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Class-based Digital Attendance Management System with Computer Vision

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Abstract

Attendance taking is an age long practice used to validate a student's presence in class. The traditional attendance system is done with pen and paper where students write their names on the attendance sheet. This method is marred with a lot of irregularities, inefficiencies and proxy attendance(s) where students record attendance for their friends and classmates who are not present in class. This paper, therefore, develops an attendance management system that leverages on computer vision technology to detect and recognize faces and a file management system to record the recognized faces against a spreadsheet of students present in a class session. It employed a face-recognition library built using dlib's and a deep learning mechanism with an accuracy of 99.38%, OpenCV, Pandas, and web app technology, namely HTML5, CSS3, JavaScript, and python/flask. The database design was based on the resident computer file system and a CVS file type was used to handle the row-column structure of the attendance records. The panda library was implemented to mimic a structured query language. This research paper has been able to solve the problem of proxy attendance recorded in a manual attendance system by recording the registered students' attendance automatically as they walk into the class.

Keywords

Attendance, OpenCV, dlib, Python, Face Recognition, Pandas

INTRODUCTION

Attendance systems have been an age-long practice where students' attendance are taken when they are seated in a class for lectures. The traditional attendance system is done with pen and paper where the students write their names on the attendance sheet. In some situations, the students' names are typed already on the attendance sheet and all they need to do is just to sign their signatures where their names appear. This method is time-consuming, highly inefficient, and can have a lot of proxy attendance(s) where students sign attendance for their friends and classmates who are not in class. This paper, therefore, develops an attendance management system that uses computer vision and a computer-based file management system to take and record the attendance of the students who are present in class.

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Computer vision is a branch of artificial intelligence (AI) that enables computers and systems to get the required information from digital images, videos, and other visual inputs and make recommendations based on that information. Computer vision employs machine learning to train machines on how to tell objects apart, how far away they are, whether they are moving, and whether there is something wrong with an image. Computer vision performs these functions using cameras, data, and algorithms rather than retinas, optic nerves, and the visual cortex as human vision does.

Two technologies used to achieve computer vision are deep learning (which is a type of machine learning) and convolutional neural networks (CNN). The computer vision employed in this work is basically used for facial recognition, where it is able to recognize the faces of students in a specific database of reach. Facial recognition is a process of identifying or confirming an individual's identity using their face. Facial recognition is one of the categories of biometric security. Other forms include voice recognition, fingerprint recognition, and eye retina or iris recognition. A facial recognition system uses biometrics to map facial features from a photograph or video and compares the information with a database of known faces to find a match. The attendance system developed in this paper uses a camera to capture students' faces at the point of registration and store the images in a database. So, the database contains a list of all the faces of the students registered for the particular class and the particular course. The system captures students' faces as they enter the class, matches the face with the faces on the database and when a match is recognized, attendance is taken automatically.

RELATED WORK

A facial recognition system is a technology which matches a human face from a digital image or a video frame against a database of faces usually employed to authenticate users. Facial recognition is widely adopted as a good biometric technology due to its contactless process (Chen & Chang, 2014). Facial recognition systems are used in advanced human-computer interaction, video surveillance, and automatic indexing of images (Bramer, 2006).

Many systems have been developed for attendance management. One of such systems is the system developed by Asri et al (2020). This system developed by Asri et al (2020) generates a smart attendance system that uses a Quick Response (QR) code to track and record attendance. The students and the professors are given a unique QR code at the beginning of the course. The students are required to scan their QR code using a QR-reading device. Once the QR code is scanned, attendance is recorded for such students. The problem with Asri et al (2020) system is that there is still room for proxy attendances as anybody can use anybody's QR code and scan an attendance for such a person whether the person is in class or not.

Meor et al (2014) developed an attendance monitoring system using fingerprint biometrics to monitor the presence of students. Their system reduces the chances of marking proxy attendance and minimizes the problems of missing papers of attendance. Teachers come to class with a small fingerprint scanner where the students press their fingers for their attendance to be taken. Their system is quite slow because the students will queue up and be pressing the fingerprint scanner one after the other for their attendance to be taken thereby wasting a lot of time.

