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A Survey on Face Recognition Process

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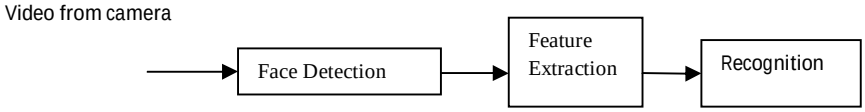
Abstract-Face recognition from under uncontrolled environment is still a big unsolved problem. Robust Face Recognition is needed today, because it has main role bio security. Recognition is done in two ways, with user cooperation, without user cooperation. At first category used for intrusive recognition, which is done with user knowledge, second one is without user knowledge (user cooperation), used for authenticate person .Recognition has major role in bio metric, security applications. Face recognition from controlled environment is not a problem, but in real world application various illumination condition, various pose variations and occlusions are exists. Robust Face recognition dependent upon two factors, methods used for feature extraction, methods used for Recognition (classification). This section gives details survey about feature extraction and classification which are used in face recognition.

KEYWORDS- Face Recognition, Intrusive Recognition, Feature Extraction, Controlled Environment

I. INTRODUCTION

Face Recognition is more complex work since 1990s, because image taken from uncontrolled environment has many problem like various lighting conditions , different pose variations , various occlusion problems. Generally Face Recognition process divided into three process , face detection ,feature extraction , face recognition.



A. FIG1 – Face Recognition Process

From past 20 years, several methods are introduced for face detection. First method based on 1) local feature one 2) Global Feature based .Local Feature based on local component like eye ,nose , mouth and its geometric relationship between them. Global Feature take entire image as feature .This section gives the details about types of feature, types of feature extraction methods , various method used for Recognitions.

II. FEATURE EXTRACTION

This section gives the description about for various feature extraction techniques, and their advantages & disadvantages. This techniques are categorized into holistic approach,local approach and hybrid approach [1].

Local method
Global methods
Hybrid Approach

III. HOLISTISC METHOD

Holistic representation is mainly used in face recognition. This method,whole images are taken into account. An image can treat as high dimensional vector space. The size of the image directly propositional to no of pixel in image. For example, an image of size 256x256 pixelscan be seen as a 65536 dimensional feature space. High computational cost result in when dealing with high dimensional vector space.Dimensionalityreduction technique the solution to the above problem.This method can be linear or non linear .In Global method ,each pixel in image are considered as valuable information. Dimensionality Reduction technique apply some transformation inorder to reduce the dimensionalty with out lossing their accuracy. Various methods comes under this approach are eigenfaces, fisher faces, support vector machine, hidden markov model (HMM). They all are based on principal component analysis (PCA)[2]

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A. Karhunen-Lo`eve expansion

By applying Karhunen-Lo`eve expansion to face recognition, it finds a small number of features,this define the principal components of the face. The principal components of the face are found by projecting two dimensional face vector space into a one dimensional subspace, then selecting the principal components which capture the highest variances amongst individual faces. Specifically, the principal components of the individual faceare calculated by the eigenvectors and eigenvalues of the covariance matrix . In other words, the eigenvectors consist of a small number of features that represent variations amongst faces in the training data set . The small number of features can also be called the feature space. Then finding the best features among them , it represent faces without decreasing accuracy.[3]

B. Histograms of Oriented Gradients (Hog) Features

It is one of Shape descriptor which is based on theedge orientationgradient[6],mainly used for object recognition .Local object appearance and shape can be characterized by the distribution of local intensity gradients or edge direction.

HOG features are calculated by taking orientation histograms of edge intensity in local region.We extract HOG features from 16×16 local regions .In this cell, gradient orientation is calculated. Sobel filters are used to obtain the edge gradients and orientations.[5]

C. Steps for Calculating Histogram Of Oriented Gradient

1) A fixed window is choose for face recognition
2) Normalize Gamma and color correlation for each block
3) Compute Gradient for each block
4) Collect the weighted votes for each gradient orientation for each spatial block
5) Collect Hog for all block in the image

For a smooth region like wall of a building, the histogram of the oriented gradients smooth distribution. But , in the case of texture region or edge like sea image or hair of image HOG of particular image has large value, it indicate the presence of edge.

D. Advantage

1) It is robust to the local geometric and photometric transformations.
2) It is invariance to luminance changes and background shading

IV. LOCAL FEATRE METHOD

Local feature extraction refers to describing only a local region/part of the image by using some transformation or specific measurements. The geometry feature-based approach methods describe local features such as nose, eyes and their geometric relationships.

