Effect of Tiling in Row Mean of Column Transformed Image as Feature Vector for Iris Recognition with Cosine, Hadamard, Fourier and Sine Transforms

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ABSTRACT
Iris recognition is a biometric authentication method that uses pattern-recognition techniques based on high-resolution images of the irises of an individual's eyes. Iris recognition has been a fast growing, challenging and interesting area in real-time applications. A large number of iris recognition algorithms have been developed for decades. This paper presents the techniques of iris recognition using image transforms such as Cosine transform, Sine transform, Fourier transform and Hadamard transform. Here iris recognition is done using the image feature vector set extracted as row mean of transformed column iris image. Image tiling is further used for feature extraction for each transform and the performance is compared with the single tile based iris recognition method. Parameters such as False Acceptance Rate and Genuine Acceptance Rate are used to test the performance of the techniques. The results have shown that the proposed Iris recognition methods performs better with increased number of tiles of Iris image up to certain extent of tiling.

Keywords
Iris Recognition, Row Mean, Image Tiling, Image Transforms.

1. INTRODUCTION
The iris is a thin, circular structure in the eye, responsible for controlling the diameter and size of the pupils and thus the amount of light reaching the retina [1]. A primary visible characteristic is the trabecular meshwork, a tissue that gives the appearance of dividing the iris in radial fashion [2]. Other visible characteristics include rings, furrows, freckles, and the corona. Iris' are composed before birth and, remain unchanged throughout an individual's lifetime; until accidently the eyeball is injured. Iris patterns are very complex, which carry an astonishing amount of information and it has over 200 unique spots [2]. The fact that an individual's right and left eye differ and that patterns are easy to capture, make iris-scan technology very resistant to false matching and fraud. Iris Recognition has a number of applications in every authenticating system such as computer logins, national border surveillance, forensics, personal certificates etc [3,4].

2. ROW MEAN OF TRANSFORMED COLUMN IMAGE
In the procedure of computing the row mean of a transformed column iris image, selected transform is applied to every column of the iris image [5,6]. Then the mean of the values in each row of the transformed column matrix is computed. These row means now form a column vector (n x 1 where n is the number of rows in the transform matrix). This column vector is the feature vector for the iris image sample.

The feature vectors for all the images are calculated and used for comparison with the feature vector of the query image instead of comparing actual pixel intensity values of the images [7]. Since the size of the feature vector (n x 1) is less than the size of the actual image (n x n), the computations are reduced and the code runs at a faster rate than normal pixel by pixel comparison [8].

Here four different image transforms alias Cosine transform [6, 9, 10], Sine transform [9], Hadamard transform [11, 12, 6] and Fourier transform [3] are used. The process of computing row mean of transformed column iris image is as shown in figure 1.

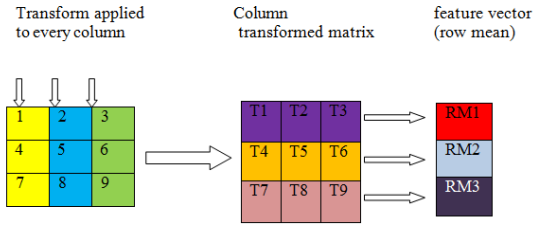


Figure 1 – Row Mean of Column Transformed Iris Images

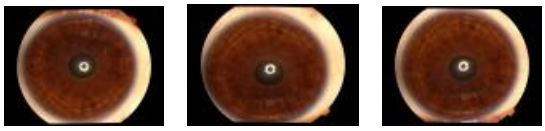
3. IRIS DATABASE
The techniques proposed are tested on an Iris Database created at Palacky University, Moravia, Czech Republic. This database has 6x64 (i.e. 3x64 left iris and 3x64 right iris) images (each of size 576 pixels by 768 pixels), corresponding to 64 persons, including both males and females [4, 13]. Sample images are shown in figure 2 and figure 3. The irises were scanned by TOPCON TRC50IA optical device connected with SONY DXC- 950P 3CCD camera [13].

Peron 1:

1.png 2.png 3.png

Figure 2 – Sample set of Left Iris Images of Person 1

Person 1:



1.png 2.png 3.png

Figure 3 – Sample set of Right Iris Images of Person 1

4. IRIS RECOGNITION USING ROW MEAN OF TRANSFORMED COLUMNS

In iris recognition based on one tiled image (1T) the entire image as a whole is considered, as shown in figure 4. The transforms DCT [6, 9,10], DST [9], Hadamard [11, 12, 6] and FFT [3] are applied on the columns of the image, one column at a time. Then, row mean of the column transformed images is calculated. Now the 256x256x3 sized image is converted into its feature vector (FT) of size 256x1x3. In this way, feature vector is calculated for all the images in the database and absolute difference between the FV of the query image and that of the database images is calculated.

