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Research Article

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Automated grading of diabetic retinopathy stages in fundus images using SVM classifer

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ABSTRACT

Medical image analysis is a very popular research area in these days in which digital images are analyzed for the diagnosis and screening of different medical problems. Diabetic Retinopathy (DR) is an eye disease caused by the increase of insulin in blood and may cause blindness. An automated system for the early detection of DR can save a patient vision and can also help the ophthalmologist in screening of DR which contains different types of lesion, i.e., microaneurysms, hemorrhages, exudates. This paper presents a method for detection and classification of exudates in colored retinal images. It eliminates the replication exudates region by removing the optic disc region. The detection of optic disc is indispensable for this approach which has been detected by Region of Interest (ROI) K-means clustering techniques. Exudates are found using their high gray level variation, and the classification of exudates is done with exudates features and SVM classifier. The proposed system is evaluated and tested on publicly available e-Optha-Ex database.

Keywords: Diabetic Retinopathy (DR), K-means Clustering, Kirsch's template, Exudates, SVM classifier

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INTRODUCTION

In clinical research the retinal disease which causes poor vision is Diabetic retinopathy (DR). It is an eye disease that is associated with long standing diabetes. Diabetic retinopathy is a leading cause of vision loss for approximately 50% of patients with diabetic retinopathy. Automatic exudates detection would be useful in order to detect and treat diabetic retinopathy in an early stage [1]. DR patients require frequent, at least six monthly screening and automating the process will go a long way in relieving the burden on the specialist and reducing the most common cause of preventable blindness [2]. An approach to detect exudates by the combined region growing and edge detection is proposed [3]. A method of SVM and kNN classifier has been proposed to classify the input image as normal or diseased one based on the color and texture features of hard exudates [4]. Candidates are detected using a combination of coarse and fine segmentation. The coarse segmentation is based on a local variation operation to outline the boundaries of all candidates which have clear borders. The fine segmentation is based on an adaptive thresholding and a new split-and-merge technique to segment all bright candidates locally [5]. Segmentation of exudates is by thresholding and classification is by Fuzzy C-Means (FCM) clustering techniques with classification accuracy of 85% [6].

Diabetic retinopathy diagnosed by machine learning techniques with three models Probabilistic Neural Network (PNN), Bayesian Classification and Support Vector Machine with input features as blood vessels, hemorrhages and exudates. It is inferred that SVM outperforms good accuracy results [7]. Detection of hard exudates is proposed with top down image segmentation and local thresholding with the combination of edge detection and region growing [8]. The neural network classifier types Multilayer Perceptron, Radial Basis Function and Support Vector Machine has been analyzed for the detection of hard exudates [9]. Based on the marker-controlled watershed segmentation techniques exudates has been extracted [10]. The algorithm of mixture model with dynamic thresholding is used for the analysis of retinal images [11]. The diabetic retinopathy has been diagnosed based on the detection of exudates

by morphological operations [12]. Features like blood vessel, microaneurysms, exudates, fovea regularity employing with curvelet transform is implemented and classifies the DR into three categories with the help of SVM classifier [13]. A new exudates segmentation based on mathematical morphology, normalization, denoising and detecting reflections and artifacts. Contextual features are used to train the random forest algorithm which classifies the exudates [14]. However automation of diabetic retinopathy grading analysis with modern tools of image processing techniques gives way for the radiologists in early treatment to avoid vision loss. In this paper, we focus on the detection of exudates, one of the symptoms for the presence of DR. As the exudates and optic disc appear as white/yellow structures in retinal images, it is necessary to remove the replication of the exudates region i.e optic disc. The optic disc is detected by Region of Interest (RoI) and removed by K-means Clustering techniques. The exudates are identified with the gray level variation and the detected exudates are classified using the exudates and statistical features trained using SVM classifier and grading of DR done as No exudates, low, medium and severe based on the area of exudates region. The proposed methodology is tested on the e-Optha-Ex database.

The rest of the paper is organized as follows. Section II illustrates the block diagram of proposed methodology. Section III brief the detection of optic disc, Section IV brief the detection blood vessels, Section V brief the detection of exudates. Section VI describes the classification and grading analysis of Diabetic Retinopathy. Section VII describes the results and discussion. Section VIII discusses the conclusion of the paper.

PROPOSED METHOD

This paper proposed the methodology for detecting optic disk, blood vessels and exudates as the outline frame work shown in Fig.1. The methodology was developed and implemented on the e-Optha-Ex database fundus images [15] specially designed for the scientific research in diabetic retinopathy (DR) consisting of 47 images with exudates and 35 images with no lesions.

The main objective of the paper is to map the grading of Diabetic Retinopathy (DR) based on the statistical features of the exudates in fundus images and to manage the disease appropriately to decrease the chances of vision impairment. The representation of an image in RGB color space allows to study separately the different channels of the spectral response. The three channels are (red, green and blue) each of which has intensity value ranging between 0 and 255. Exudates detection faces some of problems that affect the efficiency of any detecting algorithm. One of the major problems faces exudates detection is the intensity similarity between optic disc and exudates and to separate true and false exudates. Classification of the disease has been rated as No Exudates, Low, Medium and Severe based on the exudates features and classified by means of SVM classifier.

