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Intelligent Face Recognition Based Students' Attendance System

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***Abstract* - This paper aims at developing an intelligent face recognition students' attendance system to enhance school attendance tracking. The system is made up of four phases- database of students' details, face detection, face recognition and attendance report. The database stores all the students' details and images of the students' face captured while face detection and recognition is carried out with convolutional neural network algorithms from the face recognition and opencv library. As faces are detected and recognized from live streaming video of the classroom, attendance are recorded into an excel file and then sent to a real time database. The system also contains a mobile interface through which the course instructors can access information at all time. The methodology adopted for this work is object-oriented analysis and design methodology (OOADM) while programming language used is Python. This work has helped immensely to eliminate the issue of proxy attendance as well as reduce the time wasted in manual attendance system. It is very beneficial to schools and other institutions where attendance is required.**

Keywords: Attendance, Biometric, OpenCV, Convolutional Neural Networks, Face Detection, Face Recognition, Eigenface.

1. Introduction

With technological innovations all over the world, every field of human endeavour tends to lean on technology. The higher institutions have also kept abreast with this technological trend in order to enhance and improve learning. This evident in the well-equipped labs, classrooms, offices and overall administrative processes found in schools currently.

However, one of the few areas in which higher institutions still lag behind is in attendance systems as most institutions still depend on the conventional methods such as paper attendance which are not efficient and reliable. With the tremendous growth in computing domain especially in the areas of Artificial Intelligence and image processing, attendance methods can be automated to provide time efficient and reliable means of keeping records of students' attendance.

Face recognition is a biometric method of identifying an individual by comparing images captured at real-time with the images stored in the database (Margaret Rouse, 2012). We might not be aware the several actions involved in identifying human faces and objects around us, but the brain through the help the eyes undergoes a lot of processes daily as face recognition is very vital in human life. Most decisions are made through perceptions, of which eyes are the key players.

The benefit of human sight cannot be overemphasized as information are received through the images projected towards the eyes, when light on getting to the retina are converted into electric signals by the special cells called photoreceptors. These electric signals travel through the optic nerves to our brain where they are transformed to images.

The research on face recognition started in 1960 when Woody Bledsoe, Helen Chan Wolf and Charles Bisson introduced a system for identification of the eyes, ears, nose and mouth from other images. They calculated and compared the distance and ratios between the identified features and the regular reference points. The work was expanded in 1970 by Goldstein, Harmon, and Lesk by automating recognition through the use of other features like hair colour and thickness of the lip. Then in 1988, Kirby and Sirovich proposed the use of technique known as the principle component analysis (PCA)in solving face recognition problem. More researches are still on-going in face recognition technology.

Today, the popularity of face recognition system has increased because it is very efficient and easy to use. For example, airport protection systems and FBI employ face recognition for investigation of criminal cases through tracking of the perpetrators, missing children and drug transactions (Robert Silk, 2017). Also some social networking sites such as Facebook employ face recognition technology to enable the users tag their friends in photos (Sidney Fussell, 2018). In addition, In Intel Company, users are allowed to use face recognition to gain access to their online account (Reichert, C., 2017) and users of Apple mobile phone and iPhone now unlock them with face recognition technology (DeAgonia, M., 2017).

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Since the technology of Artificial Intelligence has continued to evolve due to its simplicity and efficiency, we could build and adopt such efficient systems in our higher institutions to make the management and learning exercise easier and reliable.

2. Review of Related Works

Attendance is a very important factor in any educational institution if we must monitor and track the students' performance. Attendance systems have evolved over the years from manual to automated systems, making it easier for schools to manage attendance.

National Center for Education Statistics (2016) defined School attendance as a means of tracking the presence or absence of students in schools. It can be achieved manually by using paper attendance or electronically through the use of biometrics, smart cards and mobile devices.

Divya, M. S. et al. (2019) developed a computerized attendance system for educational institutes using facial recognition technology. They used OpenCV library for facial recognition system and developed a three-stage process including face detection, feature extraction, and recognition. The system makes use of the Histogram of Oriented Gradients (HOG) algorithm for feature extraction and the k-nearest neighbor (k-NN) algorithm for face recognition. It has different modules such as new users' registration module, report module for report generation and a warn module that sends alerts on attendance status to the provided number during registration.

Gayathri, V.K. et al. (2019) designed facial recognition based attendance system for schools. The authors also made use of OpenCV library for facial recognition. The system has face detection, feature extraction, and recognition. Local Binary Pattern (LBP) algorithm was used for feature extraction while the K-Nearest Neighbors (KNN) algorithm was used for face recognition. The system comprises of a registration module for enrolling new students into the system and a report module for attendance reports generation.

