Classification of Different Stages of Diabetic Retinopathy from Retinal Images Based on Artificial Neural Networks

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Abstract- **Measurements of retinal blood vessel morphology have been shown to be related to the risk of cardiovascular diseases. The wrong identification of vessels may result in a large variation of these measurements, leading to a wrong clinical diagnosis. This is a challenging problem due to ambiguities caused by vessel bifurcation and crossovers. Diabetes affects slowly the circulatory system including that of the retina. So the vision of a patient may start to deteriorate and lead to diabetic retinopathy. This work proposes an algorithm for the detection of retinal landmarks based on optic cup location and anatomical structural details from diabetic retinopathy (DR) images of both left and right eye. This algorithm uses color fundus images. The algorithm proceeds through four main steps. (i)Color image pre-processing, (ii) Detection of optic nerve head, (iii)Detection of macula, (iv)Detection of vasculature. Detected optic disc area is validated.**

Keywords- **Diabetic retinopathy, Retinal landmarks**.

I. INTRODUCTION

Examination of blood vessels in the eye allows detection of eye diseases such as glaucoma and diabetic retinopathy. Retinal image provides information about what is happening inside the human body. Traditionally, the vascular network is mapped by hand is a time-consuming process that requires both training and skill. Automating the process allows consistency, and most importantly, frees up the time that a skilled technician or doctor would normally use for manual screening. While success has been achieved on normal, abnormal or diseased retinal images - for which accuracy is more crucial than ever – the algorithms frequently fail. For instance, popular convolution approaches suffer from variable retinal background and low contrast between vessels and surrounding pixels. Tracking algorithms fail in special cases on abnormal images; they are often sidetracked by light objects and sometimes experience difficulty in locating starting points. However, they require the accurate extraction of distinct vessels from a retinal image. This is a challenging problem due to ambiguities caused by vessel bifurcations and crossover.

II. EARLY METHODS

Nowadays there are many different methods to segment the retinal vasculature from the fundus images. This method overcomes the problems of initialization and vessel profile modeling that are encountered in the literature and automatically tracks fundus vessels. The main tool for determining vessel and nonvessel regions along a vessel profile is the fuzzy C-means clustering algorithm that is fed with properly preprocessed data. Another method is a semi-automatic method to measure and quantify geometrical and topological properties of continuous vascular trees in clinical fundus images is described. Measurements are made from binary images obtained from segmentation process.

Identification and measurement of blood vessels in retinal images could allow quantitative evaluation of clinical features, which may allow early diagnosis and effective monitoring of therapies in retinopathy. A system is proposed for the automatic extraction of the vascular structure in retinal images, based on a sparse tracking technique. Vessel detection is an important process in many medical imaging applications. An edge tracking scheme is proposed for the detection of blood vessels in retinal images. This method detects edge points iteratively based on a Bayesian approach using local grey levels statistics and continuity properties of blood vessels. Unsupervised methods for automatic vessel segmentation from retinal images are attractive when only small datasets, with associated ground truth markings, are available.

Since the ratio of people afflicted with diabetic retinopathy to the number of eye specialist who can screen these patients is very high, there is a need of automated diagnostic system for diabetic retinopathy changes in the eye so that only diseased persons can be referred to the specialist for further intervention and treatment. Image analysis tools can be used for automated detection of these various features and stages of Diabetes Retinopathy and can be referred to the specialist accordingly for intervention, thus making it a very effective tool for effective screening of Diabetic Retinopathy patients.

III. DIABETIC RETINOPATHY

Nowadays there are many different methods used to segment the retinal vasculature from the fundus images. For example, blood vessel segmentation using wavelet transform, region growing or adaptive filtering has been used. However, due to the unique properties of each technique, a single generally accepted vessel detection algorithm does not exist. Moreover usually the better segmentation method is used the more time the computation takes. The main goal of this method is a fast blood-vessels segmentation based on two-dimensional discrete wavelet transform (2D DWT). This method consists of four main parts such as preprocessing, decomposition by 2D DWT, thresholding procedure, reconstruction with summation.

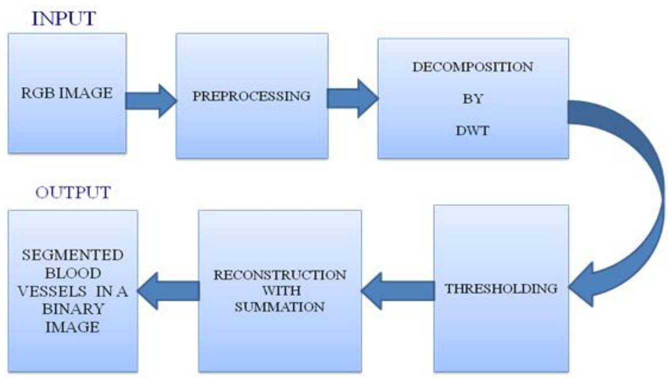

Figure1. Block Diagram for Blood Vessels Extraction

In Preprocessing (image enhancement) **-** the retinal images has been taken in a RGB mode by fundus camera Canon CF-60UDi with a digital camera Canon D20. However, the best vasculature information is in the green channel. So the first step is to separate this channel to a new image. Before applying the vessel segmentation algorithm it is necessary to remove noise from the image. This is done by a filter based on anisotropic diffusion. The filter iteratively uses diffusion equation in combination with information about the edges. As a consequence, the homogenic (but noisy) areas are blurred and the edges are preserved. Histogram equalization technique increases the dynamic range of the histogram of an image. It assigns the intensity values of pixels in the input image such that the output image contains a uniform distribution of intensities.

