Blood Vessel Extraction Using Wiener Filter and Morphological Operation

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Abstract: Diabetic retinopathy (DR) is a common retinal complication associated with diabetes. Along with optic disk and blood vessel of normal patients, the diabetic patient's retinal image has exudates. Depending on the severity of diabetics micro aneurysms and hemorrhages may also present. So in the diagnosis of diabetic retinopathy, the detection of exudates plays the fundamental role. Sometimes exudates and optic disk are similar in brightness, color and contrast. It is very important to differentiate them. To detect exudates correctly, optic disk should be detected first and then it should be masked. The blood vessel is extracted and the meeting point of the blood vessel is the center of the optic disk. In this the blood vessel is extracted using Wiener filter and morphological operation opening and closing. The peak signal to noise ratio is calculated for both the methods and are compared. The edge of the blood vessels are clearly detected by applying Laplacian and Gaussian operators and the thinning of blood vessel is done using morphological operator and smoothened for better clarity in the extracted blood vessel.

Keywords: Diabetic retinopathy, micro aneurysms, optic disk, exudates

1. INTRODUCTION

The prevalence of Diabetic Retinopathy is high and the incidence is growing in step with worldwide increases in Diabetic Maculopathy. Diabetic screening programmes are necessary in addressing all of these factors when working to eradicate preventable vision loss in diabetic patients. When performing retinal screening for Diabetic Retinopathy, some of these clinical presentations are expected to be imaged. Diabetic retinopathy is globally the primary cause of blindness not because it has the highest incidence because it often remains undetected until severe vision loss occurs.

Advances in shape analysis, the development of strategies for the detection and quantitative characterization of blood vessel changes in the retina are therefore of great importance. Automated early detection of the presence of exudates can assist the ophthalmologists to prevent the spread of the disease more efficiently.

Direct digital image acquisition using fundus cameras combined with image processing and analysis techniques has the potential to enable automated diabetic retinopathy screening. The normal features of fundus images include optic disk, fovea and blood vessels. Exudates and hemorrhages are the main abnormal features which is the leading cause of blindness in the working age population.

Optic disk is the brightest part in the normal fundus images which can be seen as a pale, round or vertically slightly oval disk. The change in the shape, color or depth of the optic disk is an indicator of various ophthalmic pathologies especially for glaucoma.

Exudates are one of the most common occurring lesions in diabetic retinopathy. Exudates can be identified as areas with hard white or yellowish colors and varying sizes, shapes and locations near the leaking capillaries within the retina. The shape, brightness and location of exudates vary a lot among different patients.

Retinal images of human plays an important role in the detection and diagnosis of many eye diseases for ophthalmologists. Exudates can be identified by segmenting the blood vessels and removing it. Swelling of blood vessel can also be the symptom of diabetes. Chwialkowski et al [2] accomplish segmentation of blood vessels using multi resolution analysis based on wavelet transform.

The segmentation process is applied to the magnitude image and the velocity information from the phase difference image is integrated on the resulting vessel area to get the blood flow measurement. Vessel boundaries are localized by employing a multivariate scoring criterion to minimize the effect of imaging artifacts such as partial volume averaging and flow turbulence. Niki et al [7] describe their 3D blood vessel reconstruction and analysis method.

Vessel reconstruction is achieved on short scan cone-beam filtered back propagation reconstruction algorithm based on Gulberg and Zeng's work. Schmitt et al [10] combine thresholding with region growing technique to segment vessel tree in 3D in their work of determination of the contrast agent propagation in 3D rotational XRA image volumes. Poli and Valli [8] develop an algorithm to enhance and detect vessels in real time.

The algorithm is based on a set of multiple oriented linear filters obtained as linear combination of properly shifted Gaussian kernels. Figueiredo and Leitao [4] describe their non smoothing approach in estimating vessel contours in angiograms. This technique has two key features. First it does not smooth the image to avoid the distortions introduced by smoothing. Second it does not assume a constant background which makes the technique well suited for the non subtracted angiograms. Donizelli [3] combines mathematical morphology and region growing algorithms to segment large vessels from digital subtracted angiography images. Krissian et al [5] develop a multi scale model to extract and reconstruct 3D vessels from medical images.

The method uses a new response function which measures the contours of the vessels around the centerlines. It consists of three main steps. First the multi scale responses from discrete set of scales are computed. Second, the local extreme in multi scale response is extracted. Finally the skeleton of the local extreme is created and the result is visualized. Aylward et al [1] utilize intensity ridges to approximate the medial axes of tubular objects such as vessels. Fuzzy clustering is another approach to identify vessel segments. It uses linguistic descriptions like "vessel" and "non vessel" to track vessels in retinal angiogram images. One disadvantage of the vessel tracking approaches is that they are not fully automatic.

Rost et al [9] describe their knowledge-based system, called SOLUTION and designed to automatically adopt low-level image processing algorithms to the needs of the application. Smets et al [11] present a knowledge-based system for the delineation of blood vessels on subtracted angiograms. The system encodes general knowledge about appearance of blood vessels in these images in the form of 11 rules (e.g. that vessel have high intensity center lines, comprise high intensity regions bordered by parallel edges etc.).

