

Research Review Perspective on Retinal Clinical Features diagnosis Automation of Non-Proliferative Diabetic Retinopathy (NPDR)

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Abstract

Diabetic retinopathy is caused by individuals who are suffering from long-run diabetes for more than 10 to 15 years. And it also can be varied from years of having diabetes. Generally, it is treated as a case which leads to damages to blood cell. These blood vessels are further extended and represented as blood leaking and fluids on the retina to form different anatomical structures like microaneurysms, haemorrhages, hard exudates, cotton wool spots. Vigilant treatment and monitoring of the eyes could reduce at least 90% of blindness in new cases. Beneficial preventing visual impairment and blindness can be achieved by early diagnosis with regular screening and treatment. This work focuses on the review of automatic detection of Non-proliferative type of diabetic retinopathy with various methods used to detect the symptoms of the disease in early stages to avoid blindness with the most recent developments and methods using new software version.

Keywords: Diabetic Retinopathy; Exudates; Hemorrhages; Micro aneurysms; Optical coherence tomography (OCT); Optical disk; Pre-processing.

Introduction

Major Challenging in the ophthalmology research is process of automation which is useful in prior detection and diagnosis of advance eye diseases [1]. In screening major number of eye patients with Image processing practical tool [2]. Diabetic eye screening and monitoring is generally done with fundus imaging. Though the fundus image analysis is cumbersome task due to its variability of images with gray and color levels [3], still it is preferred for its effective high quality. There can be wrong interpretation due to dissimilar Morphology of the anatomical structures and few features existence in retina for all the patients [4]. From some of the research investigations we can identify the severe stages of diabetic retinopathy in the form of cotton wool spots which causes nerve fiber layer blocking and blown up [5,6], along with the other pathological parameters like optic disc, optic cup, Blood Vessels, Micro aneurysms Hemorrhages detection and lesions like hard and soft exudates [7,8]. Figure 1 shows pathological features of retinal image of typical diabetic retinopathy [9]. This paper focuses on the major contributions and review towards the detection methods pertaining to Non-proliferative DR to analyze the severity of disease in fundus images.

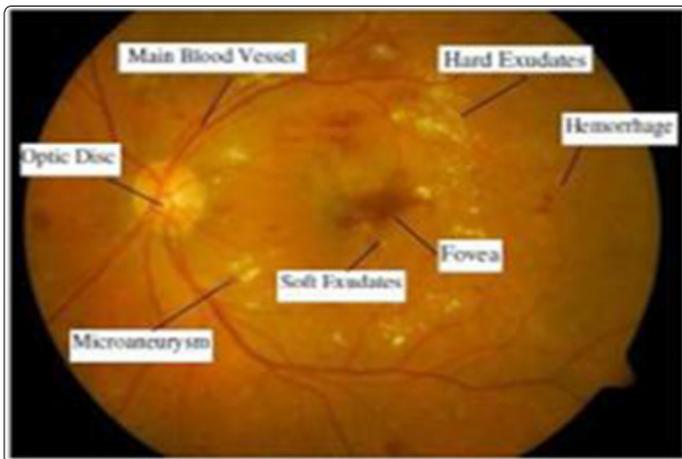


Figure 1. Pathological features of retinal image of typical Diabetic Retinopathy image [9].

Diabetic Retinopathy Detection Methods

In recent years, the methodologies to facilitate the screening and evaluation procedures for diabetic retinopathy have been highly motivated for researchers because of drastic increment in diabetic patient numbers.

The following algorithm steps [10] in literature describe various detection methods used for automation of diabetic retinopathy.

A. Optical disk detection

The extraction of optic disk [11] described the consideration of conversion and contrast improvements for effective diagnosis of different types of retinopathy diseases with techniques of boundary segmentation, edge detection, and circular approximation methods. The comparative performance measure and approaches of diabetic eye optical detection have been summarized in the given table 1.

Table 1. Survey on optic disc detection.

