Analysis of Different Techniques for Face Recognition System

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Abstract- Biometrics are automated methods of recognizing a person based on a physiological or behavioral characteristic. Among the features measured are: face, fingerprints, hand geometry, handwriting, iris etc. Biometrics is becoming the foundation of an extensive array of highly secure identification and personal verification solutions. As the required level of security rises, the need for highly secure identification and personal verification is also growing. Biometric-based solutions are able to provide confidential financial transactions and personal data privacy. Enterprise-wide network security infrastructures, government IDs, secure electronic banking, investing and other financial transactions, retail sales, law enforcement, and health and social services are already benefiting from these technologies. Utilizing biometrics for personal authentication is becoming convenient and considerably accurate. Human brain can remember and recognize a vast array of faces, getting a computer to do the same is difficult but in modern world there would be many uses of such systems. Face reorganization has been a fast growing, challenging and interesting area in real time application. It can be widely used for image and film processing; this requires computational models for the identification of the face. In this paper we will review the different methods for face recognition, their advantages and disadvantages.

Keywords – Face Recognition, PCA, LDA, ICA, Neural Network, ANN, Templates, SVM

I. INTRODUCTION

The process of recognizing a face in an image has two phases:

- ***Face detection –*** detecting the pixels in the image which represent the face. There are several algorithms for performing this task. (fig 1)
- ***Face recognition*** – the actual task of recognizing the face by analyzing the part of the image identified during the face detection phase. (fig 2)

Facial recognition system store video or photographs and try to find recognizable facial characteristics and match them against known facial templates to identify individuals. Most current facial recognition system processes the 2D camera image, although recent products have emerged that try to map the face in 3D using multiple camera angles. Face recognition has the greatest advantage of not requiring any sort of contact, so there are no hygienic concerns. The biometric samples here are typically taken as 2D images of the frontal section of the face, using one or more digital cameras. Typical technical approaches to achieve this recognition include geometrical, eigenfaces, template and graph matching, neural networks and Hidden Markov Models, or a combination of these. Although there are significant advantages to this technology, mainly due to the extrovert characteristics of face images and the user acceptability, the recognition accuracy has shown to be rather inaccurate in practice. The inaccuracy can be explained by a high sensitivity to environmental conditions such as lighting and image background, and also due to changes in the appearance of a face with regards to hairstyle, beard and glasses for example. Despite the rather poor

recognition accuracy, face recognition appears to be among the most interesting biometrics for user authentication in ID document scenarios, simply because of the simple image acquisition and the intuitive concept of comparing face images to images included in the document. Consequently, standards for the layout of facial images, as well as digital storage formats are currently developed.

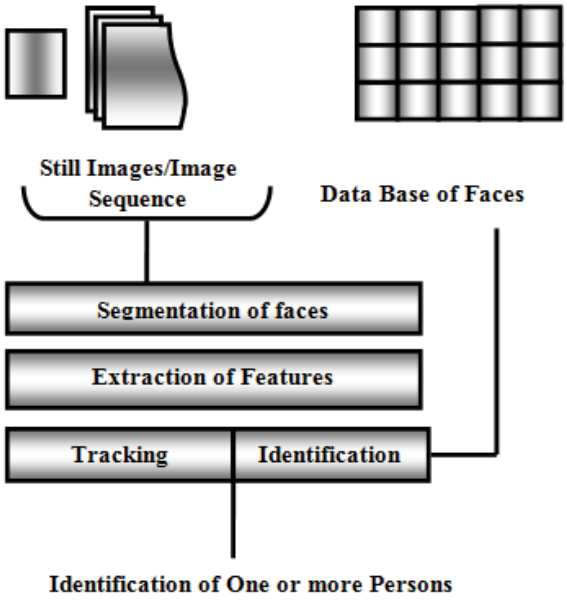


Fig. 1 Process of Detection.

