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A Multiresolution Analysis Based Detection of Abnormalities for Retinal Pathologies

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ABSTRACT

Diabetic retinopathy is the vision-threatening damage to the retina of the eye caused by diabetes. Chronically high blood sugar from diabetes is related with damage to the tiny blood vessels in the retina, leading to diabetic retinopathy. The retinal swelling and deposits are the signs of early stages of the disease. In later stages, leakage from blood vessels can cause serious vision problems and eventually lead to blindness. Early detection of this disease can prevent vision loss. This paper proposes an approach which uses preprocessing with adaptive histogram equalization, segmentation of the vessels using curvelet transform, and active contour based detection of exudates. Abnormalities detection can be obtained using wavelet transform and active contour model in the retinal fundus image. The proposed method is tested on many images from DRIVE database and gives better results. Simulated results will be shown that the blood vessels and exudates can be effectively detected from retinal fundus images.

Keywords: Retina, multiresolution, blood vessel, fundus, curvelet.

1. INTRODUCTION

The retina detects light and converts it to signals sent through the optic nerve to the brain. Diabetic retinopathy can cause blood vessels in the retina to leak fluid or hemorrhage (bleed), distorting vision. In its most advanced stage, new abnormal blood vessels proliferate (increase in number) on the surface of the retina, which can lead to scarring and cell loss in the retina. Once high blood sugar damages blood vessels in the retina, they can leak fluid or bleed.

Diabetes is a disorder of metabolism. The energy required by the body is obtained from glucose which is produced as a result of food digestion. Digested food enters the body stream with the aid of a hormone called insulin which is produced by the pancreas, an organ that lies near the stomach. During eating, the pancreas automatically produces the correct amount of insulin needed for allowing glucose absorption from the blood into the cells. In individuals with diabetes, the pancreas either produces too little or no insulin or the cells do not react properly to the insulin that is produced. The buildup of glucose in the blood, overflows into the urine and then passes out of the body. Therefore, the body loses its main source of fuel even though the blood contains large amounts of glucose .The effect of diabetes on the eye is called Diabetic Retinopathy (DR). It is known to damage the small blood vessel of the retina and this might lead to loss of vision. So there is a need to detect blood vessels with faster algorithm. Faster segmentation can be achieved through the multi-scale image processing method [1].Since the blood vessels in retinal images are distributed in various directions, we use the morphology functions with multidirectional structure elements to extract the blood vessels from the retinal images [4].Curvelet transform is a fast transform [2].Automated blood vessel segmentation is an important issue for assessing retinal abnormalities and diagnoses of many diseases [8].The adaptive histogram equalization is applied to the images to enhance the contrast of the blood vessels [10].Morphological opening by reconstruction using multistructure elements removed the false edges, while preserved the thin vessel edges perfectly [5]. The performance evaluation

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that the curvelet based approach for retinal blood vessel analysis provides significant results when compared with other existing techniques [7].The segmented image can used for diagnosis of diseases like diabetic, and blind spot [3].

2. METHODOLOGY

This work is one of the method in the application of medical diagnosis in order to lessen the time and stress undergone by the ophthalmologist and other members of the team in the screening, diagnosis and treatment of diabetic retinopathy.

The method is divided into four phases: Pre-processing, Optic disc removal, Blood vessel segmentation, and Detection of exudates. In the first step of proposed methodology landmarks are segmented as it was described earlier they are optic disc and blood vessels. Then in the next step exudates are detected taken on a different image. Fig 1 shows a chart of the proposed scheme.

In this method, the retinal fundus image is preprocessed to enhance the vessels and segmented using curvelet transform. For diseased persons the diameter of the blood vessels may vary or otherwise there is a possibility for growth of new vessels when compared with normal person's blood vessels. The blood vessels get swallowed for diabetic patients and it gets narrower for glaucoma diseased patients[6].Curvelet transform contains more useful information than the source images, thus enabling the radiologists to locate the im-perfections accurately, making the treatment easier and perfect [9].

