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Iris Recognition using Fractional Coefficients of Cosine, Walsh, Haar, Slant, Kekre Transforms and Wavelet Transforms

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***Abstract**: The goal of Iris recognition is to recognize human identity through the textural characteristics of one's Iris muscular patterns. Iris recognition has been acknowledged as one of the most accurate biometric modalities because of its high recognition rate. Here performance comparison among various proposed techniques of Iris Recognition using the fractional coefficients of transformed Iris images is done considering Genuine Acceptance Ratio(GAR).The proposed method presents Iris recognition using Fractional coefficients of Cosine , Walsh, Haar, Hartley, Slant and Kekre Transforms and their Wavelet Transforms. The experiments are done on 384 samples of palacky university dataset. The experiments showed that the fractional coefficient of transformed iris images gives higher GAR than considering 100% coefficients giving faster and better iris recognition. Results show that Cosine Transform and Cosine Wavelet Transform at 0.10% energy Compaction, Walsh wavelet at 0.10% energy compaction, Haar Transform and Haar Wavelet Transform at 0.10%energy compaction gives the best results as far as other Transforms and wavelet transforms are considered. It also proves that Wavelet Transforms outperforms Transforms by giving higher GAR at various energy compaction levels.*
***Keywords**: Feature vector, Discrete Cosine Transform, Walsh Transform, Haar Transform, Slant Transform, Kekre Transform, and Wavelet Transform.*

I. Introduction

Biometric methods, which identify people based on physical or behavioral characteristics, are of interest because people cannot forget or lose their physical characteristics in the way that they can lose passwords or identity cards. The basis of every biometric trait is to get the input signal image and apply some algorithms like neural network, fuzzy logic, wavelet transform, etc to extract the prominent features. Biometric methods based on the spatial pattern of the iris are believed to allow very high accuracy, and there has been an explosion of interest in iris biometrics in recent years. Biometrics deals with automated methods of recognizing a person based on physiological characteristics such as face, fingerprints, hand geometry, iris, retinal, and vein.

Iris is a colored ring of tissues around the pupil through which light enters; dilator and the sphincter muscles are responsible for entering the amount of light entering pupil [2]. It consists of Stoma and Epithelial cells beneath. Eye color is the color of iris which comes in various varieties like brown, green, blue and can be grey, violet or pink. Iris is formed in early life in a process called morphogenesis which begins to form during the third month of gestation. Once fully formed texture is stable throughout the life and pattern becomes permanent after puberty [1]. Iris Recognition has a wide range of applications like passport-free automated border-crossings, national ID systems, premises access control, secure access to bank accounts at cash machines, internet security, anti-terrorism, computer login, cell phones and other wireless-device based authentication[2].Basically iris recognition system involves four main modules. The first module consists of image acquisition which deals with capturing sequence of iris images from the subject using cameras and sensors. The second module, pre-processing involves various steps such as iris liveness detection, eyelid detection and removal and normalisation. Many different methods like Hough transform, gradient based edge detection and integrodifferential operator are used to localize the portions of iris and pupil from the eye image. Mapping of extracted iris region to the normalised form is essential. The third module Feature extraction identifies the most prominent features for classification. In this module patterns are encoded to a format suitable for recognition and the last module recognition achieves result by comparison of feature vectors with stored pattern [4].

Today the major approach for iris recognition research is to generate feature vectors with dimensionality reduction for faster recognition with improvised accuracy.

When the input data to an algorithm is too large to be processed and it is suspected to be notoriously redundant then the input data will be transformed into a reduced representation set of features also named as features vector. Features extracted can be used to perform the desired task instead of using the full size input. This process reduces the query execution time, speed of matching from the templates stored in the database, and in todays world such fast, robust and secure implementation techniques are needed. This paper discusses some of the existing transforms like DCT and Walsh, their wavelet generation and Hybrid wavelet generation with the consideration of fractional coefficients of transformed iris images than considering 100% coefficients. Experimental results have shown that better performance can be achieved using wavelet transforms and than the respective orthogonal transforms and fractional coefficients of transformed images give faster and more accurate iris recognition.

I. Orthogonal Transforms

A. CosineTransform (DCT)

DCT is a technique of converting a signal into elementary frequency components. DCT is a close relative of the discrete Fourier transform (DFT), The DCT decomposes a signal into its elementary frequency components. When applied to an MxN image or matrix, the 2D-DCT compresses all the energy information of the image and concentrates it in a few coefficients located in the upper left corner of the resulting real-valued MxN DCT/frequency matrix [6].