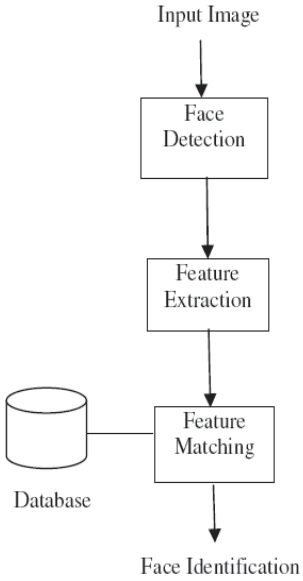


Figure 2 Face Recognition System

II. DIFFERENT FACE RECOGNITION TECHNIQUES

(a) *Principal Component Analysis (PCA):-* Principal component analysis (PCA) is a dimensionality reduction technique which is used for compression and face recognition problems. It is also known as eigenspace projection. PCA calculates the eigen vectors of the covariance matrix, and projects the original data onto a lower dimensional feature space, which is defined by eigen vectors with large eigen values. PCA has been used in face representation and recognition where the eigen vectors calculated are referred to as eigen faces.PCA is a useful statistical technique that has found application in fields such as face recognition and image compression, and is a common technique for finding patterns in data of high dimension. It is one of the more successful techniques of face recognition. The benefit of PCA is to reduce the dimension of the data. No data redundancy is found as components are orthogonal. With help of PCA, complexity of grouping the images can be reduced. The application of PCA is made in criminal investigation, access control for computer, online banking, post office, passport verification, medical records etc. [1], [3], [4], [5], [9], [10], [12], [14], [15], [16], [17], [18].

Advantages of PCA

i. Recognition of face using PCA is much simpler and efficient than other matching approaches.
ii. Lack of redundancy of data.
iii. Smaller database representation is required as only the training images are stored in the form of their projections.

Disadvantages of PCA

i. PCA has computing complexity associated with it. It is difficult to evaluate the covariance matrix in an accurate manner.
ii. The method is highly sensitive to scale, therefore, a low-level preprocessing is required for scale normalization.

(b) *Linear Discriminant Analysis (LDA):-* As highly structured two-dimensional patterns, human face images can be analyzed in the spatial and the frequency domains. These patterns are composed of components that are easily recognized at high levels but are loosely defined at low levels of our visual system. Each of the facial components has a different discrimination power for identifying a person. First, we need a training set composed of a relatively large group of subjects with diverse facial characteristics. The database should

contain several examples of face images for each subject in the training set and at least one example in the test set. These examples should represent different frontal views of subjects with minor variations in view angle. They should also include different facial expressions, different lighting and background conditions. It is assumed that all images are already normalized to m x n arrays. Second, for each image and subimage, starting with the two-dimensional m x n array of intensity values I(x, y), we construct the lexicographic vector expansion. This vector corresponds to the initial representation of the face. Thus the set of all faces in the feature space is treated as a high-dimensional vector space. Third, by defining all instances of the same person's face as being in one class and the faces of different subjects as being in different classes for all subjects in the training set, we establish a framework for performing a cluster separation analysis in the feature space. Also, having labeled all instances in the training set and having defined all the classes, we compute the within- and between-class scatter matrices. [3], [5], [9], [10], [15], [18].

Advantages of LDA

i. The Fisherface projection approach is able to solve the illumination problem by maximizing the ratio of between-class scatter to within-class scatter.

Disadvantages of LDA

i. It fails when all scatter matrices are singular.
ii. Small Sample Size (SSS) problem is encountered in practice since there are often a large number of pixels available, but the total number of training samples is less than the dimension of the feature space.

COMPARISON OF PCA AND LDA

Principal Components Analysis	Linear Discriminant Analysis
PCA mainly performs feature classification.	LDA mainly performs data classification.
The shape and location of the original data sets changes when transformed to a different space.	In LDA, the location doesn't get changed but it only tries to provide more class separability and draw a decision region between the given classes.
PCA calculates best discriminating components without knowledge about groups	LDA calculates the best discriminating components about groups which are defined by the client (user).

Table 1 PCA V/s LDA

(c) ***Neural Networks Approach*:-** Artificial Neural Network is an information processing system, in which the elements called as neurons, process the information. The signals are transmitted by means of connection links. The links possess an associated weight, which is multiplied along with the incoming signal (net input) for any typical neural network. The output signal is obtained by applying activations to the net input. [5], [13], [14], [15], [16].

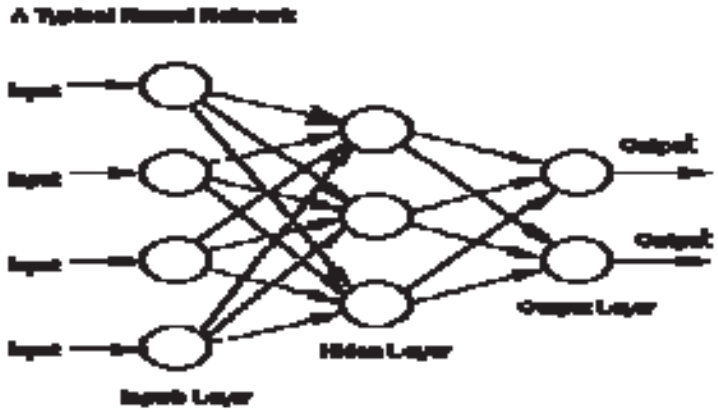


Figure 3 Neural Network

Advantages of Neural Network Approach

i. When an element (Artificial neuron) of the neural network fails, it can continue without any problem by their parallel nature.

ii. A neural network learns and does not need to be reprogrammed.

iii. It can be implemented in any application. If there is plenty of data and the problem is poorly understood to derive an approximate model, then neural network technology is a good choice.

