DIABETIC RETINOPATHY DETECTION USING OPTIMISED GABOR FILTER WITH LOCAL ENTROPY THRESHOLDING

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Abstract: **Diabetic retinopathy (DR) is one of the largest cause of blindness that occurs to the retina due to diabetes mellitus. It is a serious sight-threatening complication of diabetes. Around 80 percent of the people having diabetes for 20 years or more are affected with diabetic retinopathy. Blood vessels in retina play a vital role in medical diagnosis of diabetic retinopathy. In addition, many diseases like hypertension, autoimmune disorders, high cholesterol, and cancer can also be detected. Segmentation of blood vessels is helpful for ophthalmologists to detect patients suffering with diabetic retinopathy.**

Imaging and computer vision systems offer the ability to quantitatively determine the human physiology. Manual interpretation requires tremendous amount of work, expertise, and processing time. Automated segmentation offers a varied range of applications in the field of biomedical imaging. In this project, an algorithm comprising optimized Gabor filter with local entropy Thresholding was utilized for automatic segmentation of blood vessels. The frequency and orientation of Gabor filter is tuned to match part of blood vessels that are to be enhanced. The classification of blood vessel pixels is done using local entropy Thresholding technique. The proposed algorithm is evaluated on the DRIVE database and is shown to provide an average accuracy (ACC) of 97.72% and sensitivity (Se) of 98.15%. Results indicate that the proposed approach presents a path toward precise and automated diabetic retinopathy diagnosis on a massive scale.

Keywords: *Diabetic mellitus, Retinal blood vessels, Diabetic retinopathy, Optimized Gabor filter, Local entropy thresholding*.

I. INTRODUCTION

This chapter gives an overview of extension in Automated segmentation of retinal blood vessels using Gabor filter with local entropy thresholding which was intimated in the below data. It crucially comprises of optimized Gabor filter with entropy threshold.

Background:

Diabetic Retinopathy (DR) is the result of damage due to diabetes to the very small blood vessels which are located in the retina. The blood vessels which are affected from diabetic retinopathy leads to vision loss. Diabetic retinopathy is a leading reason of adult blindness, and screening can decrease the incidence. Screening just increases the chances that a condition will be neglected, found early, or are able to be cured. It is widely suggested that all persons with diabetes should regularly check for diabetic retinopathy.

Computer aided analysis for automatic segmentation of blood vessels in retinal images will help ophthalmologists to screen larger patient database for vessel abnormalities. So many varieties of paths have been suggested for retina blood vessels segmentation. Many image processing methods proposed for retinal vessels extraction. This work is based on **"AUTOMATED SEGMENTATION OF RETINAL BLOOD VESSELS USING OPTIMIZED GABOR FILTER WITH LOCAL ENTROPY THRESHOLDING"**. Gabor filters have been widely applied to image processing and computer vision application problems such as face recognition and texture segmentation.

Gabor filter methods often give false positive detections and fail to detect vessel of different widths. And also detection process is much more complicated when retinal image abnormal condition. This paper has been proposed a much robust and fast method of retinal blood vessels extraction using optimized Gabor filter with local entropy thresholding.

Types of Diabetic Retinopathy:

This is a group of metabolic diseases in which a person has high blood sugar, either because the pancreas does not produce enough insulin, or because cells do not respond to the insulin produced by the body. This high blood sugar produces the classical symptoms of polyuria, polydipsia, and polyphagia .There are two main types of diabetes mellitus (DM).

- ***Diabetes mellitus Type1 (DM1)***

  Results from the body's failure to produce insulin, and currently requires the person to inject insulin or wear an insulin pump.

- ***Diabetes mellitus Type 2 (DM2)***

  This type results from insulin resistance, a condition in which cells fail to use insulin properly, sometimes combined with an absolute insulin deficiency. Others forms of diabetes mellitus are recognized, including a genetically mediated form secondary to endocrinopathies and drug –or chemical –induced diabetes mellitus. Diabetes mellitus affects the blood vessels leading to microvascular and macrovascular complications which manifest in the eyes, kidneys, brain, extremities and other parts of the body.

Materials:

The main material used to check the performance of the algorithm is done by using Matlab with drive software. The preferable software versions are 2012a, 2013a, 2013b and 2014a. Here we will take the image with pixel size above 256 pixels that is RGB image as shown below.

Fig: RGB color image

Proposed methodology:

The proposed algorithm contains the following steps they are:

(1) Original RGB color image.

(2) Original RED image.

(3) Green channel extraction.

(4) Gabor filter extracted image.