The system is successful where the image contains high contrast between the vessel and the background and that the system has considerable problems at vessel bifurcations and self-occlusions. Nekovei and Sun [6] describe their back-propagation network for the detection of blood vessels in X-ray angiography. This system does not extract the vascular structure. Its purpose is to label the pixels as vessel or non-vessel.

2. BLOOD VESSEL EXTRACTION USING WIENERFILTER

Filters are commonly used to extract a desired signal from a background of random noise or deterministic interference. The most design techniques of filters are based firmly on frequency domain concepts. By contrast, Wiener filters are developed using time-domain concepts. They are designed to minimize the mean-square error between their output and a desired or required output. The performance of the wiener filter may be evaluated by listening to signals and noise.

In this method, the retinal image is taken as the input image. Then the input retinal image is pre-processed. In pre-processing stage, the input image is resized to [576,576] and the green channel image is separated as the blood vessel appears brighter in the green channel image. Then filter is used to remove the noise in the input image. Then histogram equalization is applied to the filtered image. Then bottom hat transform is applied to the equalized image. Figure 2.3 shows the results of blood vessel extraction using wiener filter.

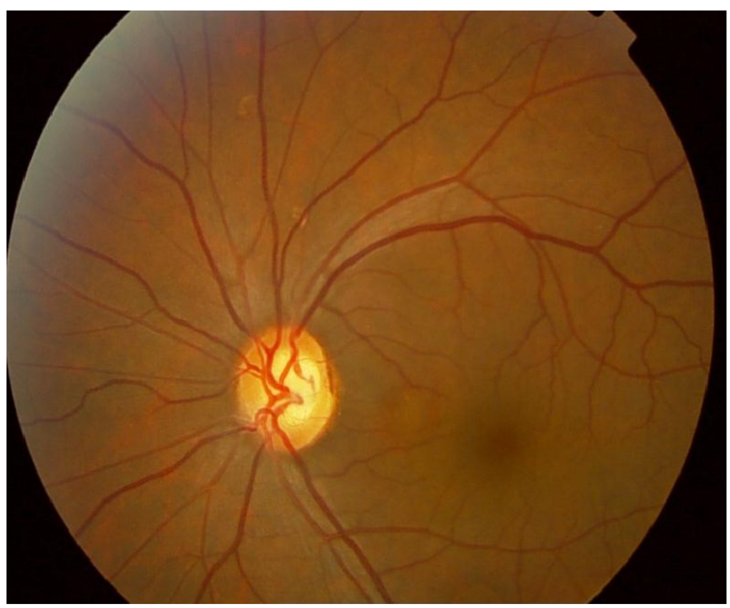

Figure.2.1 Input Retinal Original image

Figure 2.2 Histogram equalized image

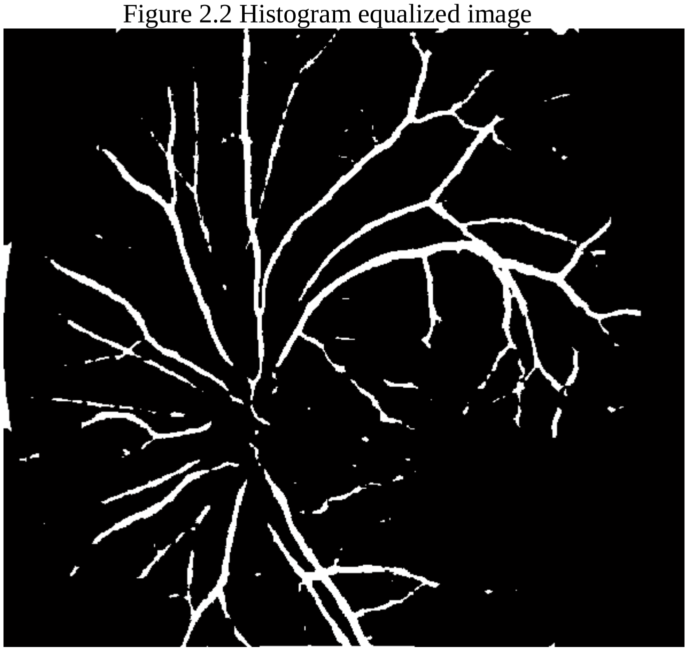

Figure 2.3 out put of Extracted blood vessels

3. BLOOD VESSEL EXTRACTION USING MORPHOLOGICAL OPERATION

In this method, the retinal image is taken as the input image. Then the input retinal image is pre-processed. In pre-processing stage, the input image is resized to [576,576] and the green channel image is separated as the blood vessel appears brighter in the green channel image. Then morphological operation is performed on the green channel image.

The primary morphological operations are dilation and erosion. The more complex morphological operations are opening and closing. Dilation is an operation that grows or thickens objects in a binary image. The specific manner and extent of this thickening is controlled by shape referred to a structuring element. Dilation is defined in terms of set operation. Erosion shrinks or thins objects in a binary image. The manner and extent of shrinking is controlled by a structuring element.