Disadvantages of Neural Network Approach

i. The detection process is slow due to train the nonface window.

ii. The result is not so much accurate.

iii. The methodology is complex.

(d) *Template Matching* **:-** For recognizing any object, human beings compare it to images of similar objects that they already have stored in memory. By comparing to a variety of stored data for different objects, it is possible to identify the object by the one that it most closely resembles. In image processing concept, a very similar idea has been used for detecting different objects in the image.
In a template matching system there is a training phase, in which a directory of image examples is processed by a digital computer to derive component vectors. As well there is a search phase, in which a digital computer processes a target image with vectors selected using component vectors to determine the presence of one or more image examples in the target image. The training phase can be conducted off line in order to come up with a template that can match the objects that are of most interest in the target image. In the searching phase, the template searches through the scaled binary image. The search-box runs exhaustively over the scaled down version of the original image. Each time, the template is tried to be matched over the search area if the skin patch underneath it is greater than the threshold value.

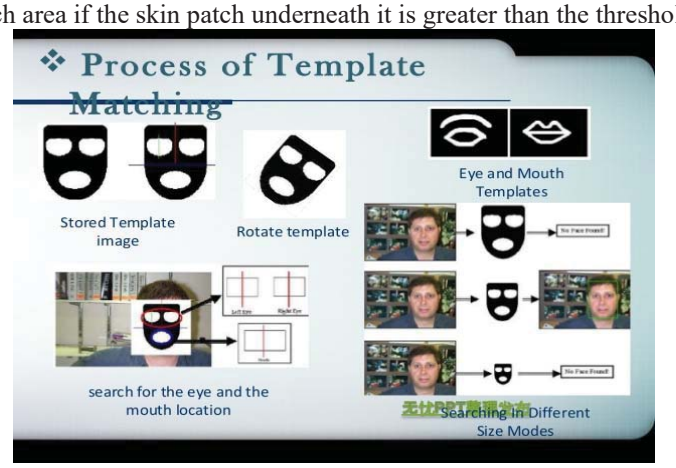


Figure 4 Template Matching

Figure above shows the template that is being used for face detection purpose. The template is designed in a way to return only edges in the areas where normal and non-rotated face of human eyes and mouth are most likely to be there. The gradient values and edges are essential in our face detection algorithm. The value related to the edge scores directly influence the decision region. Among different face candidates the one with the highest face-score is being selected. The final score is calculated based on different factors such as symmetry of the gradient values between right and left eyes, net power which determines the gradient power captured in the eyes and mouth area and finally good/bad ratio that determines how high the difference between white and black area is. The number of edges that are captured and considered as the left eye, the right eye and the mouth and the edge-symmetry present in those areas determine the Face Score. These factors measure the face balance. Based on the Face Score value, the best face candidate will be nominated as the detected face. [15].

Advantages of Template Matching approach

i. There is abundant physiological support that simple features (lines and edges of particular orientations) are represented in the nervous system with template-like receptive fields in the visual cortex.

ii. They are amazingly reliable.

Disadvantages of Template Matching approach

i. The difficulty with template matching as a model for perception is that contexts are rarely constrained.

ii. Normalization with regard to size, shape, and orientation is one possible way around the problem, but individuals can read written messages that contain gaps in letters and variations in writing instruments, so the number of normalizations would be enormous.

iii. Even with replication and normalization, it would be difficult to represent the third dimension (depth) with template matching (since the retina is a two- dimensional receptor array).

iv. Standard templates contain no information about whole-part relations.

(e) *Independent Component Analysis (ICA)* :- It is a statistical technique that reveals the hidden factors that underlie sets of random variables or signals. The information describing a face may be contained in both linear as well as high-order dependencies among the image pixels. These high-order dependencies can be captured effectively by representation in ICA space. [3], [5].

Advantages of ICA

i. ICA has a good performance in pattern recognition, noise reduction and data reduction.

ii. In ICA, independent components are extracted through an iterative optimization procedure hence at different point of times there is little variation in the answer.

Disadvantages of ICA

i. The separation reliability of ICA is largely influenced by the assumption that the sources of artifacts and activity remain spatially stationary in time, which is not always true all over the trials.

ii. ICA does not discriminate between signals of interest (task-related) and signals not of interest.

