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Automatic Drusen Detection and Area Calculation from Color Retinal Images

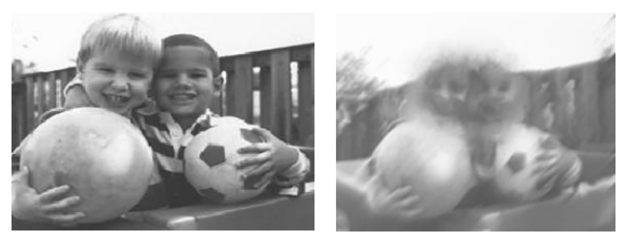
Ranjan Jana[1], Amrita Roy Chowdhury[2], and Chhanda Ray[1]
[1] *RCC Institute of Information Technology, Kolkata, India*
[2] *Academy of Technology, West Bengal, India*

Abstract

Drusens are white or yellow spots in eye fundus that consist of extra cellular material. The health of the retina deteriorates with age in some people due to the appearance of drusens. Nowadays, ophthalmologists use fundus camera to examine patient's retina. The retinal image is then captured and analyzed its appearance to locate the abnormalities, e.g., drusens. Since a large number of retinal images are taken each day, ophthalmologists have to spend much time in screening process. To reduce screening time, one automatic screening method has been proposed for detecting and segmenting drusens. This paper concerns a method to automatically detect drusens in a colour retinal image without human supervision or interaction. Automated detection and analysis can provide vital information about the quantity and quality of the drusens. In this paper, we report on one method that we have developed to reliably detect, count and measure the area of the drusens.

1. Introduction

Age-related macular degeneration (ARMD) is a common eye disease that affects vision in adults older than 50 years of age. This degenerative condition gradually degrades macula, a part of the retina, which is responsible for central vision. The proper function of macula allows us to see appropriate details, to read, to drive, or to recognize faces [1, 8]. ARMD causes no pain and most of patients do not notice any change in their vision until they cannot see objects in front of them clearly. ARMD may only cause blurred vision or slight distortion. In worst cases, it causes a complete loss of central vision, making reading or driving impossible. Figure 1 shows scenes viewed by normal and patients with ARMD. They may have distorted view, blur, or view with scotoma (blind spot). These abnormal vision examples are shown in figure 1(b). Drusen is one of the most common early signs of ARMD.



(a) (b)

Figure 1: (a) Normal vision (b) Same scene viewed by people with AMD.

Figure 2(a) shows normal retina image and figure 2(b) shows the drusen affected retina image.

(a) (b)

Figure 2: (a) Normal retina image. (b) Drusen affected retina image.

The exact cause of the presence of drusen is still unknown [9]. Over a period of time, drusen slowly develop their sizes, shapes, and numbers. The ophthalmologists use these features as keys to classify stage of ARMD and to give appropriate treatment to patients. However, these changes may be prevented if drusen are observed early [3].

An accurate count of drusens in a colour retinal image provides sufficient information about the extent of disease [7]. The task of automatic detection poses various challenges. Drusens appear as yellowish, cloudy blobs in a retinal image. They exhibit no specific size or shape. The modification of size in individual drusens and their confluence seem to be an essential risk factor in developing macular degeneration [8]. Drusens are classified as either hard or soft. Hard drusens tend to be smaller; more sharply defined and are generally less harmful than soft drusens. Soft drusens may be accompanied by other symptoms such as new vessel formation or fluid build-up in macula. The fuzzy boundaries of soft drusens pose a challenge in accurately locating the actual drusen region [6].

There are very few attempts specifically on automated drusen detection or segmentation in retinal imagery. [2] use a modified morphological operator to detect the brightest points (peaks) within individual drusens. [3] adopt an adaptive local histogram based method to identify an appropriate local threshold for segmenting each drusen. These methods however require a manual segmentation of the region of interest which is the region around the macula and between the two major veins (arcades). The manual segmentation eliminates the possibilities of false detection due to other interfering structures (for example, optic disk) and non-uniform illumination. The automatic segmentation of the region of interest itself is a challenging task. Thus, both the approaches do not provide complete solutions to the automatic detection task. Brandon et al. [4] report a technique to detect and segment drusen in full retinal images without human supervision or interaction. They use a multi-level approach, beginning with classification at pixel level and proceeding to the retinal, area, and then the image level. This is however computationally expensive and the results are dependent on a good set of training data.

This paper reviews several image analysis techniques proposed for detecting and segmenting drusen in retinal image automatically and is organized as follows. Section 3 describes the algorithm proposed for drusen detection and drusen area calculation. Experimented results are mentioned in section 4. Finally, the conclusions are in section 5.

2. Drusen Detection and Area Calculation Methodology

There are several drusen detection and segmentation algorithms have been proposed [1]-[9]. Some algorithms were applied on subimages which contain drusens which are manually segmented prior to processing. Some techniques were applied to a full retinal image. In this paper, one technique is used for drusen detection and drusen area calculation. Here, we convert the dursen affected colour image into gray image. After that, we estimate the value of the background pixels of the gray image and subtract the background image from the gray image. Then we adjust the contrast of the processed image. Using the threshold value range 0.7 to 0.8, the processed image is converted into binary image. The threshold value 0.7 to 0.8 works better for gray to binary conversion of drusen affected retina image. After that, we determine the number of drusen objects in the Region of Interest (ROI) of the image and calculate the area of the drusens in the image with respect to the area of the ROI. The percentage of the drusen area gives the approximation result. We also calculate the mean and max area of drusens in the image with respect to region of interest.

