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A new Method for Iris Segmentation

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Abstract: Dividing iris borders in an image of a person's eyes is the first step to identify them from biometric iris. A variety of algorithms have been suggested for dividing of the internal border between "iris and pupil" and "the external border shared with sclera". Mistakes made in discovering and clarifying iris borders using such algorithms will meet different patterns of iris leading to mistakes in matching and recovering. In this paper, a new algorithm of iris segmentation is offered which is faster and more accurate comparing to those already known. This algorithm has been examined using 1000 of CASIA samples and results have been compared to use reference from which remarkable results have been met.

Key words: Biometric, Iris, Segmentation, Edge Segmentation, Contour.

INTRODUCTION

Today, biometric technologies are commonly used in order to identify and control access while comparing to cards and words, they are of more credit because they can not be stolen, lost or forgotten (John Daugman).

• Iris has been one of biometric specifications, known to have high certainly in the past years. Iris is the colored circle between pupil and sclera which contains elastic epithelium and grows until fetus turns 8 months (Fig. 1).

• Such muscles are of different shapes of circular, chiseled and some other figures, which will be physically constant during a person's life.

• These muscles are so exclusively different that research has shown them to be totally different not only between twins' eyes, but even between both of one person's eyes. In addition, biometric iris has a covering which is said to be safer and more secure comparing other biometric iris.

Fig. 1: Two samples of real irises and their location in eye (Daugman, 2004).

• A Special CCD camera is usually used in this biometric experiment from which high quality pictures have been taken and then used to apply algorithms to match and process images.

Identifying Based on Iris Segmentation:

• An identifying system based on iris segmentation is generally divided to four major parts (fig. 2) (" http://www.iris-recognition.org."):

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1.Iris segmentation in images
2.Image normalization
3.Encoding normalized images
4.Matching codes with each other

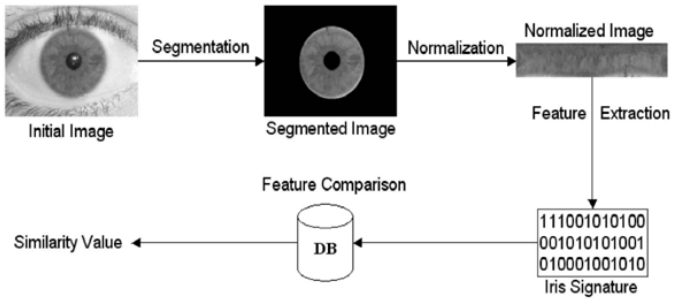

Fig. 2: steps of identification using biometric iris (“ http://www.iris-recognition.org.”).

• The first step of identification based on iris tissues is iris segmentation in images. Images are taken using digital cameras, and then pre-processing is done on them. Different algorithms are suggested for determining iris borders in images from which a movement of two concentrated circles on the surface of image could be mentioned. The inner circle represents the border between iris and pupil and the other one represents the outer iris border. (Fig. 1) shows a sample iris image and another sample with highlighted iris borders.

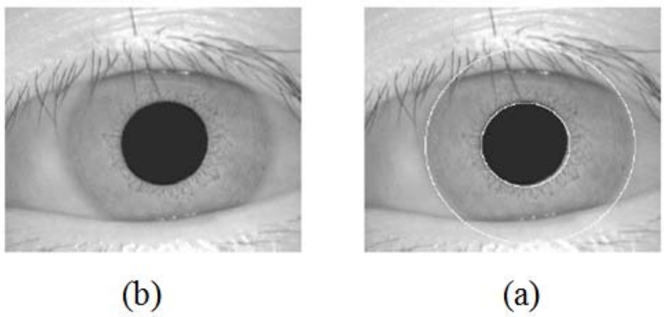

Fig. 3: Iris divisions, a: Image of an eye with highlighted iris borders. B: Image of an eye.

•An important step, on which the results of next steps are based, is to determine the inner and outer iris borders. A mistake at this step and misrepresentation of iris borders lead to wrong matching and recovering.

•In case iris is not a complete circle, iris and pupil are not concentrated, iris is covered with eyelashes from the top or bottom, segmentation is poor, or light is reflected, problems and difficulties are faced for which useful algorithms are needed.

