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Research paper

Retinal vessel feature extraction from fundus image using image processing techniques

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Abstract

Retinal Vessel detection for retinal images play crucial role in medical field for proper diagnosis and treatment of various diseases like diabetic retinopathy, hypertensive retinopathy etc. This paper deals with image processing techniques for automatic analysis of blood vessel detection of fundus retinal image using MATLAB tool. This approach uses intensity information and local phase based enhancement filter techniques and morphological operators to provide better accuracy.
Objective: The effect of diabetes on the eye is called Diabetic Retinopathy. At the early stages of the disease, blood vessels in the retina become weakened and leak, forming small hemorrhages. As the disease progress, blood vessels may block, and sometimes leads to permanent vision loss. To help Clinicians in diagnosis of diabetic retinopathy in retinal images with an early detection of abnormalities with automated tools.
Methods: Fundus photography is an imaging technology used to capture retinal images in diabetic patient through fundus camera. Adaptive Thresholding is used as pre-processing techniques to increase the contrast, and filters are applied to enhance the image quality. Morphological processing is used to detect the shape of blood vessels as they are nonlinear in nature.
Results: Image features like, Mean and Standard deviation and entropy, for textural analysis of image with Gray Level Co-occurrence Matrix features like contrast and Energy are calculated for detected vessels.
Conclusion: In diabetic patients eyes are affected severely compared to other organs. Early detection of vessel structure in retinal images with computer assisted tools may assist Clinicians for proper diagnosis and pathology.

Keywords: *Diabetic Retinopathy; Green Channel Extraction; Statistical Features.*

1. Introduction

Recent statistics from World Health Organisation (WHO) states that more than 250 million people are affected by Diabetes. People with diabetes can have eye disease called Diabetic retinopathy (DR), where blood vessels in retina can become weak and swell, and sometimes abnormal vessels may grow in retina, may lead to permanent visual loss in human beings. Early detection of the disease in retinal vessels with computer assisted techniques may assist clinicians to diagnose properly and to follow remedial methods to cure. Image processing techniques helps doctors/clinicians with less complexity and fast recognition. The blood vessels in retinal images are nonlinear in nature. In literature [1], various approaches used to detect blood vessels like edge detection, contour detection and some morphological methods. Each method has its own limitations, which are used for segmentation of medical images. Still it's a challenging problem to detect blood vessels exactly.

2. System implementation

Normal and Diabetic Retinopathy (DR) images are obtained from fundus photography of DRIVE data set. The steps followed are pre-processing the image, filters are used to enhance local phase details and morphological operators applied to detect interested region (i.e. blood vessels in the retina) form the fundus photographic image. Statistical features are calculated for the detected vessels.

3. Pre-processing

In pre-processing stage, green channel is extracted from the original RGB image, as it consists of more information with high PSNR as compared to Red and Blue channel. The image is resized to 256 X 256, for easy process and converted to grey scale image.

4. Histogram processing

Histogram is a graphical representation of grey level images with range of intensities. It gives the details about the frequency of occurrence of image elements called pixels with various intensity levels. This paper uses intensity based information.[6] Intensity of each and every pixel in an image plays major role in detecting blood vessels. From the histogram, processing adaptive threshold value is obtained to increase the contrast levels of the image. Blood vessels are nonlinear in nature, so to increase brightness level, Cauchy filter kernels [4] & [7] are applied to enhance the image further processing. As the blood vessels are nonlinear in nature enhancing filters are more useful to detect the required/interested region.

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5. Image segmentation

Image segmentation is useful to extract the interested region in a given image. It is mainly classified into supervised and unsupervised methods. Supervised methods use priori knowledge for segmentation and training of classifier is needed. Whereas unsupervised methods use local and global features to extract the interested region. With cluster analysis, un-supervised learning uses minimum description of features, so the computational complexity is less. Morphological operators [9] and Wavelet filters are used to extract the blood vessels in Retinal images. Signal can be decomposed into several bands with wavelets [3], [5], which is not possible with conventional filters as they mainly based on Fourier transform. Statistical features like correlation, energy, homogeneity are calculated.

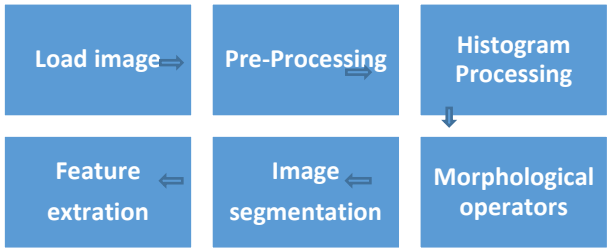


Fig. 1: Flow Chart for System Implementation.

