Detection of Diabetic Retinopathy in Retinal Images

Miss.Sheetal N. Pore [1], [2]Dr. C M Jadhao, [3]Prof. S. S. Mhaske

M.E.-Student[1], Principal and Professor [2], HOD and Assistant Professor [3]
Department of Electronics and Telecommunication[1],
Mauli Group of Institution College of Engineering and Technology, Shegaon, India[1]

Abstract :
The rising situation in the developing world suggests diabetic retinopathy may soon be a major problem in the clinical world [15]. Hence, the detection of Diabetic Retinopathy is important now a days. Diabetes is a chronic disease that occurs when the pancreas does not secrete enough insulin or the body is unable to process it properly. Detection of diabetic retinopathy in early stage is essential to avoid complete blindness. This paper proposes the use of bilateral filter, feature extraction and classifier for the detection of blood vessels and diseases.

***Index Terms* –Retinal Image, Classification, Diabetic Retinopathy, Random Forest, Feature Extraction**

I. Introduction

Diabetic retinopathy, also known as diabetic eye disease, is a medical condition in which damage occurs to the retina due to diabetes and is a leading cause of blindness. Diabetes occurs when the pancreas fails to secrete enough insulin, slowly affecting the retina of the human eye, leading to diabetic retinopathy. It affects up to 80% of people who have had diabetes for 20 years or more. At least 90% of new cases could be reduced if there were proper treatment and monitoring of the eyes. Each year in the united states diabetic retinopathy accounts for 12% of all new cases of blindness. It is also the leading cause of blindness for people aged 20 to 64 years.
Effects: Diabetes affects the kidney, eyes, nerves and heart. We have discussed these affects in the following section.

Diabetic nephropathy: Nephropathy means kidney disease. It is a chronic loss of kidney function occurring in those with diabetes mellitus. Proteins loss in the urine due to damage to the glomeruli may become massive, and cause a low serum albumin with resulting generalized body swelling and result in the nephrotic syndrome.

Diabetic cardiomyopathy: Diabetic cardiomyopathy is a disorder of the heart muscle in people with diabetes. It can lead to inability of the heart to circulate blood through the body effectively, a state known as heart failure, with accumulation of fluid in the lungs (pulmonary edema) or legs (peripheral edema).

Diabetic neuropathy: Diabetic neuropathy is a type of nerve damage that can occur if you have diabetes. High blood sugar (glucose) can injure nerve fibers throughout your body, but diabetic neuropathy most often damages nerves in your legs and feet.

Diabetic retinopathy: Diabetic retinopathy, also known as diabetic eye disease, is a medical condition in which damage occurs to the retina due to diabetes and is a leading cause of blindness.

II. Literature Review:

- Earlier study emphasizes on extraction of blood vessels using Contrast Limited Adaptive Histogram Equalization (CLAHE) which reduces contrast enhancement on image by divide and conquer rule, through it increases sensitivily but decreases predictivity[11].
- The different edge extraction methods used earlier such as wavelet transform edge detection has some drawbacks such as accuracy of edge localization is small, clustering and enhancement is poor in wavelet extraction.
- The study also include neural network and after the classification of normal and abnormal retinal images it was found that the sensitivity is 80.2% and specificity is 70.66%. But as per British Diabetic Association Guidelines, it is recommended that it should have minimum 80% sensitivity and 95% specificity which is not fulfilled and many cause problems in screening[12].
- Watershed transformation algorithm which was used in previous study for detection of Diabetic Retinopathy, it was found that in two images the contrast was very low or the red channel very saturated, the algorithm failed and the result was not accepted[13].

III. Stages of Diabetic eye Disease:

1) Non-proliferative diabetic retinopathy (NPDR);
This is the early stages of diabetic eye disease. With NPDR, tiny blood vessels leak, making the retina swell. Macular edema is when the macula swells. This is the most common reason why people with diabetes lose their vision.
2) Proliferative diabetic retinopathy (PDR);
Proliferative diabetic retinopathy happens when the retina starts growing new blood vessels. This is called neovascularization. From scar tissue these new blood vessels are form. Problem related with the macula or lead to a deatched retina is only because of scar tissue. PDR is very serious and can steal both your central and peripheral vision.

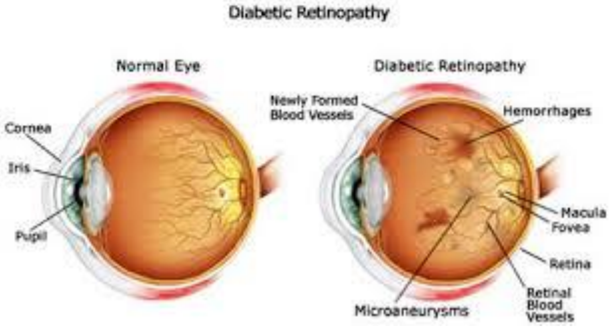

Figure1. Diabetic Retinopathy

Depending on the presence of specific DR features, the stages can be identified. Following are the three sub-classes of NPDR and PDR.

a. Mild NPDR: Non-proliferative diabetic retinopathy is the early stage of the disease in which symptoms will be mild or nonexistent. Approximately 40% to 45% of people with diabetes have at least mild signs of diabetic retinopathy.
b. Moderate NPDR: Numerous microaneurysms and retinal haemorrhages are present.
c. Severe PDR: In severe forms of PDR there are lot of haemorrhages. To prevent new vessel growth laser treatment is needed.