• Once iris and its borders are segmented in the image, the second step is to resize the image to new and constant measures in order to make it possible to compare the patterns in the next steps. Image normalization makes the two iris images of the same person, which are taken in different conditions, have the same sizes. Iris and pupil are not always concentrated and that pupil could be moved toward one side of the iris is of crucial importance in iris segmentation.

• The other issue that could cause mistakes in identification is iris rotation around its center in different conditions. The third step in identification based on iris segmentation is o extract features from the normalized image. Applying filters on extracted features is a common method at this point. The aim is to extract features which make major differences between normalized images.

• The purpose in the final step is to find the proper value to compare extracted features with each other, using which similarity values could be derived.

• Different algorithms are suggested at this step, for instance: Xiaofu He in (Xiaofu He, 2007), Daugman in (John Daugman; Daugman, 2004), Wildes in (1997; 1994), Li Ma in (2004), Ritter in (1999), Li Yu in (2007) and Wang Anna in (2007). The used method in this article is similar to those of (John Daugman; Daugman, 2004; Xiaofu He, 2007) although we have included a new technique to find iris and pupil circles.

Suggested Method:

• Iris identification begins by finding iris in an image, determining inner and outer borders shared with pupil and sclera, clarifying the upper and lower eyelids when half closed, and finding and removing any other thing like eyelashes or light reflection from cornea or glasses. The process is called dividing which is the first step to identify an iris.

• Iris area could be estimated by the two circles, one for inner iris border and the other for outer iris border with sclera. Accuracy in clarifying iris inner and outer borders, whether they are hidden, is of great importance when finding iris in a dimension free system.

• Mistake in discovering iris borders could cause of one iris which ma lead to a mismatch. Normally upper and lower eyelids cover and hide the border between pupil and sclera which makes it difficult to divide the needed parts. Light reflection could sometimes cover iris as well.

Extracting Iris and Its Borders:

• The first step in extracting iris and its borders from the image is to make a binary system of the taken image.

• Considering that pupil is lighter than other parts in an eye, setting a limit, pupil is set apart from other parts in the image and the limit is then calculated by a histogram of the image to divide the pupil. To do so, a Canny operator is used to reach a binary
(fig. 4).

• Once the eye image is binary, since upper eyelashes are lighter than lower ones, some noise could be seen in the upper part of the binary image.

• To remove the noise, two morphological operations (dilation, erosion) are used. This way we can remove most of the noise made by eyelashes.

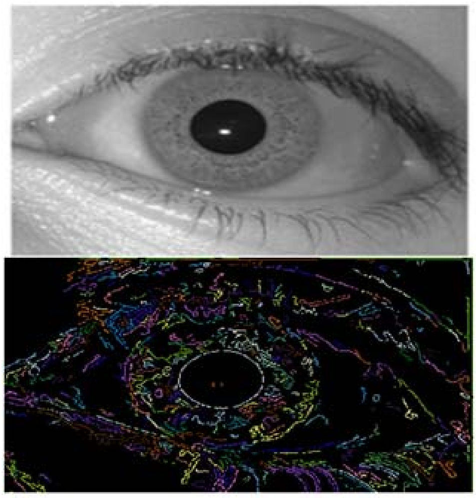

Fig. 4: A binary image from a sample database (CASIA) before morphological operation is done.

• Using the extract contour function, the contour of edges are achieved and then each is saved after applying equation1 to credit it in a one-dimensional shape.

$$\begin{cases} if \quad c_i \geq (image \rightarrow height / 50) \times 20 \, then \\ m_j = c_i \end{cases} \tag{1}$$

• In the next step from each shape 3 points are selected using equation2:

$$\begin{cases} a = Round(k/12) \\ b = Round(k/6) \\ c = Round(k/3) \end{cases} \tag{2}$$

• That in this equation K is length of the shape and round () is random choosing function in the needed range.

• To figure out whether these three points on the contour belong to pupil, we suppose that the three points are on a circle as in (Fig. 5).

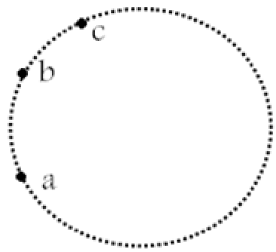

Fig. 5: Three points on an imaginary circle.

