A Survey on Segmentation Techniques for Detection of Diabetic Retinopathy

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***Abstract*— Diabetic has become a common disease for people above 40. The probability of becoming a diabetic patient is more now a days. Two major areas that are affected due to the increase in sugar level in blood is foot and eye. There are three types of diabetic eye disease namely diabetic retinopathy, cataract and glaucoma. In which Diabetic retinopathy is a common eye disease in most of the developed countries. It has about 80% occurs in almost all diabetic cases and is the main cause of blindness. It is caused by changes in blood vessels of the retina. Blood vessels may also swell and leak fluid. Diabetic patient have three Diabetic macular edema (DME) is an advanced symptom of diabetic retinopathy and can lead to irreversible vision loss. In this paper we have done a survey on the different techniques used for detection of different stages of diabetic retinopathy.**

Keywords- Diabetic Retinopathy, Image Segmentation, Optic disc, Macula, Blood Vessels, Digital Fundus Images

I.INTRODUCTION

Diabetic has become a common disease for people above 40. The probability of becoming a diabetic patient is more now a days .Two major areas of affect due to the increase in sugar level in blood is foot and eye. The anatomical structure of eye is shown in fig 1.There are three types of diabetic eye disease namely diabetic retinopathy, cataract and glaucoma. Diabetic retinopathy is the damage of the blood vessels in the retina.

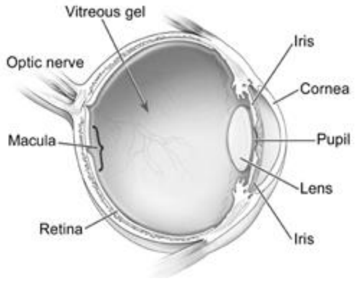

Fig 1 anatomical structure of eye

Cataract is clouding of the eye's lens. Cataracts develop at an earlier age in people with diabetes. Whereas Glaucoma is caused due to increase in fluid pressure inside the eye that leads to optic nerve damage and loss of vision. All these above mentioned problems can cause severe vision loss or even blindness A person with diabetes is nearly twice as likely to get glaucoma as other adults. In some people with diabetic retinopathy, blood vessels may swell and leak fluid. In other people, abnormal new blood vessels grow on the surface of the retina. The retina which is a light-sensitive tissue at the back of the eye has to be healthy for good vision. If a person is detected of diabetic retinopathy, at first the person may not notice changes in the vision. But over time, diabetic retinopathy can get worse and cause vision loss. Diabetic retinopathy usually affects both eyes.

Diabetic retinopathy has four stages namely Mild Nonproliferative Retinopathy,Moderate Nonproliferative Retinopathy, Severe Nonproliferative Retinopathy and Proliferative Retinopathy.

Doctors identify diabetic retinopathy during an eye examination that includes Visual acuity test, Pupil dilation were the eye pupil is dilated allowing the doctor to see more of the retina and look for signs of diabetic retinopathy. Ophthalmoscopy is an examination of the retina in which the doctor looks through a slit lamp biomicroscope with a special magnifying lens that provides a narrow view of the retina, or by wearing a headset (indirect ophthalmoscope) with a bright light, looks through a special magnifying glass and gains a wide view of the retina. Fundus photography generally recreate considerably larger areas of the fundus, Fundus Fluorescein angiography (FFA) is an imaging technique which relies on the circulation of Fluorescein dye to show staining, leakage, or non-perfusion of the retinal and choroidal vasculature. Optical coherence tomography (OCT) is an optical imaging modality based upon interference, and analogous to ultrasound. It produces cross-sectional images of the retina (B-scans) which can be used to measure the thickness of the retina and to resolve its major layers, allowing the observation of swelling. Digital Retinal Screening Programs is a Systematic programs for the early detection of eye disease including diabetic retinopathy .This involves digital image capture and transmission of the images to a digital reading center for evaluation and treatment referral.

To identify the early signs of disease segmenting the blood vessel, optical disc and the red lesion becomes necessary for the doctor to identify the severity of the disease. Thus by automating the process of segmentation of

DR fundus images it becomes easier to safe the patient's eye sight. The flow of segmentation process is as per the flow diagram in fig 2.

