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A Review on Feature Extraction Methods and Classifiers

Mithila Sompura[1]
PG Student
Computer Engineering Department
Hashmukh Goswami college of Engg & Tech
Ahemdabad, India

Vinit Gupta[2]
Assistant Professor
Computer Engineering Department
Hashmukh Goswami College of Engg & Tech
Ahemdabad, India

Abstract: ***Computer vision and machine learning is the hottest research area in recent years .Face recognition is the one of the core problem in computer vision due to difficulties of highly nonlinearity. Hence face recognition is the most popular and difficult task in various domains because of various applications. This paper focus on various research work done in recent years on face recognition system. In this paper various feature extraction methods, feature extraction techniques and classifiers are discussed with their comparative analysis. Overview of recent methods for face recognition is discussed with sub categories with recognition rate. From our survey we found PCA & LDA based feature extraction methods are widely used for higher recognition rate with k-NN***

Keywords: PCA (Principle Component Analysis), LDA (Linear Discriminant Analysis), SOM (Self-organizing Map), Kernel PCA, FLDA (Fisher Linear Discriminant), Gabor Wavelet, LBP (Local Binary Pattern), RBFN (Radial Basis Function), Multi-layer Feed Forward, KNN (k- Nearest Neighbour)

I. INTRODUCTION

Face Recognition is the challenging task in today's era in the field of computer vision and image analysis [4]. Multiple passwords required in corporate companies for employee and waste more time in logging so face recognition do not User Corporation. The main advantage of ANN is their adaptive nature where the problem of programming is solved by learning by examples [3]. Face recognition is most widely used in security and low enforcement applications. It is a difficult task to build an automated system which is able to recognize human face in any condition [16]. There are many areas in which face recognition is appropriate topic which are machine learning, pattern recognition, neural networks [3], image processing, computer vision, phycology, and computer graphics. Facial expression, reading gestures, interpretation of emotions, facial animation, and head pose determination are the issue related to recognition. Face recognition is still a demanded and unsolved technology. There some technique available to recognize the face: 3D image base model, intensity images, and video sequences.

Table - I

Comparison of Feature Extraction Methods with Recognition Rate, Training Time and Classifier

Sr no.	Feature Extraction method	Classifier	Recognition Rate	Training time	Year
1.	SLGS [1]	MLP	96%	-	2014 (Elsevier)
2.	LBP [5]	-	higher	-	2014 (IEEE)
3.	Gabor Wavelet [6]	k-NN, Multiclass SVM	88.6%	-	2013 (IEEE)
4.	OCA [9]	RBFN (Training) BP (Identification)	81.25%	-	2013 (IEEE)
5.	PCA, 2DPCA[10]	k-NN	92.3%	-	2013 (ICCCI)

6.	FSIF [11]	SMLDA	99.71%	-	2013 (IEEE)
7.	PCA, BDPCA, LDA [2]	FLDA	87.16%	-	2012 (IEEE)
8.	Analytic and Holistic based approach, PCA[3]	Multilayer Feed forward	97%	-	2012 (IEEE)
9.	Eigen value, Eigen vector [4]	k-NN	92.7%	-	2012 (IEEE)
10.	LPP [7]	RBFN	95.67%	-	2007 (IEEE)

Table-II

Comparison of Feature Extraction Methods with Training Samples, Testing Samples

Sr No.	Feature Extraction methods	Training Samples	Testing Samples	Year
1.	SLGS [1]	360	40	2014 (Elsevier)
2.	LBP [5]	-	-	2014 (IEEE)
3.	Gabor Wavelet [6]	4	-	2013 (IEEE)
4.	OCA [9]	36	320	2013 (IEEE)
5.	PCA, 2DPCA[10]	360	40	2013 (ICCCI)
6.	FSIF [11]	3	5	2013 (IEEE)
7.	PCA, BDPCA, LDA [2]	-	-	2012 (IEEE)
8.	Analytic and Holistic based approach, PCA[3]	10	-	2012 (IEEE)
9.	Eigen value, Eigen vector [4]	700	350	2012 (IEEE)
10.	LPP [7]	32	32	2007 (IEEE)

II. Feature Extraction Techniques

A. Geometric Based approaches

Geometry-based approaches extracted features using geometric information such as relative Positions and sizes of the face components. In geometric based approach Local Features and their geometric relationships are analyzed [16]. Nevertheless these techniques require threshold, which given the prevailing sensitivity, may adversely affect the achieved performance. In template*e based approach it compare the input images with the set of template [13] and the set of template are constructed using the statistical tools like PCA [8, 10], LDA [2] and ICA[15]. To extract the facial features energy function is used [13].

