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Image and Artificial Intelligence based Person Identification for Automation of Attendance Extraction for Classrooms

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***Abstract*— Currently, precious time of a teacher is wasted on taking a student's attendance manually. In some cases, students stand in queues to give their biometrics before entering the class through some biometric attendance systems. In both cases, precious time is wasted, and the result is not fruitful. Hence, an automated attendance system that uses image and artificial intelligence is proposed, which helps to solve all these current-day problems and allows institutions to take classes seamlessly.**

The proposed system concentrates on extracting multiple real-time face recognition without human intrusion through a surveillance camera. The traditional methods produce lots of false recognition due to the usage of Edge detection for face detection and pixel matching for recognition. The proposed methods combined the Viola-Jones algorithm for face detection with convolution neural network (CNN). CNN is used to refine the detected faces which results in removing false positives identification. This scheme produces more accurate results compared to the traditional methods and is quicker than an artificial neural network. In addition, Open CV, Emgu CV, Harcascade classifier, and principal component analysis with the Eigenface algorithm can improve the system's efficiency.

***Index Terms*— Hysteresis Thresholding Convolution Neural Network (CNN), Emgu CV, Harcascade classifier, principal component analysis, Eigenface algorithm, Automated attendance extraction and monitoring.**

I. INTRODUCTION

The usage of face recognition systems for authentication has been a new security and swift development in many handled and static devices [1]. Many applications such as entry pass systems, personality authentication, surveillance systems, unlocking smartphones and social media accounts have started using face recognition systems [2]. However, these practices do not use face recognition as the standard form for conceding entry or access control but, it's a good form of system that can be adopted for a new era with new technological updates. However, with advanced computer technologies and suitable algorithms, facial recognition is accomplished over passwords and fingerprint scanner authentication systems.

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Face recognition systems have the potential to have the skill to alleviate many risks especially in the era of COVID. There are many applications that use authentication that have imparted facial recognition systems. However, we found that face recognition systems can be employed for human face identification using Viola-Jones algorithm for face identification, Linear Binary Pattern Histogram (LBPH) for feature extraction, and Euclidean distance classifier for face recognition [1]. Hence, an attempt to adopt the same for the automation of attendance monitoring in educational organizations is employed and verified the effectiveness through the implementation. The proposed work is done in open CV using Python which is more efficient compared to the traditional identification and recognition system of the results.

II. Literature Survey

Educational institutions faced many challenges in India during post and pre-pandemic situations for collecting and marking attendance in schools and colleges. This is a bigger challenge when the strength of the online class is more than 100. In India, many educational institutes mark attendance by calling out either a student name or roll number or by taking student signs on paper. But both approaches were time-consuming and difficult. This challenge motivates us to think about an automated student attendance management system to assist the staff/faculty in preserving automatic attendance marking. Many research works concentrate on automated authentication systems for many applications [11, 12], but many applications were proposed on image recognition systems [13, 14, 15]. Many systems also came with face recognition system based on video [6, 7]. Especially the face recognition using video is based on Faster R-CNN and SeetaFace to improve face recognition accuracy in classroom settings [6]. However, the [7] developed an improved version with higher efficiency based on the Histogram of Oriented Gradients (HOG) and the Local Binary Patterns Histogram (LBPH), with deep learning frameworks. An automatic face recognition system [3] was also found using Viola-Jones to detect and Square Euclidean distance to determine the distance between two images, for similarity check. A similar methodology for face recognition is proposed [4] on the information theory approach by combining the principal component analysis and feed forward back propagation Neural Network. The work was tested in the Oracle Research Laboratory (ORL) with a dataset of 400 images. Similarly, the framework in [5] introduced image representation for quick feature extraction and computation. Here, the classifier selects a small number of visual features from a large set of potential features. It gave an idea to combine classifiers in the background regions of the image to discard spending extra computation on face-like regions. The work produced face detection for 15 frames per second. Many contributions were found, and we were motivated to use both image and AI for face recognition in an automated attendance monitoring system. Another work on principal component analysis [10] is used for dimensionality reduction in face recognition tasks. However, a recent work [17] concentrated on real-time attendance monitoring in the internal standards classroom. However, the Indian scenario of classrooms is different as that of international standard classroom. Many challenges of infrastructure arise while collecting the data. By keeping the infrastructure and information technology in mind a cost-effective monitoring system was proposed in this paper.

