IRIS Texture Analysis and Feature Extraction for Biometric Pattern Recognition

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Abstract. In this paper we propose a new biometric-based Iris feature extraction system. The system automatically acquires the biometric data in numerical format (Iris Images) by using a set of properly located sensors. We are considering camera as a high quality sensor. Iris Images are typically color images that are processed to gray scale images. Then the Feature extraction algorithm is used to detect "IRIS Effective Region (IER)" and then extract features from "IRIS Effective Region (IER)" that are numerical characterization of the underlying biometrics. Later on this work will be helping to identify an individual by comparing the feature obtained from the feature extraction algorithm with the previously stored feature by producing a similarity score. This score will be indicating the degree of similarity between a pair of biometrics data under consideration. Depending on degree of similarity, individual can be identified.

Keywords: Biometric, eyeprint, IRIS, IER, Pattern Recognition and Degree of Freedom.

1 Introduction

The human iris recently has attracted the attention of biometrics-based identification and verification research and development community. The iris is so unique that no two irises are alike, even among identical twins, in the entire human population.

Automated biometrics-based personal identification systems can be classified into two main categories: identification and verification. In a process of verification (1-to-1 comparison), the biometrics information of an individual, who claims certain identity, is compared with the biometrics on the record that represent the identity that this individual claims. The comparison result determines whether the identity claims shall be accepted or rejected. On the other hand, it is often desirable to be able to discover the origin of certain biometrics information to prove or disprove the association of that information with a certain individual. This process is commonly known as identification (1-to-many comparison).

Actual iris identification can be broken down into four fundamental steps. First, a person stands in front of the iris identification system, generally between one and three feet away, while a wide angle camera calculates the position of their eye. A second camera zooms in on the eye and takes a black and white image. After the iris system has one's iris in focus, it overlays a circular grid (zone's of analysis) on the image of the iris and identifies where areas of light and dark fall. The purpose of overlaying the grid is so that the iris system can recognize a pattern within the iris and to generate 'points' within the pattern into an 'eyeprint'. Finally, the captured image or 'eyeprint' is checked against a previously stored 'reference template' in the database. The time it takes for a iris system to identify your iris is approximately two seconds.

In the iris alone, there are over 400 distinguishing characteristics, or Degrees of Freedom (DOF), that can be quantified and used to identify an individual (Daugman, J. & Williams, G. O. 1992). Although, approximately 260 of those are possible to captured for identification. These identifiable characteristics include: contraction furrows, striations, pits, collagenous fibers, filaments, crypts (darkened areas on the iris), serpentine vasculature, rings, and freckles. Due to these unique characteristics, the iris has six times more distinct identifiable features than a fingerprint.

2 Previous Works

Plenty of works are done on Iris Recognition System, since last 3-4 years. Most of the cases, authors claimed the better performance of speed in capturing images and recognition over the existing systems available at that time. To gather the knowledge, we have considered the following selective works.

Lye Wi Liam, Ali Chekima, Liau Chung Fan and Jamal Ahmad Dargham, in 2002, proposed [1] a system consisting of two parts: Localizing Iris and Iris Pattern Recognition. They used digital camera for capturing image; from the captured images Iris is extracted. Only the portion of selected Iris then reconstructed into rectangle format, from which Iris pattern is recognized.

Eric Sung, Xilin Chen, Jie Zhu and Jie Yang, December 2002, proposed a modified Kolmogora, complexity measure based on maximum Shannon entropy of wavelet packet reconstruction to quantify the iris information [2]. Real-time eye-comer tracking, iris segmentation and feature extraction algorithms are implemented. An ordinary camera with a zoom lens captures video images of the iris. Experiments are performed and the performances and analysis of iris code method and correlation method are described. Several useful findings were reached albeit from a small database. The iris codes are found to contain almost all the discriminating information. Correlation approach coupled with nearest neighbors classification outperforms the conventional thresholding method for iris recognition with degraded images.

