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Automated Drusen Detection in Age-Related Macular Degeneration

C. Jeyakarthikeyan[1]
Department of Computer Applications
SSN College of Engineering
Tamil Nadu - India

C. Jayakumari[2]
Department of Computer Applications
SSN College of Engineering
Tamil Nadu - India

Abstract: Age-related macular degeneration (AMD) is a progressive eye disease that stands as one of the major cause of blindness. This condition is developed due to the aging process and most of the people having this defect are in the age group of 55 to 65. The disease is caused as a result of extra cellular fatty deposits called drusen in the Bruch's membrane and when more and more drusens deposits are formed, it leads to a loss of central vision. The ophthalmologists can rightly screen the drusens manually but that consumes more time. So an automatic screening process will help to reduce the screening time. In this paper, a texture based approach for the automatic detection of drusen is suggessted.

Keywords: Macula, Retina, Retinal pigment epithelium, Drusen, AMD.

I. INTRODUCTION

One of the main challenges in the current health care industry is the vigorous development of Age-related Macular Degeneration (AMD) [1]. AMD is a disease that causes progressive deterioration of macula which is responsible for the central vision. AMD disorder leads to irreversible loss of central vision [2][3]. Since a large number of retinal images are taken each day for diagnosing the retinal diseases, the ophthalmologists have to spend a lot of time in screening process. To reduce screening time, an automatic screening method has been proposed for segmenting the drusens.

There are two categories of AMD, namely dry and wet. Drusens are small hyaline deposits yellowish in color that grow beneath the retinal pigment epithelium [4][5]. In most cases of macular degeneration, the severity of the ailment can be prohibited if it is detected in the early stage. In general, there are no salient symptoms in the premature stages, but the number and size of drusens predominantly increases in due course of time. Screening the retina to detect AMD and thereby monitoring the progression has been very effective in prevention of vision loss.

The dominant signs of AMD are blurred vision, slight distortion or the complete loss of central vision. The images in figure 1 show the fundus images of (a), a normal retinal image and (b), the retinal image with drusen deposits [16].

The images in figure 2 show scenes viewed by a normal person and patients with AMD. In the figure 2, (a) shows the normal vision, (b) displays a slightly distorted vision, the early stage of AMD, (c) depicts the blurred vision, an advanced stage of AMD and (d) shows the loss of central vision [16].

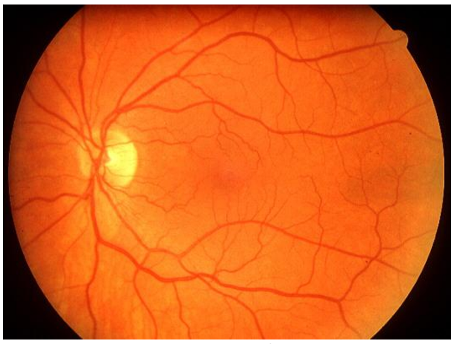

Figure 1 (a): Normal fundus image
Courtesy: Treasure State Eye Care Center

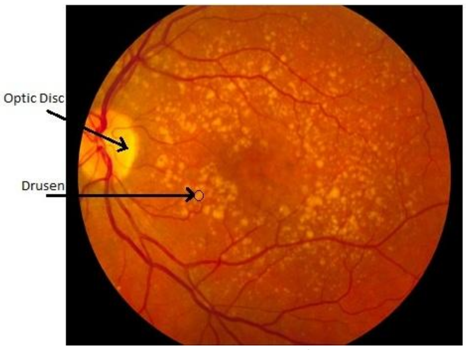

Figure 1(b): Drusen deposits in fundus image with AMD
Courtesy (Image): National Eye Institute

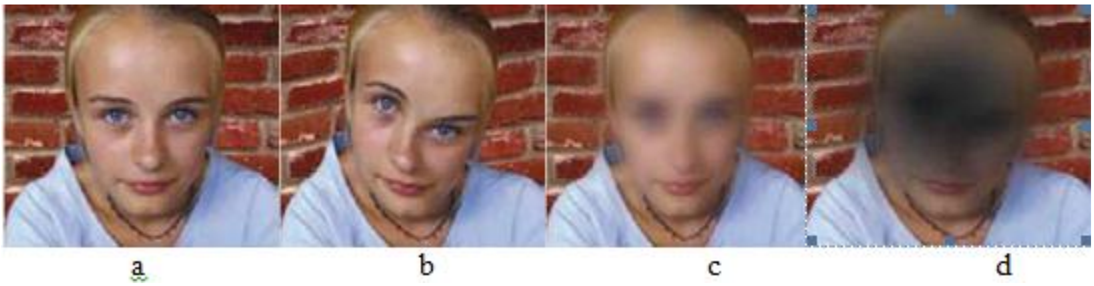

Figure 2: Normal vision and vision with age-related macular degeneration. (a) Normal vision. (b), (c) & (d) The same scene viewed by people with AMD

Courtesy: The Retina Institute of the Carolinas.

II. Schematic Flow Diagram

The objective of this paper is to segment the drusen from the retinal fundus images using the texture analysis algorithms in the early stage. The steps required for the segmentation of drusen is depicted in the figure 3.

