DR Detection of Fundus Retinal Images: Review

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ABSTRACT
Retinal images of humans play an important role in the detection and diagnosis of many eye diseases for ophthalmologists. Ocular fundus image can provide information on pathological changes and early signs of diabetic retinopathy. During the last decade, Retinal image analysis is maturing as a field, making steady progress towards automated detection and representation of eye diseases. This paper reviews the algorithms and techniques used for DR detection.

Keywords
Fundus image segmentation, Diabetic Retinopathy (DR), Microaneurysms and retinal diseases.

1. INTRODUCTION
World Health Organization reports that about 285 million people are visually impaired worldwide: 39 million are blind and 246 million have low vision (severe or moderate visual impairment). Causes of visual impairment and blindness are increasing due to uncontrolled diabetes [1].

Many important diseases manifest themselves in the retina and originate either in the eye, the brain, or the cardiovascular system. The most prevalent diseases that can be studied via eye imaging and image analysis are Diabetic Retinopathy, Age-Related Macular Degeneration, Glaucoma and Cardiovascular Disease [2].

Up to 75% of all blindness and visual loss in diabetic patients can be prevented through annual screening and early diagnosis [1]. Retinal images of humans play an important role in the detection and diagnosis of many eye diseases for ophthalmologists [6]. Ocular fundus image can provide information on pathological changes and early signs of diabetic retinopathy.

Fundus photography, Optical coherence tomography (OCT) and fluorescein angiography are widely used Retinal imaging techniques. Fundus imaging is the most established way of retinal imaging among them [2].

Conventional retinal disease identification techniques are based on manual observation which is highly subjective, time consuming and prone to error. Despite a 54% increase in the diabetes population there will be less than a 2% growth in the number of ophthalmologists by 2030 [3]. Based on current estimates by 2030, 35 patients should be examined by each ophthalmologist per second [4].

An analyzing and interpreting fundus image has become a necessary and important diagnostic procedure in ophthalmology and a considerable research effort has been devoted to automate this process [7]. The automated disease identification system is consists of various modules as shown in Figure 1

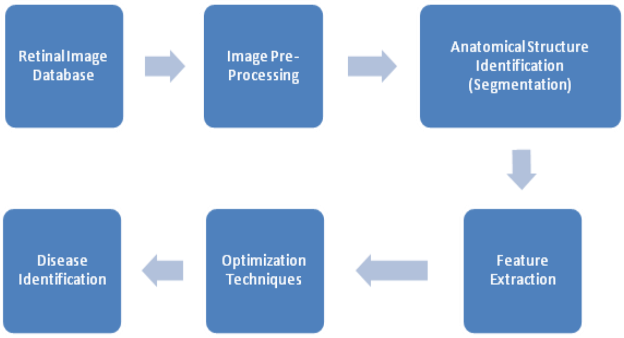

Figure 1: Automated Disease Identification System

Fundus images taken at standard examinations are often noisy and poorly contrasted; over and above that illumination is not uniform. Techniques improving contrast and sharpness and reducing noise are therefore required and done in preprocessing.

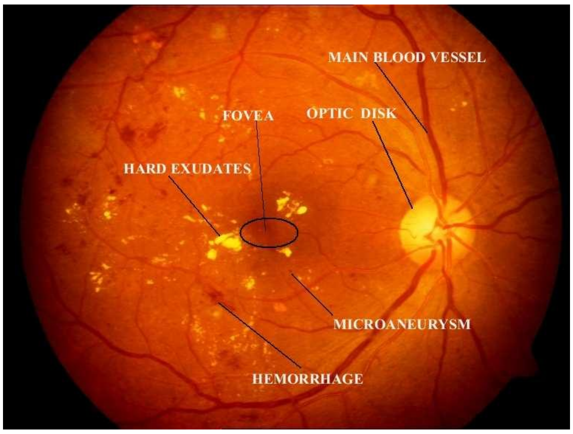

Figure 2: Retinal Fundus Image of DR patient

The presence of microaneurysms and dot hemorrhages (red lesions) and/or hard exudates (bright lesions) are indicative of early stage DR. To build such automated systems, different components are needed for recognizing retinal anatomical structure and extracting features from optic disc, macula, blood vessels, and certain pathologies, such as exudates, hemorrhages, and microaneurysms [8].

