

Combining the Goodness of Euler Number and Cumulative Sum to Achieve Higher Accuracy for Iris Recognition Systems

N.F. Shaikh,

Department of Computer Engineering
Modern Education Society's College of Engineering
Pune, India

Dr. D. D. Doye,

Department of E&TC
SGGS IET, Nanded, India

Abstract—Biometrics has dominated the areas of security for its ability to provide uniqueness, higher accuracy and minimum invasion instances. Using iris and its texture as a means of verification and validation evolved three decades ago and since then it has been one of the most reliable security methods with work being done to increase efficiency along with minimizing cost. The method proposed and implemented considers the two above stated requirements as its essence. Two algorithms have been proposed i.e. Euler number and Cumulative Sum for feature extraction. Both have simple mathematical computations which require less processor time thus reducing cost. Fusion of the two algorithms gives higher accuracy since cases of contradicting results can be cross verified with the individual algorithm score. Euler Number works on topographical features and gives scope for rescaling and resizing. Eight bit planes are obtained of which the four least significant bits are discarded since they give brightness and are random. Using the four most significant bits templates are formed. Cumulative Sum on the other hand explores the uniqueness of every iris template, calculating the cumulative sum where deviation from the mean is calculated and added to the previous value in the template. Each algorithm individually computes its own score which is then fused to obtain a final result. The fusion is carried out after template matching and normalization of the scores, ensuring a more accurate result. Different algorithms for template matching i.e. Vector Difference matching and modified version of Hamming Distance have been implemented. The focus therefore lies in the fusion model which has the underlying assumption that verifying an iris image with not just 1 but multiple algorithms would enhance the system, yielding more accurate results.

Keywords—Iris Recognition, Segmentation, Feature Extraction, Fusion, Score, Template Matching.

I. INTRODUCTION

A. HUMAN IRIS

The iris of the human eye which is a thin circular diaphragm lies between the cornea and the lens. Figure 1 shows the structure of the human eye. The eye has a perforation at the center made by the pupil. The iris controls the amount of light entering through the pupil by adjusting the sphincter and the dilator muscles. Studies show that the average radius of the human iris is 12mm. The iris is layered with the epithelial tissues at the bottom which have dense pigmentation cells. The next layer above it is the stromal layer which determines the color of the iris. They have the blood vessels and pigmentation cells. The outermost layer which is visible has two zones. An outer ciliary zone and an inner papillary zone divided by the collarette—a zigzag pattern.

Iris Formation begins in the third month of embryonic life. The unique patterns are formed in a random manner and not related to any genetic factor. Also due to the epigenetic nature of the iris pattern the two eyes of the same individual contain completely different and independent iris pattern. Same is the case of identical twins which possess uncorrelated iris patterns.

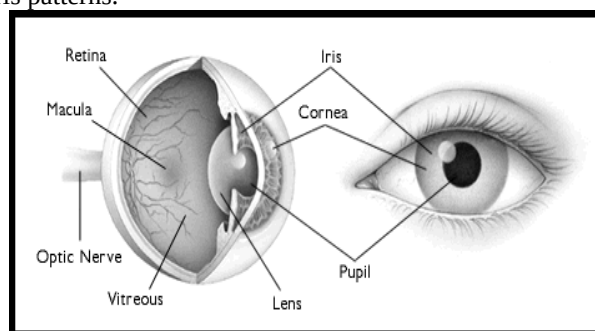


Fig.1. Structure of the human iris

B. IRIS RECOGNITION

Iris Recognition systems have been studied and proposed earlier but it was not until the beginning of the 20th century that the Cambridge researcher, John Daugman, implemented a working model of the iris recognition system. Pioneering and extensive work has been done on iris recognition by Daugman using Gabor wavelet. Though his system has since been widely implemented and tested, there remains scope for improvement. Recently, other researchers including Wildes, Boles and Boashash [1], [2], Ma *et al.* [3], [4], have contributed new methods. Research has been done removing occlusions as well [5]. However, there still persists some critical problems and significant work needs to be done before mass-scale deployment on national and international levels is thought for. This paper contributes a realizable solution to some of the problems since here we use a novel method of algorithm score fusion which would give a mean and more appropriate value.