Zhen C. et al. (2018) in his work termed Facial Recognition for Automated Attendance Tracking in Higher Education proposed a face recognition-based attendance system for higher institutions. They argued that conventional attendance tracking systems, such as paper attendance are not efficient enough and are highly prone to errors. Hence the developed a system that uses face recognition technique to automatically take student attendance. The system hasOpencv and dlib libraries, utilizes SVM for recognition and matching and captures images of students using a camera placed at the entrance of the classroom.

In 2019, Kim J. et al. also opined that traditional attendance systems, such as manual method, are not only error prone but consumes a lot of time. As a result, they proposed a face recognition system that automatically tracks student attendance. The system employed Fisherface and viola jones technologies respectively in feature extraction and recognition.

Ajayi, V. et al. (2019) presented facial recognition attendance system with modern face detection technology for schools. With this system, image capturing was done prior to entering the class. The system uses opencv and dlib libraries for face detection and feature extraction, alignment/normalization respectively.

Rathod, S. S. et al. (2021) proposed a smart attendance system using facial recognition technique for educational institutes. The algorithm used for facial recognition in the system is made up of various steps which include face detection, face alignment, feature extraction and recognition. The authors used Viola-Jones algorithm for face detection, and the Local Binary Patterns (LBP) algorithm for feature extraction. The recognition algorithm applied Support Vector Machine (SVM) classifier to identify the registered students from the face images captured.

Alkhateeb, M. et al. (2019) developed a facial recognition attendance system for vocational training centers in Saudi Arabia. They opined that conventional attendance tracking system, such as manual attendance consumes a lot of time and error prone. Hence they proposed facial recognition system that automatically tracks students' attendance. The system captures the images of students' faces as they enter the classroom using the cameras placed at the entrance. These images are then compared to a database of student photos to verify their identity and mark them as present. The authors conducted experiments to evaluate the accuracy and efficiency of their system and found that it was able to correctly identify students with an accuracy rate of 98.

Morocho-Cayamcela S. et al. (2020) developed a face recognition attendance system for automatic tracking of student attendance in university. KNN and HOG methods were employed by the system and opencv's HAAR cascade was used for training and extraction. The system shows accuracy rate of 94%.

Shuaib Arafat et al. (2021) presents an automated attendance system for educational institutes that uses facial recognition technology. The system consists of a camera, a microcontroller, and a database for storing student information and attendance records. The system used the OpenCV library for facial recognition and implemented a three-stage procedure that involves face detection, feature extraction, and recognition. The system uses the Eigenface algorithm for

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feature extraction and the K-Nearest Neighbors (KNN) algorithm for face recognition. The system's software architecture includes a registration module for enrolling new students into the system and a reporting module for generating attendance reports. The system also includes a user-friendly web interface for administrators to manage the system.

3. Types of School Attendance System

- **Traditional Attendance Systems:** Traditional attendance systems are manual methods of recording attendance, such as paper registers or attendance sheets. These systems require teachers to take attendance manually and record it in a ledger or spreadsheet. This method is time-consuming and prone to errors, but it is still widely used in many schools. Studies have shown that traditional attendance systems can be inaccurate, with teachers reporting attendance inaccurately up to 5% of the time (Kearns & Furlong, 2010). Additionally, these systems can be easily manipulated by students who sign in for absent classmates. Despite these limitations, traditional attendance systems are still widely used in many schools due to their low cost and simplicity.
- **Automated Attendance Systems:** Automated attendance systems involve the computer-based or electronic means of maintaining students' attendance in schools (Shahzad et al. 2020). Such approaches include:
    i. **Biometric Attendance Systems:** These systems of attendance are achieved through the use of biological attributes like fingerprints, face recognition, or iris scans in identifying students and recording their attendance automatically. The biometric systems are becoming prevalent in schools as they are more secure and accurate compared to conventional attendance system. Although, these systems can be expensive to implement and present some concerns about privacy and protection of data, it has been shown by researchers that biometric attendance techniques significantly improve attendance rates and reduce absenteeism (Bhardwaj et al., 2018; Karthick et al., 2020).
    ii. **Smart Card Attendance Systems:** These systems make use of Radio Frequency Identification (RFID) technology in tracking students' attendance with smart cards or ID badge. Like biometric technique, they are more secure than conventional attendance systems and require less manual input from teachers. Smart card attendance systems yield better attendance result (Tan et al., 2017; Nour & Alhajjaj, 2019), however, they cost a lot to develop and involve huge hardware and software investment.
    iii. **Mobile Attendance Systems:** In these attendance systems, mobile devices like smartphones and tablets are used in taking attendance. These systems are easily incorporated into other school management systems and teachers and students find them more convenient to use. The systems have also recorded improved attendance rates and reduction in absenteeism (Begum et al., 2020; Li et al., 2021). The main disadvantage of these systems is that they require the use of mobile devices by students and not all the students can afford it.