Amena et al (2015) developed an attendance management system using iris recognition. Their system uses the iris pattern of the students for attendance. Live images of students' iris are captured by the camera and stored in the database. They used the gray coding algorithm to measure the

radius of the iris and the radius is matched with the radius of each student in the database and the attendance of that student is recorded for that class.

The system proposed by Shreyak et al (2019) uses two databases (face database and attendance database). The facial images of students are stored in the face database during enrolment. The camera captures the images of the classroom and the attendance is marked in the attendance database after face detection and recognition are done. Their system used the AdaBoost algorithm and Principal Component Analysis (PCA) for face detection and face recognition respectively.

The system developed by Sandhya et al (2021) stores the facial images with the unique ID of the students at the time of enrolment. At the time of attendance, the real-time images are captured with a camera and matched with the faces in the pre-trained dataset. Their system used the Haar Cascade algorithm for face detection and the Local Binary Patterns Histogram (LBPH) algorithm for face recognition and training of the stored dataset which generates the histogram for stored images and the real-time image. In order to recognize a face, the difference between histograms of real-time images and dataset images is calculated. When the difference is low, the best match results in displaying the name of the student, and the attendance of that student is automatically updated in the excel sheet.

A descriptive framework of facial recognition was designed by Radhika and Bageshree (2018). This system used DNN to detect the faces of students and PCA and LDA algorithm for image matching and an SVM classifier and CNN. Their accuracy rate is 86%.

The authors Adrian et al (2014) developed a face recognition algorithm with OpenCv 2.4.8. the authors compared two famous face recognition algorithms, PCA (Eigenface) and LDA (Fisher's face) using a ROC curve on their training set. Their result showed that Eigenface performed better than fisher face.

MATERIALS AND METHODS

The proposed attendance management system employed the use of a face-recognition library, which in turn employs a Convolutional Neural Network (CNN), a branch of deep learning. We built a web UI/UX interface around the model to enhance performance. We leveraged a computer base-camera system for static and motion image capture of students. Figure 1.0 illustrates the design architecture, which indicates the use of CV2 and dependencies. This undoubtedly, comprises OpenCV, dlib, face-recognition library, pandas, OpenCV, front-end-web frameworks namely HTML5, CSS3, and JavaScript, and the back-end framework of python/flask.

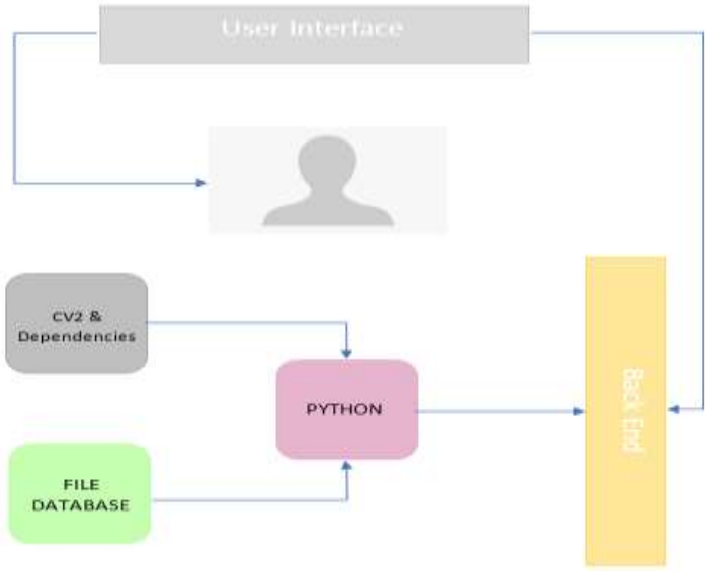

Figure 1: Block Diagram of the Attendance Management System

The system is designed in two broad categories:
1. User Interface and
2. Back End

