BIOMETRIC IDENTIFIER BY RETINA ANALYSIS

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Abstract: *Blood vessels at the back of the eye have a unique pattern. A retinal scan involves using a small intensity source of coherent light, which is projected on the retina to illuminate the blood vessels, which are then photographed and analyzed. Retinal scan can not be falsified because it is currently impossible to achieve a human retina. A scan of the retina has an error rate of 1 in 10 million, compared with fingerprint identification error, which is sometimes as high as 1 in 500. The reason for the selection was given by the fact that these characteristics remain unchanged over the years and degradations are possible to occur only due to eye diseases such as glaucoma and retinopathies. Human intervention on the retinal vascular network is not a problem solved at present. The proposed algorithm is composed of six basic steps.*

1. OVERVIEW

Blood vessels at the back of the eye have a unique pattern, differring from a person's eye to another person's eye. Retinal scans require a person to remove his/her glasses and bring the eyes close to the scanner, focusing on a certain point and to remain still for an appropriate period of time of about 10 to 15 seconds, while the scan is completed.

A retinal scan involves using a small intensity source of coherent light, which is projected on the retina to illuminate blood vessels, which are then photographed and analyzed. A special coupler is used to read the patterns of blood vessels.

Retinal scan can not be falsified because it is currently impossible to achieve a human retina. In addition, the retina of a deceased person decays very quickly, so it cannot be used to mislead a retinal scan. A scan of the retina has an error rate of 1 in 10 million, compared with fingerprint identification error, which is sometimes as high as 1 in 500.

Retinal patterns have very distinctive features. Each eye has its own totally unique pattern of blood vessels, even identical twin eyes are distinct.

Although normally each model remains stable over a person's life, it can be affected by disease such as glaucoma, diabetes mellitus, arterial hypertension and autoimmune deficiency syndrome.

The fact that the retina is small, internal and difficult to measure, it makes the capturing of its image more difficult than most biometric technologies. An individual must position the eye very close to the lens of the retina scanning device, to look directly into the lens and remain fixed, while a tiny camera scans the retina through the pupil. Any movement can interfere with the scanning process. The entire scanning process can easily last more than one minute. The pattern generated only has 96 bytes, one of the lowest in biometric technologies.

The identification procedure is based on three structural elements of the human eye retina. These are the optic nerve, macula and the vascular network. The reason for selection was given by the fact that these characteristics remain unchanged over the years and degradations are possible to occur only because of eye diseases such as glaucoma and retinopathies. Human intervention on the retinal vascular network is not a problem currently solved.

2 ALGORITHM FOR THE RETINA ANALYSIS

The proposed algorithm is composed of six basic steps:

1. Identification of the optic nerve and macula;
2. Detection of the vascular network through Gaussian and statistical filters;
3. Removal of noise by filtering the dimension;
4. Detection of branch points;
5. Grouping of branching points;
6. Adapting to the vascular network by affine geometric restorations.

2.1 Pre-processing

Before entering the dominant stages of processing, the retina image is handled so that it can later undergo basic standards for its processing. Standards to be met are image dimensions, color and lighting standard. Specified dimensions are 512x512 pixels. To overcome a low intensity image its histogram is normalized.

2.2 Detection of the optic nerve

The optic nerve disc is the brightest area of the retina (for retinas of healthy individuals). This procedure is based on a limitation technique to 90% of the highest intensity in the image. After the image segmentation, a sequential algorithm erodes and dilates the binary image in order to remove noises and to eliminate the joining of parts torn from image objects. At the end of the stage, the largest object is labeled optical disc. Its mass center is considered to be in the center of the optic nerve disc. In order to calculate the mass center of an object the following relation is used:

$$x_i = \frac{\sum_{1}^{m} x_m}{m} \quad y_i = \frac{\sum_{1}^{n} y_n}{n}$$

2.3 Detection of the macula

The techniques applied in this process are similar to the phase of the detection of "the optic nerve". The problem here is that, in most cases, it is very difficult to distinguish the macula, from the background. The intensity near the area in which the maculais situated, is similar to the macula intensity. To overcome this problem, the algorithm is defined as a region of interest - ROI, in which the detection of the macula will be performed. ROI is a rectangular area, the size and location are predefined in the sample, through observation.