S. No.	Authors	Technology	Performance Measure
1	Foracchia et al. (2004)	Geometrical model of vessel structure	Accuracy: 98%
2	Meindert et al. (2007)	Single point distribution-model	Accuracy: 94%
3	Novo et al. (2009)	Genetic algorithm optimized Topological active nets	--
4	Meindert et al. (2009)	k-Nearest Neighbor regressor	Sensitivity- 99.4% Specificity- 93.0%
5	Huiyu et al. (2010)	Improved gradient vector flow algorithm	--
6	Daniel et al. (2010)	Adaptive morphological approach.	DRIVE-100% DIARETDB1-97.75%

B. Blood vessels detection

Segmentation of blood vessels in retinal images is a primary and important screening process of early detection of retinopathy Automation [12]. Table below analyses the blood vessel detection methods in the literature, focus on feature extraction filtering, operator's estimation and segmentation technology of blood vessels tabulated in table 2.

Table 2. Survey on blood vessels detection.

S.No	Author	Technology	Performance Measure
1	Elena et al (2007)	Multi-scale feature extraction	True Positive Rate-75.05% False Positive Rate -4.38%
2	Mohammed etal (2007)	Improved matched filter	Accuracy: 0.9533 Multi-resolution hermite
3	Farnell et al (2008)	Multi scale line operators	Efficiency: 0.953
4	Marios & Evangelos (2010)	Multi-scale retinal vessel Segmentation	Sensitivity-0.747 Specificity-0.955
5	Doaa & Solouma (2012)	Feature-based selective Segmentation	Sensitivity-80 % Specificity-100 %
6	Girish et al (2012)	2D-Match (Gabor) filters, hysteresis thresholding	Accuracy: 93.1%
7	Nguyen et al (2013)	Multi-scale line detection	Sensitivity : DRIVE-0.9407, STARE-0.932
8	Usman & Khan (2013)	Multi-layered Thresholding	Accuracy: 94.85%
9	Yangfan et al (2013)	Multi-wavelet kernels	Accuracy: 95%
10	Abdolhossein & Ahmad (2013)	Complex continuous wavelet Transform	Accuracy: 95% Sensitivity: 79%

C. Microaneurysms and hemorrhages detection

Several comparative investigations of detecting and automation of microaneurysms and hemorrhages in fluorescein angiography retinal fundus images [7], were done and concluded with best results have been listed in the tables 3 and 4.

Table 3. Survey of hemorrhages detection.

S. No.	Authors	Technology	Performance Measure
1	Giri et al (2010)	Local relative entropy based thresholding.	Sensitivity-100% Specificity-91%
2	Saleh & Eswaran (2012)	Dark object segmentation	Sensitivity-87.53% Specificity-95.08%
3	Cemal et al (2012)	Inverse segmentation method	Sensitivity-90%
4	Le et al (2013)	Splat feature classification	Splat level: Area under curve-0.96 Image level: Area under curve-0.87

Table 4. Survey of micro aneurysms detection

S. No.	Authors	Technology	Performance Measure
1	Meindert et al (2005)	Combining works of Spencer and Frame with two important new contributions	Sensitivity: 100% Specificity: 87%
2	Fleming et al (2006)	Local contrast normalization and Local vessel detection	Sensitivity: 85.4% Specificity: 83.1%
3	Thomas et al (2007)	Diameter closing and an automatic threshold scheme.	Sensitivity: 88.5%
4	Giri et al (2010)	Local relative entropy based thresholding	Sensitivity: 100% Specificity: 91%
5	Saleh & Eswaran (2012)	Dark object segmentation	Sensitivity: 84.31% Specificity: 93.63%
6	Cemal et al (2012)	Inverse segmentation method	Sensitivity: 90%
7	Balint & Andras (2012)	Ensemble-based system	AUC: 0.90 ± 0.01
8	Anderson et al (2012)	Points of interest and Visual dictionaries	AUC: White Lesion-95.3% Red lesion-93.3%
9	Meysam et al (2013)	Radon transform and Multi-overlapping windows	Sensitivity: Mashhad Database- 94%, Local Dataset-100% Specificity: Mashhad Database- 75%, Local Dataset-70%

D. Exudates detection

Exudates, associated and identified as an important problem with prevalent earliest signs contribution for the detection and automation process of diabetic retinopathy [13]. Table 5 shows the survey of exudates detection with performance measure and technology with various authors' contributions.