III. System Design

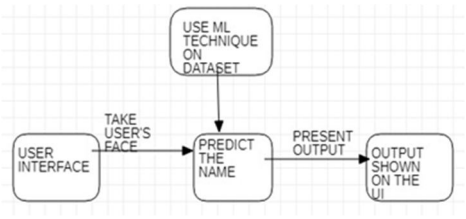


Figure 1. Block Diagram of Proposed Architecture

Figure 1. shows architectural design depicting the interaction of the subsystems. In context to Figure 1, Figure.2 gives a sequence diagram that shows how object interactions are arranged in time sequences. The sequence diagram contains two actors - the user and the system. The system actor is set up for training the machine learning model using a modified dataset for optimum use for further calculations and the training process. The whole process occurs in the system without any interventions. The user actor then opens the Windows application, and the data loading happens through the application by choosing the functionality he/she wants to use. If the user chooses the register student button, he/she will be asked for inputs, which are sent to the system with the application acting as the median. The system opens the camera connected to the system to take images

of the user and train the model, giving a prompt on the application stating that the images are taken successfully, and the system is trained accordingly. If the user chooses the take attendance button, he/she will be asked for inputs, which are sent to the system. The system opens the camera connected to it and captures the faces present in the window. The system makes the required calculations required to predict the name of the faces being detected and gives an output to the user, marking the attendance of the faces present in a .csv file.

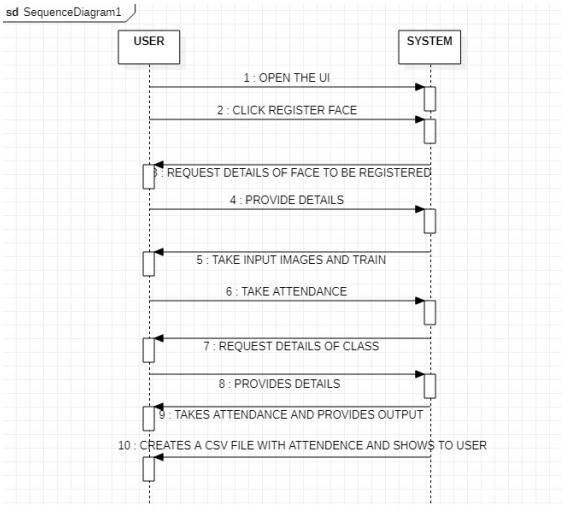


Figure 2. Sequence Diagram of the Proposed System

IV. METHODOLOGY

This section provides the methodology for implementation of each module defined for the proposed system.

A. Data Collection

The dataset for this project is manually created by collecting sample images of students from a classroom by mounting the camera on the corner and center of the classroom facing the students at 20-degree angle from the corner. A program to detect the students and click of images is initiated when students entered the class and took up their positions on chairs. To evaluate the overall performance of the proposed system, we collected face images for attendance using a webcam with the help of OpenCV library in Python. Fig. 3, to 5 shows real time data samples taken for training the system. In the dataset of about 4,000 images of 15 students of the class is collected, in which 72 images for each student is collected with image size of 64x64. The collected images are stored in local server for processing. Instead of storing in cloud we prefer to adopt edge computing for getting faster response. An attempt to store the images in cloud was found in work [16] and was taken as reference while evaluating the performance with respect to response time.

Figure 3. Sample data with low lighting condition

Figure 4. Sample data with face orientation

Figure 5. Sample data with full lighting

B. Image Processing

The collected images are in their respective folders according to their names. The images that were taken are 3-dimensional images and processing them will take a long time and more space. So, the photos will be converted into 2-dimensional pictures from RGB to Greyscale images. Using the OpenCV library, we achieved this and it was taken for further processing. Next, we want to remove the image noise, and the required features will decrease the processing time and increase the proposed model's accuracy.