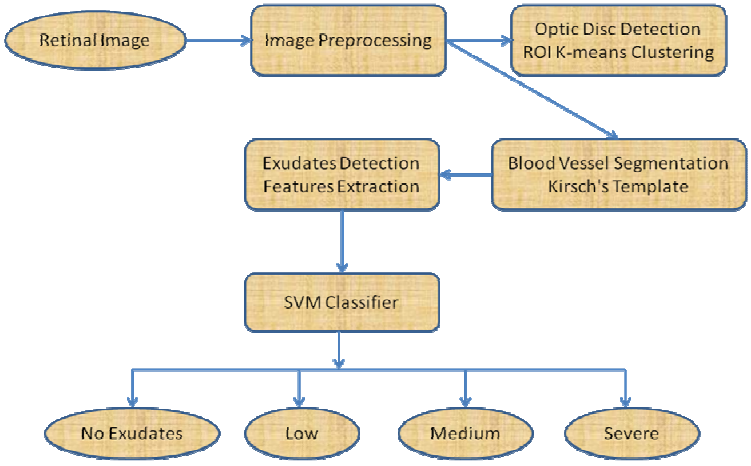
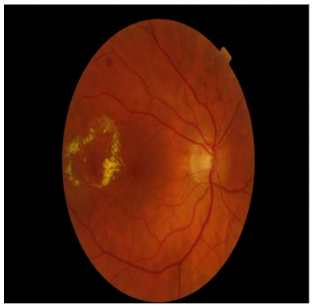


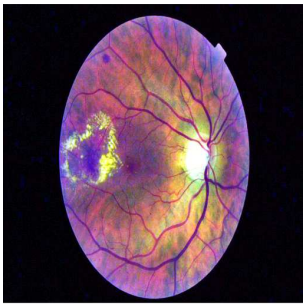
Fig.1 Bock Diagram of the Proposed Methodology

I. OPTIC DISC DETECTION

The initial footstep in our work is the fundus image in an RGB channels (red, green, and blue) has been preprocessed and adjusted for contrast adaptive histogram equalization, median filtering and separation of retinal images into red and green channel images shown in Fig.2. The blue channel is characterized by low contrast and does not contain much information and neglected. The main anatomy of the retinal image is the optic disc which has the brightest intensity scale factor. The Optic Disc is identified with the help of the Region of Interest (ROI) marked by the user and the particular region has been cropped and subject to K-means clustering techniques. The clustering techniques detect the optic disc brightest part shown in Fig.3

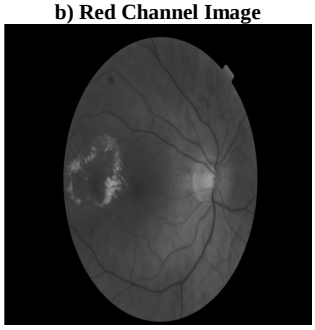


a) Original RGB Image



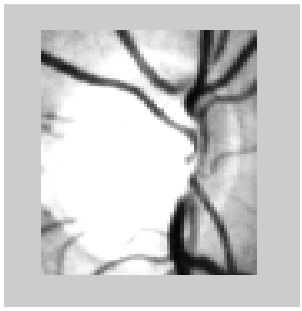
b) Red Channel Image

c) Green Channel Image



d) Median Filtered Image

Fig.2 (a) RGB Image (b) red channel (c) green channel (d) median filtered image

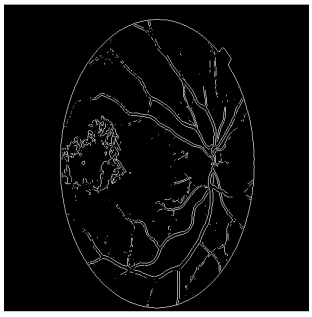


a) ROI K-means clustering

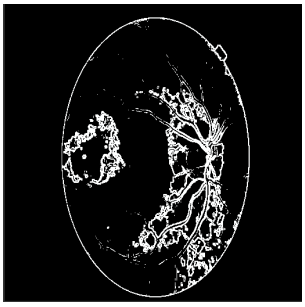
Fig.3 a) Extracted Optic Disc Image

II. BLOOD VESSEL DETECTION

The retinal blood vessels are able to be seen in the red channel but red channel contains much noise. The green component of the RGB retina image provides good results in contrast of blood vessels. Hence, the green channel of the image is used in this work for blood vessel extraction [16]. Retinal blood vessel extraction and segmentation was implemented with the spatial filtering by kirsch's template and the segmented blood vessels eliminated by subtraction of original images and the blood vessel image so that the output image shows only the exudates presence as shown in Fig.4.



a) Blood Vessel Extraction



b) BV and Exudates

Fig.4 a) Extracted Blood Vessel, b) BV and Exudates

III. EXUDATES DETECTION

With the detection of optic disc and retinal blood vessels, the symptoms exudates can easily be identified by subtracting the detected images i.e optic disc and blood vessels from the original RGB image. The detected exudates

based on the high gray level variation have been analyzed and features have been extracted trained in order to classify the exudates from false exudates. Based on the presence of the exudates region by calculating the area as one of the features, the severity level of DR has been graded.

