A Robust Face Recognition method

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Abstract - This paper presents face recognition system using curvelet transform. Face feature extraction has been done by taking the curvelet transform of the bit quantized images. The coefficient of curvelet transform is taken as a feature set using SVM classifier. The experimental results shows that the number of coefficients used in feature sets are less with higher efficiency of recognition. The experimental analysis also suggests that a multimodal biometric recognition system can be implemented using minimum feature sets and curvelet transform can be used as a robust method for feature extraction.

Keywords - Biometrics, Face image ,Face detection, Feature extraction, Face recognition, Curvelet transform, SVM classifier

1 INTRODUCTION

Face is most common biometric used by humans to recognize people. Face recognition has received substantial attention from researchers due to human activities found in various applications of security like airport, criminal detection, face tracking, forensic etc. Compared to other biometric traits like palm print, Iris, finger print etc., face biometrics can be non-intrusive and can be taken even without users knowledge and further can be used for security based applications like criminal detection, face tracking, airport security, forensic and surveillance systems.

Face recognition involves extracting a face image from a video, surveillance camera or from images and are compared with the stored data base. Face biometrics system is to train known images, classify them with known classes and are stored in the data base. When a test image is given to the system it is classified and compared with stored data base. Face biometrics is a challenging field of research with various limitations imposed for a machine face recognition like variations in head pose, change in illumination, facial expression, aging, occlusion due to accessories etc,. Various approaches were suggested by researchers in overcoming the limitations stated.

Automatic face recognition involves face detection, feature extraction and face recognition. Face recognition algorithms are broadly classified into two classes as image template based and geometric feature based. The template based methods compute correlation between face and one or more model templates to find the face identity. Principal component analysis, linear discriminant analysis, kernel methods etc are used to construct face templates. The geometric feature based methods are used to analyze explicit local features and their geometric relations(elastic bung graph method). Multi resolution tools such as contour lets, ridge lets were found useful for analyzing information content of images and found its application in image processing, pattern recognition, and computer vision. Curve lets were used for texture classification and image de noising and its application for feature extraction and image processing is still under research.

This paper presents face recognition system using curvelet transform. Face feature extraction has been done by taking the curvelet transform of the bit quantized images. The coefficient of curvelet transform is taken as a feature set using SVM classifier. The percentage of recognition obtained using curvelet transform feature extraction with SVM classifier is found to be higher . The paper is organized as face recognition system and its feature extraction in section 2 ,curvelet transform based feature extraction using SVM classifier in section 3, Implementation and results using bit quantized images in section 4 and discussion and conclusion in section 5.

2 FACE RECOGNITION SYSTEM

The face recognition system consists of four modules face detection, face normalization face feature extraction and matching (as shown in fig). The face recognition process can be operated in face verification, face identification and face watch (tracking, surveillance). In face verification a query face image is compared against a template face image whose identity is being claimed. In face identification a query face image is compared against all templates in the data base to determine the claimed identity. In face tracking and surveillance , face images are tracked and compared with the stored data bases (used for suspects, crime detection etc.,).[1][2][3][4][5]

Fig1. Face Recognition System

Feature extraction methods:

Extraction of facial features is an integral process involved in face detection, face modeling, face recognition, animation, facial expression determination, model based image coding etc. Facial feature extraction is sensitive to noise, variations in illuminations and pose. Various approaches were used to address these problems. Geometric based, color segmentation based, appearance based, template based techniques are proposed to increase the performance of the face recognition system.[8][13][14][15] In automatic face recognition system, face image is detected, features are extracted, and identified. The most common approaches used are geometrical based technique, template based technique, appearance based etc. In geometric based techniques face geometrical configuration is considered for feature extraction. Facial features like eyes, nose, mouth, eyebrows, shape of the face and their positional relationship between them is used to extract features.[17] Edge detection methods, gradient analysis method, Haar- life feature block in Adaboost method, etc are used. In template

based techniques features of face like eyes, nose, mouth etc are extracted based on template function and appropriate energy function. Energy function is defined to edges, peaks, valleys in the image intensity with corresponding property of the template. Template matching is done by altering its value to minimum with the matching template. i.e, to find the best fit. In appearance based techniques linear transformations and statistical methods are used to find basic vectors to represent the face. Each of the feature extraction methods has its own advantages as well disadvantages and no technique is considered as optimal.[7][9][12][16][18] Template based do not represent global face structure, appearance based which do represents global face structure but at a high computational cost.

