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Implementation of a Facial Recognition System for Attendance Tracking Utilizing the K-Nearest Neighbors Algorithm

Abhishek Tripathi
Department of Computer Science Engineering
Kalasalingam Academy of Research and Education
Srivilliputhur, Tamil Nadu, India
tripathi.abhishek.5@gmail.com

Chirukuri Manohar
Department of Computer Science Engineering
Kalasalingam Academy of Research and Education
Srivilliputhur, Tamil Nadu, India
manoharchirukuri09@gmail.com

Dhiraj K Patel
Department of Electronics and Communication Engineering
Indian Institute of Information Technology
Surat, India
er.dhirajpatel@gmail.com

Subhashish Tiwari
GITAM University
Bengaluru, Karnataka, India
stiwari@gitam.edu

Rajat Paliwal
Thadomal Shahani Engineering College
Mumbai, Maharashtra, India
rajat.paliwal@thadomal.org

***Abstract*—In today's digital age, facial recognition systems are crucial across industries for authentication, security, and identity verification. While slightly less precise than iris or fingerprint recognition, facial recognition's non-invasive nature fuels its growing popularity. It's extensively used for attendance tracking in various institutions, replacing error-prone manual processes. The proposed framework involves four stages: attendance updating, face detection, recognition, and database construction, employing techniques like Local Binary Patterns and Haar-Cascade classifier. Notably, in the recognition stage, the K-Nearest Neighbors (KNN) algorithm plays a pivotal role. KNN aids in accurately identifying individuals based on facial features, ensuring precise attendance tracking. Attendance records are then emailed to relevant faculty members at the end of each class, streamlining administrative tasks.**

***Index Terms*—Facial Recognition, KNN, Attendance System, PCA and LDA.**

I. Introduction

MANY schools and universities find that recording attendance using the traditional way is an arduous undertaking [1]. Additionally, it adds to the workload for the teachers who have to personally call the names of the pupils, which may take the full five minutes meeting. This consumes a significant amount of time and may result in proxy attendance. As a result, numerous institutions began utilizing a wide range of additional methods to record attendance, such as Radio Frequency Identification (RFID), iris identification, and biometric identification [2]. However, these systems may utilize more resources and have an invasive quality due to reliance on queues. Face recognition, on the other hand, offers a non-intrusive and readily attainable biometric characteristic [3]. Face recognition systems can be categorized into two main categories: face verification, which compares faces in a 1:1 matching method, and face identification, which involves comparing a query face picture with multiple template face images (1:N matching) [4]. The goal of this system is to create an efficient attendance system using face recognition algorithms as its foundation. Face recognition technology has been increasingly applied in various fields and offers promising solutions for attendance management [5]. In this work, we propose a method that recognizes children's faces from live streaming video in the classroom, making attendance recording quicker and more efficient compared to traditional methods.

The paper is organized as follows: Section II presents a Literature Review summarizing existing approaches to facial recognition and attendance systems. Section III details the Proposed System, including its architecture and components. Section IV explains the Methodology, covering data preprocessing, feature extraction, and the K-Nearest Neighbors algorithm. Section V discusses the Results and Discussions, analyzing system performance and accuracy. Finally, Section VI concludes with key findings and future directions in Conclusion.

II. Literature Review

Researchers have introduced various models for automatic attendance systems, with a focus on integrating radio frequency identification (RFID) with facial recognition [5]. RFID is utilized to identify and count approved pupils as they enter and exit the classroom, maintaining an authentic record of enrolled students [6]. Additionally, the system retains information about each student enrolled in a particular course in the attendance record and provides the necessary information as required. Furthermore, attendance systems based on biometric iris data have been implemented, where participants register their information and provide an original iris template [7]. During attendance recording, the system automatically captures the attendee's image, identifies them through their iris, and matches them with the database.

Another proposed attendance system involves face identification, employing methods such as Viola-Jones and Features from the Histogram of Oriented Gradients (HOG), along with a Support Vector Machine (SVM) classifier [3]. This system addresses various real-time situations, including scale, lighting, occlusions, and posture. A quantitative study conducted using Peak PSNR values in MATLABGUI revealed that Eigenface yielded superior outcomes compared to Fisher face [8]. Moreover, a technique for tracking student attendance using facial recognition technology in the classroom was proposed, integrating Discrete Wavelet Transforms (DWT) with Discrete Cosine Transforms (DCT) to extract facial features [9]. Radial Basis Function (RBF) was then utilized to classify facial features, achieving an accuracy percentage of 82% [4].