In this method, dividing the face region into smaller sub images,in this sub region transformation is applied in order to extract the local feature. The most commonly used local feature extraction techniques in face recognition is the Gaborwavelet transform based features , discrete cosine transform DCT-based features .

A. Advantage:

1) The main advantage of the local facial features did not vary with pose, direction of lighting and facial expression.

B. 2D Discrete Cosine Transform

Another local feature extraction methodis DCT based method.It decompose the highly correlated image into uncorrelated image transformed coefficient.In this DCT transform is applied ,block by block basis.**[7]**

$$\mathbf{I(u,v)} = \boldsymbol{\alpha}\mathbf{(u)}\boldsymbol{\alpha}\mathbf{(v)}\boldsymbol{cos}\left[(\mathbf{2}\boldsymbol{x}+\mathbf{1})\frac{\boldsymbol{\pi u}}{\mathbf{2}\boldsymbol{N}}\right]\boldsymbol{cos}\left[(\mathbf{2}\boldsymbol{y}+\mathbf{1})\frac{\boldsymbol{\pi u}}{\mathbf{2}\boldsymbol{M}}\right]\mathbf{I(x,y)}$$

In this I(x,y) represent original image pixel intensity values.I(u,v) represent transformed coefficient.

u varies from 0 to M-1, and v varies from 0 to N-1, where M*N is the size of the image.

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$$\alpha(u)\alpha(v) = \begin{cases} \sqrt{\frac{1}{N}} & \text{for u} \quad v \neq 0 \\ \sqrt{\frac{1}{M}} & \text{for u} \quad v = 0 \end{cases}$$

For DCT based feature extraction , the following steps are performed

1) Image is divided into multiple non overlapping blocks
2) size of block multiple of 8 or other
3) DCT transformation applied to each block separately
4) In this transformed coefficient ,select the DC value
(it contain the low frequency value which invariant pose variance ,luminance)
5) Use any one of classifier(SVM,Euclidian distance classifier) to recognition.
In this DCT based feature extraction method is combination of feature selection and reduction.
Like PCA, feature selection and reduction performed at the same stage.

V. HYBRID APPROACH

In[8],hybrid method used for feature extraction , "Local and Global" feature , DCT transformation is applied for locally for each eyes ,noses , mouth for extracting local feature , totally 50 coefficients are extracted , at the same time entire face used as feature , in this also totally 50 coefficient are extracted , Euclidian distance of 50 coefficient are calculated and sum together for representing particular feature, this method is applied for locally and globally . This method is applied for all training and test image particular X coefficient calculated . Test image coefficient , compared with training image , with minimum value coefficient rank as 1 . The ranks of both the global feature and local features are compared. If both the ranks are '1' only then is the person accepted, else the person's entry is termed as 'invalid'. Thus the false acceptance rate is zero in this case.

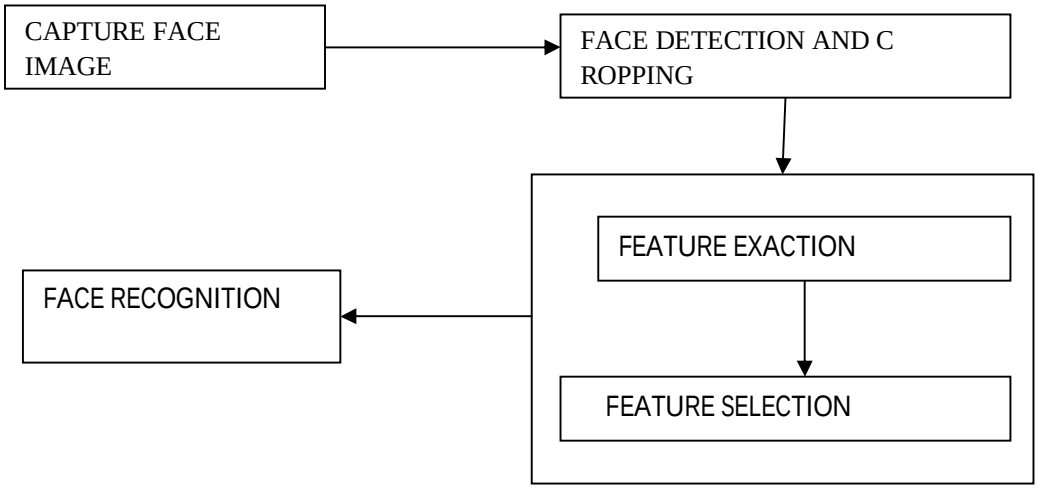

FIG 2 – Steps In Face Recognition Process

A. Common Visual Feature

The common visual features are: Color, Texture, and Shape

B. Color And Texture Features

Color is one of the main features of images. Many no of color features are proposed .

