Detection of Diabetic Retinopathy in Earlier Stages

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***Abstract*: This paper describes an improved diabetic retinopathy detection scheme by the extraction of hard exudates and soft exudates (cotton wools). Exudates are one of the main symptoms of Diabetic Retinopathy (DR). DR is an eye disease which occurs due to the damage of retina as a result of long illness of diabetic mellitus which leads to blindness. The current technique of screening uses fundus photography and the data is sent to a grading centre for reading where expert human readers estimate the disease severity. This requires qualified experts and it fails to give timely treatment. An early detection of exudates prevents the patients from vision loss. This approach majorly focuses on the procedure of automated techniques for detection of exudates (hard and soft) and hence detects DR in early and advanced stages. After the exudates are detected, it is classified into normal eye, non-proliferative and proliferative DR eye. Linear SVM is used for the classification. Furthermore, this paper reviews the contribution of many researchers in this field and highlights the significant improvement achieved by them.**

***Keywords*: Diabetic Retinopathy, Hard exudates, Soft exudates (cotton wools), Non-Proliferative Diabetic Retinopathy (NPDR), Proliferative Diabetic Retinopathy (PDR), SVM.**

I. INTRODUCTION

Diabetes mellitus, commonly referred to as diabetes, isa group of metabolic disorders in which there are high blood sugar levels over a prolonged period. It affects the eyes when blood glucose is too high, that results in poor vision or even blindness. The retina is the inner lining at the back of eye that senses light and turns it into signals that brain decodes, so one can see the world around you. Damaged blood vessels can harm the retina, causing a disease called diabetic retinopathy. Diabetic retinopathy is an eye related disease which is the side- effect of prolonging diabetes. When the sugar level in the blood vessels of retina increases, it leads to dampening of blood vessels. Dampening of blood vessels results in leakage of blood or fluid like substance which usually gets deposited under macular edema. These depositions are called exudates. Exudates can be classified into two main categories, hard and soft exudates. The formation of exudates is the main symptom of Diabetic Retinopathy. DR has been classified into two major types such as Non Proliferative and Proliferative, based on the presence of neo-vascularization which is the abnormal blood vessel growth. The stage of the retina without any abnormal vessel growth (neo-vascularization) is called as Non Proliferative Diabetic Retinopathy (NPDR), which is the early stage of DR. The disease leads to the swelling in the side of the blood vessel called micro aneurysm. These micro aneurysm forms hemorrhage due to the rupture. Hence, the blood vessels are weakened and start to leak fluid in the retina. This fluid affects the function of macular edema by getting deposited under macular edema. This sediment is usually called as hard exudates. The other form of exudates is soft exudates (cotton wools). These are the greyish white patches present in nerve fibre layer which have fluffy edges. The presence of more than six soft exudates in one eye results in loss of vision. These exudates are detected and severity of disease is detected using digital image processing. The three main steps involved in the Diabetic Retinopathy are, pre-processing of fundus images, feature extraction and classification of DR. Pre-processing is an important stage in DR because retinal images suffer from uneven illumination, poor contrast and noise. Pre-processing of fundus image is executed in order to increase the contrast. Feature extraction aims at finding the features that are most relevant to exudates in a retinal fundus image. Extracted features are used for training the parameters of classifier. Classification of DR is performed by support vector machine (SVM). Through the research, the International Diabetes Federation says that, the number of adults with diabetes is around 415 million that is, 1 in 11 adults have diabetes. These people with diabetes are easily prone to diabetic retinopathy. The range of prevalence of diabetic retinopathy in the southern part of India is estimated to be 12.2% to 18.03% of the population who already have diabetes. In urban areas like Chennai, the prevalence of diabetic retinopathy is around 28.2%.

The paper is organized in following ways: section II contains literature review of related work on automated method for diabetic retinopathy detection, especially on microaneurysm detection. Section III explains proposed method for DR detection. Section IV contains result and section V concludes overall work.