Our proposed approach targets the three main stages in iris recognition system

1. Image pre processing
2. Feature Extraction
3. Template Matching

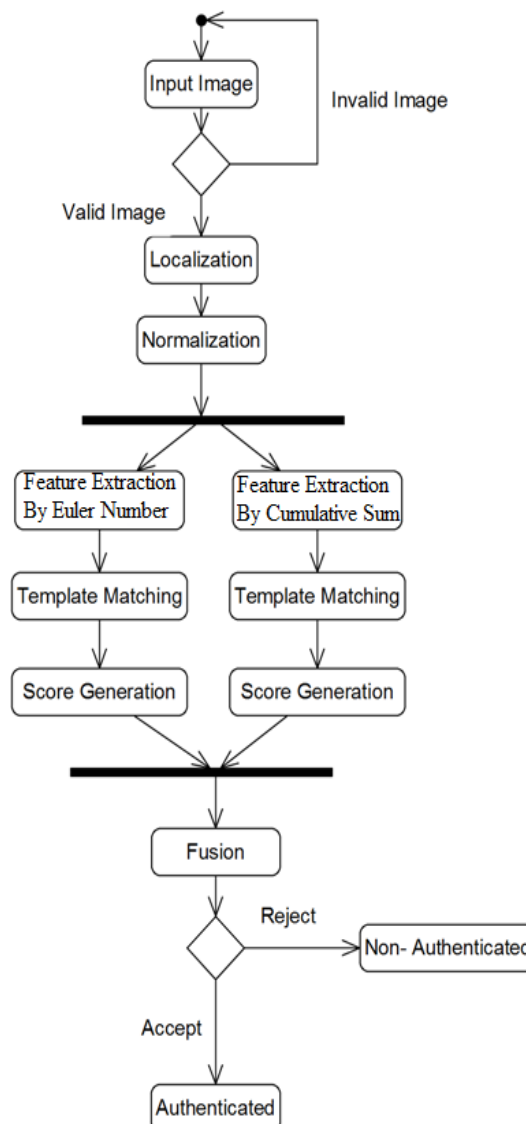


Fig.2. Flowchart of the process

II. IMAGE PREPROCESSING

A. LOCALIZATION:

To detect the inner and outer boundary of the iris, localization is carried out, with the estimate that the shape of the iris is circle. To generate templates for accurate matching, iris localization is imminent. To remove eyelid eyelashes occlusions and specular reflections which corrupt the iris pattern, and locate the circular iris recognition, a technique is required.

Read the image from database the image could be indexed or otherwise. The first step of localization of the eye is detection that approximates the edges and centre of the pupil. The algorithm for localization proceeds in the following manner:

All pixel brightness value is summed which is then divided by the total number of pixels to obtain average brightness value of pixels. Average brightness value is multiplied by a factor 0.46 (obtained by trial and error method). The matrix so obtained is converted into a binary image. The sum of the values in the binary matrix across the rows and columns is obtained in different vectors. The difference of each value with adjacent value is stored in another two vectors. The highest and lowest value so obtained denotes the maximum change in intensity. The maximum and minimum value across the vertical projection of pupil is subtracted to give diameter. Carry out similar operation for vertical projections. Highest value out of the two is chosen as a radius and the centres are obtained by adding the radius to the columns where minimum and maximum values are obtained. Centre of pupil is derived from the radius and the circular outer pupil boundary (inner iris boundary) is marked using centre and radius values. Edge of image obtained using canny edge detection. Iris boundary on left and right is obtained assuming the iris radius to be 1.5 times the pupil radius. Change in intensity is observed in a binary matrix around the assumed region and iris boundary is detected on the right and left border. Radius and centre of iris is obtained from iris edges. Mark the centre and radius of the iris circle. The iris region is thus localized.