(5) Morphological clone.

(6) Entropy analysis.

(7) Histogram span.

(8) Highlighted probable areas.

(9) Gabor filter image response.

In this proposed system Blood vessels will normally have low local contrast compared to background. The proposed algorithm uses the following steps as given above. In this the green channel image extraction has high pixel size than the normal image that is the intensity of the image is increased. This is as shown below in the below figure.

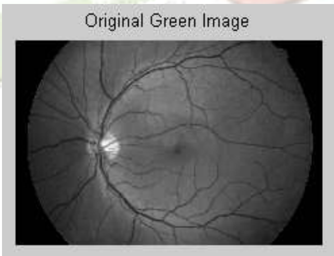


Fig: Green channel extracted image

Fig: standalone Gabor filter

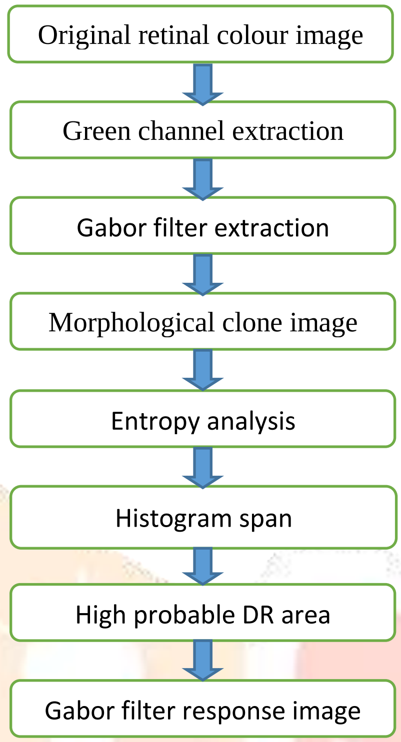
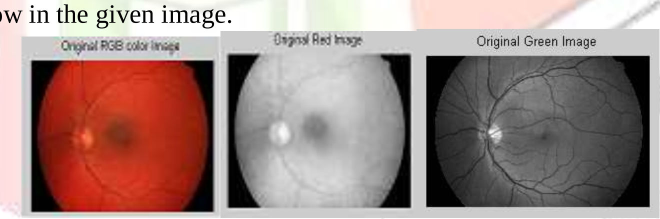


Fig: Flowchart of the proposed methodology

Preprocessing:

This done to remove the noise in the image where all the further processing are performed in the image with help of green channel extraction method which is also called as preprocessing. This algorithm is used to increase the contrast and intensity and precision of images and also helps to decrease some responses from abnormalities which do not resemble any blood vessels otherwise reduce the performance of blood vessels segmentation methods. The green channel extraction of the image is done to extract the quality of the image. This is as below in the given image.



(a) (b) (c)

Fig: (a) live image (b) binary image (c) green channel extracted image

Morphological clone:

To this the input image given is extracted with the help of morphological tools. This image is called morphologically cloned image. This is as shown below.

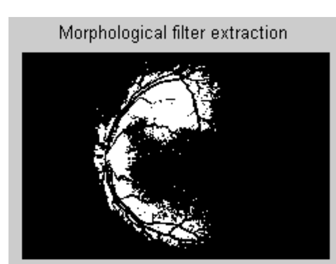


Fig: Morphological clone image

Optimized Gabor filter:

This filter is otherwise called as white Gaussian filter. It is used to remove the noise from the image. These are mainly of two dimensions they are

(1) 2-D
(2) 3-D

But here we will use 2-D filter where these are used for multi directional filtering purposes. Gabor filter is applied for detecting the blood vessel in retinal image. These Filters are a set of enhanced and frequency sensitive filters which have the optimal localization in both the frequency contents of the patterns. These are a set of band pass filters. Gabor filter kernels are sinusoids modulated.

$$\sum_x = K$$

$$\sum_y = \sum_x / \gamma$$

$$X_o = x \cos \theta + y \sin \theta$$

$$Y_o = -x \sin \theta + y \cos \theta$$

Optimized Gabor filter kernel:

$$g_\theta(x, y) = \exp\{-\frac{1}{2}(\frac{x^2{}_\theta}{\sigma_x} + \frac{(\gamma y_\theta)^2}{\sigma_y})\} \cos(2\pi \frac{x_\theta}{\lambda} + \psi)$$

Where,

$\sum$x: Standard deviation of Gaussian in x direction along the filter that determine the bandwidth of the filter.
$\sum$y: Standard deviation of Gaussian filter that control the orientation selectivity of the filter.
ϴ: Orientation of the filter, an angle of zero gives a filter responds to vertical feature.
λ: Wavelength of the cosine factor of the Gabor filter kernel i.e. preferred wavelength of this filter.
Ɣ: Spatial aspect ratio, specifies the elasticity of the support of the Gabor function.
ψ: Phase offset.

