Segmentation of Neovascularization And Macula Using GKFCM Technique

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Abstract- *This paper demonstrates Digital Image Processing technique for the segmentation of Neovascularization and Macula using the Gaussian Kernel Fuzzy C means Clustering. Neovascularization refers to the formation of new blood vessels and it indicates the onset of Diabetic Retinopathy. Proliferative Diabetic Retinopathy (PDR) is the most advanced stage and will lead to sudden vision loss if not detected earlier. Diabetic Macular Edema (DME) occurs as a consequence of Diabetic Retinopathy. Macula is important for sharp vision and it is the most sensitive part of the retina. Macular Edema occurs when there is abnormal leakage and accumulation of fluid in the Macula from the damaged blood vessels in the nearby retina. The proposed image processing technique involves Preprocessing, Filtering, Binary region extraction, segmentation, locating the region of Convergence and classification. The techniques which is used in the proposed method makes the processing more accurate and efficient with less computation time. The proposed algorithm is computationally simple, efficient and can be used to assist ophthalmologists for screening various types of eye related ailments. We achieved an average sensitivity of 100% on the randomly selected test set.*

Keywords- Neovascularization, Macula, Diabetic Macular Edema, Proliferative Diabetic Retinopathy;

I. INTRODUCTION

Diabetic eye diseases comprise a group of eye conditions that affect people with diabetes. These conditions include diabetic retinopathy, diabetic macular edema (DME), cataract, and glaucoma. All forms of diabetic eye diseases have the potential to cause severe vision loss and blindness. Neovascularization is the indicator of diabetic retinopathy which is the second most common cause of blindness in the developed world which refers to the formation of new blood vessels. Formation of new blood vessels is a natural process. When the count of new blood vessels increases than the old blood vessels, the new blood vessels will break as they are fragile and this will lead to loss of vision. People with high diabetes are easily affected due to this. If the blood sugar level increases, the count of new blood vessel also increases.

The retina is a thin layer of tissue that lines the back of the eye ball where light is converted into neural signals sent to the brain. It is located near the optic nerve. The purpose of the retina is to receive the light that the lens has focused, convert the light into neural signals, and send these signals on to the brain for visual recognition. Retina consists of the rods and cones. Rod cells are responsible for vision at low light levels and the cone cells are responsible for colour vision in bright light. Diabetic retinopathy can cause blood vessels in the retina to leak fluid or haemorrage (bleed), distorting vision. In its most advanced stage, new abnormal blood vessels increase in number on the surface of the retina, which can lead to scarring and cell loss in the retina. The advanced stage of diabetic retinopathy is the macular edema. The macula (macula lutea) is an oval shaped yellowish area close to the centre of the retina of the human eye. Structures in the macula are dedicated for high acuity vision. It acts as a natural sun block because of its ability to absorb excess blue and ultra-violet light which enters the eye. The macula is important for sharp, straight-ahead vision that is used for reading, recognizing faces, and driving. The damage to the macula will result in loss of central vision. Vision loss due to diabetic retinopathy is sometimes irreversible. However, early detection and treatment can reduce the risk of blindness by 95 percent.

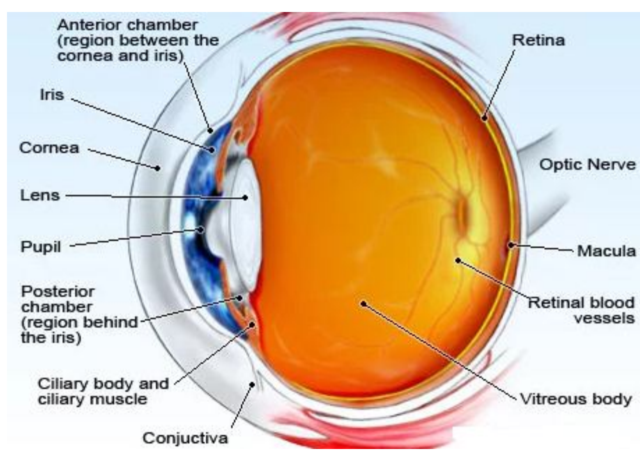

Fig -1. Eye Anatomy

Image processing method has been proposed for accurate detection of neovascularization and macular edemaImage processing is to obtain an output image that is an accurate representation of the input image, and then to analyze it and extract as much diagnostic information from the image as possible.

