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Retinal Identification and Connecting this Information to Electronic Health Record

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ABSTRACT

This paper aims at identification of individuals using the retinal image that the extraction of blood vessels based on density classification and identification is carried out according to the Fuzzy logic and then according to the performed operations of individual’s electronic healthrecord. For this purpose, a new algorithm was presented for extraction of specific characteristics of retina based on image analysis and statistic calculations. Extraction of eye blood vessels is carried out based on adaptive filters. Our proposed method in comparison to previous methods which merely have carried out the identification through individually comparison of retina has a higher accuracy and speed. This distinction in the identification accuracy and speed was used in the type of classification and Fuzzy rules. In this paper, we will cluster the image noise at the first stage and at the end of clustering; two classes of noise and the original image will remain. This clustering will be done using the density method of Density-Based Clustering. Then we will extract the eye vessels using adaptive filters. After identifying classes and eye vessels extraction, we will identify the image of the retina under experiment based on the five-stage Fuzzy logic and rules and extract the individual’s file.

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1. INTRODUCTION

The term “biometric” was derived from the Greek terms “bios” which means life and “metrikos” with the meaning of measurement. All of us have a series of characteristics to identify each other which are unique to each individual including speech and footpace. A biometric system is essentially a system of pattern identification which recognizes an individual based on his vector of specific physiological or behavioral characteristics and after extraction, this vector is usually stored in the data base. The biometric system which we study in this paper is the retina. The significance of blood vessels detection in the retinal images is that vessels are very important for diagnosis of many diseases including Diabetes, blood pressure and cardiovascular diseases. Also, in laser eye surgeries, the location of blood vessels is an important and essential operator for addressing the robot. We have two objectives in this paper; the first one is the extraction of eye vessels for ophthalmology studies to diagnose a disease easier and more accurate. We use the method of eye vessels extraction using the improved adaptive algorithm. This is stronger than the two previous methods such as WEF method and geometric patterns, and provides us accurate and optimal information about vessels and also helps a doctor to diagnose a disease. After the extraction of retinal vessels, we save the information about the retina and study the procedures of doctor’s diagnosis and prescribed medicines by creating an electronic medical file for a patient. The second one is the retina identification and the extraction of the electronic medical file from among the numerous files of patients using the retinal image [4]-[5].

1.2. Dense Clustering

In this paper, we use a density-based clustering algorithm for solving a new problem called "determining the areas of noise in the medical images of retina". This stage is important, because the accuracy of other stages is highly dependent to the preprocessing stage. In this paper, we present a non-supervisory approach for the segmentation of noises of retinal images according to the DBSCAN clustering algorithm. Here, we briefly explain the DBSCAN algorithm. DBSCAN is a clustering algorithm which was designed to detect the clusters and noise in a set of spatial data. This algorithm has two main parameters: Eps and MinPts. The vicinity of an object which has an Eps rays called the vicinity of Eps in relation to that object. If the vicinity of Eps in relation to an object at least has MinPts objects, this object is called the core object. DBSCAN starts like 0 for finding a cluster with a desired object in datasets. If the 0 object is a core object with w.r.t. Eps and MinPts, a new cluster with 0 like the core object is created [3]. The algorithm continues to expand clusters by adding all the objects available based on the density of the cluster object [16]-[17].

2. SEGMENTATION AND NOISE EXTRACTION BY DBSCAN

In this paper, we use an area-based approach for the segmentation of colorful images. The aim is to segment the images into the non-connected areas according to the healthy parts of the eye and under the areas among noises. We used Dr. Adam Hoover's dataset.

