COMPARATIVE APPROACH TO THE USE OF WAVELET TRANSFORM AND FILTER BANK FOR IRIS FEATURE EXTRACTION

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Abstract— This paper discusses two algorithms, orthogonal wavelet and biorthogonal filter bank (CDF 9/7), for extracting iris features. The methods have been compared using correct recognition rate, equal error rate.The performance of both the approaches have evaluated using UBIRIS, CASIA-V3-I, MMU V1, MMU V2.Results show superiority of biorthogonal filter bank over orthogonal filter for feature extraction.

Index Terms—Feature Extraction, Biorthogonal Filter Bank, Wavelet Transform, Equal Error Rate.

I. INTRODUCTION

Biometrics is the term used to describe the use of biological, physical or behavioural characteristics such as fingerprints, face, iris, retina, gait, palm-prints and hand geometry etc to identify a person. Iris-based recognition is an extremely reliable method for identity authentication among various biometric techniques. Iris is an annular part between the pupil and sclera of an eye image, having an intricate structure with many characteristics such as furrows, freckles, crypts and cornas. For every subject, these characteristics are unique as a result of the individual differences that arise in the development of anatomical structures during embryonic development. The iris patterns of the two eyes of an individual or those of identical twins are completely independent and uncorrelated, and are highly stable over a person's lifetime and lend itself to noninvasive identification because it is an externally visible internal organ. Fig.1shows the generalized block diagram of iris recognition system. It mainly consist of five steps Image Acquisition, Iris segmentation, normalization, feature extraction and matching. Image acquisition uses an imaging system to capture the distinct features of iris of high resolution. The segmentation phase consists in finding the location of iris within the human eye image. Normalization consists of unwrapping the segmented portion of iris in the form of a rubber sheet model of fixed Dimensions. In feature extraction, templates of normalized iris images are generated and then matching of generated template is done.

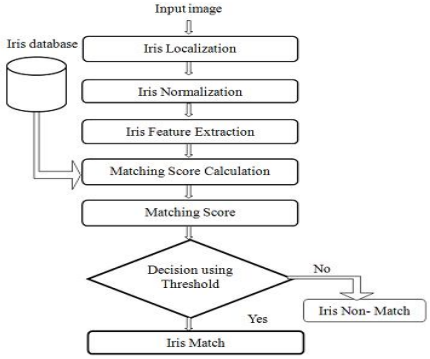


Fig .1: Generalized Block Diagram

II. LITERATURE REVIEW

Daugman proposed the first successful algorithm for iris recognition. In this algorithm, even and odd Gabor filters are proposed to demodulate phase information in each iris region. Boles and Boashash used one-dimensional wavelet transform (WT) to compute the zero-crossing representation at different resolution levels of a concentric circle on an iris image. Wildes characterized the iris texture through Laplacian Pyramid with four different resolution levels. Lim et al. used 2-D Haar Wavelet to decompose an iris image into four levels. Nabti et al. presented a multi-resolution iris feature extraction technique by analyzing the iris using wavelet maxima components and then applying a special Gabor filter bank on the normalized iris image to extract all dominant features. Monro et al. presented iris feature representation scheme based on the difference of optimized discrete cosine transform (DCT) coefficients of overlapped angular patches from a normalized iris image. Dong et al. Introduced a personalized iris-matching strategy using a class-specific weight map learned from the training images of the same iris class.

In this paper two approaches of feature extraction of iris image using orthogonal wavelet transform(db4) and biorthogonal filter banks(CDF 9/7) are discussed and compared for extracting the iris feature.

The rest of the paper is organised as follows, Section III presents the review of the filter bank and wavelet tranform used and Section IV reviews the iris pre-processing steps and describes the feature extraction technique. Section V summarizes the experimental results and compares both the approaches followed by conclusion in Section VI.

III. REVIEW OF PROPOSED ALGORITHMS

A. Review of Wavelet Transform

Wavelets are mathematical functions that cut up data into different frequency components and then study each component with a resolution matched to its scale. All wavelet transforms are derived from the CWT i.e. Continuous Wavelet Transform equation. Wavelet transform decomposes signal into set of basic functions, CWT is given by:

$$X_\omega(a,b) = \frac{1}{\sqrt{|a|}} \int_{-\alpha}^{+\alpha} x(t)\psi^*\left(\frac{t-b}{a}\right)dt \qquad (1)$$

where $X_\omega(a,b)$ represents the analyzed signal, a and b represents the scaling factor (dilatation/compression coefficient) and translation along the time axis (shifting coefficient). $\psi_{a,b}(t)$ is obtained by scaling the wavelet at time b and scale a. However, calculating wavelet coefficients for every possible scale involves a considerable effort and a vast amount of data.Hence DWT is used for implementation given by:

$$Y_\omega(m,n) = a_0^{-\frac{m}{2}} \int_{-\omega}^{+\omega} x(t)\psi(a_0^{-m}t - nb_0)dt \qquad (2)$$