1) Color histogram[10]
2) Color moment[11]
3) Color coherent vector[12]

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In [9] uses Mahalanobis distances metric for Skin color model and invariant Fourier-Mellin moments used her for shape analysis to automatically detect and locate human faces in two-dimensional complex scene images. In[13], proposed a feature based similarity measure (FBSM) for find the spatial differences between feature points of two high dimensional image vector. The feature-texture similarity sensitive to pose variations of two face images.

C. Texture features

Texture is a very useful characterization for a wide range of image. In general, color is usually a pixel property while texture can only be measured from a group of pixels. A large number of techniques have been proposed to extract texture features.
They can be broadly classified into

1) Spatial texture feature extraction methods
2) Frequency domain texture feature extraction methods.

For the former approach, texture features are extracted by computing the pixel statistics or finding the local pixel structures in original image domain, whereas the latter transforms an image into frequency domain and then calculates feature from the transformed image.

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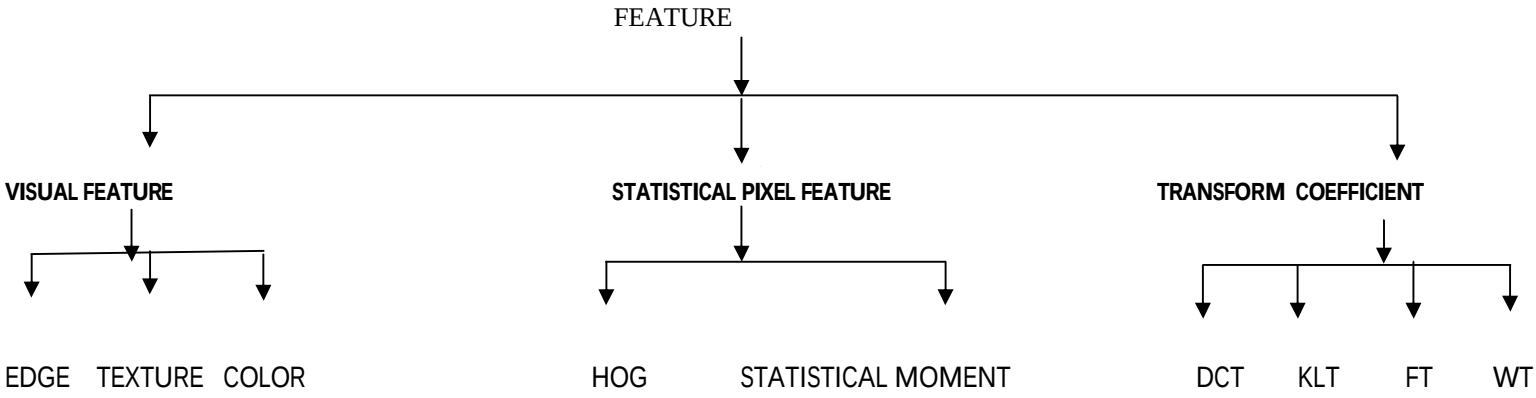

HOG – Histogram of Oriented Gradient DCT – Discrete Cosine Transform FT-Fourier Transform WT- Wavelet Transform
FIG 3 – Types Of Feature

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VI. LINEAR FEATURE EXTRACTION OF DIMENSIONALITY REDUCTION TECHNIQUES

In Dimensionality Reduction , feature extraction has main role. In[23],Feature extraction apply transformation on original feature in order to get subset of feature from original one. Transformation shall be linear or non linear based on basis function used. This section gives details description on both linear or non linear transformations.

A. Principal Component Analysis (PCA)

One of the best known technique is PCA , from 1990 by M.A.Turk and A.P.Pentland[25]. It is one of the holistic approach ,i.e whole entire raw image taken for consideration. It find subspace , its corresponds to maximum variance direction to original space. More details study about PCA held in[14-19]. MPCA and KPCA are variation of PCA.

