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Original Research Article

BLOOD VESSEL SEGMENTATION IN RETINAL FUNDUS IMAGES USING MATCHED FILTER

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Abstract-
This paper presents a new study for blood vessel detection in retinal fundus images using Matched Filter algorithm. The segmentation of retinal blood vessels in the retina is a critical step in diagnosis of diabetic retinopathy. The method was evaluated on the publicly available DRIVE and STARE databases, widely used for this purpose. Performance of two different template matching algorithms are analysed for detection of blood vessels in retinal images for both gray level and green component of color images. The Gaussian matched filter (GMF) is used on gray level images and Kirsch Template Matched Filter (KMF) is used on color images. Experimental results show that our implementation based on GMF is more preferable than implementation based on Kirsch Templates.

Keywords- Diabetic retinopathy, Vessel segmentation, GMF, Kirsch Template, DRIVE.

INTRODUCTION

Diabetic Retinopathy is the leading ophthalmic pathological cause of blindness amongadults aged 20-74 in developed countries. It is an ocular manifestation of diabetes, a systemic disease, which affects up to 80% of all patients who have had diabetes for 10 years or more. It is damage to retina caused by complications of diabetes, which can eventually lead to blindness.It occurs when blood vessels in the retina change. Sometimes these vessels swell and leak fluid or even close off completely. In other cases, abnormal new blood vessels grow on the surface of retina. Retinal images can be difficult to interpret, and computational image analysis offers the potential to increase efficiency and diagnostic accuracy of the screening process. Automatic blood vessel segmentation in the images can help speed

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diagnosis and improve the diagnostic performance of less specialized physicians. An essential step in feature extraction is blood vessel segmentation of the original image. Many algorithms have been developed to accurately segment blood vessels from images with a variety of underlying pathologies and across a variety of ophthalmic imaging systems.

We have studied two different template matching algorithms viz. Gaussian Matched filter (GMF) and Kirsch Template Matching (KMF). These two algorithms are described and their results are compared. The performance of each algorithm was tested on the DRIVE dataset. This database contains 40 images, 20 for training and 20 for testing. These images are manually segmented by two trained researchers. The algorithms are implemented on the original images and the hand segmentations are used to evaluate the performance of developed algorithms.

GAUSSIAN MATCHED FILTER (GMF)

This algorithm is based on the following observations from the retinal blood vessels: Blood vessels usually have limited curvature. Therefore, the anti-parallel pairs can be approximated by piecewise linear segments. It is observed that the vessel diameters decrease as they move radially outward from the optic disk and range from 2 to 10 pixels in the resulting images from the DRIVE database. The cross section gray level pixel intensity of blood vessels has a Gaussian profile.

Pre-processing- The following steps are performed under pre-processing: Smoothening of original image by 5*5 mean filter to reduce the effect of these spurious noises. Apply Laplacian filter of size 3*3 and alpha of value 0.2for sharpening of this image. The parameter alpha controls the shape of the Laplacian which must be in the range of 0 to 1. Apply the contrast function to enhance the contrast of the image so as to get an approximately equal intensity distribution.

Apply the Morphological opening with the structuring element disk of radius 20 to reduce the effect of central vessel light reflex, a brighter section along the vessel ridges. Edge fitting-For implementation of this algorithm, a 2D matched filter for Gaussian profile is used. 12 different kernel filters are implemented in 15 degree increments to cover all directions. This kernels are then used as convolution mask across the image. All 12 kernels are convolved with the image and at each neighbourhood, the filter that generates the maximum result is considered the correct vessel orientation. These 12 results are added to get the final result of Matched Filter.

Thresholding- A pixel is labelled as a part of a vessel if the convolution output at this given pixel exceeds a proper threshold. An automatic thresholding algorithm, Otsu's method, is used for selecting the threshold value.

KIRSCH TEMPLATE MATCHING

The kirsch operator is one of the first order derivative operator used for edge detection. It is a new method proposed for color images in which a new edge detector called kirsch operator is used for detection of blood vessels in retinal images.