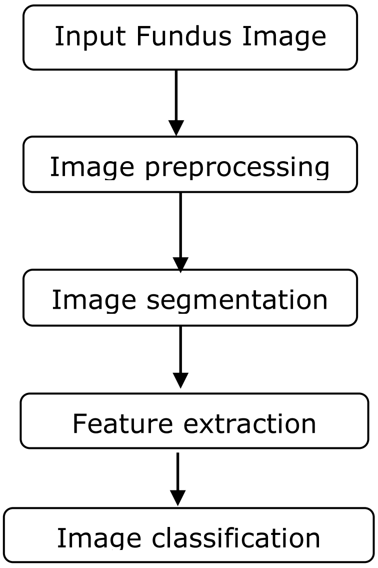

Fig 2 Flow diagram of DR image analysis

The remainder of this paper is organized as follows. Section II is the discussion of methodologies of different types of segmentation of blood vessels, OD and red lesions. In Section III gives a brief comparison on the different methods. The paper is concluded in Section VI.

II METHODOLOGY

A. SEGMENTATION OF BLOOD VESSELS

Diabetic retinopathy has four stages. The first stage is where small areas of balloon-like swelling appear in the retina's tiny blood vessels. They are called microaneurysms. That is the blood vessels that nourish the retina are blocked in the moderate NPR retinopathy stage. When this stages turns to be sever more number of blood vessels are blocked, restricting the flow of blood to several areas of the retina. These deprived areas send signals to the body to grow new blood vessels for nourishment. At this proliferative retinopathy stage, the signals received from retina for nourishment invokes the growth of new blood vessels. They grow along the retina and on the surface of the gel that fills the inside of the eye. At this stage, the blood vessels do not cause symptoms or vision loss. However, if there is leakage of blood, severe vision loss and even blindness can result.

Doctors diagnosis and treat various retinal disorders by obtaining the Digital fundus retinal images. To satisfy this robust segmentation of blood vessels is of utmost importance. Blood vessel segmentation approaches are broadly classified as template-based, edge detection–based, morphology-based, deformable contour-based, classification-based and tracking-based approaches. In these some are not robust to noise like Edge operator and Morphology based methods, some techniques contribute to false edges when the images are with exudates and other pathologies. A quadtree decomposition approach for edge detection is presented in [1]. This approach is also sensitive to noise. Tracking-based [2] and classification-based approaches [3] is complex in terms of time and computation. The author [4] has used fraction derivative method for the segmentation. The aggregated fractional difference operation enhances the edges by "peaking" in positive or negative directions while maintaining the original characteristics of the function. Applying it to an image transforms bright regions to brighter regions and dark regions to darker regions thus enhancing the edges. By doing so we enhance that is "peaking" in positive directions and enhancing in "peaking" in negative directions.

From the color retinal fundus image the green component is separated. Blood vessels in the green component have relatively low intensity values, even in the diseased images. Fractional differencing is applied to the green component image with a fractional index of r=0.97. The detail procedure is as follows

1. Find an image mask of size 5x5 for r.
2. Convolve the image with the mask to obtain the aggregated fractionally differenced image.
3. Apply a median filter 3×3 for smoothening of the blood vessel regions while preserving the edges.
4. Obtain a threshold **T** using the Otsu's threshold method [5].
5. Segment the image obtained in step 3 using threshold **T**.
6. Perform a binary inversion of the segmented image. As a result, all blood vessel pixels have value of 1 and remaining a value of 0.
7. Set a pixel value to 1 if five or more pixels in its 3×3 neighborhood have value 1; otherwise, set the pixel value to 0. This is performed in order to close the gaps between the walls of blood vessels, if present.
8. Remove all connected components (objects) that have fewer than 50 pixels.

Then simple subtraction of preprocessed image is used by the author [6].Pre-processing stage is to attenuate the noise, to improve the contrast and to correct the non-uniform illumination. Pre-processing stage includes Intensity conversion uses indexed images or RGB images. As done by the previous author green channel image which exhibits the best contrast between the vessels and background is used where as the red and blue ones tends to be more noisy. Then median filtering is used, as it is very robust and has the capability to filter any outliers and noise.

After which adaptive histogram equalization is performed to improve the image quality. It is used to find cumulative distribution function for a given probability density function. After all these transformation, the image will have an increased dynamic range and high contrast. Thresholding of image is segmenting image based on the pixel intensity value. It also converts an intensity image to a binary image. Otsu's method chooses the threshold to minimize the interclass variance of the black and white pixels.