*B. Linear Discriminant Analysis (LDA):*LDA uses linear transformation for data classification and also reduce the dimension. It find base vector which gives best discrimination among these class , reduce intra class variation , maximize inter class variation. Variation of LDA is D-LDA ,R-LDA , K-LDA are variation of LDA[19,20,21,22,24,26,27 ,28].

C. Singular Value Decomposition (SVD): SVD is also has great role in signal processing , linear dimensionality reduction method using covariance matrix. It apply linear transformation on original dimension ,finding few linear combination of original variable with great variance[22] , has main application in face recognition.

D. Independent Component Analysis (ICA): ICA closely related to factor analysis and Principle Component Analysis. ICA finds k independent component from original variable .Using linear combination of independent variable, express that original variable. Covariance matrix constructed by cosine measurement, it outperforms than LDA and PCA.

VII. NON LINEAR FEATURE EXTRACTION OF DIMENSIONALITY REDUCTION TECHNIQUES

Non-linear methods can be broadly classified into two groups: a mapping (either fromthe high dimensional space to the low dimensional embedding or vice versa), it can be viewed as a preliminary feature extraction step and visualization is based on neighbor's data such as distance measurements. Research on non-linear dimensionality reduction methods has been explored extensively in the last few years. In the following, a brief introduction to several non-linear dimensionality reduction techniques will be given.

A. Kernel Principle Component Analysis(KPCA)

Kernel PCA based on kernel function in high dimensional space. Kernel PCA finds predominant eigenvectors of kernel matrix not from covariance matrix, this is main difference between traditional PCA and KernelPCA. Kernel
Matrix is similar to in product of data point using kernel functions in high dimension space.

B. Isometric Mapping (ISOMAP)

ISOMAP preserve data point using pair wise geodesic distance between two point. This divided into two parts, for adjacent point Euclidian distance in original space is the approximation for geodesic distance .[20]But faraway point ,short hop is used for geodesic approximation. ISOMAP having advantages of PCA,LDA

C. Locally Linear Embedding

Locally Linear Embedding uses non linear transformation for dimensionality reduction, similar to ISOMAP.LLE using graph representation for similarity measure. It describes properties of data point xi , by weighted linear combination of wi , Weights are assigned to data point by K nearest neighbors of data point xi [29][30]

VIII. FACE RECOGNITION METHODS

This section gives more details about list of methods introduced for face recognition.

A. Geometric Feature Based Methods

In this method, facial features are detected and also geometric relationship among the feature are joined together in order to form feature vector . Then minimum distance between feature vector of test and training image is calculated in order to identify the test image. In[31], Brunelli and Poggio explain that template based method have significant performance over geometric based method.

1) Feature based Method

a) Kernel Direct Discriminate Analysis Algorithm: This method uses non linearity feature pattern distribution[32] .This method solves small size problem found in most face recognition method .This method used only small set features and also has minimum error rate compared to kernel-PCA and Generalized Discriminant Analysis (GDA)

