: DLFacer Dashboard

The Figure 8 shows the registration interface of the system which performs the verification and authentication of relevant users. Students are also registered for their individual courses using the system and their pictures were taken at the point of registration and stored in the database.

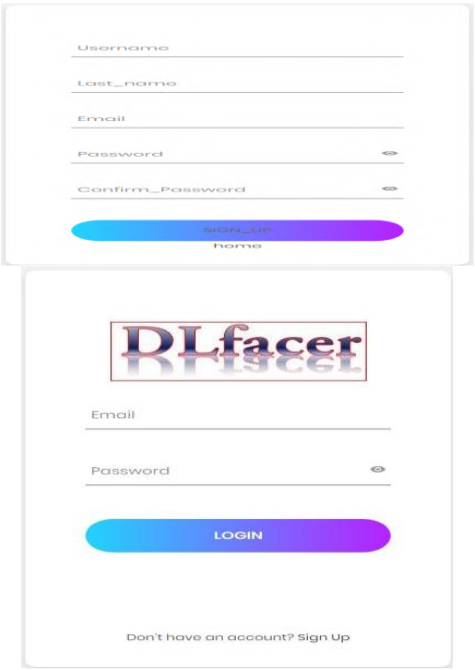


Figure 8: DLFacer Registration Interface

The system automates the traditional way of marking course lecture attendance during in a classroom. It is implemented with the help of a CCTV camera mounted in front of the classroom. The camera takes the picture of the class every lecture hour. As shown in Figure 9, at the end of the lecture, a professor/lecturer (an authenticated user) loads the pictures into the DLFacer. The faces of the students would be detected and recognized by using the model to match each registered and detected face. The attendance is taken automatically by marking all recognized (matched) faces present for the lecture.

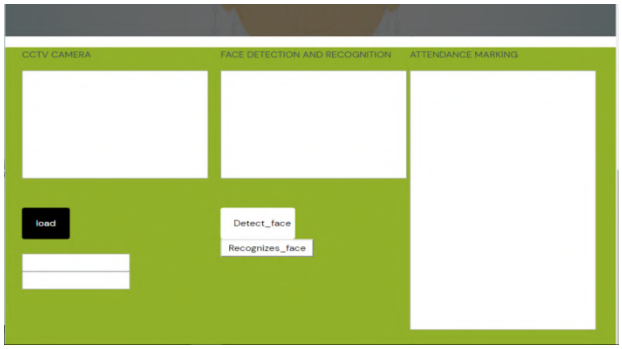


Figure 9: System Implementation

Some of the faces recognized by the app are presented in Figure 10. It shows the students were present in class and was recognized by the system with an accuracy of 97 - 99%. The recorded accuracy is a good improvement over existing systems like Anushka *et al.* (2018) and Syafeeza *et al.* (2014). Apart from the good evaluation result, the system was validated through providing images of students who were not registered for the course under investigation. It detected their faces but were unable to recognize (match) them and hence could not record their attendance.

Figure 10: Sample Outputs

The students' consents were not obtained to display their full face in this research, hence the eyes feature of the sample outputs were covered or blinded to take care of privacy concerns in this report; this was not necessary in the actual system.

This attendance system gives some advantage to the faculty by reducing the administrative burden on the staff/lecturer. This system would save time and be useful for security purposes as it also captures everyone in the classroom yet would not mark attendance for those not enrolled for the class/lecture. The use of this system will prevent ghost attendance marking and will enforce total compliance to lecture attendance. It will discourage students from missing classes and/or skipping lectures without informing the lecturer.

Comparing the efficiency of this system over existing systems, one would notice that the accuracy of the system is quite remarkable under different parameters. Table 1.0 shows comparison report

Table 1.0: Efficiency in relation to other systems

System	Detection	Recognition	Attendance
Anushka *et al.* (2018)	Not available	98.3%	Not available
Syafeeza *et al.* (2014).	Not available	85.15%	Not available
Yamini *et al.* (2019)	100%	Not available	Not available
DLFacer	100%	97 – 99%	100%

Above all, its deployment in a web based platform demonstrates the cost effectiveness of the system as any browser can run the application through a handheld phone without needing any third party vendor software. Again, even though the current implantation uses a CCTV camera mounted in front of the classroom, the system may still be operated with the camera of a handheld phone effectively.

Conclusion

This work had been able to design and develop an automated attendance record system using face recognition of students in a Nigerian University with a good accuracy. The aim of the research had been achieved through the deployment of the DLFacer app. The work had also provided a local dataset of students for further analysis in face recognition problems. Although the model recorded a good accuracy, it returned a fluctuating score of 97% to 99%. This is most likely not unconnected to the small amount of dataset used in the training phase. Therefore, as a future work, we intend to increase the dataset up to 10,000 images and make use of courses with large students' registration in order to improve or obtain a more reliable/steady accuracy. Our future work will also cover a smooth integration and deployment of the model into the DLFacer app (with a facility to further analyze the recorded attendance) for use in other courses across African Universities. The system is strongly recommended to Universities and Schools across Africa to serve as a tool for more accurate attendance record system.

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