Real Time Face Attendance System using Deep Learning

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Abstract:- Face is an individual's unique representation, and therefore, we propose an automated system for student attendance using face recognition. Face recognition systems have significant applications, particularly in security control systems. For instance, the airport protection system relies on face recognition to identify potential suspects, while the Federal Bureau of Investigation (FBI) utilizes this technology for criminal investigations. Our proposed approach begins with video framing, initiated through a user-friendly interface. By employing the Viola-Jones algorithm, we detect and segment the region of interest (ROI) containing the face from the video frame. In the preprocessing stage, we perform image scaling as necessary to preserve information integrity. Next, we apply median filtering to eliminate noise and convert color images to grayscale. To enhance image contrast, we implement contrast-limited adaptive histogram equalization (CLAHE). In the face recognition stage, we utilize enhanced local binary pattern (LBP) and principal component analysis (PCA) to extract facial image features. Subsequently, we record the attendance of the recognized student, saving the data in an Excel file. Unregistered students have the opportunity to register on the spot, and notifications are triggered if a student signs in more than once. The recognition accuracy is 100% for high-quality images, 94.12% for low-quality images, and 95.76% for the Yale face database when training with two images per person.

***Keywords**:- Face recognition system, Median filtering, CLACHE, LBP, andPCA Image Extraction.*

I. INTRODUCTION

The main objective of this project is to develop face recognition based automated student attendance system. To achieve better performance, the test images and training images of this proposed approach are limited to frontal and upright facial images that consist of a single face only. The test images and training images must be captured by using the same device to ensure no quality difference. In addition, the students must register in the database to be recognized. The enrolment can be done on the spot through the user-friendly interface.

Traditional student attendance marking technique is often facing a lot of trouble. The face recognition student attendance system emphasizes its simplicity by eliminating classical student attendance marking technique such as calling student names or checking respective identification cards. The disturbances during the teaching process and distractions faced by students during exam sessions have become a significant issue. In addition to verbally calling out names, the traditional method of passing around an attendance sheet in the classroom is also disruptive. This problem is particularly challenging in large lecture classes were passing around the attendance sheet becomes impractical. To address these challenges, we propose the implementation of a face recognition student attendance system. This automated system will eliminate the need for manual signing, which is not only burdensome but also leads to student distractions. Moreover, the face recognition technology employed in this system will help mitigate fraudulent approaches, and lecturers will no longer have to repeatedly count the number of students to ensure their presence.

The challenges related to facial identification have been highlighted in previous studies. One such challenge is distinguishing between known and unknown images [1]. Furthermore, [2] discovered that the training process for face recognition student attendance systems can be slow and time-consuming. Additionally, [3] pointed out that variations in lighting conditions and head poses can significantly impact the performance of face recognition-based student attendance systems.

Therefore, it is imperative to create a real-time student attendance system that operates within specific time constraints to ensure accurate identification without any omissions. The extracted facial image features, which serve as the students' identity representation, must remain consistent despite changes in background, lighting conditions, pose, and facial expressions. The performance of the system will be evaluated based on its high accuracy and fast computation time.

A. *Objectives*

The goal of this project is to create an automated student attendance system based on face recognition. The expected outcomes to achieve these objectives are as follows:

- To detect the face segment from the video frame.
- To extract the useful features from the face detected.
- To classify the features to recognize the face detected.
- To record the attendance of the identified student.

II. EXISTING SYSTEM

Currently, face recognition systems have gained popularity owing to their ease of use and impressive performance. For example, face recognition technology is employed in airport protection systems and by the FBI for criminal investigations, enabling them to track suspects, locate missing children, and combat drug-related activities [4]. Similarly, popular social networking platform Facebook utilizes face recognition to facilitate user-friendly features like tagging friends in photos for entertainment purposes [5]. Additionally, Intel Company provides users with the ability to access their online accounts through face recognition [6]. Apple also incorporates face recognition technology in their iPhone X, allowing users to unlock their mobile phones [7].

A. STUDENT ATTENDANCE SYSTEM

The drawbacks of RFID (Radio Frequency Identification) card systems, fingerprint systems, and iris recognition systems have been discussed. The RFID card system is chosen for its simplicity, but it is susceptible to misuse as users may assist their friends in checking in using their ID cards. The fingerprint system, while effective, is not efficient as it requires individuals to line up for verification one by one, leading to time-consuming processes. On the other hand, face recognition systems utilize the human face, which is always visible but contains less information compared to iris recognition Although iris recognition provides more detailed information, it raises concerns about user privacy. Voice recognition is an alternative, but it is less accurate compared to other methods. Therefore, it is suggested to implement a face recognition system for the student attendance system to overcome these limitations [8].