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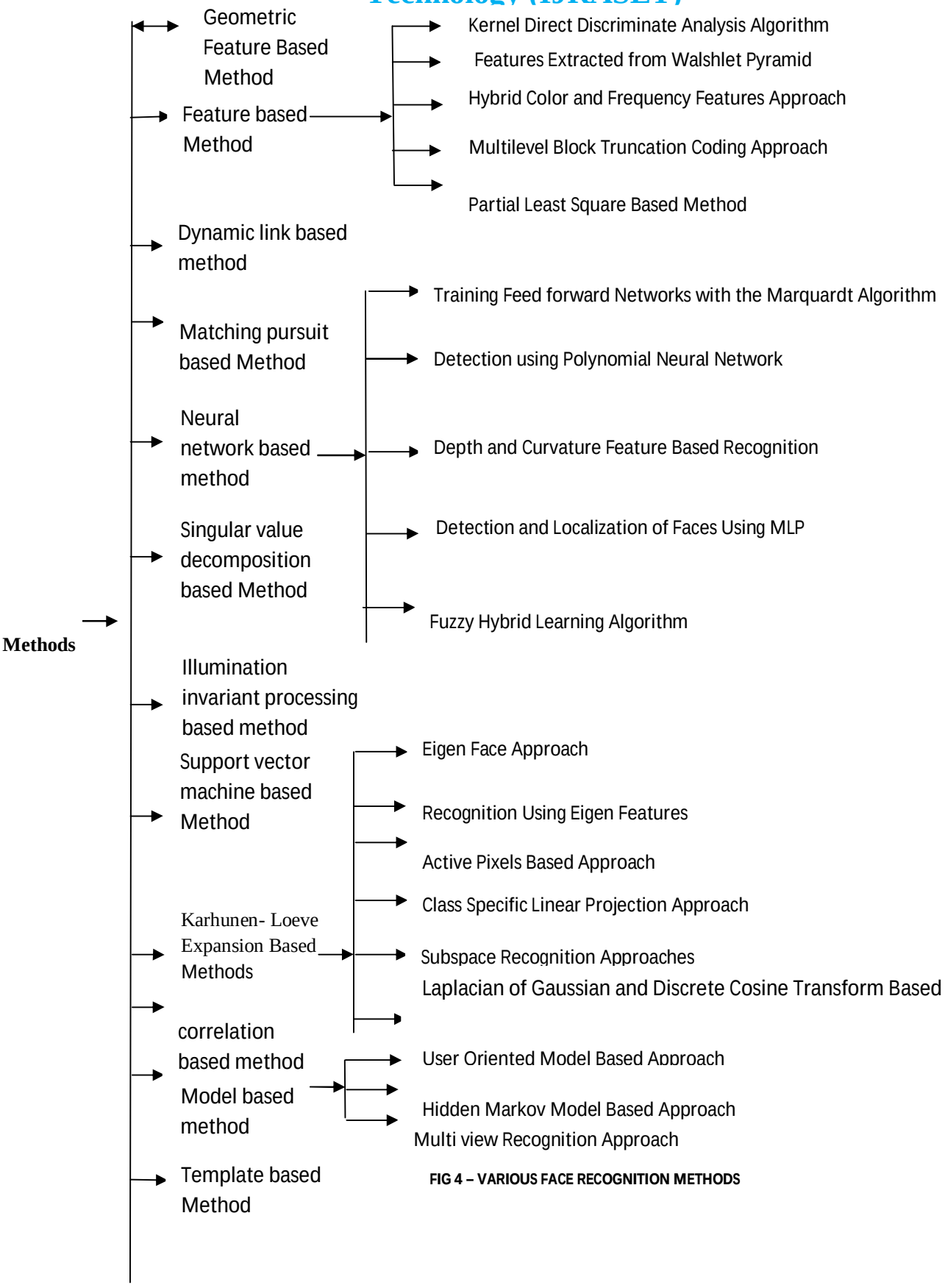

FIG 4 – VARIOUS FACE RECOGNITION METHODS

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III. NEURAL NETWORK BASED METHOD

A. *Training Feed forward Networks with the Marquardt Algorithm*

In [34] , Marquardt algorithm used for nonlinear least squares and is built-in into the back propagation algorithm for training feed forward neural networks. This method tested on several approximation problems, it also compared with several method like a conjugate gradient , variable learning rate algorithm .This method gives the best result when neural network contain very few hundred weights.

B. *Detection using Polynomial Neural Network*

Here recognition is done by using polynomial neural network (PNN). In this [35], PNN takes as inputs the binomials of the projection of local image onto a feature subspace learned by principal component analysis (PCA). From the feature subspace, Distance is calculated also combined with Polynomial Neural Network to improve the detection performance

C. *Depth and Curvature Feature Based Recognition*

Generally , face are descripted by bag of feature descriptor .In [36] , Depth and curvature feature are used rather than conventional intensity based feature. Depth and curvature feature has several advantage 1) best descries ptor for describing region face like cheeks , forehead , chin . because this area most affected by pose variation. Recognition is done by using comparing feature vector of test image and database.

D. *Detection and Localization of Faces Using MLP*

In[37] , face detection and recognition is done by using Machine learning ,by multi resolution analysis of digital images. This is method is suitable to any specific condition (people , environment) .This method gives best result learning is performed on more no of training sample. In Recognition stage , Multi Layer Perceptron (MLP) are used as classifier.

V. FUZZY HYBRID LEARNING ALGORITHM

This Fuzzy Hybrid Learning algorithm uses both gradient method and linear least square method for neural network connection . This method define no of hidden neuron in Radial Basis Function Neural Network by using Cluster validity indices with majority rule [38]. Shape descriptor feature are extracted from face and dimensionality reduction is done using PCA , This Shape feature vector feed into RBFneural network , Fuzzy Hybrid Learning Algorithm used in classifier in face recognition system. This method require a hidden layer with few neurons ,also providing fast convergence in training stage.The efficiency of the proposed method is demonstrated on the ORL and Yale face databases, and comparison with other algorithms indicates that the FHLA yields excellent recognition rate in human face recognition

VI. CONCLUSION

PCA,ICA and LDA are traditional linear feature extraction method since 1990. Nowadays , Local Linear Embedding , ISOMAP ,KPCA are most used technique for nonlinear feature .Most researchers are focusing hybrid method which includes combination of both linear and non linear methods for dimensionality reduction process.The main purpose of this paper is to give more details description about list of various types features , various feature extraction process , list of dimensionality reduction methods which includes both linear and no linear methods , and also contains various methods (include both supervised and unsupervised method) used for recognition.

