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LOCALISATION OF FOVEA IN RETINAL IMAGES

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ABSTRACT

The retinal fundus photograph are widely used in the diagnosis and treatment of various eye diseases such as Diabetic Retinopathy, glaucoma etc. Diabetic Retinopathy is the leading cause of blindness in the working age population. If the disease is detected and treated early, many of the visual losses can be prevented. An efficient detection of anatomical structures in retinal images is the fundamental step in an automated retinal image analysis system. This paper presents an algorithm for the segmentation of blood vessel and localisation of fovea. The blood vessels are detected using kirsch operator. The fovea is identified by finding the darkest region in the image following the priori geometric criteria based on anatomy of human eye. The candidate region of fovea is defined an area circle. The detection of fovea is done by using its spatial relationship with blood vessel. The algorithm is evaluated against a carefully selected database of 139 ocular fundus images. The system achieves an accuracy of 90.7% for the fovea.

Keywords: Blood Vessels, Fovea, Fundus Images, Kirsch Operator, Macula,

I. INTRODUCTION

Macula is an oval shaped highly pigmented, located roughly in the center of the retina, temporal to the optic nerve. It is a small and highly sensitive part of the retina responsible for detailed central vision. The fovea is at the centre of the macula. Fig.1 shows Fundus image with the main parts of normal fundus are marked. With a limited search space around the optic disc, the fovea was located using matching correlation [1], [3] use a modified version of the method described by Pinz et al. [4] to localize the fovea. In this method, a square region of interest with sides 1.5 and centered at a point that is 1.75 temporal, and 0.5 below the center of the optic disk is constructed. The darkest pixels inside the region of interest are detected as the pixels having intensities less than a threshold. The largest connected component from this segmented result is detected, and a new ROI centered on the centroid of this component is constructed. The ROI is smoothed, and the thresholding operation is repeated with a new threshold. The centroid of the largest component obtained from the thresholding is the estimate of the center of the fovea. This two-step approach helps to localize the fovea even in images which are very dark with low relative contrast. However, the algorithm fails in certain rare cases. When there is a dark pathology very near the fovea, or when the fovea appears bright instead of being dark, the algorithm could produce erroneous results. Other methods described in the literature include the work of Goldbaum et. al. [5] who fixed the position of the fovea relative to the optic disk; Li and Chutatape [6] who estimated the position of the fovea by extracting the points on the main blood vessels and fitting a parabola with the optic disk as the focus.

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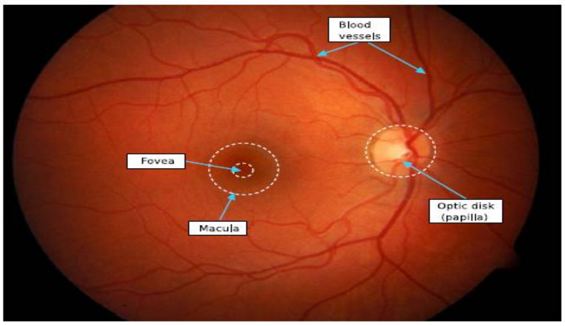

Fig 1.Fundus image with the main parts of normal fundus.

The fovea is then located at two disk diameters from the optic disk on the main axis of the parabola. [2] The center of the fovea was usually located at a distance of approximately 2.5 times the diameter of the optic disc, from the center of the optic disc. It was the darkest area of the fundus image, with approximately the same intensity as the blood vessels. The fovea was first correlated to a template of intensities. The template was chosen to approximate a typical fovea. The location of maximum correlation between the template and the intensity image, obtained from the intensity-hue-saturation transformation, was chosen as the location of the fovea, subject to the condition that it be an acceptable distance from the optic disc and in a region of darkest intensity. The criteria deciding the existence of the fovea were a correlation coefficient more than 0.5 and a location at the darkest area in the allowed neighborhood of the optic disc. Digital images were obtained at a resolution of 570x550 with 256 grey levels for each red, green, blue pixel element. A typical digital color fundus image contrast at the center of retinal images tended to be of good quality but diminished towards the periphery. A pre-processing technique was applied to minimize this effect, thus producing a more uniform image. Non uniform illumination is especially a problem in retinal imaging due to a combination of factors including the difficulty of achieving uniform illumination through narrow lens even with the fully dilated pupil, due to instrument limitations such as the ring-shaped illumination pattern, and due to imaging along various illumination axes, that are different from the optical axis of the eye. When comparing images taken at different times for changes, one must compensate for this spatially non uniform illumination.