Connected components are labeled by scanning an image pixel by pixel in order to identify connected pixel regions. It groups its pixels into components based on pixels connectivity. After group formation each group is labeled with different color. The main objective of segmentation is to group the image into regions with same characteristics. It is used to convert the image meaningful and easier to analyze. It is also used to locate objects and boundaries (lines, curves etc.) in the images Blobs are detected after performing all above operations on the fundus image which is the sign of PR.

B. SEGMENTATION OF OPTICAL DISC

Digital retinal fundus image has a healthy brightest feature know as the OD. It is approximately circular and measures around 1800 μm. Localizing OD helps to detect the location of macula and fovea. OD posses the following properties

(a) The biggest region that consists of pixels with the highest gray levels.

(b) It is the area with most variation of intensity of adjacent pixels.

(c) It is the convergence point of the blood vessels.

The blood vessel is considered as entrance and exit region of Optic Disc (OD). For an automated retinal imaging system, localization and segmentation are important task. Prerequisite for identification of anatomical structures is OD localization. Exudates have characteristics like OD thus it can be detected as apart of OD thereby creating a false positive. Thus the main focus is to automatically detect the location of OD. The method for localization of OD [7] is edge detection followed by circular Hough transform. In [8] OD is the region were we can find areas with highest change of intensity of adjacent pixels. Detecting the OD [9] uses pyramidal decomposition followed by Hausforff-based template matching. Morphological filtering techniques and watershed is also used for OD localization and segmentation [10]. The minimum distance between projection of the image principle component and the original image helps in identifying the center of OD in [11] and [12]. This approach is time consuming and has been tested only on some images. A geometric model of BV and localize the OD by simulated annealing is built by Foracchia et al [13]. The blood vessels focal point which is the optic disc is exploited in a fuzzy convergence algorithm [14] to locate the OD. OD segmentation and localizes OD [15] is done by Principle Component Analysis (PCA) and for detects boundary Gradient Vector Flow (GVF) snakes is used. Detection of OD boundary is based on treating OD as a circle or an ellipse. Here Hough transform, Hausdorff-based matching between the detected edges and circular templates of different sizes [16] is done and deformable contour models are also used.

The author in [15] this paper has tried a novel approach of OD localization based on the similarity of the projection of candidate regions to the basis ICA space. It is quoted that ICA performs significantly better than using cosines. Here the author has suggested a modified structural similarity measure (m-SSIM) and has also illustrated that it outperforms cosines measure. It has been found that it is robust and significantly better than the PCA based methods.

In [17] the author involves color normalization and morphological closing of input image in Lab color space. Homogenization of OD region is done followed by boundary detection using GVF snakes. For finding the OD center Principal Component Analysis (PCA) method is used. The Lab space color morphology preprocessing step completely removes the blood vessels and then performs segmentation.

In this paper the proposed method has 4 stages. Starting with Detection of bright regions followed with Preprocessing using Fast Gray Level Grouping (FGLG) applied on the green channel of the image. Then the blood vessel detection using Morphology and then finally OD localization. The green channel of the RGB image as the contrast of the image is high compared to the other channel. Smoothing operation is done using large size median filter to remove noise. The bright regions are heightened by taking the difference between image the median filtered image from the green channel of the original image the thresholded is obtain from the bright regions. Since the diameter of the OD is in the range of 65-100 pixels in the retinal image of size 565x584, the author has aimed to find a square of size 110x110 pixels that contains the OD. There are other regions such as exudates which are also bright, but the density of blood vessels in these regions is low. We exploit this property for OD localization.

C. SEGMENTATION OF RED LESIONS

Red lesion is nothing but microaneurysms and haemorrhages put together. These are signs of DR where the number of them indicates the intensity of DR. An automatic and early detection of red lesion will help the patient from not losing the eye sight. There are basic three steps in detection of red lesion, the first step is shade correction then the blood vessels have to be removed followed by classification. Morphological top hat transform is mostly used in eliminating blood vessel. Watershed retinal region growing and contrast normalization are used in contrast enhancement for MA detection. The author [18] has used automatic seed generation for candidate selection after contrast enhancement and shade correction. In order to increase the sensitivity the author has used a hybrid classifier incorporating KNN and GMM. In the green plan red lesion appears with high contrast. For further contrast enhancement the author has used GLG. Median filter is used for smoothing which is wider than the widest BV.

