DCT AND DWT BASED IMAGE FUSION FOR ROBUST FACE RECOGNITION

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Abstract

We propose the face recognition system using image fusion for illumination invariant robust face recognition. The proposed method is useful when less number of samples or images available in the training dataset. In our system complexity of PCA algorithm is also reduced as we are using very few (only one) fused images to train instead of more (four) images in the training dataset. Hence processing time of face recognition system also reduces as compared to the conventional method. Generally, recognition rate is better when more or sufficient training images of different illumination are available. We have used the Discrete Cosine Transform (DCT) and discrete wavelet transform (DWT) based image fusion for fusing the different illumination face images. For processing the illumination varying image, low frequency components of DCT are used to normalize the illuminated image, illumination variation, which lies mainly in the low frequency band, is normalized in the DCT domain. Other effects of illumination variation which manifest themselves by the formation of shadows and specular defects are corrected by manipulating the properties of the odd and even components of the DCT. In DWT based method the image is decomposed in high (sub-bands LH, HL and HH) and low frequencies (LL2). The approximation coefficients (low frequency), and at the same time the details are enhanced (high frequency) by averaging each element of the detail coefficient matrix. The image is reconstructed from its approximation coefficients and details coefficients in all the three directions by using the inverse wavelet transform, resulting the normalized image. With the illumination correction there is an improvement in the recognition rate, the wavelet method generates the best result, improving the recognition rate. This is due the fact that face image resultant from wavelet processes has not only enhanced contrast but also enhanced edges and detail that will facilitate the further face recognition task .

Keywords: Image Fusion, Genuine Acceptance Rate (GAR), False Acceptance Rate (FAR), Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), Principal Component Analysis (PCA).

1. Introduction

Face recognition technology is well advanced. Many commercial applications of face recognition are also available such as criminal identification, security system, and image processing. Face recognition has many applicable areas. Moreover, it can be categorized into face identification, face classification, or sex determination [1]. The most useful applications contain crowd surveillance, video content indexing, personal identification (ex. driver's license), mug shots matching, entrance security, etc Humans often use faces to recognize individuals and advancements in computing capability over the past few decades now enable similar recognitions automatically. Face recognition faces challenging problems in real life applications because of the variation in the illumination of the face images. In the recent years, the research is focused towards Illumination-invariant face recognition system and many approaches have been proposed. But, there are several issues in face recognition across illumination variation which still remains unsolved.

2. PCA for Face Recognition

PCA is a method for pattern recognition in a given database and expresses the similarities and differences with respect to a target image. The PCA method consists in calculating the mean value of the training data set, the covariance matrix, the eigenvectors and the eigen values. Each image class is projected into PCA space. The PCA space has reduced dimensionality without much loss of information. Using min Euclidian distance classifier it is able to identify if a face image belongs or not to the database. Kirby and sirovich (1990) applied PCA to representing faces [1][2] and Turk and Pentland (1991) extended PCA to recognizing faces [3].

3. Illumination Normalization Methods

3.1 DCT Based Image Fusion for Face Recognition

For processing the illumination invariant image, low frequency components of DCT are used to normalize the illuminated image, odd and even components of DCT is used for compensation in illumination variation and PCA is used for recognition of face images [4]. Discrete Cosine Transform (DCT) is employed to compensate for illumination variations in the logarithm domain. Since illumination variations mainly lie in the low-frequency band, an appropriate number of DCT coefficients are truncated to minimize variations under different lighting conditions. It improves the performance significantly for the face images with large illumination variations. Also it does not require any modeling steps and can be easily implemented in a real-time face recognition system [5]. The DCT method is less sensitive to illumination variations. When using DCT, usually the feature vector used for classification is formed with the low frequency coefficients because they contain most of the face image information. For normalization methods, the methods on discarding low-frequency coefficients are simple but effective way to solve the illumination variation problem. However, a more accurate model needs to be studied instead of simply discarding low-frequency coefficients [10]. DCT coefficients exhibit the expected behavior in which a relatively large amount of information about the original image is stored in a fairly small number of coefficients. The features are extracted with the help of DCT. Low frequency DCT coefficients do concentrate more energy than others. There is no need of pre-processing. DCT generate a set of coefficients from which it is possible to restore the original samples of the signal. A mathematical transform has an important property: when applied to a signal, i.e., they have the ability to generate de-correlated coefficients, concentrating most of the signal's energy in a reduced number of coefficients. [3]

