IRIS DATA PARAMETRIZATION BY HERMITE PROJECTION METHOD

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Abstract

Hermite projection method is used for human iris identification. Expansion of iris intensity information into a series of eigenfunctions of Fourier transform enables us to perform information analysis of the signal and its Fourier transform at the same time. Effectiveness of the method with test iris database images is shown.
Keywords: iris recognition, Hermite projection method.

1. Introduction

Iris recognition is a very reliable method for person identification. The iris image is unique for each person. The probability that two different persons have the same iris image is about 10^{-78}, whereas the world population is about 10^{10}. An iris image could change during the life only as a result of eye-illness like cataract, but often the image keeps the same as before or changes a little even after an eye-operation.

Human identification by iris recognition is more defensible than by finger-print and by face detection, because iris image is fortuitous to a greater extent (and the more fortuity the more probability that the image will be unique). Mathematically the fortuity is described by degrees of freedom. Some researches estimate iris texture degree of freedom as 250, more than degree of freedom of finger-print (35) and face-images (20) [1-3]. It means that using iris recognition methods is defensible and is going to have great potential.

2 Iris Normalization

Besides iris, the human eye has such components like pupil, sclera, eyelashes and eyelids. This eye information is not of interest in iris recognition. To extract the iris image from the eye we must locate the inner and outer boundaries of the iris. These boundaries are supposed to be close to circle.

First we find the approximate centre of the pupil [2], using rough criterion

$$X_{cent} = \arg \min_x \sum_y I(x, y)$$

$$Y_{cent} = \arg \min_y \sum_x I(x, y)$$

Then we specify the centre of the pupil and find an inner and outer boundaries of the iris using a modification of criteria from [1]:

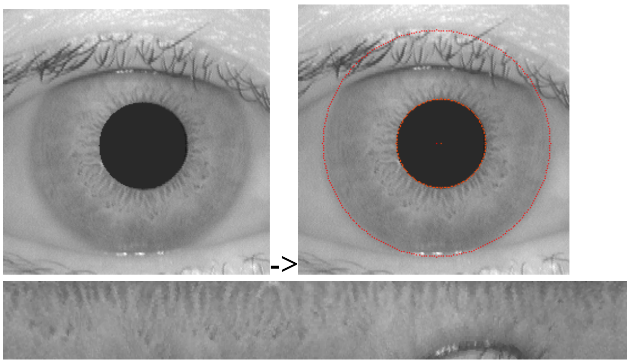
$$\max_{r, x_o, y_o} \left| \frac{\partial}{\partial r} G_\sigma(r) * \oint_{r, x_o, y_o} \frac{I(x, y)}{2\pi r} ds \right|$$

where $*$ denotes convolution; $G_\sigma(r)$ is a Gaussian of scale σ; (x_o, y_o) – are possible coordinates of the centre of the pupil; $r \in [r_{\min}, r_{\max}]$ is the radius of iris boundary; The integration is realized along the circle contour.

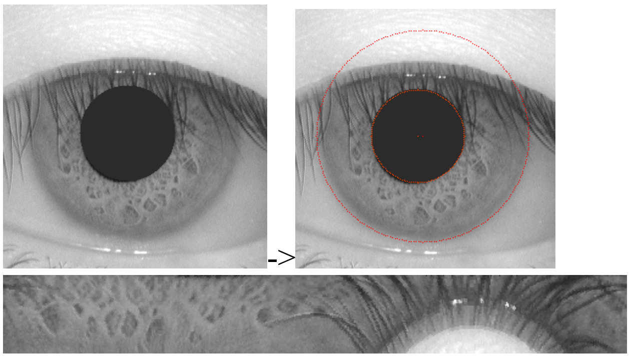
The pupil isn't located in the centre of the iris and it is closer to the nose [1]. Thus positions of the found centers usually differ.

Then the iris is mapped from pseudo-polar coordinates to a 512*64 pixel rectangular image. We use only 3/5 part of iris that is close to the pupil in order to exclude regions of eyelashes and eyelids.

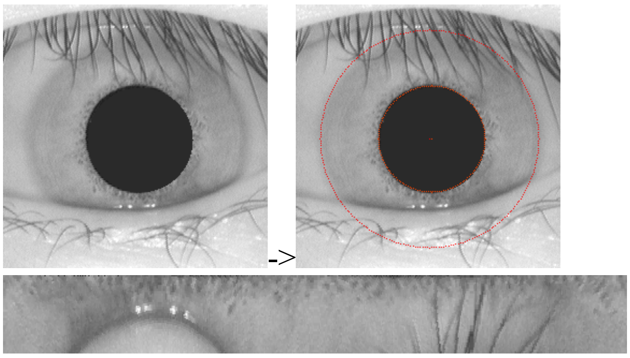
Figures 1(a)-1(c) show different variants of processed eye images. For each case the top left image is the initial one; the top right image shows the found iris boundaries; the bottom image shows the final rectangular image for the identification



(a)



(b)



(c)

Figure 1. Iris Normalization

Because the right part of normalized image often contains the eyelashes and eyelids (see Figure 1.b) we use only the left part of image. Because the top part of normalized image contains more information than the bottom part (the top part correspond to the region that is closer to the pupil) and because the bottom part often contains eyelids (see Figure 1(c)) we use only the top left quarter of the normalized image that correspond to a 3/20 part of whole iris image. It is marked in Figure 2.