3. Algorithm for Drusen Detection and Area calculation

In case of drusen detection, typically, retina images are taken by different sensors. For left or right retina images, the optic disc is in a fixed position. So, except the area of optic disc, the whole area is the region of interest.

Step 1: Read a drusen affected color retinal image.

Step 2: Convert the colour image into gray image.

Step 3: Estimate the value of background pixels.

Step 4: Create an image with a uniform background.

Step 5: Adjust the contrast in the processed image.

Step 6: Create a binary version of the image using threshold value 0.7 to 0.8.

Step 7: Determine the number of objects (actually the number of drusens) in the Region of Interest.

Step 8: Compute statistical properties of objects (actually statistical properties of drusens) in the image.

4. Experimental Results

This section introduces the experimental results. The result of the above algorithm is shown step by step in figure 3.

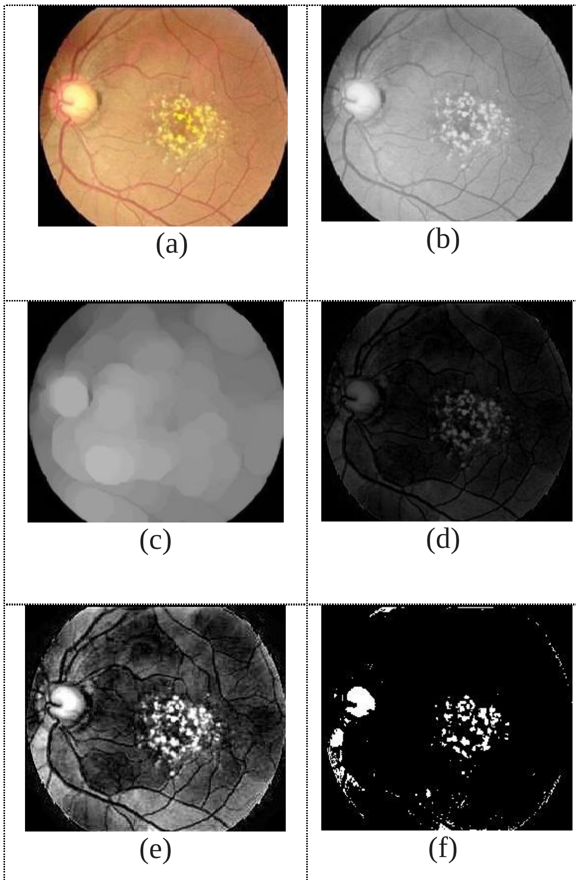


Figure 3: (a) Drusen affected image, (b) Gray image, (c) Background approximation image, (d) Image with uniform background, (e) Contrast image, (f) Binary image

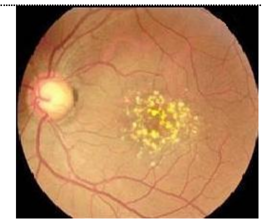
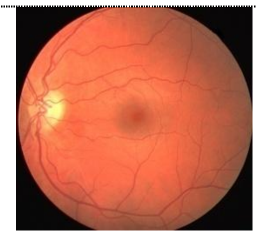
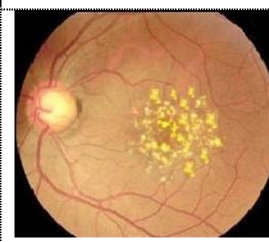
 (a)	Affected area= 1.9037 % Max Area =1.1698% Mean Area= 0.0198%
 (b)	Affected area= 0.0022% Max Area = 0.5083% Mean Area= 0.0161%
 (c)	Affected area= 2.5961% Max Area = 1.1087% Mean Area= 0.0229%

Figure 4: (a) and (c) Drusen affected retina image, (b) Normal image

In figure 4, we have taken three different retina images. One of these is normal retina image and others are drusen affected retina images. The above algorithm gives the corresponding result. The affected area is more important, which specify the percentage of affected area with respect to retina area. Percentage of affected area increase means drusen area increased. Max area specifies the biggest dursen size in the image, whereas; mean area specifies the average drusen size of the images. The retina image that is displayed in figure 4(c) is more drusens affected comparable to the retina image that is displayed in figure 4(a). For this reason, figure 4 shows the affected area of the first retina image is 1.9037% and the affected area of the third retina image is 2.5961%. Mean area of the third retina image (0.0229%) is higher than the mean area of the first retina image (0.0198%).

5. Conclusion

Since a number of ophthalmologists in many developing countries are still inadequate, it is necessary to develop an automatic drusen detection system to help ophthalmologists to reduce screening me. A new algorithm for drusen detection, count and area measurement has been proposed. This review may help researchers in this field to see the problems and the state of the art techniques of drusen detection, count and measurement of drusen's area. However, there are still some weak points, which need to be improved. The possibility to detect drusen in presence of other bright lesions (for example, exudates) should also be explored.

The suitability of any drusen detection approach should be evaluated based on the actual aim of the work: to get an accurate count of drusens and to segment them for grading (identifying soft/hard drusens based on the area/size). A drusen count in a given retinal image provides ample information about the potential risk for ARMD. The task of grading drusens involves segmentation of entire drusen regions. Grading of drusens can be achieved using the statistical information (number of drusens, area of biggest drusen and average area of all drusens). In summary, since accurate count of drusens as well information for grading them they seem to be the most promising for automatic drusen detection.

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