AEMDS-2013

Design and Development for Detection of Blood Vessels, Microneurysms and Exudates from the Retina

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Abstract. Diabetic retinopathy is the cause for blindness in the human society. Early detection of it prevents blindness. Diabetic retinopathy as a leading cause of blindness in developed countries, Diabetes Mellitus is the inability of the body to use and store sugar properly, resulting in high blood sugar levels. Results in changes in veins, arteries and capillaries in the body. Diabetes is the major cause of blindness in adults ages 20–74. Diabetic Retinopathy is the largest example of diabetic eye disease. Up to 24,000 Americans and in India 14% lose their sight yearly due to diabetic retinopathy. Diabetic retinopathy is a condition in which high blood sugar causes retinal blood vessels to swell and leak blood. In this paper we present a method for automatic detection and identify Normal, Non-Proliferative diabetic retinopathy and Proliferative retinopathy from color fundus images. These systems support physician's to diagnose, measure important anatomical structures, monitor changes by comparing sequential images and plan for the better treatment. In computer based retinal image analysis system, image processing techniques are used in order to facilitate and improve diagnosis. Manual analysis of the images can be improved and problem of detection of diabetic retinopathy in the late stage for optimal treatment may be resolved. The features are extracted from the raw image, using the image processing techniques and served to the support vector machine (SVM) for classification. The results showed a sensitivity of 90% for the classifier and specificity of 0%.

Keywords. Diabetic Retinopathy, Support Vector Machine, Sensitivity, Specificity.

1. Introduction

Diabetic retinopathy is the cause for blindness in the human society. Early detection of it prevents blindness. Diabetic retinopathy as a leading cause of blindness in developed countries, Diabetes Mellitus is the inability of the body to use and store sugar properly, resulting in high blood sugar levels. Results in changes in veins, arteries and capillaries in the body. Diabetes is the major cause of blindness in adults ages 20–74. Diabetic Retinopathy is the largest example of diabetic eye disease. Up to 24,000 Americans and in India 14% lose their sight yearly due to diabetic retinopathy. Diabetic retinopathy is a condition in which high blood sugar causes retinal blood vessels to swell and leak blood [2]. Retinal images of humans play an important role in the detection and diagnosis of many eye diseases for ophthalmologists. Some of the diseases are glaucoma, Diabetic retinopathy and macular degeneration. Diabetic Retinopathy is a severe and widely spread eye disease which can be regarded as manifestation of diabetes on retina. Retinopathy literally means damage to retina. There are two types of retinopathy. The most common type is background of non-proliferative diabetic retinopathy [8]. In this condition, diabetes get damage in capillaries of retina and microscopic leaks are formed in these vessels. Leakage causes retina to swell, which interferes with normal vision. Background or non proliferative diabetic retinopathy may be associated with macula edema. The macula is the part of affected retina and edema refers to swelling caused by leakage [13]. The second type of retinopathy is proliferative diabetic

retinopathy. In this condition, the capillaries of retina shut down. This causes new blood vessel to grow in retina [1].

Presentation of results, we discuss the ROC analysis with reference to the model of visual search and make predictions for the algorithm performance on larger data.

2. Classification of Diabetic Retinopathy

Diabetic retinopathy is classified into two main stages, namely non-proliferative diabetes retinopathy (NPDR) and proliferative diabetes retinopathy (PDR). Non-proliferative Diabetic Retinopathy.

In NPDR, depending on the presence and extent of the features such as hard exudates, microaneurysms or cotton wools spots due to leakage of fluid and blood from the blood vessels, can be classified to mild, moderate or severe stages as following [4].

2.1 *Mild non-proliferative diabetic retinopathy*

It is the early stage of the disease. During this stage micro aneurysms occur. Microaneurysms are small areas of balloon-like swelling in retina's tiny blood vessels.

2.2 *Moderate non-proliferative diabetic retinopathy*

As the disease progress, some of the blood vessels that irrigate the retina become blocked. It is more than "mild" but less than "severe" stage. There will be microaneurysms or hemorrhages of greater severity in one to three quadrants and leakage might occur, resulting cotton wool spots and exudates etc to be present in the retina [11].

2.3 *Severe non-proliferative diabetic retinopathy*

During the severe non-proliferative diabetic retinopathy, more and more blood vessels are blocked, depriving several areas of the retina with their blood supply. These areas which are deprived of blood supply are areas of the retina that send signals to the body to grow new blood vessels for nourishment [10].

2.4 *Proliferative diabetic retinopathy*

In proliferative diabetic retinopathy, new blood vessels are formed that emerge from the area of the optic disk and spread toward the macula or emerge from peripheral vessels [5].

3. Related Work

In this paper, an automated approach for classification of the disease diabetic retinopathy using fundus images is presented. In order to diagnose the disease diabetic retinopathy, a number of features such as area, mean and standard deviation of the preprocessed images are extracted to characterize the image content. Support vector machine (SVM) training process is applied to analyze training data to find an optimal way to classify images into their respective classes namely PDR, NPDR or Normal [4,5].

In the process of Diabetic Retinopathy identification system, the steps are as followed

- Conversion of raw images to grey images
- Radon transform
- Classification of input features using Support Vector Machine.

