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Identification of Ocular Pathology in retinal fundus images

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Abstract: **-- Automated fundus image analysis plays an important role in the computer diagnosis of ophthalmologic disorders. A lot of eye disorders, as well as cardiovascular disorders, are known to be related with retinal vasculature changes. Many important eye diseases as well as systemic diseases manifest themselves in the retina. While a number of other anatomical structures contribute to the process of vision, this paper focuses on retinal image analysis and their clinical implications. The most prevalent cause of blindness in the industrialized world is age related macular degeneration. Nowadays, the digital retinal image is frequently used to follow-up and diagnoses eye diseases. In age related macular degeneration, the macula is responsible for the sharp central vision needed for detailed activities such as reading, writing, driving, face recognition and ability to see colors. Age related macular degeneration is degeneration of the macula area and the delicate cells of the macula become inactive and stop working. Unfortunately, age related macular degeneration cannot be completely cured, but if diagnosed at an early stage degeneration laser treatment can help some people to prevent further deterioration of macula. The algorithm locates disease affected pixels on macula and displays their location. After pre-processing particle analysis tool is applied to locate the effected parts on the fundus image.**

Index Terms **— Age related macular degeneration, drusen and retinal fundus image.**

I. INTRODUCTION

The eye's fundus is the only part of the human body where the microcirculation can be observed directly. Age-related macular degeneration (AMD) is the leading cause of irreversible vision loss among the elderly in developed countries. Many studies have confirmed that the presence of the so-called drusen, identified as gray-yellow deposits that build up in or around the macula of the retina, represents a significant risk factor for the development of visual loss from AMD [1]. Drusen are deposited by products of rod and cone metabolism located just beneath the retinal pigment epithelial (RPE) cell layer [2]. It is believed that they may signal the presence of an altered pathophysiology of the retinal pigment epithelium and consequently they may be a marker for the degree of diffused RPE dysfunction in patients with AMD [3]. The existing strong indications for the correlation between AMD and drusen development characteristics suggest that the clinical assessment of the latter might have predictive value in determining if and when a patient will suffer visual loss from (AMD). Additionally, it could facilitate the development of efficient, fast and accurate clinical tests for the evaluation of the effectiveness of different treatment modalities.

Routinely, drusen characteristics are evaluated by inspecting the retina with the aid of an optical imaging apparatus known as Fundus camera. In some cases and in order to assist the evaluation of features of diagnostic importance, slides or digital images of the retina are submitted to Medical Centers, where specialized professionals asses the drusen characteristics. In other clinical studies this assessment is performed with the aid of comparisons with standard photographs or with templates [4].

Besides the subjectivity and the lack of reproducibility, visual assessment is not efficientin analyzing and classifying complex morphological patterns. Drusen vary in size from a few microns in diameter to large confluent complexes , which may extend to hundreds or even thousands of microns [5]. Moreover, their color appearance varies notably even within the same eye, depending on the amount of the deposited byproducts beneath the RPE in each spatial location. Their color appearance is also affected by the color of the overlaid RPE, which also varies as a function of the location within the same eye, while it is strongly affected by several factors such as blood vasculature, race, etc. The appearance of the retinal features is also affected by the non-uniform transfer function of the illumination-imaging optics of the Fundus camera. These variables affect randomly the perceived contrast between drusen and background, which makes the attempt for the automatic drusen extraction

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a demanding image analysis task. The problem of automated, unsupervised drusen detection has received considerable attention over the last decade by various research groups [6]. In the last years the ophthalmology is always more heavily driven by image analysis. In fact, a number of image analysis tools have been developed for tracing vasculature, identifying key structures, segmenting pathologies and comparing several morphologies to normal ones. In particular, the retinal fundus image analysis allows physicians to detect in more robust and automatic way pathologies as macular degeneration, diabetic retinopathy ,glaucoma, retinopathy of prematurity and so on.