The user interface was developed using HTML5, CSS3, and JavaScript. In the front end of the application, the HTML was used for the structuring and presentation of the content on the world wide web, the CSS was used to describe the presentation and structure made by the HTML in a more user-friendly way using styles and colors and the JavaScript was used to modify the HTML and CSS in order to update the user interface through the Document Object Model Application Programming Interface. JavaScript as a scripting language was used to dynamically inject the name of the captured faces on the DOM element and send out the name, date, and time the student was captured to the back end for further processing. The python language was used for the main programming which is the back end.

CV2 and Dependencies:

The Computer Vision Version Two (CV2) which is a module import name for OpenCV-Python was used to build computer vision-related Apps and integrated with various libraries like NumPy, Pandas, etc. These libraries, when pre-loaded with CV2 and other libraries used in this research work are called dependencies.

DATABASE DESIGN

The database design for the Attendance Management system is based on the resident computer of the said App file system. Based on the several built-in modules and functions for handling files, the database was structured to leverage this prebuilt module.

A CSV file type was used to handle the row-column structure of the attendance records. For properly structured query on these data, Panda library was implemented as the structured query

Language. Students' records, in terms of attendance, are saved automatically by the attendance system into a CSV file type, which is available for digital retrieval and or printing. Figure 2 shows the design method for the database, while Figure 3 shows the CSV file of the attendance management system.

