A Novel Approach for Facial Feature Extraction in Face Recognition

A. Srinivasan[1] and V. Balamurugan[2]

[1] Department of Information Technology
Misrimal Navajee Munoth Jain Engineering College
Anna University, Chennai, Tamilnadu, India
asrini30@gmail.com
[2] Department of Computer Science and Engineering
Chandy College of Engineering, Thoothukudi
Anna University, Tamilnadu, India

Abstract. Face recognition is the process of identifying a person by comparing his facial image with the existing image in a trained database. The crucial step in face recognition system is the extraction of facial feature. We propose an efficient facial feature representation by using Dual Tree Complex Wavelet Transform (DT-CWT). The Complex WT face characterizes the geometrical structure of facial images by using the properties of DT-CWT such as approximate shift in-variance and good directional selectivity. Since the efficiency retained with DT-CWT is inadequate, a new block design using Dual Tree Complex Wavelet Transform along with efficient normalization and noise reduction techniques is developed and using that design a face recognition system is developed.

1 Introduction

Face recognition recognizes the face images by extracting the facial features from a test image and compares it with trained facial images. The intensity variations due to illumination, shift, pose, and occlusion in human faces result in a highly complex distribution. Generally, the solution to this drawback is to extract the facial features before discriminant analysis which brings robustness against these variations. Face recognition system uses several techniques for feature extraction, examples for the feature extraction methods include i) Discrete Wavelet Transform, ii) Gabor Wavelet Transform and iii) Dual Tree Complex Wavelet Transform. The properties of DT-CWT such as approximate magnitude shift-invariance, good directional selectivity, limited redundancy and efficient linear computation can be harnessed to compute the accurate estimates of the geometrical structure in images.

Organization of this paper is done as, Section 2, elaborates the related works done in this field and approaches available. Section 3 reveals the existing system. Section 4 details the proposed system design. Section 5 deals with implementation, experiments done using public database and are explained, it also discusses experimental results. Section 6 concludes the paper.

S.C. Satapathy et al. (eds.), *ICT and Critical Infrastructure: Proceedings of the 48th Annual Convention of CSI - Volume II*, Advances in Intelligent Systems and Computing 249,
DOI: 10.1007/978-3-319-03095-1_17, © Springer International Publishing Switzerland 2014

2 Related Work

Anudeep Gandam et al. proposed a post processing algorithm [1] for detection and removal of corner outliers. This method uses signal adaptive filtering technique to remove outliers. Heng Fui Liau et al. implemented a method for illumination invariant face recognition based on discrete cosine transform (DCT) [2]. This is done to address the effect of varying illumination on the performance of appearance based face recognition systems. Chao-Chun Liu et al. proposed [3] a novel facial representation based on the Dual Tree Complex Wavelet Transform for face recognition. It is experimentally verified that the proposed method is more powerful to extract facial features robust against the variations of shift and illumination than the discrete wavelet transform and Gabor wavelet transform. Srinivasan et al. [4] proposed and designed a Face Recognition System using HGPP & Adaptive Binning. This method overcomes the drawback of high dimensional histogram features by using adaptive binning technique.

3 Existing System

The existing system (Figure 1) is a novel feature representation based on DT-CWT for face recognition, referred as complex-WT-face. It is different from the existing DT-CWT based techniques since it uses only the single scale information and it approximately reduces the dimensionality of image to its one eighth. The performance of DT-CWT is studied under the variations of shift and illumination for facial image using DWT and GWT for comparison. Moreover, there are some large artificial singularities in border generated due to finite-support of facial image, which can affect the accuracy of representation. So, a clip method is proposed to reduce their effects on normal intrinsic singularity extraction. The efficiency in the current trend of face recognition system is reduced owing to

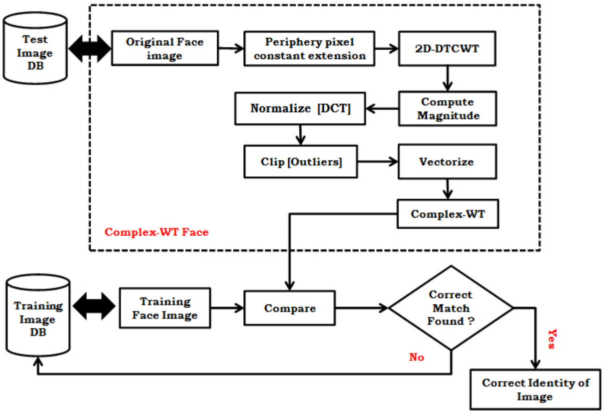


Fig. 1. Existing System

factors such as illumination variation, outliers and noises. The current trend of face recognition utilizes Zero Mean and Unit Variance normalization to overcome illumination variation. But the efficiency retained using ZMUV normalization is not adequate. The images consist of corner outliers that result in degradation at block boundaries.