Drusen are roughly distinguished visually from their background by means of their brightness, morphology and yellowish color [7]. However, the color by itself does not convey consistent information for discrimination. Thus, in order to evaluate the contribution of color to the characterization of the symptoms, an experimental analysis was initially performed considering the RGB. Several references for color processing can be found that use different color bands for enhancement purposes. We studied drusen visibility in various color spaces and concluded that the gain in visual improvement is less than or almost the same as that of the green band of the RGB space. More specifically, the red band provides information for reflectance in the image and therefore is strongly affected by the non-uniform illumination, whereas the blue band contains almost no useful information for drusen. The green band is more informative and less affected from the overall variation of illumination. Our empirical observations also agree with the selection of the green channel in, as the channel with the maximum contrast. Another issue related to illumination concerns the normalization of surfaces to light exposure and reflection. When irregular surfaces are illuminated, the amount of light reflected back to the camera from each region is a function of its orientation with respect to the source of light and the camera. The shape irregularity of the retina produces variable shading across the field of view when illuminated with a bright source, as in the Fundus camera . In this paper we propose to distinguish between back ground and drusen regions.

II. MATERIALS

Retinal fundus image is the image of retina obtained by using a special device called fundus camera [8]. It takes the photograph of the interior surface of the eye including the retina, optic disc, macula and posterior pole. The images are captured with 35 ° field of view, and stored in RGB color format is given in fig.1 and image with age related macular degeneration is given in fig.2.

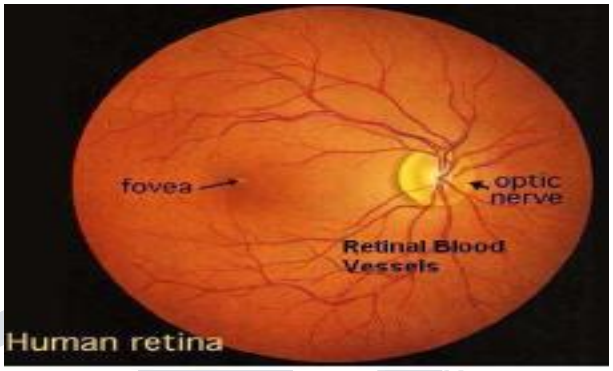

Fig.1.Healthy Retinal Fundus image

Fig.2.Image with Age related macular degeneration

III. METHOD

The input fundus image with age related macular degeneration was read and the back ground was subtracted from the fundus image. Extract the red and green components from the subtracted image. Adjust the thresholding to the image to extract the drusen part of the image and then convert the image to the black and white format to get the required output.

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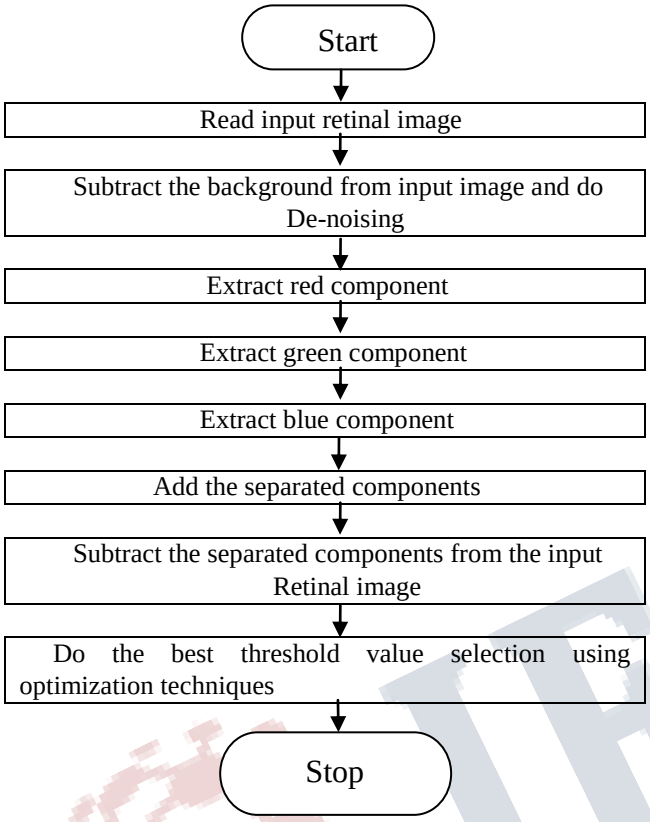

Fig.3 steps involved in the detection of age related macular degeneration

The macula is dark pattern and the gray level variations in this region are higher than in any other part of the image. The green component of the image shows a good variation between macula and background variations. In thresholding we we choose a single threshold value for the wholw document. This method exhaustively searches for the threshold that minimizes the intra-class variance. The goal of thresholding is to divide the pixels of given image into two classes black and white. Back ground subtraction is process of extracting foreground objects from maintained background model. A foreground object is an entity that detected by producing difference of the every frame of sequence to background model.