Overview of classifier system:

Image Acquisition
↓
Image Resize
↓
Convert RGB,HSV,LAB,GRAY to Colorspace
↓
Bilateral Filter
↓
CLAHE
↓
Feature Extraction
↓
Classifier Predict

Figure 2: Algorithm for Diabetic Retinopathy

A. IMAGE ACQUISATION:

The first stage of any vision system is the image acquisition. After the image has been obtained, various methods of processing can be applied to the image to perform the many different vision tasks required today. Without an image, no processing is possible. Image acquisition is the creation of photographic images.

B. BILATERAL FILTER:

Bilateral filtering is one of the most popular image processing techniques. The bilateral filter is a nonlinear process that can blur an image while respecting strong edges.

C. CLAHE:

Clipped Local Adaptive Histogram Equalization is an advancement on Adaptive Histogram Equalization. CLAHE limits the amplification by clipping the histogram at a predefined value before computing CDF. AHE is a computer image processing technique used to improve contrast in images. AHE has a drawback of overamplifying noise.

D. FEATURE EXTRACTION:

Feature plays a very important role in the area of image processing. Before getting features, various image preprocessing techniques are applied on the sampled image. After that, feature extraction techniques are applied to get features that will be useful in classifying and recognition of images. It is related to dimensionality reduction. When the input data to an algorithm is too large to be processed and it is suspected to be redundant, then it can be transformed into a reduced set of feature. The main goal of feature extraction is to obtain the most relevant information from the original data and represent that information in a lower dimensionality space. Feature extraction is done after the preprocessing.

Feature extraction is an important step in the construction of any pattern classification and aims at the extraction of the relevant information that characterizes each class.

E. RANDOM FOREST:

Random forests are an ensemble learning method for classification and regression, that operate by constructing a multitude of decision tree at training time and outputting the class that is the mode of the classes or mean prediction. Random Forest is a supervised learning algorithm. Random Forest is a flexible, easy to use machine learning algorithm that produces, even without hyper-parameter tuning, a great result most of the time. Because of it's simplicity and the fact that it can be used for both classification and regression, this algorithm is one of the most used algorithm.

Algorithm for Random Forest:

Preliminaries: decision tree learning:

Decision trees are a popular method for various machine learning tasks. Tree learning "come's closest to meeting the requirements for serving as an off-the-shelf procedure for data mining", "because it is invariant under scaling and various other transformations of feature values, is robust to inclusion of irrelevant features, and produces inspectable models. However, they are seldom accurate". In particular, trees that are grown very deep tend to learn highly irregular patterns: they overfit their training sets. Random forests are a way of averaging multiple deep decision trees, trained on different parts of the same training set, with the goal of reducing the variance. This comes at the expense of a small increase in the bias and some loss of interpretability, but generally greatly boosts the performance in the final model.

Tree bagging

The training algorithm for random forests applies the general technique of bootstrap aggregating, or bagging, to tree learners. Given a training set $X = x_1, ..., x_n$ with responses $Y = y_1, ..., y_n$, bagging repeatedly (B times) selects a random sample with replacement of the training set and fits trees to these samples:

For $b = 1, ..., B$:

1. Sample, with replacement, n training examples from X, Y; call these X_b, Y_b.
2. Train a classification or regression tree f_b on X_b, Y_b.

After training, predictions for unseen samples x' can be made by averaging the predictions from all the individual regression trees on x': or by taking the majority vote in the case of classification trees.

This bootstrapping procedure leads to better model performance because it decreases the variance of the model, without increasing the bias. This means that while the predictions of a single tree are highly sensitive to noise in its training set, the average of many trees is not, as long as the trees are not correlated. Simply training many trees on a single training set would give strongly correlated trees (or even the same tree many times, if the training algorithm is deterministic); bootstrap sampling is a way of de-correlating the trees by showing them different training sets. Additionally, an estimate of the uncertainty of the prediction can be made as the standard deviation of the predictions from all the individual regression trees on x':

The number of samples/trees, B, is a free parameter. Typically, a few hundred to several thousand trees are used, depending on the size and nature of the training set. An optimal number of trees B can be found using cross-validation, or by observing the out-of-bag error: the mean prediction error on each training sample x_i, using only the trees that did not have x_i in their bootstrap sample.The training and test error tend to level off after some number of trees have been fit.

