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Feature Fusion of Palm and Face Based on Curvelet Transform

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Abstract - This paper presents feature level fusion approach using multi resolution Curvelet transform for face and palm biometrics.In this paper feature extraction has been done by taking the curvelet transform of bit quantized images.The curvelet coefficient thus obtained acts as feature set for classification.The five sets of coefficients from five different versions of images are used to train five SVMs.During testingthe results of SVMs of palm and face are fused in a single column feature vector to determine the final classification.The results of fusion are compared with that of unimodal biometric system of palm and face separately.Using a common feature extraction method for both unimodal and fusion helps in analyzing the efficiency of recognition.The experimental results show that the proposed scheme out performs the unimodal biometrics using curvelet transform.All the experiments are carried out on two well-known data bases AT&T for face and POLY U for palm print images.

Keywords - *Face biometrics, Palm biometrics, Multimodal biometrics, Feature level fusion*

1. Introduction

Biometric based person identification is an automatic recognition of individuals based on their physiological and behavioral characteristics. Unimodal biometric system uses single trait such as face, palm, iris, fingerprints etc for person identification. Multimodal biometric uses the fusion of multiple biometric traits to achieve more accuracy and to overcome the disadvantages of unimodal biometrics like noisy sensor data, non- universality, spoof attacks etc.Ross and Jain presented an overview of multimodal biometrics with various levels of fusion namely sensor level,feature level,matching score level and decision level.[1]-[3].

Fusion at matching score, rank and decision levels have been extensively studied in the literature of biometrics [4],[5]. It is alsoobserved that a biometric system with information fusion at an earlier stage of processing can provide more accurate results than the information fusion at a later stage. Features of biometric have a rich source of information and the fusion at this level is expected to provide more accurate results. Feature level contains rich information from the source data compared to the later stages of processing. Fusion at feature level involves consolidation of feature sets corresponding to multiple biometric traits and feature sets have to be compatible and their relationship in the feature space should be known without any dimensionality problems.As a result feature level fusion is relatively understudied problem.

Feature extraction of an image should satisfy the condition of resolution, localization, critical sampling, directionality and anisotropy. Feature level fusion of biometric system was studied by various researchers applying different techniques for feature extraction [6], [7]-[9]. Application of wavelet transform as a feature extraction technique gave promising results as shown in the work of [10]-[12] because of its ability of localization in time and frequency domain.

The limitation of wavelets is that it can only transform point singularities in an image rather than curves and edges.Using curvelet transform for feature extraction which is a multi-scaleand multiresolution transform allows an optimal non adaptivesparse representation of objects with edges and uses relatively small amount of coefficient to reconstruct edge details of an image. Curvelet is an efficient transform method in representing edge discontinuity in 2D.Palm,Face recognition using curvelet transform was introduced in the work of[13],[14] and found to be used as a unimodal biometric. Applications of curvelets for multimodal biometric are still an understudied problem. Face and palm with its rich features can be fused to get more accurate multimodal biometric system.

This paper proposes an efficient feature level fusion of palm and face addressing many of the problems stated above using a multi resolution curvelet transform as common feature extraction scheme and SVM classifier.Palm is selected for its rich information in its features like principle lines, ridges, wrinkles etc which are unique for an individual and face is chosen as it has its application in the biometric over a decade. Palm and face features can be easily concatenated on feature space and are user friendly in acquiring images.In this paper palm and face are studied as both unimodal and multimodal. The block diagram of the system is shown in the fig1 which consists of four stages namely image acquisition,bit quantization,feature extraction and matching. The face and the palm images are subject to bit quantization to get five resolution images in each of two bit, four bit, eight bit. For feature extraction, curvelet transform is applied to each bit resolution (of five images) with a total of fifteen resolution images for 2, 4, 8 bit quantized images and the resultant feature vectors are calculated. SVM classifiers are trained with feature sets. The concatenated feature vector is calculated from the fusion of all the classifieroutput using majority voting. Five resolution images are used to ensure the accuracy of recognition.The rest of the paper is presented as a brief review of curvelet transform and feature extraction of palm, face and it's fusion in section II, classification using one to all method of SVM classifier, data sets used, results obtained in section III and finally conclusion in section IV.

