Novel Iris Recognition Techniques using Energy Compaction and Partial Energies of Transformed Iris Images with Cosine-Kekre and Cosine-Hartley Hybrid Wavelet Transforms

Dr. Sudeep Thepade, Pushpa R. Mandal
Professor, M.E Student,
Department of Computer Engineering,
Pimpri Chinchwad College of Engineering,
University of Pune, India
Email: sudeepthepade@gmail.com, pushpamandal287@gmail.com

Abstract—The paper presents novel Iris Recognition technique using Energy Compaction and Partial Energies of transformed iris images with the Hybrid wavelet transform namely ‘Cosine-Kekre’ and ‘Cosine-Hartley’ Hybrid wavelet transform. These two Hybrid wavelet transforms are applied on the iris images to obtain transformed iris images from which the feature vectors are generated in five different ways. The feature vector with 100% energy considers all of the coefficients of the transformed iris images to generate the feature vector so the size of feature vector is very large, in Energy compaction based feature vectors only the coefficients that hold 99%, 98%, 97% and 96% of energy are considered. Use of Partial energy reduces the feature vector size to a great extent and also it leads to lesser number of computations. The results tested using generic iris image database consisting 384 iris images have shown performance improvement in partial energy percentages with reduced feature vector size as indicated by higher Genuine Acceptance ratios as compared to 100% energy consideration.

Keywords—Biometrics, Iris Recognition, Feature Vector, Genuine Acceptance Rate, Energy Compaction, Hybrid Wavelet Transform.

I. INTRODUCTION

Iris recognition is an emerging biometric trait that uniquely identifies an individual based on the person’s iris patterns. Irises have the advantage that they are stable so one enrollment can last a lifetime, no two irises are same, even identical twins have different iris patterns even for a single person his left eye and right eye have different iris patterns and from the age of two the person’s iris pattern does not change. Due to these advantages irises have various security related applications.

In an Iris recognition system feature extraction is the crucial step. A new set of Iris recognition techniques using Partial energies and Energy Compaction are proposed here. The transforms have the advantage that when they are applied on an image they separate the high frequency and low frequency components from each other. The most of the discriminating information is present in low frequency components and hence only the low frequency coefficients can be used to generate feature vector which reduces the feature vector size to reduce computations of matching between feature vectors. The paper proposes reduction of the feature vector size by considering partial energies of transformed iris images. Feature vectors are generated for 5 different energy percentages viz. 100%, 99%, 98%, 97% and 96%. For 100% energy all of the coefficients of the transformed iris images are considered to form feature vector but for partial energy percentages only those coefficients that hold partial energy are considered to form feature vectors. To find the number of coefficients for a particular partial energy percentage concept of Energy compaction in transformed iris images is used which is elaborated in section II.

II. ENERGY COMPACTION IN TRANSFORM DOMAIN

The transforms have the advantage of desegregation of the high frequency and the low frequency components from each other. This property of transform is known as energy compaction. The low frequency components contain much of the information about the iris image and hence one can use only these low frequency coefficients to generate the feature vector instead of using all the coefficients of the transformed iris images. When feature vector is generated by considering all of the coefficients i.e. 100% energy of the transformed iris images then the size of the feature vector is very large. But when partial energy percentages are considered then the size of feature vector reduces drastically. For partial energy percentages only the coefficients that hold the particular cumulative partial energy are considered to form feature vector.
III. PROPOSED IRIS RECOGNITION TECHNIQUES

The iris image database [18] used consists of total 384 iris images and each image is resized to 256x256 for processing. So when 100% energy is considered then the size of feature vector becomes 256x256x3. The number of coefficients that needs to be considered to generate feature vector for a particular energy percentage is represented by table1. The process of finding out the number of coefficients for respective partial energy percentages is followed as listed set of steps given below:

Step 1: Apply Hybrid wavelet transform on each image in input database to obtain 384 transformed iris images.

Step 2: Do element wise addition of energies of all the 384 transformed iris images to obtain Average Energy matrix. Average Energy matrix represents the average energy compaction done by the transform on all the images in database.

Step 3: Store Average Energy matrix as a four column matrix with first column representing the coefficient value, second column representing the squared coefficient value, third and fourth column representing the row and column index value.

Step 4: Sort the Average Energy matrix by second column in descending order and swap the corresponding column values to obtain sorted Average Energy matrix.

Step 5: From the sorted Average Energy matrix, add the energy values from the first coefficient to last coefficient in a cumulative way to obtain Summed Energy matrix. Summed energy matrix signifies the summed energy up to the considered coefficient. Summed energy matrix is a two column matrix with first column representing the number of coefficients and second column representing the energy values.

Step 6: From the Summed Energy matrix coefficient table can be found out by simply scanning the Summed Energy matrix for a particular energy value and the corresponding column value represents the number of coefficients that needs to be considered for generating feature vector for that particular energy value.

As the percentage of energy considered is reduced, the number of coefficients required also reduces drastically, reducing the candidate feature vector size as compared to all coefficients consideration in 100% energy.

| Table 1 Number of coefficients considered to generate feature vector for different percentages of Partial energies using Hybrid wavelet transform |
|-----------------|-----------------|-----------------|
| Percentage Energy | Cosine-Kekre Hybrid wavelet transform | Cosine-Harlety Hybrid wavelet transform |

The proposed Iris recognition technique consists of two modules as Feature extraction and Query execution using partial energies coefficients of Hybrid wavelet transformed iris images consisting the energy percentages alias 99%, 98%, 97% and 96% of energy as compared to 100% energy (contained in all coefficients).

