Elicitation of Drusen to Envision Age Related Macular Degeneration

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Abstract

Age Related Macular Degeneration is an eye impairment which degenerate the macular region of the retina. The presence of drusen in the macula indicates an abnormality, which is the early symptom of Age Related Macular Degeneration and leads to vision loss if not treated earlier. An automatic screening system has been designed using MATLAB for localization of macula, automatic drusen extraction, quantification of the drusen and to evaluate the level of risk associated with it.

Keywords:- ARMD; Drusen extraction; Macula; Fundus Image; Machine Learning;

I. INTRODUCTION

Age Related Macular Degeneration (ARMD) is a progressive eye ailment that distresses the dominant vision of the individual earlier than the marginal vision which results due to the degeneration of the macula. The macula is the small and specific part of the retina. It encompasses the photo receptors, which permits the perception of colour and recognize objects. The major cause of vision loss of elderly people is due to ARMD[1]. But its presence in early or middle age is to be considered as the alarm and care should be taken to avoid it. By the end of 2020 the approximate number of people affected worldwide due to ARMD exceeds 196 million[2]. Indian statistics exposes a predominance degree of ARMD extending from 1.2 % to 4.7 %. Since it is an irreversible, the adversity affects the quality of vision of the individual and they need to depend on others for living. The disease is caused by the yellow lipids formed within the macula region of the eye[2] called drusen. The clinical characteristics of drusen are yellow deposits of small and discrete[3]. Fig. 1(a) shows a healthy fundus image and the spots yellow spots appearing in fundus photograph in Fig. 1(b) shows the visibility of drusen in the macula[2] and it is mainly of two types namely hard and soft. Drusens are differentiated as either hard or soft by the appearance of the margins. Hard drusen are small and have distinct margins, while soft drusen are large and have indistinct edges[2][4].

Usually drusen occur in normal aging process. So indication of small drusen is not always the symptom of ARMD, but the frequency of its occurrence and size of it is associated with are the development of risk factor[4]. The incidence of hard or dry drusen are generally more in percentage[5] when compared with soft or wet nature

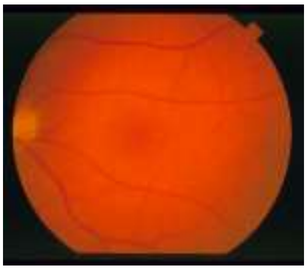


Fig. 1(a) Healthy Fundus Image

Fig. 1(b) ARMD affected Fundus Image

Computerized analysis can also be useful for quantitative measurements of various diagnostic parameters for consistent assessment and follow-up examinations [1]. Medical image processing is a boon to the field of medicine, where medical images are processed with the help of computer and the results generated help in diagnosing in a better way. This paper compares the performance of thresholding and k-means clustering techniques in segmenting the optic disc and optic cup from the retinal image in order to compute the cup to disc ratio. Section II discusses the methodology of classifying the image as either healthy or glaucoma suspected by using cup to disc ratio (CDR). Section III mentions the statistical analysis followed by result analysis and conclusion in section IV and V respectively. The progression and risk can be controlled by proper diagnosis at right time. Human perception is outweighed by automatic machine perception. Human eye discriminates a drusen from Colour Fundus image (CFI), but an algorithmic approach of an automatic system enhances the process in terms of efficiency and accuracy. More imaging devices and techniques are available and Computer Aided Design (CAD) is more popular and it gains insight in biomedical processing of ocular diseases, due to its precision and accurateness. Even the smallest pixel variation can be noted clearly and pave a way for better diagnosis and also inexpensive compared with the medical aids. OCT is an imaging modality, which is mostly used in hospitals for the flawless diagnosis of retinal diseases. As it is expensive the usage of these devices in large scale applicability may be tedious. To make it reality to the economically underprivileged, fundus imaging applied with CAD tool can be used as an alternative imaging technique. Fundus image is a digital image captured with the fundus camera. Due to its inexpensiveness and compactness, compared with OCT, the usage of it as a mass screening methodology is an ideal solution. Most of the early studies dealt with extraction and the aim of this article is to analyze the fundus image and study dry drusen to explore the risk of ARMD by measuring the factors allied with drusen. The methodology of the research work is elaborated in Section II, the experimental explanation is in Section III and the conclusion is in Section IV.

II. Proposed Algorithm

Drusen is the clinical indicator of ARMD. The process of its extraction and the assessment of risk factor is elaborated in the following phases and the conceptual framework is shown in Fig. 2.

2.1 Pre-processing

Pre-processing enhances the appearance of any image and facilitates in selecting the appropriate feature of interest. The black area, the optic disk and the exudates present outside the macula of the colour fundus image (CFI) is not of relevance to this process and deviate the extraction process, and hence macula to be the region of interest (ROI) is segmented from the CIF for further processing. This method applies LAB colour space conversion to the ROI macula. As the size of the ROI is considerably less than the original image, it is evident that the computational complexity is also reduces. The preprocessed images are shown in Fig. 3.