II. LITERATURE SURVEY

Screening and diagnosis of diabetic retinopathy is popular research area and many research scholars are focusing to contribute towards the improvement of study in this area. Automated detection of diabetic retinopathy screening were proposed in order to address the manual screening issues, such as high cost, low sensitivity and specificity, time consuming and low human detection ability. The aim of automated detection for screening is to identify the need of referral for further treatment. Sergio Bortolin junior et al. [1] has proposed an automated detection of microaneurysm and hemorrhages in color eye fundus images. This methods consists of five methods: pre-processing, enhancement of low intensity structure, detection of blood vessels, elimination of blood vessels, and elimination of fovea. Green channel and CLAHE are used for pre-processing. Enhancement of low intensity has been achieved with the help of applying alternating sequential filtering (ASF). Detection of blood vessels and elimination of blood vessels was performed by applying ASF and morphology opening with multiscale structuring element. Sarni Suhaila Rahim et al. [2] proposed several techniques for detection of microaneurysm. In system I, they have used adaptive histogram equalization, discrete wavelet transform, and filtering and morphology process for pre-processing. Area of pixels, mean and standard deviation are the extracted features of DR. Decision tree, K-nearest neighbor, polynomial kernel SVM and Radial basis function (RBF) kernel SVM have been used for classification. Result of system I has been shown in [3]. They used histogram equalization, shade correction, vessel segmentation, and morphological operation for pre-processing. Area of pixels, mean, standard deviation are extracted features from the pre -processed fundus images. Decision tree, KNN, and SVM has been used for detection of diabetic retinopathy. Balint Antal et al. [4] has proposed an ensemble based system for microaneurysm detection. They proposed an ensemble-based framework to improve the microaneurysm detection. They have used combination of pre-processing such as Walter-Klein contrast enhancement, contrast limited adaptive histogram equalization (CLAHE), vessel removal and extrapolation illumination equalization and candidate extractors are used in detection of microaneurysm. MAs extraction based on their visibility & spatial location. An adaptive weighting approach for ensemble-based MAs detection also presented. Sopharak A et al. [5] proposed hybrid method for fine MAs detection from non-dilated DR retinal images, using mathematical morphology, naïve Bayes classifier. Adal K M et al. [6] used scale-adopted blob analysis and semi-supervised learning for automated detection of microaneurysms and evaluate the performance on ROC competition database. R. A. Welikala et al. [7] used two vessel segmentation methods, such as standard line operator and modified line operator and latter apply SVM for dual classification.

III. Proposed System

Diabetic retinopathy detection system consists three main steps: pre-processing techniques, feature extraction and classification techniques. There are verity of techniques have been proposed for pre-processing, feature extraction and classification of DR. We propose different combination of pre-processing, feature extraction and classification techniques to improve DR detection. The architecture of the system is shown in Fig 1. Fundus images are taken from database DIARETDB1.

A. Pre-processing

Colour retinal fundus images often show light variation, poor contrast, and noise hence these images have to go through pre-processing stage. The enhancement is necessary since fundus images suffer from non-uniform illumination and noise. Pre-processing of fundus image is performed in order to improve the contrast. In order to enhance the contrast of the retinal images, some information is commonly discarded before processing such as the red and blue components of the image. Green channel is extensively used in pre-processing as it

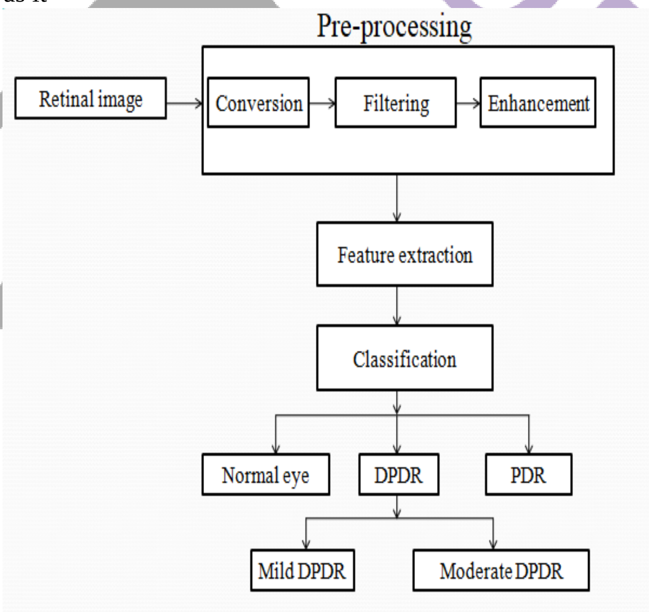

Fig. 1 Block diagram of DR detection

displays the best vessels/background contrast and greatest contrast between the optic disc and retinal tissue. Red channel is relatively bright and vascular structure of the choroid is visible. The retinal vessels are also visible but show less contrast than green channel. Blue channel is noisy and contains little information.

Adaptive histogram equalization (ADHE) is used for contrast enhancement. ADHE computes several histograms of image and uses them to reallocate intensity value of image. Hence, ADHE is more appropriate to improve regional contrast and edge enhancement in each region of image [8]. Mathematical morphology operation is applied for noise removal. Closing operation is applied in order to remove noise from object region.

After pre-processing, *exudates* are extracted from colour fundus image. For detection of exudates, the pre-processed green channel image is obtained, which is further enhanced by ADHE. After that a marker has been generated using median filter which subtracted from the median filtered image using morphological process to extract the exudates.

