EFFECT OF CONTRAST ENHANCEMENT IN RETINAL BLOOD VESSEL IMAGE SEGMENTATION

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***Abstract*: The retina has two sources of oxygen and nutrients: the retinal blood vessels and the choroid, which lies under the retinal pigment epithelium. The blood vessels within the retina itself that carry oxygen and nutrients are called arteries. Blood vessel is also very useful in tracking of disease progression. Assessment of blood vessels network plays an important role in a variety of medical disorders. Detection and quantitative measurement of variations in the retinal blood vessels can help diagnose several diseases including diabetic retinopathy. Morphological operation to smoothen the background, Disc structuring elements were used in this work. The proposed algorithm has employed modules such as gray scale conversation, contrast enhancement, morphological operation .The techniques describe in the paper is based on morphological operation and apply on the publicly available DRIVE and STARE datasets. An average accuracy of 0.96 has been respectively achieved on the DRIVE and STARE datasets, which are not only greater than most methods, but are also superior to the second human observer's performance. Paper mainly describes effect of contrast enhancement in detection of blood vessels. The results show that the proposed method gives good results with less time complexity.**

***IndexTerms*: contrast enhancement, blood vessels, Morphological operations**

I. INTRODUCTION

Several pathologies affecting the retinal vascular structures due to diabetic retinopathy can be found in retinal images. Retinal images are influenced by all the factors that affect the body vasculature in general. The human eye is a unique region of the human body where the vascular condition can be directly observed. In addition to fovea and optic disc, the blood vessels contribute one of the main features of retinal fundus image and several of its properties are noticeably affected by worldwide major diseases such as diabetes, hypertension, and arteriosclerosis[1]. Further, certain eye diseases such as choroidal neovascularization and retinal artery occlusion also make changes in the retinal vasculature. As per previous statement, the segmentation of blood vessels in retinal images can be a valuable aid for the detection of diabetic retinopathy and glaucoma diagnosis. Automatic and accurate blood vessel segmentation system could provide several useful features for diagnosis of various retinal diseases, and reduce the doctors' workload. However, the retinal images have low contrast, and large variability is presented in the image acquisition process which deteriorates automatic blood vessel segmentation results.

An automated segmentation and inspection of retinal blood vessel features such as diameter, color and tortuosity as well as the optic disc morphology allows ophthalmologist and eye care specialists to perform mass vision screening exams for early detection of retinal diseases and treatment evaluation. This could prevent and reduce vision impairments; age related diseases and many cardiovascular diseases as well as reducing the cost of the screening. Over the past few years, several segmentation techniques have been employed for the segmentation of retinal structures such as blood vessels and optic disc and diseases like lesions in fundus retinal images. However the acquisition of fundus retinal images under different conditions of illumination, resolution and field of view (FOV) and the overlapping tissue in the retina cause a significant degradation to the performance of automated blood vessel and optic disc segmentations. Diabetic retinopathy is a complication of diabetes and is a major cause of blindness in developed countries. The patients might not notice a loss of vision until it became too severe, hence early diagnosis and timely treatment is vital to delay or prevent visual impair and even blindness[2]. Retinal vessel segmentation can simplify screening for retinopathy by reducing the number of false positive results in micro aneurysm detection and may serve as a means of image registration from the same patient taken at different times by delineating the location of the optic disc and fovea. However, manual detection of blood vessels is not simple because the vessels in a retinal image are complex and have low contrast.
Detecting abnormalities such as venous looping or beadings is critical for early treatment as they are in most cases indication of potentially sight-threatening retinopathy. In order to utilize these useful characteristics of retinal blood vessels, it is very important to obtain their locations and shapes accurately. Blood vessels appeared as networks of either deep red or orange-red filaments that originated within the optic disc and were of progressively diminishing width. Several approaches for extracting retinal image vessels have been developed which can be divided as; one consists of supervised classifier-based algorithms and the other utilizes tracking-based approaches. Supervised classifier-based algorithm usually comprise of two steps. First, a low-level algorithm produces segmentation of spatially connected Regions.