3. Hierarchical Hermite Projection Method

The Hermite functions derivate a full orthonormal in $L_2(-\infty,\infty)$ system of functions. They are also egenfunctions of the Fourier transform. The joint localization of Hermite functions in the both spaces makes this method very stable to information errors and very promising to be used in image processing and analysis [4].

At first we project the whole of the selected rectangular image on horizontal axis and the result of the projection expand into a series of 64 Hermit functions. All coefficients of this expansion will be used in verification mode.

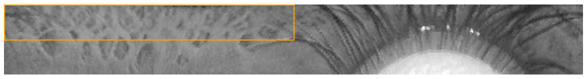
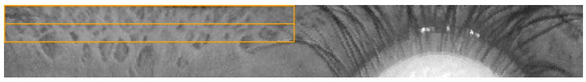


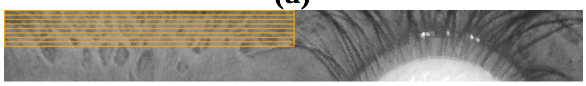
Figure 2.

Figure 2 shows the selected region of normalized image 1(b) where we apply our method. The area where we apply hierarchical Hermite projection method is marked as a rectangular in the top left.

Then we do the same with two halves (Figure 3(a)), four quarters and eight eighths (Figure 3(b)) of normalized iris image.



(a)



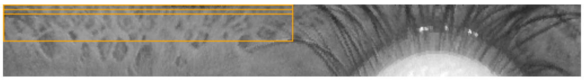
(b)

Figure 3.

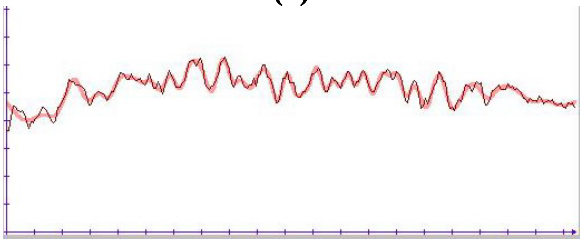
To indicate the required region of image we use notation (m.n). If the level of hierarchy is k, then m=2^{k-1} (it shows how many fields contains our region of interest) and n is the number of the chosen region.

4. Comparison mode

To compare iris images we use the sum of squares of deflection coefficients as the metric. To sort iris images by distance from the concerned image we use only 64 coefficients. These are the coefficients of expansion of the region (8.2) into a series of Hermite functions.



(a)



(b)

Figure 4.

The region (8.2) that was only used for this study is indicated inside the rectangular in Figure 4(a).
Figure 4(b) shows the expansion of the average intensities in region (8.2) of the image 1(b) into a series of Hermite functions.

To make our method robust to rotation of eye we perform also the 1, 2 and 3 pixels cyclical shifts to the right and to the left for each identification procedure.

5. Results

To test our method we used the CASIA Iris Image Database (version 1.0) by Tan[2]. This database includes 756 iris images from 108 eyes, so each eye has 7 images. We took first 10 eyes from the database with 7 samples of each eye (10 eye-classes).

№ of class\ № of sample	1.1	1.2	1.3	2.1	2.2	2.3	2.4
1	6	5	4	4	6	5	4
2	5	4	5	3	4	5	5
3	4	5	5	4	6	4	4
4	3	5	3	3	3	4	5
5	3	5	3	4	4	3	5
6	2	2	3	4	3	4	3
7	3	2	3	1	3	3	3
8	2	4	3	4	4	5	4
9	6	5	6	4	6	6	6
10	6	4	4	4	4	4	6

For the specific image the values in the table show how many images from the eye-class of the sample are first in the list of nearest database images (it may possess the values from 0 to 6). The method succeed in all cases (we do not have 0 values in the table).

6. Conclusions

Only a part of available eye database information was tested by our projection procedure. At the same time only very small part of Hermite hierarchical information was used by the analyzed algorithm. We need to increase stability of recognition (values in the table) and to treat bigger databases using additional Hermite information in the regions of eye without eyelashes and eyelids. This work is under investigation.

The work was supported by RFBR grant 06-01-39006-ГФЕН.

7. References

1. John Daugman. “High Confidence Visual Recognition of Persons by a Test of Statistical Independence”, IEEE Transaction on Pattern Analysis and Machine Intelligence, vol. 15, no. 11, pages 1148—1161, November 1993.

2. Li Ma, Tieniu Tan, Dexin Zhang, Yunhong Wang. “Local Intensity Variation Analisys for Iris Recognition”, Pattern Recognition 37(6), pages 1287-1298, 2004.

3. Degtyareva A., Vezhnevets V. “Some methods of human identification using iris recognition” (in Russian). http://cgm.graphicon.ru/content/view/61/62/

4. Krylov A.S., Korchagin D.N. “Fast Hermite Projection Method”, LNCS, 2006, vol. 4141, p. 329-338.

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