

Research Article

A Comparative Study of Various Exudate Segmentation Techniques for Diagnosis of Diabetic Retinopathy

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Abstract

Diabetic retinopathy is a health problem which causes blindness in middle and advanced age group. Automatic identification of exudates in retinal images can contribute to early diagnosis of DR. Many approaches in literature are discussed on segmenting the exudates. This paper has shown different techniques of exudates segmentation with its benefits and limitations. All discussed techniques have improved the performance in terms of accuracy, specificity and sensitivity. The comparison has shown that ant colony optimization based segmentation has better results over each technique.

Keywords: Diabetic Retinopathy, Retinal images, Exudates Segmentation, Blood vessels

1. Introduction

Diabetic Retinopathy is an eye disease occurred by complication of diabetes that causes abnormalities in the retina. Early detection of Diabetic retinopathy is very important for saving vision pairment and for effective treatment. Exudates are the symptoms of DR. Due to Diabetic retinopathy problem, there are many these types of the blindness cases of eye diseases found in world. The signs of DR cannot be analysed and monitored in its earlier stage. Earlier disease is found, more effectively it can be treated. Diabetic retinopathy has mainly 2 stages. First is non-proliferative stage and the second is the proliferative stage. Exudates found in the non-proliferative stage are mentioned as soft exudates and exudates in the proliferative stage are called as hard exudates. It causes harm to the blood vessels in retina hence the vessels become leaky and the fluid coming out of the vessels will collect as exudates. These exudates appear as shiny yellow-white dots with sharp borders.

Exudates have been detected by many other methods like segmenting the image by watershed algorithm, region splitting and growing method, pure splitting method and adaptive thresholding method etc.

For the diagnosis of the diabetic-related complications, it is very important to locate the exudates. Exudates can be identified by many other approaches like segmenting the image by watershed algorithm, region splitting and growing method, pure splitting method and adaptive In case of dark lesions

like exudates this task is difficult due to these reasons: First, due to presence of anatomical structures like vessels, optic disc that share similar information of intensity, texture with those of the lesions, second the illumination variability cause imaging effect and third the eye movement and difference in head positions. The automatic screening approaches for exudate detection have great significance in saving cost, time and labour. Image processing techniques for exudate detection can help in extracting the location, size .There is automated method which detects the diabetic retinopathy by identifying exudates through morphological process in colour fundus retinal images and then segments these lesions or exudates.

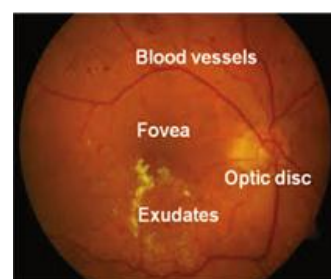


Fig.1: Retinal image with exudates and main features

Several segmentation techniques are used to segment the exudates. These techniques are as follows:

A. Projection Based Segmentation

There are mainly two stages to segment exudates, pre-processing and segmentation. The pre-processing

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method is used for background removal through contrast enhancement and noise removal. In the next stage, the pre-processed image is divided horizontally and vertically into many slices and then corresponding projection values are achieved in order to select the threshold value for each of the image slices.

B. Multilevel Thresholding Based Segmentation

This technique is used to segment a gray-level image into different distinct parts. Its capacity to divide a graphic into many meaningful segments. This makes the image suited for other pattern recognition and machine vision areas. In the multilevel thresholding cases, there are two conditions that are: first one computation time that is high with respect to the complexity of the image to be processed and another concerns the consideration of the threshold number, corresponds to how many the regions assembling the image.

C. Watershed Segmentation

This technique is used to solve the problem of over-segmentation. Watershed algorithm is applied in image segmentation techniques and get image's pixel wide, continuous closed object boundary. So, the traditional watershed segmentation algorithm results in the generation of a sizable quantity of false edges. The adaptive and marker-extraction algorithm are used to improve the watershed problem. Watershed transform is calculated for the marker modified gradient for controlling over segmentation problem.

D. Markovian Model Based Segmentation

This model approach is used that segments and detect exudates on RGB images. This approach uses grayscale morphology for candidate extraction and initialization of this segmentation model to detect the contours of the candidates. At last, this classify only the candidates as true or false based on region-wise characters.

E. Region-Based Segmentation

This technique is used a pure splitting algorithm is in which the image is divided into four quadrants to obtain homogeneous smaller images based on predefined criteria. First, there is preprocessed image which obtained after removing the detected optic disk. Then optic disk mask used to make its location on preprocessed image by a color equal to intensity of preprocessed image with new image.