All the extracted features do not guarantee high accuracy. The presence of insignificant features reduces the output accuracy besides increasing the computational time period. Since both these parameters are highly essential, a methodology must be framed to eliminate the insignificant features [10].

2. LITERATURE REVIEW

2.1 Literature Survey on Retinal Image Pre-processing:

The preprocessing includes various techniques such as contrast enhancement, foreground/background differentiation, image de-noising, etc. We could not apply the same technique to zones with large dark areas e.g., macula, papilla or zones with large exudates [11].

Marco et al [12] have used the compensation based technique for eliminating the luminosity and contrast variations in the retinal images. However, few zones are not affected by this normalization.

Peng et al [13] have used the transform based techniques for edge enhancement in low contrast images. The enhancement function tends to changes the width of blood vessels, so we need find the best appropriate parameters.

Salvatelli et al [14] used morphology and homomorphic filtering for non uniform illumination and, morphology and local enhancement for contrast correction.

George et al [15] have implemented a derivative based technique for background foreground differentiation. The convolution of 2D Gaussian kernel with the second derivatives of the input image is performed to highlight the blood vessels. But the drawback of this system is low accuracy.

2.2 Literature Survey on Segmentation and Feature Extraction:

The feature extraction techniques for retinal images are broadly divided into two classes. In first category textural features are extracted from the pre-processed images directly. In second category various anatomical structures are initially segmented from the preprocessed images and then features are extracted from these anatomical structures. These anatomical structures include vascular network (retinal blood vessels), macula, optical disk and certain pathologies.

2.2.1 Vascular network segmentation: Hoover et al [16] used piecewise thresholding iterative method for blood vessel segmentation. They use local and global vessel features cooperatively to segment the vessel network. However, there is significant disagreement in the identification of vessels even amongst expert observers.

Soares et al. [17] present a method for segmentations by classifying each image pixel as vessel or nonvessel, based on the pixel's feature vector. The major limitations are in false detection of noise and other artifacts, inability to capture some of the thinnest vessels and ignoring useful.

Morlet wavelet transform based retinal vessel segmentation is performed by Joao et al [9]. A Gaussian mixture model classifier is used to classify each pixel as either a vessel or non-vessel pixel. But addition of noise to the image degrades the quality of the output.

Elisa Ricci et al. [18] introduced a method for segmentation of blood vessels in retinal images using line operators and support vector machine classifier. Incapability of thin vessel detection and lack of a proper performance measure are the demerits of this approach.

Marin et al. [19] presented a neural network based supervised methodology for the segmentation of retinal vessels. A multilayer feed forward neural network is utilized for training and classification. The method proves to be effective and robust with different image conditions and on multiple image.

Chaudhuri et al. [20] presented 2-D matched filter algorithm. The advantages are, it is completely unsupervised and may result in a good initial estimate of the vessels. But the requirement for huge convergence time period, discontinuity in vessel, missing the small vessel and junctions are the major drawback of this technique.

Gaussian filter approach is used for retinal vessel detection by Luo et al [7]. The vessel width measurement is incorporated in this technique which yields superior results than the matched filter approach.

The application of vessel detection for image registration is explored by Zana et al [21]. The Hough transform with Bayesian approach is used for vessel segmentation in this approach.

The usage of blood vessel extraction technique for Diabetic Retinopathy detection is demonstrated by Cornforth et al [22]. The concept of wavelet transforms is used in this work for segmentation. But this approach is not applicable for images with noisy background.

Elena et al [23] have used the multiscale feature extraction principle for retinal vessel segmentation.. The advantage of this approach is that it is able to detect the blood vessels with different widths, lengths and orientations.

Line tracking based retinal vessel segmentation is implemented by Marios et al [24]. The major drawback of the proposed algorithm is the high misclassification rate of the optic disk.

A hybrid approach with Laplacian operators and thresholding for retinal blood vessel detection is proposed by Vermeer et al [25]. This method is capable of detecting blood vessels even in images with specular reflection.