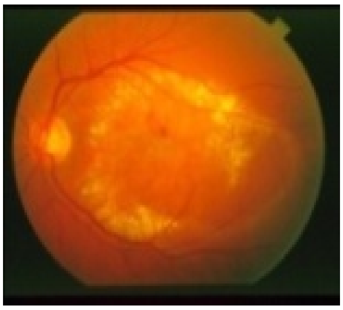

Figure 1. The original image

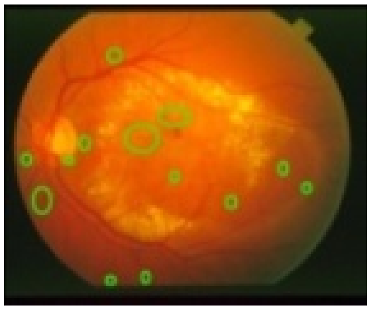

Figure 2. Image noises detection

In Figure 1 we have a retinal image. As can be seen, there are small noises in the middle and around the retina which are underlined [1]-[2].

These noises occurred according to the photography time because lenses were dirty and or they occurred during saving the image or other defects. These small noises will lead to an error in identification and also eye vessel recognition in other devices. We have two basic stages: First, the image will be divided into smaller areas until all the areas fulfill a standard named "threshold" which is determined for division. Then, these areas will integrate to form the final areas using DBSCAN algorithm [11]-[12].

2.1. Clustering Areas

Here, clustering is a top-bottom process. If an area does not fulfill a similarity standard, this area will be divided into four subareas. The process of dividing from the area will start from the highest degree which is called "image whole" which should be segmented. Each area in the image will be shown by using the medium color which is calculated in the RGB color space. For determining the similarity of one area, Euclidean distances will be calculated between this area and each of the four potential subareas. If each of the color spaces calculated above is larger than the isolation threshold, this area will be isolated. Otherwise, the area remains without change. The isolation process will recursively continue until it detects whether each area is similar to another or is very small for being isolated. The isolation threshold is a very important parameter and if it is assumed to be very high, the segmentation accuracy will decline. The result will show the rectangular borders around the pieces, and vice versa if the isolation threshold is considered to be very small, the image may be additionally segmented by most of the pieces which are as small as pixels. The isolation threshold will be determined automatically. The black areas in the Figure 3 show the noises. They cannot be integrated into each cluster because they are rejected in the test.

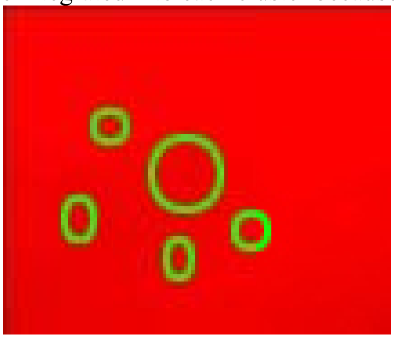

Figure 3. Finding the image noises

Figure 4. Removing the found noises

So, we detected the noises using the above method. Now, we will cleanup noises by means of the sound pieces near this area through which the below image will be created. We see that the noise is extensively reduced and we can use it for the next stages [13].

2.2. The Adapted Filter for the Blood Vessels

An adapted filter will describe the predicted appearance of a desired signal for the adaption purposes. In the reference [18] the Gaussian function is proposed as a model for the blood vessel profile. This model is generalized in two dimensions. Since the vessels may appear in any direction, a set of two-dimension piece profiles will be considered as a filter bank in equal angle directions. These filters are implemented using twelve 16x16 pixel cores. The details in relation to true values of the cores are presented in the reference [18]. The adapted filter will be implemented by integrating a retinal image with all the twelve cores. MFR is considered as the value of the largest degree of core in each pixel.

2.3. Probing the Threshold [6-7-8]

The main operation here is probing the available areas in the MFR image. During each probing, a set of standards will be tested for determining the probe threshold; then, it is determined whether the area which is probed is a blood vessel (actually a piece) or not. In the Figure 3 a flowchart of this algorithm is shown. First, a row of points will be initialized and each of them will be used for a probe. After completing a probe, if the desired piece is chosen as a vessel, the final points of the piece are added to the row. In this way, different probes with different thresholds can be implemented all over the image.