4. Face Recognition Biometrics

Face recognition is the process of identifying human faces in images and videos. It is used to determine whether the face in two images belongs to the same individual and searching for a face among different collection of existing images. The software capable of identifying or confirming people's identity using their faces is referred to as face analyzer. It carries out this work by identifying and measuring facial features in an image. Biometric security systems employ face recognition in order to uniquely identify people during user logins and fortify user authentication system. Also mobile and personal devices often utilize face analyzer to ensure security of gadgets.

4.1 Merits of Face Recognition System

Some of the merits of face recognition systems include:

Improved security: Face recognition is a very fast and effective verification method. It appears faster and more convenient in comparison with other biometric methods such as fingerprints or retina scans and we have lesser touch points in face recognition than using passwords or PINs. It also makes provision for multifactor authentication for extra security measures.

Smoother integration: Face recognition technique is compatible and can be incorporated into other security technologies easily.

Enhanced accuracy: Face recognition system provides better accuracy in identifying people than using means such as phone number, address, email address or IP address. For instance, almost all the exchange services make use of face recognition to ensure customers' security.

4.2 Uses of Face Recognition Systems

Face recognition systems can be used for the following:

- **Fraud detection:** face recognition system can be used by companies to uniquely identify users who create new

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accounts online. Through face recognition, the identity of the actual user of the account can be verified in case of any malicious or suspicious activities on the account.

- **Cyber security:** With the help of face recognition systems, companies now enjoy better cybersecurity unlike the use of password. It is very difficult to access facial recognition systems unauthorized as everyone has a unique face. Face recognition techniques is not only easy to operate but a very accurate security tool to unlock smartphones and other personal devices.
- **Airport and border control:** Nowadays, most airports employ biometric data as passports. This eradicates the issue of long queue faced by travellers as they pass through computerized terminal to reach their gate faster. This e-Passports provided by face recognition technique has reduced waiting times and enhanced security.
- **Banking:** These days, transactions are authenticated so easily by people through looking at their phone or computer rather than the use of one-time passwords or two-step verification. Face recognition provides stronger security as there are no passwords for hackers to compromise. Also, some ATM transactions can be authenticated by face recognition.
- Healthcare: Face recognition can be used to access records of patients, as well as auto-detect patients' pains and feelings.

4.3 Face Recognition Mechanism

Face recognition system operates in three steps:

- Detection
- Analysis
- Recognition

Detection: This involves the process of finding a face in an image. With the aid of computer vision, face recognition is able to detect and identify people's faces from an image consisting of one or more people's faces. It detects face data in both front and side face views. Face detection algorithms apply several techniques such as Haar cascades, Viola-Jones algorithm, and deep learning-based methods like CNN (Convolutional Neural Networks) in detecting faces.

Analysis: The face recognition system analyses the image of the face by mapping and reading the face geometry and facial expressions. It identifies the major face landmarks that distinguish a face from other objects. The face recognition technique mainly looks out for the following:

- Distance between the eyes
- Distance from the forehead to the chin
- Distance between the nose and mouth
- Eye socket's depth
- Cheekbone's shape
- Lips, ears, and chin contour

During the analysis, the face recognition data are being converted to string of numbers or points known as face print. Every individual possesses unique face print, just as the case of fingerprint.

Recognition: Face recognition system identifies a person through comparison of the faces in two or more images and checking the possibility of the face match. For instance, it is able to verify that a face captured by a mobile camera is a match to the one in an image of one's ID document. Like a driver's license or passport or verify that the face shown captured by the camera does not match a face in the database of faces previously captured. Face recognition algorithms apply techniques such as Eigen faces, Fisher faces, Local Binary Patterns, and deep learning-based methods like CNNs in recognizing faces.

4.4 Face Recognition Algorithm

The common algorithm used for face recognition is the Euclidean distance algorithm. It is usually used in face recognition to measure the similarity between two face feature vectors. The algorithm works by calculating the Euclidean distance between two vectors in a high-dimensional feature space.