3.2 DWT Based Image Fusion for Face Recognition

Wavelet provides powerful signal analysis tools, which is widely used in feature extraction, image compression and de-noising applications. Wavelet decomposition is the most widely used multi-resolution technique in image processing. Wavelet based normalization method uses wavelet decomposition to get different band information of face images. Then the different band coefficients are manipulated separately. Compared with the popular histogram equalization method, it has the advantage of taking into account both contrast and edge enhancements simultaneously [9]. Daubechies wavelet transform, called as D2, coefficients from visual and corresponding coefficients computed in the same manner from thermal images are combined to get fused coefficients. After decomposition up to fifth level (Level 5) fusion of coefficients is done. Inverse Daubechies wavelet transform of those coefficients gives us fused face images. The main advantage of using wavelet transform is that it is well-suited to manage different image resolution and allows the image decomposition in different kinds of coefficients, while preserving the image information. Fused images thus found are passed through Principal Component Analysis (PCA) for reduction of dimensions and then those reduced fused images are classified using a multi-layer perception [10]. Wavelets have been successfully used in image processing. Their ability to capture localized spatial-frequency information of image motivates their use for feature extraction [11]. A facial image is decomposed into high and low frequencies using DWT decomposition. Illumination component (low pass component) is set to be zero. In recovering process the processed illumination component and the reflectance component (high pass component) are used to perform inverse DWT [12]. Since, CWT provides redundant information and requires a lot of computation, generally DWT is preferred. The two-dimensional wavelet transform is performed by consecutively applying one-dimensional wavelet transform to the rows and columns of the two-dimensional data [6].

4.Steps in the Face Recognition System

The following steps are involved in the recognition process:

4.1 Initialization:

The training set of face images is acquired and Eigen-faces are calculated which define the face space. Eigen Face Calculation: When a new face is encountered, a set of weights based on input image and M Eigen-faces is calculated by projecting the input image onto each of the Eigen-faces.

4.2 Euclidian Distance Classifier:

The image is determined to be face or not by checking if it is sufficiently close to face space. If it is a face, the weight patterns are classified as either a known person or an unknown one**.** Euclidian distance classifier is used as it is very efficiently classify the variability or dissimilarities between the objects which is useful in face recognition.

5.Methodology

5.1 Algorithms

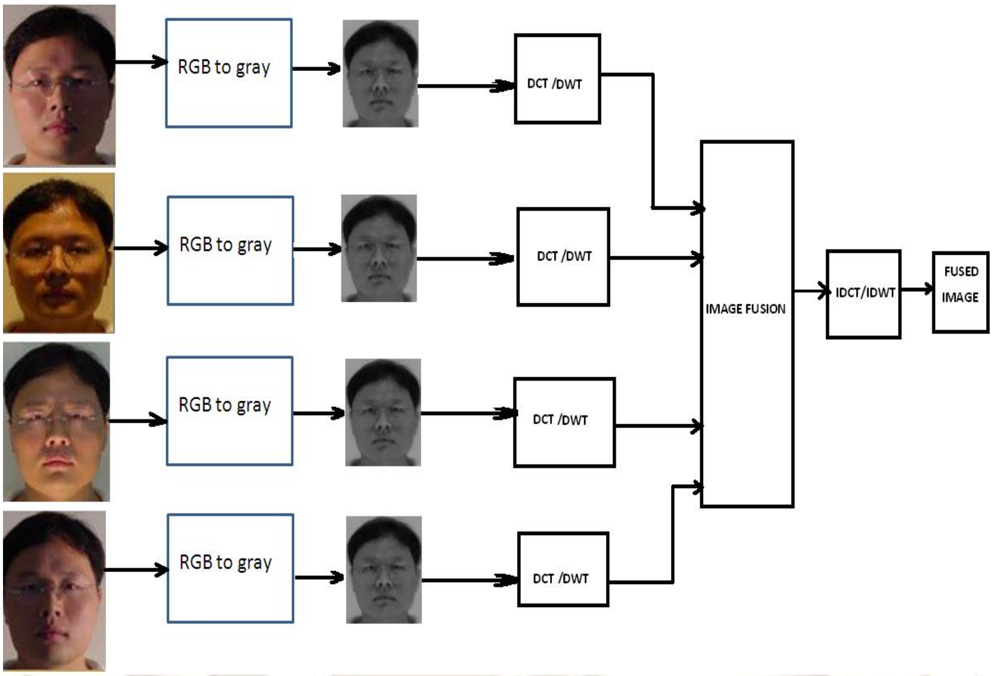
Face recognition is performed using PCA-principle component analysis method, by extracting most relevant information contained in the face. PCA approach used here is to extract different features from face with variation in illumination. The Euclidian distance classifier is used for recognition and identification of the images. The different fusion approaches like averaging; DCT and DWT are used for fusion. In our system we propose to use fused images as a training image set. The results have been compared for the recognition rate for different fusion algorithms i.e. DCT and DWT based fusion.

5.2 Database

Asian face image database from Intelligent Multimedia research laboratories is used for experimentation. Face images of 56 male persons containing 4 different illumination images of a person. Image resolution is 112×92 pixels [9].