Jiali Cui, Yunhong Wang, JunZhou Huang, Tieniu Tan and Zhenan Sun have proposed [3] the iris recognition algorithm based on PCA (Principal Component Analysis) is first introduced and then, iris image synthesis method is presented. The synthesis method first constructs coarse iris images with the given coefficients. Then, synthesized iris images are enhanced using super resolution. Through controlling the coefficients, they create many iris images with specified classes. Extensive experiments show that the synthesized iris images have satisfactory cluster and the synthesized iris databases can be very large.

Hyung Gu Lee, Seungin Noh, Kwanghyuk Bae, Kang-Ryoung Park and Jaihie Kim have introduced [4] the invariant binary feature which is defined as iris key. Iris image variation is not important in their work. Iris key is generated by the reference pattern, which is designed as lattice structured image to represent a bit pattern of an individual. Reference pattern and Iris image are linked into filter. In the filter Iris texture is reflected according to the magnitude of iris power spectrum in frequency domain.

Zhenan Sun, Yunhong Wang, Tieniu Tan, and Jiali Cui, in 2005, proposed [5] to overcome the limitations of local feature based classifiers (LFC). In addition, in order to recognize various iris images efficiently a novel cascading scheme is proposed to combine the LFC and an iris blob matcher. When the LFC is uncertain of its decision, poor quality iris images are usually involved in intra-class comparison. Then the iris blob matcher is resorted to determine the input iris identity because it is capable of recognizing noisy images. Extensive experimental results demonstrate that the cascaded classifiers significantly improve the system's accuracy with negligible extra computational cost.

Kazuyuki Miyazawa, Koichi Ito, Takafumi Aoki, Koji Kobayashi, Hiroshi Nakajima developed [6] phase-based image matching algorithm. The use of phase components in 2D (two-dimensional) discrete Fourier transforms of iris images makes possible to achieve highly robust iris recognition in a unified fashion with a simple matching algorithm.

Pan Lili and Xie Mei, proposed [7] a new iris localization algorithm, in which they adopted edge points detecting and curve fitting. After this, they set an integral iris image quality evaluation system that is necessary in the automatic iris recognition system.

Iris image denoising algorithm is proposed by Wang Jian-ming and Ding Run-tao [8], in which phase preserving principle is held to avoid corruption of iris texture features. Importance of phase information for iris image is shown by an experiment and the method to implement phase preserving by complex Gabor wavelets is explained. To verify the algorithm, white noise is added to iris images and Hamming distances between the iris images are calculated before and after the denoising algorithm is applied.

Weiki Yuan, Zhonghua Lin and Lu Xu have analyzed eye images [9] that they have based on structure characteristics of eyes, they put forward a rapid iris location arithmetic. Firstly, they have got an approximative center by gray projection, have got two points that located at left and right boundary by threshold value respectively, and have got a point that located at the lower boundary by direction edge detection operators, then they ensured the boundary of pupil and probable center. Secondly, they have got exact pupil boundary and center by Hough transform that is processed at a small scope surrounding the probable center. Thirdly, they have searched two points that located at left and right boundaries between iris and sclera along horizontal direction by using the exact center and direction edge detection operators. Then they ensured the horizontal coordinate of the center of iris based on the above two point accurately. Finally, they have searched two points that located at upper and lower boundaries between iris and sclera beginning at the horizontal coordinate of the center of iris along the directions that making plus and minus thirty angles between horizontal direction respectively by using direction edge detection operators, so they ensured the coordinate of the center of iris and the boundary between iris and sclera. The experiments indicated that this method reached about zero point two second at speed and percentage of ninety nine point forty five at precision. This method is faster than existing methods at speed, they claimed.