The advantages of using structural features are demonstrated by Harihar et al [26]. In this algorithm, the dual-Gaussian model is used to estimate the cross sectional intensity profile of retinal vessels. But the system failed in case of thin blood vessels.

2.2.2 Macula segmentation: **Ga**gnon et al [27] have used the apriori geometric criteria for macula localization. The exact center of the macula is then determined by searching the darkest pixel in the fine resolution image.

Kenneth et al [28] have proposed a parabolic model based approach for macula detection. This approach yields superior results with an exception for various instances of retinopathy.

Tapio et al [29] have used the intensity variation based approach for macula detection. Several characteristic patterns are extracted from the macula region which is then used to distinguish the normal and abnormal retinal images.

2.2.3 Optical Disk segmentation: Snake active contour methodology for optical disk detection is proposed by Thitiporn et al [30]. The contrast of the optical disk is used as the significant feature in this work. But the initialization of size and shape of the contour is the practical difficulty of this approach.

Abramoff et al [33] have employed the K-Nearest Neighbour classifier for OD detection. This algorithm is a pixel based classification approach in which intensity, simple edges, Gaussian filter outputs and Gabor wavelets are used as the feature set.

Juan et al [34] have used a modified active contour model for OD detection. The smoothing update equation of snake model is modified and used in this approach for performance enhancement. Robustness and the immunity to noise characteristics are highly improved due to these modifications.

2.2.4 Exudates, Hemorrhages, and Microaneurysms Detection:

By detecting the lesions in the retinal images, one can identify the grading of diabetic retinopathy. The review of the major techniques of lesion detection is as follows:

Quellec et al [35] suggested a novel, general, optimal filter framework for detecting target lesions in retinal images. The optimal filter framework has been tested on the detection of two important lesions in eye disease: microaneurysms and drusen. Drawback of the system is that, Scale range for the target lesion is very important, and then several classifiers may have to be trained using a different size of samples each time. having to develop a training database that requires each lesion to be annotated by metaclassification. Explore alternatives for the bag-of-visual words (BoVW)-based lesion detectors, which critically depends on the choices of coding and pooling the low-level local descriptors

Carla Agurto et al [36] propose the use of multiscale amplitude- modulation-frequency-modulation (AM-FM) methods for discriminating between normal and pathological retinal images. The principal advantage of this approach is that the methodology can be trained with only global classification of images, e.g., no DR or DR present, without having to develop a training database that requires each lesion to be annotated.

Balint Antal et al [37] propose an ensemble-based framework to improve microaneurysm detection. Novel framework relies on a set of (preprocessing method, candidate extractor) pairs from which a search algorithm selects an optimal combination.

Ramon Pires et al [38] introduce an algorithm to make that decision based on the fusion of results by metaclassification. Explore alternatives for the bag-of-visual words (BoVW)-based lesion detectors, which critically depends on the choices of coding and pooling the low-level local descriptors.

2.3 Literature Survey on DR Identification Process:

Conor et al [39] have used the skeleton operations to determine the change in retinal anatomy for DR detection in abnormal images. The features used in this work are vessel width and tortuosity. The experiment is analyzed in terms of accuracy.

Alireza et al [40] have used the combined FCM and neural techniques for exudates detection in diabetic retinal images. This methodology is implemented on color retinal images. The convergence rate reported in this work is also significantly high.

Contrast normalization method based microaneurysm detection in retinal images is performed by Alan et al [41]. This detection is based on the width of the detected blood vessels. Experimental results are analyzed in terms of sensitivity and specificity. But this method failed in case of small size abnormalities.

Morphological operations based DR detection is implemented by Jagadish et al [42]. The features extracted using morphological operators are then used as input for the neural classifier. Only bi-level classification is reported in this paper.

3. CONCLUSION

The merits and demerits of the existing techniques of DR detection are exposed from this literature survey and hence suitable techniques are to be developed to maximize the performance measures of the automated systems. This survey also paves way for new innovative approaches such as hybrid techniques for performance enhancement. Finally, this review also suggests suitable methods to be develop for application in various stages of automated abnormality diagnosis systems.

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