III. Proposed System

Each student in the class is required to register by providing necessary information. Subsequently, their pictures will be taken and stored in the dataset. Faces will then be identified from the live-streamed classroom footage during each session. These identified faces will be compared to the pictures in the dataset. If a match is found, attendance will be recorded for the corresponding student. After each session, a list of absentees will be emailed to the faculty member in charge of the meeting. The system architecture of the proposed system is provided below. Generally, this process consists of four steps.

A. Creation of Datasets

A webcam is used to capture images of the children, with each student being photographed multiple times while displaying various movements and poses. These images undergo preprocessing steps, which include trimming to extract the Region of Interest (ROI) for subsequent recognition processes. The cropped photos are then resized to specific pixel dimensions. Following this, the RGB images are converted to grayscale. Finally, the processed images are saved in a file along with the corresponding student's name. Fig. 1 illustrates the system architecture designed for a face recognition attendance system.

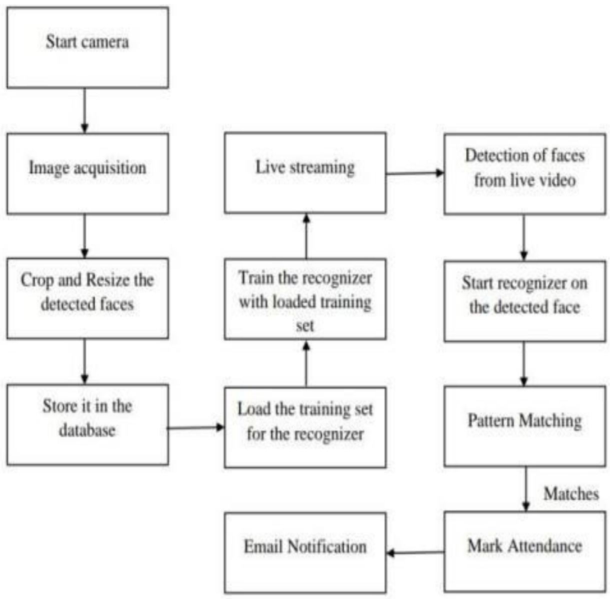

Fig 1. System architecture for face recognition attendance system.

B. Facial Recognition

In this context, facial detection is achieved using the Haar-Cascade Classifier provided by OpenCV. Prior to its application in facial recognition, the Haar Cascade method requires training to identify individuals' faces, a process known as feature extraction. This involves utilizing an XML file named "haar cascade_frontal face_default" as training data, which contains the cascade of Haar characteristics essential for recognition. Fig. 2 depicts a theoretical face model utilizing Haar Features for robust facial recognition. In this instance, the OpenCV detect MultiScale module is utilized to surround the faces in an image with rectangles, which is necessary for detection. Three criteria need to be considered: scale Factor, min Size, and min Neighbors. The scale Factor determines how much each image scale should be reduced. The min Neighbors parameter specifies how many neighboring rectangles each candidate should have. Higher ratings typically result in fewer detected faces but better recognition quality. The min Size parameter indicates the minimal size of an object, which is set to (30,30) by default. In this system, the parameters scale Factor and min Neighbors are set to 1.3 and 5, respectively.

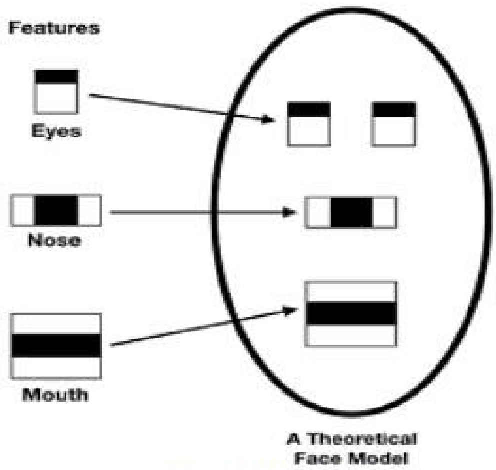

Fig 2. Theoretical face model utilizing Haar Features for robust facial recognition.

The face recognition process comprises three steps: preparation of training data, training of the face recognizer, and prediction. The photographs in the dataset serve as the training data, and each is assigned an integer label indicating the corresponding student. Subsequently, face recognition is applied to these images. This system employs a Local Binary Pattern Histogram as the face recognizer. Initially, the local binary patterns (LBPs) of the entire face are obtained and converted into decimal numbers. Histograms are then created for each decimal value. For every image in the training set, a histogram is generated. During the recognition process, the histogram of the face to be identified is computed and compared with the previously computed histograms to determine the label that best matches the corresponding student.

C. *Attendance Updation*

Following the face recognition procedure, the faces that were identified will be noted as present on the excel sheet, while the remaining faces will be noted as absent. A list of the absentees will then be mailed to that particular faculty. Faculty members will be informed with monthly attendance record at each month's conclusion.