B. UNWRAPPING IRIS: SEGMENTATION AND NORMALIZATION

The detected iris image is ring shaped but is not always of the same size or width. However, for further processing we need all the templates to be of same size. Hence, we unwrap iris with segmentation and normalization. Unwrapping the iris involves turning the iris ring into a strip of standard dimension, which is later used for feature extraction. The procedure begins with determining the number of points. That will be used to display the iris, how many parts will divide the angle and radius. The angle is increased by factor $d_i = 2/\pi n$, where 'n' is the number of division to obtain every new division. We decide on further having 64 radial segments. Every part of the iris is bordered by 4 points: considered pa, pb, pc and pd and the mean of their values gives the pixel value in the image segment. The result of this procedure for all shapes and sizes of the iris ring is a tape of the same size. Further increase the contrast of the tape before proceeding with extracting features.

III. FEATURE EXTRACTION

To ensure accurate recognition of individuals, the most discriminating information present in an iris pattern must be extracted. To make comparisons between templates, only significant features of the iris must be encoded.

Feature extraction can be carried out using the following algorithms:

1. Cumulative Sum
2. Euler Number

A. Cumulative Sum

1. Divide the iris unwrapped tape i.e. normalized image (36 x 360) into basic cell regions. Each cell has 3 rows and 10 columns (3 x 10)
2. Calculate the average value of each cell which represents the average gray value. Thus, we get 432 average gray values.
3. Calculate Cumulative Sum over each group i.e. dividing the average value matrix, column wise and row wise i.e horizontally and vertically with 6 continues values in each group.
4. Generate iris feature codes.

The above steps are explained in following example.

Consider a sample matrix of dimensions 36 x 360. Form smaller matrices or cell of dimensions 3 x 10. Therefore we get 432 smaller cells.

Compute average values of each cell.

	1	2	3	4	5	6	7	8	9	10	
1	1	2	4	1	5	6	7	8	9	10	
2	2	3	5	3	6	7	8	9	10	1	
3	3	4	6	4	7	8	9	10	11	12	
4	4	5	7	8	8	9	10	12	3	4	
5	5	6	8	9	9	10	11	1	14	4	
6	6	7	9	10	10	11	1	5	6	4	
.											
.											
.											
.											
36											

⇒ First Cell

⇒ Second Cell

For e.g. the first cell gives an average of 5.7

And the second cell gives an average of 5.766

Thus we get 432 such average values.

Calculate the cumulative sum in following way :

- Calculate the average where X_i are continuous 6 values both column wise and row wise.
- Calculate the cumulative sums by adding the difference between the current value and the average to the previous sum.

Suppose that $X_1, X_2, \dots$, and X_5 are five representative values of each cell region.

1. Calculate the average $X = (X_1 + X_2 + \dots + X_5) / 5$.

2. Calculate cumulative sum from 0 i.e. $S_0 = 0$.

$$S_i = S_{i-1} + (X_i - X) \text{ for } i = 1, 2, \dots, 5$$

Cumulative sums are calculated by addition and subtraction, so the cumulative-sums-based feature extraction method creates a lower processing burden than other methods. After calculation, iris codes are generated for each cell using the following algorithm.

3. Iris_code_generation

```
{ for (2 times loop)
  { // for horizontal and vertical directions}
    MAX = max(S1,S2,...,S5); MIN = min(S1,S2,...,S5);
    if Si located between MAX and MIN index
      { if (Si on upward slope) set cell's iris_code to 1
        if (Si on downward slope) set cell's iris_code to 2
        } else set cell's iris_code to 0
      }
  }
```

Thus algorithm generates template by analyzing cumulative sums which describe the variations in the grey values of iris patterns.

Upward slope of cumulative sum means that iris pattern change from darkness to brightness. Downward slope means the opposite.

B. Euler Number

Euler number uses bit plane coding method and is used to extract topological features. A digital image can be represented by one or more topological properties which typically represent the geometric shape of an image.

Euler number is defined as the difference between number of connected components and number of holes. Connected components are objects whose pixels are adjacent and connected and there exists a path which comprises all the pixels of that object. Holes are the regions within the connected components. The number of holes and number of objects is not going to change even after scaling operation. If an image has C connected components and H number of holes. The Euler number E of the image can be defined as $E = C - H$

Steps for Algorithm:

Now consider pixel $h(1, 1)$ i.e. first pixel of matrix.