Sobel kernel is used to smooth image with filtering in the horizontal and vertical directions. Here, derivative in the horizontal direction is considered as (Gx) and the vertical direction as (Gy). To find the edge gradient (G) and direction for each pixel (θ), (1) and (2) are used respectively. The gradient direction is considered to be perpendicular to edges. However, the vertical angle, horizontal angle and two diagonal directions are rounded to one.

$$Edge\ Gradient\ (G) = \sqrt{G_x^2 + G_{xy}^2} \quad \text{.....(1)}$$

$$Angle\ (\theta) = tan^{-1}\left(\frac{G_x}{G_y}\right) \quad \text{... ... ... (2)}$$

Where Gx and Gy are the partial derivatives in the x and y directions, respectively.

After getting the gradient magnitude and direction an unwanted pixel is removed. The process shown in Fig.6, illustrates the process to remove any unwanted pixels, however, this may not constitute the edge. Conversely, each pixel is checked for the maximum neighbourhood in the direction of the gradient.

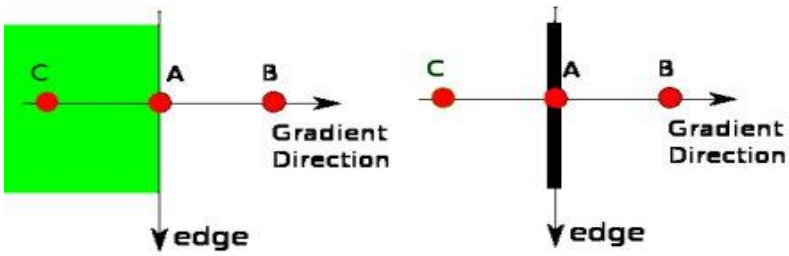


Figure 6. Defining orientation of an edge

In Figure 6., point A is considered as an edge in the vertical direction and the gradient direction in horizontal direction. The point B and C are in gradient directions. But point A is checked with points B and C to verify whether they form the local maximum. The uncertainty is considered for the subsequent stage; otherwise, it is put to zero. Thus, the result will be a binary image with "thin edges".

A Hysteresis Thresholding module is used to choose whether edges are really edges or not by considering minVal and maxVal thresholds. In the process if the intensity gradient is more than maxVal then considered to be edges and below minVal is considered as non-edges. The same conclusions are drawn in Fig. 7. However, in Fig.7, edge A is considered as "sure edge" and as the edge C is below maxVal, it is connected to edge A. Hence, all are considered valid edges. But edge B, is considered as not "sure edge", and discarded due to minVal. However, there is a necessity to select the appropriate minVal and maxVal to get an accurate result.

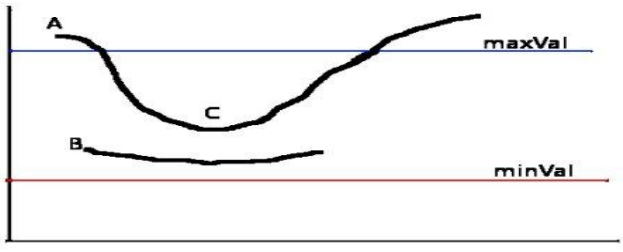


Figure 7. Hysteresis Thresholding

C. Feature Extraction

Feature extraction is done using Local Binary Pattern Histogram (LBPH) for face-recognition of an user due to its high performance. Figure 8. depicts the general working of the LBPH.

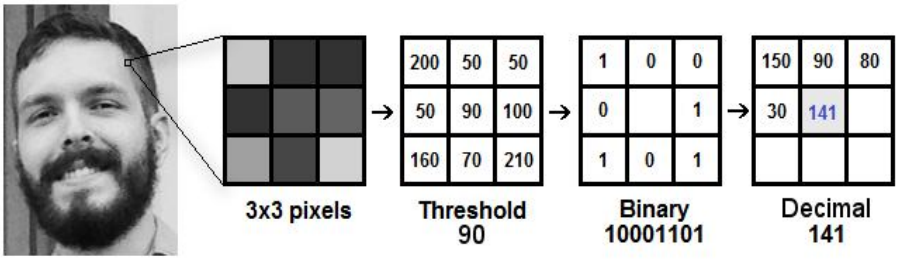
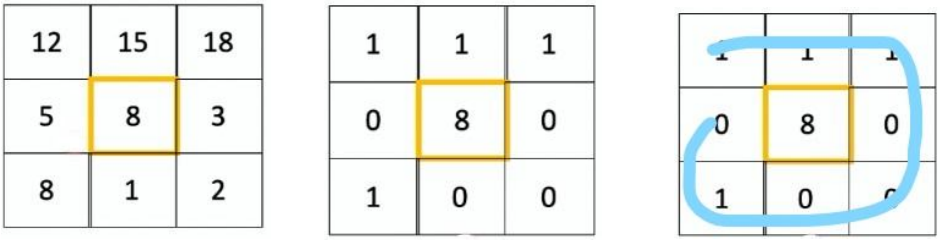


