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Abnormality Detection and Classification at the Non – Proliferative Stage of Diabetic Retinopathy

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***Abstract*—Diabetic retinopathy is one of the complications of diabetics, which affects the retinal blood vessels. It is the chronic progressive disease which advances from mild non–proliferative diabetic retinopathy to moderate and to severe proliferative diabetic retinopathy. Early detection and diagnosis can prevent the patient from vision loss. In this work the early stage of reliable segmentation of bright lesions Exudates, is done to detect the severity level .This work has been performed on the standardized online dataset STARE and DRIVE. The main contribution is the reliable vessel extraction and removal which further enhances the quality of feature extraction. The proposed method not only helps for early stage diagnosis but also regarding the treatment decision making.**

I. INTRODUCTION

Number of people suffering from diabetics is increasing due to increase in population, aging, increase in prevalence of obesity and physical inactivity. According to the World Health Organization (WHO) there could be a rapid rise in the rate of diabetic patients around 2030 [1]. One of the progressive impact of diabetics leads to Diabetic retinopathy. Diabetic retinopathy (DR) is the complicated mellitus of diabetics, which affects the retinal blood vessels. It is a chronic progressive disease which advances from mild non-proliferative diabetic retinopathy to moderate and severe non-proliferative diabetic retinopathy. Only after reaching the proliferative stage of diabetic retinopathy, the patient will show the symptoms of this disease. The initial manifestation of this disease appear due to the appearance of lesions on the retinal membrane. These lesions are mainly the blood clots and the lipid deposits due to the increase in level of blood glucose. The mild non-proliferative diabetic retinopathy is characterized by the presence of a very few micro aneurysm (MA), these are the leakage of blood in deeper layers of retina. They usually appear as dark red lesions with irregular contours.

Hard exudates (HE), which are the lipids and the protein deposits formed into a light yellow clusters on the retinal membrane which occurs as a symptom of hypertensive retinopathy, seems to be in white gray color having fuzzy contours. The severe stage of non-proliferative DR would show the presence of lesion in greater amount. The proliferative stage of DR will show the immense presence of these lesions. Studies reveals that the prior detection and diagnosis of the disease would prevent 80% of these cases from going blind. Also this non-proliferative stage is not only a threatening condition to DR, but also to many other forms of retinopathies such as diabetic macular edema and diabetic macular ischemia. These diseases could lead to vision impairment at any stage of disease. Current therapy for diabetic retinopathy includes laser photocoagulation, surgery, and metabolic control. This could cause side effects and possible complication. The severity of the disease and the amount of medical treatments required, could be estimated through the early stage detection. Here, in this work the stage abnormality level of diabetic retinopathy is done by the quantitative and qualitative presence bright lesions. However large number of patients visit eye hospitals for routine examination, where huge number of retinal fundus images are acquired. (i) Since manual screening is a tedious process. (ii) Requires an expert advice (iii) Interpretation of minute candidate lesions due to the similarity in shape and intensity with the anatomical structures.

The main aspect of computer aided detection method is segmentation, feature extraction and classification. There are various methods proposed according to literature survey. The prior vessel extraction is done using various methods, the studies on single scaled matched filter of varying vasculature widths was implemented on 2D Gaussian filter was employed by Chaudhary [3] .A much improved filtering method as achieved by the local thresholding scheme for pixel classification proposed by Hoover [4].This method showed a TRP of 75% .The main drawback in these methods was, it responded to both vascular and non-vascular segments in the fundus image. A vascular tracing method tracks the blood vessel according to the variation in their vessel properties proposed by Zhou et al [5]. In this method a fast algorithm for vessel detection was implemented based on the prior knowledge of vessel geometry, spacial properties of the vessel segment's position orientation and width, here also the algorithm works for only healthy database vessel tracing, if there is a presence of any abnormality such as, CWS and hemorrhages the tracing would be difficult. A supervised method for classifying blood segments was proposed by soares et al [6].This method involves the training of images in order to decide whether they belong to vascular or non-vascular structures. The method achieves the performance accuracy of 94.66%and 94.81% percentage DRIVE and STARE database respectively. Another important aspect regarding the elimination of optic disc is due to the similarity in intensity between the bright lesions and optic disc .To effectively segment the optic disc adaptive thresholding using mixture mode based clustering was proposed by Sanchez et al [7].. To detect the vascular convergence point a fuzzy convergence and voting type algorithm was performed by