- Apply Median filter on image of size $[3, 3]$, Followed by same size of mean filter.
- Remember the order of filtering is also useful if you will apply mean filter before median filter then salt pepper noise will get add in the image. We can use other sophisticated filters also.
- Convert this intensity value of pixel in binary number of 8bits. Representation of 139 into binary is 10001011.similarly convert other intensity values into binary format. Now we have binary value for each pixel in 8 bits. We can represent each value in $b_7b_6b_5b_4b_3b_2b_1b_0$.
- Next step is formation of 8 bit planes. In this we are separating all b_7 bits of all pixels in 8^{th} plane. b_6 bits of all pixels in 7^{th} plane. And so on. At the end of this step we will have 8 matrices. i.e. 8 planes. Follow the same procedure for remaining bits
- Now we have 8^{th} planes (or 8 matrices). But will discard 4 LSB's as those bits have random value which is also known as brightness information. Four MSB bits contain structural information which is useful for us.
- Here comes the last step of our algorithm Each of these 4binary planes (vectors) is converted to corresponding reflected gray code (g_7, g_6, g_5, g_4).

$$\begin{aligned} g_7 &= b_7 \\ g_6 &= b_7 \text{ XOR } b_6 \\ g_5 &= b_6 \text{ XOR } b_5 \\ g_4 &= b_5 \text{ XOR } b_4 \end{aligned}$$

- Compute the Euler Number for each plane i.e. $\{g_7, g_6, g_5, g_4\}$. We get an Euler Vector consisting of four values. We will use this Euler Vector as a template for feature extraction.

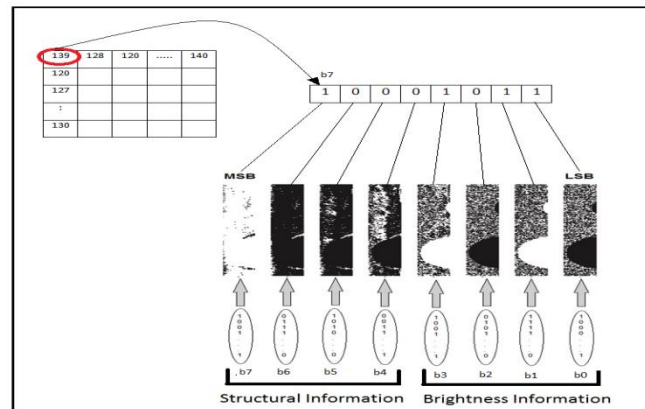


Fig .3. Euler number partial output

IV. TEMPLATE MATCHING

Template Matching is a method where the features extracted from an image called user template are compared with the templates of the images stored in database. It helps us to verify the authenticity of the person. A matching metric is used to compare similarity between two iris images.

A. TEMPLATE MATCHING FOR CUMULATIVE SUM ALGORITHM

To calculate similarity of 2 iris codes- a modified version of hamming distance is used. Lower Hamming distance indicates higher similarity.

$$HD = \frac{1}{2N} \left[\left(\sum_{i=1}^N A_h(i) \oplus B_h(i) \right) + \left(\sum_{i=1}^N A_v(i) \oplus B_v(i) \right) \right]$$

Only when $A_h(i) \neq 0$ and $B_h(i) \neq 0$;

$A_v(i) \neq 0$ and $B_v(i) \neq 0$;

Where $A_h(i)$ and $A_v(i)$ denote the enrolled iris code over horizontal and vertical direction respectively.

$B_h(i)$ and $B_v(i)$ denotes the new user input iris code over horizontal and vertical direction respectively.

N is the total number of cells.

$\oplus$ is an XOR operator used.

As we discard cells containing zero as value. We will have just 1 and 2 values. So the $\oplus$ XOR operator cannot be used as it is just designed for inputs zeros and ones. Hence, we need to define operator based on the same basic logic of $\oplus$ XOR gate.

B. ALGORITHM FOR TEMPLATE MATCHING FOR EULER NUMBER.(VECTOR DIFFERENCE MATCHING)

The Euler template consists of 4 values. These values are then compared with all the template values stored in database and the difference(absolute) between these values is obtained. By setting a threshold value we convert the values in terms of 0's and 1's i.e.

if difference > threshold then set 1

else 0

The 4 bit binary value obtained is converted into its corresponding decimal value. Priorities or match decreases with decrease in value.

