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Detection of Lesions and Classification of Diabetic Retinopathy

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ABSTRACT

According to the increasing consumption of sugar materials in human life and growing trend of the machine life, the prevalence of diabetes is on the rise. It is observed all patients with this disease mostly suffer from decrease or loss their vision. Detection of diabetic retinopathy in early stage is essential to avoid complete blindness. The retinal fundus images of the patients are procured by capturing the fundus of the eye with a digital fundus camera. The abnormalities in retinal fundus images due to DR are lesions which includes Microaneurysms and Haemorrhages. The proposed method is to detect the abnormalities in retinal fundus image is based on dynamic shape features and SVM classifier. In this study the Gaussian filter is used to enhance images and separate vessels with a high brightness intensity distribution. In this study canny's edge detector is used for detection of Lesions and features are extracted. SVM is used for classification of DR as NPDR or PDR.

Keywords : Fundus image, Lesions, Gaussian Filter, Canny edge detector, Support Vector Machine (SVM), NPDR & PDR.

I. INTRODUCTION

Diabetic retinopathy is damage to the retina, specifically blood vessels in the retina, caused by complications of diabetes mellitus. Diabetic retinopathy can eventually lead to blindness if left untreated. Approximately 80% of all patients who have had diabetes for at least ten years suffer from some of diabetic retinopathy. The retina is light sensitive membrane that covers the back of the eye. If diagnosed and treated early blindness is usually preventable. Diabetic retinopathy generally starts without any noticeable changes in vision. However an eye doctor can detect the signs. Blood vessel extraction from fundus poses an important step in automated diagnosis process [1].

In diabetic patients due to increase of glucose level in blood there will be rupturing of the small blood vessels called capillaries in the eye. Due to this the blood leaks into the retina of the eye. The abnormal features related to DR which can be found can be microaneurysms, haemorrhages, hard exudates, cotton wool spots etc. This disease causing damage to the retina which also leads to the loss of vision if not detected and treated is termed as Diabetic Retinopathy (DR). The presence of any of the abnormal features helps in classifying the stage of the disease. In order to avoid increased screening time and human error, there is a need for efficient and accurate Automated DR detection systems which can provide simple approach for classifying the images as normal or DR [1], [2]. The earliest symptoms of Retinopathy are the Micro aneurysms, which occur due to dilatations of the blood capillaries and they appear as dark red spots on the retina. Haemorrhages occur when the microaneurysms burst. Bright-yellow colored Lesions such as hard exudates occur as a result of fluid leaking into the retinal surface from the capillaries or from Microaneurysms. The first stage of retinopathy is known as Non-Proliferative Retinopathy (NPDR). In NPDR stage, various features like micro-aneurysms, haemorrhages, soft exudates cotton wool spots are present. Depending upon number of these features the classification is performed. Accordingly, Non-proliferative stage can be categorized as Mild, Moderate, and Severe. In PDR stage, new abnormal blood vessels are formed at very high rate. This may result in severe vision loss [5].

II. PROPOSED WORK

The main objective of this project work is to detect the early stage of DR using the features extracted from the pre-processed image. The objective is to develop a system for Diabetic Retinopathy detection and classification. Diabetic Retinal image used in the paper is from DIARETDB0 (Standard Diabetic Retinopathy Database Calibration level 0). DIARETDB0 [2] data set contains 130 images and size of [1500x1152] pixels.
The image obtained from the database is subjected to the pre-processing steps such as green channel extraction, contrast enhancement, Gaussian filtering and histogram equalization. [2] After pre-processing, the image is morphologically operated. Detection of Blood vessel [1], Microaneurysms[10], [11], and Exudates , [6] using canny's edge detector. The Gray Level Co-occurrence Matrix (GLCM) is utilized to extract textural features [8]. The classification is done depending on the area of blood vessel, area of microaneurysms, area of exudates, the values of texture features namely contrast, correlation, energy and homogeneity using SVM classifier.

A. Image Pre-processing

Pre-processing is an important step as it aids in accurate feature extraction and classification with higher accuracy. In case of Diabetic Retinopathy, the retinal images in the dataset are often noisy and poorly illuminated because of unknown noise and camera settings.