3 Our Work

We have divided our work into three main phases related with three different algorithms, which are given and discussed hereunder:

2.1 24-bit bitmap Color Image to 8-bit Gray Scale Conversion

a) At first a picture of an individual's Eye with a Powerful Digital Camera, such that the picture must be a size of 100*100 in 24-Bit BMP format.
b) Take this 24-Bit BMP file as Input file and open the file in Binary Mode.
c) Copy the ImageInfo (First 54 byte) of the Header from Input 24-Bit Bmp file to a newly created BMP file and edit this Header by changing filesize, Bit Depth, Colors to confirm to 8-Bit BMP.
d) Copy the ColorTable from a sample gray scale Image to this newly created BMP at 54th Byte place on words.
e) Convert the RGB value to Gray Value using the following formula-
   blueValue = (0.299*redValue + 0.587*greenValue + 0.114*blueValue);
   greenValue = (0.299*redValue + 0.587*greenValue + 0.114*blueValue);
   redValue = (0.299*redValue + 0.587*greenValue + 0.114*blueValue);
   grayValue = blueValue = greenValue = redValue;
f) Write to new BMP file.

Take 24-bit BMP color image as input. Then convert it to 8-bit Gray Scale image by following this algorithm. This 8-bit Gray Scale image is the output of the algorithm. In this algorithm, first read the red, blue and green value of each pixel and then after formulation, three different values are converted into gray value.

2.2 IRIS Edge Detection

a) Load resultant 8-bit Grayscale Image from Algorithm1 into memory

b) Convert the Loaded Image into PlanarImage
c) Set the Horizontal and Vertical kernels (3 x 3; float type), respectively as follow:

$$\begin{bmatrix} 1.0 & 0.0 & -1.0 \\ 1.0 & 0.0 & -1.0 \\ 1.0 & 0.0 & -1.0 \end{bmatrix}_{3 \times 3} \qquad \begin{bmatrix} -1.0 & -1.0 & -1.0 \\ 0.0 & 0.0 & 0.0 \\ 1.0 & 1.0 & 1.0 \end{bmatrix}_{3 \times 3}$$

d) Generated PlanarImage in Step-b, is passed through kernels created in Step-c.
e) Modified fine-grained PlanarImage is stored into Image File.
f) Close all Image file(s).

Here we are considering 8-bit Image, two-pass masking is used, namely, Horizontal and Vertical kernels. The PlanarImage now passed through these masks or kernels. Resultant transformed Image generates the distinct marks for IRIS area; the process is edge detection [10].

2.3 IRIS Effective Region Extraction and Pattern Generation

(Extracting a 8*12 Iris Pattern from Edge Detected IRIS Image)

a) Take the 8-Bit BMP Image produced from previous Algorithm as Input and open this BMP file in binary Read Mode.
b) Read the raster Data and Store the raster Data into a Matrix of vectorsize. Where vectorSize = filesize - (54+(4*256)).
c) Then a 8*12 Iris Pattern is extracted from Edge Detected BMP using following logic-

```
for (x=0;x<=originalImage.rows-1;x++) {
  for (y=0;y<=originalImage.cols-1;y++) {
  if ( y<30 && x=((originalImage.rows/2)+4) && GrayValue == 255) {
       for (i=0;i<8;i++) {
       for (j=0;j<12;j++) {
         *(edgeImage.data + (i * edgeImage.cols) + j) = *(originalImage.data
         + (x * originalImage.cols) - (i * originalImage.cols) + (y + j));

         Write to new BMP Image file
         }
       }
  }
  }
}
```

Take 8-bit BMP image produced from previous step as an input. Then convert it to 12X8 8-bit BMP image by following this algorithm. This 12x8 8-bit BMP image is the output of the algorithm. In this algorithm, first go to the middle row and first column of the input image, then go to the 4 pixels upward and check the gray value of each pixel until gray value becomes 255 (white). After this start reading the pixels and store the corresponding gray value into a 8x12 matrix.

4 Result

Our testing results shown in Fig. 1 through Fig. 4. 24-bit Color eye picture is taken by using a powerful digital camera, located in a suitable position. Numerous pictures are taken and these are resized and converted to 8-bit Images, here, these are considered as Iris Samle-1 through Iris Sample-n, which are displayed in Fig. 2. For every sample Edge detection is done, here shown for Iris Sample-1 in Fig. 3.