B. Color Segmentation Based Approach

Mostly all the image contains background color which can be considered as a noise. In this technique the skin color is detected then the facial features such as eyes and mouth are extracted. After getting the image from the skin color the binarization of the image is taken, and the gray-scale image is obtained. After gray scale conversion it is necessary to apply the suitable threshold to eliminate the hue and saturation. This approach limited because of the background noise [13].

C. Appearance Based Approach

Appearance based approach represents the face in terms of several raw intensity images [16]. When we apply the feature extraction method it is necessary to keep the important features as it is when recognize the face. Example of this approach is PCA, LDA, or ICA. The main advantage of this approach is it keeps the important features as it is and removes the redundant features.

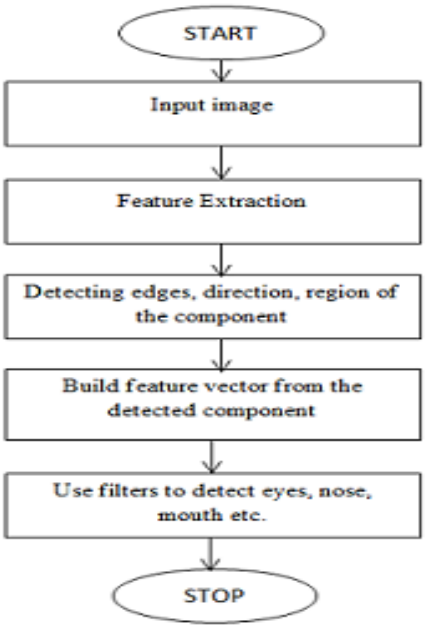

Fig.1 Flowchart for basic face recognition system

D. Template Based Approach

In this approach compare the set of images with the template [13] and the set of template are constructed using the statistical tools like PCA [8, 10], LDA [2] and ICA [15]. To extract the facial features energy function is used [13].

III. Feature Extraction Methods

Feature extraction defined as to extract relevant features from a face image. So to extract information from the photograph is very challenging task for computer vision because we can recognize any person if we know, even they are covered with the glasses or hat. Feature extraction involves some steps:

1) First reduce the dimensionality of face

2) Extract features from the image and last step face selection.

a) PCA based method

Principal component analysis (PCA) is a mathematical procedure that uses to convert a set of observations of possibly correlated variables into a set of values of uncorrelated variables called principal components [4] and it is referred to as linear method [15].Main idea of PCA (Karhunen-Loeve expansion) [10] for faces is to find vectors that best account for variation of face images in entire image space. In [6] author had used PCA to reduce the dimension of a fused image. This method is mainly used as dimension reduction which finds vectors and A group of Eigenfaces is extracted from the original image. These vectors are called Eigen-vectors. Linear combination obtained using Principle component are called Eigenface [10]. Compute the covariance matrix M [12]

$$M = \frac{1}{n}\sum_{i=1}^{n}(x_i - \mu)\,(x_i - \mu)^T \quad (1)$$

b) LDA based Method

LDA is an enhancement to PCA Constructs a discriminant subspace that minimizes the scatter between images of same class and maximizes the scatter between different class images [16]. The between-class scatter matrix V_b, within-class scatter matrix V_w and the projective matrix P are defined as follows [7]:

$$V_w = \sum_{i=1}^{c}\left(\sum_{j=1}^{N_i}(x_j^{(i)} - m_i)(x_j^{(i)} - m_i)^T\right) \quad (2)$$

$$V_b = \sum_{i=1}^{c} N_i\,(m_i - m)(m_i - m)^T \quad (3)$$

$$P = \arg\max\left|\frac{P^T V_b P}{P^T V_w P}\right| \quad (4)$$

Where m_i and N_i are the mean face and sample number in a individual face class respectively, $x_j^{(i)}$ is the j-th sample in the i^{th} class. For recognition, the linear distance function is computed as

$$d_{LDA} = W^T(T - P) \quad (5)$$

While taking class discriminatory information at that time perform dimensionality reduction. When classes are separated seek to find direction. Due to variation in illumination and expression LDA is more capable of distinguishing image variation.