Hence we can say that if the number is 15 in decimal then it has a higher priority, whereas if it is 0 then it is least priority. In case of conflicts, score is computed by the addition of the differences originally acquired. Lower the score, higher the match.

V. FUSION

Algorithm for fusion is as follows:

1. If the output best match image from Euler Number and Cumulative sum is same, then that is the final output for the input image.
2. One algorithm is given preference over the other depending on the efficiency of each algorithm.
3. If the first image returned by both the feature extraction algorithm are not the same then the first best match of first preferred algorithm is matched with a predefined number of images returned by the second algorithm .If a match is found then it is displayed as the final output.
4. If not matched then the next best matched image of first algorithm is considered and the above step is repeated.
5. This continues to a defined value for the first algorithm until a match is found. If not found then the output is displayed as no match.

VI. RESULTS

Algorithm	Results
Euler Number	95%
Cumulative Sum	97%
Fusion	98%

VII. CONCLUSION

The implemented paper aims at improving iris recognition using fusion model expected to have higher accuracy and better precision. The system developed uses the combination of algorithm to meet its requirements. The fusion model follows similar approach for image preprocessing and normalization and then proceeds to follow different algorithm for feature extraction, template matching and score fusion.

Our main job is

1. To provide security.
2. To obtain better accuracy and results.
3. To obtain minimum false accept and reject rate.
4. To compare the implementation of individual algorithm with the system as whole.

REFERENCES

- [1] W.W. Boles and B. Boashash, "A Human Identification Technique. Using Images of the Iris and Wavelet Transform," IEEE Trans. Signal Processing, vol. 46, pp. 1185-1188, 1998.
- [2] W.W. Boles, "A Security System Based on Human Iris Identification Using Wavelet Transform," Proc. First Int'l Conf. Knowledge-Based Intelligent Electronic Systems, vol. 2, pp. 533-541, 1997.
- [3] L. Ma, T. Tan, Y. Wang, and D. Zhang, "Personal Identification Based on Iris Texture Analysis," IEEE Trans. Pattern Analysis and Machine Intelligence, vol. 25, pp. 1519-1533, 2003.
- [4] L. Ma, T. Tan, Y. Wang, and D. Zhang, "Efficient Iris Recognition by Characterizing Key Local Variations," IEEE Trans. Image Processing, vol. 13, pp. 739-750, 2004.
- [5] N. F. Shaikh, D.D. Doye, "An Efficient Method for Iris Segmentation to remove Noise and Eyelash Occlusion", International journal of Advances in Management, technology and Engineering Sciences, pp 171-176, Vol 1 Issue 9, June 2012.
- [6] M. Vatsa, R. Singh, A. Noore, "Improving Iris recognition performance using segmentation, quality enhancement, match score fusion, and Indexing", IEEE Transaction on systems, man, and cybernetics-part B: Cybernetics, Vol. 38, No.4, pp. 1048-1056, 2008.
- [7] Mr. P.P.Chitte, Prof. J.G.Rana, Prof. R.R.Bhambare, Prof. V.A.More, Mr. R.A.Kadu, M.R.Bendre, "IRIS Recognition System Using ICA, PCA, Daugman's Rubber Sheet Model Together", International Journal of Computer Technology and Electronics Engineering (IJCTEE) Volume 2, Issue 1
JIN-XIN SHI, XIAO-FENG GU, "The Comparison of Iris Recognition Using Principal Component Analysis, Independent Component Analysis and Gabor Wavelets", Vol: 1 pp: 61 – 64 July 2010. 978-1-4244-5540-9/10/\$26.00 ©2010 IEEE
- [8] Makram Nabti, Ahmed Bouridane, "AN EFFECTIVE IRIS RECOGNITION SYSTEM BASED ON WAVELET MAXIMA AND GABOR FILTER BANK", 1-4244-0779-6/07/\$20.00 ©2007 IEEE
- [9] Richard Yew Fatt Ng, Yong Haur Tay and Kai Ming Mok, "An Effective Segmentation Method for Iris Recognition System", 2008 The Institution of Engineering and Technology