4 Proposed System

By virtue of the good properties of DT-CWT, such as approximate shift invariance and good directional selectivity, the complex-WT face can characterize the geometrical structure in facial image. The proposed system improves the efficiency of face recognition, by reducing the impact caused flaws in the existing trend. The proposed design mainly concentrates on solution for i) Normalization, ii) Outlier reduction [5] and iii) Noise Reduction. Figure 2 shows the architectural flow of the proposed system. Given a facial image of size $n_r x n_c$, we extend its size to a critical size $n_r^e = ([n_r/2^L]+1)*2^L$ and $n_c^e = ([n_c/2^L]+1)*2^L$ by periphery-pixel constant extension, so that the decomposition can proceed till the given level L. Then the DT-CWT is performed on the extended facial image to generate a series of different-scale sub band constitute of complex coefficients. After that, only the sub bands of scale L are considered. The high-frequency sub bands whose scales are smaller than L are considered as noises caused by environmental variations and hence are discarded. The reason for using magnitudes of complex coefficient as features is, it provides an accurate measure of spectral energy, and approximately it becomes insensitive to small image shifts. For each L-scale sub band, we compute the magnitudes of its complex coefficients. In each scale, 2-D dual-tree complex produces two low-pass sub-images and six high-pass sub-images. Below algorithm 1 shows the steps involved in the implementation of the proposed work.

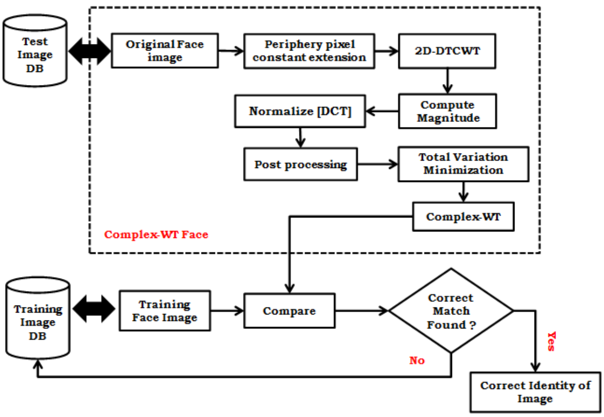


Fig. 2. Proposed System Design

Input: Input Image
Output: Complex Wavelet Face Representation
1.Extenstion
1a. Let the size of input image be $n_r x n_c$.
1b. The size of the extended image will be $n_{re} x n_{ce}$
$n_r^e = ([n_r/2^L] + 1) * 2^L$ and $n_c^e = ([n_c/2^L] + 1) * 2^L$ where L is the level of decomposition of DTCWT.
2. Dual Tree Complex Wavelet Transform
2a. DT-CWT is performed for feature extraction
2b. The input is image is decomposed to six high frequency and two low frequency sub bands.
3. Normalization
3a. Normalization is done to overcome illumination variation.
3b. The normalization is done using Discrete Cosine Transform.
4. Outlier reduction
4a. The images may consist of corner outliers.
4b. A post processing algorithm is implemented[corner outliers].
5. Noise reduction
5a. TVM approach is implemented to reduce blocky and mosquito noises.
6. Vectorization
6a. The eight sub images are vectorized and joined together to form a large vector.
6b. This represents complex-WT-face representation.

Algorithm 1. Implementation Steps for DT-CWT Processing

A post processing is used to eliminate corner outliers. A corner outlier is visible at the corner point of the block, where the corner point is either much larger or much smaller than the neighbouring pixels. A post processing is applied and based on signal adaptive filtering is proposed to reduce outliers. For smooth regions, the continuity of original pixel levels in the same block and the correlation between the neighbouring blocks is used to reduce the discontinuity of the pixels across the boundaries. For texture and edge regions, an edge preserving smoothing filter is applied. In this approach the image is divided into $8x8$ DCT blocks. The blocks are named $A, B, CandD$. The corner outliers are detected first and then they are eliminated. A global edge map is obtained by thresholding with global threshold value T_g, which is given by:

$$T_g = 10Qf + 8 \tag{1}$$

where Qf is the quantization factor of JPEG compression. The detection procedure is done by using a threshold value m, which is 20% of T_g. From this detection procedure, the return point is a corner outlier. A detected corner outlier and adjacent pixels are replaced by the weighted average. If a pixel of A to D is detected as a corner outlier, the pixels of $A, A1, andA2$ will be replaced with the proposed values of $A, A1, andA2$, respectively, as follows:

$$a = int[(5 * A + B + C + D)/8]$$
$$a1 = int[(2 * A1 + A2 + a)/4]$$
$$a2 = int[(2 * A2 + A1 + a)/4] \quad (2)$$