In this paper, we propose an automatic image processing technique for the segmentation of neovascularization and macula using Gaussian Kernel Fuzzy C Means Clustering (GKFCM) technique which is more efficient and accurate.

II. EXISTING WORK

The automatic detection of neovascularization in the optic disc region (NVD) for colour fundus retinal image is explained in the existing method. The new vessels are fragile and pose a high risk for sudden vision loss. Therefore, the importance of accurate and timely detection of NV cannot be underestimated. And it proposed an automatic image processing procedure for NVD detection that involves vessel segmentation using multi-level Gabor filtering, feature extraction of vessel morphological features and texture features, and image classification with support vector machine.

Optic disc is automatically identified and located via local phase symmetry method on vessel removed green channel. The ROI is selected as the square region that enclosing the optic disc. Then, the selected ROI is pre-processed with illumination correction to remove unevenly distributed brightness. Particularly, non-local means filter is employed to remove the fine vessels to get an image with thick and normal vessels only. After pre-processing step, two different images are obtained: the illumination corrected original image and fine vessel removed image. Subsequently, vessel segmentation is performed on the two images with multi-level Gabor wavelet. After binary segmentation with adaptive thresholding, the fine vessels can be obtained by the difference between the two binary vessel images. Multiple features, including vessel morphological features and texture-based features, are then extracted from each image, which establishes a feature vector with length of 42. Further feature selection procedure with recursive feature elimination method has selected the optimal feature subset with length of 18. Finally, the support vector machine is utilized to classify whether the retinal image contains NVD or not. The algorithm is robust and achieves high accuracy on the publicly available databases. It was tested on 400 images from Messidor database and is able to accurately detect the optic disc on 96.25% of the images. Here only the region of optic disc is screened for neovascularization. Screening the presence of new blood vessels in other regions of the eye is mandatory to identify many eye diseases. Hence a new method is needed to identify the vessels in retina as well as the fluid leakage in the macula.

III. PROPOSED SYSTEM

The overall framework for the classification of Neovascularization and Macula is illustrated in Fig. 1.2. The main contribution of this paper is an efficient detection and automatic extraction of Macula [11] from the retinal image with reduced time using various morphological operations which is independent of any feature related to fundus image. Furthermore, the proposed method is computationally simple since the basic property used for extraction of the macular region is the difference in the intensity levels of fundus image. Unlike other methods, the proposed method is computationally simple, efficient, less time consuming and is independent of any complicated feature extraction algorithms.

The proposed method of segmentation of Neovascularization and Macular edema is divided into five subsections. (A) Pre-Processing. (B) Filtering. (C) Binary region extraction. (D) Segmentation. (E) Classification. The block diagram of the proposed method is shown below:

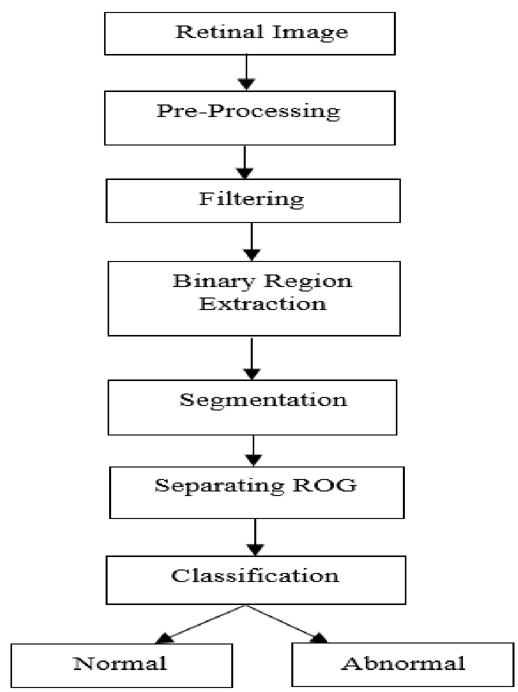

Fig. 1.2 Proposed Method

(A)Preprocessing

The aim of pre-processing is to improve the image data that suppresses unwanted distortions or enhances some image features important for further processing. Initially the

Retinal image [4] is converted into grey image and it is resized. The grey image is rotated to the desired rotation angle in degrees. If it specifies a positive rotation angle, the image rotates counter clockwise and if it specify a negative rotation angle, the image rotates clockwise. Now, the rotated image is automatically cropped in order to locate the Optic Disc. The Optic Disc is segmented from the cropped area. The segmented area appears white and the other regions appear black. The contrast of the grey scale image is enhanced by transforming the values of segmented data along with the size of the grey image using Contrast Limited Adaptive [10] Histogram Equalization (CLAHE).

(B)Filtering

The proposed system utilizes median filtering and gaussian filtering. The median filter is a non-linear digital filter technique, often used to remove noise from an image or signal. Such noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image). The enhanced grey image is subjected to Gaussian filtering. A special gaussian function is used for this purpose. As a result, a two-dimensional low pass filter with specified size and sigma value is obtained. The filtered image will be blurred since it is a two-dimensional low pass filter. Then the blurred image is also sharpened in this process.

A special gaussian function creates Gaussian filters using the formula

$$h_g(n1,n2) = e^{-(n1^2+n2^2)/(2\sigma^2)}$$

(C)Binary Image Extraction

In binary image extraction the morphological [6] technique is used, where closing of an image is defined as a dilation followed by an erosion and since closing an image starts with a dilation operation, dark regions that are smaller than the structuring element of the image are removed. Morphological filtering of a binary image is conducted by considering compound operations like opening and closing of filters. For example, opening with a retinal image, structuring element smooths corners from the inside, and closing with a disc smooths corners from the outside. These operations can filter out any details from an image that are smaller in size than the structuring element, e.g. opening is filtering the binary image at a scale defined by the size of the structuring element [3]. Only those portions of the image that fit the structuring element are passed by the filter and the smaller vessels are blocked and excluded from the output image. The size of the blood vessels is very important to eliminate noisy details but not to damage the output of interest.

The opening of A by B is obtained by the erosion *A* by *B*, followed by dilation of the resulting image by *B*:

$$A \circ B = (A \ominus B) \oplus B$$

The closing of *A* by *B* is obtained by the dilation of *A* by *B*, followed by erosion of the resulting structure by *B*:

$$A \circ B = (A \oplus B) \ominus B$$

Extracting the boundary (or outline) of an object is often extremely useful. The boundary can be simply given as:

$$\beta(A) = A - (A \ominus B)$$

(D)Segmentation

The goal of segmentation is to simplify the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate the objects and boundaries (lines, curves, etc.) in images. Clustering of numerical data forms the basis of many classification and system modelling algorithms. The purpose of clustering is to identify natural groupings of data from a large data set to produce a concise representation of a system's behaviour. Also, Clustering is one of the efficient techniques in medical and other image segmentation because of its simplicity and easiness to implement. ROG is the region of convergence, here the clustering process is applied in order to group the similar objects. In this paper we propose Gaussian kernel-based fuzzy c-means (GKFCM) [2][9] clustering technique that can approximate the boundaries of Region of Interest (ROI) with parameter estimation simultaneously well. It provides noise-immunity and preserves the image details. It can be useful in various fields like medical image analysis, such as tumour detection, study of anatomical structure, and treatment planning. GKFCM is also known as Alternate Fuzzy c-means (AFCM). GKFCM can automatically learn the parameters by the prototype driven learning scheme.