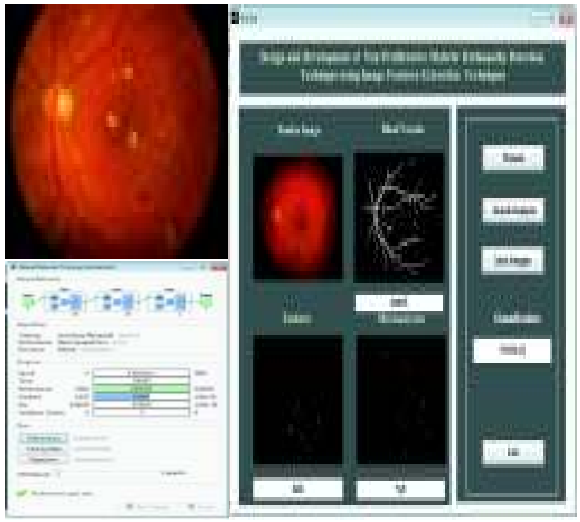

Figure 1. Illustration of GUI

In this work, the system was designed to screen image for different stage of DR (Diabetic Retinopathy) Each image taking the test either has or does not have the disease. The test outcome can be positive (predicting that the image has the disease) or negative (predicting that the image does not have the disease). The test results for each subject may or may not match the subject's actual status. It can be set as follow:

- True positive: disease image
- False positive: incorrectly identified as disease
- True negative: correctly identified as disease
- False negative: disease image incorrectly identified

Table 1. Result analysis.

Techniques	Formula	Result	Range
Sensitivity	$\frac{a}{a+b}$	= 91.67%	95% CI: 61.46% to 98.61%
Specificity	$\frac{d}{c+d}$	= 50.00%	95% CI: 8.17% to 91.83%
Positive Likelihood Ratio	$\frac{\text{Sensitivity}}{100-\text{Specificity}}$	= 1.83	95% CI: 0.45 to 7.41
Negative Likelihood Ratio	$\frac{100-\text{Specificity}}{\text{Sensitivity}}$	= 0.17	95% CI: 0.02 to 1.72
Disease Prevalence	$\frac{a+b}{a+b+c+d}$	= 85.71% (∗)	95% CI: 57.16% to 97.80%
Positive Predictive Value	$\frac{a}{a+c}$	= 91.67% (∗)	95% CI: 61.46% to 98.61%
Negative Predictive Value	$\frac{d}{b+d}$	= 50.00% (∗)	95% CI: 17% to 91.83 %

Table 2. Receiver operating characteristic (ROC).

Test	Disease Present	n	Disease Absent	n	Total
Positive	True Positive	$a = 84$	False Positive	$c = 5$	$a + c = 89$
Negative	False Negative	$b = 5$	True Negative	$d = 1$	$b + d = 6$
Total		$a + b = 89$		$c + d = 6$	

Sensitivity, Specificity and Positive Predictive Accuracy (PPA) are determined as follows:

The sensitivity of a test is the probability that it will produce a TP result when used on an infected image The sensitivity of a test can be determined by calculating [13,14]

$$\text{Sensitivity}(\%) = \frac{TP}{TP + FN} \times 100\% \qquad (1)$$

The specificity of a test is the probability that a test will produce a TN result when used on a non-infected image. The specificity of a test can be determined by calculating,

$$\text{Specificity}(\%) = \frac{TN}{TN + FP} \times 100\% \qquad (2)$$

The PPA of a test is the probability that an image is infected when a positive test result is observed. The PPA of a test can be determined by calculating,

$$\text{PPA}(\%) = \frac{TP}{TP + FP} \times 100\% \qquad (3)$$

The number of training and testing images used in the three groups. The percentage of correct classification shows the accuracy of the SVM classification. The percentage correct classification for the different classes is as shown below in the table. To improve the condition of accuracy, we might want to insert more images for the proliferative class for both training and testing data.

We have designed one GUI in MATLAB, for result analysis we have used Receiver Operating Characteristic (ROC) curve, this algorithm achieves a true positive rate of 95%, false positive rate of 5%, and accuracy score of 1.

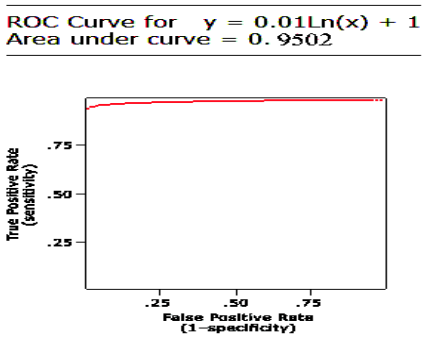

Figure 2. ROC curve

4. Conclusion

This work is a computer based approach for the detection of diabetic retinopathy stages using color fundus images. The features are extracted from the raw image, using the image processing Techniques. In this work, we have investigated and computer based

system to identify Normal, Non-Proliferative diabetic retinopathy and Proliferative retinopathy. SVM classifier as the diagnostic process to help in the detection of the diabetic retinopathy stages. The results showed a sensitivity of 95% for the classifier and specificity of 95%.

5. Acknowledgments

We are thankful to University Grant Commission (UGC) for offering the Major Research Project titled as "Development of Color Image Segmentation and Filtering Techniques for Early Detection of Diabetic Retinopathy" F. No.: 41–651/2012 (SR) and also for providing us a financial support.

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