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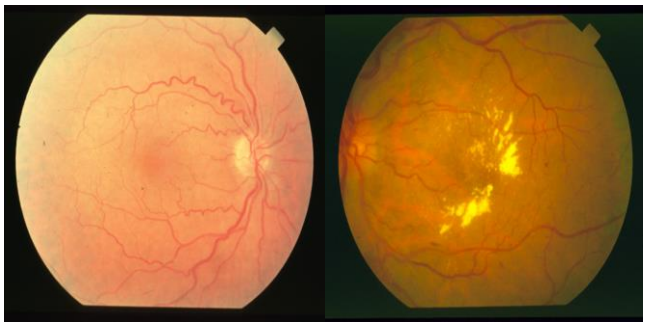
Niemeyer, Abramoff & Vann Ginneken [8]. The problem with this algorithm was it showed false detection of optic center.

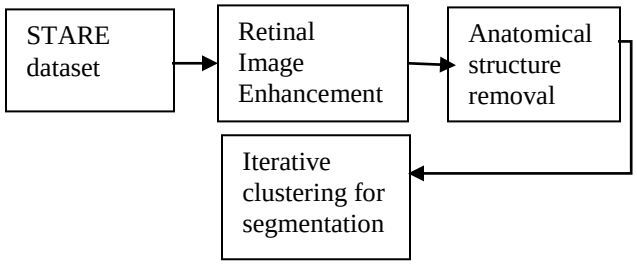


(a) Healthy Retinal Image (b) Bright lesion database

II. MATERIALS AND METHOD

The open source database of retinal fundus images are available with various features and objectives. These are standardized database with expert evaluation about the pathology. The work is mainly done using STARE and DRIVE online database. STARE (structural analysis of the retina) comprises of 400 colored retinal fundus images with are captured using Topcon TRV-50 fundus camera with the resolution of 605 x 700 pixels at 35° FOV with 8 bit per plane. DRIVE (digital retinal image for vessel extraction) comprises of 40 colored retinal fundus database, within which there are 33 healthy and 7 pathological images. These images were acquired by canon CR5 non mydriatic 3CCD camera with the resolution of 768 x 584 pixel at 45° FOV with 8 bit per color channels.

The proposed method for bright lesion segmentation comprises of (i) Retinal image enhancement (ii) segmentation and elimination of anatomical structures (iii) iterative clustering.



Block diagram of proposed system

A. Retinal image Enhancement

To know the actual severity of the disease, it is necessary to segment even the smallest distinctive part of the lesion. For getting a clearer view of the level of abnormality, it is necessary to enhance the quality of the image. In fact an effective filtering at the pre-processing stage could create a much effective segmentation result. Additionally the artifacts and blur appear during the image acquisition, impose degradation in the quality of the image. Therefore the retinal image enhancement is an essential step for the refinement of the image. Many filters have been tested to serve this purpose. After making the comparison with various filters such as median filter, CLAHE, 2D high pass filtering, it was found that 2D high pass filtering has an average MSE value of 0.3721 and PSNR value of 49.73. It is therefore considered as the pre-processing filter accompanied by an adaptive scaling factor depending on the local intensity variation. 2D high pass filtering, which removes the low frequency and retains the high frequency components. This enhances the edges and other frequency components.

B. Segmentation of Anatomical Structures

The variations within the retinal fundus images makes it difficult to distinguish between the lesions. It is mainly due to the presence of anatomical structures such as blood vessels and optic disc. The brightness in optic disc is at the almost similar to that of the exudates, this results the false segmentation of optic disc as exudates. These components could interfere the accurate lesion segmentation. Therefore it is essential to remove the unwanted and false regions prior to the segmentation. This mainly comprises of 2 steps (a) segmentation and elimination of blood vessels. (b) Segmentation and elimination of optic disc.