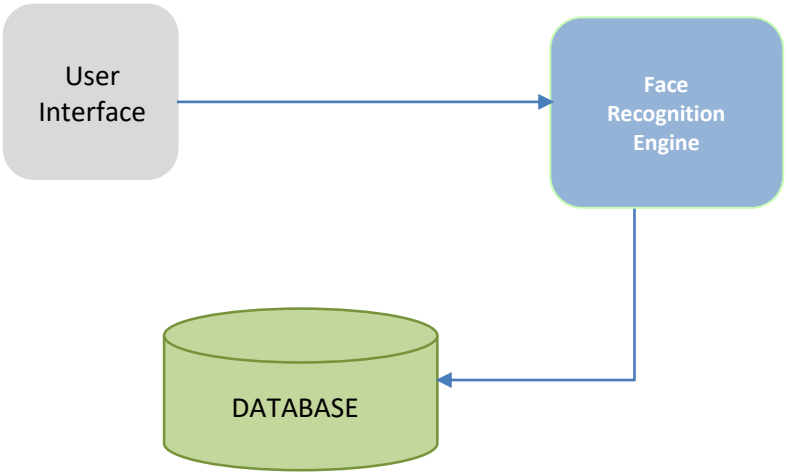

Figure 2: Attendance Management System Database Structure

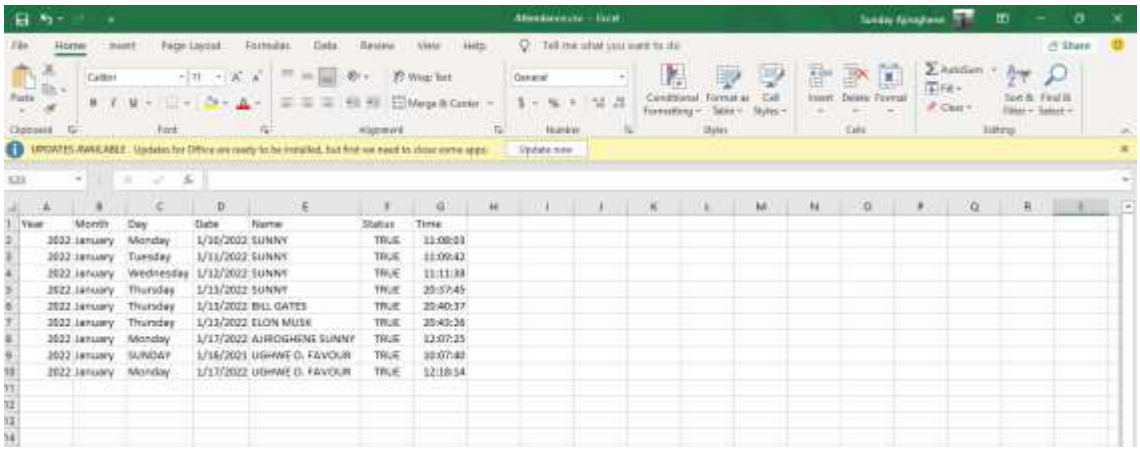

Figure 3: Attendance Management System CSV-Database

In the process of attendance taking on the webpage, once the program is executed, an interface pops up on the web browser. However, the interface is served from Python/Flask server which runs the face-recognition script. At first load, a series of initialization steps are done such as loading the trained data to the recognizer and etc. The attendance-taking process will then proceed in a loop to acquire, identify and mark the attendance for each of the students that are obtained

from the computer-based camera. The flow chart of the attendance-taking process is shown in figure 4 below.

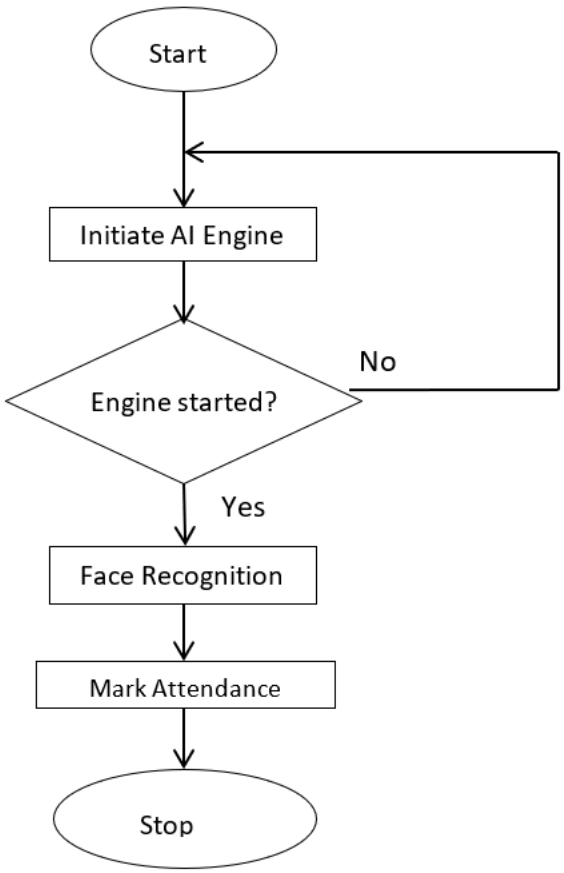

Fig 4: Attendance Management System Flow-Chart

RESULTS AND DISCUSSIONS

Principle of Operation

The application was designed in two broad sections, the User interface, and the Back end. The user interface was designed with HTML5, CSS3, and JavaScript while the Back End was designed with Python and CV2/dependencies.

In the user interface section, the user positions his/her face for the back end of the process. A squared box interface pops up for the user to take pictures.

The Attendance Management System begins by launching the start button provided by the IDLE in the window's environment. The user of the application being a student that is to take attendance, positions his/her face against the camera. The face of the user is displayed on the user interface with the name written on the image if such student is a registered student for the course of interest, however, if such use is not in the database of the course of interest, an "unknown" is displayed

alongside the face. The project makes use of the Face Recognition Library to uniquely identify and differentiate between different people.