IV. Methodology

Throughout our face recognition endeavor, we extensively explored a myriad of methodologies prevalent in the field. This encompassed a thorough examination of existing literature to discern the strengths and limitations of various recognition systems. Our chief aim was to address the shortcomings of prevailing approaches and devise a proficient face recognition system. At the core of our investigation lay the fusion of Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) for feature extraction. We employed Eigenfaces and Fisherfaces for subspace projection, with matching facilitated by a Euclidean classifier for distance assessment. Diverse strategies for facial recognition were explored, all yielding favorable results. Our attention extended to real-time applications, with PCA demonstrating exceptional performance in this realm. Insights gleaned from literature emphasized the necessity of refining the system to accommodate variations in facial angles, underscoring our dedication to bolstering resilience and adaptability. An intriguing avenue explored involved the potential amalgamation of gait recognition with facial recognition software, offering a comprehensive approach to identity verification. Challenges posed by low-light conditions were acknowledged, with recognition that while the system functions adequately in such scenarios, achieving optimal resolution remains an ongoing endeavor. Fig. 3 delineates a flowchart delineating the methodology adopted in the face recognition system.

Firstly, the algorithm begins by importing necessary libraries such as numpy for numerical operations, face_recognition for face detection and recognition, cv2 for computer vision tasks, os for file and directory operations, datetime for handling date and time data, and xlsxwriter for generating Excel files. Next, the algorithm defines two key functions. The first function, findEncodings(images), processes a list of images by converting them to RGB format, detecting faces within the images using the face_recognition library, and then appending the encodings of these faces to a list. The second function, markAttendance(name), handles the attendance marking process by reading and writing to a CSV file containing attendance data, ensuring each student's attendance is appropriately recorded along with the current date and time.

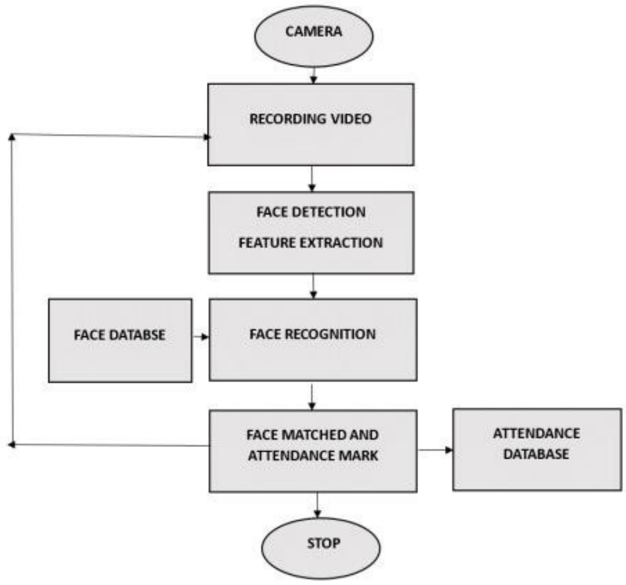

Fig 3. Flow chart of methodology.

Subsequently, the algorithm defines a dictionary containing student names and their corresponding roll numbers. This data will be used to populate the Excel worksheet with student information, ensuring accurate attendance tracking. Following that, the algorithm loads images of students from a specified directory, extracting class names from the filenames to identify each student. This step prepares the system to recognize known faces during the attendance marking process. Then, the algorithm encodes the known faces using the findEncodings function, which prepares them for comparison with faces detected in real-time video frames. This encoding step is crucial for accurate face recognition during the attendance tracking process. Lastly, the algorithm captures video frames from the webcam, continuously processing each frame to detect faces, compare them with known faces, and update the attendance status accordingly in real-time. Once a specified number of frames have been processed, the video capture object is closed, and the attendance data is saved in the Excel workbook for further analysis and record-keeping.

V. Results And Discussions

Through a GUI, users can communicate with the system. Users will primarily have access to three options here: mark registration, faculty registration, and student registration. presence. It is expected of the students to participate in all the necessary information on the student registration form. Upon When you click the "Register" button, the webcam launches immediately. The window, as seen in Fig. 4, appears and begins to detect the picture's faces. Then it begins to click on its own. pictures up until CRTL+Q is pushed or

60 samples are gathered. After that, these photos will be kept and pre- processed in folder for training pics.

The faculties are supposed to register with the respective course codes along with their email-id in the faculty registration form provided. This is important because the list of absentees will be ultimately mailed to the respective faculties.

Fig 4. Face detection sample as captured picture of some students.

Each session, the appropriate faculty member needs to input their course code. The camera will then turn on by itself after the course code has been entered. Fig. 5 displays face recognition technology. window that shows the names of two enrolled pupils and if they hadn't registered, it would have been evident "Unknown." You can close the window by hitting CTRL+Q. and names will be entered in the Excel file along with attendance of absentees to the appropriate faculty member by letter.

