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Review

A review on exudates detection methods for diabetic retinopathy

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ABSTRACT

The presence of exudates on the retina is the most characteristic symptom of diabetic retinopathy. As exudates are among early clinical signs of DR, their detection would be an essential asset to the mass screening task and serve as an important step towards automatic grading and monitoring of the disease. Reliable identification and classification of exudates are of inherent interest in an automated diabetic retinopathy screening system. Here we review the numerous early studies that used for automatic exudates detection with the aim of providing decision support in addition to reducing the workload of an ophthalmologist.

1. Introduction

The focus of this paper is on the image segmentation of bright lesions i.e. exudates which quantifying the early changes associated with diabetes. Since the optic disc and exudates exhibit similar brightness, color and contrast, removal of optic disc has proposed prior to the process of automatic exudates detection. The aim of the various approaches is to remove false positives so that only true exudates candidate detection is possible.

1.1. Clinical trial

Duration of Diabetes is one of the major risk factor responsible for progression of DR. Non- proliferative and proliferative diabetic retinopathy are the two stages related to the clinical profile of diabetes.

In its initial stage due to retinal capillary loss, fluid leaking and bleeding from the blood vessels cause retinal swelling and formation of lipoprotein exudates deposits into the retinal tissue. To avoid these DR progressions, natural medicines is highly important and antioxidants have major potential for it. Vitamins C, E, A, D, K + CU and Zinc, Selenium, carotenoids lutein, Zeaxanthin, Astaxanthin in the form of water-soluble antioxidants, lipid-soluble antioxidants and specialized enzymes is beneficial as natural protective components as the frontline defence for further metabolic abnormalities in DR progression. Intake of antioxidants through diet and nutritional supplementation includes the major role in reducing diabetic complications. Besides this antioxidants topology, Laser photocoagulation or surgery are the treatment available for DR therapy then also still there is the requirement for further advances in the treatment of this disease.

2. Main attributes of exudates

Appearance of exudates consists of three structure hard exudates, circumscribed plaques of exudates and fluffy exudates. Hard exudates appear as bright yellow regions lying superficially or deep in the retina. Plaque exudates represent the diffused accumulation of lipoprotein and having variation in size. Fluffy or soft exudates have the white fuzzy appearance and paler yellow tend to lie more superficially in the sensory retina. Exudates are a class of lipid fundus lesion visible through retinal imaging. Exudates are ranging in color from white to yellow with varying patterns, size, contrast and shapes. Exudates are the bright lesions having maximum intensity value with relatively distinct margins (Fig. 1).

3. Related work

Most image segmentation approaches for exudates detection have placed in one of the following classes: Global and Adaptive thresholding [1–14], Region Growing [15–20], Clustering [21–33], Morphology [34–47], classification [48–63] and others [64–75] which includes mixture modelling, edge and boundary detection, characteristics feature approach techniques.

3.1. Thresholding

One of the simplest exudates extraction methods has based on grey level thresholding [1]. For exudates segmentation, a multilevel thresholding based on the histogram was used. The combined method of median filtering, adaptive intensity thresholding and recursive region growing was described for exudates extraction. For exudate

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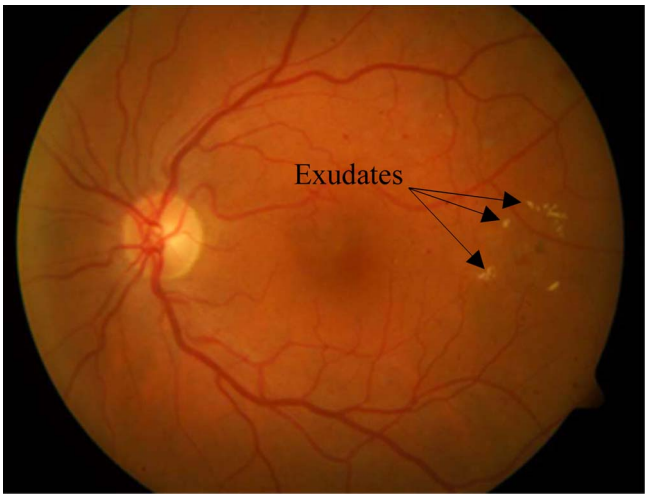


Fig. 1. A typical retinal image that contains Exudates.