Figure 8. General working of the LBPH



(a) Sample matrix (b) Changing pixel values to 1 or 0 (c) Finding the decimal value of the pixels surrounding the center

Figure 9. Matrix with changing pixels with decimal value finding

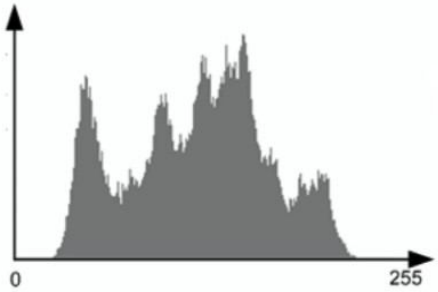


Figure 10. Histogram of Colours appearing for the proposed system

Let's consider Figure 9(a), which depicts a sample matrix. The sample matrix represents a piece of image. However, as we learned earlier, all the images are represented in the formats represented in Figure 9. In Figure 9(a), there are three rows and three columns, resulting in nine total pixels. Let us consider the central pixel, i.e., eight pixels to apply the condition. The result is '1' when the value is equal to or greater than 8, otherwise the result is zero. After applying the condition, the matrix will look like Figure 9(b). The LBPH algorithm uses a matrix condition for selecting the centre element to generate a binary value as 11100010. Thus, the LBPH algorithm will apply the condition as shown in Figure.9(c). The LBPH adopts the condition from the top left corner element and goes up to the 1 element of the 2nd row making a circle. A Decimal Value = 226 was evaluated after converting the Binary value indicating central value equal to 226. However, this evidence is enough to conclude that this algorithm is robust concerning to lightning. However, an experiment was done by placing a flashlight on the image. But the value of the pixels increased after flashlight adoption. Thus, it is evident that higher values mean brighter images, lower values mean, dark images. Hence, the algorithm results good on light and dark images. This result is due to the enhancement of pixels in the neighbourhood. After placing the light, the matrix values will look like Figure 9(c). After applying the light on the image, a binary data of 11100010 is received. The next step creates a histogram, created by statistics concepts. The histogram is counted for each time when every colour appears in all squares. Figure 10 shows the histogram for the assumed condition for the proposed system.

D. Feature Classification

Feature classification is done using the Haar cascade classifier. The Haar features are relevant for face detection, and they are like convolutional kernels. Various types of Haar features include the most dominant features used for 2 Rectangular, 3 Rectangular and 4 Rectangular Haar features shown in Figure 11.

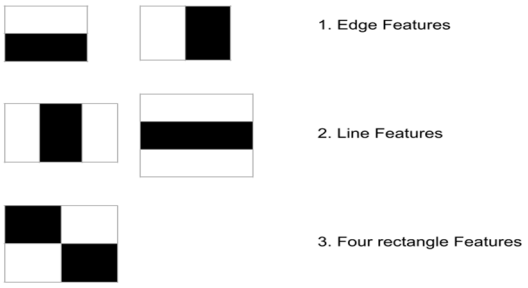


Figure 11. Types of Features that can be detected

As Haar-like features are used, the possible sizes and locations results in around 200k feature when calculated for big numbers. The time complexity of Haar operations is defined by O(n*n). An average for a given region is calculated for multiple times. However, an integral image approach is achieved through O(1). Thus, for a given image, the sum of all the pixels on the left and all the pixels above it is an integral part for the reference image. Figure 12 depicts how a sample image is converted to an integral image.