Table 5. Survey of exudates detection

S. No.	Authors	Technology	Performance Measure
1	Thomas et al. (2002)	Morphological reconstruction.	Sensitivity -92.8% Mean Predictive Value- 92.4%
2	Akara et al. (2008)	Mathematical morphology methods.	Sensitivity-80% Specificity-99.5%
3	Sanchez et al. (2008)	Fisher's linear discriminant analysis	Lesion and based Criterion: Sensitivity - 88% Image-based Criterion: Sensitivity-100% Specificity-100% Accuracy-100%
4	Maria et al. (2009)	Multilayer Perceptron (MLP), Radial Basis Function Network (RBFN) and SVM.	Lesion-based criterion: MLP: Mean Sensitivity (SEI)-88.14%; RBF: SEI=88.49% SVM: SEI=87.61% Image-based criterion: MLP: SEI-100% Mean Specificity(SPI)-92.59% Mean Accuracy (ACI)-97.01% RBFN: SEI=100%; SPI=81.48% and ACI=92.54% SVM: SEI=100%, SPI=77.78% ACI=91.04%
5	Alireza et al. (2009)	Computational intelligence techniques	Sensitivity-96.0% Specificity-94.6%
6	Sanchez et al. (2009)	Mixture models, Dynamic thresholding	Lesion-based criterion: Sensitivity-90.2% Positive Predictive Value-96.8% Image-based criterion: Sensitivity-100%, Specificity-90%
7	Daniel et al. (2010)	Coarse-to-fine strategy	Sensitivity-70.48%, Specificity-98.84%
8	Luca et al. (2012)	Wavelet decomposition and automatic lesion segmentation	Area under ROC curve between 0.88 and 0.94
9	Haniza et al. (2012)	Inverse surface adaptive thresholding	Sensitivity : DIARETDB1-98.2% Local dataset-90.4%

E. Classification and methods adopted

CAD tools gained importance for assisting the radiologists in interpreting medical images by using dedicated computer systems. Various Studies on CAD systems and technology proved that they improve diagnostic accuracy, and reduce the burden of radiologists in terms of workload. CAD for diabetic retinopathy mainly focuses on the various technologies to detect pathological features in retinal eye shown in table 6.

Table 6. Survey of diabetic retinopathy classification.

S. No.	Authors	Abnormality	Technology	Performance Measure
1	Ege et al 2010	Microaneurysms Hemorrhages, Exudates, and Cotton Wool spots	Mahalanobis Classifier	Sensitivity-69, 83, 99 and 80%.
2	Wong et al (2012)	Microaneurysms, Hemorrhages and Exudates	Three-layer feed forward neural network	Sensitivity-More than 90% Specificity-100%
3	Maria et al (2009)	Microaneurysms and Hemorrhages'	MLP, RBFN, SVM and a combination of three using majority voting schema	Lesion-Based Criterion: SEI-86.01% PPVI-51.99% Image based Criterion: SEI-100% SPI-56.00% ACI-83.08%

4	Jayakumari & Murthi (2012)	Exudates	Echo state Neural network	Sensitivity-93.0% Specificity-100%
5	Saleh & Eswaran (2012)	Microaneurysms and Hemorrhages	Rule based grading	Sensitivity-89.47% Specificity-95.65%

Discussion

A. Critical comments on optic disc detection

The group of authors focused their work about the optic disc detection with various techniques which is specified in table1. But consideration of Fundus image size quality and storage requirement along with accuracy and robustness of locating the optical disk as to consider for increase the efficiency of the algorithm.