From bagging to random forests

The above procedure describes the original bagging algorithm for trees. Random forests differ in only one way from this general scheme: they use a modified tree learning algorithm that selects, at each candidate split in the learning process, a random subset of the features. This process is sometimes called "feature bagging". The reason for doing this is the correlation of the trees in an ordinary bootstrap sample: if one or a few features are very strong predictors for the response variable (target output), these features will be selected in many of the B trees, causing them to become correlated. An analysis of how bagging and random subspace projection contribute to accuracy gains under different conditions.

Extra Trees

Adding one further step of randomization yields extremely randomized trees or extra trees. These are trained using bagging and the random subspace method, like in an ordinary random forest, but additionally the top-down splitting in the tree learner is randomized. Instead of computing the locally optimal feature/split combination (based on, e.g., information gain), for each feature under consideration, a random value is selected for the split. This value is selected from the feature's empirical range (in the tree's training set, i.e., the bootstrap sample)

IV. RESULTS AND DISCUSSION

In this article, the proposed method is implemented in Ubuntu version 16.04. Three dataset namely DRISHTI,KAGGLE, and REVIEW were used to obtain retinal images. The proposed algorithm takes 15 seconds for execution. Obtaining power spectrum of retinal image[], this retinal images helps a lot to the ophthalmologist to detect early symptoms of Diabetic Retinopathy with ease. Dig. 3(a) shows the Normal Retinal image. Fig. 3(b) shows the Mild Diabetic Retinopathy. Fig. 3(c) shows the Moderate Diabetic Retinopathy. Fig. 3(d) shows the Severe Diabetic Retinopathy. Fig. 3(e) shows the Prolific Diabetic Retinopathy.

Fig. 3(a) Fundas Image

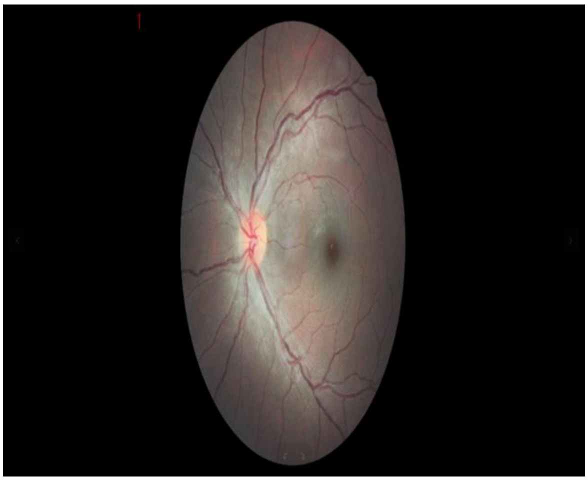

fig. 3(b) Mild DR

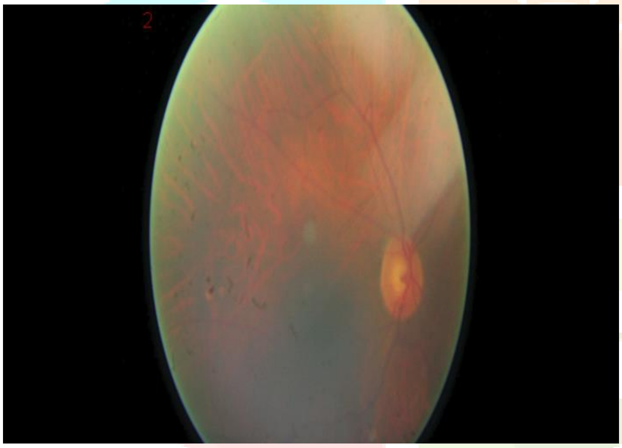

fig. 3(c) Moderate DR

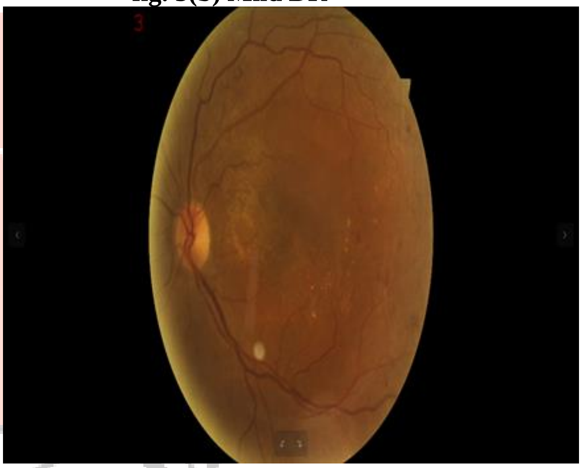

fig. 3(d) Severe DR

fig. 3(e) Prolific DR

V. CONCLUSION:

Prolonged diabetes leads to Diabetic Retinopathy , in which damage occurs to the retina due to fluid leaking from the blood vessels, hemorrhages and texture. We have discussed algorithms for detection of Diabetic Retinopathy and highlights various technologies used for detection of diabetic eye disease. On the basis of this work, the researchers can get an idea and more effective methods to diagnosed diabetic retinopathy.

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