These DCT coefficients can be used as a feature vector (FV) to retrieve the iris images. The retrieval of images becomes feasible because of the DCT coefficients as the DC components of DCT coefficients reflect the average energy of pixel blocks whereas the AC components reflect the intensity. DCT is a lossy compression technique that separates an image into discrete blocks of pixels of differing importance with respect to the overall image [7].

B. Walsh Transform

The Walsh transform matrix was proposed by Joseph Leonardo Walsh in the year 1923 and contains only the entries+1 and -1[8, 9]. Each row of a Walsh matrix corresponds to a Walsh function. The entries of the matrix are either +1 or −1. It has the property that the dot product of any two distinct rows (or columns) is zero [11, 12, 13]. The sequency ordering of the rows of the Walsh matrix can be derived from the ordering of the Hadamard matrix by first applying the bitreversal permutation and then the Gray code permutation [9]. The Walsh matrix (and Walsh functions) are used in computing the Walsh transform and have applications in the efficient implementation of certain signal processing operations [10]

C. Haar Transform

Haar transform has a number of advantages like it is conceptually simple, fast, memory efficient. A 5-level Haar wavelet is decomposed into cD1h to cD5h (horizontal coefficients), cD1v to cD5v (vertical coefficients), cD1d to cD5d (diagonal coefficients). Among these only cD4h, cD4v, cD4d, cD5h, cD5v, cD5d represents the core of the iris patterns, thus other redundant information can be removed and only core part can be considered.

D. Slant Transform

Slant transform is a member of the orthogonal transforms. It has a constant function for the first row, and has a second row which is a linear (slant) function of the column index. The matrices are formed by an iterative construction that exhibits the matrices as products of sparse matrices, which in turn leads to a fast transform algorithm.

E. Kekre Transform

Kekre's transform matrix can be of any size NxN, which need not to be an integer power of 2. All upper diagonal and diagonal elements of Kekre's transform matrix are 1, while the lower diagonal part except the elements just below diagonal is zero.

II. Wavelet Transforms

Wavelet Transforms are used to extract information from many kinds of data.. Wavelets are mathematical functions that cut up data into different frequency components, and then study each component with a resolution matched to its scale. Using a shift, multiply and sum technique called as convolution, wavelets can be combined to extract information from an unknown signal. In analyzing physical situations where the signal contains discontinuities and sharp spikes they prove advantageous over traditional Wavelet transform matrix of size P^2xP^2 can be generated from any orthogonal transform M of size PxP. For example, if we have orthogonal transform matrix of size 4x4, then its corresponding wavelet transform matrix will have size 16x16 i.e. for orthogonal matrix of size P, wavelet transform matrix size will be Q, such that $Q = P^2$. Consider orthogonal transform M of size PxP as shown below in Fig 1 and its corresponding wavelet transform generated shown in Fig 2

M_{11}	M_{12}	....	$M_{1(P-1)}$	M_{1P}
M_{21}	M_{22}	....	$M_{2(P-1)}$	M_{2P}
. .	. .	....	. .	. .
M_{P1}	M_{P2}	....	$M_{P(P-1)}$	M_{PP}

Fig. 1PxP Orthogonal Transform Matrix

Repeated P times first column of M				Repeated P times second column of M					Repeated P times pth column of M			
M_{11}	M_{11}	...	M_{11}	M_{12}	M_{12}	...	M_{12}	...	M_{1P}	M_{1P}	...	M_{1P}
M_{21}	M_{21}	...	M_{21}	M_{22}	M_{22}	...	M_{22}	...	M_{2P}	M_{2P}	...	M_{2P}
. .	. .	... ...	. .	. .	. .	... ...	. .	... ...	. .	. .	... ...	. .
M_{P1}	M_{P1}	...	M_{P1}	M_{P2}	M_{P2}	...	M_{P2}	...	M_{PP}	M_{PP}	...	M_{PP}
M_{21}	M_{22}	...	M_{2P}	0	0	...	0	...	0	0	...	0
0	0	...	0	M_{21}	M_{22}	...	M_{2P}	...	0	0	...	0
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
0	0	...	0	0	0	...	0	...	M_{21}	M_{22}	...	M_{2P}
		... ...				... ...		... ...			... ...	
M_{P1}	M_{P2}	...	M_{PP}	0	0	...	0	...	0	0	...	0
0	0	...	0	0	0	...	0	...	0	0	...	0
0	0	...	0	M_{P1}	M_{P2}	...	M_{PP}	...	0	0	...	0
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
0	0	...	0	0	0	...	0	...	M_{P1}	M_{P2}	...	M_{PP}

Fig. 2 QxQ Wavelet transformed generated from PXP Orthogonal Transform

III. Proposed Iris Recognition Method

In the proposed system Iris recognition is done using two steps, first step is Feature Extraction and second is Matching Feature Vector. Fractional coefficients are generated using DCT and Walsh transform. The transform concentrate the energy co-efficient of the image in the upper left corner of the transformed image matrix.