B. Review of Filter Bank

It is always desirable to have a filter bank with some valuable properties like biorthogonality, perfect reconstruction, and linear phase for image processing application. Regularity of wavelets is another important property which is imposed in the design of the filter banks by having maximum zeros at aliasing frequency (i.e. at z=-1).Fig.2 shows two channel biorthogonal filter bank with output is given by:

$$Y(z) = \tfrac{1}{2}\left[G_0(z)H_0(z) + G_1(z)H_1(z)\right]X(z) + \tfrac{1}{2}\left[G_0(z)H_0(-z) + G_1(z)H_1(-z)\right]X(-z) \qquad (3)$$

where $X(z)$ is the input; $Y(z)$ is the output; $H_0(z), G_0(z)$ are analysis and synthesis low pass filters respectively and $H_1(z), G_1(z)$ are analysis and synthesis high pass filters. The alias cancellation can be achieved by using:

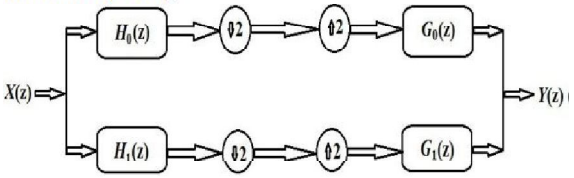


Fig. 2: Two Channel Filter Bank.

$$H_1(z) = z^{-1}G_0(-z) \quad \text{and} \quad G_1(z) = zH_0(-z) \qquad (4)$$

The Perfect Reconstruction condition is given by:

$$P(z) + P(-z) = 2z^{-m} \qquad (5)$$

where $P(z)$ is the product filter defined as $P(z) = H_0(z)G_0(z)$ .Thus, the design of the filter bank reduces to the design of the half band filter, followed by its factorization to obtain $H_0(z)$ and $G_0(z)$ [9]. The popular CDF family of filter banks is designed by factorizing the family of Lagrange half band filter (LHBF) given by:

$$P(z) = L_k(z) = z^k\left[\frac{1+z^{-1}}{2}\right]R_k(z) \qquad (6)$$

where, $R_k(z) = \sum_{n=0}^{k-1}\left[\begin{matrix}k+n-1\\ n\end{matrix}\right]\left[\frac{2-(z+z^{-1})}{4}\right]^n$

The LHBF has a maximum number of zeros at z=-1, and hence, a maximally flat frequency response, i.e.,

$$\left.\frac{d^pP(e^{j\omega})}{d\omega^p}\right|_{\omega=0} = 0 \qquad \text{for p=0.....2k-1} \qquad (7)$$

The 9/7 pair of CDF family is the most commonly used filter bank for all image processing applications and is advocated by many authors as the best pair when used for a wide range of image types .hence have been used for feature extraction.

IV. IRIS REGONITION SYSTEM

A. Iris Pre-processing

The original eye image must be pre-processed in order to extract iris features from an eye image. The pre-processing involves localization and normalization of the iris image. In this paper, the iris is localized using Daugman's integro-differential operator (IDO) and normalized with the help of Daugman's rubber sheet model. The half iris is preferred from the entire normalised iris image, for extracting the iris features, because the region closer to the pupil provides more discriminating iris information.

B. Iris Feature Extraction

For feature extraction the wavelet transform and filter banks are applied on normalized half iris and then decomposed to third level using wavelet transform and filter bank separately. Since decomposing the iris region of 300X40 pixels will produce a very large number of coefficients, hence, we only choose to take the third level of decomposition to reduce the code length.Table.II shows the length of feature vector obtained after decomposition. The coefficients thus obtained after decomposition are converted to binary iris code by converting positive to 1 and negative to 0.Fig.3 describe the feature extraction algorithm.

Following steps describe algorithm in detail:

1. Iris image is segmented using integro-differential operator.
2. The segmented iris image is normalized using Daughman's rubber sheet model.
3. The normalized image is decomposed using proposed algorithm, where LL1 represents approximation image and LH1, HL1, and HH1 represent detailed images for horizontal, vertical and diagonal orientation in first level.
4. The sub-image LL1 is decomposed, resulting in two-level wavelet decomposition, sub-image LL2 is decomposed, resulting in third level decomposition.