c) Independent component analysis

ICA aims to find independent, rather than uncorrelated image decomposition and representation. This method separates non-Gaussian distributed features [13]. This method is the enhancement of PCA which leads to a discriminant analysis criterion [16].

d) Kernel PCA

To increase the capability of PCA Scholkopf et al. have developed a nonlinear PCA called kernel PCA [15]. In this method first nonlinear mapping is applied to the input and then for the resulting feature subspace it solves a linear PCA [16].

e) Gabor wavelet

This method is biologically motivated and used as a linear filter which uses Gaussian kernel function modulated by sinusoidal plane wave and the kernel function is denoted by [6]:

$$\tau_{\mu,\vartheta}(Z) = \frac{\left\|k_{\mu,\vartheta}\right\|^2}{\sigma^2}\, e^{\frac{\|k_{\mu,v}\|^2\|z\|^2}{2\,\sigma^2}}\left[e^{i\,k_{\mu,v}z} - e^{\frac{\sigma^2}{2}}\right] \quad (6)$$

Where Z = (*x*, *y*) is the point with horizontal and vertical coordinates x and y, μ and ϑ are orientation and scale of Gabor kernel respectively, σ is standard deviation of Gaussian, k is wave vector, and || || is the norm operator.

f) Local Binary Pattern

This is the most powerful method for the face recognition which describes the image as a texture and it is mainly divided in to three different features which are: pixel level, region level and global level [5]. This method assigns the label to each pixel by the 3*3 neighborhood of each pixel and assigns the one pixel as a center pixel with the threshold and that label of histogram is used as texture. LBP is most widely used in face recognition because of its unique feature and less computation time [1].

IV. CLASSIFIERS

a) Radial Basis Function

The RBFN is a feed-forward neural network and local network that trained in a supervised manner [7]. RBFN accomplishes as input-output nonlinear mapping by a linear combination [9]. RBF separates the class distribution by locate the radial basis function. Training of RBFN is comparatively faster than MLP. Radial basis function network has the one hidden layer. The distance between the input and weight is the distance between the arguments of each hidden unit activation function. Most conveniently used RBF output function is a Gaussian function given as follows:

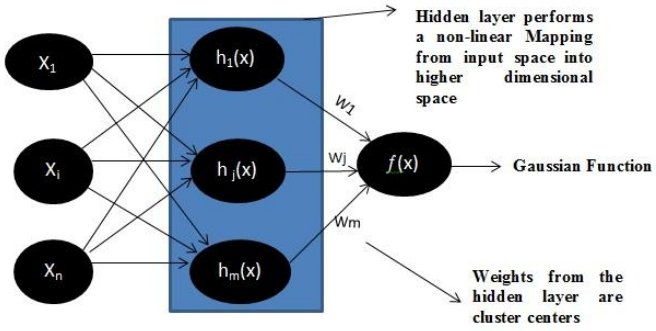

Fig. 2 Radial basis function network [19]

b) Multi-layer feed forward

Multilayer Feed-Forward network consists of multiple layers. In [3] they have used Multi-layer feed forward network which consists of multiple layers to increase the recognition performance rate. This architecture having input and output layer with one or more intermediary layers called hidden layer which are also known as Hidden Neurons. Before direction input to the hidden layer intermediate computation are carried out at the hidden layer.