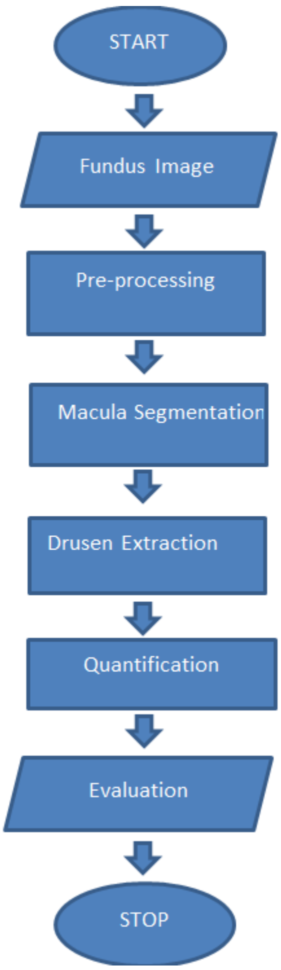
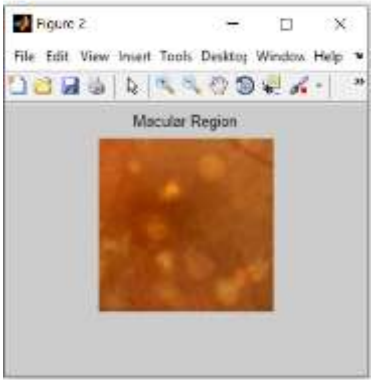


Fig.2. Flowchart of proposed Technique



3(a) Macular Region

Fig. 3(b) LAB Colour Space

2.2 Drusen Extraction using Machine Learning Algorithm

Machine learning is a technique of Artificial Intelligence and K-means clustering is an unsupervised machine learning algorithm. Pixel classification pertaining to drusen is essential in drusen extraction process, so drusen candidate pixel is labelled using k-means clustering algorithm and the clusters are excavated. The self-learning technique categorizes pixels into clusters based on some characteristics. Neighboring pixels having similar property were assigned to the same cluster[6]. The likelihood of sharing the same cluster is based on intra cluster distance. Neighboring pixels with shortest intra cluster distance to the cluster center is grouped using Euclidean distance as in (1), this makes the boundary of each drusen well delineated from the neighboring drusen. The extracted drusen in the macular region by clustering is shown in Fig. 4 (a).

$$J = \sum_{j=1}^{k} \sum_{i=1}^{n} \left\| x_i^{(j)} - c_j \right\|^2 \quad (1)$$

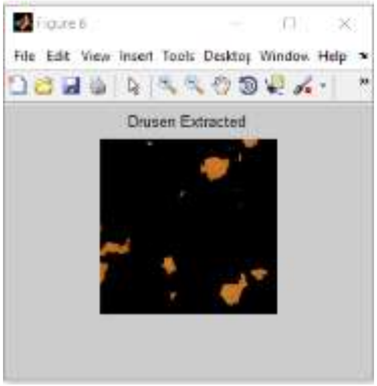
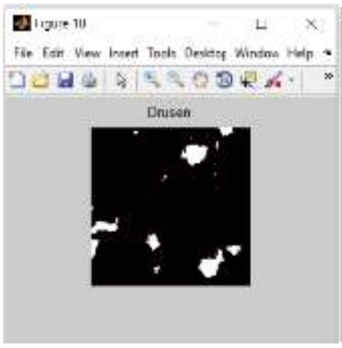


Fig. 4(a) Drusen in Macular Region

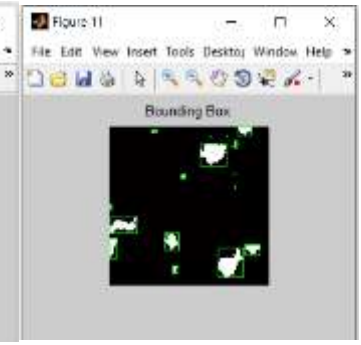
2.3 Post processing

The extracted image is subjected to post processing. The processed binary image is shown in Fig. 4 (b). If either the difference in intensity between the foreground and background differs by the threshold T, or the ratio of height and width of the drusen is smaller than the Threshold T1, the pixel is identified as false positive and eliminated[1], as specified in (2) . Binary thresholding technique applied and fine-tuned localized drusen image is shown in Fig. 4 (c).

$$(x,y) = \begin{cases} o, & g(x,y) < T \\ 1, & g(x,y) \geq T \end{cases} \qquad (2)$$



4(b) Drusen Extracted



4(c) Drusen Localization

2.4 Quantification

The drusen present in the macular region is the clinical symptom of ARMD, and it is quantized to assess the risk associated with it. The presence of drusen can be analysed in terms of clinical features like size, area, colour and number of drusen[2].