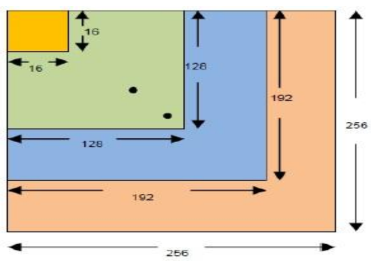

Fig. 3 Selection of Fractional Coefficients from high energy area in transformed Iris images.

Proposed system uses only these upper-left coefficients and discards the remaining coefficients. These fractional coefficients are considered as feature vectors for iris recognition. Here along with the individual Cosine, Walsh transforms, their respective wavelet transforms and hybrid wavelet transforms are also considered for fractional coefficients based feature extraction It should also be noted that these fractional coefficients would reduce the complexity of the system as the number of coefficients are reduced as given in Figure.5

In all seven varied percentages as100%, 25%,6.25%, 1.56%, 0.39%,0.10% and 0.02% are considered with 10 variations of transforms as Cosine, Walsh, Haar, Slant, Kekre, Cosine Wavelet, Walsh Wavelet, Haar Wavelet, Slant Wavelet and Kekre Wavelet Transform variations of proposed Iris Recognition.

IV. Experimentation

A. Platform

The experiments were performed on Matlab7.11.0 (R2010b), Intel Core TMi5 2450M CPU (2.5 GHz).

B. Test Bed

The techniques are tested on Iris Database created at Palacky University [14]. This database has 6x64 (i.e. 3x64 left and 3x64 right) iris images (each with 768 pixels by 516 pixels), corresponding to 64 persons, including both males and females. The six images taken per person for three people are shown in Figure 6

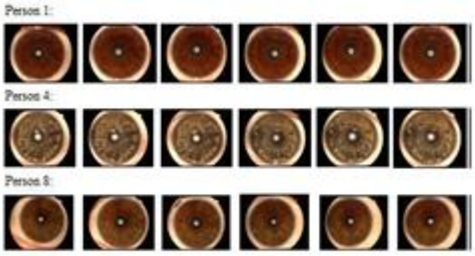

Fig. 4 Images from Palacky University Database

C. Similarity Criteria

Mean squared Error (MSE) is used to quantify the difference between values implied by an estimator and the true values of the quantity being estimated. It measures the squares of the "errors". The error is the amount by which the value implied by the estimator differs from the quantity to be estimated. Because of randomness or because the estimator doesn't account for information that could produce a more accurate estimate, the difference occurs

D. Performance Comparison

The genuine acceptance rate (GAR) [10] is the measure of the likelihood that the biometric security system will correctly accept an access attempt by an authorized user. A systems GAR typically is stated as the ratio of the number of correct acceptance divided by the number of identification attempts.

E. Results and Discussion.

Initially Feature Vectors are created for the database images with specific transformation methods as given in the proposed plan. We have used Palacky University Database which consist irises of 64 individuals. Each individual has 3 images corresponding to the left and 3 images corresponding to the right eye. Six iris images in portable network graphics format of each individual were taken into consideration. GAR values for iris recognition methods using DCT, Walsh, Slant, Kekre and Haar transforms, their wavelet transforms given in Table .1 percentage of fractional coefficients considered using various iris recognition methods.

Fractional coefficients	DCT Transform	WALSH Transform	HAAR Transform	SLANT Transform	KEKRE Transform
0.02%	69.9183	62.38834	70.0354	58.84259	62.43192
0.10%	71.94172	62.65795	72.36383	60.21514	62.57353
0.39%	70.12255	64.15577	71.20643	60.78976	65.69717
1.56%	68.56754	66.33442	70.49292	61.25817	65.35675
6.25%	68.37691	68.38508	68.95153	62.10784	66.17375
25%	68.84804	70.95316	68.40414	65.42484	67.10512
100%	68.94063	68.94063	68.94063	68.94063	68.94063

Table 1 Percentage of coefficients considered for proposed iris recognition methods.