(E)Classification

Support vector machine is used to classify the normal and the abnormal images. In machine learning, support vector machine are supervised learning model associated learning algorithms that analyze data used for classification and regression analysis. A support vector machine [3] (SVM) was chosen as the classifier for its rapid training phase and good classification performance. SVMs seek a linear decision surface (hyper-plane) that can separate classes of objects and has the largest distance (largest gap or margin) between border-line objects (that are also called support vectors). If the classes are not linear separable the SVM [5] maps the data in a higher dimensional space known as the feature space, where the separating linear decision surface exists and can be determined. The feature space results from a mathematical construction known as the kernel trick. There are numerous different kernel functions. Besides the standard linear kernel, the most popular kernel functions are Gaussian radial basis function kernel (RBF) and the polynomial kernel. The majority of kernels possess parameters which need to be selected. Another parameter associated with SVMs [6] is the soft margin parameter C which is tuned to deal with noisy measurements and outliers. The SVM is used for deciding the boundary of the optic disc and to analyze the vessels for damage in their retina and also in the macula region.

IV. EXPERIMENTAL RESULTS

The experimental analysis of the work indicates that the proposed method of segmentation of neovascularization and macula is accurate and requires low computational time.

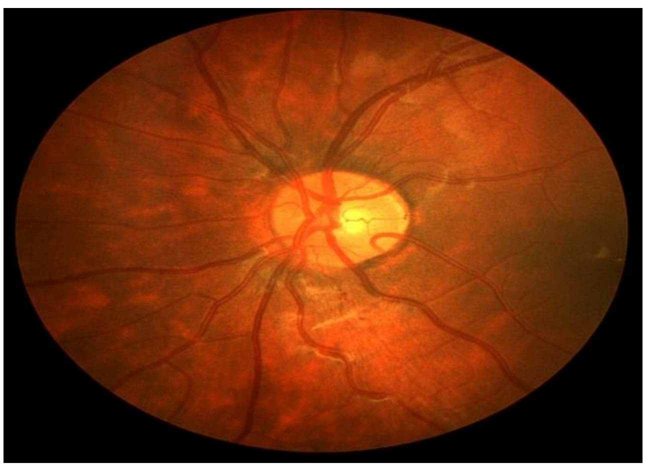

Fig 1.3 Input retinal image

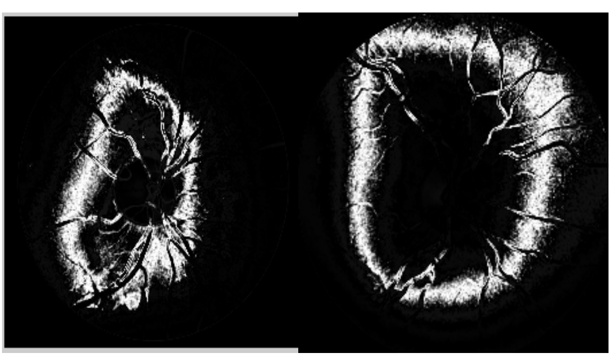

Fig (a) Fig (b)

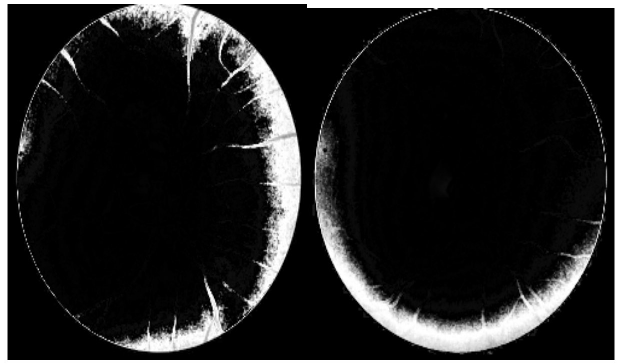

Fig (c) Fig (d)

