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Extraction of Retinal Blood Vessels in Colour Retinal Images: An Analysis

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Abstract: ***Medical imaging is the process of visualizing the interior components of the human body for diagnostic purposes. Nowadays medical imaging has become a very essential tool in the medical field. In medical imaging, digital image processing and pattern recognition techniques help in finding retinal diseases. In retinal image analysis changes in retinal Blood Vessels (BVs) aids in identifying retinal vascular diseases such as Diabetic Retinopathy (DR), Macular Edema and Glaucoma. In this review article, a concise introduction to retinal blood vessels is provided, and segmentation methods and techniques are described in detail. This paper also addresses the segmentation of BVs-related issues.***

Keywords: Diabetic Retinopathy (DR), Diabetic Maculopathy (DM), Blood Vessels (BVs)

1. Introduction

The macula, an area that contains light-sensitive cells, allows light to enter the human retina, a stratified sensory tissue lining at the back of the eye, where it is converted into electrical signals. These electrical signals are transmitted to the brain via the optic disc and converted into visual images. Since the human retina is very important for vision and retinal BVs are one of the most significant anatomical components of it. Retinal BVs appear as a tree-like structure that helps in carrying blood and oxygen to the retina. For proper functioning of the retina, BVs must be normal if not it affects the vision which may lead to blindness [1]. Figure1 shows retina and its BVs.

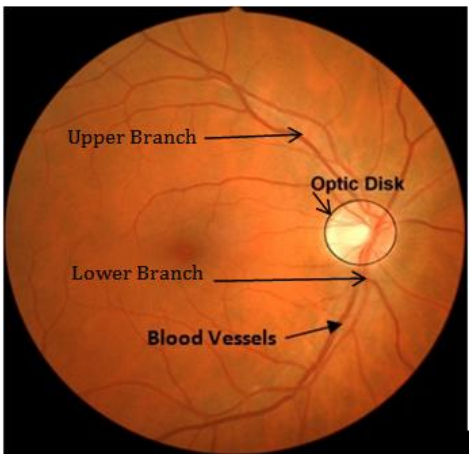

Figure 1: Retina and BVs

Through the optic nerve, the main retinal BVs enters the eye and divides into higher and lower branches. Then these vessels split out more like the branches of a tree, until the when they frame a fine thin BVs called capillaries. Generally, BVs damage happens in the human retina because of thin BVs present in the retina. The damage to the retinal BVs affects the human eye and the retina, if damage happens to the retinal BVs and not identified in an early stage then loss of vision can take place. Identification of changes in the retinal BVs helps in detecting retinal diseases like DR, Diabetic Maculopathy (DM), and Glaucoma etc.

The causes for BVs damage in the retina are unidentified. It may happen even when the BVs become too thin. However, some of the risk factors that affect the flow of blood in the human retina and damage the retinal BVs are listed below [2].

- Diabetes
- High blood pressure
- Blood clots
- Heart problems
- High cholesterol
- Being overweight
- Regular use of drugs (Mainly Antibiotics)
- Older age people (age above 60)
- Glaucoma
- Smoking

The remainder of the survey paper is organized as follows: Section 2 provides a concise overview of the literature on BVs extraction, and Section 3 discusses the issues involved in OD detection. Section 4 presents the conclusion to the paper.

2. Literature Survey

Blood vessels are crucial to the effective functioning of the retina in the human eye. If the functioning of BVs are not proper it leads to retinal disorders that affect the vision. Automatic segmentation of BVs helps in finding the retinal

vascular disorders. Extraction of BVs is a basic step in identifying the affected vascular area. There are a number of methods/techniques for BVs extraction; some of them are discussed below.

In [3], author Jyothiprava Dash and Nilamani Bhoi proposed a procedure, in which CLAHE and a median filter are used to enhance the input image before blood vessels are extracted using a thresholding-based technique. Mean-thresholding is then used to segment the enhanced image. Finally, the morphological operation is used to eliminate unwanted areas and pixels. On the CHASE_DB1 and DRIVE datasets, the technique obtained 95.4% and 95.5% accuracy, respectively.

In [4], author Aziah Ali et. al used an unsupervised method with automatic thresholding to extract BVs from the color retinal fundus image. Initially, the green channel image is utilized to produce Gabor Feature image (GF) with the help Gabor Wavelet. To highlight the BVs, vessel-enhancement of both green channel and GF image is done. Then by using automatic thresholding it is converted into binary image to get final vessel output. This algorithm is evaluated on the DRIVE dataset and achieves an accuracy of 94.53%.