Mathematical Proof of the Suggested Method:

• Here we must prove that the three points are located on the circle. A geometric method is used to prove it right.

• Lines between the points which are chords of the imaginary circle are considered and as a theorem we know that lines that cut the chords to half at 90° will meet at the center of the circle (Fig. 6).

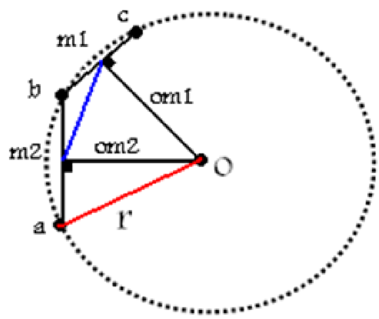

Fig. 6: Imaginary lines between the selected points

• We find the length of $\overline{ab}$ and $\overline{bc}$ using equations 3 and 4:

$$\overline{ab} = \sqrt{(a.x - b.x)^2 + (a.y - b.y)^2} \tag{3}$$

$$\overline{bc} = \sqrt{(b.x - c.x)^2 + (b.y - c.y)^2} \tag{4}$$

• We make the om1, m2 triangle considering the points to be in the middle of $\overline{bc}$ and $\overline{ab}$ (Fig. 7).

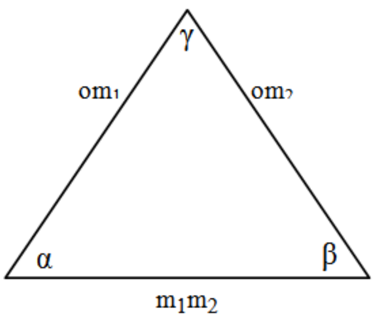

Fig. 7: Triangle om1,m2

• To find m1 and m2 we use equation

$$\begin{cases} m_2.x = a.x + \dfrac{(\frac{1}{2}\overline{ab} \times \dfrac{(b.x - a.x)}{\frac{1}{2}\overline{ab}})}{2} \\ m_2.y = a.y + \dfrac{(\frac{1}{2}\overline{ab} \times \dfrac{(b.y - a.y)}{\frac{1}{2}\overline{ab}})}{2} \\ m_1.x = b.x + (\frac{1}{2}\overline{bc} \times \dfrac{(b.x - c.x)}{\frac{1}{2}\overline{bc}}) \\ m_1.y = b.y + (\frac{1}{2}\overline{bc} \times \dfrac{(b.y - c.y)}{\frac{1}{2}\overline{bc}}) \end{cases} \quad (5)$$

• According to (Fig. 6) we use these two points to make om1, om2 and m1,m2 that make the two triangles om1,m2 and bm1,m2 and the angles α with ά and β with β' because of the 90° angle, they will supplement each other, therefore, angles y and y' will complement each other as well:

$$\overline{m_1m_2} = \sqrt{(m_1.x - m_2.x)^2 + (m_1.y - m_2.y)^2}$$

Theorem 1: if α + α = 90° so sin (α) = cos (α)
Theorem 2: if α + α =180° so sin (α) = sin (α)

$$\sin\alpha = \frac{((\frac{1}{2}\overline{bc})^2 + (\overline{m_1m_2})^2) - (\frac{1}{2}\overline{ab})^2}{2 \times (\frac{1}{2}\overline{bc} \times \overline{m_1m_2})}$$

$$\sin\beta = \frac{((\frac{1}{2}\overline{ab})^2 + (\overline{m_1m_2})^2) - (\frac{1}{2}\overline{bc})^2}{2 \times (\frac{1}{2}\overline{ab} \times \overline{m_1m_2})}$$

$$\sin\gamma = \frac{((\frac{1}{2}ab)^2 + (\frac{1}{2}bc)^2) - (m_1m_2)^2}{2 \times (\frac{1}{2}ab \times \frac{1}{2}bc)}$$

• Now here if we can find the length of either om1 or om2 of the triangle in (Fig. 7), we can get to the radius of the circle using Pythagoras theorem.

$$\overline{om_1} = \sqrt{\frac{\overline{m_1m_2}^2}{\frac{\sin(\beta)}{\sin(\alpha)} \times (\frac{\sin(\beta)}{\sin(\alpha)} - 2 \times \cos(\gamma)) + 1}}$$