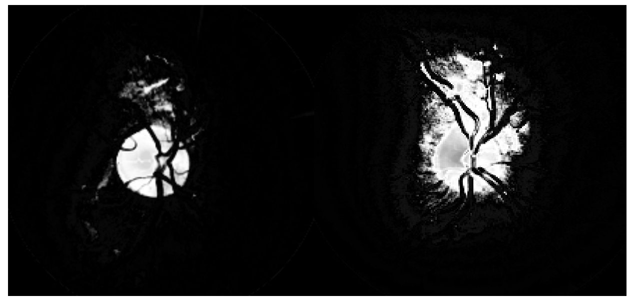

Fig (e) Fig (f)

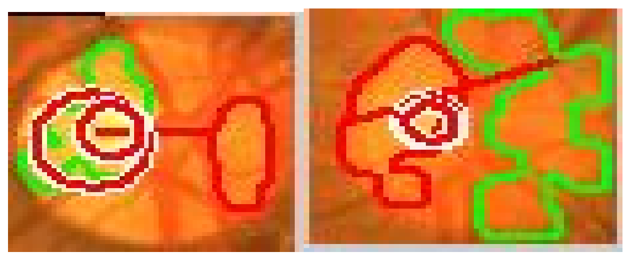

Fig (g) Fig (h)

Fig (i) Fig (j)

Fig (a) represents the pre-processed image of the normal eye which indicates the presence of blood vessels in the outer edge of the optic disc. Fig (b) represents the pre-processed image of the abnormal eye which indicates the presence of more number of blood vessels in the outer edge of the optic disc. Fig (c) indicates that the blood vessels in the boundary of the retina are proper and in good condition. Fig (d) indicates that the blood vessels in the boundary of the retina are improper and are not in good condition. Fig (e) indicates that there is no fluid leakage in the macula. Fig (f) indicates that there is fluid leakage in the macula which makes the vision blurred.

Finally we can conclude that if there are more number of new blood vessels there will be fluid leakage in the macula and this will lead to loss of vision. And the classification of normal and abnormal eye is based on the above mentioned criteria. In Fig (g) and Fig (h) the green ring specifies the new blood vessels and the red ring specifies the macula. Fig (i) and Fig (j) indicates the experimental results of normal and abnormal retinal images.

TABLE I
FEATURES OF DIFFERENT SAMPLES

Samples	Accuracy	Sensitivity	Overall CDR Threshold	Precision
Sample 1	72%	100%	2.72	71%
Sample 2	75%	100%	3.60	73%
Sample 3	72%	100%	4.27	71%
Sample 4	75%	100%	3.49	73%
Sample 5	78%	100%	3.34	75%
Sample 6	80%	100%	4.24	76%

TABLE II
COMPUTATION TIME OF SAMPLES

Samples	Computational time (in sec)
Sample 1	36.7
Sample 2	24.2
Sample 3	36.2
Sample 4	17.3
Sample 5	16.9
Sample 6	21.6

V. CONCLUSION

The proposed method for the segmentation of Neovascularization and Macula by using GKFCM algorithm in colour fundus images requires low computational search time and is accurate. The experimental results indicate that the neovascularization achieves a high sensitivity and specificity.

Future work of this method is to explore alternate choices of ROI selection and improving the brightness of retina from low intensity, computational speed and expand to detection of neovascularization elsewhere (NVE), which will be more challenging because of the existence of DR lesions and lower vessel contrast.

VI. ACKNOWLEDGMENT

We would like to express our sincere gratitude to our guide, Prof. Vishnuvinayagan. Rwho helped us out to overcome many obstacles to complete our project successfully. And we would like to thank the Head of the Department Prof. Mrs. Sreelatha for giving us the opportunity to take up this paper, for her guidance and supervision in all respects of this paper.

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