Several illumination correction techniques have been described in the literature. These methods are based on adaptive histogram equalization [7], Gamma correction, Gamut mapping [8] and Retinex based algorithms [9]. Methods used for correcting the illumination problem in change detection systems include linear and nonlinear background correction [17-21], homomorphic filtering [11]–[14], and surface fitting [15]. [16] Proposed a novel algorithm, named "Iterative Robust Homomorphic Surface Fitting (IRHSF)" that combines the advantages of homomorphic filtering and surface fitting, and exploits retina-specific information such as the vasculature, optic disk, fovea, and lesions, to estimate the retinal reflectance in a robust manner.

II.METHODS

2.1 Pre-processing of colour retinal images

This process includes local contrast enhancement and green band extraction of the digital fundus image. If necessary, color standardization to reduce the variation of retinal color found in a racially heterogeneous patient sample may be applied. The local contrast enhancement function provides large contrast enhancement for an

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initially small σ (poor contrast) and little contrast enhancement for an initially large σ (high contrast). As a result of local contrast enhancement, the dark area is brighter and clearer showing more detail.

2.2 Recognition of main retinal components: Fovea

The fovea is a small depression on the fundus, which is like a deep-red or red-brown color in color retinal images. It is temporal to and slightly below the optic disk. The fovea is the darkest part in most of the retinal images, while it is not obvious in some images due to high illumination or being covered by the lesions. Its geometrical relation to other structures is employed to locate the fovea robustly. The candidate region of fovea is defined as an area of circle. The main features of a fundus image were defined as the optic disc, fovea and blood vessels. Retinal blood vessels are one of the most important components in ophthalmic diagnosis. As the network of the retinal blood vessels doesn't change very much over time, detecting abnormalities such as venous looping or beadings is critical for early treatment, as they are, in most cases, indications of potentially sight-threatening retinopathy. In order to utilize these usual characteristics of retinal blood vessels, it is very important to obtain their locations and shapes accurately. In many of the reported studies on automatic fundus image analysis and diagnosis normal components within the image, such as blood vessels or fovea, are detected and identified before starting abnormal component detection. Pathologies such micro aneurysms or hemorrhages, located close to blood vessels, may be misclassified as blood vessels and removed in the pre-processing, resulting in reduced specificity of pathology detection and hence possible misdiagnosis. Accurate retinal blood vessel extraction is therefore required as a pre-processing component of an automatic diagnosis/screening system. The main blood vessel is obtained as the thickest and largest blood vessel emanating from the optic disk by kirsch operator. The Kirsch edge operator is particularly useful for this task because it assigns each edge a value, which is higher for the sharper ones .The entire course of the main blood vessel is obtained (from the image of the thicker vessels) by looking for its continuity from the optic disk. Hough transform a technique capable of finding geometric shapes within an image, is employed to localize the fovea. Hough transform was applied only to pixels on or close to the retinal vasculature in a binary image of the vasculature obtained by kirsch method. The fovea is a dark region located in the center of the macula region of the retina. It commonly appears in microaneurysms and hemorrhages detection results much as the optic disk does in exudates detection results. The fovea is detected using the location of curvature of the main blood vessel. This vessel is modeled as a parabola. The vertex of the parabola is taken as the pixel on the main blood vessel that is closest to the center of the optic disk circular mask. The fovea is located approximately between 2 to 3 optical disk diameter (ODD) distances from the vertex, along the main axis of the modeled parabola and is taken as the darkest pixel in this region. The physical diameter of the optic disc is about in the range of 1.5mm to 1.8 mm, on average. The region of the fovea is taken to be 1 optic disk diameter of the detected fovea location.

III. RESULTS

We have tested proposed algorithm on 139 fundus images using Matlab. Fig 2 shows the results of the proposed algorithm for fundus images in GUI format. We have used publicly available database DRIVE, diaretdb1 and diaretdb0. In Fig.3 some of the results from above mentioned database for the gray scale images are shown. The

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proposed method achieves an average accuracy of 90.7% summarizes the results of fovea localisation for all databases as shown in Table 1. We have presented a simple but effective algorithm for localization.