3 Face Feature Extraction using Curvelet transform

Image is represented in a spatial domain using pixels. Direct use of pixel values as features is not possible due to huge dimensionality of the faces. Principal component analysis was used to represent Eigen faces with lower dimension but suffers from computational load and correlation of facial features. Image representation should satisfy the condition of multi resolution, localization, critical sampling, directionality and anisotropy. Multi resolution analysis tools more popularly wavelets have been found quite useful in analyzing the information content of images. Wavelet satisfies most of the conditions but has the limitations for fulfilling the dimensionality and anisotropy.[10][11]

Curvelets which is a multi-scale, multi-resolution transform overcomes the limitations of wavelets and provides optimal representation of objects with curve singularities. Curve lets requires relatively small number of coefficients to represents a line or a curve in a given image.

3.1 Curvelet transform

Curvelet transform was first developed by Candes and Donoho in 1999.Thefirst generation curvelet is based on Ridgelet transform where the curve singularities were handled by smooth partitioning of band pass images. The second generation curvelet is based on Fourier transform and is much faster, less complex, less redundant with two implementations of FFT, and wrapping techniques. Curvelets is emerging as a powerful feature extraction technique in image processing due to its ability to identify edges and edge discontinuities in an image. Curve singularities can be approximated with very few coefficients and in anon adaptive manner.[19] The steps involved to obtain curvelet coefficients are as follows.

If f[t_1,t_2],0$\leq t_1, t_2$<n Is taken to be a Cartesian array and $\hat{f}[n_1, n_2]$ to denote its 2D Discrete Fourier samples then procedural steps followed in obtaining curvelet coefficients via wrapping is

1. 2D-FFT is applied to obtain Fourier samples$\hat{f}[n_1, n_2]$
2. for each scale j and angle ℓ the product $\widetilde{U_{l,l}}[n_1, n_2].\hat{f}[n_1, n_2]$ is formed, where$\widetilde{U_{l,l}}[n_1, n_2]$ is the discrete localizing window.
3. This product is wrapped around the origin to obtain $\widetilde{f_{l,l}}[n_1, n_2]$ = W $(\widetilde{U_{l,l}}\hat{f})[n_1, n_2]$; where the range for n_1 and n_2 is now $0 \leq n_1 < L_{1,j}$ and $0 \leq n_2 < L_{2,j}$; $L_{1,j} \sim 2^j$ and $L_{2,j} \sim 2^{j/2}$ are constants.
4. Inverse 2D FFT is applied to each$\widetilde{f_{l,l}}$obtaining discrete curvelet coefficients.

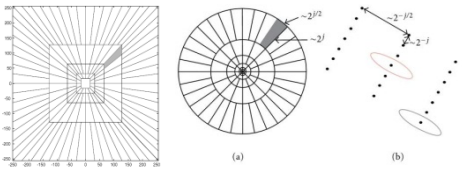

Fig 2 a) 5-level curvelet digital tiling of an image
b)spectral domain c) spatial domain

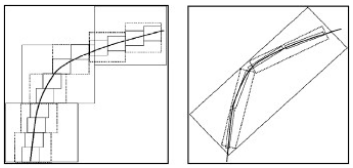

Fig 3. Curvelet edges

3.2 SVM Classifier:

Support Vector Machine was originally designed for binary classification using a hyper plane to define decision boundaries separating between data points of different classes. SVM can handle simple, linear as well as complex non- linear classifications. The idea behind SVM is to map original data points from input space into high dimensional vector space to simplify the classical problem of feature space. The mapping is performed using suitable kernel functions. SVM and its extension to multiclass has achieved superior performance in wide range of applications such as speech recognition, content based image retrieval, biometrics, etc. The most widely used implementation is one against all method which constructs M SVM classifiers and is combined to make a final decision. The classifier which generates the highest value from its decision function is selected as a winner.[6][20] A very brief review of one against all SVM classifier is given. Consider an M class problem where we have N training samples$\{x_1, y_1\}$….$\{x_N, y_N\}$. Hence $x_i \in R^m$is m dimensional feature vector and $y_i \in$ {1, 2….M} is corresponding class label. In this approach M binary SVM classifiers are constructed, and each of which separates one class from the rest. The ith SVM is trained with all the training examples of the ith class with positive labels, and all the other with negative labels. The ith SVM solves the problem giving ith decision function