Table 1: Advantages& Disadvantages of Different Existing System

System type	Advantages	Disadvantage
RFID card system	Simple	Fraudulent usage
Fingerprint system	Accurate	Time-consuming
Voice recognition System	_	Less accurate compared to others
Iris recognition System	Accurate	Privacy Invasion

B. FACE DETECTION

There is often confusion between the concepts of face detection and face recognition. Face detection specifically aims to locate and isolate the face segment or region within an image. On the other hand, face recognition goes beyond detection and focuses on identifying the owner or individual depicted in the facial image. Various factors can contribute to the challenges faced in both face detection and face recognition processes. These factors include background variations, differences in illumination, changes in pose, facial expressions, occlusions, rotations, scaling, and translations. Let us now define each of these factors in more detail.

Previous researchers have conducted various studies on face detection methods. However, many of these studies focused on utilizing frontal upright facial images containing a single face. These images typically depict fully exposed face regions without any obstructions or glasses [9][10]. The Viola-Jones algorithm was recommended by [9] and [10] for face detection in student attendance systems. These researchers concluded that among the different approaches such as face geometry-based methods, feature invariant methods, and machine learning-based methods, the Viola-Jones algorithm stands out for its speed, robustness, high detection rate, and ability to perform well in different lighting conditions.

We can also propose that Viola-Jones algorithm is the most efficient among all algorithms, for instance the AdaBoost algorithm, the Float Boost algorithm, Neural Networks, the S-AdaBoost algorithm, Support Vector Machines (SVM) and the Bayes classifier.

C. PRE-PROCESSING

Pre-processing plays a crucial role in enhancing the performance and accuracy of the face recognition system. Scaling is an important step in pre-processing as it allows for manipulation of the image size. Scaling down an image can significantly increase the processing speed by reducing the computational load, as it decreases the number of pixels [4]. The size and pixel count of an image contains valuable spatial information, which refers to the smallest distinguishable details within an image [4]. Therefore, it is important to handle spatial information carefully during manipulation to avoid distortions and prevent artifacts like the checkerboard effect. For normalization and standardization, it is preferred to have images of the same size [6]. In their work, [6] proposed using Principal Component Analysis (PCA) to extract features from facial images and preferred images to be scaled to 120x120 pixels in order to maintain consistent length and width.

In addition to image scaling, it is common practice to convert color images to grayscale during pre-processing. Grayscale images are known to be less sensitive to variations in illumination and require less computational time. Grayscale images are represented as 8-bit images, with pixel values ranging from 0 to 255, while color images are represented as 24-bit images, with pixels capable of having 16,777,216 different values. Consequently, color images necessitate more storage space and computational power compared to grayscale images.

When color information is not essential for the computation, it is considered noise and can be discarded. Moreover, pre-processing is crucial for enhancing the contrast of images. One commonly used method for pre-processing is histogram equalization, which aims to improve image contrast. By providing a uniform distribution of intensities across the intensity level axis, histogram equalization can reduce the impact of uneven illumination.

D. FEATURE EXTRACTION

The feature represents the information contained within an image and is crucial for face recognition. However, selecting appropriate features can be a challenging task. A feature extraction algorithm needs to be consistent and stable across various changes to achieve high accuracy results. Principal Component Analysis (PCA) is a widely recognized method known for its robustness and high-speed

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computation. Essentially, PCA captures data variations and removes unnecessary correlations among the original features. It acts as a dimension reduction algorithm, compressing each facial image, represented by a matrix, into a single column vector.Additionally, PCA centralizes the image data by subtracting the average value from each image. The Principal Components of the distribution of facial images are referred to as Eigenfaces. Each individual facial image from the training set contributes to the creation of Eigenfaces, encoding the most significant variations among the known facial images. To perform recognition, both the training and test images are projected onto the Eigenface space, resulting in projected training images and projected test images, respectively. Recognition is then carried out by computing the Euclidean distance between the projected training images and the projected test image. It's important to note that PCA feature extraction involves all trained facial images, and as a result, the extracted features retain correlations among the facial images in the training set.

