Face Recognition Based Attendance System Using Machine Learning Algorithms

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Abstract- **The identification of person from the facial features is referred as face recognition. A facial feature can be used in the different computer vision algorithms like face detection, expression detection and many video surveillance applications. Recently, face recognition systems are attracting researchers toward it. In this approach, three different methods such as SVM, MLP and CNN have been presented. DNN is used for face detection. For SVM and MLP based approach, the features are extracted using PCA and LDA feature extraction algorithms. In CNN based approach, the images were directly feed to the CNN module as a feature vector. The proposed approach shows the good recognition accuracy for CNN based approach. The SVM, MLP and CNN achieves the testing accuracy around 87%, 86.5% and 98% on self-generated database respectively.**

Keywords— DNN, face recognition, PCA, MLP, CNN, LDA, SVM

I. INTRODUCTION

In recent years, the government agencies of the country like India are working on the development of security system development to fight against terrorism. The most of the authentication systems of the offices, government organization are based on the security data which are based on the behavioral and physical conditions called as biometrics. The biometric system processes the raw data like face, fingerprint, iris etc to the valuable features from it. A feature describe nature of the data provided to biometric system and make a decision according to it.

There are different biometric systems based on face, iris, fingerprint, palm-print etc. but in most of the cases, face recognition is used as a prominent technology. Face recognition technology is not only used in offices, immigration control in airport but also used in the new generation technologies like robotics, digital cameras and various websites like Facebook.

In order to create attendance system the database is created by taking videos of different persons facing in different directions. In this system, image is captured through the camera and then face is detected. If input image matches with images in the database then and then only person gives the authentication of this system [12].

Machine learning is the branch of computer science which designed the system by learning the different sample of the data, create a model and behave like trained model. The input data is the features of the image which represent the image behavior.

II. LITERATURE SURVEY

Xiaoguang Lu [1] proposed a number of algorithms which are divided approaches based on model and appearance. Three linear subspace analysis are described in the methods based on appearance. Also for face recognition non-linear manifold analysis is explained.

S.T.Gandhe [2], presents the face recognition approach to identify the person using different experimentation. This system provides the authentication to the system by face as a biometric. This system suggested different applications like identification system, access control and document control.

Anil Kumar Sao et al. [3] proposed template matching algorithm for face recognition. This approach addresses the pose problem in face recognition. First the faces are representing in edge view. Then template matching is applied over the image. Edginess based approach represent the image in 1 dimension. The person identification is performed based on the matching score.

Sujata G. Bhele [4] presents face detection systems reviews. This paper is mostly focused on the soft computing methods like SVM, ANN etc. to detect the face. These approaches may give better results. This paper discussed the different features extraction algorithms like PCA, LDA and ICA. In this paper some problems are also mentioned ehich reduce accuracy like image quality, pose variations and illumination changes.

Riddhi Patel [5] proposed a summary of face recognition & discusses the method and its working. It also compares different techniques of face recognition. It highlights the techniques that gives good efficiency for illumination changes and different environmental conditions.

III. FACE RECOGNITION SYSTEM

The proposed methodology for face recognition is based on machine learning algorithms. Fig. 1 describe the proposed system block diagram.
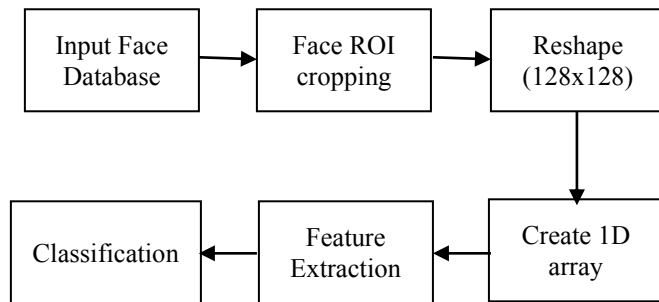
```
Input Face      →   Face ROI     →   Reshape
Database            cropping         (128x128)
                                        │
                                        ↓
Classification  ←   Feature      ←   Create 1D
                    Extraction       array
```

Fig. 1. Block diagram of proposed Face recognition system

A. Input Face Database Creation

The database is created by capturing videos of 11 persons looking in different directions. Then from these videos, face is detected and frames are extracted. The database is created through 13MP camera of mobile phone. Each class contains 234 images. The resolution of the image is 244x244.