f(x)= $w_i^T \emptyset(x) + b_i$
minimize: L (w,ξ_i^j)= $\frac{1}{2}\|w_i\|^2$ + C $\sum_{i=1}^{N} \xi_{ji}$
Subject to: $y_i(w_i^T \emptyset(xj) + b_i) \geq 1-\xi_i^j$ for $\xi_i^j \geq 0$
Where $\overline{y_i}$ = 1 if y_i= I and y_i= -1 otherwise

At the classification phase sample x is classified as in class i^* whose f_i^* produces the largest value.

$i^* = \arg\max f_i(x) i = 1 \ldots\ldots M$
= arg max $(w_i^T \emptyset(x) + b_i i = 1 \ldots\ldots M$

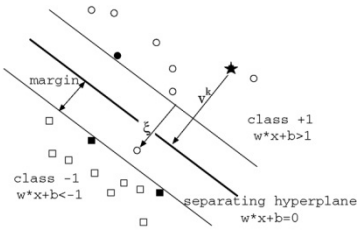

Fig 4. SVM classifier separation

4 Implementation and Results

Face recognition system is implemented using Curvelet transform for feature extraction. The images used are from AT&T data base which contains 10 different images of each of 40 distinct subjects. 6 images per person is taken as training and remaining 4 as testing. The color image is converted to black and white. Black and white images are represented into 8 bits resulting in 256 gray levels. The image is bit quantized into 2 bits and 4 bits to represent only the bold edges. The variation in edge information by quantization is shown in the fig 5.8. The grey level quantized images are curvelet transformed and the coefficient of curvelet transform contains the information of bold edges. Curvelet transform is taken at 5 different resolutions. The multi resolution analysis allows from course to fine relation of images. A single gray scale image of 2 bit, 4 bit and 8 bit image has total of 15 samples. They are classified by SVM classifiers and final decision is taken by using majority voting. The feature extraction using curvelet transform is shown in the Results.

No.of train images	No.of Test images	Face Recognition	Percentage
2x40=80	7x40=280	240	85.71
3x40=120	6x40=240	213	88.75
4x40=160	5x40=200	177	88.50
5x40=200	4x40=160	155	96.88
6x40=240	3x40=120	115	95.83

Table 1. Recognition Rate is shown with respect to training and testing images

4.1 AT & T DATA BASE:

The data base contains ten different images of each of 40 distinct subjects. The images are taken at different times, with variation in lighting, facial expression of open/closed/smiling/not smiling/with and without glasses. All images are taken at dark homogeneous background with subjects in upright and frontal positions. 6 images per person is served as training set and remaining 4 consisted of testing set. The random segregation into training and testing was done thrice.

4.2 RESULTS

The results obtained from Face recognition feature extraction is shown in the figures below.

Fig 5 Bit quantized images: 2bit, 4 bit and original image of 8 bits

Fig 6 Curvelet coefficients at 5 different resolutions from fine to course

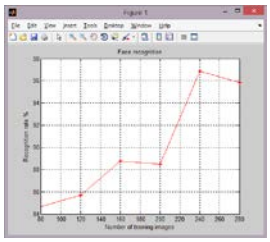

Fig7.Receiver Operating Characteristics showing the Recognition rate

5 DISCUSSION AND CONCLUSION

Face as biometric character has universal acceptance. Face recognition can be intrusive and are found in various applications like criminal detection, forensic, surveillance etc. In this chapter an overview of face recognition system with processing stages of face detection, feature extraction and face recognition using curvelet transform is given.It is found that image edge detection and feature extraction using curvelet transform uses only small number of coefficients compared to other transform techniques like wavelets.The results of Feature extraction using curvelet transform feature extraction was implemented and presented. The present work is tested on AT&T Data base. The number of coefficients used in the feature vector is considerably less compared to other methods. The dimensionality problem of feature vectors can be addressed using this method.

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