- The very first step done behind the scenes is Finding user faces using Histogram of Oriented Gradient (**HOG**) technology. Once the face is captured, a WARP is applied. Warp is a special technology used to flatten captured faces so that all the face features (aka **landmark)** can be uniquely presented. Warping of an image uses the **dlib** behind the scene. The technology works great for faces captured sideways or tilted.
- The second step is to send the Warp image to a Neural Network trained for Facial Recognition.
- The Neural Network returned the encoded features. Features basically is the face contour type and style represented also in the measurement between the eyes to the mouth, distance measurement between the nose to lips, to the ears, the size of the lips, chin et *cetera.*
- The encoded features the network returns are 128 generated measurements, which is then used to define a person and the difference between different people.
- To capture the name of each user, during the image capture, the name of each image fed into the network is assigned so that the machine can label the image accordingly. Supervised Machine Learning was used to achieve this.

System Interfaces

Figure 5 below illustrates a student with an academic record in a school management system who has been duly registered. The model proves efficient as it was able to validate the student. The web service was extended to automatically interface and synchronize with the school management system and pull up necessary data. The application identifies the student as a student duly registered for that particular course and automatically records attendance for him.

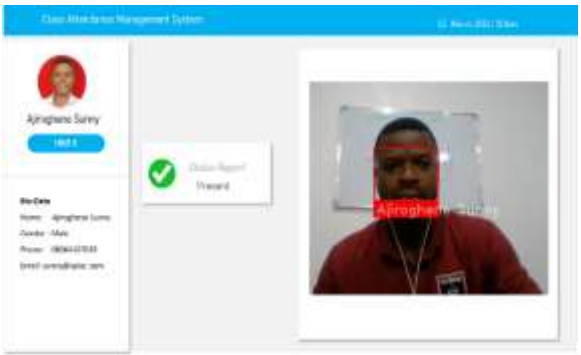

Figure 5: A Registered Student

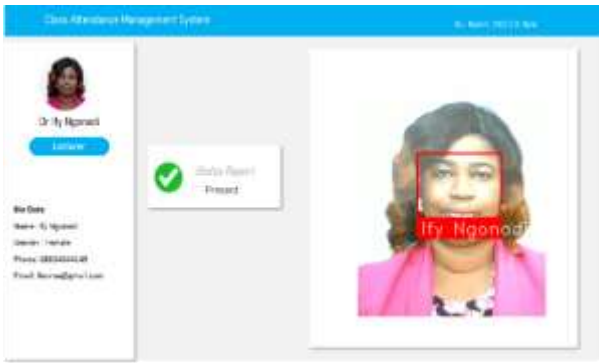

Figure 6: A Registered Lecturer

Figure 6 shows the image of a lecturer who is also registered in the school management system.
Figure 7 below illustrates a student with a non-academic record in a school management system, the model proves efficient as it was able to invalidate the student. The web service was extended to automatically interface and synchronize with the school management system and pull up necessary data. The student who is not duly registered for that course is not validated and therefore attendance cannot be recorded for such a student since he is not a registered student.
This application can also be very useful in validating students' eligibility for writing examinations.

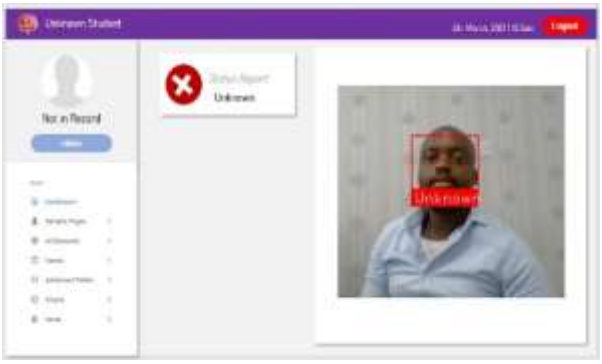

Figure 7: A Non Registered Student

CONCLUSION AND FUTURE WORK

The Attendance Management System which was designed and presented in this work records the attendance of students automatically as they walk into their class. The Convolutional Neural Network which is one of the technologies used to achieve computer vision was employed to detect and recognize the faces of registered students who attend classes. This method eliminates proxy attendance(s) and ensures that attendance is marked for only registered students who are present in class. Future work will be on developing an application that is able to calculate the percentage of each student's attendance that qualifies them to write an examination.

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