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Face recognition using Fast Discrete Curvelet Transform via Wrapping

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***Abstract*—In this paper, an efficient face recognition method based on fast discrete Curvelet transform via wrapping is proposed. Feature vector is generated using the curvelet transform coefficients of low frequency and high frequency with different scale and orientation. Further dimensionality reduction of feature vector, principal component analysis are used on feature space. Distance classifier is used to match the feature vector coefficients of training dataset and testing image.The experiments are carried out for face recognition using Face94 and IIT_Kanpur database.**

***Index Terms*— Discrete Curvelet Transform; Euclidian Distatnce; Principal Component Analysis;Feature Extraction;Eigen value.**

I. INTRODUCTION

Intelligent systems aim to realize the real world applications targeted to Automated Visual Surveillance, Traffic Monitoring System, Intelligent Vehicle System, Robot Navigation and Animations etc [1]. Object Recognition in machine vision is the task of finding an object in the given image or video sequence. Humans recognize an object with little effort. But for a machine, an image is a projection of 3D structure to 2D. Differing appearance of the same object with variation in the different viewpoints, viewing distance, scaling, translation, rotation, varying illumination, cluttered background, intra-category appearance variations etc. make the task difficult[2].

Object detection and classification have been done in different ways. Gupte etc al. [1] uses a background subtraction and tracking updates to identify the vehicle positions in different scene. Kirby and Sirovhich [2] proposed the use of the Principal Component analysis in reducing dimensions and extract featured parts of objects. A concept of Eigen picture was defined to indicate the Eigen functions of the covariance matrix of a set of face images. Turk and Pentland [3] have developed an automated system using Eigen faces with a similar concept to classify images in four different categories, which help to recognize true/false of positive of faces and build new set of image models. Use of Eigen spaces and Support Vector Machine for nighttime detection andclassification of vehicles has been mentioned by Thi et al. [4]. S.Zehang, G.Bebis, and R.Miller [6] usedPCA based vehicle classification framework. Harkirat S.Sahambi [7] and K.Khorasani used a neural network appearance based 3-D object recognition using Independent component analysis. N.G.Chitaliya and A.I.Trivedi [19,22,23] used Wavelet-PCA based feature extraction Contourlet based feature extraction for face recognition.

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Recently, a theory for high dimensional signals called multiscale geometric analysis (MGA) has been developed. Several MGA tools were proposed such as Curvelet [9, 10,16,17], bandlet and Contourlet [8, 11, 12, 14, 15] etc. Feature extraction coefficients are extracted by applying Curvelet transform that overcomes the problem of representing an image with smooth contours in different directions by providing two additional properties: directionality and anisotropy [20] as compared to the Discrete Wavelet Transform (DWT). The Curvelet Transform was developed initially [20] in the continuous domain via Multiscale filtering followed by a block based Ridgelet transforms applied to the subband images. The second generation Curvelet transform [21] was defined directly via frequency partitioning without using the Ridgelet transform. Both Curvelet transforms require a rotation operation and correspond to a 2D frequency partition based on polar coordinate. This makes the Curvelet construction simple in continuous domain but caused the implementation for discrete images sampled on a rectangular grid to be very challenging [21]. This makes algorithm implementation difficult. This fact leads the development of a directional multiresolution transform like Curvelet, but directly in the discrete

This paper is organized as follows. Section 2 provides brief background information on use for multi-level decomposition using the Discrete Curvlet transform , Principal Component Analysis . Section 3 describes our Methodology for feature extraction and recognition for the face image. Section 4 describes experiment results of the proposed technique using face database face94 and IIT-Kanpur. Section 5 concludes the paper and gives future directions of work.

II . Feature Extraction and Feature Selection

A. Discrete Curvlet Transform via Wrapping

Curvlet transform based on wrapping of Fourier samples takes a 2-D image as input in the form of a Cartesian array f[m,n] such that $0 \leq m < M$, $0 \leq n < N$ and generated a number of curvlet coefficients indexed by a scale *j*, an orientation *l* and two spatial location parameters (k1,k2) as output To form the curvlet texture descriptor, statistical operations are applied to these coefficients. Discrete curvlet coefficients can be defined by [20]:

$$C^D(j,l,k_1,k_2) = \sum_{\substack{0 \le m < M \\ 0 \le n < N}} f[m,n]\varphi^D_{j,l,k_1,k_2}[m,n] \qquad (1)$$

Wrapping based curvlet transform is a multiscale transform with a pyramid structure consisting of many orientations at each scale.Combination of the frequency response of curvelets at different scales and orientations gives the frequency tilting that covers whole image in spectral domain as shown in the Figure 1.

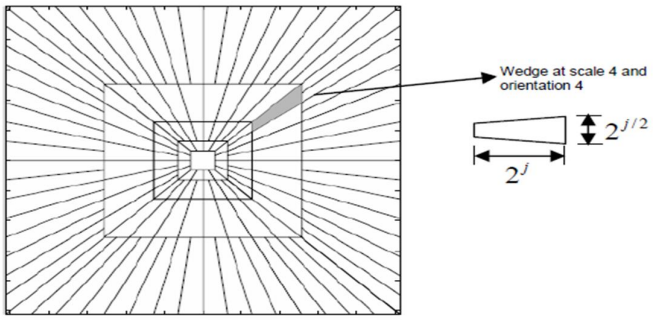

Figure 1: Frequency Tilting of an image with 5 levels Curvelet[20]

Let S is the dataset having P images. Let f (m, n) is a gray level image of size N x N. The Curvlet Transform of 1 coarsest level and 8 angles are applied on the face images. In the proposed method, the image is decomposed into single scales using real-valued curvelets. The number of second coarsest level angles used is 8. This results in 1 subband at finest level (L=1), 8 subbands at second coarsest level (L=2) and again 1 subband corresponding to last coarsest level (L=3).These resultant Curvelet Coefficients are used to reorder the column vector I_i of the images. Image Vector I_i is constructed by converting coefficients to a column

vector and then concatenation of all coefficient vectors. Let I = $[I_1, I_2, I_3, \ldots I_P]$ is the Feature Image Matrix constructed by Discrete Curvelet Coefficient.