For detection of red lesion fig 3 from the shade corrected the pixels are classified as foreground pixel and background pixel. Blood vessels are classified as foreground pixel as they have the same intensity as the red lesion. If the pixel p is a seed pixel then it should belongs to the foreground and it should also be similar to the neighbor pixels. The standard deviation and mean is used to find the similarity between pixels. Larger blood vessels do not contribute to the red lesion. Thus a threshold value D is used for the selection of seeds of the candidate. Then classifiers are used for classification.

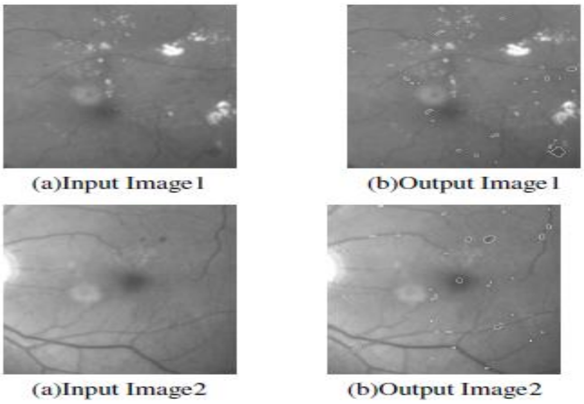

Fig 3 Detection of red lesions

III ANALYSIS

The fractional derivative approach for segmentation of blood vessels with convolution mask for r=0.97 gives good resultas shown in fig 4. More accurate results are obtained with r=0.998849.In the retinal blood vessel segmentation algorithm for diabetic retinopathy and abnormality detection using image subtraction the author is able to detect and segregate the digital fundus image as NPDR or PDR .

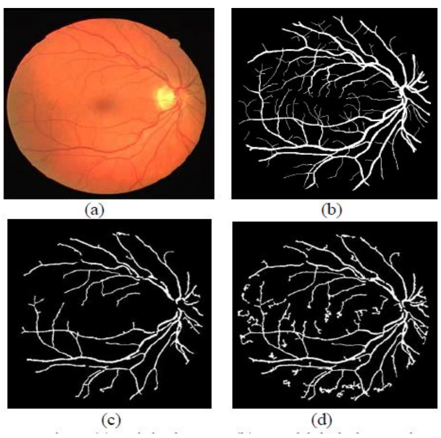

Fig 4 a) original image b) hand labeled vessel segmented c) r=0.98 d) r=0.9849

It is found from his results that the process is 85% successful. The segmentation of anatomical structures is the foremost process after it is identified as a PDR or NPDR. One of the anatomical structure is the optic disc, the author in localization of optic disk using independent component analysis and modified structural similarity measure has used ICA and m-SSIM in which a 74% result has be obtained. Where as it has been 100% successful for normal retinal image. Anantha vidhya sagar in A novel integrated approach using dynamic thresholding and edge detection for automated detection of exudates in digital fundus retinal images have used PCA for segmenting the optic disc. In this paper they have found sensitivity of 79.62% in exudates detection. The same author has also used GVF (gradient vector flow) to find the region of optic disc. Then he uses gray level grouping to segment the optic disc in automatic detection of anatomical structures in digital fundus retinal images. The author in his paper A simple and fast algorithm for the automatic localization of optic disc in digital fundus retinal images has first detected the bright region, applied FGLG on green component. These two steps allow for blood vessel detection. By doing so it becomes easy to detect the OD as it is the centre of the blood vessels. The success rate of this algorithm is 93.75%.Its has a run time of 17 seconds. In this paper [17] optic disc boundaries are detected using GVF snakes. They have achieved a better appropriate segmentation. In the red lesion detection the author in [18] has used ASG and MTH later classified the findings. This method has increased the sensitivity than the normal methods.

IV CONCLUSION

The foremost step in analysis of digital fundus image is segmentation of the anatomical structures of the image. They consist of blood vessels, optic disc, exudates and the red lesions. There by we would be able to classify these images as PDR or NPDR. In optic disc segmentation it is found that fractional derivate method yields the maximum results. In blood vessel segmentation the prepossessing with FGLG and then using morphological process yields the best result. Where as in red lesion mostly morphological process yields better results.

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