Fig 5. Live facial recognition.

Fig. 6 displays the updated attendance sheet following the procedure of recognition. The marking system assigns a value of '1' to recognized students and '0' to absentee students. The absences list will be mailed to the relevant faculty member's email address.

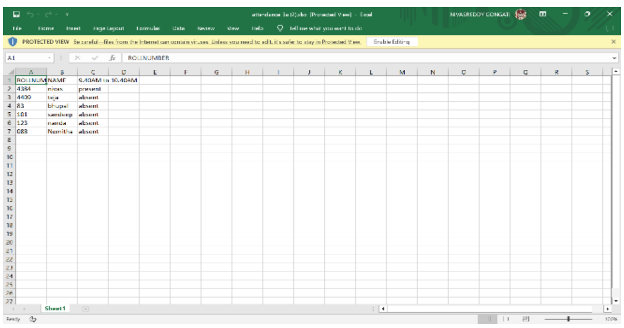

Fig 6. Collected data in attendance sheet.

Fig.7 presents a comparison between the actual and predicted values obtained from a K Neighbors Regressor model with $K = 5$ K=5 and uniform weights.

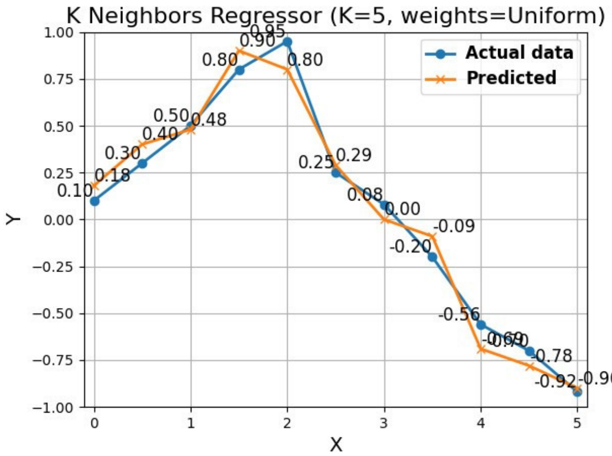

Fig 7. Comparison of actual and predicted values generated by a K Neighbors Regressor model.

As indicated in Table 1, we split the datasets into training and test sets in order to conduct the experiment. The results of the experiments indicate that LDA provides a higher recognition rate than that of PCA, as the graphics demonstrates.

TABLE1 DESCRIPTION OF DATASETS

Dataset	Total Image	Individuals	Training image	Training image
ORL Dataset	400	40	120	280
Class Dataset	25	5	10	15

The bar chart in Fig. 8 depicts the frequency of recognition results for a facial recognition system. It compares the recognition of correct faces against instances of false recognition across different total 10 faces analyzed.

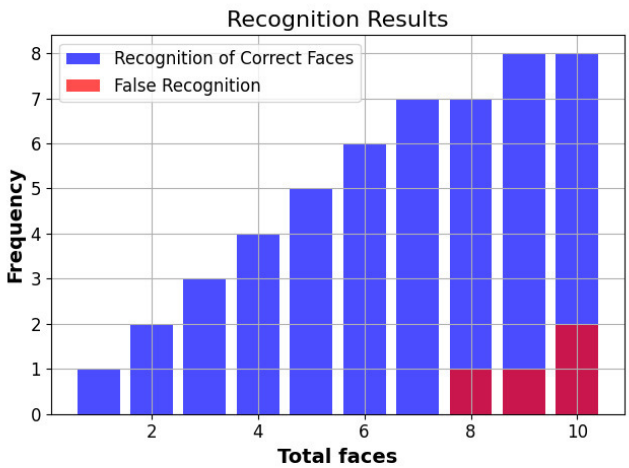

Fig 8. Comparison of correct and false facial recognition frequencies.

VI. Conclusion

Our observations revealed significant insights, showcasing the commendable performance of both PCA and LDA in specific scenarios, including normal lighting conditions, consistent posture, and an optimal camera distance of 1-3 feet. Notably, a higher resolution is imperative for precise pixel-by-pixel operations during calculation. While PCA exhibited a shorter recognition time compared to LDA, the latter demonstrated superior recognition capabilities, aligning with our research goal of optimizing accuracy. This preference for LDA underscores its crucial role in face recognition systems, essential for identifying unknown individuals. Moving forward, further investigation into the algorithm's recognition capabilities is warranted. In summary, our research offers a comprehensive exploration of face recognition techniques, highlighting strengths, limitations, and innovative solutions to enhance system performance. Our commitment to future studies and the integration of multi-modal recognition approaches reflects our forward-looking approach to continuous system refinement.

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