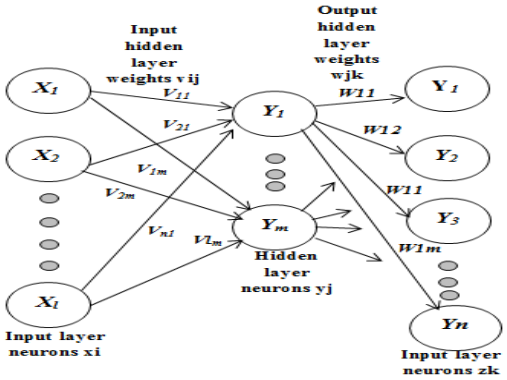

Fig. 3 Multi-layer feed forward network [3].

c) K Nearest Neighbors

k-NN is a simple algorithm of all available algorithms. Based on similarity measures k-NN stores all the cases and classify new cases. KNN have been used in statistical estimation and pattern recognition. In this Classifier image is classified by majority votes of its neighbor then after it forms a distance matrix [4]. The Euclidean distance between two points or tuples, P_1= (x_{11}, x_{12}… $x1_n$) and P2= (x_{21}, x_{22}… $x2_n$) is [14]:

$$dist\ (\mathrm{X1},\mathrm{X2}) = \sqrt{\sum_{i=1}^{n}(x_{1i} - x_{2i})^2} \quad (7)$$

KNN – Number of neighbor

- If K=1 , select the nearest neighbor
- If K>1 , For classification select the most frequent neighbor
- For regression calculate the average of K neighbor.

d) Self-Organizing Map (SOM) classifier

Kohonen Self Organizing Map (KSOM) has the property of clustering the data that preserves the topology of the input vector that means even data with the minor changes gets clustered in closer zones. Because of this property it better classify the facial expression data, as similar data with the small change gets clustered [8].

The algorithm is summarized as follows [15]:

1. *Initialization*: Choose the random values for the initial weight vector $\mathbf{w}_i(0)$, $i = 1, 2 \ldots l$. Where l total number of neurons and these neurons are in the lattice.
2. *Sampling*= Draw a sample **x** from the input space. Than vector **x** is presented to the lattice. The dimension of the vector **x** is similar to the *m*.
3. *Similarity matching*= find the best-matching unit (neurons) i(**x**) at time-step *n* by using minimum-distance criterion

$$I(\mathrm{X}) = \mathrm{ARG\ MIN} \left\| \mathrm{X}(n) - \mathrm{W}_j \right\|, \quad J = 1, 2 \ldots L \tag{8}$$

4. *Updating*= use the update formula to set the weight vector of all the excited neurons

(9)

5. *Continuation*= Repeat step 1 until no changes are seen in the feature map.

e) Fisher's linear discriminant analysis

FLDA is a LDA based method used for machine learning, statistics, and pattern recognition to find a linear combination of feature which separates two or more classes of objects. Before classification FLDA is used to reduce the features to a manageable number. Linear combination obtained using FLD are called Fisher faces because each of the new dimensions is combinations of pixels which are linear and they form a template. In [2] Author have used FLDA as classifier which classifies unlabelled features based on their similarity with features in their training sets and it is maximized over all linear projection, V:

$$\mathrm{J}(w) = \frac{|\mathrm{m1} - \mathrm{m2}|^2}{S1^2 + S2^2} \tag{10}$$

V. CONCLUSION

Face recognition is the core problem in computer vision because of highly nonlinearity which is widely applicable in many domains. This paper describes various feature extraction methods by surveying the recent research works with comparison of various aspects and parameters. Our core focus is on recognition rate, training time, training samples and overall system performance. Various feature extraction methods has its one results with different classifiers. From this study we found most of work done with minimal dataset hence it not justifies with global applicability in real time scenario where larger dataset is involved. Also when dataset increase this all methods get higher recognition rate but overall system performance is decrease in terms of time. If there is the possibility to recognize the hundreds of image with each image contains different expression so at that instance the system should take less time for the classification with better performance rate. It is mentioned in the table that if there are less training samples the recognition rate gets higher. There are several criteria for the research such as decrease Error rate, Training time or increase the recognition rate. In this paper the various classifier and feature extraction techniques is discussed with its advantage and disadvantage.

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AUTHOR(S) PROFILE

Mithila R Sompura , received the B.E Degree from C.K. Pithawala College of Engg & Tech in 2012. She is now pursuing M.E from Hashmukh Goswami college of Engg & Tech with area of interest Artificial intelligence.