5. In order to obtain iris code, the coefficient Ai,j is encoded using:

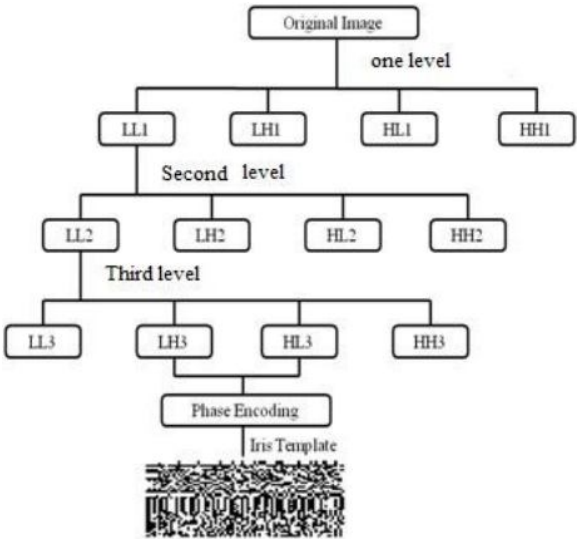
$$Ai,j = \begin{cases} 1 & , \text{ if } LH3(x,y) \text{and } HL3(x,y) \text{are positive} \\ 0 & , \text{ otherwise} \end{cases}$$

C. Iris Matching

For comparing the two iris code; a nearest neighbour approach is used, where the distance between two iris codes is measured using hamming distance given by:

$$HD = \frac{1}{N}\sum_{i=1}^{N} X_i (XOR) Y_i \qquad (8)$$

where HD is the Hamming distance between ith X and Y binary codes and N is the number of coefficients.



V. EXPERIMENTAL RESULTS

In this paper, performances of wavelet transform and filter banks have been evaluated using four databases: UBIRIS, MMU (V1) and CASIA-IRIS-V3-Interval. In identification mode, each of the iris images is matched against all other test data, which consist of images of the same iris and also different irises. In verification mode, Correct Recognition Rate (CRR) and Equal Error Rate (EER) have been compared and calculated. Receiver operating characteristics between FAR (False Acceptance Rate) and FRR (False Rejection Rate) has been plotted by varying the threshold between 0 and 1.Fig.4-5 gives the ROC for filter bank and wavelet transform respectively and Table I compares the EER and CRR for both approaches.CRR is given by:

CRR= (No. of correct matches/Total no. of test images) x 100%.

Table I: Comparison of CRR and EER

Databases	WAVELET(db4)		FILTER BANK(9/7)	
	CRR (%)	EER (%)	CRR (%)	EER (%)
UBIRIS	93.84	.35	98.84	.18
MMU1	91.14	.40	98.50	.30
MMU2	87.5	.42	97.81	.30
CASIA-V3-I	83.00	.39	98.37	.35

Table II: Comparison on the basis of speed

Methodology	Template (bytes)	Feature Extraction(sec)	Matching (sec)
Wavelet(db4)	1960	.7019	.0646
Filter bank (9/7)	**1056**	**.2653**	**.03114**

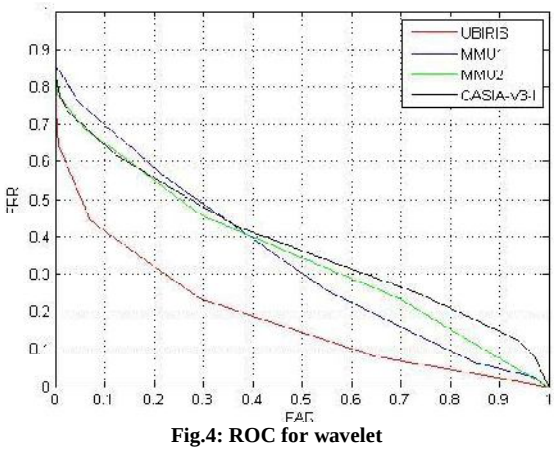


Fig.4: ROC for wavelet

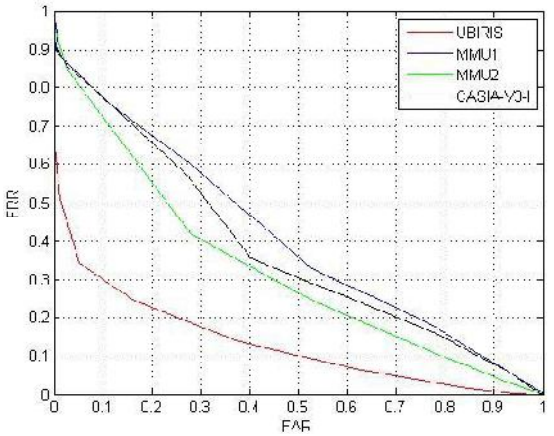


Fig.5: ROC for CDF 9/7

CONCLUSION

In this paper, two approaches of wavelet transform and filter banks have been implemented and compared by calculating Equal Error Rate (EER) and Correct Recognition Rate (CRR). It is observed that BO Filter bank has higher CRR as compared to orthogonal wavelet transform and thus gives lower FAR and FRR, as seen from the ROC, than wavelet filter. It is also seen that CDF 9/7 filter bank takes less time for feature extraction than wavelet transform.

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