An Approach for the Detection of Vascular Abnormalities in Diabetic Retinopathy

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Abstract-Diabetic Retinopathy is a common complication of diabetes that is caused by changes in the blood vessels of the retina. The blood vessels in the retina get altered. Exudates are secreted, micro-aneurysms and hemorrhages occur in the retina. The appearance of these features represents the degree of severity of the disease. In this paper the proposed approach detects the presence of abnormalities in the retina using image processing techniques by applying morphological processing techniques to the fundus images to extract features such as blood vessels, micro aneurysms and exudates. These features are used for the detection of severity of Diabetic Retinopathy. It can quickly process a large number of fundus images obtained from mass screening to help reduce the cost, increase productivity and efficiency for ophthalmologists.

Key words - Diabetic retinopathy (DR), blood vessels, exudates, micro aneurysms, image processing, morphological processing, optic disc, disease severity.

I. INTRODUCTION

Diabetic Retinopathy is a common complication of diabetes and the primary cause for visual impairment and blindness in adults that is caused by changes in the blood vessels of the retina. The symptoms can blur or distort the patient’s vision. Retinopathy is often asymptomatic and the patient is unaware of retinopathy until the eyes are routinely examined or until visual impairment is detected. It is important to note that it is not possible to diagnose diabetic retinopathy using laboratory tests. Regular screening is essential in order to detect the early stages of diabetic retinopathy for timely treatment to prevent further deterioration of vision. However, a significant shortage of professional observers has prompted computer assisted monitoring. The retina is a unique site where the in vivo microvasculature can be directly visualized and monitored repeatedly over time. Recent advances in retinal photographic imaging techniques have facilitated the development of computer assisted methods to measure and quantify subtle variations and abnormalities in the retinal microvasculature. The blood vessels in the retina get altered. Exudates are secreted, micro aneurysms and hemorrhages occur in the retina. The appearance of these features represents the degree of severity of the disease. Micro aneurysms are focal dilations of retinal capillaries and appear as small round dark red dots. Hemorrhages occur when blood leaks from the damaged retinal vessels. Exudates occur when lipid or fat leaks from abnormal blood vessel or aneurysms. An early detection and diagnosis will aid in prompt treatment and a reduction in the percentage of visual impairment due to these conditions, it will aid for a better treatment plan and to improve the vision related quality of life.

II. RETINAL STRUCTURE OVERVIEW

The retina is the delicate, transparent neural tissue that lines the posterior two-thirds of the eyeball. Macula is the portion of the retina responsible for central vision. The photoreceptors on the retina capture light rays and convert them into electrical impulses which travel along optic nerve to the brain. The nerve layer of the retina contains blood vessels.

![Fig. 1. Features in the retina](image)

Diabetic retinopathy causes damage to the blood vessels in the retina and as the disease progresses the presence of micro aneurysms, exudates and new blood vessels can be observed. Fig. 1 shows the different features present in the normal and disease retina.

III. LITERATURE SURVEY

Gerald Liew et al. [1] have highlighted that the quantitative and qualitative assessments of retinal vasculature demonstrate a close association of retinal vascular signs to both clinical and subclinical cerebrovascular and metabolic outcomes. Identification of retinal blood vessels needs assistance of a trained grader. Kittipol Wisanet al. [2] proposed a method for detecting the exudates pathologies of diabetic retinopathy using Fuzzy C-Means (FCM) clustering and morphological methods. If any applications need to detect maximum number of exudates pixels or require execution speed, the FCM clustering technique could be used in isolation. Tomi et al. [4] demonstrated the protocol with a baseline method including the available tool kit. But the maturity of the tool must be estimated before starting the technology transfer from the research laboratories to practice and industry. Jaspreet et al. [11] proposed a blood vessel segmentation method using morphological filters. Increasing the number of filter banks did not result in significant improvement of result but increased the time consuming convolution operation. Hussain et al. [12] proposed a method for the detection of exudates using adaptive thresholding and classification is proposed in which the retinal structures are used to remove artifacts from exudate detection results. This method still needs to be expanded to include all signs of DR. The motivation behind to put this paper is signs of...
DR disease which are directly related to retinal edema and visual loss. And also to recommend a technique for automated diabetic retinopathy mass screening system which offload the work of ophthalmologists and also decreases the waiting time of the patients at the hospital to some extent. The techniques quoted above are not been tested on large volumes of retinal images. Some of them were found to fail for large numbers of retinal images, in contrast with the successful performance of morphological operation. Methods fail if exudates similar in brightness, color property and size to the optic disk are present. The micro aneurysms are difficult to segment due to their similarity in color and proximity with blood vessels. Some methods have used blood vessel intersection property to obtain the optic disk. However, they use the whole blood vessel network which can lead to wrong or inconclusive result because of noise from the fringe blood vessels.