Figure 4 – Image tiling in to 1 part

In iris recognition based on four tiled image (4T), as shown in Figure 5, the image is divided in to 4 parts each of size 128x128. Now, row mean of transformed column images are calculated (separately for each part). Thus, it results in 4 feature vectors for each plane of the image, each of size 128x1. These 4 FVs are then combined together [5] to give a resultant FV of size 128x4x3.

Figure 5 – Image tiling in to 4 parts

In iris recognition based on sixteen tiled image (16T), as depicted in Figure 6, the image is divided in to 16 parts each of size 64x64. The, row mean of transformed column images are calculated (separately for each part). Thus, it results in 16 feature vectors for each plane of the image, each of size 64x1. These 16 FVs are then combined together [5] to give a resultant FV of size 64x16x3.

Figure 6 – Image tiling in to 16 parts

5. RESULTS AND OBSERVATIONS

Observation of all techniques used on the entire image without tiling (GAR Values are used for Comparisons)

Table 1 - Observations of the Various Techniques used (on the whole image without tiling; GAR values are depicted in the table)

Techniques	Left Iris Database	Right Iris Database
Full Image as Feature Vector	0.7361	0.7535
Row Mean of Column – DCT	0.6285	0.691
Row Mean of Column – DST	0.6146	0.6667
Row Mean of Column – Hadamard	0.6076	0.6771
Row Mean of Column – FFT	0.6111	0.7396

From Table 1, it can be inferred that using the full image as the feature vector shows the best results. However, this technique has the major drawback of being extremely time consuming. To overcome this disadvantage, the paper proposes a solution to minimize the size of the feature vector. Also as it can be seen in the figure 7, it can be concluded that the best result is obtained for the images in the left iris database using DCT transform while that for images in the right iris database, is obtained by using the FFT transform.

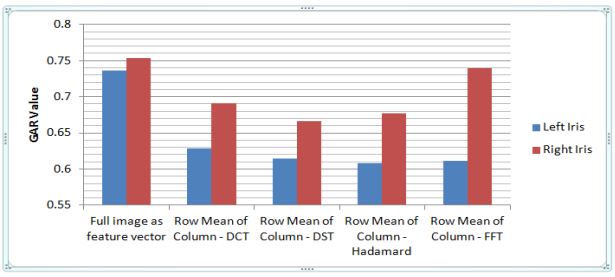


Figure 7 – Techniques used for computing GAR values for image as a whole

Observations of DCT computations with Image Tiling

Table 2 - Observations of DCT Row Mean of Column Computations with Image Tiling (GAR values are depicted in the table)

Techniques	Left Iris Database	Right Iris Database
Entire Image	0.6285	0.691
4 Tiled Image	0.6597	0.7066
16 Tiled Image	0.6771	0.7135

From Table 2, it can be inferred that the accuracy of the result increases with image tiling from 1 part to 4 parts and then to 16 parts. Hence the best result is shown when the image is tiled in to 16 parts. Also, results obtained are better for images in the right iris database. The same can be seen in Figure 8, in the form of a bar chart.

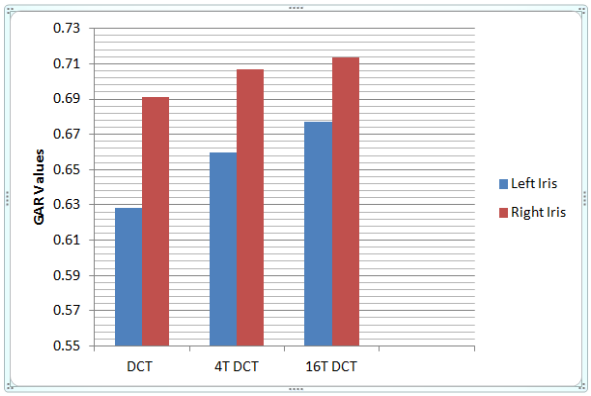


Figure 8 – Iris Recognition using DCT transform with image tiling

Observations of DST Computations with Image Tiling

Table 3 - Observations of DST Row Mean of Column Computations with Image Tiling (GAR values are depicted in the table)

By observing table 3, it can be seen that the accuracy of the result increases with image tiling from 1 part to 4 parts and then to 16 parts wherein the accuracy goes up to 70%. Hence the best result is shown when the image is tiled in to 16 parts.