Table 1 : Performance of Proposed Algorithm

Feature	Number of tested Images	Accuracy
Fovea	139	90.7%

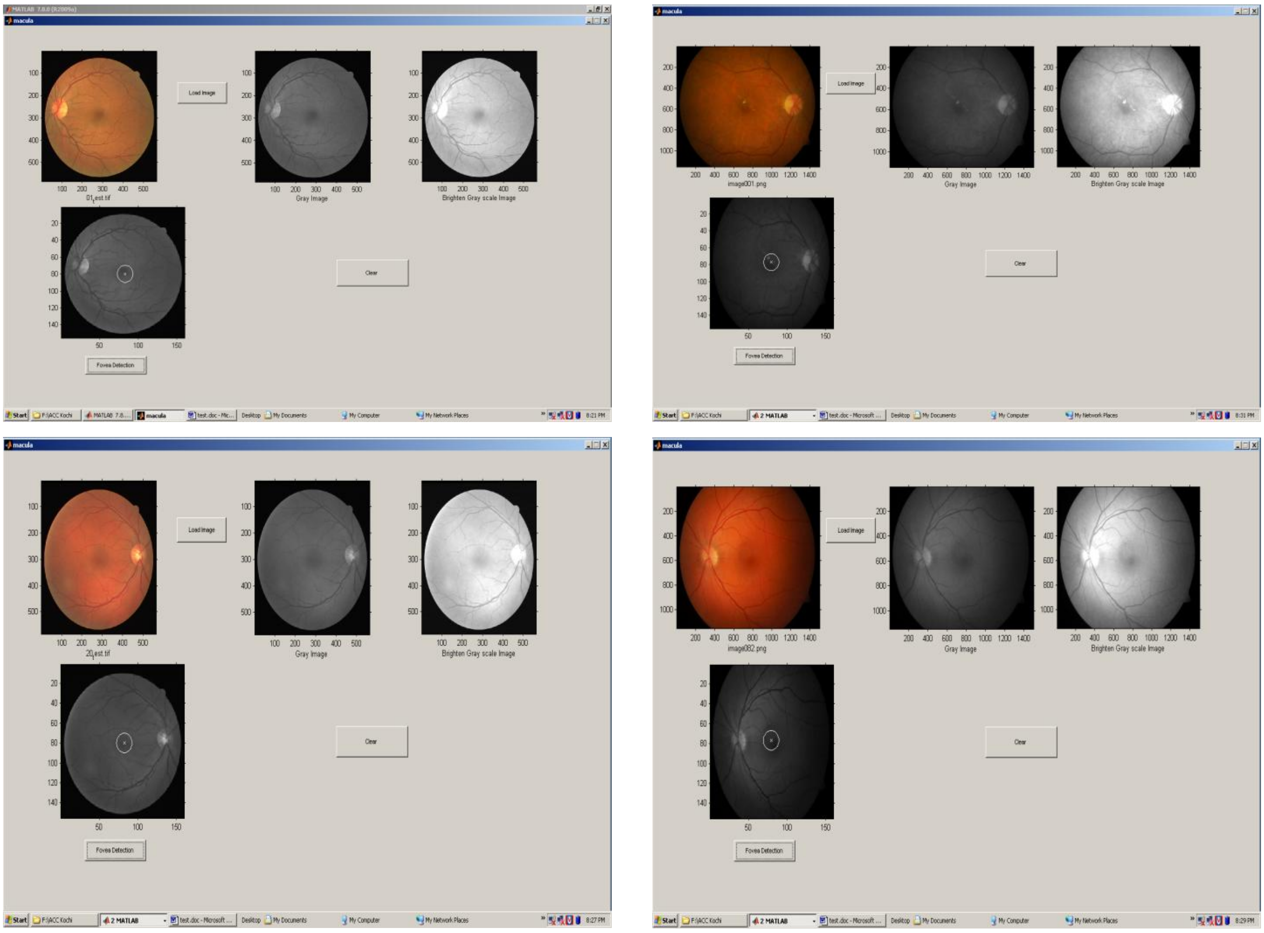

Fig 2.Results for DRIVE, diaretdb0 and diaretdb1 images

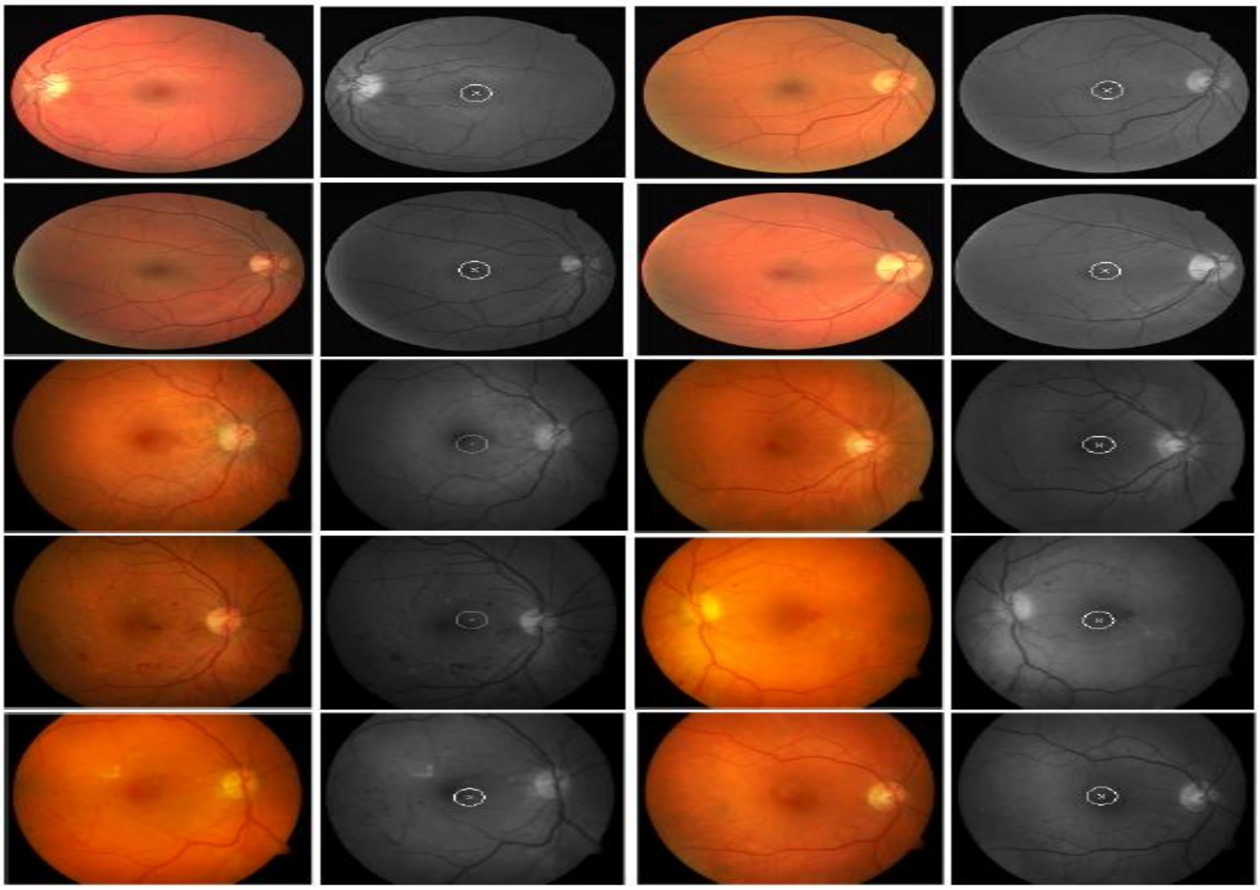

Fig 3.Some more results from above mentioned database

VI. CONCLUSION

In this study computer based algorithms are used to detect the main region: Fovea of the fundus without any intervention from an operator. The accuracy of the detection is high for the fovea (Especially when the image contained the whole fovea area). It is hoped that the detection of this regions will aid the examination of fundus disorders. The fovea is missed in a number of cases but usually when there is poor centration of the fovea in the image. This can be easily remedied by more careful fundus photography. The detection of the major blood vessels is performed using kirsch method. To detect feature of retinopathy minimal preprocessing is employing. The preprocessing used in this study improves the efficiency of the computer analysis.

V. FUTURE SCOPE

5.1 Predicting the Severity of Disease with distance of exudates from fovea

In diabetic maculopathy, fluid rich in fat and cholesterol, leaks out of damaged blood vessels. If fluid and cholesterol accumulates near the center of the retina (the macula) it can cause distortion and permanent loss of central vision. There are the two types of maculopathy eye disease: Non-Clinically Significant Macular Edema (NCSME). In this stage the patient will not realize that he is affected, because there are no visible symptoms. Exudates start to leaks, and the retina becomes boggy like a sponge but the patient’s vision is not seriously affected, because the locations of the exudates are far away from the fovea. The distribution of the exudates lesions about the fovea can be used to predict the severity of Diabetic macular edema. The International Council of Ophthalmology lists 5 levels for Diabetic Retinopathy based on these criteria: none, mild, moderate, severe, and proliferative. In the Clinically Significant Macular Edema (CSME) stage, most of the retinal blood vessels are damaged and the leakage area becomes bigger. The exudates leak out and this liquid concentrates very close to the fovea. The visibility is greatly affected, because the detected image cannot be focused on the macula properly. The exudates occurring in the macular region are more dangerous and require immediate medical attention than the ones farther away. Similarly, the size, count and distribution of microaneurysms and hemorrhages are also used to predict the severity of DR. A computer- based system for the identification of CSME, non-CSME and normal fundus eye images appropriate macula detection is most important.

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