Subtractions of closed images across two different scales (S1 and S2 be size of structuring elements) give the blood vessel segments of image. Disk shaped structuring element is used. S2 is set as high value so that the main blood vessels get closed. S1 is chosen as 1 or 2 pixels below S2 to obtain thicker blood vessels or S1 is chosen as at least 4 pixels below S2 to obtain entire blood vessels.

Then edge detection is performed on the morphologically operated image. Laplacian and Gaussian operator detects the blood vessels accurately. Then thresholding is performed on the edge detected image. The blood vessel edges are thinned to a single line width. Then the blood vessels are smoothed. Smoothing function is used to smooth the thinned image for the betterment of blood vessel extraction. The smoothing is performed using box method with window size 5. Figure 3(c) shows the blood vessel extraction using morphological operation.

Figure 3.1 Original image

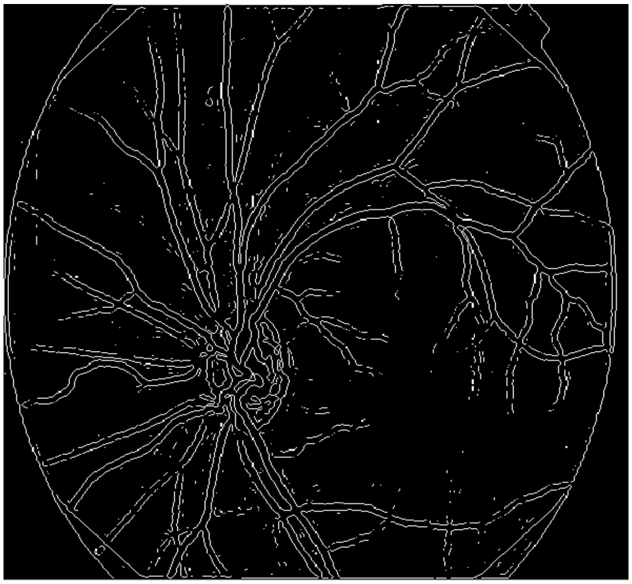

Figure 3.2 morphologically thinned image

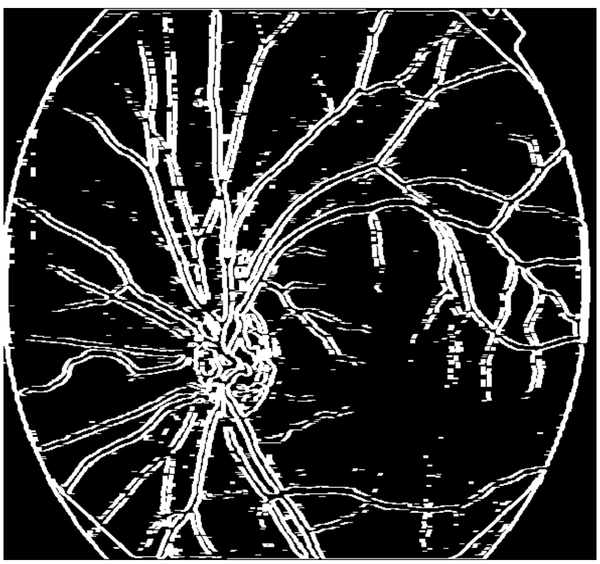

Figure 3.3 Extracted blood vessels

The PSNR values for 50 images are calculated and the average is shown in the table 1.

Table 1

Method	Wiener filter	Morphological method
PSNR(average)	5.6861	5.8025

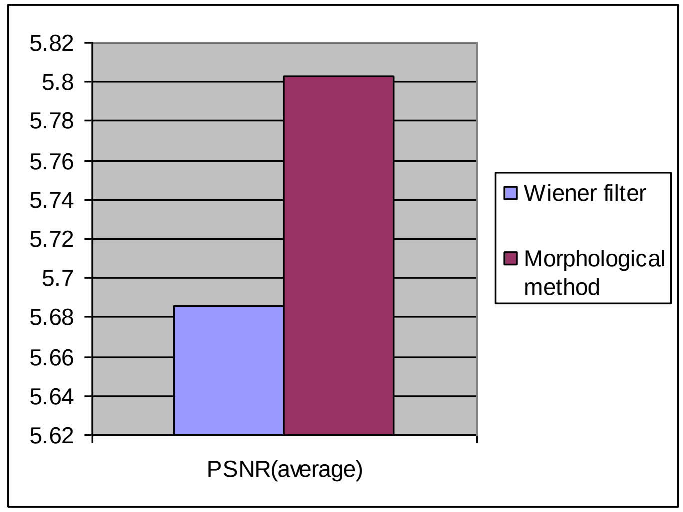

Figure 3.4 Extracted blood vessel and Wiener filter

4. CONCLUSION

The green channel image from RGB image is taken and the blood vessel is extracted from the retinal image. The extraction is done using wiener filter and morphological operation. The average PSNR obtained from the 50 retinal images shows that the performance is better in morphological operation. This extraction is important in the diagnosis of diabetic retinopathy. Once the blood vessel is extracted and segmented then the exudates can be easily detected. The optic disk and exudates can be detected in future. Also the thickness of the vessel and other anatomical features can be measured.

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Author Biography

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