B. Critical comments on blood vessels, hemorrhages detection and microaneurysms

The diabetic retinopathy detection through lesions, observes minor corrections. Optic disc detection depends on blood vessels the processing time is focused by reducing or resizing of sample images. The focused work of the authors listed tables2-4 related to feature extraction filtering, operator's estimation and segmentation technology, but the human expert is well ahead of the system. So there is still scope for improvement in the automatic system performance for better computational efficiency.

C. Critical comments on exudates detection

The work quoted by the author listed in table 5 has a necessity to consider the accuracy caused due to the additive noise, faded exudates responsible for false detection, varying image quality such as contrast and brightness and characterization of color differences due to improper back ground of fundus images caused by inhomogeneous illumination. Detection of soft exudates due to non-uniform illumination by background subtraction and no distinct variation of background intensity.

D. Critical comments on classification and methods adopted

Accuracy of the system mainly depends on the range of selected samples and large number of variation considerations. To solve this problem the solution can be performing a feature selection for required factors and well established training has to be performed to identify the distinct features. Proposed systems utilized to extract abnormalities of diabetic retinopathy without considerations of over-segmentation problem.

E. Future research directions

From the findings of the review, we found different types of approaches for diabetic retinopathy. The listed methods have their own merits and demerits. But future researcher should concentrate on advanced acquisition system, adapting hybrid models for effective accuracy and efficiency to overcome the short comings of existing technology

Conclusion

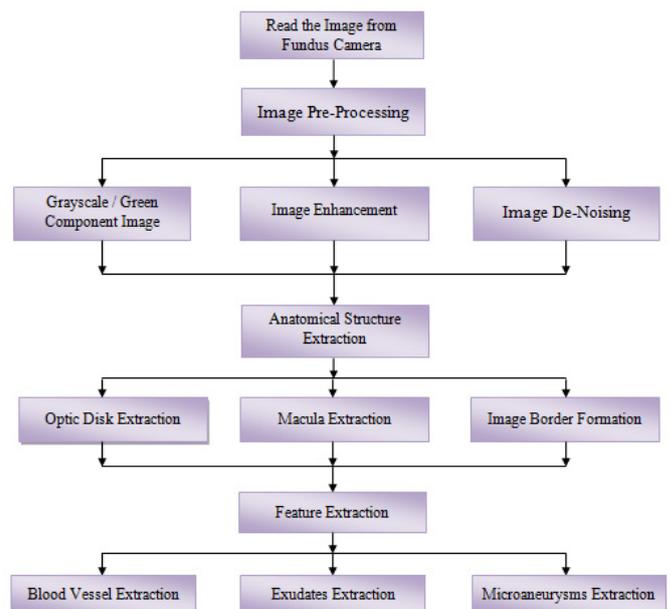
In this paper we have focused on the current status of automation and diagnosis of NPDR type diabetic retinopathy. The techniques described in the literature are related to the detection of ocular diseases like diabetic retinopathy and their

types aimed at optic disc localization, optic disc blood vessels, boundary obscuring, and edge detection algorithms, region growing methods for finding the problem in seed selection for segmentation. Attempts based on specialized features and morphological reconstruction techniques are highly sensitive to image contrast. Existing methods of exudates detection based on size and orientation are not sufficient for lesion detection. While the results are encouraging, existing techniques are limited by suboptimal feature selection and pixel classification techniques. Optic cup detected using thresholding and imaging system of the funds camera needs to be developed in effective manner with high resolution so that the diagnosis of NPDR can be detected at early stage. The performances of existing techniques in practical situations are not up-to the mark. So researchers would concentrate on developing a system that would be effective in real life. In addition, researchers may focus on developing a hybrid system, which is suitable for real life application.

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Appendix



Supplementary Figure 1. Flow diagram of diabetic retinopathy detection system (taken from ref [10]).