2. Literature Survey

(Eswaran *et al*, 2014) has proposed an algorithm for segmentation of automated exudates. This algorithm consists of two major stages, pre-processing and segmentation. The pre-processing stage is used for background removal by using contrast enhancement and

noise removal. In the next stage, the pre-processed image is divided into horizontally and vertically into many slices and the relatively projection values are achieved in order to select threshold for each of the image slices. At last, optic disc is eliminated to correct detection of exudates

(Mahendran *et al*, 2014) has shown an automated method which detects the diabetic retinopathy through identifying exudates by Morphological process in color fundus retinal images and then segments the severity of the lesions. In this method, the severity level of the disease was achieved by Cascade Neural Network classifier.

(Rajput and Patil, 2014) has proposed a reliable method to detect and classify the exudates as hard and soft exudates. In this approach, firstly retinal image in color space is pre-processed to eliminate noise. Then blood vessels network is eliminated to detect and removal of optic disc. Hough transform technique is used to eliminate optic disc. The candidate exudates are then detected by using k-means clustering method. Finally, the exudates are classified as hard and soft exudates which based on their edge energy and threshold values.

(Zhang *et al*, 2014) has highlighted the method which performs not only denoising and normalization task but detect reflections in the image also. This candidates segmentation method that based on mathematical morphology is proposed and these candidates are characterized using classical and contextual features. This method has been validated on the e-optha EX database, achieving higher accuracy.

(Soman and Ravi, 2014) has proposed a method for automatic detection of exudates in the human fundus image. In this method, the optic disk detection is done by using circular Hough transform and bit plane slicing and extraction of the exudates using morphological operations. These two methods are compared with earlier literature that gives higher accuracy rate in finding exudates.

(Harangi and Hajda, 2014) has shown a method for the automatic segmentation of exudates which extract the exudates by exact contour detection and region-wise classification. In this, grayscale morphology is used to extract the exudate candidates and their proper shape is given by a Markovian segmentation model that considering the edge information. Finally, mention these candidates as true or false ones by an adjusted SVM classifier. This proposed method outperformed various state-of-the-art exudate detectors.

(Devaraj, D *et al*, 2014) has proposed a graphical user interface MATLAB-based approach. This method segments the blood vessels using adaptive median thresholding. Several features of blood vessels like area, mean, standard deviation, energy, entropy and histogram are calculated. The GUI using MATLAB is implemented and the feature parameters are calculated.

(Ali *et al*, 2013) has suggested that a novel statistical atlas-based segmentation method for exudates. Firstly, warped the test fundus image on the

atlas coordinate and then a distance map is obtained with the mean atlas image. The Post-processing schemes are introduced for final segmentation of the exudate. The method is also compared to few most other segmented methods.

(Sreng.S *et al*, 2013) has shown that the proposed method first preprocesses to improve the quality of fundus image and Optic Disc is detected and eliminated to prevent the interferences to the result by techniques: image binarization, Region Of Interest based segmentation and Morphological Reconstruction. Then, exudates are detected by applying the maximum entropy thresholding to filter out the bright pixels from the result of OD region eliminated. The result contains some noises which appear as bright light at the edge of fundus area in some images.

(Eadgahi *et al*, 2012) has proposed a method for segmentation of hard exudates in retinal color image based on morphological operation. In this proposed method, the retinal fundus images preprocessed, optic disc and the blood vessels identified initially and they eliminate from the image. Then, the hard exudates are

segmented by mixture of morphological operation such as Top-hat, Bottom-hat and reconstruction operations. By comparing with recent automatic method available in the literature, this proposed method can obtain acceptable exudates detection result in term of sensitivity.

(Pardeep *et al*, 2011) has proposed a method in which exudates are segmented by extraction of pixels that comes in the spot of color range and important features include the count of the exudates, maximum size, percentage affected, color intensity of the spot, average size. The diagnosis is supported by error-boost feature selection technique. This technique classifies the retinal images as normal or abnormal that based on the features achieved from the segmented image. The error boost feature selection algorithm selects the important features which classify the retinopathy more accurately.

(Jaafar.H *et al*, 2011) has proposed that a method for the detection of exudates by using adaptive thresholding. In this, retinal structures are used to remove artifacts from exudate detection results. This proposed method proceeds through two stages.