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II. LITERATURE SURVEY

In [1], The Fuzzy Cmeans (FCM) clustering algorithm was used to classify the feature vectors into vessel or non-vessel based on the texture properties. They compared their method with hand labeled ground truth segmentation for five images and achieved 84.37% sensitivity and 99.61% specificity.

In [2] a hybrid method for efficient segmentation of multiple oriented blood vessels is proposed. Initially, the appearance of the blood vessels is enhanced and background noise is suppressed with the set of real component of a complex Gabor filters. Then the vessel pixels are detected in the vessel enhanced image using entropic thresholding based on gray level co-occurrence matrix.

In [3] first the simultaneous two-boundary segmentation problem is modeled as a two-slice, 3-D surface segmentation problem, which is further converted into the problem of computing a minimum closed set in a node-weighted graph.

In [4] the contrast enhancement and thresholding offers an automated segmentation procedure for retinal blood vessels on 40 images collected from DRIVE database. None of the techniques quoted above has been tested on large volumes of retinal images. They were found to fail for large numbers of retinal images, in contrast with the successful performance of morphological operation.

In [5], Xiayu et al. used graph based approach for blood vessel boundary delineation. The widths of the retinal blood vessels are measured and its edges are segmented. The graph is constructed based on the vessels weight. The REVIEW database was used in this work. This paper has some deficiencies, such as the crossing points and branching points are currently not treated individually, and consequently the blood vessel detection points are not clearly indicated.

In [6], Benson et al. proposed line-shape concavity measuring model to remove dark lesions which have an intensity structure different from the line-shaped vessels in a retina. This method achieved 95.67% of an average accuracy for the blood vessel detection with respect to ground truth images in DRIVE database, while provided 95.56 % of an average accuracy for the blood vessel detection with respect to ground truth images in STARE database.

In [7], Miguel et al. presented multi-scale feature extraction and region growing algorithm for retinal blood vessels segmentation. This implementation allowed a faster processing of these images and was based on a data partitioning

III. PUBLICLY AVAILABLE RETINAL IMAGE DATABASES

A summary of all the publicly available retinal image databases known to us is given in this section. Most of the retinal vessel segmentation methodologies are evaluated on two databases (DRIVE and STARE).

1. DRIVE database

The DRIVE (Digital Retinal Images for Vessel Extraction) is a publicly available database, consisting of a total of 40 color\ fundus photographs. The photographs were obtained from a diabetic retinopathy screening program in the Netherlands. The screening population consisted of 453 subjects between 31 and 86 years of age. Each image has been JPEG compressed, which is common practice in screening programs. Of the 40 images in the database, 7 contain pathology, namely exudates, hemorrhages and pigment epithelium changes. See Fig. 2 for an example of both a normal and a pathological image. The images were acquired using a Canon CR5 non-mydriatic 3-CCD camera with a 45◦ field of view (FOV). Each image is captured using 8 bits per color plane at 768 × 584 pixels. The FOV of each image is circular with a diameter of approximately 540 pixels. The set of 40 images was divided into a test and training set both containing 20 images. Three observers, the first and second author and a computer science student manually segmented a number of images[8]. All observers were trained by an experienced ophthalmologist (the last author). The first observer segmented 14 images of the training set while the second observer segmented the other 6 images. The test setwas segmented twice resulting in a set X and Y. Set Xwas segmented by both the first and second observer (13 and 7 images, respectively) while set Y was completely segmented by the third observer. The performance of the vessel segmentation algorithms is measured on the test set. In set X the observers marked 577,649 pixels as vessel and 3,960,494 as background (12.7% vessel). In set Y 556,532 pixels are marked as vessel and 3,981,611 as background (12.3% vessel).

2. STARE database

The STARE database contains 20 images for blood vessel segmentation; ten of these contain pathology. Fig. 3 shows retinal images from the STARE database. The digitized slides are captured by a Top Con TRV-50 fundus camera at 35◦ field of view. The slides were digitized to 605 ×700 pixels, 8 bits per color channel. The approximate diameter of the FOV is 650 × 500 pixels. Two observers manually segmented all the images. The first observer segmented 10.4% of pixels as vessel, against 14.9% vessels for the second observer. The difference in segmentation between the two observers is due to the fact that the second observer segmented many more of the thinner vessels than the first one. Performance is computed with the segmentation of the first observer as the ground truth.