The Haar wavelet transform applied to the fundus image to decompose the image into Approximation and Detail Coefficient, and features are extracted and segment the class boundary. Finally, detection of abnormalities like exudates are detected for the use medical personnel in the hospital.

2.1. Pre-Processing Stage

In detecting abnormalities associated with fundus image, the images have to be preprocessed in order to correct the problems of uneven illumination problem. This section, which is Pre-Processing stage, can be regarded as the bedrock of this research work. The block diagram of the sub sections that constitute the Preprocessing

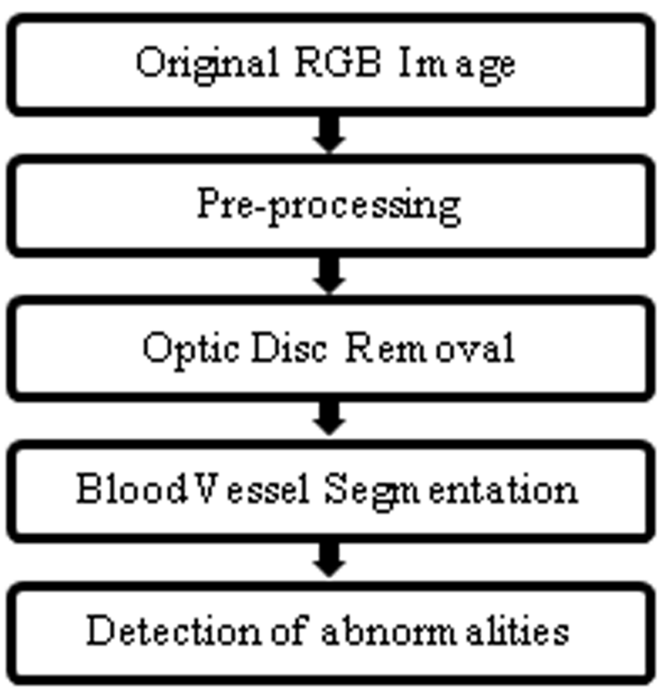

Figure 1: Block Diagram

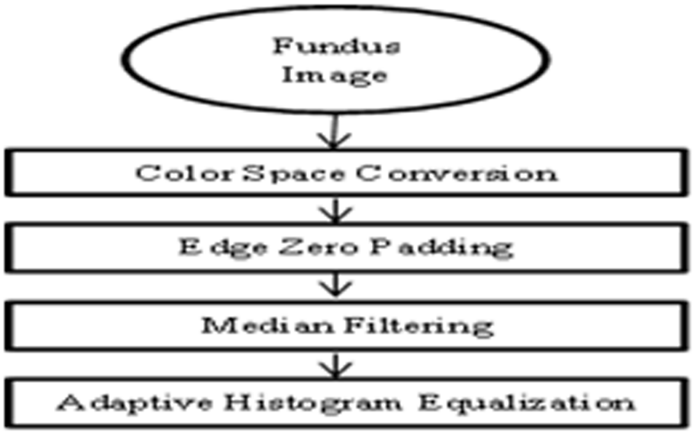

Figure 2:Preprocessing Stage

stage (PPS) is as shown in Fig- 2.First the retinal image is taken from the database and converted into grey scale image.

Basically preprocessing steps include contrast enhancement using Contrast Limited Adaptive Histogram Equalization (CLAHE) is applied as the original image taken is blurred and the contrast is very low. Hence to improve the contrast of the image is a very necessary step.

The first stage in pre-processing stage is the color space conversion. The input fundus image can be converted into a grey scale image. The result of this color space conversion section is fed to the edge padding section of PPS. In this subsection, the image is padded with zeros so as to remove unwanted noise that may be introduced during the intensity enhancement and segmentation stage and also to be able to calculate the minimum and maximum intensity value of the whole image.

The Algorithm is as follows.

