



Performance Comparison of Cosine, Walsh, Haar, Kekre and Hartley Transforms for Iris Recognition using Fractional Energies of the Transformed Iris Images

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Abstract: This paper presents a novel Iris feature extraction technique using fractional energies of transformed iris image. To generate image transforms various transforms like Cosine, Walsh, Haar, Kekre and Hartley transforms are used. The above transforms are applied on the iris images to obtain transformed iris images. From these transformed Iris images, feature vectors are extracted by taking the advantage of energy compaction of transforms in higher coefficients. Due to this the size of feature vector reduces greatly. Feature vectors are extracted in 5 different ways from the transformed iris images. First way considers all the higher energy coefficients of the transformed iris image while the rest considers 99%, 98%, 97%, and 96% of the higher energy coefficients for generating the feature vector. Considering fractional energies lowers the computations and gives better performance. Performance comparison among various proposed techniques of feature extraction is done using Genuine Acceptance Rate (GAR). Better Performance in terms of Speed and Accuracy is obtained by considering Fractional Energies. Among all the Transforms, Cosine and Walsh Transform gives good GAR value of 85% by considering 99% of Fractional Energy. Thus, using Fractional Energy gives better performance as compared to using 100% energies. The proposed technique is tested on Palacky University Dataset.

Keywords: Discrete Cosine Transform, Feature vector, Haar Transform, Iris Recognition, Walsh Transform, Kekre Transform, Hartley transform.

I. Introduction

Iris Recognition is a biometric that uses a person's iris patterns to uniquely identify an individual. It comes under biometrics because it makes use of person's irises, which is a bio-logical characteristic of a person. Human iris has advantage that it is unique, stable and non-invasive in nature and hence it is the most reliable biometric. Iris Recognition has many biometrics based applications. It is growing very fast and has become a very challenging and interesting area in real life applications. An Iris recognition system firstly gathers the person's one or more detailed eye image and then it generates a feature vector for that eye image and compares the generated feature vector with the feature vectors in the database. If a corresponding match is found, then that person is accepted else the person is rejected.

Iris recognition has a wide range of security-related applications like access control, secure online transactions, time and attendance management system, government and law enforcement, passport-free automated border-crossings, national ID systems, secure access to bank accounts at cash machines, internet security, anti-terrorism, computer login, cell phones and other wireless-device based authentication [15]etc.

There are many advantages of Iris recognition technology. The most important advantage of Iris Recognition technology is that irises are stable, so one enrolment can last a lifetime. Even for a single person his irises are same. Also, identical twins have different iris patterns and the left and right eye of the same person are also different. Moreover, from the age of two the iris pattern doesn't change for a person. Also, it has the highest accuracy in comparison with other biometrics.

II. Image Transforms

A. Discrete Cosine Transform(DCT)

DCT is a lossy image compression technique. When discrete cosine transform (DCT) is applied to an image, it separates the image into parts of differing importance. The DCT and discrete Fourier transform are both similar [3] since they both transform a signal or image from the spatial domain to the frequency domain. When DCT is applied to NXM image or matrix, all the low frequencies gets desegregated at upper left corner of the image

([2], [4], [5]). These low frequencies represent the higher energies. These low frequencies represent much of the image information. These high energy values can be used to form a feature vector.

B. Walsh Transform

Joseph Leonardo Walsh proposed Walsh transform in the year 1923. Walsh transform contains only the entries +1 and -1([2], [6]-[9]). Each row of a Walsh matrix corresponds to a Walsh Basis function. The property of Walsh transform matrix is that the dot product of any two distinct rows or any two distinct columns is zero [5]. The sequence ordering of the rows of the Walsh matrix can be derived from the ordering of the Hadamard matrix by first applying the bit reversal permutation and then the Gray code permutation [7]. 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 [8].

C. Haar Transform

Haar transform is an orthogonal transform. The elements of Haar transform are derived from Haar matrix whose elements are either +1, 0, -1 multiplied by integer powers of $\sqrt{2}$. Haar transform has the advantage that it is fast, memory efficient and computationally simple [5].

D. Kekre Transform

Kekre transform matrix can be of any size $N \times N$. N need not be 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 [2].

E. Hartley Transform

The Discrete Cosine Transform (DCT) utilizes cosine basis functions, while Discrete Sine Transform (DST) uses sine basis function. The Hartley transform utilizes both sine and cosine basis functions.

III. Proposed Iris Recognition Technique

The proposed method includes two modules. First is Feature Extraction module and second is Query Execution module. Following figure represents the block diagram of proposed method.