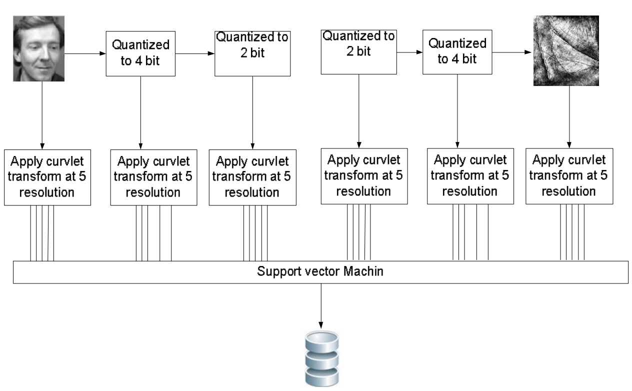

Fig.1. Block diagram of feature fusion of palm and face

2. Curvelet Based Feature Extraction

2.1Curvelettransform

Curvelet transform was first developed by Candes and Donoho in 1999.Thefirst generation curvelet is based on Ridgelet transform where the curvesingularities 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 USFFT, and wrapping techniques. Explanation of Curvelet transform is beyond the scope of this paper and readers are suggested to refer [18] for understanding. The steps involved to obtain curvelet coefficients are as follows

If f$[t_1, t_2]$,0≤ 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

$\widetilde{U_{J,\ell}}[n_1, n_2].\hat{f}[n_1, n_2]$ is formed, where$\widetilde{U_{J,\ell}}[n_1, n_2]$ is the discrete localizing window.

3.This product is wrapped around the origin to obtain $\widetilde{f_{J,\ell}}[n_1, n_2]$ = W $\left(\widetilde{U_{J,\ell}}, \hat{f}\right)[n_1, n_2]$; where the range for n_1 and n_2 is now 0≤ n_1<$L_{1,j}$ and 0≤ n_2<$L_{2,j}$; $L_{1,j}$ ~2^j and $L_{2,j}$ ~$2^{j/2}$ are constants.

4. Inverse 2D FFT is applied to each$\widetilde{f_{J,\ell}}$obtaining discrete curvelet coefficients.

2.2 Feature extraction

Face recognition system introduced in [14] is based on curvelet transform feature extraction on bit quantized images. As the curvelet transform uses minimum coefficients in its feature vector the proposed work is carried out using this efficient technique for multimodal biometric fusion. Curvelets is emerging as a powerful feature extraction technique in image processing due to its ability to identify edges and edge discontinuities of an image .In this paper application of curvelet to multimodal feature extraction is proposed and the aim is to get higher recognition with a unique feature extraction method used for both unimodal and multimodal biometrics.

Palm feature extraction using curvelet transform was found to have a good recognition rate as per study of K.Dong [13] and also used by researchers for fusion. In the present work the center of palm image is extracted as ROI. The bit quantized ROI images are used for feature extraction. Curvelet transform is used as feature extraction technique on each bit quantized image with five different resolutions.15 feature vectors are obtained for each image with different quantization versions. Palm features with its variable edge information are obtained in each feature vector.

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Face, palm images are bit quantized into 2, 4, 8 bitversions. Curvelet transform are taken at five different resolutions of each quantized image. Multiresolution allows coarse to fine approximation of the images. Over all we obtain 15 resolutions of each image under different quantized level. Each version of the image is trained using SVM classifier and this ensures recognition. During testing each image is converted to 15 different versions and is classified by SVM classifiers. Results from the classifier are fused to find final classification. Using Majority voting final decision is obtained.

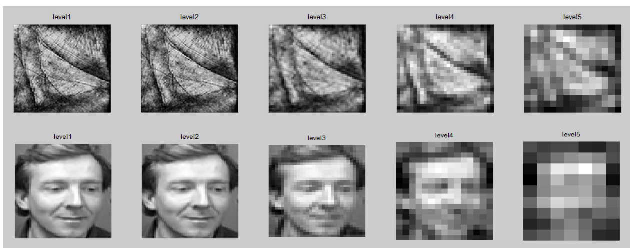

Fig.2. Bit quantized images of palm print and face

2.3 Fusion of Face and Palm Features

The feature level fusion is carried out with 15 feature vector of palm and 15 feature vectors of face from the bit quantized images.Fig.1 shows the block diagram of features of palm and face fused. SVM classifier is trained with the feature vectors and concatenated feature vector is calculated. During testing the test image is bit quantized and features are extracted using curvelet transform.