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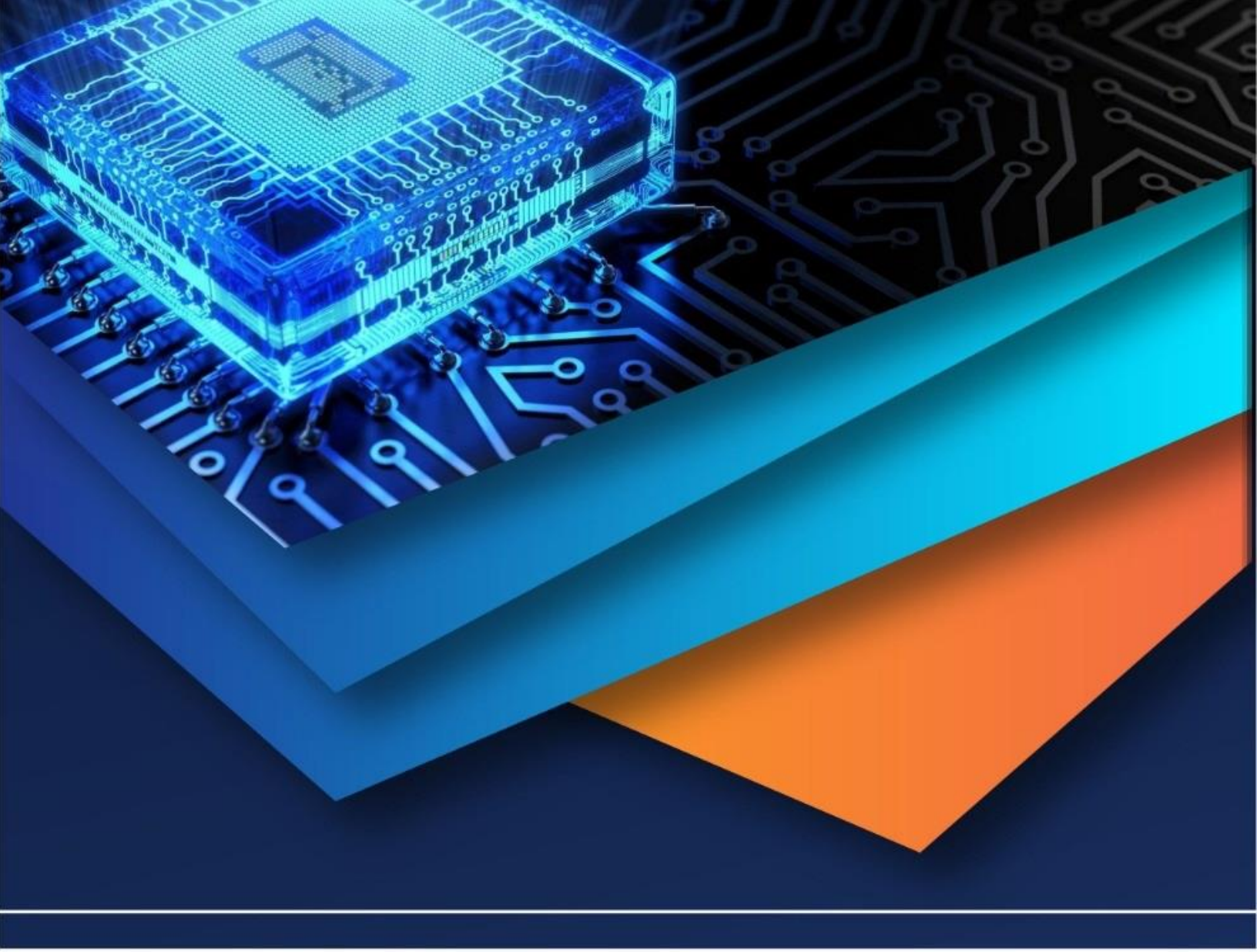

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