(f) *Support Vector Machines (SVM)*:- SVMs are a new technique suitable for binary classification tasks, which is related to and contains elements of non-parametric applied statistics, neural networks and machine learning. Like classical techniques, SVMs also classify a component as solvent or insolvent according to its score value, which is a function of selected financial ratios. [5], [18].

Advantages of SVM:-

i. By choosing an appropriate generalization grade, SVMs can be robust, even when the training sample has some bias.

ii. SVMs deliver a unique solution. This is a great advantage of SVM over Neural Networks, which have multiple solutions associated with local minima because of which they may not be robust over different samples.

iii. It only needs to train N two class classification support vector machine, the number of the classification function obtained is (N) small and the classification is of relatively fast speed.

Disadvantages of SVM:-

i. This requires solving quadratic programming problems of n variables the number of the N. Because each support vector machine training speed slowed sharply along with the increasing number of training samples, this method is of relatively long training time.

ii. If there is more than one output result is 1, and then the sample will not be able to classify.

iii. All categories may not be separated from each other well, i.e., the generalization ability is not good.

III. RESULT ANALYSIS OF DIFFERENT TECHNIQUES

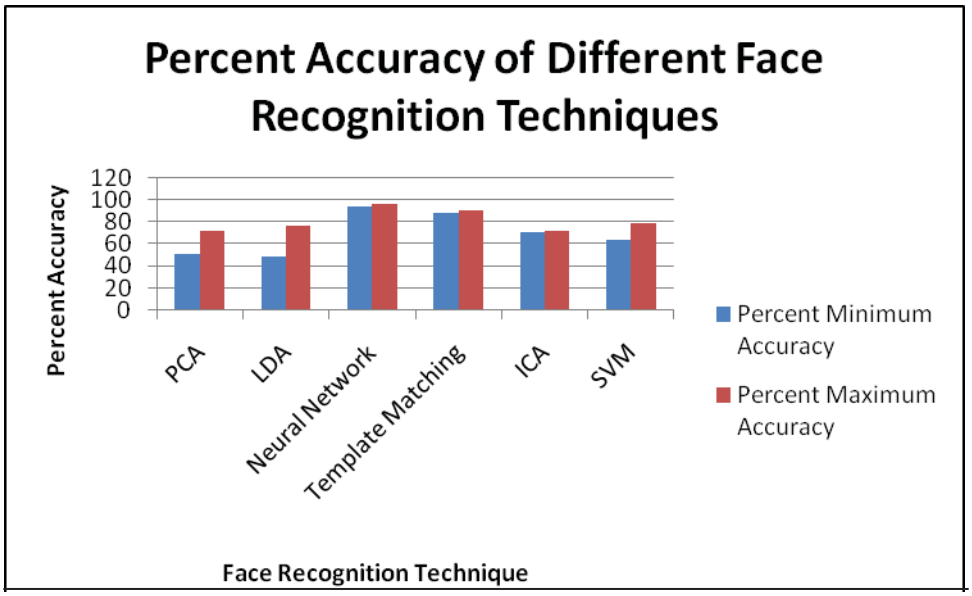
The survey reflects the analytical comparison of different techniques in the domain of face detection and recognition. The study reveals that for improved face recognition new algorithm has to be evolved using a combination of soft computing tools such as PCA, LDA, ANN, SVM etc. It may give a better performance.

Among various face recognition algorithms, PCA has range of accuracy from (51-72)%, LDA (48.50-76.50)%, SVM (63.5-79)%

Technique	Accuracy
PCA [18]	51-72%
LDA [18]	48.5- 76.5%
Neural Network	94- 96.2%

Template Matching	88- 90%
ICA	70- 71.7%
SVM [18]	63.5- 79%

Table 2 Percentage Accuracy for Face Recognition Techniques



Graph 1

IV. CONCLUSION

Face recognition by machines is no longer a scientific fiction. Face recognition systems have rapidly evolved in the last decade. However, it still faces a number of challenges. The reason is that, even today with so much different techniques and algorithms for different requirements, face recognition system fails. New algorithms have increased accuracy dramatically, but overcoming a number of different variables in unconstrained settings is still the biggest challenge in facial recognition. Several factors such as image quality, image size, face angle, processing and storage etc. limit the effectiveness of facial-recognition technology. With the advancement of technology, higher-definition cameras will be developed. Computer networks will be able to transfer more data, and processors will work faster. Facial-recognition algorithms will be more effective in picking out faces from an image and recognizing them in a database of individuals whose data is already stored in the database. The simple mechanisms that lead to the failure of current algorithms, such as changing of hairstyle or covering parts of the face with sunglasses and masks, will be easily overcome.

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