Retina Vessels Detection in Fundus Images by New Morphology Operation and the Anisotropic Diffusion Filter

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Abstract: This paper proposes a new method for the detection of retina vessels in fundus images based on a new morphology operation and the anisotropic diffusion filter. The retina vessels detection in fundus images is needed for the diagnosis of an eye disease. However, it is an extremely exhausting and time consuming task for medical doctors, and therefore an automatic retina vessel detection method is strongly required. After the actual experiments on particular sets of fundus images, it has been found that the proposed method works better compared with the conventional detection methods.

Keywords: retina vessels detection, fundus images, new morphology operation, anisotropic diffusion filter.

1. Introduction

The fundus image is the creation of the interior surface of the eye which is used by medical doctors for monitoring the progression and the diagnosis of a disease. The analysis of those images is commonly done by visual inspection. However, it is an extremely exhausting and time consuming task for medical doctors, not only because the fundus image has low quality and uneven illumination, but also because it is very complex.

Several automatic retina vessel detection methods have been proposed so far. Parameters in the method [1] however are very difficult to tune to be used for all images. For this reason, in this paper, a new mathematical morphology is proposed to provide more advanced tool for it, the anisotropic diffusion filter are further utilized for the detection of retina vessels in fundus images.

2. Fundus Image and Retina Vessel Detection

The fundus image shown in Fig.1 is used to diagnose and evaluate symptoms of retinal detachment or eye diseases such as glaucoma. Retinal vessel detection in fundus images is a challenging task and has been in the focus of research for years. An automatic retina vessel detection is strongly needed to speed up the diagnosis of the diseases.

3. Proposed Method

From the negative image of the fundus image, it can be observed that the vessel areas have bright regions. For this reason, the white (bright) image regions need to be extracted by modifying the morphology operation in [2].

Firstly, white image regions are extracted by the white multi-scale image regions as follows:

$$WTH_i = f - (f \circ g_i(a_i)),$$

where $g_0(a_0), g_1(a_1), ..., g_m(a_m)$ are the structure elements with the same shape and increasing sizes. $a_i$ is the size of structure element $g_i$, and $a_i$ is obtained by $a_i = a_{i-1} + a$. $a$ is an increment of the structure element size.

The sum of the extracted white multi-scale image region at all scales is calculated as follows:

$$f_{wc} = \sum_{i=1}^{m} WTH_i.$$  \hspace{1cm} (2)

Secondly, the white image region between neighboring scales $i$ and $i+1$ are extracted by:

$$WTH_{i,i+1} = WTH_{i+1} - WTH_i.$$  \hspace{1cm} (3)
and the sum of white image regions between all neighboring scales is defined as follows:

$$f_{wd} = \sum_{i=1}^{m} WTH_{i,i+1}. \quad (4)$$

In the final step, the final white image regions are obtained by:

$$f_{wc} = c_1 f_{wc} + c_2 f_{wd}. \quad (5)$$

where $c_1$ and $c_2$ are parameters.

The retina vessel detection procedure is summarized as follows:

1. Take a green component from the fundus image.
2. Take a negative image.
3. Apply a new morphological operation (5) to enhance the image and after that adjust contrast of the image.
5. Adjust the contrast of the image.
6. Apply adaptive thresholding to obtain a binary image.

The adaptive thresholding is defined by:

$$I_{\text{result}} = \begin{cases} 1, & AF(I) - I \geq C \\ 0, & AF(I) - I < C. \end{cases} \quad (6)$$

where $C$ is a parameter, $I$ is the image before adaptive thresholding, and $AF$ is an average filter.

4. Experimental Results and Discussions

The proposed method was applied to 8 fundus images from the STARE (Structured Analysis of the Retina) database. In the STARE database, the true retina vessel detection results obtained by hands of the specialist are also included. Those images were used as benchmark. The effectiveness of the proposed method were compared with the conventional methods [1,3].

Fig.2(a) shows the fundus image that is to be processed. Figs. 2(b), 2(c) and 2(d) show the detection results by the method [1], the method [3] and the proposed method, respectively.

The numerical evaluation of the retina vessel detection results are evaluated by the True Positive Rate (TPR) and the False Positive Rate (FPR) as defined in [3]. The TPRs and FPRs of the proposed method and the conventional methods [1,3] are shown in Table 1. From Table 1 it can be observed that the TPR of the proposed method is much better than that of the method [1], and the FPR of the proposed method has no difference compared with the method [1]. The FPR of the proposed method is very small compared with that of the method [3]. The TPR of the proposed method compared with the method [3] is not too significantly different. This means that the proposed method can decrease miss-detection. All in all it can be concluded that the proposed method has better performance compared with the methods [1,3].

5. Conclusion

We have proposed a new method for retina vessel detection in the fundus images by the new morphology operation and the anisotropic diffusion filter. The proposed method has better performance than the conventional methods [1,3].

<table>
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<tr>
<th>Method</th>
<th>TPR</th>
<th>FPR</th>
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<tbody>
<tr>
<td>Method [1]</td>
<td>53.9</td>
<td>3.5</td>
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<tr>
<td>Method [3]</td>
<td>72.5</td>
<td>27.7</td>
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<tr>
<td>Proposed method</td>
<td>70.7</td>
<td>5.5</td>
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References