B. Face ROI cropping

The images contain face as well as non faces parts. So, for face recognition exact face part is needed to get better accuracy. The first objective of this process is to detect the face. In this approach, Deep Neural Network (DNN) Based face detection technique is used. DNN based method is more accurate than the state of art face detection methods [10]. The pre-trained module of caffe prototxt files for deep learning face detection is used to detect the face. This function is included in Open CV library. The DNN based face detector utilized the Single Shot Detector (SSD) framework with ResNet as the base network. Cropped images are shown in Fig. 6(a)

C. Reshapping

The cropped images may be of different size, so there is need to resize all images to same size. Hence the detected facial images are cropped and resize to 128x128 resolution. The reshaped images are again reshaped to 1D array of size $1 \times (128)2$.

D. Feature Extraction

Feature extraction plays the vital role in face recognition algorithm. Each face has unique characteristics that helps to distinguish one person from another. In this approach, PCA and LDA are used for feature extraction. Database is divided into train and test images.

1. PCA

PCA is a dimensionality reduction method but it is useful in different application like image compression, facial feature extraction, face recognition and finding the patterns from large dimension image. PCA uses Eigen faces [6]. Fig. 6(b) shows Eigen faces.

In PCA, each image is normalized to align the eyes and the mouth of the subject in an image and then reduce the size of

the data and reveal the impressive face structure. Reduction technique excludes the unwanted feature data and decomposed the facial structure into reduced orthogonal component called as Eigen faces [7]. The faces are stored in the 1D feature array. PCA need to full frontal face array to represent the face otherwise may lead to maximum false alarm.

We get feature vectors from Eigen faces. Majority of the feature points are located near the 1st PC line as shown in Fig. 2.
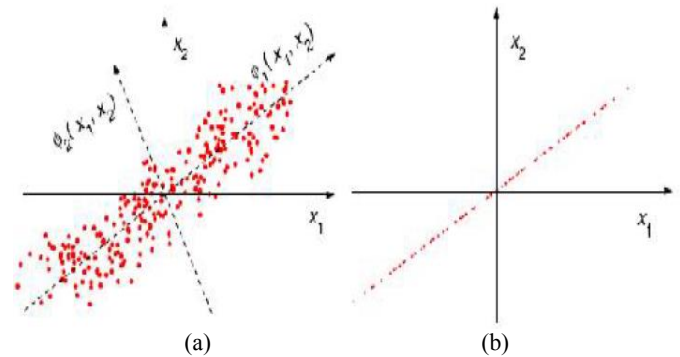

(a)   (b)

Fig. 2. Graphical Example of PCA (a) PCA basis (b) 1D representation of PCA

PCA uses Eigen values and Eigen Vector to represent the face images. The estimated vectors can treated as feature vectors.

2. LDA

LDA is one of the data description techniques. The aim of LDA is to separate the projected data into different classes. In this method the human faces are represented in terms of data matrix(X). Turk [7] was first researcher who used LDA for face recognition. LDA differ from PCA that it uses 2D vector to represent the face. LDA also known as 2-dimentional PCA. LDA was proposed which processes the Eigen vectors from covariance matrix and figure the heading which isolates the classes of appearances. The only disadvantage of PCA and LDA facial feature extraction method is; it suffers from the scalability problem.

The selection of the PCA and LDA is because of the following advantages:

1. Demand of low memory: It need not require using all the images, but it requires storing low memory Eigen vectors. In testing phase also the Eigen vector of the test image is used hence it requires low memory. PCA and LDA works on the batch mode.
2. Lower computation complexity: As the algorithms works on the low memory, this algorithm has lower computation complexity and required lower execution time.
3. Good recognition accuracy: PCA and LDA well separate the facial features using covariance matrix. It shows the good recognition accuracy.