Table 1 Comparison Analysis of the literature

Ref No.	Methodology	Issues	Benefits	Limitations
Eswaran <i>et al</i> , 2008	Marker-controlled watershed segmentation	Averaging filtering Contrast adjustment STARE and DRIVE db used	Higher sensitivity in extraction of contours of optic disc and exudates	It suffers from noise effect
Jaafar <i>et al</i> , 2010	Split-and-merge algorithm based segmentation	Local Variation operation for coarse segmentation Adaptive thresholding & split merge tech. For fine segmentation	High specificity Ratio	Noise effect is not considered in this method
Soares <i>et al</i> , 2011	Noise map distribution	Morphological operators & adaptive thresholding	Good for contrast changes and non-uniform illumination	Accuracy rate is low in this method
Jaafar <i>et al</i> , 2011	Region based segmentation	Adaptive thresholding Morphological gradient processes	Highly sensitivity in achieving performance	It takes a lot of time to find exudate
Pradeep Kumar <i>et al</i> , 2011	Error boost feature selection method	Exudate segmentation by extraction of pixels that falls in color range of spots	Highly accurate in finding exudates	Noise effect is not considered
Eadgahi <i>et al</i> , 2012	Mathematical morphology operations	Localization of hard exudates Top-hat, bottom-hat and reconstruction operations	Higher rate of sensitivity in detecting exudates	Accuracy is low in finding exudates
Ali <i>et al</i> , 2013	Novel statistical atlas based segmentation	Statistical retinal atlas used for coordinate atlas	Provides higher accuracy in finding hard exudates	Effect of noise is there
Sreng <i>et al</i> , 2013	Region of interest	Image binarization	Got high accuracy	Noise effect is there
Soman <i>et al</i> , 2014	Circular hough transform & bit plane slicing	Optic disk detection & extraction of exudates	Got high speedup	High Time Consuming Process
Zhang, Xiwei <i>et al</i> , 2014	Exudate segmentation based on mathematical morphology	New db e_ophtha with precisely manually contoured exudates	Achieve high performance for complex situations	This method is not worked well for small scale applications
Mahendran <i>et al</i> , 2014	Morphological processes based segmentation	Cascade neural n/w used for identification of disease	Automatic detects the diabetic retinopathy	It suffers from noise effect
Eswaran <i>et al</i> , 2014	Projection based algorithm	DIARETDBI db & projection values of image's slice used	Correct identification of exudates decreases false positive cases	Noise effect is not considered
Harangi <i>et al</i> , 2014	Markovian segmentation model method	Exact contour detection & region wise classification of exudates	Provides better description of edges information	Low speedup factor in detecting exudates.
Devaraj <i>et al</i> , 2014	Adaptive median thresholding	Blood vessels segmentation with GUI(matlab) in fundus images	Got high speed up	It suffers from noise effect
Rajput <i>et al</i> , 2014	K-mean clustering method	Hough transform method used for hard and soft exudates	Highly elimination of noise contents	Low accuracy in finding exudates
Pereira <i>et al</i> , 2014	Ant Colony Optimization Technique	Thresholding, Region Growing, Morphology, Supervised Method	Got high Performance in terms of accuracy, specificity and sensitivity	High time consuming process and not considered noise effect also

3. Comparison Analysis

Image decomposition into a number of homogeneous sub-images using a region-based segmentation technique and edge detection using a morphological gradient methods. Speed and performance of the proposed method shown that it is more reproducible than the manual method.

(Soares.I *et al*, 2011) has proposed a new reliable and efficient method to detect and segment the exudates in retinal fundus images. This approach is based in the computation of the noise map distribution on the basis of morphological operators and adaptive thresholding. This method gives a good measure to contrast changes, non-uniform illumination and the variable background that results in a correct identification of exudates.

(Jaafar.H *et al*, 2010) has highlighted an automated method for the detection of exudates in retinal images. Candidates are detected by using a combination of coarse and fine segmentation. Coarse segmentation is based on a local variation operation to outline the boundaries of all candidates which have clear borders and fine segmentation is based on an adaptive thresholding and a new split-and-merge technique to segment all bright candidates locally. Due to its excellent performance measures, this proposed method applied to images of different quality.

(Eswaran.C *et al*, 2008) has described an algorithm for the extraction of optic disc and exudates from fundus images based on marker-controlled watershed segmentation. In this algorithm, average filtering and contrast adjustment is used as preprocessing steps before applying the watershed transformation. The performance of the proposed algorithm is evaluated using the test images of STARE and DRIVE dB. It is shown that the proposed method can yield an average sensitivity value which is greater than the value reported earlier.

(Pereira *et al*, 2014) has proposed an unsupervised approach based on the ant colony optimization algorithm. This paper describes a new ACO based algorithm for detecting exudates in color fundus images. ACO algorithm was used as an edge detector and attained good capacity to generalize since the algorithm enhances the edges well in images with greater variability inside and between them. This algorithm's performance was evaluated with a online dataset available and the results showed that this algorithm performs better than the other approaches in detecting exudates.

4. Gaps in Literature

The review shows that nearly all algorithms have the following limitations:

1. The effect of the noise has been neglected in the fundus images segmentation.
2. The speed of various algorithms used in literature is quite slow so become time consuming.

Conclusion

Automatic identification of exudates in fundus images can contribute to early diagnosis of DR. This paper has shown different techniques of exudates segmentation with its benefits and limitations. Although ACO based segmentation has shown better results in finding exudates but still it has some limitations. In future, Genetic Algorithm will use to improve accuracy rate and to reduce the effect of noise a switching median filter can be used.

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