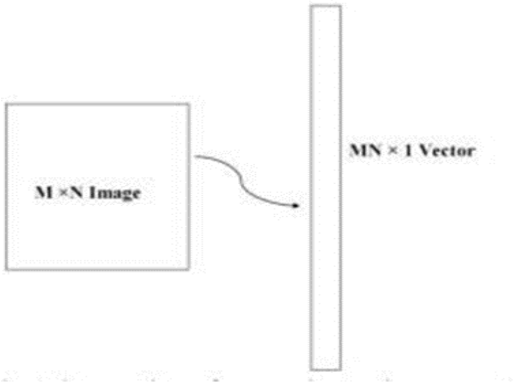

Fig. 1: PCA Dimension Reduction

LDA (Linear discriminant analysis), also known as Fisher face, is a widely used algorithm for face recognition. In [10], LDA was introduced as a method for face recognition. LDA extracts features by grouping images of the same class and differentiating them from images of different classes. One notable characteristic of LDA is its ability to perform well even in the presence of variations in facial expressions, illumination, and pose, thanks to its class separation capability.In LDA, images belonging to the same class are defined as those of the same individual but with different facial expressions, lighting conditions, or pose. On the other hand, facial images of different individuals are categorized as different classes. The within-class scatter matrix is computed based on images from the same class, while the between-class scatter matrix is computed based on images from different classes. LDA aims to maximize the ratio of the determinant of the between-class scatter matrix to the determinant of the within-class scatter matrix. It is believed that LDA achieves lower error rates compared to PCA when there are more samples per class in the training set and when the number of different classes is relatively small.

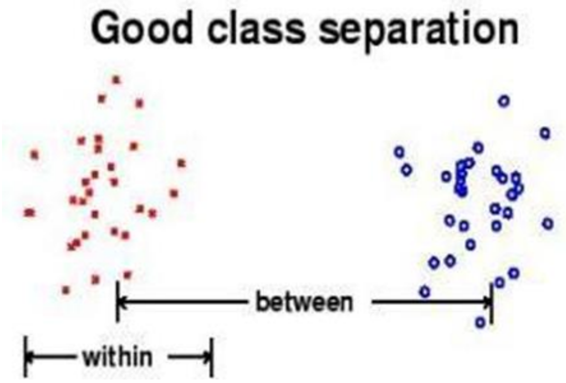

Fig. 2: Class Separation in LDA

III. ALGORITHMS USED

Neural networks were initially used only in face detection. It is then further studied to be implemented in face recognition.

A. ARTIFICAL NEURAL NETWORK

Artificial Neural Network (ANN) was studied for face recognition. ANN consists of the network of artificial neurons known as "nodes". The nodes act as human brain to make recognition and classification. These nodes are interconnected, and values are assigned to determine the strength of their connections. High value indicates strong connection. Neurons were categorized into three types of nodes or layers which are input nodes, hidden nodes, and output nodes. Input nodes are given weight based on its impact. Hidden nodes consist of some mathematical function and thresholding function to perform prediction or probabilities that determine and block unnecessary inputs and result is yield in output nodes. Hidden nodes can be more than one layer. Multiple inputs generate one output at the output node.

B. CONVENTIONAL NEURAL NETWORK

Convolutional Neural Network (CNN) is another neural network algorithm for face recognition. Like ANN, CNN consists of the input layer, hidden layer and output layer. Hidden layers of a CNN consist of multiple layers which are convolutional layers, pooling layers, fully connected layers and normalization layers. However, a thousand or millions of facial images have to be trained for CNN to work accurately and it takes long time to train, for instance Deep face which is introduced by Facebook.

IV. METHODOLOGY

The proposed approach entails a face recognition-based student attendance system. The methodology follows a sequence of steps, starting with the capture of images using a user-friendly interface. Subsequently, the captured facial images undergo pre-processing, feature extraction, subjective selection, and classification for recognition. In this approach, both Local Binary Pattern (LBP) and Principal Component Analysis (PCA) feature extraction methods are extensively studied and applied to facilitate comparisons. To mitigate the impact of illumination, LBP is enhanced within this approach. Additionally, an algorithm is devised to combine the enhanced LBP and PCA for

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subjective selection, aimed at improving accuracy. The subsequent sections will delve into the specifics of each stage in detail.

A. INPUT IMAGES

Although our own database should be used to design real time face recognition student attendance system, the databases that are provided by the previous researchers are also used to design the system more effectively, efficiently and for evaluation purposes.

Yale face database is used as both training set and testing set to evaluate the performance. Yale face database contains one hundred and sixty-five grayscale images of fifteen individuals. There are eleven images per individual; each image of the individual is in different condition. The conditions included center-light, with glasses, happy, left-light, without glasses, normal, right-light, sad, sleepy, surprised and wink. These different variations provided by the database can ensure the system to be operated consistently in a variety of situations and conditions.