After selecting the area, a Gaussian filter to smooth the image intensity is applied. What remains after filtering the image is the overall gray look, at the level of the image on the flat area. Less sharp details remain in the image when high frequencies have been attenuated.

The form of a 2-D Gaussian filter is given by the relation:

$$H(u,\upsilon) = e^{-D^2(u,\upsilon)/2D_0^2}$$

where D_0 is the cutoff frequency of the filter and denotes the distance (u,υ) from the center of the frequency rectangle:

$$D(u,\upsilon)=\sqrt{\left(u-\frac{M}{2}\right)^2+\left(\upsilon-\frac{N}{2}\right)^2}$$

The threshold is chosen from the relation:

$$thresh=\frac{mean(i)-std(i)}{2}$$

Graphically, the process is illustrated in Figure 1.

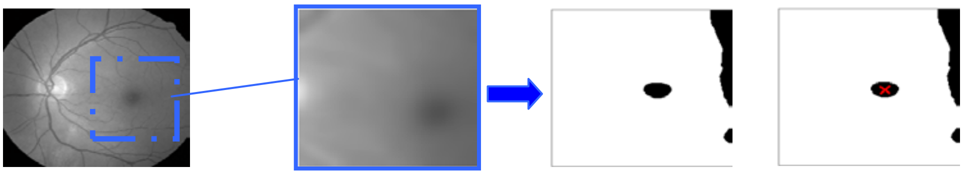

Fig. 1

In the end, the object is located near the ROI center and is labeled as the macula, and its mass center is the center of the macula. Unlike the detection of the optic nerve, the macula detection is strongly affected by noise. The image after the two stages appears in Fig. 2.

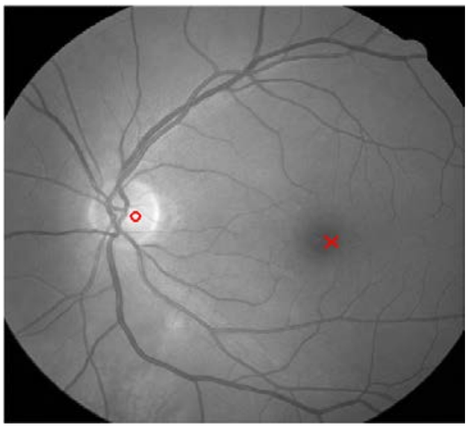

Fig. 2

2.4 Detection of the vascular network

In order to detect vascular network an algorithm which implements a Gaussian filter that attenuates low frequencies is used. In 2-D, it is described by the relation:

Cutoff frequency D_0 is equal to 7% of the image width. Before and after this process, a statistical median of the image is used, in order to reduce high frequency noise. The images obtained appear in Fig. 3.

$$H(u,\upsilon)=1-e^{-D^2(u,\upsilon)/2D_0^2}$$

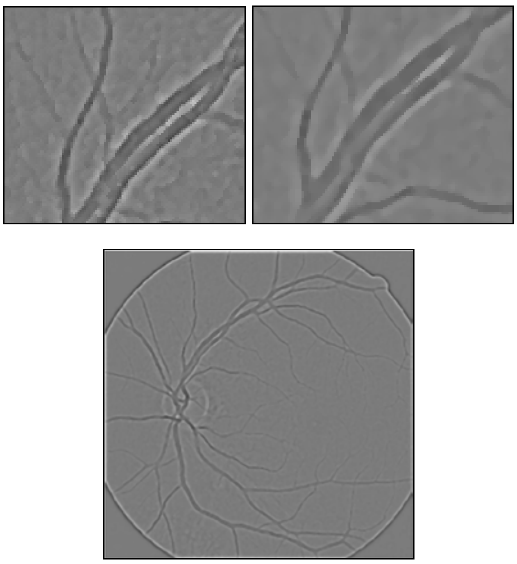

Fig. 3

After applying the threshold the image becomes black and white as in Fig. 4.

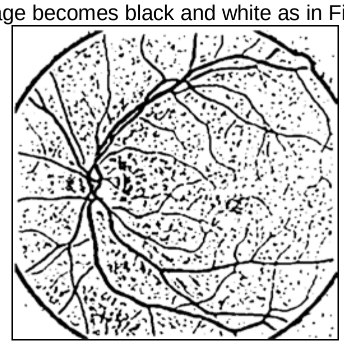

Fig. 4

The resulting picture has noise and therefore a length filter is used. The resulting image appears in Fig. 5.