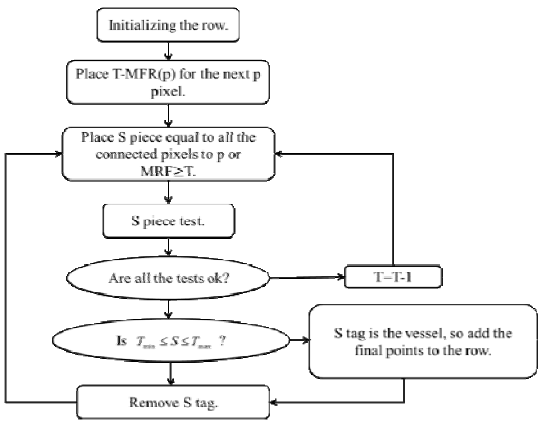

Figure 5. The proposed algorithm of the adapted filter.

In the following stages, a row of pixels which should be used as the initial points of probing, are initialized.

1) Convolve the adapted filter which is presented in [18] to obtain the MFR image (the response of the adapted filter).

2) Calculate the threshold of the MFR image using an image histogram so that the pixels which are larger than the threshold T stand higher than the threshold.
3) Consider the image which you calculated its threshold narrower (e.g. by using the presented algorithm in the reference).
4) Remove all the branch points from the narrow image and break the whole background into pieces which consists of two final points.
5) Withdraw the pieces with less than 10 pixels.
6) All the final points should be placed in the probe row.
7) If the piece size according to pixel extends Tmax, probing will be finished. It needs several pieces as well as multiple thresholds to segment the entire image. Its effect is that the probe will be able to accept the resistance of the MFR image.
8) If the threshold arrives to zero, probing will be finished. It happens when probing a small area (even a pixel) into another area which is recently classified as a vessel is entered.

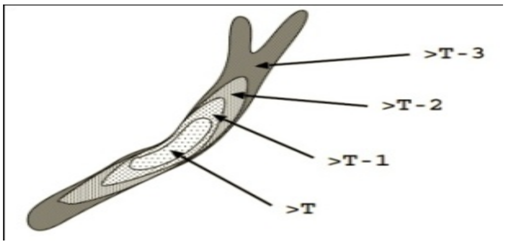

Figure 6. Determining the piece border

9) If border_pixels_touching_another_piece/total_pixel_in_piece>TFringe, then the piece will be fringed and probing will be finished. It will prevent a probe to search along the borders of the vessel pieces which have been recently segmented.
10) If _pixel_pixi_in_piece/border_in_piece<TTree, then probing will be finished. It requires a piece with a minimum range of vessels to be placed in the branch. So, over-branching in the wrong paths will be prevented.

Figure 7. A sample of vessel extraction by means of the adapted filters

The following table shows the comparison of other methods with the proposed image of eye vessels extraction.

Table 1, The percent of the proposed algorithm detection compared to other methods.

Mean Recognition Time	Recognition Rate of the Total database	Mean recognition Rate of Noise Images of the Retina	Mean recognition rate of Retinal Images without Noise in Different Directions	Method
5/86 sec.	98%	96%	100%	Jafariani method with February-Laxative function method
4/63 min.	98/5%	97%	100%	Carve-based method of blood vessels

3/34 sec.	100%	100%	100%	Adaptive filter method

As can be seen in Table 1, the proposed method has a higher accuracy and speed than the compared methods.

2.4. The Electronic Health Record

The electronic health record for each real person is a special and safe file which contains all the key medical approaches and health cares during his life. This record will be presented to the person and health providers in any time and place for supporting the special and high quality health cares. The following diagram shows the creating and saving procedures of the electronic health record.