identification and classification artificial neural network was used with exudate candidate features as inputs [2]. Image intensity thresholding used to distinguish between bright lesions and dark lesions followed by a region-growing algorithm to locate exudates. The performance of Mahalanobis classifier compared to Bayesian and K-Nearest Neighbour have the best results. A simple exudates segmentation method based on grey level thresholding was proposed in [3]. Five sequential steps were obtained for exudate segmentation. Initially, histogram modelling of green component applied to obtain an enhanced image which was then modelled by mixture model statistical technique followed by dynamic thresholding. Further automatic localization and masking of the optic disk was processed. Finally, postprocessing in terms of edge strength characterization using Kirsch's method and the morphological operation was applied to detect the sharp boundary of hard exudates [4]. Ward et al. [5] exploited the shade correction algorithm as a pre-processing of color fundus images followed by thresholding to distinguish it based on the high luminosity of exudates from the background. An approach used in [6] (Fig. 2) has a combination of global or adaptive grey level analysis and local threshold to segment exudates. In the research of [7], the threshold was selected automatically, but the region of interest must choose manually, in which any image-based accuracy provided. A disadvantage of this method has false bright lesions such as cotton wool spots could also be identified. A series of experiments such as CIELab color space conversion, binarization, mathematical morphology non-linear diffusion segmentation and color histogram thresholding was used to distinguish hard and soft exudates [8].

3.2. Region growing

In the study by [15], a recursive region growing segmentation algorithm was used for the detection of exudates. A recursive region growing technique was proposed by Sinthanayothin [16] to identify EXs in grey level images on 10×10 windows depending on the manually selected threshold value. By using Luv color space, computation of object color difference image was obtained using mean squared Weiner filtering for noise removal followed by edge detection and the improvement on region growing method on Luv color space was employed in the study of Li [17] (Fig. 3).

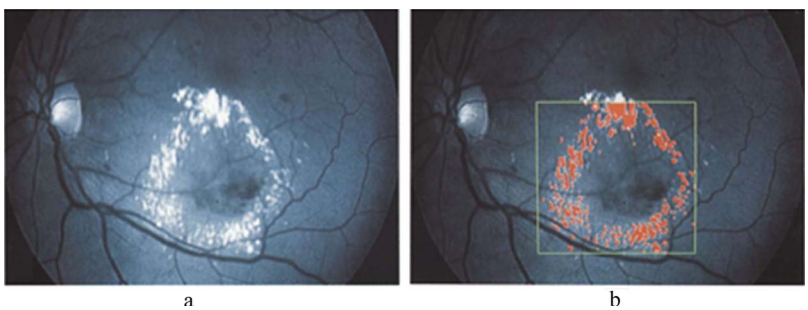
In this approach, computational issues are limited by exploiting edge detection to limit the size of regions. In these previous approaches, the problem of classification of cotton wool spots from exudate candidates has not addressed. Therefore, for improvement of exudates detection diagnostic accuracy, two main criteria have introduced i.e. lesion based and image based. In image-based criteria, the aim is to provide a decision whether the given image has any signs of DR predominantly on the basis of presence or absence of exudate candidates anywhere in the image region. The image-based criteria have measured system accuracy in terms of percentage of tested normal -abnormal images to the total number of images. Not only the number of exudates detection is sufficient for the diagnostic purpose but also the border detection in proper manner shows good statistics.

3.3. Clustering

For the extraction of exudates, candidate fuzzy C-means clustering and the neural network were applied to the color retinal images in which segmentation relies on histogram shape (Fig. 4) [21]. Osareh et al. [22] exploited pre-processing and segmentation to the color retinal images in terms of Local contrast enhancement, color normalization and fuzzy C-Means clustering followed by neural network classification to distinguish between two disjoint classes as exudates and non-exudates. The less accuracy results in case of uneven illumination by this approach but improved detection accuracy possible with Luv color space.

The Major drawback of these types of methods is not to get accurate lesion level evaluation. Due to color features criteria, other yellowish lesions such as cotton-wool spots have misclassified at the same time. Computation of intensity difference map with the use of median filtering, determination of lesion using dynamic clustering and then to improve the accuracy of exudate detection domain knowledge of large, primary and secondary vessels was proposed in [23]. A modified version of furry-c-means clustering applied by Dunn et al. [24] and improvement to it was given Bezdek et al. [25].

Sopharak et al. [26]. were proposed fuzzy c-means clustering to detect contours of exudates and statically classifier approach. For the diagnostic of DR by applying analytical approach, using cytological information and geometry was exploited in the literature [27]. The use of multiscale approaches for detecting red lesions usually used as features to be input to classification algorithms to detect exudates [28,29]. Bottom-up strategies in terms of three stage used for bright lesion detection with clear differentiation of exudates and cotton wool spots. The proposed strategies included the preprocessing module which consists of local contrast enhancement and application of an improved version of fuzzy c-means segmentation in two steps on Luv color space followed by classification based on hierarchical SVM [30].



a b

Fig. 2. (a) Original image [6] (b) Thresholding exudates detection result [6].