The Kirsch filter is implemented in the following two stages-

Color Component Filtering- This method works only on red and green component of the color images. So, the color component are extracted using color component filtering. Kirsch Matched Filter Designing- Eight different templates are implemented for detecting the edges. This templates are convolved with the image and at each neighbourhood. The result of convolution for 8 templates are added to get the final segmented image.

RESULTS AND DISCUSSION

The test image from DRIVE database is taken for analysis. The proposed algorithm is implemented using MATLAB.

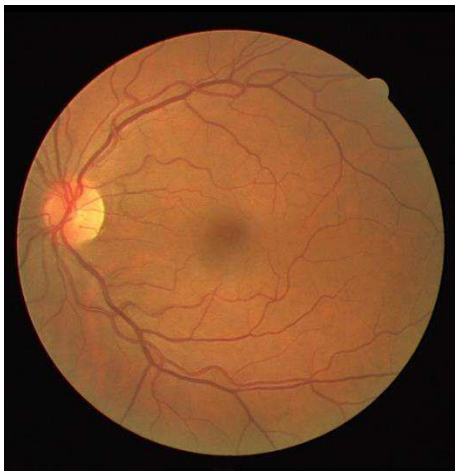

Figure 1: Original image (DRIVE)

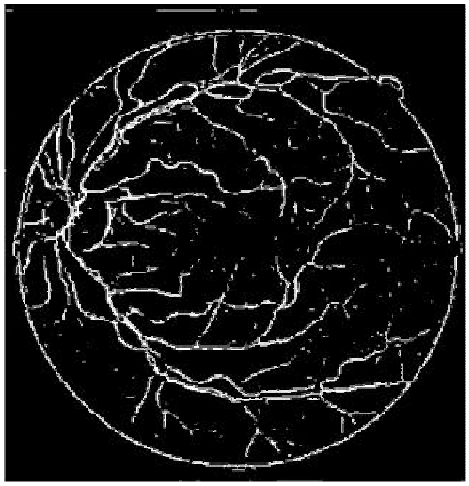

Figure 2: GMF

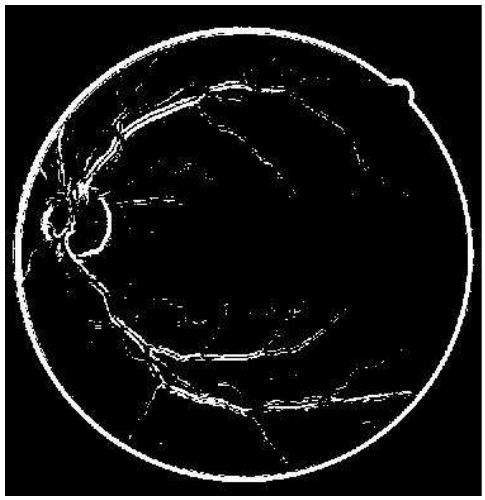

Figure 3: KMF (Green component)

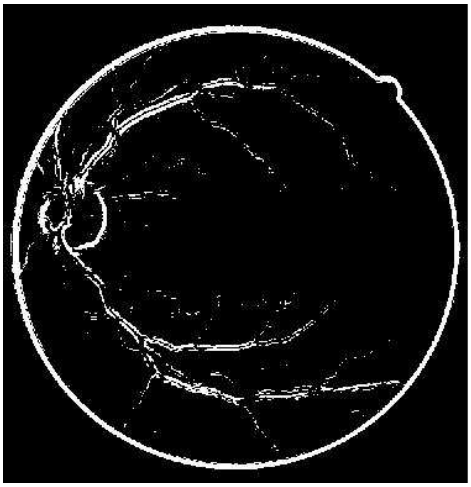

Figure 4: KMF (Red component)

Sr.no	Constraints	GMF	KMF
1.	Detection of small vessels and capillaries	NO	NO
2.	Number of templates used	12	8
3.	Requirement of post-processing	YES	YES
4.	Elimination of noise	More	Less

Table 1: Performance analysis of matched filter techniques

The automated methods for detection of blood vessels in retinal images and the comparative analysis of the methods are presented here. From our results it can be concluded that GMF gives a more accurate and precise vessel segmentation result than KMF. KMF gives a better result on the green component of an image than on the red component.

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