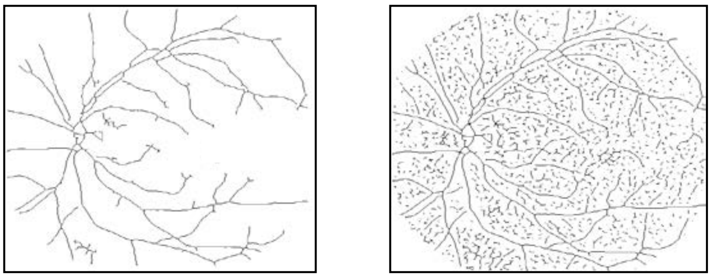

Fig. 5

The detection of branch points is done by applying a 2-D convolutions with a 3x3 matrix. After this convolution, any point whose value is greater than 4 is considered to be a branching point, Fig. 6.

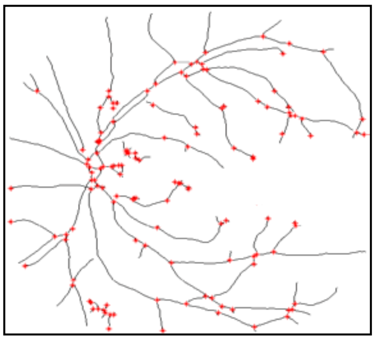

Fig. 6

Branching point matrix represents the central part of the process. The identification of the vascular network begins by calculating the distance between the optic nerve and macula of each eye. Then comes the group of branch points, Fig. 7.

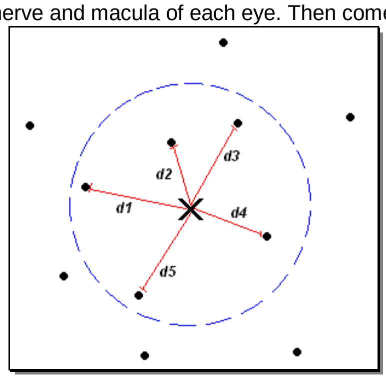

Fig. 7

Determination of overlap points is done through affine geometric transformations of the type:

$$[x \quad y \quad 1] = [w \quad z \quad 1]T = [w \quad z \quad 1] \cdot \begin{bmatrix} t_{11} & t_{12} & 0 \\ t_{21} & t_{22} & 0 \\ t_{31} & t_{32} & 1 \end{bmatrix}$$

The further comparison is exemplified in Fig. 8.a - whole space or 8.b - a detail.

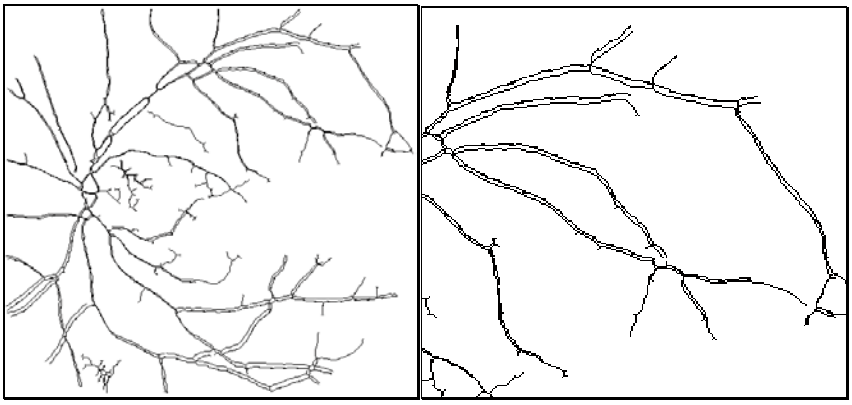

Fig. 8

The process takes about 25 seconds for images of 512x512 pixels.
Simpler analytical processes use fractal analysis of the retinal vessel network.

3. CONCLUSIONS

The retina is made out of photoreceivers (sensitive to light) and nerve cells and the identification procedure is based on the three structural elements of the retina of the human eye: the optic nerve, macula and the vascular system with characteristics which remain unchanged over the years and with damages which are possible only because of the eye diseases.

A retina scan involves the use of a source of small intensity with coherent light, which is projected on the retina in order to illuminate the blood vessels. So, the scan of the retina cannot be falsified, now being impossible to perform a human retina or interventions over the vascular system of the retina.

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