Thus to remove noise and undesired region the images are subjected to pre-processing steps. In pre-processing first green channel is extracted. As green channel has higher contrast than red and blue. The pre-processing includes contrast enhancement, histogram equalization, Gaussian filtering.

i. Green Channel Extraction

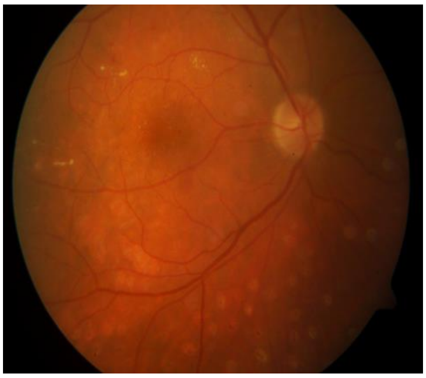
The green channel is the most contrasted one, that the red channel is saturated and that the blue channel does not contain any information [8]. Green light is less absorbed by the fundus layers than the blue part of the spectrum, but more than red light, which penetrates deeper into the layers of the inner eye. The blood containing elements (as MA or vessels) in the retinal layer are best represented and have highest contrast in the green channel [9].

ii. Histogram equalization

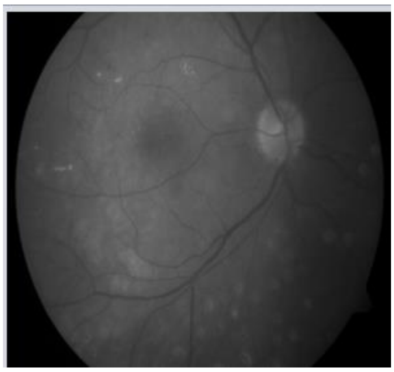
Histogram equalization defined as the process of adjusting intensity values of the image [10]. It is a technique used to enhance the contrast of the image using the histogram of the image. The histogram of image represents the frequency of gray levels in the image. The gray levels of image varying from 0 to 255, that is a gray scale image's pixel size of 8 bits. So the histogram contains freq of occurrence of values from 0 to 255. The aim of histogram equalization is used in digital image processing is to generate an image with equally distributed brightness level over the whole brightness scale.

iii. Gaussian Filtering

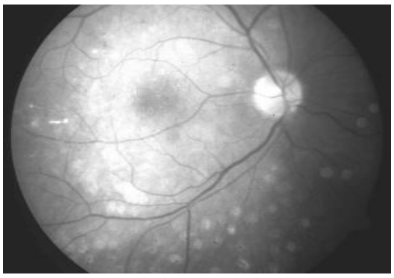
Gaussian smoothing operator performs a weighted average of surrounding pixels based on the Gaussian distribution. It is used to remove Gaussian noise and is a realistic model of defocused lens. Sigma defines the amount of blurring. The radius slider is used to control how large the template is. Large values of sigma will only give large blurring for larger templates sizes. Noise can be added using the sliders. The results are as follows:



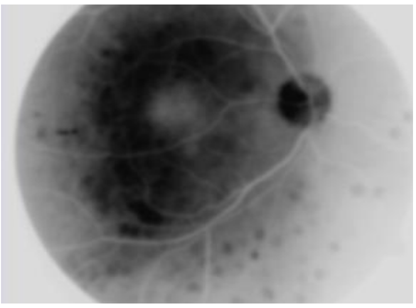
(a)



(b)



(c)



(d)

Fig.1. Pre-processing images a) Input image b) Green channel c) Gaussian filtered image d) Gray scale invert image

B. Detection of lesions

According to medical term, a lesion means any abnormal changes of tissue or organ as a result of the disease. The enhanced blood vessels from background are segmented by an edge detection method. The purpose of edge detection is to significantly reduce the amount of data in an iamge, while preserving the structural properties. Among the edge detection methods canny edge detection algorithm is one of the most strictly defined methods that provides good and reliable detection.

Canny edge detection method uses a mutli-stage algorithm to determine the blood vessel edges.

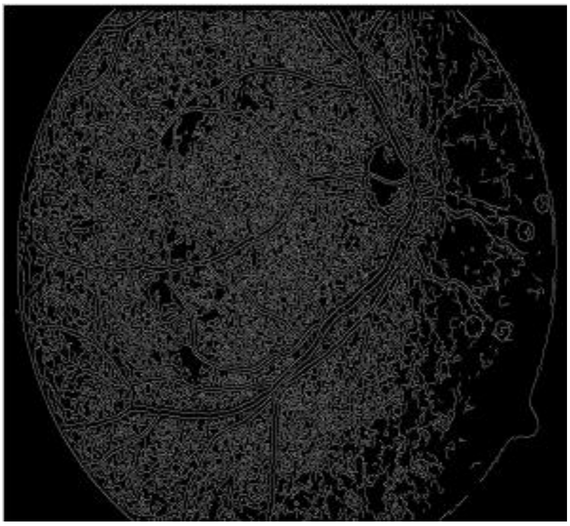


Fig.2. Detection of Blood Vessels using canny edge detector

C. Feature Extraction

To distinguish between three stages of diabetic retinopathy, various statistical features of segmented vessels are determined. These statistical features are used as input to the classification system to identify the exact stage of diabetic retinopathy disease. Following are various features extracted from segmented vessels [11]:

1) Contrast

It is measure of intensity of a pixels and neighbours over the image. It is the difference in color and brightness of the object and other objects. It is given by,

$$\sum_{i,j=0}^{N-1} (p_{ij})(i-j)^2$$

2) Correlation

It is measure of how correlated a pixel is to its neighbour over the whole image. Correlation is 1 or -1 for a perfectly positively or negatively correlated image. It is calculated as,

$$\sum_{i=0}^{M-1} \sum_{j=0}^{N-1} \frac{(i-\mu_i)(j-\mu_j)p_{i,j}}{\sigma_i \sigma_j}$$

3) Homogeneity

It is a value that measures the closeness of the distribution of an element in grey level co-occurrence matrix to the grey level co-occurrence diagonal. Homogeneity is 1 for diagonal GLCM. It is defined as:

$$\sum_{i,j} \frac{p(i,j)}{1+|i-j|}$$

4) Entropy

It shows the amount of information of the image that is needed for the image compression. Entropy is defined as:

$$\sum_{i,j=0}^{N-1} -\ln(p_{ij})p_{ij}$$

5) Area, Perimeter and Count of microaneurysms, exudates and blood vessels.

Count = max (max(l(ROI)));

Where l(ROI) is the labeling the region of interest.

Area = ∑(weights(:),[],'double')/8;

Where weights(:) is all elements of the set that results from nonlinear neighborhood operation on ROI.

Perimeter = ∑ (Tedges, Ledges, Bedges , Redges)

Where Tedges, Ledges, Bedges , Redges are the top, left, bottom and right edge of the ROI respectively.

D. CLASSIFICATION

Classification is an essential feature to separate large datasets into classes for the purpose of Rule generation, Decision Making, Pattern recognition, Dimensionality Reduction, Data Mining etc. The Neural networks have emerged as an important tool for classification. The Neural Network techniques can be divided into supervised, unsupervised and reinforced techniques. [12] In this work, two classifiers are implemented and used for classification of diabetic retinopathy stages. They are SVM and ANN classifier. They both lies under supervised learning approach. In the recent years, SVM classifiers and ANN classifiers have demonstrated excellent performance in a variety of pattern recognition problems.

SVM is a supervised machine learning method used for data classification including images. Based on the calculated features, the classification parameters are defined and every data is grouped into its most relevant class. Each data, i.e., image, is given to the SVM as point in n-dimensional space where n represents the number of extracted features. In n-dimensional space, the value of each feature is the value of a particular coordinate. Here, SVM finds all the possible hyper planes that separate the classes linearly. Next, it finds the optimal hyper plane based on the maximum distance, margin, from the nearest data point to the hyper plane of interest. In case of nonlinear data, the training data are mapped into high dimensional feature apace using a nonlinear kernel function. Although there are several image processing techniques for DR classification, SVM has the advantages of high performance in higher dimensional spaces, easier analysis of data, ability to deliver a unique solution, and the ability to perform non-liner classification. Therefore, it is used to classify retinal images.

III. RESULTS

Performance of classification for both classifiers can be examined by evaluating the performance of sensitivity, specificity, accuracy and precision. For this true positive (TP), true negative (TN), false positive (FP) and false negative (FN) parameters are calculated. From these parameters accuracy is calculated and performance is verified [14].

$$\text{Accuracy}= \frac{TP+TN}{TP+FN+TN+FP}$$

TABLE I. COMPARISON OF CLASSIFIERS

Classifier	Accuracy	Time
SVM	97%	760ms
ANN	90%	840ms

IV. CONCLUSION

This proposed system has objective of detecting and classification of DR. This uses 130 fundus images from DIARECTDB0 databases. Detection of blood vessels from input images was done. And then extracted necessary features and classified using SVM classifier. The proposed method performed up to classification accuracy 97% .The execution time took about 760miliseconds. As a future work, the classifier performance can be optimized with more images, extracting details features and using different classifier.

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