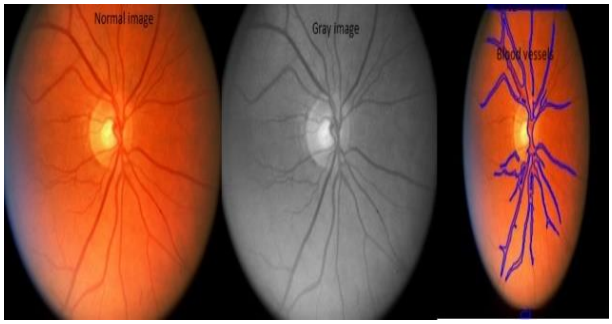


Fig. 2: Images of Normal, Grey Scale and with Highlighted Blood Vessels.

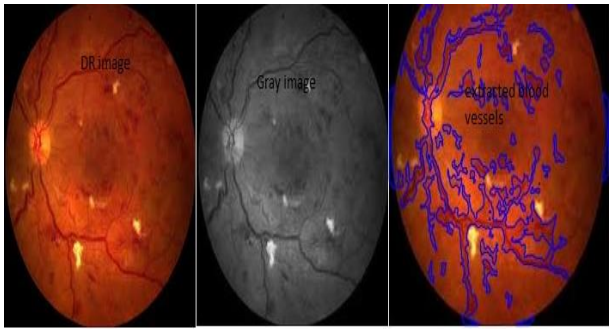


Fig. 3: Diabetic Retinopathy Image with Highlighted Blood Vessels.

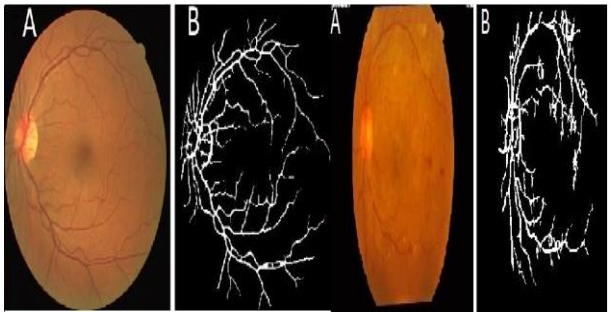


Fig. 4: Real Image and DR Images with Extracted Blood Vessels.

Feature extraction: Image features plays crucial role in automated detection. [2]
Mean μ, used to smooth pixel data of the fundus image. Mean μ of the interested region estimates the central clustering position.

$$\text{Mean} = \frac{1}{MN}\Sigma_{i=1}^{M}\Sigma_{j=1}^{N}p(i,j) \quad (1)$$

Standard deviation: Standard deviation σ , is a measure of frequency distribution of pixel values in the given image. It describes the dispersion within the local region.

$$\sigma = \text{SQRT}\{\frac{1}{MN}\Sigma_{i=1}^{M}\Sigma_{j=1}^{N}p(i,j) - \mu^2 \quad (2)$$

Smoothness: It is a relative measure of grey level contrast, denoted with letter R. It is used establish descriptors of relative smoothness.

$$R = 1 - \frac{1}{1-\sigma^2} \quad (3)$$

Entropy: Entropy is a statistical measure of randomness used to characterize the texture of an image.

$$\hbar = -\Sigma_{k=0}^{i-1} p_k(\log_2 p_k) \quad (4)$$

Contrast: Contrast is a measure of intensity, denoted with letter C, gives details of contrast between a pixel and its neighbour over the whole image.

$$C = \Sigma_{i,j}|i-j|^2 P(i,j \quad (5)$$

Energy: Energy is also known as uniformity, it refers to sum of squared elements in Grey level co-occurrence matrix.

$$E = \Sigma_{i,j} P|i-j|^2 \quad (6)$$

Table 1: Statistical Data for Normal and DR Images

S. No	Features	Normal image	DR image
1.	Mean	0.0666	0.1625
2.	Standard Deviation	0.2493	0.3689
3.	Smooth-ness	0.1672	0.1518
4.	Entropy	0.0272	0.0225
5.	Contrast	1.3586	2.3134
6.	Energy	0.8483	0.6832

6. Results

Image features for Normal and Diabetic Retinopathy images are calculated using MATLAB, and tabulated in Table 1. It shows that Mean, standard deviation and contrast are increased, but smoothness, entropy and Energy are decreased for diseased image.

7. Conclusion

Automatic detection of diseased image with blood vessel detection, at an early stage helps clinicians, and leads to proper diagnosis with less time and complexity. In future, the extracted GLCM and other local global features can be used to train the network for deep learning.

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