Fig. 3: Sample Images in Yale Face Database

In our database, student images are captured using both the laptop's built-in camera and a mobile phone camera. Each student provides four images, two for the training set and two for the testing set. The images captured with the laptop's built-in camera are considered low-quality images, while the images captured with the mobile phone camera are considered high-quality images. The high-quality images include seventeen students, while the low-quality images include twenty-six students. The recognition rates of the low-quality and high-quality images will be compared to draw conclusions regarding the performance differences between the two sets of images.


Fig. 4: Sample of High-Quality Images


Fig. 5: Sample of Low-Quality Images

B. LIMITATION OF IMAGE

The input image for the proposed approach should meet certain criteria: it should be frontal, upright, and contain only a single face. While the system is designed to recognize students both with and without glasses, it is important for students to provide facial images with and without glasses during training to improve accuracy in recognizing them without glasses. To ensure consistency in image quality, both the training and testing images should be captured using the same device. Additionally, students must register in order to be recognized by the system. The registration process can be conveniently completed through a user-friendly interface.

C. PRE-PROCESSING

Testing set and training set images are captured using a camera. However, these images may contain unwanted noise and uneven lighting, which can affect the accuracy of the face recognition system. Therefore, several pre-processing steps are required to enhance the quality of the images before proceeding to feature extraction. One of the pre-processing steps is scaling of the images.

➢ *Scaling of images*

Scaling is a common task in image processing, and it involves carefully adjusting the size of the images to prevent any loss of spatial information. In the context of face recognition, it is important to have images of the same size for accurate feature extraction. In this proposed approach, the test images and training images are standardized to a size of 250×250 pixels to ensure consistency. Other pre-processing steps include median filtering, conversion of color images to grayscale images, and adaptive histogram equalization. These steps will be discussed in detail in the subsequent sections.

➢ *Median Filtering*

Median filtering is an effective method for noise reduction in images. It is known for its ability to remove unwanted noise while preserving important details. In the case of color images captured by a camera, median filtering is applied to each of the three-color channels (red, green, and blue). This ensures that noise is effectively removed from all channels, leading to a cleaner image. Figure 4.4 provides a visual comparison of the image before and after noise removal using median filtering in the three channels. In the case of a grayscale image, median filtering can be directly applied without the need for channel separation.


Fig. 6: Median Filtering Done on Three Channels

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V. PROJECT RESULT

In this proposed approach, a user-friendly interface for the face recognition student attendance system is developed using MATLAB GUI (Graphic User Interface). The interface incorporates several buttons, each serving a specific function. The start button is used to initialize the camera and automatically perform face recognition based on the detected face. The register button facilitates the enrollment or registration of students, while the update button is designed to train the system with the latest registered images stored in the database. Additionally, the browse button allows the user to select facial images from a designated database, and the recognize button is utilized to test the system's functionality by recognizing the selected image.In this section, we have selected and utilized an enhanced Local Binary Pattern (LBP) algorithm with a radius size of two. The reasoning behind this choice and the analysis of the selected radius size will be elaborated on in the subsequent discussion.