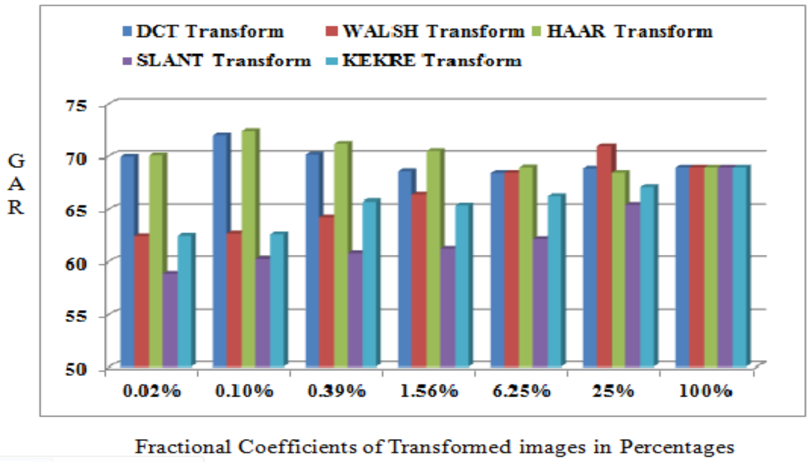

Fig. 5 Performance comparison of transforms for respective percentage of fractional coefficients considered in proposed iris recognition system.

Fractional Coefficients	DCT Wavelet Transform	WALSH Wavelet transform	HAAR Wavelet Transform	SLANT Wavelet Transform	KEKRE Wavelet Transform
0.02%	69.951	68.1454	70.0354	64.77397	64.77397
0.10%	71.9417	72.677	72.36383	67.61983	67.61983
0.39%	70.79	70.7979	71.20643	70.79793	70.79793
1.56%	69.1013	70.7979	70.49292	70.47386	70.47386
6.25%	68.4178	70.8714	68.95153	70.04902	70.04902
25%	68.848	70.8578	68.40414	68.88617	68.88617
100%	68.94063	68.94063	68.94063	68.94063	68.94063

Table 2 Percentage of coefficients considered for proposed wavelet transform iris recognition methods.

In all 102 queries were tested on our database for analysing the performance of proposed iris identification techniques. The graphs and table gives the percentage of GAR for iris identification using variations in techniques. Results are taken in 70 variations. From the results it is clear that Walsh wavelet Transform, Haar wavelet Transform and DCT Wavelet Transform outperforms over other Transforms and wavelet transforms giving better GAR at various energy compaction levels.

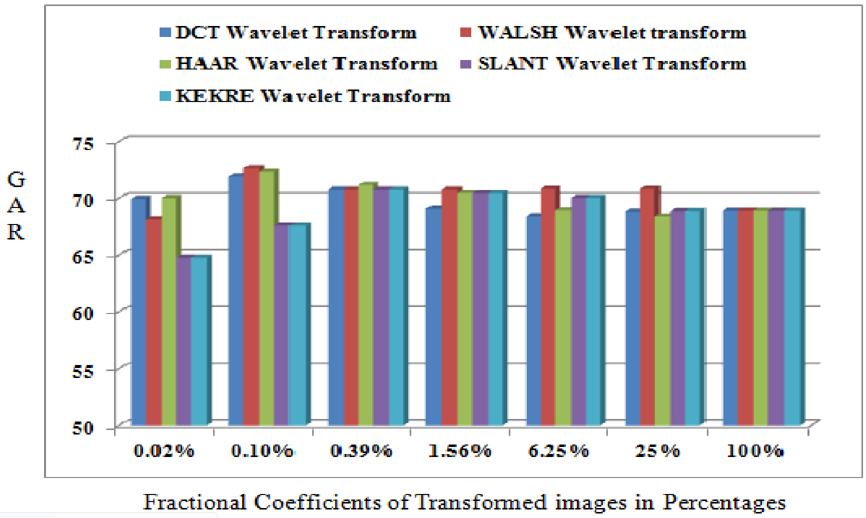

Fig. 6 Performance comparison of wavelet transforms for respective percentage of fractional coefficients considered in proposed iris recognition system.

V. Conclusion

Recognition accuracy, robust method and computational costs are topics that must be taken into account when analyzing an iris recognition method. In this paper we have discussed iris recognition using Cosine, Walsh, Slant, Kekre and Haar transforms and their Wavelets Transform. We have implemented these methods on iris images without any pre-processing or segmentation. Here it can be observed that in all transforms the fractional coefficient has given better accuracy as indicated by higher GAR values, compared to consideration of 100% coefficients of transformed iris image as feature vector. In all the Walsh Wavelet Transform and Haar wavelet transform at 0.10% of fractional coefficients based iris recognition has given best performance.

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