Steps involve in zero padding a fundus image and obtaining minimum and maximum intensity value

Step 1 : Check for the size of image, zero padding value, and obtain origin coordinate

Step 2 : Create a zero matrix equal to image size

Step 3 : Fix the original image at the appropriate coordinateobtain in 1

Step 4 : Fill exterior of the mask with zero

Step 5 : Obtain the minimum and maximum intensity withinthe mask

Step 6 : Return the new zero padded image, minimum intensity and maximum intensity values.

2.2. Optic Disc Removal

The brightest feature of the normal fundus retinal image is optic disc and its shape is Oval. Normally in colored fundus images, the optic disc appears as a bright yellowish in color. The detection of optic disc in fundus images is an important task as it is similar in brightness, color and contrast to the exudates. So it is necessary to eliminate optic disc from the retinal image. The process of automatic detection/ localization of optic disc depend upon the correct detection of centroid (centre point) of the OD. The work that has been proposed for the removal of optic disc and it is illustrated in the Fig 3.

2.3. Segmentation of Blood Vessels

The multiresolution analysis based method curvelet transform are used for segmenting the vessels.

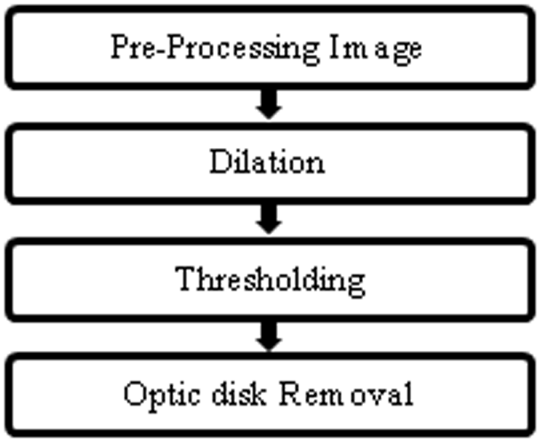

Figure 3: Flowchart of Optic Disc removal

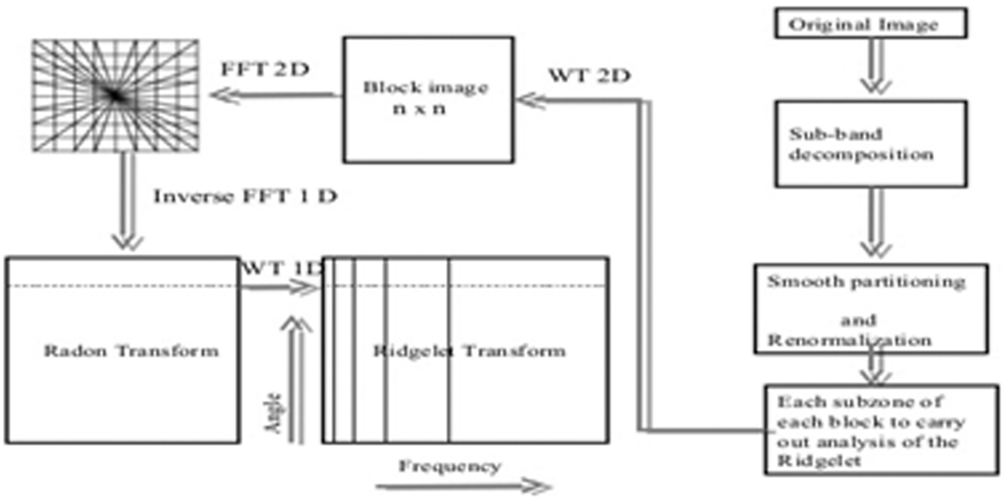

Figure 4: Process of Curvelet transform.

2.3.1. Curvelet Transform

Curvelets are appropriate bases for representing images which are smooth apart from singularities along smooth curves, where the curves have bounded curvature, i.e. where objects in the image have a minimum length scale.

Curvelets are designed to handle curves using only a small number of coefficients. Hence the Curvelet handles curve discontinuities well. Of course, curvelets are by no means the only instances of this vision which perceives those promising links between geometry and multiscale thinking and it process shown in Fig 4.