3. Experimental Results

3.1 SVM Classifier

Support Vector Machine was originally designed for binary classification and its extension to multiclass has achieved superior performance in wide range of applications. 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. We give very brief review of one against all SVM classifier and for more details readers are suggested to refer [19]. 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 i^{th} SVM is trained with all the training examples of the i^{th} class with positive labels, and all the other with negative labels. The i^{th} SVM solves the problem giving i^{th} decision function

f_i (x)= $w_i^T \emptyset(x) + b_i$ (1)

minimize: L (w,ξ_i^i)= $\frac{1}{2}\|w_i\|^2$ + C $\sum_{i=1}^{N} \xi_{ij}$ (2)

Subject to: $y_j(w_i^T \emptyset(xj) + b_i)$ ≥1-ξ_j^i for $\xi_j^i \geq 0$ (3)

Where $\bar{y_j}$ = 1 if y_j= I and y_j= -1 otherwise

At the classification phase sample x is classified as in class i^* whose f_i^* produces the largest value. $i^* = \arg\max f_i\,(x) \;\; i = 1 \ldots\ldots M$ (4)

=arg max $(w_i^T \emptyset(x) + b_i i = 1 \ldots\ldots M$ (5)

3.2 Data Sets

AT&T "The Database of Faces" contains 10 different images of each of 40 distinct subjects. For some subjects, the images were taken at different times, varying the lighting, facial expressions (open/closed eyes, smiling/not smiling) and facial details (glasses/no glasses).All the images were taken against a dark homogeneous background with the subjects in an upright, frontal position (with tolerance for some side movement).For this data set 6 images per person served as the training set and remaining 4 as testing set. Sample images of these data sets are shown.The Poly U palm print data base contains 193 persons, including left and right hand palm print, i.e., 386 total persons, 7752 total images. The samples are shown in figure. A virtual human data base was combined by choosing 40 persons, 10 images per person; from ploy U palm print database and remaining images from AT&T face data base.

3.3 Results

The experiments are carried out using 5 images per subject for AT&T and 5 images per subject for Poly U data base. Color images are converted to gray scaleimages and reduced to 4 times its length and breadth. No further preprocessing is done. Images from data bases are divided to training and testing. The image is bit quantized to 2, 4 bits and curvelets transform are taken at five different resolutions. Total of 15 resolutions for palm and 15 resolutions for face curvelet coefficients are concatenated to a column vector and these different versions of images are used to train SVM classifiers. During testing the test image is converted to 15 different versions for face and 15 different versions for palm. The final decision will be obtained by majority voting of the classifier outputs.

To compare the fusion results with that of unimodal biometrics ,experiments are conducted on face and palm images separately using the same procedure and recognition rate is calculated for palm and face recognition. According to table1, the recognition rate of multimodal fusion was higher than unimodal. The fusion recognition rate is found to be highest at 98.12%.The unimodal face, palmis 96.88%. The number of test and train images used are varied as shown in the result table. TheROC curve is as shown in fig 3 and it is found that the recognition rate is higher for fusion of palm and face features.

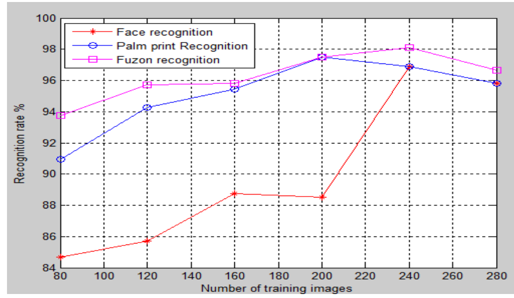

Fig.3 ROC curve for palm, face and fusion at feature level

Table .1.comparative results showing recognition rate vs number of samples taken

No. of train images	No. of test images	Face recognition	percentage	Palmprint Recognition	Percentage	Fusion Recognition	Percentage
2x40 = 80	8x40 = 320	271	84.68%	291	90.93%	300	93.75%
3x40 =120	7x40 = 280	240	85.71%	264	94.28%	268	95.71%
4x40 = 160	6x40 = 240	213	88.75%	229	95.41%	230	95.83%
5x40 = 200	5x40 = 200	177	88.50%	195	97.50%	195	97.50%
6x40 = 240	4x40 = 160	155	96.88%	155	96.88%	157	98.12%
7x40 =280	3x40 = 120	115	95.83%	115	95.83%	116	96.66%

4. Conclusion

In this paper amultimodal biometric system based on feature level fusion of palm and face is presented. The face and palm has rich information in its features and are user friendly traits and can be used for feature level fusion. Using a common feature extraction technique for both unimodal and multimodal the performance of biometric fusion is well analyzedthe results obtained for multimodal biometrics out performs the unimodal. Further improvement in the system can be carried using reduction techniques for classifiers.

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Bibilography

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