Blood vessel removal is preformed after exudates extraction. Firstly RGB image is converted into grey channel for better contrast. Grey scale conversion is done using principal component analysis (PCA). PCA is statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of correlation and dependence variables called principal components. PCA is powerful tool for analyzing data [9], [10]. It is basically used in dimensional reduction. Here, it is used to convert a 3-dimentional matrix (RGB) to 2-dimensional matrix (grey). Further CLAHE is used for contrast enhancement. CLAHE is mostly used in enhancement of low contrast retinal image. In case of CLAHE, a transformation function is derived from contrast limited procedure to each neighborhood pixel. CALHE is mainly developed to prevent over amplification of noise that ADHE raises [8]. Background is eliminated by averaging the enhanced image and subtracting it from the enhanced image. After background exclusion the image is converted to binary scale and retinal blood vessels are extracted. Resulting image is shown in Fig. 2.

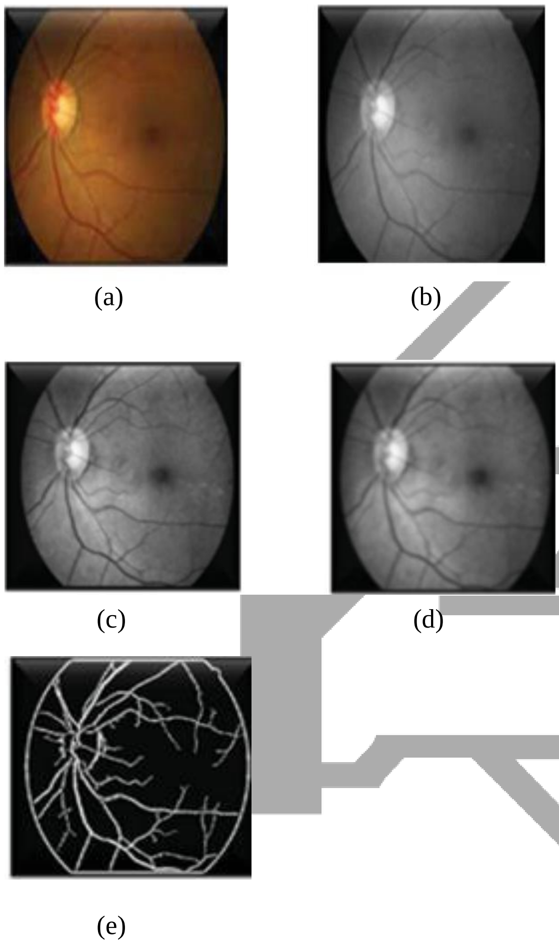

Fig. 2 (a) Colour fundus image (b) Gray image (c) CLAHE image (d) Filtered image (e) Extracted blood vessels.

Segmentation of optic disc is done in two steps named as localization and detection. First we create template by blurring image using (6x6) window and extract the (80x80) pixels optic disc. Further, we extract the color components such as red, blue and green and store their histograms. This process is applied on all images in database and the average is obtained.

For *localization of fovea*, pre-processed image has been used. The basic morphological operation is used to remove lesser area than 25 pixels, since fovea contains larger area than other structures. Fovea localization is essential since it helps to reduce the false detection of exudates. Its area varies from image to image.

Exudates has been detected from fundus image by subtracting the blood vessels, optic disc and fovea from pre-processed image.

B. Feature Extractions

There are two features of exudates, such as area of exudates and number of MAs have been extracted from fundus images.

Area of exudates is calculated as total number of white pixels in extracted image of exudates as shown in Fig. 8. The number of exudates is calculated as number of discontinuity from white pixel to black pixel.

C. Classification

SVM classifier has been used for DR detection. SVM classify the image into two classes such as DR eye and healthy eye. Parameters of SVM classifier has been calculated based on features of exudates.

Support vector machine (SVM)

SVM is derived from learning theory by Bladimir Vapnik. Objective function in SVM is convex function which never stuck into the local maximum. Optimal hyperplane is the form of the separating hyper plane and objective function of optimization problem do not depend explicitly on dimensionality of the input vector but depends only on the inner products of two vectors. This fact allows to construct the separating hyperplanes in high dimensional spaces (even in infinite dimension) [11].

SVM parameters have been trained using two input features such as area of exudates and number of exudates. Average number and average area of exudates are considered as threshold for classification of DR. Linear kernel with fivefold validation has been used to train the parameters of SVM. After training the SVM, new testing data given to SVM classifier, which gives better result.

IV. Expected Results

- Accurate stage of patients retinopathy is detected based on classification.

CONCLUSION

The proposed work detects the Diabetic Retinopathy in both non-proliferative and proliferative stages. This study proposes a classification system of DR based on exudate features. The main feature in this study are preprocessing, exudate segmentation, feature extraction, and classification of DR. The retinal images are obtained from DIARETDB1 database. The input images are preprocessed and the features were extracted. Based on the features extracted, the classifier classifies whether the input retinal image is normal or abnormal. Then the abnormal image is again classified as moderately affected or severely affected image. The feature extraction plays a very important role as the features are used in both training and testing phase of the classification. The performance of SVM classifier is measured by calculating the classifier accuracy with respect to the number of images tested. The result of classification is very useful information to the ophthalmologists for diagnosing the disease diabetic retinopathy and applying the necessary treatment in an early stage.

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