5.1 Asian Face images with varying illumination

Proposed work is organized in to two parts first part is performing image fusion and secondly using those fused images as a training data set and recognizing faces using PCA. Total 56 fused images of 56 persons are used in the training data set and 224 images (4 images per 56 persons) are used in the testing data set. Image fusion is performed as a pre-processing. By using 56 images as the training dataset (un-fused images) and 224 images as the testing dataset, the recognition rate was less as compared to the recognition with the fused images as the training dataset. With the proposed system we get improvement in the processing time.



5.2 DCT/DWT based image fusion

5.3 DCT/DWT based fused images

5.4 Eigen-faces

6. Results

TABLE 6.1

Training Images (Un-fused)	Testing Images (Unfused)	GAR	GAR After Applying Fusion	FAR	FAR after applying Fusion	GRR Same For Fused results	FRR Same for fused results
50 (13persons	50	98 %	100%	2%	0%	0%	0%
52 (13persons	52	98.08%	100%	1.92%	0%	0%	0%
100 (25persons	100	99 %	100%	1%	0%	0%	0%
148 (37persons	148	99.32%	100%	0.68%	0%	0%	0%
150 (37persons	150	99.33 %	100%	0.67%	0%	0%	0%
200 (50persons	200	99.5%	100%	0.5%	0%	0%	0%
224 (56persons	224	99.55%	100%	0.45%	0%	0%	0%

6.1 Discussion from above results

Table 6.1 indicates the results calculation of face recognition system using PCA algorithm. Firstly result is calculated on the original images i.e. without fusing the images in the training as well as testing image database as well as Secondly result is calculated on the fused images in training database and un-fused images in the testing database. Considerably better results are observed in this technique of using fused images in the training database. Also the complexity of PCA algorithm is reduced as using only few fused images.

TABLE 6.2

Training Images (fused Images)	Testing Images (un-fused images)	GAR	FAR	FRR	Increase in proc. Time
13	52	84.62 %	15.38 %	0%	7.73%
25	100	76.54 %	23.46 %	0%	22.82%
37	148	78.41 %	20.24 %	1.35%	44.95%
50	200	70..5 %	25 %	0.5%	73.61%
56	224	71.12 %	28.88 %	0%	80.17%

6.2 Discussion from above results

In table 6.2 we did some experimentation on performing simple average (pixel) based image fusion. The recognition rate varies from 71.12% to 84.62%. As the number of images increasing recognition rate also reduces as more chances for false acceptance. Here also complexity of PCA algorithm is reduced by using fused images which are very few i.e. more information in less data.

Table 6.3

Training Images (fused)	Testing Images (un-fused)	Recognition Rate		
		DCT based Fusion Method	Averaging fusion Method	Wavelet based Fusion Method
13	52	84.62%	86.54%	88.46%
25	100	76.54	78%	81%
37	148	78.41%	80.41%	82.78%
50	200	70.5%	72.5%	74,23%
56	224	71.12%	72.77%	74.8%

6.3 Discussion from above results

In Table 6.3, PCA method used for recognition and fusion method used is averaging method, DCT based method and wavelet based method used for image fusion. 13fused images of 13 persons.25 fused images of 25 persons 50 fused images of 50 persons 56 fused images of 56 persons are used.

TABLE 6.4

Training images (1 fused image/person)	Testing images	GAR DCT based fusion	GAR Averagin method	GAR Wavelet Based fusion	FAR DCT	FAR Averge method	FAR Wavelet	GRR (for all Methods same)	FRR (for all methods same)
13	52	84.62%	86.54%	88.46%	15.38%	13.46%	11.54%	0%	0%
25	100	76.54	78%	81%	23.46%	22%	19%	0%	0%
37	148	78.41%	80.41%	82.78%	20.24%	18.24%	17.22%	0%	1.35%
50	200	70..5%	72.5%	74,23%	25%	27%	25.77%	0%	0.5%
56	224	71.12%	72.77%	74.8%	28.88%	27.23%	25,2%	0%	0%

7. Conclusion

In training set images are 13, 25, 37, 50 and 56 which are 4 times less than the images in testing set viz 52,100,148,200,224 resp. Recognition rate varies from 71.12% to 84.62% and processing time increased from 7.73% to 80.17%. Using image fusion processing time of a PCA based face recognition system improves. We are using only one fused image of a person instead of four images in the training database. Hence processing time of face recognition system also reduces by using fused images as compared to the un-fused training images. As averaging method is simple r processing time is better as compared to DCT, DWT based fusion. We are also getting better recognition in DWT based method as compared to DCT and averaging fusion method although DWT method is somewhat complex. We are using visual images instead of using IR and visual image fusion; still we are getting considerably good results. To make the system illumination invariant and to improve the recognition rate it is necessary to increase the training un-fused images.

8. Future Scope

Multimodal biometric approach for recognition can be used to improve recognition rate i.e. by fusion of face and palm images to obtain better accuracy of recognition since multimodal biometric relies on multiple information, combing the information plays an important role in designing the multimodal biometric system. Also by fusion of visual and IR images for illumination invariant face recognition approach to develop robust recognition system will be useful.

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