E. Classification

The vectors of features are distinguished with the help of supervised machine classification algorithm (SVM) and Perceptron Multilayer (MLP).

1. Support Vector Machine (SVM)

SVM is an impeccable technique to discover the hyper-plane between two diverse specific classes in higher dimension component space that is utilized for grouping. It is one of the algorithms of machine learning. SVM has two stages given as training & testing.

Most classification undertakings, in any case, are not that straightforward. More perplexing structures are required so as to make an ideal partition. The information lie in a two dimensional space, a straight line can isolate the classes as shown in fig.3. For higher measurements, for instance in a 3-D space, a plane can be built to isolate the samples. For n-dimensional space, a hyper-plane can be developed [6]. The original information space can simply be mapped to some higher-dimensional component space where the sample set is distinguishable. The information can be efficiently classified by anticipating in higher measurements like 2D, 3D utilizing different hyper-planes. For non-linear data separation polynomials in higher orders are used called as kernel function. SVM has various kernel functions like linear, quadratic, radial basis function (RBF), sigmoid, etc. [11]. On the examples x & x_j RBF is applied as in eq.1 that shows feature vectors in the space of input.

$$K(xi, xj) = \exp(-\frac{||xi-xj||^2}{2\sigma^2}) \qquad (1)$$
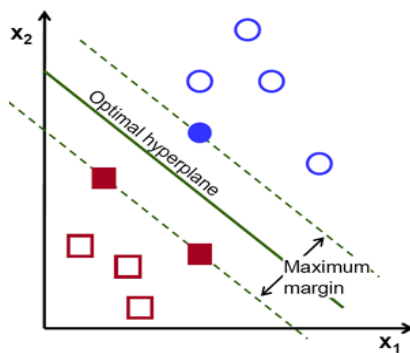

Fig. 3.   Optimal hyperplane margin

2. MLP (Multi-Layer Perceptron)

Artificial Neural Network (ANN) has a class named as MLP which is of Feed forward type. Multilayer neural network is called as multilayer perceptron. The main three layers of neural network typically given as input, hidden and output layer. The inputs are provided in the form of feature vector through input layer. In the hidden layer, weights are adjusted to get maximum performance and the output is

carried out through output layer [9]. Neural Network architecture is as shown in fig. 4.
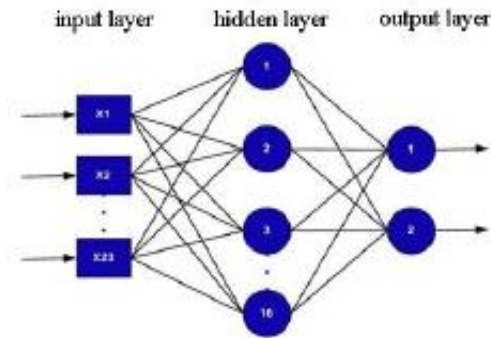

Fig. 4.   Architecture of Artificial Neural Network

In Multi-Layer Perceptron, back-propagation method is used for training purpose which falls in a supervised learning class. In this, the output is compared with the actual or target output and a cost function is created which implies errors in the predictions. Our goal is to minimize the cost function. The input will be given to hidden units along with weights heading towards output. Then as stated earlier, output is compared with the target value and if we are not getting the desired output the cost function value is back propagated and the weights are adjusted accordingly[8].

Through the step of updating the weights network learns about the different classes. For adjusting the weights and to get accurate results cost function is minimized using different aspects like boot force approach, gradient descent approach, etc. Thus training through the weight adjustment is done several times till we get minimum error rate or training is done till it reaches to the maximum iterations. Mean Square Error (MSE) is used to calculate error rate. The formula of MSE is given in equation (2). Smaller value of MSE greater the accuracy of network architecture.