Hemorrhages and micro aneurysms contribute to defects in a retina with diabetic retinopathy. All stages of diabetic retinopathy show such defects. Therefore, it is important to distinguish them from the noisy background of the retinal image. The algorithm developed uses a morphological operation to smooth the background and, as a result, veins, hemorrhages and micro aneurysms can be seen clearly. In blood vessel extraction the **2**D discrete wavelet transform is used based on a bank of filters, which corresponds to specific type of a wavelet. This algorithm used the Reversed Bi orthogonal wavelet (RBIO) as denoted in Matlab. Shape of this wavelet is almost same as the shape of blood vessels in the retinal image.

The wavelet transform decompose the image to levels, where each level represents specific frequency band of the wavelet. Its choose 3 levels 2D DWT, which is sufficient for detecting the retinal vasculature. Each level is then decomposed in three directions: vertical, horizontal and diagonal and Bi orthogonal wavelet: rbio on the left, shape of a blood vessel on the right One decomposition level of 2D DWT.

The next step is to threshold within each direction in each level. The main task of thresholding is to highlight high values of wavelet coefficients which almost correspond to the blood-vessels and suppress small values which correspond to noise or unimportant structures in the image. The key parameter in this process is the choice of the threshold value. A good way how to get this value is to use the histogram of the image. 88 % of the pixels in the wavelet coefficient image are noise or unimportant structures and only 12 %belongs to the blood-vessels (determined as a result of the experiments). The threshold value has been set to brightness value 30, because 88% of pixels are below this value. To binarize the image, a threshold should be carefully chosen. Too small a threshold will produce an image that has edges linked together. However, a big threshold will produce edge segments that form curves. It obtained good results by setting the threshold at 25% of the gray intensities contained into the image.

Now it is necessary to reconstruct the final binary image. The first step is to logically add all thresholded directions in each level. So the images reflect the segmented blood vessels. Due to the 2D DWT, before adding the images in a final image, it is necessary to interpolate them to the same size by bilinear interpolation. However the final image has to be binary. Each image includes some noise, which is necessary to remove. The possible way how to do it is to add the three images and take away the two lower layers. This will create the final binary image, which shows the segmented vasculature from the eye background. In exudates detection hemorrhages and micro aneurysms contribute to defects in a retina with diabetic retinopathy. All stages of diabetic retinopathy show such defects. Therefore, it is important to distinguish them from the noisy background of the retina image. The algorithm developed uses a morphological operation to smooth the background and, as a result, veins, hemorrhages and micro aneurysms can be seen clearly. The identification of objects within an image can be a very difficult task. One way to simplify the problem is to change the grayscale image into a binary image, in which each pixel is restricted to a value of either 0 or 1. The techniques used on these binary images go by such names as: blob analysis, connectivity analysis, and morphological image processing (from the Greek word morphe, meaning shape or form).

Figure 3. Input image

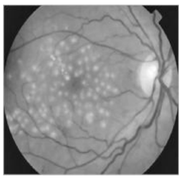

Figure 4.Median filtered image.

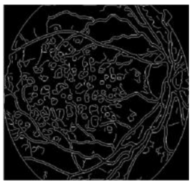

Figure 5. Edge detection by canny edge detector

Figure 6.Green layer extraction

The two most common morphological operations are erosion and dilation. In erosion, every object pixel that is touching a background pixel is changed into a background pixel. In dilation, every background pixel that is touching an object pixel is changed into an object pixel. Erosion makes the objects smaller, and can break a single object into multiple objects. Dilation makes the objects larger, and can merge multiple objects into one. Morphological operation Exudates appear as bright lesions in retinopathic images and have sharp edges and high contrast with the background. Most of the standard edge detectors like Sobel edge detection and Canny edge detection add a lot of noise and miss out key edges. A connected set of interior pixels forms an ‘‘object’’ in the binary image. Some of these objects will correspond to physical structures on the microscope slide.

The image undergoes several morphological operations using each of the structuring elements. A short explanation of the function used and the mathematics involved is as follows. The morphological opening operation erodes an image and then dilates the eroded image using the same structuring element for both operations with a disc SE where R = 10. As a result, the objects completely destroyed by the erosion are not recovered. This behavior is the very basis of the filtering properties of the opening operator. The image structures are selectively filtered out depending on the selection of the shape and size of SE. This means, all foreground image structures that do not contain the structuring element are removed by the opening. The shape and size of SE are set according to image structures to be extracted. The opened set is the union of all SEs fitting the set:

$$\gamma_B(X) = \cup\{B | B \subseteq X\}$$

where B = structuring element, X = set of pixels that make up the image, cB = opening of set using structuring element B. Alternatively, the opened set can be represented as

$$X \circ B = (X \ominus B) \oplus B = \cup_{a \in B}\left(\bigcap_{a \in B} X_{-a}\right)_a$$

The image is further processed with a disc SE of R = 18, followed by a diamond SE of R = 3, each time, and hence the image has its intensity adjusted before the SE morphs the image. This increases the contrast of the output image J as it spreads pixel intensities more evenly over the intensity range. The perimeter and area of the features can be easily extracted from these pre-processed images.

IV. CONCLUSION AND FUTURE WORK

This algorithm investigated and proposed a method based on anatomical structural details and retinal image information. This system intends to help the ophthalmologists not only in DR screening process but any other eye related abnormality which is based on retinal photography. It is not a final result application but it can be a preliminary diagnosis tool or a decision support system for ophthalmologists. Human ophthalmologists are still needed for the cases where detection results are not very obvious. This type of presentation will enable clinicians to identify retinal landmarks more quickly and will also help to take decision while treating the abnormality, particularly retinopathy.

V. REFERENCES

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