The pixels of $B, B1, andB2$ will be replaced with the proposed values of $b, b1, and$ $b2$ respectively, as follows:

$$b = int[(5 * B + C + A + D)/8]$$
$$b1 = int[(2 * B1 + B2 + b)/4]$$
$$b2 = int[(2 * B2 + B1 + b)/4] \quad (3)$$

The pixels of $C, C1, andC2$ will be replaced with the proposed values of $c, c1, and$ $c2$, respectively, as follows:

$$c = int[(5 * C + B + A + D)/8]$$
$$c1 = int[(2 * C1 + C2 + c)/4]$$
$$c2 = int[(2 * C2 + C1 + c)/4] \quad (4)$$

The pixels of $D, D1, andD2$ will be replaced with the proposed values of $d, d1, and$ $d2$, respectively, as follows:

$$d = int[(5 * D + C + A + B)/8]$$
$$d1 = int[(2 * D1 + D2 + d)/4]$$
$$d2 = int[(2 * D2 + D1 + d)/4] \quad (5)$$

Thus the corner outlier values are detected and are replaced with appropriate value. TVM method [6] is used to reduce blocky noise. The reconstructed images include the blocky noise and the mosquito noise. A new method for reducing the blocky noise and the mosquito noise using total variation minimization approach is proposed and used. In this method, by using the total variation filter, an image is decomposed to a skeleton component, which consists of smooth luminance and edges, and a texture component, which consists of small signals and noise. The Sobel filter is used for edge detection from the skeleton component, and the texture component corresponding to around the edges is filtered by using the Modified Adaptive Centre Weighted Median filter. As a result, the blocky noise and mosquito noise in the reconstructed images are reduced, and fine images are obtained.

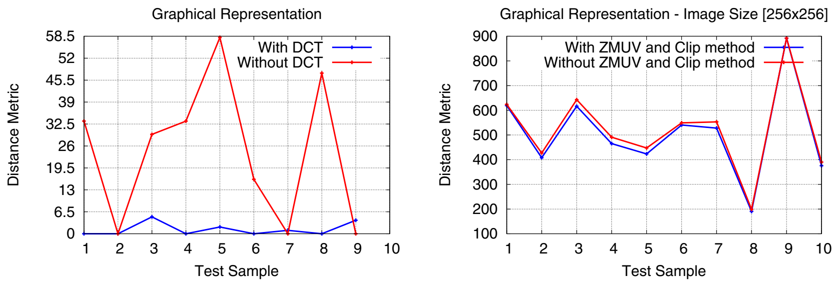
5 Results and Discussions

For implementation we have used MATLAB, which is an interactive software system for numerical computations and graphics. The results are verified using FRI CVL face database [7] and Yale database [8]. The training database consists of 100 subjects (person) with seven face images (for each subject) in different directions. The experiment is verified for different sizes such as 128x128 and 256x256 pixels. The distance value obtained by the nearest neighbour approach is used for comparison purpose. The distance value is reduced by using the normalization and outlier reduction techniques. In the proposed method, the distance values are smaller than that of the existing method. The recognition rate is improved for the candidates with minimum distance value. The distance values by using the normalization and noise reduction techniques are compared with the results obtained without using the normalization and outlier reduction techniques for both the existing and the proposed systems.

Table 1 shows the results of the distance measure with and without using the normalization and outlier reduction in the existing system. By using the zero mean and unit variance normalization and clip method outlier reduction the distance value is minimized and the plotted version is shown in figure 3.