IV. GRADING DIABETIC RETINOPATHY

The texture based statistical features such as area, intensity, entropy, smoothness and exudates region [16] were extracted and given to the SVM classifier. The output of the SVM classifier was tested with the e-Optha-Ex exudates images and DR grading was mapped corresponding to the selected exudates features. The SVM classification grading results are shown in Fig.5

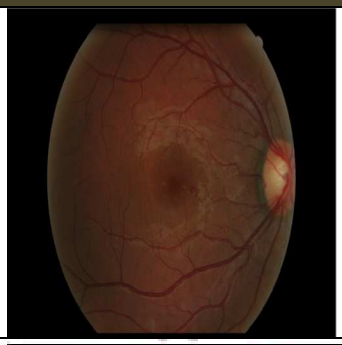
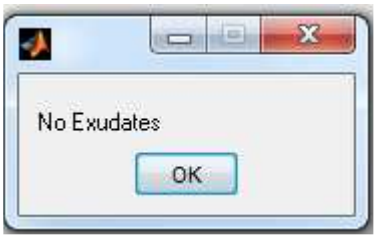
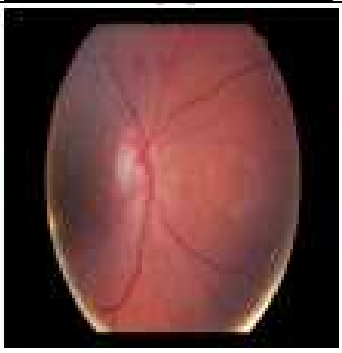
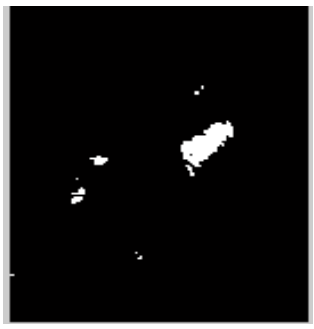
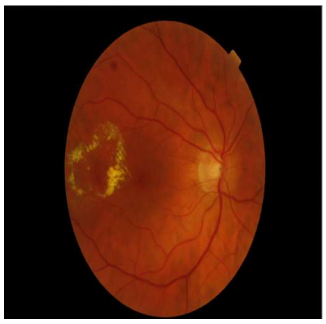
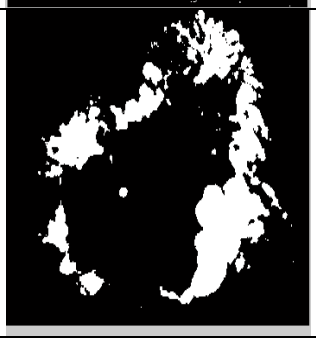
S.No	Input Image	Exudates Image	SVM mapping Result
1		No Exudates Image	
2			
3			
4			

Fig.5 DR Severity Grading based on exudates detection using SVM classifier

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RESULTS AND DISCUSSION

The proposed algorithm is successfully implemented in the publically available E-Optha-Ex database and the DR grading is analyzed with the presence of exudates in the retinal images into 1) No exudates, 2) Low level DR, 3) Medium level DR and 4) Severe level DR. The performance measurement SVM classification accuracy yielded is tabulated in Table.I and Table.II gives the confusion matrix of SVM classification.

TABLE. I CLASSIFICATION RESULTS

Image	Training Images	Testing Images	Classified Images	Classification Accuracy (%)
Normal	25	20	19	**95.00**
Exudates	25	30	28	**93.33**
Average Classification Accuracy				**94.17**

TABLE. III CONFUSION MATRIX FOR TESTING IMAGES

Image	No Exudates	Low	Medium	Severe
No Exudates	**19**	**01**	-	-
Low	-	**09**	**01**	-
Medium	-	-	**09**	**01**
Severe	-	-	-	**10**

From the Table.I, it is inferred that 95% accuracy has been attained for normal images whereas in the exudates images it yields an accuracy of 93.33%, giving 94.17% average accuracy. The decrease in exudates classification efficiency is due to the false intensity computation features.

CONCLUSION

In this paper, the finding of optic disc is made by means of K-means clustering techniques, blood vessel segmentation by means of Kirsch's template edge detection algorithm and exudates detection by means of intensity computation, thresholding and features extraction. The exudates are classified as true or false exudates with the help of SVM classifier and were able to distinguish between four different types of grading level with an average accuracy of 94.17%. As an extension of our work, it is suggested to optimize the features selected and the foremost features with different classifier techniques can be compared and analyzed.

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