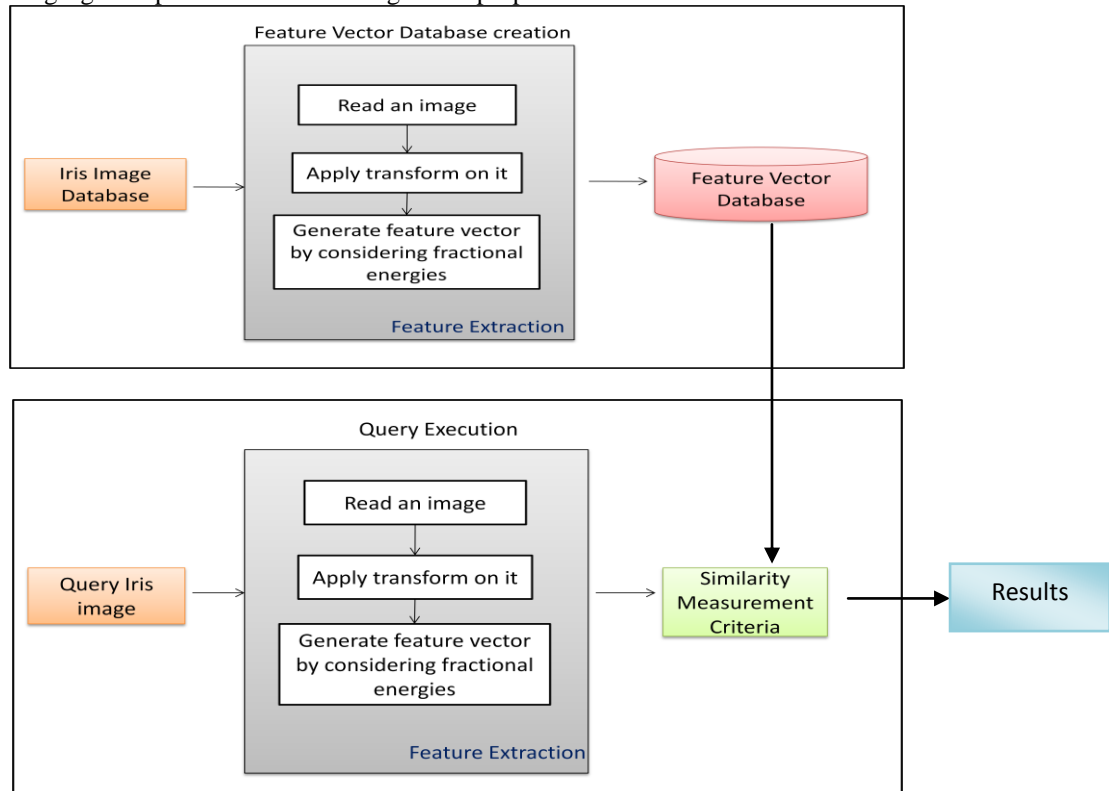


Figure 1. Architecture of system

The architecture consists of two modules:

A. Feature vector Database creation

The input is image of size NXN. Feature vector database is formed using following steps:

1. Separate the image into R, G and B components.
2. Apply transform on each to get transformed iris images.
3. Form feature vector depending upon the fractional energies considered.

So, feature vector database is formed for various transforms and by considering varied percentages as 100%, 99%, 98%, 97%, and 96% of fractional energies. Also, for NXN image the size of feature vector is as follows:

Size of Feature vector= mX3

Where,

m= number of coefficients considered to form feature vector.

B. Query Execution

Above steps are repeated for query image and the generated query image feature vector is compared with all the feature vectors in database to find a match. Comparison between the query image feature vector and the feature vectors in database is done using the Mean squared error as similarity measurement criteria.

IV. Implementation

A. Platform

Experiments are performed on Matlab R2008a version 7.6.0.324, Intel core 3 processor (4GB RAM and 2.24 GHz).

B. Database

The proposed method is tested on Palacký University Dataset. This database contains total 384 eye images. Images are of total 64 persons including images of both males and females. Total six images are taken per person i.e. 3 for left eye and 3 for right eye. The size of image is 768X576 pixels. All the images were taken in a single session [16].

Following are the sample images from the Palacký database.