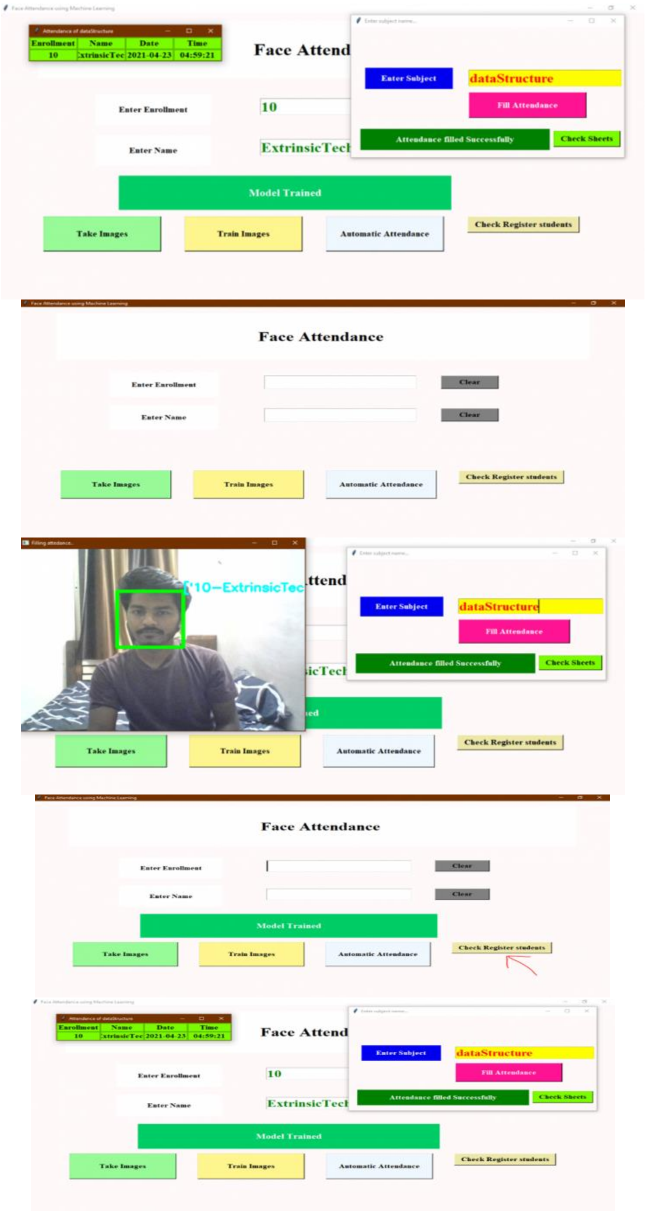

Fig. 7: Project Result

VI. OVERVIEW AND DISCUSSION

The proposed approach has been trained and tested on various datasets. The Yale face database, containing 165 grayscale images of 15 individuals under different conditions, has been employed. However, to supplement this database and account for color images, we have created our own database. This database includes both high-quality and low-quality sets, as the images exhibit varying levels of clarity and blurriness. Detailed statistics for each dataset have been previously discussed in the preceding chapter.

VII. CONCLUSION

In this approach, a comprehensive description of a face recognition-based automated student attendance system is provided. The proposed method aims to identify individuals by comparing their input image, obtained from a recorded video frame, with the training image. It includes the ability to detect and localize faces within an input facial image from the recorded video frame. Furthermore, the approach incorporates a preprocessing stage to enhance image contrast and reduce the impact of illumination. Feature extraction from the facial image is performed using both Local Binary Patterns (LBP) and Principal Component Analysis (PCA).

Regarding the analysis, facial feature extraction can be particularly challenging, especially in varying lighting conditions. To address this, Contrast Limited Adaptive Histogram Equalization (CLAHE) is employed during the preprocessing stage to effectively reduce the illumination effects. CLAHE outperforms traditional histogram equalization in terms of contrast improvement. Additionally, enhanced LBP with a larger radius size, specifically a radius size of two, demonstrates superior performance compared to the original LBP operator. It is less affected by illumination variations and exhibits greater consistency compared to other radius sizes. In terms of image enhancement, previous papers published in 2013 utilized histogram equalization to improve image contrast, while another paper did not employ any technique for enhancing image contrast. In this proposed algorithm, CLAHE is used instead of histogram equalization to enhance image contrast. While histogram equalization may provide clearer visualization of bone structures in X-ray applications, it tends to cause over-enhancement in some regions while leaving other regions inadequately enhanced. CLAHE is implemented to overcome this limitation by preventing over-enhancement and improving contrast more uniformly across the entire image. A comparison between CLAHE and histogram equalization is presented in the previous section.

A. Recommendation

In this proposed approach, there are several limitations that need to be considered. Firstly, the input image must meet specific requirements, including being frontal, upright, and containing only a single face. Secondly, the accuracy of the system may decrease significantly under extreme illumination conditions. Thirdly, there is a risk of false recognition if the captured image is blurred or of low quality. Additionally, it should be noted that LBP is a textural-based descriptor that extracts local features, therefore, to achieve high accuracy, the test and training images must have the same quality and be captured using the same device. Another limitation is that if an individual is wearing makeup in the facial image used for recognition, it can cover important facial features and potentially lead to recognition errors. Furthermore, it would be beneficial to design a face recognition system that can handle multiple faces in an image, as this would improve the efficiency of the system.

Lastly, it is important to acknowledge that the performance of the test image and training image in this approach is highly influenced by each other and is heavily dependent on the specific device used to capture the images.

B. Future Scope

The previous researcher who published the paper in 2015 conducted their study using their own image databases. In contrast, the paper published in 2013 utilized an image database called NITW-database, which consisted of 80 individuals with 20 images per person. However, the paper from 2015 did not specify the size of the image database used in their research.

In the proposed algorithm, multiple image databases are utilized for training and testing. One of the databases used is the Yale face database, which contains images captured under different lighting conditions and with various expressions. This allows for the evaluation of the proposed algorithm's performance in scenarios with uneven lighting and a variety of facial expressions. It should be noted that the Yale face database solely consists of grayscale images without any background. Therefore, in order to apply the proposed algorithm to real-time applications and perform face recognition, our own database of color images is also incorporated.

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