The Viola-Jones detects the best frontal faces compared to sideway faces images or upwards or downwards-directed faces. Before detecting a face, the image is converted into a grayscale for easy data processing with less data. Thus Viola-Jones algorithm detects the face on the grayscale image in the initial stages and then finds the location on the coloured image. Thus, Viola-Jones algorithm first outlines a box and quests for a face within the box. Thus, Viola-Jones starts probing for Haar-like features and moves pixels one stride to the right after going to each tile in the image.

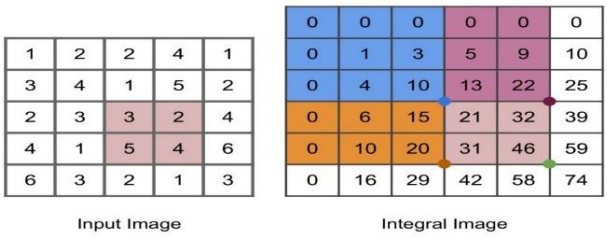


Figure 12. Input image to Integral image

V. Result Analysis

In the proposed system, an analysis is done to test different machine learning techniques for training the model and to choose the best. This is also done to improve the training and prediction of the model

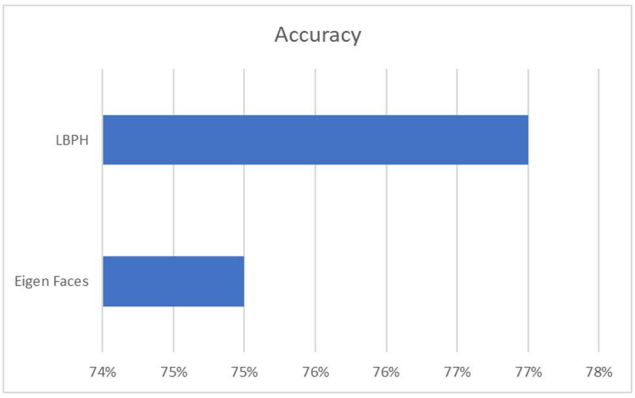


Figure 13. Accuracy in low lightning

A test case is done by keeping the camera in full lighting and low lighting cases. In this regard, Figure 18 shows the accuracy of the LBPH and Eigenfaces in low lighting conditions. Figure 13 depicts the accuracy of Linear Binary Pattern Histogram (LBPH) is 77% and the accuracy of Eigenfaces is 75%. From this analysis, it is learned that the LBPH provides the best result compared to Eigenfaces.

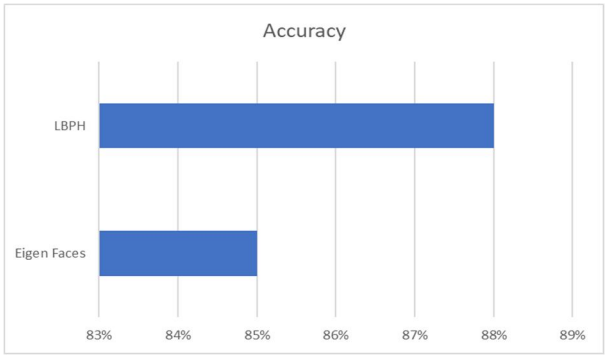


Figure 14. Accuracy for full lightning

Figure 14 shows the accuracy of the two models in normal lighting conditions. The figure depicts the accuracy of Linear Binary Pattern Histogram (LBPH) to be 88% and the accuracy of Eigenfaces to be 85%. Here, the LBPH performed well compared to Eigenfaces.

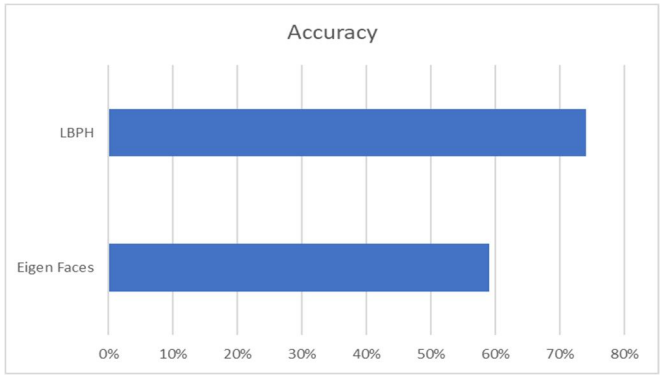


Figure 15. Accuracy for low lighting conditions with various face orientations

Figure 15 shows the accuracy of the two models when the camera is placed six meters away from the face. The figure depicts the accuracy of Linear Binary Pattern Histogram (LBPH) to be 79% and the accuracy of Eigen faces to be 56%. From the graph it is evident that LBPH performs better than Eigenface identification.