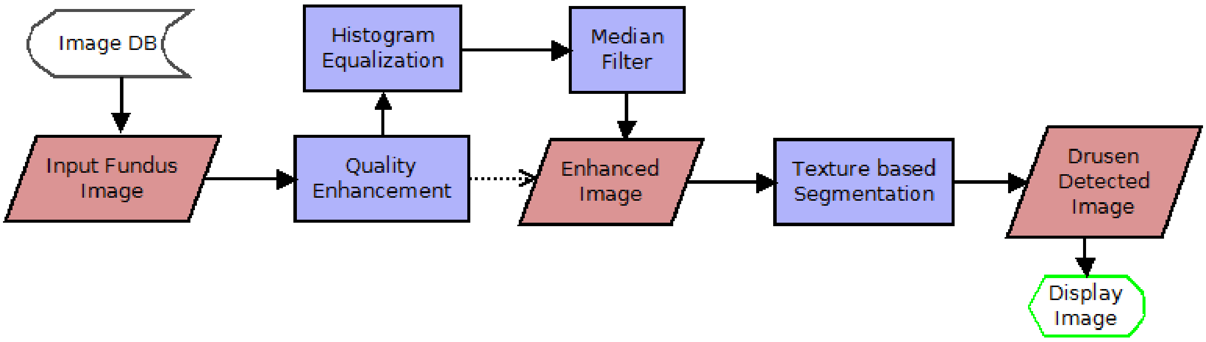

Figure 3. Schematic Flow of the Drusen segmentation

III. Literature Survey

The recent medical image processing developments include several algorithms for drusen detection and segmentation. L. Brandon et al. [6] proposed a method to detect drusen in a retinal image automatically using multi-level analysis. P.Checco et al. [7] suggested a Cellular Neural Network-based algorithm which aims to enhance drusen in monochromatic fundus image. N. Lee et al. [8] contributed an ongoing learning non homogenous texture discrimination algorithm with application to drusen detection. Z. B. Sbeh et.al. used a fuzzy logic approach to detect drusen [9]. Steffen Schmitz-Valckenberg et.al. focused on a semi-automated image processing method for identifying the geographic atrophy. The authors Jpn J et.al. Ophthalmology has proposed quantitative hyper spectral parameters for distinguishing between AMD and a normal macula [14]. They used the Near-infrared hyper spectral images process the images with exudates. Macular vectors were determined as the average spectrum for each macula, and reference vectors were used as average macular vectors for healthy volunteers [14]. Burlina P et.al. described an approach for screening abnormalities in retinal imagery [15]. They identified both normal and anomalous regions within the retina by using a hybrid parametric and non parametric characterization with the support of the probability distribution of normal retinal tissue in color and intensity feature space. The results are obtained using the green element and the algorithm is repeated for the entire image which results into the detection of the drusen pattern in the image. Chen Q et.al. used OCT images to detect the drusen [16].

In this paper, the authors propose a methodology to automatically categorize the fundus images into normal and drusen affected using texture analysis and morphological operators. The retinal color fundus images are obtained from an eye care clinic.

IV. Image Enhancement Techniques

Image pre-processing is a technique performed to enhance the quality of an original image and it consists of reducing the noise by applying various algorithms. Prior to the detection of drusen, the histogram equalization has been performed to enhance the quality of the image.

V. Histogram Equalization

Histogram equalization is a method in digital image processing to enhance the contrast of the image using the image's histogram. This method usually increases the global contrast of images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of local lower contrast to gain a higher contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values. The result of the histogram equalization is depicted in the figure 4.

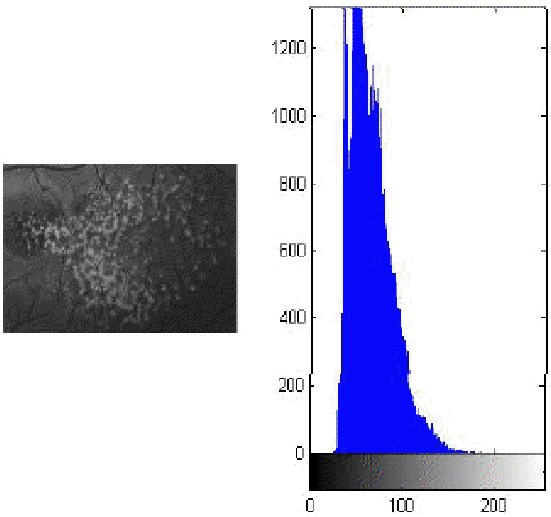

Figure 4(a): Image before Histogram Equalization

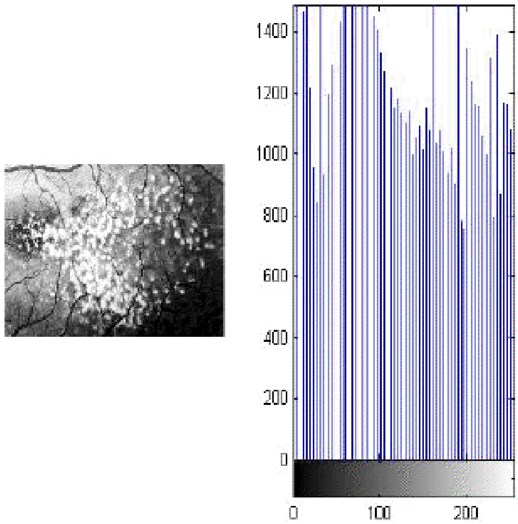

Figure 4(b): Image after Histogram Equalization

After performing the histogram equalization, the resultant images are further preprocessed using a 3by3 median filter (1) to remove the noise by preserving the edges present in the image. The result of the application of the median filtering technique is shown in the figure 5.