IV. PROPOSED RETINAL VESSEL SEGMENTATION METHOD

This research work is to implement the blood vessel detection in retina in MATLAB. It is an effort to further grasp the fundamentals of MATLAB and validate it as a powerful application tool. There are basically different files. Each of them consists of m-file and figure file. These are the programmable files containing the information about the images. The flow chart of proposed method for blood vessel detection is shown in Fig.The proposed method uses the following steps: (1) Gray Scale conversion (2) Gaussian smoothing (3) Contrast enhancement (4) morphological operations

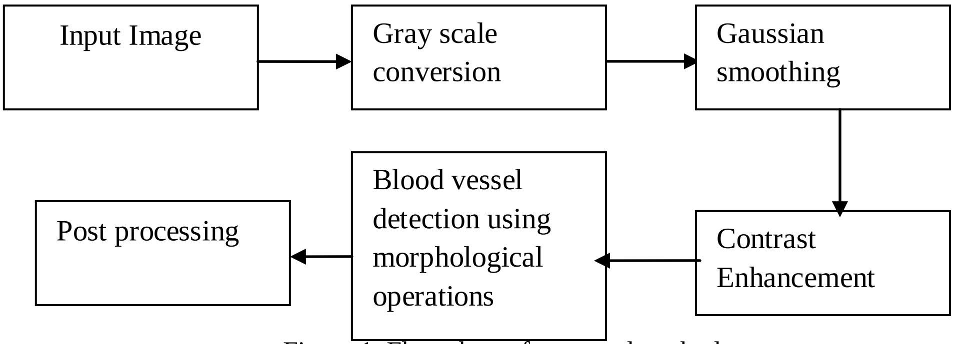


Figure 1. Flow chart of proposed method

1. Gaussian Smoothing

In image processing, a Gaussian blur (also known as Gaussian smoothing) is the result of blurring an image by a Gaussian function. It is a widely used effect in graphics software, typically to reduce image noise and reduce detail.

2. Contrast Enhancement

Image enhancement techniques have been widely used in many applications of image processing where the subjective quality of images is important for human interpretation. Contrast is an important factor in any subjective evaluation of image quality. Contrast is created by the difference in luminance reflected from two adjacent surfaces. In other words, contrast is the difference in visual properties that makes an object distinguishable from other objects and the background. In visual perception, contrast is determined by the difference in the colour and brightness of the object with other objects. Our visual system is more sensitive to contrast than absolute luminance; therefore, we can perceive the world similarly regardless of the considerable changes in illumination conditions[9]. Many algorithms for accomplishing contrast enhancement have been developed and applied to problems in image processing.

3. Blood vessel detection using morphological operation

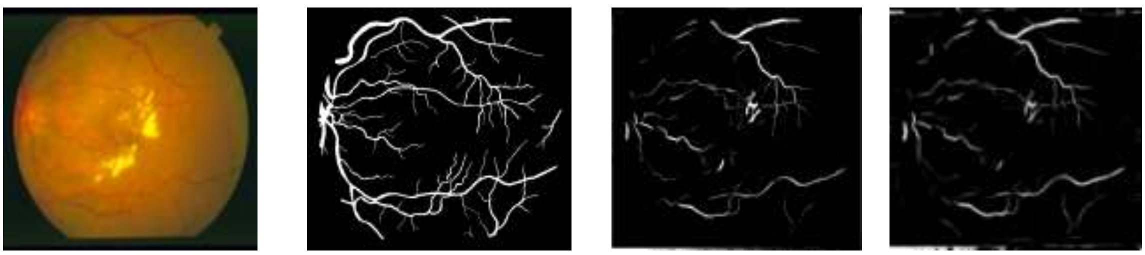
The primary morphological operations are dilation and erosion. The more complex morphological operations are opening and closing. Dilation is an operation that grows or thickens objects in a binary image[10]. The specific manner and extent of this thickening is controlled by shape referred to a structuring 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.