Techniques	Left Iris Database	Right Iris Database
Entire Image	0.6146	0.6667
4 Tiled Image	0.6632	0.7031
16 Tiled Image	0.6962	0.7188

Also, results obtained are better for images in the right iris database.
The same can be referred from Figure 9.

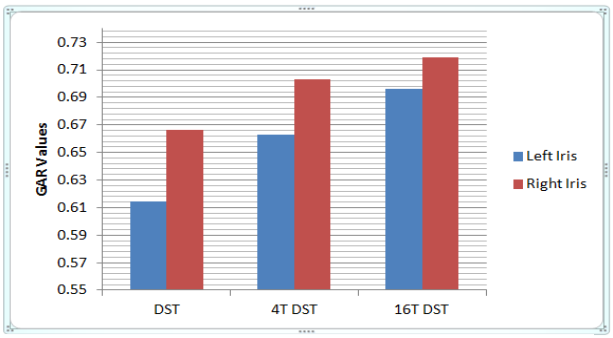


Figure 9 – Iris recognition using DST Transform with Image Tiling

Observations of Hadamard Computations with Image Tiling

Table 4 - Observations of Hadamard Row Mean of Column Computations with Image Tiling (GAR values are depicted in the table)

Technique	Left Iris Database	Right Iris Database
Entire Image	0.6076	0.6771
4 Tiled Image	0.6615	0.7014
16 Tiled Image	0.6684	0.7066

Looking at the Table 4, it can be observed that the accuracy of the result increases with image tiling from 1 part to 4 parts and then to 16 parts. Hence the best result is shown when the image is tiled in to 16 parts. Also, results obtained are better for images in the right iris database wherein the accuracy reaches up to 70.66%. The same can also be seen in Figure 10

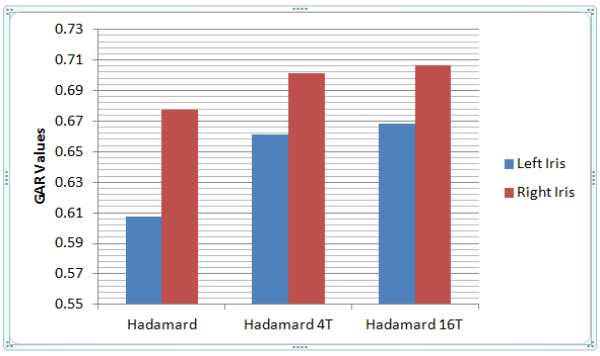


Figure 10 – Iris recognition using Hadamard transform with image tiling

Observation of FFT Computations with Image Tiling

Table 5 - Observations of FFT Row Mean of Column Computations with Image Tiling (GAR values are depicted in the table)

Techniques	Left Iris Database	Right Iris Database
Entire Image	0.6111	0.7344
4 Tiled Image	0.6337	0.6892
16 Tiled Image	0.7049	0.7222

On observing Table 5, it can be concluded that even though the accuracy of the result increases with image tiling from 4 parts to 16 parts, the best result is obtained when the entire image is considered as a single tile for the images from the right iris database. However, for images from the left iris database, the accuracy of the result increases with image tiling from 1 part to 4 parts and then to 16 parts. Here too, results obtained are better for images in the right iris database.
The same can be concluded from Figure 11.

Figure 11 – Iris recognition using FFT transform with image tiling

6. CONCLUSION

From the observations, it can be concluded that Pixel by pixel gives the best result compared to row mean of column transformed images, but the computation complexity increases, i.e. for pixel by pixel comparison, assuming a 256x256 image size, the number of comparisons made are 256x256x3 (considering the 3 planes of the image), whereas, if we use the feature vector computed by row mean of a column transformed image, then the total number of comparisons required are 256x1x3. Hence, the computations have been reduced by a factor of 256.

Also, when the full image is considered as a feature vector for comparison, a little lateral shift or movement in the image can produce erroneous results, but this is overcome by row mean of column transformed images, which works by considering columns.

For column-transformed images, DCT gives the best result on left iris images while FFT gives best for right iris images.

Tiling of the image increases the performance of the proposed iris recognition technique. Increasing the amount of tiling to only a certain extent can still increase performance. This implies that considering a sixteen tiled image gives better results than considering a four tiled image which in turn gives a better result than no tiling. The above tiling concept is contradicted by FFT for right iris images.

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8. AUTHOR BIOGRAPHIES

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