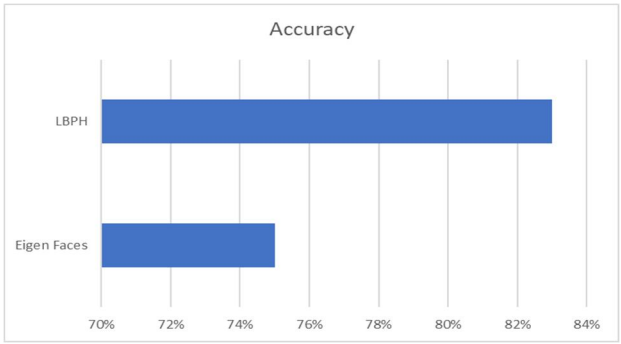


Figure 16. Accuracy for normal lighting conditions with various face orientations

Fig.16 depicts the overall accuracy of the two models, where Linear Binary Pattern Histogram (LBPH) has an accuracy of 81% and Eigen faces have an accuracy of 74%. In this scenario also it is evident that LBPH performs well compared to Eigen face identification.

After confirming the LBPH algorithm as the standard algorithm for the proposed system, response time was evaluated as images were stored on a local server for edge computing. The system was compared with [16] with respect to response time for various distances. Table 1 gives the distance versus response time evaluation for image recognition.

To evaluate the performance of the proposed system, 3 metrics are considered. The first one is response time (RT) which is the total time taken to process the image and identify the user in the classroom. The second one is

distance (D), which is the actual spatial distance between the user's face and the installed camera in the classroom. The final one is the accuracy (A) is the percentage of correct user identifications from the proposed system when openCV was adopted.

TABLE I. DISTANCE VERSUS RESPONSE TIME USING EDGE COMPUTING USING LBPH ALGORITHM

Distance in meters	Response time in ms	
	LBPH based Automation system	CNN based automation system [16]
0.2	0	0
0.4	24	26
0.6	26	28
0.8	22.32	24

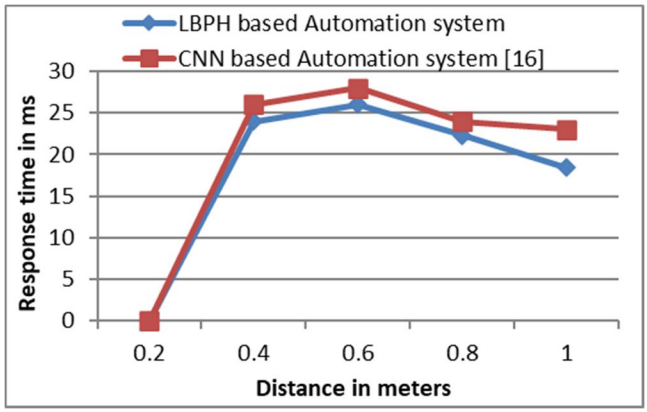


Figure 17 Response time detection versus distance

The response time of the proposed system is comparably low compared with [16] and is shown in Figure 17. The low response time is achieved as the computation and recognition is done at edge server.

VI. CONCLUSION

The proposed system has efficiently recognized the students' faces using Linear Binary Pattern Histogram (LBPH) when compared to other machine learning techniques. In all the test cases, the LBPH performed well and gave better accuracy in dull lightning, full lighting and different face orientation conditions. The proposed system outperformed with respect to response time also when compared to existing systems.
The model was found to be efficient for a defined dataset, however during real-time classification, few images were found to be miss-classified. This nature may be due to less training of the real-time data, which can be solved by training it repeatedly and tuning the model efficiently in all the dimensions and angles with hybrid machine learning models.

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