2.4. Detectionof Abnormalities

Early detection of DR is necessary for the prevention of visual loss. Exudates are one of the main signs of the DR. Due to their high occurrence; their detection would play an important role in the screening purpose, and helps in monitoring and for estimation of the disease. Hence automatic detection of exudates is a very crucial task because normally they have poor contrast, uneven illumination and color variation in retinal fundus images. Exudates become difficult to identify as the stage of diabetic retinopathy changes.

2.4.1. Wavelet Transform

- The DWT analyzes the image at different frequency bandwidth different resolutions by decomposing the signal into coarse approximation and detail information.

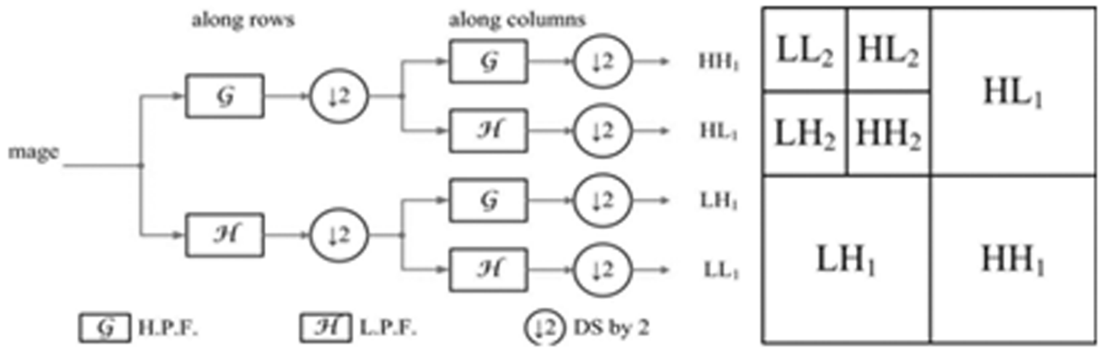

Figure 5: Decomposition of DWT

- DWT employs two sets of functions, called scaling functions and wavelet functions, which are associated with low pass and high pass filters, respectively.
- The decomposition of the signal into different frequency bands is simply obtained by successive high pass and low pass filtering of the time domain signal.

The decomposition is shown in Fig 5

3. RESULTS AND DISCUSSION

3.1. Preprocessing Stage

The input image is converted into grayscale and then zero padding and median filtering and adaptive histogram equalization.

As a result of this adaptive histogram equalization, the dark area in the input image that was badly illuminated has become brighter in the output image while the side that was highly illuminated remains or reduces so that the whole illumination of the image is same. It is worthy of mentioning that this method also used overlap mean in the final buildup of the image. The input and output images are shown in Fig 6 and Fig 7 respectively