B. Principal Component Analysis

First the covariance matrix is received from the set of feature image matrix. The Eigen vectors of covariance transformation were obtained. The Eigen vectors are those that invariant in direction during a transformation, which can be used as a representation set of the whole big dataset. Those components are called Eigenfaces in Turk and Pentland face detection application [7] and Eigen vehicles in Zhang et al. vehicle detection application [9].

Representative features of the Eigenspace will be used to derive the transformed version of each separated vehicle image in this vehicle space. In our system we call this transformed version the vehicle "weight" ω of each image in respect to the whole vehicle Eigen space, and can be used to judge the relationship between the each image with the model vehicle spaces. Our initial training set S consists of P different Face Images. These images are transformed into a new set of vector T^w of all input training weight. Figure 2. shows the Eigen value after applying PCA to the Curvelet transform of the face images. This transformation has showed how PCA has been used to reduce the original dimension of the dataset (PX N^2) to T^w (Size (PXP)) where generally P $<<N^2$. Thus the dimensions are greatly reduced and the most representative features of the whole dataset still remain within only P Eigen features.

Figure 2: Eigen faces after applying Curvelet transform

III. METHODOLOGY

The objective of the proposed work is to extract the facial features for recognition. Designing of pattern recognition system required two steps: Feature extraction and classification.

Let X_face and Y_Face represent the training and testing dataset. For gaining the best feature vector from the training dataset, at first, all images are normalized.The following steps are performed for feature extraction.

- RGB image is converted into gray scale image and resize to 64x64.
- Filtering is applied to remove noise and sharpening the image. Unsharp Contrast Enhancement filter and Multidimensional filtering is used as a Preprocessing.
- Decompose each image into the Curvelet transform. As a result of performing Curvelet Transform, coefficients of low frequency and high frequency in different scales and angles are obtained. Decomposed coefficients different size are obtained as $C_1, C_{2\text{-}1}, C_{2\text{-}2} \ldots C_{n\text{-}1}, \ldots C_{n\text{-}v}$,where $_V$ is the number of angles . These Coefficients are used to reorder the column vector I_i of the images.
- In our method we use 1 levela ngles of decomposition coefficients to construct the feature matrix. All the coefficients are arranged to make a column vector of 4028x1.
- The Feature image matrix I= $[I_1, I_2, I_3 \ldots I_P]$ is constructed from the coefficients column vector I_i. Where i represent the no of image.
- Feature matrix I is transformed to lower dimension subspace using PCA and stored as feature vector.

For Classification following steps are performed.

- Each test image transformed to a lower order subspace using Curvelet-PCA using the above steps.

- Upon observing an unknown test image X, the weights are calculated for that particular image and stored in the feature vector.
- Feature Vectore is compared with the feature matrix using the Euclidean distance. If the distance does not exceed some threshold value, then the featurevector of the unknown image is matched with the training dataset. The optimal threshold value has to be determined empirically.

IV. Experimental Results

All the algorithms are implemented all the algorithms are implemented in MATLAB 7.0.1,, Curvelet Toolbox and executed on thePentium–IV, 3.00GHz CPU with 2 GB RAM. To validate the accuracy of the proposed algorithm, two different databases are used: Face94 and IIT_Kanpur Dataset. IIT_Kanpur dataset consists of male and female images having 22 images of female faces and 38 images of male faces having 40 distinct subjects in up right, frontal position with tilting and rotation. Therefore this is a more difficult database to work with. Face94 dataset consists of 20 female and 113 male face images having 20 distinct subject containing variations in illumination and facial expression[24.25].
Table I reports the performance result obtained for all database. For face_94 female Dataset 33 imagesare selected for Training Set and 110 images are used for Testing purpose. As shown in the table the feature matrix for 33 image becomes 7225 × 33=135168 points.After applying PCA to the Feature Matrix I the weight matrix T^w becomes of size 33 × 33=1089 Points. Thus for the classification of the image required to match only 1089 points (33×33) and not 135168 points. Thus the computational cost greatly reduced by applying PCA.

Figure 2: Face Data Set[24,25]

TABLE I. Recognition rate using discrete Curvelet Transform

Dataset (JPEG Image)	Original Size of the Image	No of Images used for Training	Feature Matrix using Curvelet Transform	Matrix required for classification (after applying PCA)	No. Of Images used for Testing	Recognition Rate (%)
Faces_94 female	180 × 200	33	7225 × 33	33 × 33	110	97.33
Faces_94 Male	180 × 200	51	7225 × 51	51 × 51	170	91.76
IIT_Kanpur Female	640 × 480	30	7225 × 30	30 × 30	100	90
IIT_Kanpur Male	640 × 480	30	7225 × 30	30 × 30	100	78

The Recognition rates shown in the table 1 indicates the efficiency of the method. We got very good results for Face 94 and IIT_kanpur female dataset. Due to much variation in the IIT_Kanpur male dataset, only 78 % result received for the IIT Kanpur male dataset.

V. Conclusion

Feature extraction using Curvelet-PCA gives very high recognition rate. It also provides low dimensionality to reproduce and compare the results. Recognition and classification speed is high due to dimensionality reduction. The method is very fast and suitable for real time application for visual surveillance and robotics

systems. Further recognition rate is achieved and compared with different types of wavelets like Contourlet transform and Ridglet transform.

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