This Gabor filter image is rotated in different ways with optimized parameters set as follows

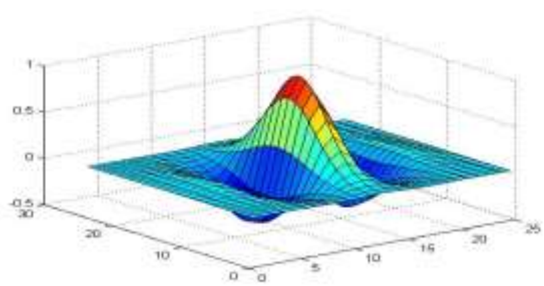
$$\sigma_x \in [3.91, 4], \lambda \in [5.1, 5.3], \gamma \in [1.2, 1.4]$$

λ = 5.7

Ɣ= 1.7

ψ= 2π

$\sum$x is required so that the shapes of the filter are invariant to the scale.
The width of the blood vessel is said to lie in between the range (1-15) pixels.



The above image is called Gabor response image. Here lambda and delta maintains false positive values. Ψ always maintains (2π) rotation phase in this method. Now let us see the Gabor response image as below.

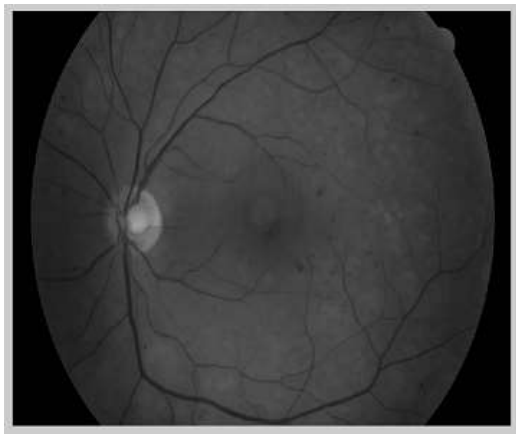


Fig: Gabor response image

Local Entropy Threshold:

Thresholding is the simplest method of image segmentation. From a grayscale image, thresholding can be used to create binary images. Image can be expressed as an information source with a probability vector described by its grey-level image histogram; histogram entropy can be used to represent a certain level of information contained in the image. The grey-level co-occurrence matrix developed by Haralick is used to obtain the Haralick texture feature for retinal image segmentation. To perform the proper segmentation of the image effective local entropy threshold is applied.

Let us assume that a Gabor filter response image has a size of M * N with L grey levels denoted by

$$G = \{0, 1. . . L - 1\}.$$

The simplest thresholding methods replace each pixel in an image with a black pixel if the image intensity I{i,j} is less than some fixed constant T (that is, $I_{i,j} < T$ I{i,j}<T}, or a white pixel if the image intensity is greater than that constant.

In the example image on the right, this results in the dark tree becoming completely black, and the white snow becoming completely white.

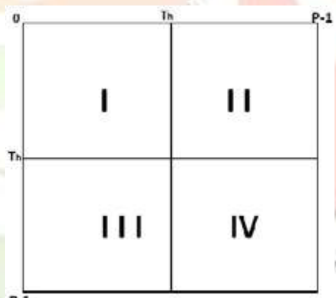


Fig: GLCM quadrants

Let t, be a value used to threshold an image. It partitions the co-occurrence matrix into four quadrants, namely, I, II, III and IV. We assume that pixels with grey levels above the threshold are assigned to the foreground (corresponding to objects), and those equal to or below the threshold are assigned to the background. Then quadrants I and III correspond to local transitions within background and foreground, respectively, whereas quadrants II and IV are joint quadrants which represent joint transitions across boundaries between background and foreground. The probabilities associated with each quadrant are then given by

$$P_{ij} = \frac{t_{ij}}{\sum_i \sum_j t_{ij}}$$

Obviously $0 <= P_{ij} <= 1$

$$P_{ij}^{(2)} = \frac{t_{ij}}{\sum_{i=0}^{s} \sum_{j=0}^{s} t_{ij}}$$

$$P_{ij}^{(2)} = \frac{t_{ij}}{\sum_{i=s+1}^{L-1} \sum_{j=s+1}^{L-1} t_{ij}}$$

The second order local entropy of the object can be given by the entropy analysis image as below.