Author Zhun Fan, et. al [5], developed a new way to improve blood vessel segmentation. By using the region feature of BVs trimap is automatically generated and then by using this matting model BVs pixel value from unknown region is extracted. This method's accuracy on the STARE, DRIVE, and CHASE_DB1 datasets was 95.7%, 96.0%, and 95.5%, respectively.

In [6], author Mariem et. al, used anisotropic diffusion filtering to re-establish the detached vessel lines and to get rid of noisy lines. Then multiscale line tracking is used to detect all vessels. This method was evaluated using the DRIVE dataset and obtained a 94.02% accuracy rate.

Author D. Siva Sundhara Raja and S. Vasuki [7] segmenting the retinal optic disc was proposed as a method for autonomous blood vessel segmentation. Firstly, using anisotropic diffusion filter, the optic disc is segmented. Later, using morphological operations retinal blood vessels are extracted. On the DRIVE and STARE datasets, this method attained 98.08 percent and 9.94 percent accuracy, respectively.

In [8], the author Thitiporn et. al, to get Matched Filter Response (MFR) image blood vessels are enhanced using matched filters. Then, the entropy thresholding scheme is used to distinguish vessels and backgrounds in MFR image. Later, filtering techniques are used to reject misclassified pixels. Finally, a window based probing process is used to detect the vascular intersections. The execution time for each image is approximately 3 minutes.

In [9], the author A. Elbalaoui, M. Fakir enhanced the green channel image using CLAHE. Then, using a vesselness filter the blood vessels are enhanced. Finally, the adaptive thresholding is used to detect BVs from the output of the vesselness filter. On the STARE, DRIVE, and CHASE_DB1 databases, this algorithm attained an accuracy of 93.26 %, 94.43 %, and 92.98 % respectively.

In [10], the author Ambaji S. Jadhav, BVs were extracted from an RGB image by enhancing the green channel. Initially, by using histogram equalization and CLAHE retinal image quality is improved. The grayscale image is then converted to a binary image. Finally, apply first level and second level segmentation along with enhancement filters for vessel detection. This algorithm is tested on DRIVE, CHASE_DB1 database and accuracy of 92.3%, 82.6% is achieved respectively.

In [11], the author Gehad Hassan et. al, developed an automated blood vessel extraction method. In pre-processing mathematical morphology with k mean clustering is applied to enhance quality of the image and to curb the underlying information. The blood vessels are finally segmented using k-mean clustering. This method is evaluated using the DRIVE dataset and achieved normal correctness of 95.10% and top correctness of 96.25%.

3. Issues in retinal blood vessels detection

- Blood vessel extraction is difficult because of variation in terms of width and diameter.
- Poor quality of retinal image makes blood vessel detection difficult.
- Low illumination of thin blood vessels than the background illumination complexes the segmentation task.
- Presence of new abnormal blood vessels creates problems in normal blood vessel segmentation.
- The Existence of more hard exudates and Drusens in the retina makes blood vessels detection complex.
- Segmentation of blood vessels becomes tricky because of similar intensity properties between the blood vessels and fovea.
- Detection of all blood vessels within the OD region becomes difficult because of the OD brightness.
- It is very difficult to extract blood vessels in the severe stage of DR, DM because in severe stage damage to the retinal blood vessels is more.

4. Conclusion

Blood vessels are one of the important anatomical components of the retina and extraction of BVs plays a major role in detecting many vascular disorders. Variation In the retinal blood vessels indicates different retinal diseases like diabetes, glaucoma and other retinal disease. By detecting and analyzing blood vessels structure of retinal images we can detect the retinal disease at an earlier stage, this helps to give proper treatment for the disease. In this survey paper, a brief introduction about retina and BVs is presented. Existing methods/techniques used for detecting BVs are discussed and this paper also addresses issues associated with BVs extraction.

As we have seen in the literature review section, there are many techniques/methods to extract the retinal BVs. Even though a lot of work has been done in retinal BVs extraction,

still there is a scope for improvement in accurate extraction of BVs and computation time and complexity using machine learning and deep learning such as Neural Network, Deep Convolutional Neural Network and five layers Convolution Neural Network with drop out mechanism.

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