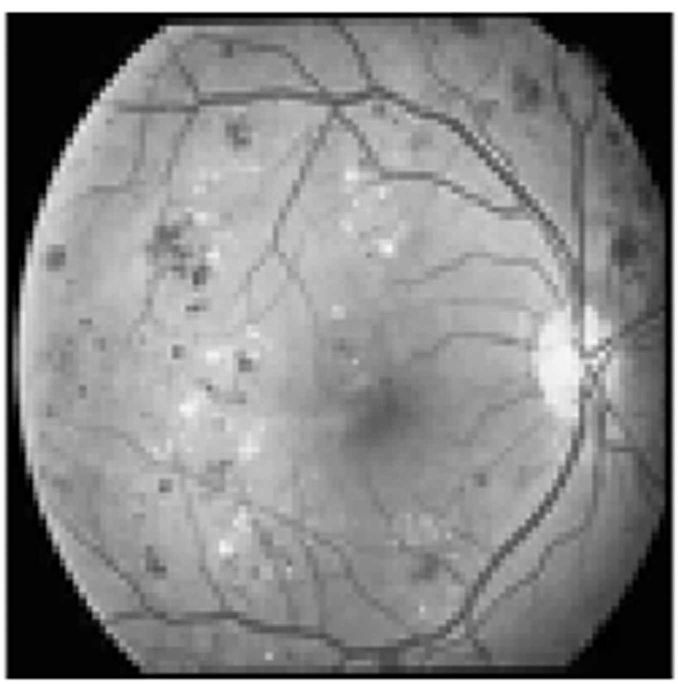

Figure 6: Input Fundus image

Figure 7: Pre-processed Image

3.2. Segmentation

The curvelet transform is used to segment the vessels in the retinal image. It is used to represent the images in different angles and different scales. A curvelet transform is used to segment the blood vessels based on its threshold value, and then they are filtering by the image and it uses high weighted pixels on its values after than the vessel is segmented. The filtering is used to remove the noises and enhancing the segmented vessels.. The segmented blood vessel is shown in Fig 8.

Figure 8: Segmented Blood vessel

3.3. Detection of Abnormalities

DWT provides a generalization of a multi resolution spectral analysis tool. The statistical features are extracted from wavelet sub bands to capture global statistical information of images at different scales. The active contour based method is used to detect the abnormalities.

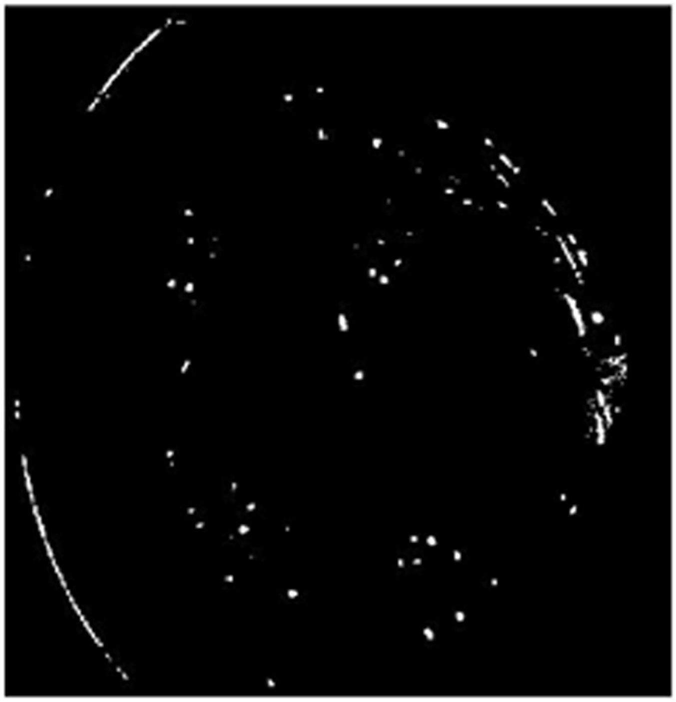

Figure 9: Detected Abnormalities

$$PSNR = 10 \log_{10}(255^2/MSE) \quad (1)$$

$$MSE = \frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n}\left\|I_o(i,j) - I_e(i,j)\right\|^2 - \quad (2)$$

The input retinal fundus image is taken from the DRIVE database and the proposed method tested with 20 images and average PSNR and MSE values are calculated as shown in the Eq(1) and Eq(2)and its value listed in the Table 1.

Table 1
Performance Analysis

Parameters	*Input Image as original*	*Output Image*
PSNR	46.71	77.41
MSE	0.72	0.01

4. CONCLUSION

The manual segmentation and measurement of DR lesions are quite difficult, proneto mistakes and time consuming. The results of the segmentation can vary depending on the image quality and experience of user. Hence for this application certain standard parameters are used to evaluate the segmentation performances. The performance of the proposed system is validated on test images of publicly available DRIVE database. It is seen that the proposed methodology achieves better accuracy in vessel segmentation when compared to the existing techniques. The future work in this area will include optimizing the registration algorithm to increase speed. This research also seeks to test the verification system on larger retina databases with high quality color images and multiple samples, when such become available.

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