Chapter 13

IRIS Effective Region Extraction and Pattern Generation for Biometric Identification
13.1 Introduction

In this chapter 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.

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.

13.2 Background

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 [136] 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 [137]. Real-time eye-corner tracking, iris segmentation and feature extraction algorithms are implemented. Video images of the iris are captured by an ordinary camera with a zoom lens. 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 [138] 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 [139] 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 [140] 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.


Pan Lili and Xie Mei, proposed [142] 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 [143], 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 are applied.

Weiki Yuan, Zhonghua Lin and Lu Xu have analyzed eye images [144] 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.

Christopher Boyce, Arun Ross, Matthew Monaco, Lawrence Hornak and Xin Li examined [145] the iris information represented in the visible and IR portion of the spectrum. It is hypothesized that, based on the color of the eye, different components of the iris are highlighted at multiple wavelengths. To this end, an acquisition procedure for obtaining co-registered multispectral iris images associated with the IR, Red, Green and Blue wavelengths of the electromagnetic spectrum, is first discussed. The components of the iris that are revealed in multiple spectral channels/wavelengths based on the color of the eye are studied. An adaptive
histogram equalization scheme is invoked to enhance the iris structure. The performance of iris recognition across multiple wavelengths is next evaluated. They claimed the potential of using multispectral information to enhance the performance of iris recognition systems.

Chengqiang Liu Mei Xie, proposed [135] Direct Linear Discriminant Analysis (DLDA) which combines with wavelet transform to extract iris feature. In their method, firstly, they apply wavelet decomposition to the normalized iris image whose size is 64×256 and just choose the coefficients of the approximation part of the second level wavelet decomposition to represent the iris image because this part contains main feature of the original iris image but the size of this part is only 16×64. And then make use of DLDA to extract the iris feature from this approximation part. During classification, the Euclidean distance is applied to measure the similarity degree of two iris classes.

Hugo Proenca and Luis A. Alexandre [146] analyzed the relationship between the size of the captured iris image and the overall recognition's accuracy. Further, they have identified the threshold for the sampling rate of the iris normalization process above that the error rates significantly increased.

An efficient technique on iris image acquisition, iris de-nosing, iris localization, and quality assessment have proposed by Kefeng Fan, Qingqi Pei, Wei MO, Xinhua Zhao, and Qifeng Sun [147]. An automatic focusing system based on a decision function is introduced into the iris acquisition device to achieve the feedback control, which can capture the high-resolution iris image with real-time. Iris localization differs from previous iris localization schemes in that it combines iris acquisition with edge detection technique. On the basis of coarse detection, the iris accurate detection is based on the combination of wavelet-based least square method, Laplacian of Gaussian function and an improved Hough Transform. They claimed that the technique has a
good performance, which not only capture high quality iris image, but also improve the speed and accuracy or iris localization.

13.3 Proposed work

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

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

1. 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.

2. Take this 24-Bit BMP file as Input file and open the file in Binary Mode.

3. 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.

4. Copy the ColorTable from a sample gray scale Image to this newly created BMP at 54th Byte place on words.

5. Convert the RGB value to Gray Value using the following formula:
   \[
   \text{blueValue} = (0.299*\text{redValue} + 0.587*\text{greenValue} + 0.114*\text{blueValue});
   \]
   \[
   \text{greenValue} = (0.299*\text{redValue} + 0.587*\text{greenValue} + 0.114*\text{blueValue});
   \]
   \[
   \text{redValue} = (0.299*\text{redValue} + 0.587*\text{greenValue} + 0.114*\text{blueValue});
   \]
   \[
   \text{grayValue} = \text{blueValue} = \text{greenValue} = \text{redValue};
   \]

6. 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.

**IRIS Edge Detection: Technique A**

1. Take 8-Bit gray Scale Image produced from previous Algorithm as input and open this BMP file in Binary Read mode.
2. Detect the PUPIL Boundary and set the boundary pixels to 255 (white) using following logic:

```java
for(x=0;x<=originalImage.rows-1;x++)
{
    for(y=0;y<=originalImage.cols-1;y++)
    {
        if (Grayvalue(x, y)==0)
        {
            if((GrayValue(x,y-l)!=0) && (GrayValue(x,y+l)!=0)))
            {
                Gray Value (x, y-1) = 255
            }
            else if((GrayValue(x,y-l)==0) && (GrayValue(x,y+l)!=0)))
            {
                Gray Value (x, y+1) = 255
            }
            else
            No change in the Gray Value.
```
3. Detect the IRIS Boundary and set the boundary pixels to 255 (white) using following logic:

```c
for(x=0; x<=originalImage.rows-1; x++)
{
    for(y=0; y<=originalImage.cols-1; y++)
    {
        if(x>12 && x<70 && y>12 && y<50)
        {
            if(Grayvalue(x,y)<100 &&
                Grayvalue(x,y)!=0)
            {
                if( ((Grayvalue(x,y-1))-
                    (GrayValue(x,y+l))>24 &&
                    (Grayvalue(x,y-l))>=100 &&
                    (Grayvalue(x,y-1))!=255 &&
                    (Grayvalue(x,y+l))<100 &&
                    (Grayvalue(x,y+l))!=0)
                {
                    GrayValue(x,y-l) = 255
                }
            }
        }
    }
}
```