IV. EXPERIMENTATION

The proposed iris recognition techniques are tested on Palacky University Iris Database consisting of total 384 iris images of 64 persons. Total six images are taken per person i.e. 3 for left eye and 3 for right eye. All the images were taken in a single session [18].

The feature vectors are matched using Mean squared error. It is a similarity measurement criterion for matching the feature vectors. Genuine Acceptance Rate (GAR) is used as a performance comparison metric to evaluate the performance of proposed iris recognition system. Figure 1 shows sample images from the input database.

V. RESULTS AND DISCUSSIONS

A. Results of GAR obtained for proposed Iris recognition techniques using Hybrid wavelet transforms

Figure 2 shows GAR values obtained for proposed Iris recognition techniques using different Hybrid wavelet transforms for respective percentages of energies. It can be observed that partial energies based iris recognition gives better performance as compared to using 100% energy in both Hybrid wavelet transform with reduced feature vector size. When 100% energy is considered then both Hybrid wavelet transform gives GAR of 67%. For 99% partial energy Cosine-Kekre Hybrid wavelet transform and Cosine-Hartley Hybrid wavelet transform...
wavelet transform gives second highest GAR of 70%. For 98% partial energy Cosine-Kekre Hybrid wavelet transform gives highest GAR of 71%. In all the cases Cosine-Kekre Hybrid wavelet transform performs better than Cosine-Hartley Hybrid wavelet transform.

Fig 2. Performance comparison of Hybrid wavelet transforms for respective percentage of energies.

![Fig 2. Performance comparison of Hybrid wavelet transforms for respective percentage of energies.](image)

Figure 3 shows GAR values for different percentages of energies for respective Hybrid wavelet transform based Iris recognition methods. From figure it can be concluded that when partial energies are considered then there is improvement in GAR and also the feature vector size is reduced greatly. Highest GAR of 71% is given by Cosine-Kekre Hybrid wavelet transform for 98% of partial energy. Whereas second highest GAR of 70% is given by Cosine-Kekre Hybrid wavelet transform and Cosine-Hartley Hybrid wavelet transform when using 99% of partial energy. So, the performance is improved greatly by considering partial energies as indicated by higher GAR percentages as compared to 100% energy consideration, proving the worth of proposed iris recognition techniques.

B. Analysis of Experimentation Results for Hybrid wavelet transforms

Table 2 summarizes the performances given by both the Hybrid wavelet transforms for different energy percentages. Here it is observed that for 98% partial energy Cosine-Kekre Hybrid wavelet transform gives highest GAR of 71% with 96.64% reduction in feature vector size. Whereas second highest GAR of 70% is given by Cosine-Kekre Hybrid wavelet transform and Cosine-Hartley Hybrid wavelet transform when using 99% of partial energy. Also the feature vector size is drastically reduced by considering partial energies and also the performance has increased.

<table>
<thead>
<tr>
<th>Hybrid Wavelet Transforms</th>
<th>Energy considered to form feature vector</th>
<th>No of coefficient considered to form feature vector</th>
<th>Percentag e Reduction in size of feature vector</th>
<th>GAR</th>
<th>Percentage improvement in GAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cosine-Kekre</td>
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<td>65536</td>
<td>0</td>
<td>67%</td>
<td>-</td>
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<td>99%</td>
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<td>99.23%</td>
<td>67%</td>
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</tbody>
</table>

VI. CONCLUSION

Minimizing the feature vector size without compromising the performance is the current thirst of biometric domain. Novel energy compaction based iris recognition techniques using partial energies of transformed iris images with hybrid wavelet transforms is proposed. The performance of proposed Iris recognition techniques is evaluated using Palacky University test bed consisting of 384 iris images. The 384 iris images are fired as query image and the GAR obtained by each query fired is averaged to get the GAR for that technique.

Using the proposed iris recognition techniques, feature vector size reduction to extent of 95.57% to 99.23% is achieved with 4% improvement in GAR. Results show that for 98% partial energy Cosine-Kekre Hybrid wavelet transform gives highest GAR of 71% with 96.64% reduction in feature vector size. Whereas second highest GAR of 70% is given by Cosine-Kekre Hybrid wavelet transform and Cosine-Hartley Hybrid wavelet transform when using 99% of partial energy.

The herculean task of achieving performance improvisation in case of iris recognition using partial energy percentages over consideration of 100% coefficients is achieved. The energy compaction in Hybrid wavelet transformed iris images have not only helped in tremendous minimization of feature vector size to be considered but also it helps in focusing on more discriminative characteristics of iris images being concentrated in high energy region and in removing the non-discriminative features present in low energy region of transformed iris images resulting in better performance.

REFERENCES

[1] Dr. Sudeep Thepade, Pushpa R. Mandal, “Performance Comparison of Cosine, Walsh, Haar, Kekre and Hartley Transforms for Iris Recognition using Fractional Energies of