Brightness and contrast adjustment

Two commonly used point processes are multiplication and addition with a constant is given in equation.

$g(i, j) = \alpha . f(i, j) + \beta$

The parameters α and β are often called the gain and bias parameters to control contrast and brightness respectively. This method exhaustively searches for the threshold that minimizes the intra-class variance. The goal of thresholding is to divide the pixels of given image into two classes black and white Drusen are roughly distinguished visually from their background by means of their brightness.

IV. RESULTS AND DISCUSSIONS

The results of age related macular degeneration are given in fig.3 (a), (b), (c), (d), (e), and (f). The rate of sensitivity and specificity are two parameters considered evaluation parameters and the experimental result is given in table.

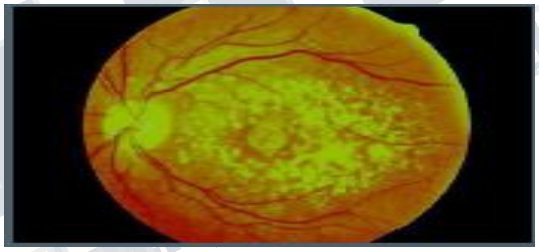

Fig.3(a) Input image

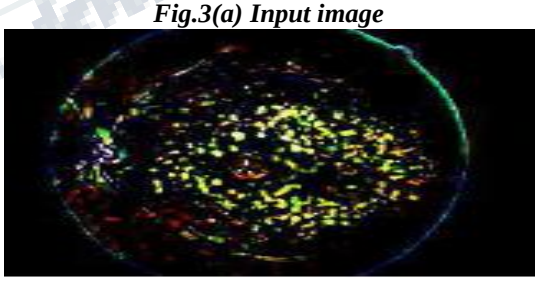

Fig.3(b) image after subtracting the input from the background

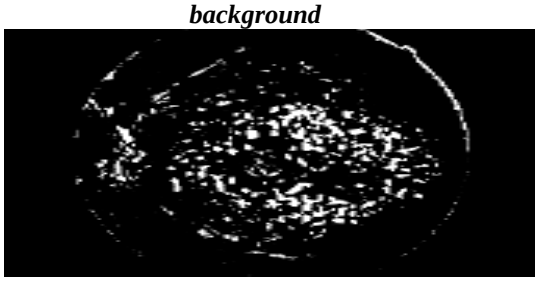

Fig.3(c)image after converting from RGB to gray

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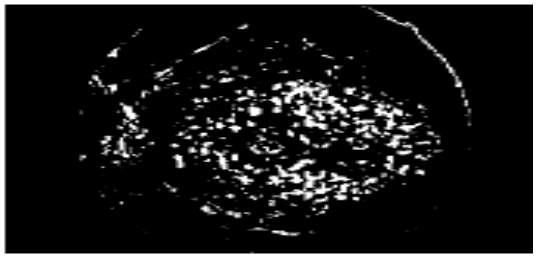

Fig.3(d) image with only green components

Fig.3(e) image after adjusting image intensity values

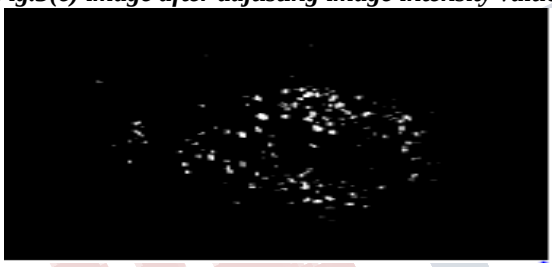

Fig.3(f) final output

We tested our algorithm using a set of images acquired by the fundus camera. They were actually captured from the left and the right eye of patients. We focused in the central part of the retina, gray-scale versions of the original color images. Drusen show up as bright blobs, but it is evident that the automatic extraction of these pathological features is difficult, since drusen vary strongly in shape and size and they tend to spread (varying brightness) around their location. Additionally, small bright regions of the background tend to create larger areas that can be mistaken as large drusen.