3. Detect the IRIS Boundary and set the boundary pixels to 255 (white) using following logic:

```c
for(x=0; x<=originalImage.rows-1; x++)
{
    for(y=0; y<=originalImage.cols-1; y++)
    {
        if(x>12 && x<70 && y>12 && y<50)
        {
            if(Grayvalue(x,y)<100 &&
                Grayvalue(x,y)!=0)
            {
                if( ((Grayvalue(x,y-1))-
                    (GrayValue(x,y+1))>24 &&
                    (Grayvalue(x,y-1))>=100 &&
                    (Grayvalue(x,y-1))!=255 &&
                    (Grayvalue(x,y+1))<100 &&
                    (Grayvalue(x,y+1))!=0)
                {
                    GrayValue(x,y-1) = 255
                }
            }
        }
    }
}
```
else
No change in the GrayValue
}
else
No change in the GrayValue.
}
else
Write to new BMP file
}

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 [100].

**IRIS Edge Detection: Technique B**

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:

\[
\begin{bmatrix}
1.0 & 0.0 & -1.0 \\
1.0 & 0.0 & -1.0 \\
1.0 & 0.0 & -1.0
\end{bmatrix}
\begin{bmatrix}
1.0 & 0.0 & -1.0 \\
1.0 & 0.0 & 0.0 \\
1.0 & 1.0 & 1.0
\end{bmatrix}\text{ }3 \times 3
\]

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, output of the algorithm is shown in Figure 13.5.

**IRIS Effective Region Extraction and Pattern Generation**

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

1. Take the 8-Bit BMP Image produced from previous Algorithm as Input and open this BMP file in binary Read Mode.

2. Read the raster Data and Store the raster Data into a Matrix of vectorsize. Where

   \[
   \text{vectorsize} = \text{filesize} - (54+(4*256)).
   \]

3. 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) && Gray Value = 255) {
               for (i=0;i<8;i++) {
                   for (j=0;j<12;j++) {
                       *(edgelmage.data + (i * edgelmage.cols) + j) = *(originalImage.data + (x *
                       origina1mage.cols) - (i * originalImage.cols) + (y + j));
                   }
               }
               Write to new BMP Image file
           }
       }
   }
   ```

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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.

Generally, there are four major processes for a particular iris recognition system. They are image acquisition, iris preprocessing, feature extraction and matching.

In our work we have considered MMU1 iris database where a total number of 450 iris images which were taken using LG IrisAccess®2200. This camera is semi-automated and it operates at the range of 7-25 cm. On the other hand, MMU2 iris database consists of 995 iris images. The iris images are collected using Panasonic BM-ET100US Authenticam and its operating range is even farther with a distance of 47-53 cm away from the user. 100 volunteers with different age and nationality contribute these iris images. They come from Asia, Middle East, Africa and Europe. Each of them contributes 5 iris images for each eye [148].

13.4 Result

Our testing results shown in Figure 13.1 through Figure 13.4. 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 Sample-1 through Iris Sample-n, which are displayed in Figure 13.2. For every sample Edge detection is done, here shown for Iris Sample-1 in Figure 13.3. Now using algorithm “IRIS Effective Region
Extraction and Pattern Generation” Iris Effective Region is extracted, which is clearly shown in Figure 13.4 surrounded by rectangle. From this rectangle the 2D-Array is generated, shown in Table 13.1. In this process n number of 2D-Arrays will be generated for n number of IRIS Images.

We are considering the Table 13.1 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.
Figure 13.1. 24-bit bitmap Image

Converted to 8-bit Grayscale and stored as an IRIS Sample each

Iris Sample-1
Iris Sample-2
Iris Sample-n

Figure 13.2.

Figure 13.3.

Figure 13.4. Highlighted \([ n \times m ]\) Red Rectangle from Figure 13.3 Sample-1.

Table 13.1. 8*12 Matrix IRIS Pattern.

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Pictures taken several times of eye of an individual by a powerful digital camera, resized into N x M.

24-bit bitmap Color Image

Converted to 8-bit Grayscale and stored as an IRIS Sample each time

Iris Sample-1  Iris Sample-2  Iris Sample-n

IRIS Effective Region Extracted

Highlighted [n x m] Rad Rectangle from Sample-1.

Figure 13.5.