Now using algorithm "IRIS Effective Region Extraction and Pattern Generation" Iris Effective Region is extracted, which is clearly shown in Fig. 4 surrounded by rectangle. From this rectangle the following 2D-Array is generated, shown in Table-1.

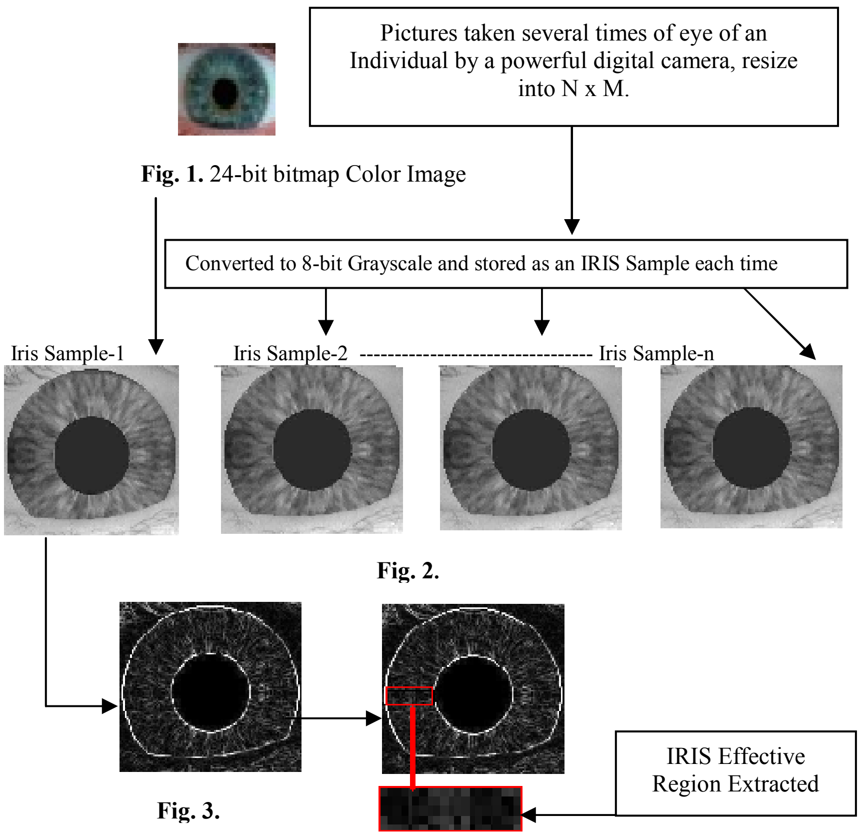

Fig. 1. 24-bit bitmap Color Image

Fig. 2.

Fig. 3.

Fig. 4. Highlighted [n x m] Red Rectangle from Fig. 3 Sample-1.

In this process n number of 2D-Arrays will be generated for n number of IRIS Images.

We are considering the Table-1 is the IRIS Pattern of Iris Sample-1, so, we will get n number of IRIS Patterns of an individual. From this n number of IRIS Patterns one single ‘IRIS Pattern’ of an individual can be generated by Statistical Analysis, which can be strongly used for Pattern Recognition or over all Human Recognition.

5 Conclusion

In this work a huge IRIS Database is used for testing. Only one such example is shown here. By considering Biological characteristics of IRIS we will further use Statistical Correlation Coefficient for this ‘IRIS Pattern’ recognition where Statistical Estimation Theory can play a big role.

Table 1. 8*12 Matrix IRIS Pattern.

61	56	66	67	67	82	57	72
61	56	66	67	67	82	57	72
56	50	56	63	63	84	79	90
63	57	54	67	67	73	93	104
63	57	49	67	67	73	93	104
48	65	56	61	61	76	91	94
48	65	56	61	61	76	91	94
39	61	69	68	68	73	77	80
39	61	69	68	68	73	77	80
36	40	50	43	43	56	67	80
36	40	50	43	43	56	67	80
42	49	53	56	56	67	67	65

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