The results of the proposed algorithm for the detection of defect regions (drusen) inside the human retina are presented in this section. Fig 3 demonstrates the detection potential of the proposed algorithm on three representative images from the available set of retinal images; one image with small and large drusen, a second one with large drusen, and a third one with small sparse drusen. A qualitative evaluation from experts is presented at the end of the current section. The below figure shows the effectiveness and robustness of the algorithm. The presence of noise is strong, as it is detected at background regions. In addition, large drusen do not differ sufficiently from the background. Except of the circular bright drusen, all others are noisy and intermixed with surrounding areas. Even in this case, our algorithm detects correctly all small drusen and loses only few parts of larger ones, which appear at the central part of the figure. In general, the presence of vessels and their interaction in intensity with drusen pose serious problems even in manual drusen detection.

The proposed algorithm overcomes this problem and does not experience false detection, in the entire test set of images. This is due to the appropriate consideration of features in local areas that can separate drusen from vessel distributions. Overall, the proposed algorithm performs quite efficiently in the entire set of macular degeneration images tested. This set of images covers a wide range of possible drusen sizes and formations, including vague, non-canonical shaped and thin blobs. In order to provide a statistical analysis of the algorithm's performance, we asked for experts' assistance in determining the actual drusen areas. Notice that all images reflect actual test cases without any prior information on the status and extent of AMD. Thus, for testing the algorithm's classification (drusen versus normal background) against an 'actual' state, we are based on clinical evaluations performed by the experts. Two experts have extensively studied the retinal images and all the areas that are considered drusen by the doctors have been manually separated. Their intersections, i.e. the areas that are classified as drusen by both experts, are considered true drusen areas. Thus, our statistical tests give priority to 'correct detection' than to 'false alarm'. Statistical measures, such as the rate of true positive detection (sensitivity or TPR), false positive detection (1-specificity or FPR) and false negative detection (FNR) have been computed in order to establish the performance of the algorithm. The sensitivity and specificity of the algorithm exceed 96% for almost all test cases. Only in one case the sensitivity falls around 88% due to noise. The FNR statistic reveals that the algorithm underestimates drusen areas in this case. The overall performance of the proposed algorithm on the retinal images tested is presented in the table.

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Further demonstrating the efficiency of the proposed algorithm, the results are subtracted from the original images, so that the detected regions appear black. Parts of the drusen that are not detected should appear bright, retaining their original gray level. The areas inside the solid lines are underestimated (in size), while those inside dotted lines are overestimated. Overestimation is experienced mainly at the borders, due to the different lighting model from the center to the edges of the image. These false alarm areas can be easily rejected by the doctor inspecting the results and do not pose any problems to the early detection of AMD cases. In general, the drusen of interest in AMD examination are located inside or around the macula, the central part of the eye. In these areas, our proposed methodology does not produce false alarms. Underestimation of drusen areas is a more severe problem.

Sensitivity:

Sensitivity of a test refers to how many cases of a disaease a particular test can find. Numerically sensitivity is the ratio between number of true positive (TP) results to the sum of true positive and false negative (FN) results. Sensitivity relates to the test's ability to identify positive results.
Sensitivity = *TP/(TP+FN)*

Specificity :

The specificity of a test refers to how accurately it diagnosed a particular disease without giving false positive results. Numerically, specificity is the ratio between number of true negative results (TN) to the sum of true negative and false positive (FP) results. Specificity relates to the test's ability to identify negative results.
Specificity=*TN/(TN+FP)*

V.CONCLUSION

This paper considers the feature detection technique for the problem of automatic AMD evaluation. The detection of anomalies in human eye's retina is a biomedical problem appropriate for image processing and automated analysis, whose solution is intended to help the ophthalmologists in their decision making process. Use of the proposed detector may reduce false negatives and give reliable detection accuracy in both position and mass size. The obtained output images determine the abnormality in an eye. The objective of algorithm is to develop a system which detects age related macular degeneration automatically. The algorithm was simple, robust and faster. The proposed method is able to detect actual drusen in various cases tested. We obtained sensitivity and specificity as given in table.

Rate of sensitivity and specificity

Pathology	Sensitivity	Specificity	Accuracy
Age related macular degeneration	0.899	0.821	79.463

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