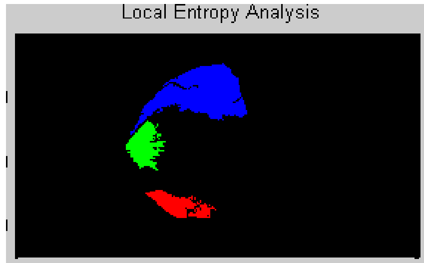


Fig: Entropy analysis

RESULTS:

Detection of the diabetic areas:

The input of the image is taken as the entropy analysis image from there, the image is converted to histogram span by using adaptive histogram equalization. The image is shown as below.

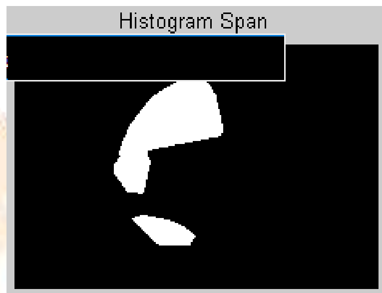


Fig: Histogram span

Now from the above image the image is converted to original color image with highlighted probable areas. This image is as shown below with the diabetic detection.

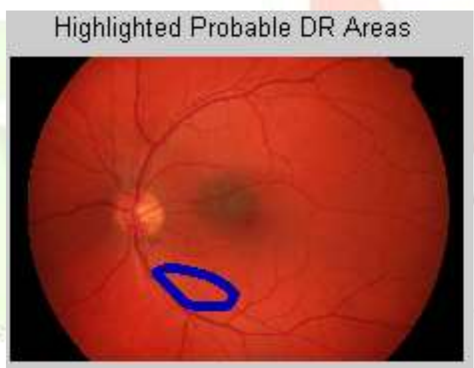


Fig: detection of diabetic retinopathy (mild stage)

The above figure represents mild stage of the diabetic person now let us see the severe stage of diabetic person which leads to permanent blindness.

Fig: detection of diabetic retinopathy (severe stage)

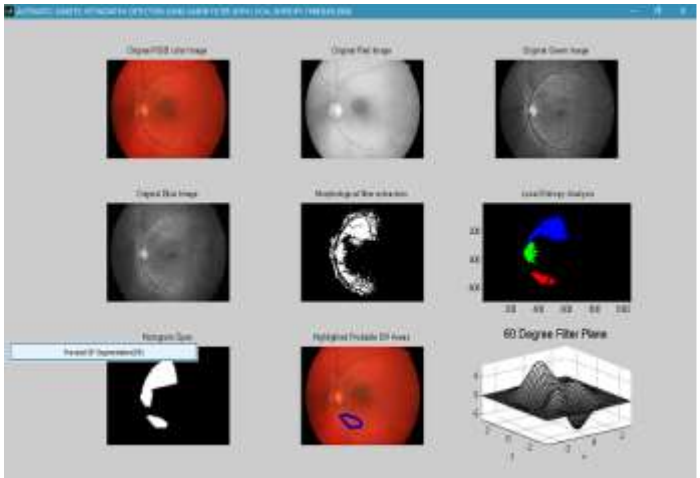


Fig: The overall segmentation and detection of the original image

Finally the image is complimented for evaluating the sensitivity, specificity and accuracy with respect to ground truth image given in DRIVE database. By using this method we can get the result within 4 to 6 seconds maximum. The speed of execution also come in with accuracy and sensitivity.

To enhance the speed of this algorithm we used Matlab 2014a with Intel i7 processors and 3.0 GHz speed system. To get complete result of the algorithm it took overall 5.36 seconds. To get required results as given above use the systems with the above specifications. Now let us compare our proposed result with other results we got as below.

Method	Accuracy	Sensitivity
Frangi et al	89%	64%
Hoover et al	91%	89%
Our Proposed method	97%	94%

Conclusion:

The retinal blood vessels are highly responsible for the detection of retinal pathology therefore segmentation of retinal blood vessels from their background is an important task. In this paper, an automatic local entropy thresholding based fast, efficient and accurate retinal blood vessels segmentation method is proposed by modifying the standard Gaussian shaped matched filter to identify the thin blood vessels together with large blood vessel segments. The proposed method has been tested for their efficacy for forty retinal images taken from DRIVE database and segmented results were compared with hand-labeled ground truth images also available in the DRIVE database. The efficacy of the proposed method was examined and presented in terms of overall sensitivity, specificity and accuracy. Further, the performance of the proposed algorithm was compared with some other existing standard methods for the same task available in literature and the performance of the proposed method was found to be performing significantly better.

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