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(\hat{y} - y)^2 \qquad (2)$$

Where, $\hat{y}$= target value
       y= output value
       n=amount of data

3. CNN (Convolutional Neural Network)

The CNN is a modified version of a feed-forward ANN which is able to extract important characteristics from the input images that defines each input image. CNN excludes the need of feature extraction step. From the input images it extracts important features and hence learns through the training. CNN preserves important features and moreover accounts for spatial & temporal distortions. Also for the rotation, translation, compression, scaling like geometric transformations it remains invariable. CNN combined three architectures such as scaling, shifting and distortion invariance. The CNN network trained similar to back propagation neural network [10] [11]. CNN classifies the input by a set of connection operations. CNN architecture for face

recognition is as shown in the Fig.5 with 5 convolutional layers, pooling layer and fully connected layers.
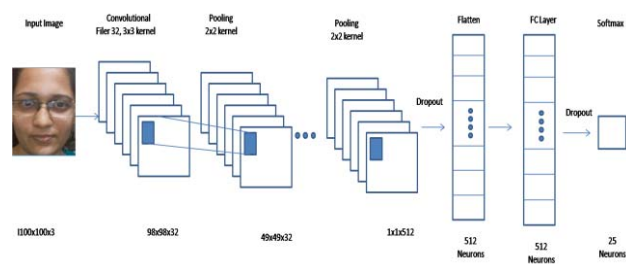

Fig. 5. Architecture of CNN for proposed approach

In convolutional layer the convolutional operation between input image and kernel of size 3x3 has been performed. The various varieties of filters are available to create a convolutional mask. The convolutional operation between input image I(x,y) and kernel K(i-x, j-y) is as follows:

$$F_c = \sum_m I(x, y)k(i - x, j - y) \qquad (3)$$

The output of the convolutional network is the feature map with reduced size. Feature maps are linear hence it is important to make them linear. The Rectifier Linear unit (ReLu) is applied over the feature map which increases the non-linearity in the feature map. Linear function makes the system unstable. The ReLu feature map is calculated using formula,

$$f_r = ReLu(X_i) = \max(0, X_i) \qquad (4)$$

(X_i) Shows pixel value at i^{th} location in feature map.

The pooling layer is used to preserve the characteristics of the image. Grouping reduces the size of images. Different varieties in pooling are mean, max, sub-sampling, etc. The minimum pool takes the minimum value of the cluster. The maximum grouping is the same as the sampling reduction operation. The maximum combination reduced the useful parameters to avoid over-processing. Sub-sampling is the type of mean pooling. This is generated by taking the average value.

Flattening is used to convert the two-dimensional image into a single 1D vector. Where each cell is a characteristic map and this unique vector is inserted in the fully connected layer.

The Fully connected layer is also known as artificial neural network (ANN). Completely associated layers interface each neuron in one layer to each neuron in next layer. The prediction of a class from mutually exclusive classes is done using softmax. Probabilistic output of a softmax function is calculated as :

$$P(Y_i) = \frac{\exp(X_i)}{\sum_{k=1}^{n} \exp(X_k)} \qquad (5)$$

The output of softmax function is probability distribution, which gives the values 0 or 1.
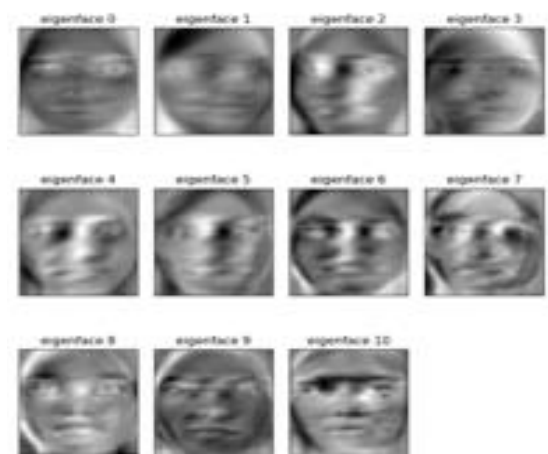
IV. RESULT

The result of the face recognition system is given with qualitative analysis as shown in Fig 6 and quantitative analysis as given in Tables 1 & 2 respectively.