4. Post processing

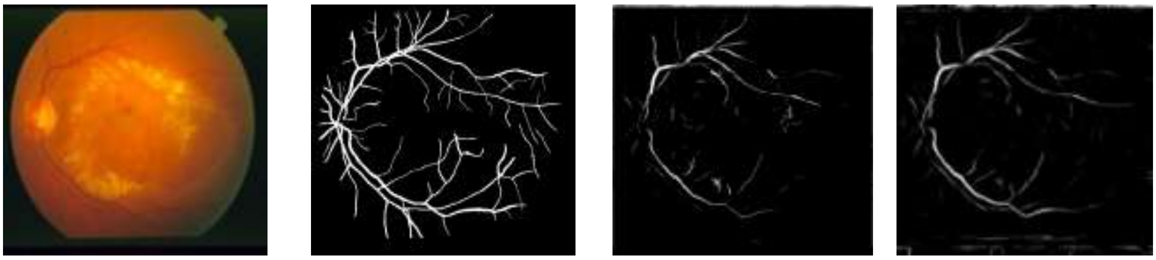
Finally, in the visual inspection, small isolated regions misclassified as blood vessels are also observed. If the vessel region is connected with no more than 30 pixels, it will be reclassified as non-vessel.

V. RESULTS AND DISCUSSIONS

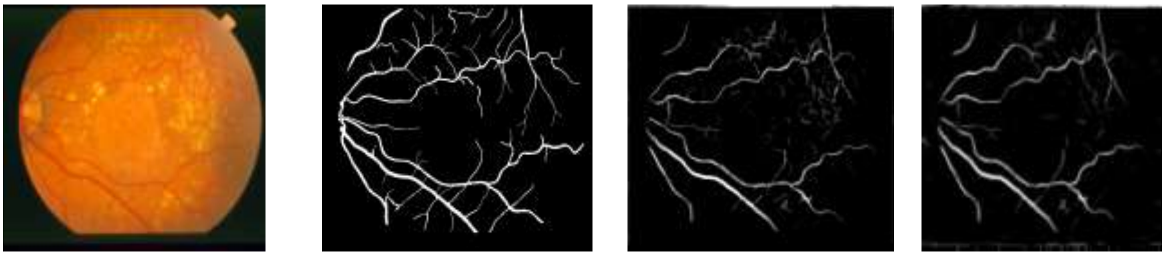
The proposed blood vessel detection and segmentation methodology is applied on images available in DRIVE and STARE databases and the segmentation results were compared with their respective ground truth images.
To measure the performance of the proposed method for the detection of blood vessels on the fundus image, the proposed vessel segmentation method is compared to its corresponding ground truth images. The performance of proposed vessel detected image is experimentally validated with ground truth images



1(a) 1 (b) 1 (c) 1 (d)



2(a) 2(b) 2 (c) 2 (d)



3(a) 3(b) 3(c) 3 (d)

Figure 2. Detection Results (a)Input image (b) Ground truth Image (c) Results w/o contrast enhancement (d) Results with contrast enhancement

Images	Accuracy		Time complexity(sec)	
	Image w/o enhancement	Image with enhancement	Image w/o enhancement	Image with enhancement
1	0.956	0.96.7	47.87	48.17
2	0.943	0.96	47.17	48.69
3	0.924	0.953	47.27	48.09

Table 1. Performance results on DRIVE database images, as per Accuracy and Time complexity

From performance results we can see that blood vessels are effectively detected in Contrast enhancement results compared to w/o contrast enhancement results with lower compromise in time complexity.

VI. CONCLUSION

This study shows the effect of contrast enhancement in retinal blood vessels detection. Contrast is an important factor in any subjective evaluation of image quality. Many algorithms for accomplishing contrast enhancement have been developed and applied to problems in image processing. Morphological operations applied after enhancement for detection. Our method is applied on the DRIVE and the STARE database with available gold standard images. From the visual inspection and quantitative validation of our method in the experiments, it is evident that our method gives better results with lower compromise in time complexity.

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