Table 1. Distance metric results [Existing vs Proposed for image size(128X128)]

Test sample	Existing System		Proposed System	
	With ZMUV and Clip method	Without ZMUV and Clip method	With DCT and post processing	Without DCT and post processing
1	150.1055	150.8426	8	49
2	91.1823	98.0295	6	38
3	39.7284	44.058	4	16
4	105.2331	119.2366	6	34
5	115.5132	133.6785	0	33
6	97.0818	109.0456	0	30



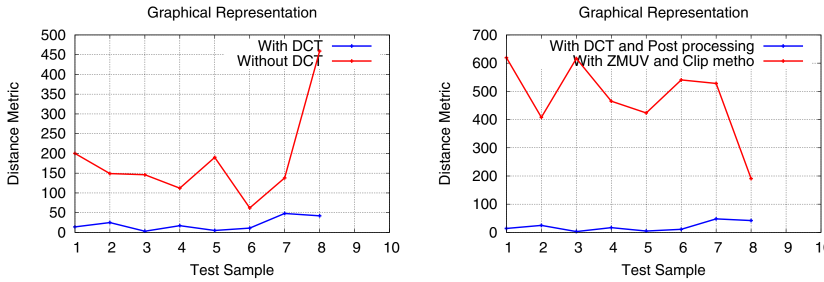
(a) Existing (b) Proposed

Fig. 3. Distance Metric Results Existing and Proposed (128X128)

Table 2 shows the results of the distance measure with and without using the normalization and outlier reduction in the existing system. By using the zero mean and unit variance normalization and clip method outlier reduction the distance value is minimized and the plotted results are shown in figure 4.

Table 2. Distance metric results [Existing vs Proposed for image size($256X256$)]

Test sample	Existing System: With ZMUV and Clip method	Existing System: Without ZMUV and Clip method	Proposed System: With DCT and post processing	Proposed System: Without DCT and post processing
1	619.218	623.7625	14	200
2	407.8989	426.9476	25	149
3	616.3582	642.8839	3	146
4	465.1737	491.0688	17	112
5	423.4235	447.4157	5	190
6	540.5289	549.2032	11	62



(a) Existing (b) Proposed

Fig. 4. Distance Metric Results Existing and Proposed ($256X256$)

The experiment for the recognition rate is verified for 700 images with 100 test images. It is verified for two image sizes such as $128x128$ and $256x256$. Table 3 shows the recognition rate for two image sizes. An example is provided where the training folder has 15 subjects with seven images for each subject. The existing system (E) recognizes thirteen images out of the fifteen for the size $128x128$. The recognition rate of the existing system is 86.66%. The proposed system (P) recognizes fourteen images out of fifteen test samples. The recognition rate of the proposed system is 93.33%. The existing system recognizes ten images out of the fifteen for the size $256x256$. The recognition rate of the existing system is 66.66%. The proposed system recognizes eleven images out of fifteen test samples. The recognition rate of the proposed system is 73.33%.

Table 3. PSNR table: Recognition Rate

TEST	$128x128$		$256x256$	
sample	E	P	E	P
Recognition Rate(%)	86.66	93.33	66.66	73.33

6 Conclusion

An advanced algorithm for face recognition using Dual Tree Complex Wavelet Transform is developed. The system uses Discrete Cosine Transform for normalization to overcome the effect of illumination variation. A post processing algorithm is used to reduce corner outliers. Total Variation Minimization is used to reduce blocky noises. The proposed system improves the efficiency of the Face Recognition System. The work is assessed with FRI CVL and Yale face databases.

References

1. Gandam, A., Sidhu, J.S.: A Post-Processing Algorithm for Detection & Removal of Corner Outlier. International Journal of Computer Applications 4(2) (2010) ISSN:09758887
2. Liau, H.F., Isa, D.: New Illumination Compensation Method for Face Recognition. International Journal of Computer and Network Security 2(3), 5–12 (2010)
3. Liu, C.-C., Dai, D.-Q.: Face Recognition Using Dual-Tree Complex Wavelet Features. IEEE Transactions on Image Processing 18(11), 2593–2599 (2009)
4. Srinivasan, A., Bhuvaneswaran, R.S.: A New Design for Face Recognition Using HGPP and Adaptive Binning Method. In: International Conference on Foundations of Computer Science, pp. 80–85. Monte Carlo Resort, Las Vegas (2008)
5. Cevikalp, H., Triggs, B.: Face recognition based on image sets. In: 2010 IEEE Conference on CVPR, Computer Vision and Pattern Recognition (CVPR), pp. 2567–2573 (June 2010)
6. Chambolle, A.: An Algorithm for Total Variation Minimization and Applications. Journal of Mathematical Imaging and Vision 20(1-2), 89–97 (2004) ISSN:0924-9907, doi:10.1023/B:JMIV.0000011325.36760.1e
7. http://www.lrv.fri.uni-lj.si/facedb.html
8. http://cvc.yale.edu/projects/yalefaces/yalefaces.html