• Therefore we will have the radius length of:

$$r = \sqrt{(\overline{om_1})^2 + (\frac{1}{2}\overline{ab})^2}$$

• To find out the center of the circle:

$$o.x = m_1.x + (\overline{om_1} \times \frac{(b.x - a.x)}{\frac{1}{2}\overline{ab}})$$

$$o.y = m_1.y + (\overline{om_1} \times \frac{(b.y - a.y)}{\frac{1}{2}\overline{ab}})$$

• To see how correct the results are, control parameters are used indeed. If calculations are right, the rest of the points in the following equation and with±2 tolerance will be checked. (Samples are random and selected

in the range of $\frac{1}{4}n$).

$$r^2 = (x - x_0)^2 + (y - y_0)^2$$

• The selected tolerance is coefficient of the circle, and if increased, the amount of reception coefficient of the circle will increase. In addition the condition of accepting the contour as a circle, is that, the correctness of the above equation is more than $\frac{3}{4}n$ (Fig. 8) is the result of applying this algorithm on (fig. 4).

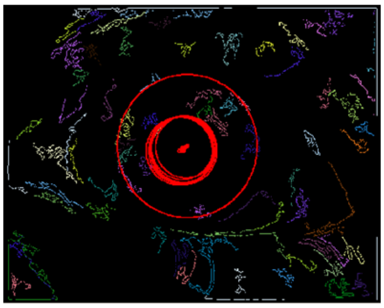

Fig. 8: The result of applying given algorithm on (fig. 4)

Evaluation of the suggested method:

• To evaluate the accuracy of the suggested method in discovering iris inner or outer borders, Xiaofu used a semi-automatic method to extract features of Ground Truth of his database. Normally to extract features of data, needed information from data is normally manually extracted.

• For instance, to determine inner radius of iris, instead of making an algorithm to calculate such quantity, only counting iris pixels of iris radius will suffice. It is presumed that results of such method are closely actual size. But because working on each of them is time consuming, it is most likely to make mistakes in such methods, also, since the results depend on person's taste, they could differ one from another.

• Evaluation standards of algorithm in the suggested method:

1. Extracting pupil
2. Extracting pupil edges and noise removal
3. Calculating center and radius of pupil
4. Discovering outer border of iris
5. Removing pupil and noise in the image
6. calculating center and radius of iris

• This algorithm was experimented on 1000 samples of CASIA database on a computer with a P4 2.4 GHz CPU + 512 Mb RAM. Average rate of discovering iris borders in this experiment is given in (table 1) with offered method in (Xiaofu He, 2007) which, according t survey, is a better method comparing with those offered in other references.

Table1: Average rate comparison for suggested method and Ref (Xiaofu He, 2007) method in iris segmentation

Outer iris border discovery time (seconds)	Inner iris border discovery time (seconds)	Method
0.56	0.18	Ref. 4
0.15	0.15	Suggested method

Table2: Comparison between iris center and iris radius for suggested method and Ref [4] method.

Accuracy		Difference between calculated radius & its actual amount (pixel)		Difference between calculated center & its actual amount (pixel)		Method
Radius	Center	Standard deviation	Average	Standard deviation	Average	
99.42	98.0	2.9076	1.3858	3.7525	4.2009	Ref. 4
99.87	99.80	2.2281	1.1736	2.4301	2.8012	Suggested method

• As seen, discovery rate results using suggested method is far better than those using other methods in the references.

• Consider that this algorithm is reached using Intel Open CV Image Processing Library plus C++ Compiler on a Microsoft Visual Studio 6 Platform.

Conclusion:

Iris Identification is a great method since iris is left unchanged during a person's life and the possibility of being damaged is low. Other specifications of this exclusive technique are: stability, accuracy, quickness, scalability and certainty.

Identification using biometric iris segmentation has been of great attention in the past few years and for which different methods and algorithms have been offered.

The offered method for iris determination, is of great accuracy and speed in iris segmentation. A geometrical method has also been used to determine inner iris border that has acceptable accuracy with reduction of calculations, which is one the important steps in the process of identification.

The results of applying such method on 1000 samples of CASIA database represent a remarkable improvement comparing results of other methods in references.

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