(a) Segmentation and elimination of blood vessels

Blood vessels are the significant source of false positive during the segmentation. The Existing system regarding the blood vessel segmentation was a Gaussian modelled matched filter [13]. A much more modified version of matched filter is used for the vessel segmentation MF-FDOG- Matched Filter with its First Derivative of Gaussian. The MF Gives response to both vascular and non-vascular segments in the fundus image. The filter is based upon the fact that, the cross section of true vascular segment is a symmetric Gaussian f_n while the non-vascular structure is approximated as the step edge. Filtering original retinal fundus image with a mean filter w, gives the normalized value D_m. it is observed that the value of D_m for the vascular structures is Gaussian f_n is very low and that of non-vascular structures is very high. Thus the response of MF-FDOG gave a much precise o/p.

(b) Segmentation and elimination of optic disc

CHT, circular Hough transform is for the detection of circular objects from the image. For the detection of a circle, the HT is based on the equation of circle, defined as

$$(x_i-a)^2 + (y_i-b)^2 = r^2$$

Where, (a, b) represents the coordinates of the center of the circle and r denotes the radius. In order to increase the performance of CHT we resize all images to a common resolution and search for the bright circles with an experimented selected radius range of 29–50 pixels. Among circular responses generated by CHT we take only strong circle. Strong circles are the ones that correspond to the OD

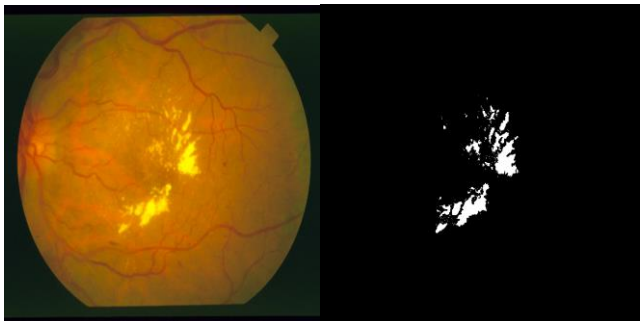
while the rest are either exudates or misleading regions. By performing the morphological operation the desired OD region is masked using region fill operation.

C. Segmentation of Candidate Lesion

The input at the next stage will be the retinal image database without blood vessel and optic disc, which would in turn enhance the quality of segmentation. Retinal lesion image will comprise of clusters of similar pixels with homogeneous appearance and intensity. These clusters of pixel are termed a candidate lesions. The grouping of these pixels are carried out by iterative clustering method .This method is an adaption of k-means clustering process. In the actual k-means clustering process the pixels are arbitrarily divided into color groups based on k initial cluster centers, selected randomly where k is an user defined parameter. Afterwards, through iterative process the centers are updated by computing the average pixel value of each clusters. The k-means method mainly rely on the distance measurement between each pixel and all other center pixels of a clustered image .Here in the new method, once new cluster center is obtained, the spacial distancing of each clusters which was A^2 initially during k-means clustering process, was assumed to be 2A x 2A area around the cluster center in x, y plane. Thus the searching speed of the new iterative clustering would increase, reduces the computation complexity.

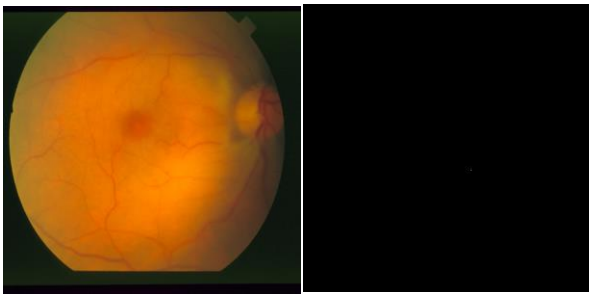
III. RESULT AND DISCUSSION

The proposed aided detection method was implemented in MATLB version 2017a on a PC with Intel core i7 processor. The proposed method effectively segments the bright lesions and shows effective result during the healthy lesion segmentation. The method was tested for almost 36 datasets and almost 80% percentage of which showed the effective segmentation comparing the bright lesion ground truth.



(a) The result obtained when the proposed method tested on a pathological dataset.

Similarly when the proposed method was tested on healthy datasets, It showed almost zero segmentation. This signifies that the difference between the healthy and pathological datasets are clearly identified using this method of segmentation.



(b) Segmentation result for a Healthy dataset

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