IV. SYSTEM METHODOLOGY

The automated detection system involves following processes:
(a) Read the fundus image, (b) Pre-Processing, (c) Anatomical Structure Extraction, (d) Feature Extraction, (e) Disease Severity Classification. These techniques are explained in the following sections.

![Block diagram of overall system](image)

V. IMAGE PRE-PROCESSING

Color fundus image is first converted into a gray-scale/green-channel image in order to facilitate the blood vessels segmentation. From visual observation, blood vessels generally exhibit the greatest contrast from the background in the green band. Gray-scale image provides only the luminance information from the color image after eliminating the hue and saturation. Most of the information needed is contained in the intensity matrix and hence suitable for diagnosis of Diabetic Retinopathy. It is necessary to improve the contrast of these images to provide a better transform representation for subsequent image analysis steps. CLAHE, contrast limited adaptive histogram equalization technique is adopted to perform the contrast enhancement. The contrast especially in homogeneous areas of intensity can be limited to avoid amplifying noise. The command ‘imadjust’ adjusts the image intensity values and increases contrast of the output by suppressing the darker pixels which tend to contain less information. The command “bwareopen” is also used to remove the small area of pixels considered to be noise after applying morphological operations. The steps involved in pre-processing are as shown in fig.3.

![Pre-processing steps](image)

VI. ANATOMICAL STRUCTURE EXTRACTION

The detection of optic disk is a very important task because it is similar in brightness and contrast to the exudates. The optic disk is brighter than any other part in the retinal image and is circular in shape. Hence we create a circular mask for the optic disk region by finding the brightest pixels in our image that is being processed. The processing needs to be performed only on the region of interest (ROI), i.e. the retina. Generally the border of the image does not contain much of the significant information.

Thus, the border formation is to clean off the noisy edges and retain the ROI. There are two methods in detecting the circular border of the image. The circular border is extracted after subtracting the dilated image with the eroded image obtained by applying morphological dilate and erode. Mask for optic disk and the circular border are as shown in fig.4.

![Mask and circular border](image)
VII. FEATURE EXTRACTION

The fundus image is first preprocessed to standardize its size to 576x720. The features such as blood vessels, exudates and micro aneurysms are detected and extracted using morphological operations such as dilate, erode, opening and closing. The “colfilt” filter is used. Following segmentation AND logic is applied to the binary image to detect the features. After feature extraction area of each feature is calculated to classify the severity of the disease. Fig.5. shows features extracted from a fundus image.

VIII. DISEASE SEVERITY CLASSIFICATION

In order to detect the severity of Diabetic Retinopathy the area of the features is calculated. Based on the results of area computation, the system uses the classification as normal, mild, severe to identify the stages of non-proliferative diabetic retinopathy. In the normal stage, there are no micro aneurysms and exudates. In the mild stage, there are micro aneurysms. In the severe stage, both exudates and micro aneurysms are present.

IX. RESULTS

Table I shows the extracted feature and disease severity classification. The input fundus image is processed, after processing we get segmented images of blood vessels, micro aneurysms and exudates. In the processing of images area of all the extracted features are also calculated. Then by depending on the area we notify the severity of the disease.

X. CONCLUSION

In summary, a system for the automatic diagnosis of the primary signs of Diabetic Retinopathy (DR) has been developed by applying effective image processing techniques on the fundus images obtained from various databases. By using MATLAB, the features such as blood vessels, micro aneurysms and exudates are extracted and detected by applying morphological processing techniques. Based on the results of area computation of features, the system uses the classification as normal, mild, severe to identify the stages of non-proliferative diabetic retinopathy. This system intends to help ophthalmologists in the screening process to detect symptoms of Diabetic Retinopathy quickly and more easily. This can be a preliminary diagnosis tool or decision support system for ophthalmologists. The proposed technique does not require any user intervention, and has consistent performance in both normal and abnormal images. Retinal vascular digital image analysis will play an ever greater role in clinical ophthalmology.

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Table I. The Following Table Shows Extracted Features And Disease Severity Classification

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Input Fundus Image</th>
<th>Blood vessels</th>
<th>Exudates</th>
<th>Micro aneurysms</th>
<th>Disease Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><img src="a" alt="Image" /></td>
<td><img src="b" alt="Image" /></td>
<td><img src="c" alt="Image" /></td>
<td><img src="d" alt="Image" /></td>
<td>MILD</td>
</tr>
<tr>
<td>2.</td>
<td><img src="e" alt="Image" /></td>
<td><img src="f" alt="Image" /></td>
<td><img src="g" alt="Image" /></td>
<td><img src="h" alt="Image" /></td>
<td>SEVERE</td>
</tr>
<tr>
<td>3.</td>
<td><img src="i" alt="Image" /></td>
<td><img src="j" alt="Image" /></td>
<td><img src="k" alt="Image" /></td>
<td><img src="l" alt="Image" /></td>
<td>NORMAL</td>
</tr>
</tbody>
</table>

REFERENCES