$$y[m, n] = median \{ x[i,j],(i,j) \in w \} \quad \ldots(1)$$

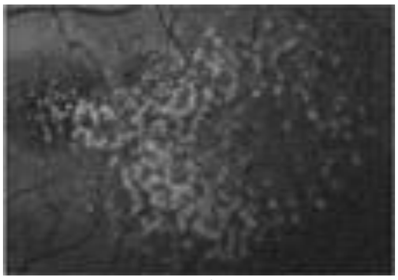
Figure 5(a): Image before Median Filtering

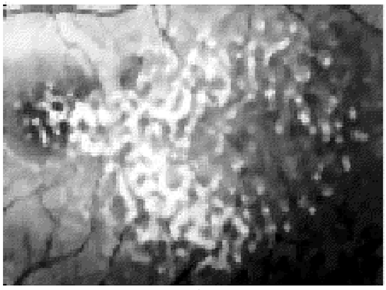
Figure 5(b): Image after median Filtering

VI. DRUSEN DETECTION USING TEXTURE BASED APPROACH

Image segmentation is used to partition the given fundus images into two regions namely drusen region and any **other** retinal features region. After preprocessing the images with histogram equalization and median filtering, the texture based image segmentation technique is used. Texturing is one of the difficult procedures in the image segmentation method [10].

A. Entropy

The value of the entropy is low if the same pair of pixels appears frequently and high if all the grayscale or color levels are faintly represented. If the image consists of same type of pixels, many existing techniques can be used for the segmentation of images and that will contain only homogeneous color regions. [11]. However, images with natural scenes are rich in both color and texture. Most of the texture segmentation algorithms [12][13] require the estimation of texture model parameters.

After the application of entropy, very small objects from the images are removed using the area opening. The holes in the gray scale image are filled using the surrounding dark pixels as reference and then the function is applied for the final detection of drusen. In figures 6 and 7, (a) shows the original image and (b) shows the drusen detected image.

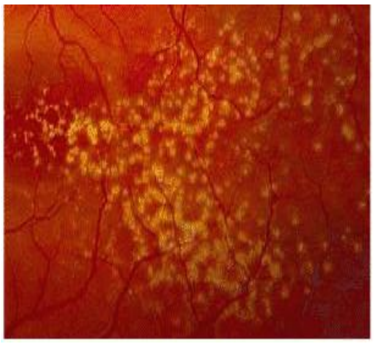

Figure 6(a): Original Image

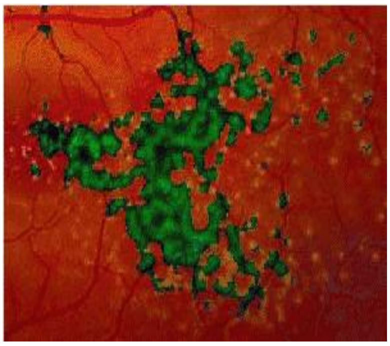

Figure 6(b):Drusen detected image

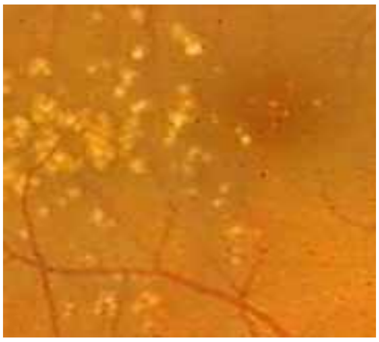

Figure 7(a): Original Image

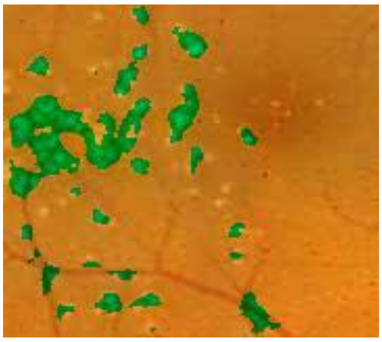

Figure 7(b): Drusen detected image

VII. CONCLUSION

This paper presents a texture based segmentation algorithm to detect drusen in color fundus images. The method automatically segments drusen regions in an image portions with region of interest. The results show that the accuracy of the method is 85% and the sensitivity is 86%. This study can be further extended to test the algorithm with full images rather than the area of interest. Further work includes the improvement of accuracy and sensitivity using any new algorithms. However, the outcome of this implementation is quite encouraging with respect to the objectives that would help us to develop a more robust method.

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