Table 1: Clinical Features

Feature ID	**Feature Name**
F1	Number
F2	Size
F3	Colour
F4	Area

Area of the connected region gives the area affected, which is identified by the number of pixels in the identified region. As given in (3), the affected ratio of the macular region is the area of the drusen to the area of the macular region. Correct measurement of these structures support experimental studies for evaluation[7].

$$Ratio = \frac{Area\ of\ drusen}{Area\ of\ the\ macula} \quad (3)$$

2.5 Evaluation

The computer assisted learning algorithm proposed excerpts the drusen inevitably and measure the extracted feature, to classify the image as either little risk or high risk. As per Cologne Image Reading Centre and Laboratory (CIRCL) protocol[6], the ranking benchmarks for ARMD are tabulated in Table 2. The scheme ascertains the presence or absence of drusen in the macula. Decision tree technique is applied to distinguish the given input image as healthy or not healthy. Based on the dimension of the factors, the status of the level is categorized as early, moderate or advanced as shown in Table 2. In case of abnormality, the person can be warned before getting worse effect.

Table 2: CIRCL Protocol for ARMD Prediction

Features		**Prediction**
Number of Drusen	**Size μm**	
No Drusen		Normal Image
>10 small	<63	Early ARMD
>15 small	>63 and < 124	Moderate ARMD
>15 small	>125	Advanced ARMD
Not clear Image		Not Gradable

III. Experiment and Result

The medical features needed to be extracted for the diagnosis of ARMD pose many challenges. The quantifying factors like size, colour, area and the number for the assessment of drusen may not be clear if the image acquisition is not good and depend upon the quality of the image capturing device. The extracted drusen is measured for the features[3] as per Table 2.

Table 3: Visualization of ARMD Images

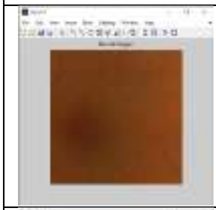
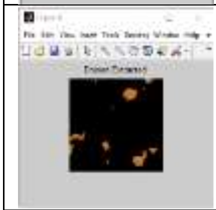
Image	Number	Ratio Affected	Interference
	Nil	Nil	No Drusen
	4	0.0242	Small Drusen
	17	2.8333	Medium Size Drusen
	59	8.4286	Large number of Small Drusen

Table 3 visualizes the extraction and quantification process of the proposed method. The standard deviation of drusen obtained for an image is shown in Fig. 5. It indicates the presence of large number of drusen of varying size. The STARE database has been used for evaluation of the proposed method[8].

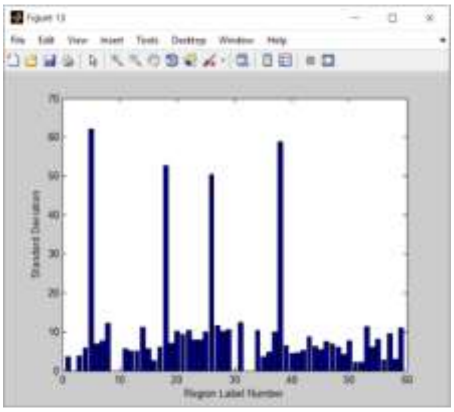


Fig. 5 Standard Deviation of Drusen

The persons may not be aware until they notice a change in the vision, instead an eye exam can reveal it [9]. Manual analysis is possible, but it is tiresome and time consuming for large group reportage and working out of above features is not consistent. The developed system extracted and evaluated the features in a right way, the results generated are impressive and the CAD greatly aids the individual who are the victims of ARMD. From the features extracted and tabulated in Table 3, it is evident that the input image can be very well differentiated between macular with the presence of drusen and without the presence of drusen and can be classified as healthy, mild, moderate or advanced stage. Thus the person can be informed about the status of the retina, and the process of treatment can be carried out well in advance without causing the hard times. As it is irreversible, inhibition of the progression[10] is the need of the hour.

IV. CONCLUSION

The system developed using Math Works software MATLAB, extracts the drusen and the appraisal is done based on the physiognomies. The system clearly ascertains and set apart a healthy image and ARMD affected image based on the features. Analysing a large amount of images manually consumes time and an automatic screening tool helps in locating the malfunction at the early stage. This can be functional in outreach programs in rural belts where lack of doctors is apparent. A trained technician can capture the retinal image using the image acquisition device and fed into the system to figure out the risk. It offers a commercially feasible solution for airing and gauging the degree of age related macular degeneration, in a cost effective way, thus making sustainable elucidation to the individual in the timely phase and for follow up checkups in an unswerving manner. The future enhancement can apply soft or wet ARMD forecast and the work can be drawn-out to real time data.

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