In face recognition, deep neural network is usually used in extracting features from faces. The extracted features are represented as a vector in a high-dimensional feature space. A small Euclidean distance between two feature vectors is an indication that the two faces possibly belong to the same individual while large distance indicates that the two faces may belong to different persons.

Practically, face recognition systems uses threshold value in determining whether two faces can be said to match. When the distance between two features vectors is below the threshold, they are considered to match else they are taken as non-match.

In comparing two face images, the neural network is initially used to compute their feature vectors, after which, the Euclidean distance between the two vectors is calculated with the formula below:

$$\mathbf{d}=\sqrt{(\boldsymbol{X1}-\boldsymbol{Y1})^2+(\boldsymbol{X2}-\boldsymbol{Y2})^2+\cdots+(\boldsymbol{Xn}-\boldsymbol{Yn})^2}/$$

X and Y are the two feature vectors under comparison and n is the number of dimensions in the feature space.

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5. Operation of the System

The key players involved in this system are the students whose faces are to be captured, the instructors and the system administrators. the system administrator registers the students by collecting their details and capturing their faces. This registration is carried out on a per course basis. The details of students and the snapshot of their faces stored in the database are used to train the image dataset and generate trained or encoded information that will be used in face recognition.

During attendance taking, the students present themselves for the face capturing and recognition. The system captures the digital images of student's face and compares it with the one previously stored in the database. The attendance is granted if the image captured matches with the one in the system, else it is denied. With the help of a mobile app provided in the system, the instructors can access the results of the facial recognition in real time. The app is linked to the database of the system and can be easily navigated by the instructors whenever the attendance summary or details are needed.

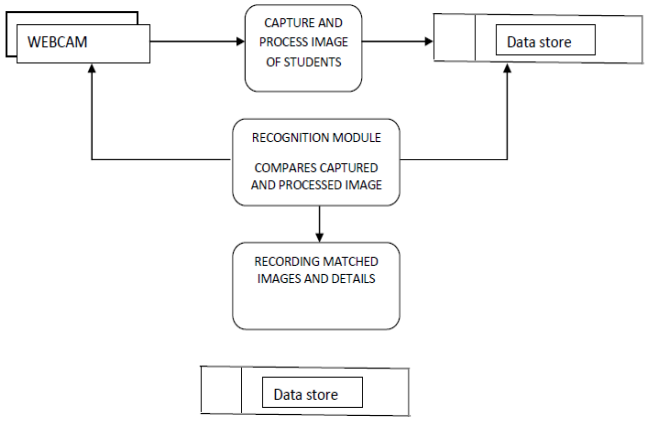

Figure 1: Dataflow Diagram of the System

Sample Outputs of the System

Some of the sample outputs include:

Admin Login:

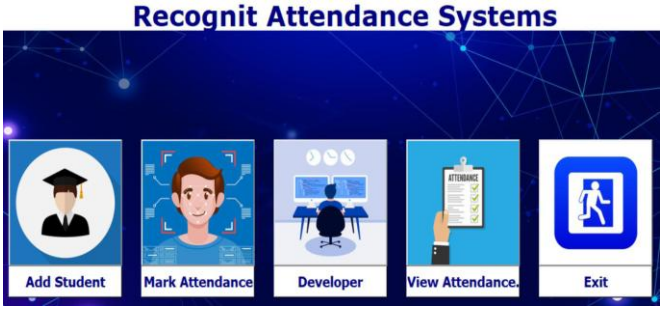

Figure 2: Admin Login

Course Attendance Report:

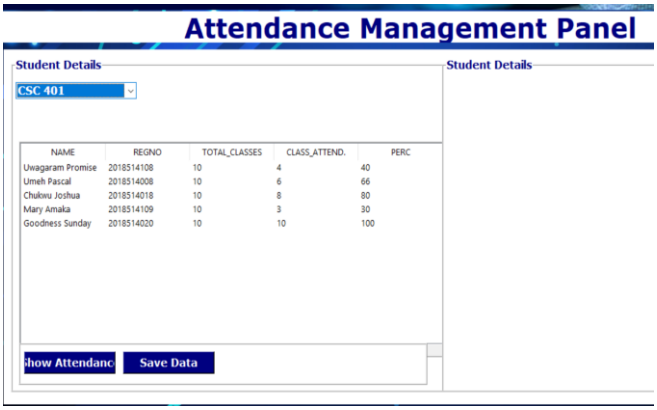

Figure 3: Course Attendance Report

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