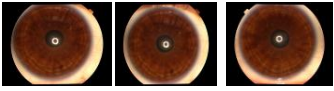

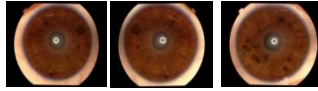
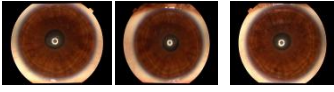
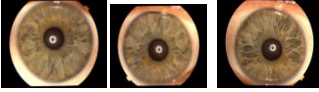

	Person 1:	Person 3:	Person 5:
Left eye			
Right eye			

Figure 2. Sample images from Palacký Database

C. Similarity Measurement criteria

The feature vectors are matched using Mean squared error. It is a similarity measurement criterion for matching the feature vectors. Mean squared error between two feature vectors x and y is calculated as follows,

$$MSE = \frac{1}{N} \sum_{i=1}^N (x_i - y_i)^2 \quad (1)$$

Where, N is the size of the vectors to be compared. Low MSE indicates higher similarity between the feature vectors x and y.

D. Performance Comparison metric

Genuine Acceptance Rate (GAR) is used as a performance comparison metric to evaluate the performance of proposed iris recognition system.

GAR is defined by following equation,

$$GAR = \frac{\text{number of correct acceptances}}{\text{number of identification attempts}} \quad (2)$$

V. Results and Discussions

To test the performance of the proposed method, total 384 queries were fired on the database containing 384 iris images. Matching between query feature vector and the feature vector in database is done using Mean Squared Error. Following figure 3 represents the GAR values using Cosine, Walsh, Haar, Kekre and Hartley Transforms.

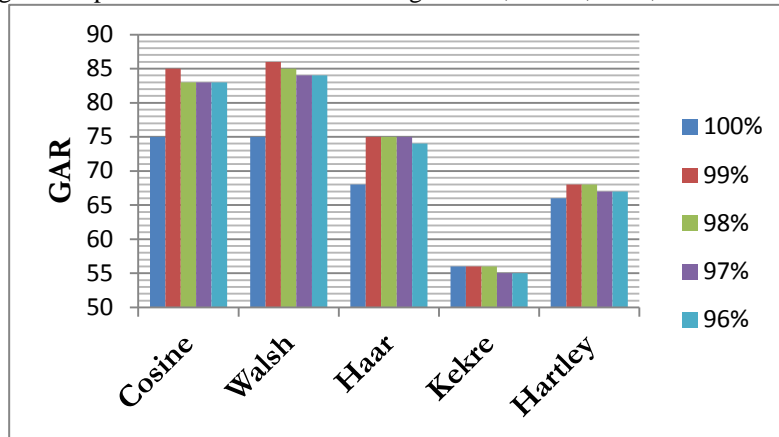


Figure 3. Performance comparison of transforms for respective percentage of fractional energies.

Following table shows the performance comparison between the proposed methods.

Transforms	Energy considered to form feature vector	No. Of Transform Domain coefficient considered	Reduction in size of feature vector	GAR	Percentage improvement in GAR
Cosine	100%	256X256X3	0	75%	0%
	99%	5X3	196593	85%	10%
	98%	4X3	196596	83%	8%
	97%	4X3	196596	83%	8%
	96%	4X3	196596	83%	8%
Walsh	100%	256X256X3	0	75%	0%
	99%	10X3	196578	85%	10%
	98%	6X3	196590	85%	10%
	97%	5X3	196593	84%	9%
	96%	5X3	196593	84%	9%
Haar	100%	256X256X3	0	68%	0%
	99%	20X3	196548	75%	7%
	98%	11X3	196575	75%	7%
	97%	8X3	196584	75%	7%
	96%	7X3	196587	74%	6%
Kekre	100%	256X256X3	0	56%	0%
	99%	3920X3	184848	56%	0%
	98%	2645X3	188673	56%	0%
	97%	2169X3	190101	55%	-1%
	96%	1887X3	190947	55%	-1%
Hartley	100%	256X256X3	0	66%	0%
	99%	9X3	196581	68%	2%
	98%	7X3	196587	68%	2%
	97%	6X3	196590	67%	1%
	96%	6X3	196590	67%	1%

Table1. Comparison of Methods

Results have shown that by considering fractional energies gives better results as compared to considering 100% energies. Also, the retrieval speed and computations are reduced greatly. Finally, Cosine and Walsh Transform gives better performance as compared to other transform.

VI. Conclusion and Future Scope

Since the iris patterns are unique for every individual, iris recognition is a reliable biometric. In this paper an attempt is being made to achieve good performance and higher accuracy. Better feature extraction techniques are proposed using various transforms and by considering fractional energies of the transformed iris image. Future scope will be to achieve much higher accuracy, improve the performance and achieve fast computational speed.

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