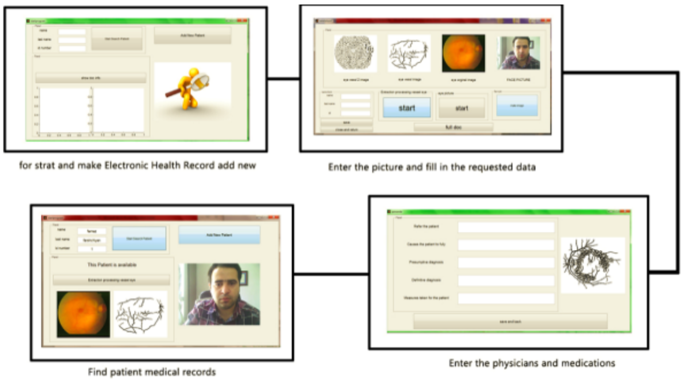

Figure 8. Creating the electronic health record and filling out information

3. Identification through Fuzzy Rules

We used the Fuzzy method after stages of removing the noise by means of density algorithm and then extraction of the retinal blood vessels after saving the medical file for detection and extraction of the medical profile. This method is done as follows: [9]

3.1. Designing the Fuzzy Part:

Our proposed method for identification is comprised of 5 layers which according to FIgure 1, xi is the input of the above images and yi is the circuit's output. As can be seen, outputs are of a smaller size compared to inputs. The length of these outputs depends on the number of rules in the Fuzzy circuit. These rules depend on the extracted blood vessels.

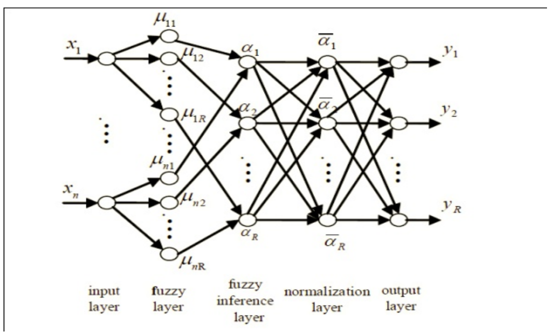

Figure 9. The Fuzzy diagram

3.2. Making the inputs Fuzzy

Equation (1) is the triangle membership function in which a, b and c are the locations of triangle function placement on x inputs. In this relation, the Fuzzy inference system will receive inputs and determine the inputs membership degree for each of the Fuzzy sets.

u (xi a, b, c)= max (min($\frac{x-a}{b-a}$, $\frac{c-x}{c-b}$), 0) (1)

3.3 Implementing Fuzzy Operators:

After making fuzzy, the accuracy degree of each of components of the supposed parts (inputs) is determined. The Equation (2) is the calculation function of the Fuzzy interface [14]

αj= $\prod_{i=1}^{R} \mu ij$. $\frac{1}{Nadj}$ (2)

Where R shows the number of the parts of the operator Fuzzy which was created for compounding to provide the accuracy degree of parts and numbers as the accuracy degree of the supposed parts .Nadj is the equivalent coefficient which in this paper is supposed to be n/4. n is the number of retinal vessels [15].

3.4. Implementing the Implication Approach:

The result section is a Fuzzy set determined through the membership function. The process input and output indicate a number and a Fuzzy set, respectively. The output 90 jth according to Equation (3)

is:αi = αi/$\sum_{i=1}^{R} \alpha i$ (3)

3.5. Outputs Integration:

As the decisions in a Fuzzy interface are made according to the assessment of all the rules, in this layer, we integrate them, and the output 90 kth according to relation 4 is:

yk = $\sum_{j=1}^{R} wjk$ ‘αj, k= 1,2,A,R (4)

Where Wjk is the weight of each rule implemented on the calculated value from the supposed part. Some weights are created in the output of this circuit that we will be able to identify by comparing it with other images. Identification using the Fuzzy method is presented in Table 2.

Table 2. The extent of identification verification using the Fuzzy method.

True Identification Percent	The Used White Noise Percent	The Used Image Number
100%	0/2	100
98.3%	0/2	500
99.1%	0/5	100
97.1%	0/5	500
0.96	0/3	1000

4. CONCLUSION

In this paper, we presented a new combination approach for extracting the blood vessels by removing the noises through the density method and extracting the vessels through an adaptive filter. After the blood vessels extraction, they are saved in the medical file and finally the patient identification is done through the Fuzzy method, according to the retina. The results indicate the strength of the proposed method from the vessel extraction accuracy and patient identification points of view.

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