1. Qualitative analysis

In qualitative analysis, Fig. 6(a) & Fig. 6(b) shows the results of face ROI cropping and PCA features i.e. Eigen faces respectively.


(a)

(b)

Fig. 6 (c) shows recognized output using PCA & SVM. First, splitting the database images into train and test images. While testing output of face recognition, the test images are given as an input. The classifier model will predict the label for the each input image. Then predicted and true labels are displayed.

The output is also checked by taking real time video input through the mobile camera. Fig.6 (d) & Fig.6 (e) shows real time output of SVM and CNN classifiers respectively. It
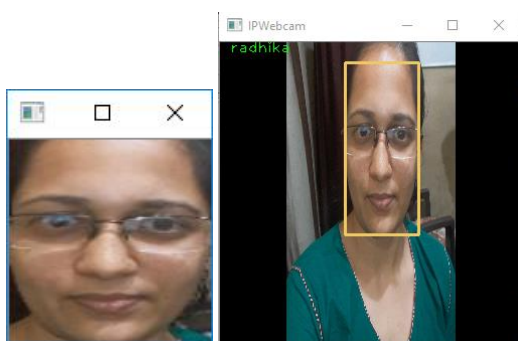
displays name of recognized person at the top left corner in face image.

(c)
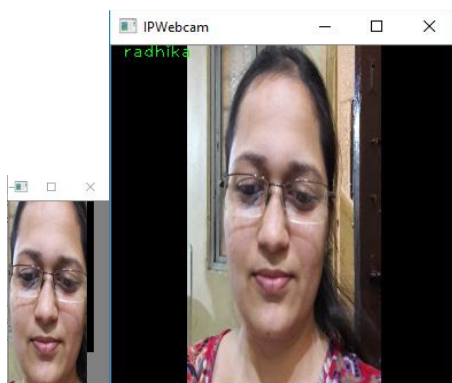
(d)

(e)

Fig. 6. Results of proposed face recognition system (a)Cropped Faces (b) eigen faces (c) Recognized faces (d) SVM output of face recognition (e) CNN output (person's name is displayed on top left corner of the image)

2. Quantitative analysis

$$Accuracy = \frac{No.of\ faces\ correctly\ detected}{Total\ no.of\ samples} \quad (6)$$

The quantitative analysis of the proposed system is calculated using accuracy parameter. Eq. (6) defines the face recognition accuracy. To calculate percentage accuracy eq. (6) is multiplied by 100.

Table 1 represents the cross validation accuracy of presented algorithms by referring to eq. (6)

TABLE 1: Performance Evaluation

Sr. No.	Classifier	Feature Extraction technique	Accuracy (%)
1	SVM	PCA	88
		LDA	86
2	MLP	PCA	86
		LDA	87
3	**CNN**	-	98

Table 2 represents real time testing accuracy (taking video input from camera). While checking results there are many factors like camera, image quality, illumination, etc. Hence, these factors affect accuracy of face recognition in real time.

TABLE 2: Performance Evaluation for real time input

Sr. No.	Classifier	Feature Extraction technique	Accuracy (%)
1	SVM	PCA	57
		LDA	55
2	MLP	PCA	55
		LDA	57
3	**CNN**	-	89

V. CONLUSION

This paper propose the system for face recognition using both computer vision and machine learning techniques. The face detection is carried out using robust DNN base face detector. The pre-trained module is trained with number of images. The accuracy of the DNN based face detection is more than state of art methods. SVM, MLP and CNN are used as a classifier to evaluate the face recognition. The SVM, MLP and CNN achieves the testing accuracy of 87%, 86.5% and 98% on self-generated database respectively. While checking real time output, face input is taken through camera. Due to the factors like camera quality, illumination the result accuracy decreases. There is around 56% accuracy for both SVM and MLP classifiers and around 89% for CNN

In future, for robust attendance system good quality webcam should be used and instead of displaying name of a person in the image, excel sheet for the present students can be made. Also faces of more number of persons in different environments can be used for classification to increase accuracy.

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