Diabetic Retinopathy Analysis using Image Mining to Detect Type 2 Diabetes

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ABSTRACT

Diabetes is the leading cause of deaths in various developing countries, many techniques have been proposed using image processing methods and data mining technology for the same. Type 2 diabetes can be detected by various methods one of them is through retina analysis also called as diagnosis for retinopathy. Diabetic retinopathy has been researched a lot to find out the methods to prevent type 2 diabetes. The paper presents study of various systems proposed and implemented for detection of diabetic retinopathy. We have proposed a system where wavelet features and texture features are combined together for classification. Standard database DIARETDB1 and HRF are used to test the results of the system. The preprocessing stage uses the green channel of the fundus image. Various preprocessing methods such as sharpening, resizing, binarization are applied. Shape features are extracted by applying second order edge detection operator; these are combined with wavelet features extracted using the wavelet transform. Classification will be done by KNN classifier and evaluation parameters such as sensitivity, specificity, accuracy will be used to determine the efficiency of the proposed system.

Keywords: Diabetic retinopathy, Type 2 Diabetes, Laplace, Sharpening, Specificity.

I. INTRODUCTION

Type 2 diabetes is leading cause of diabetes and reason of death in the world. Medical field has tried to diagnose type 2 diabetes by various methods and different ways. One way to detect type2 diabetes is through diabetic retinopathy which may prevent vision loss. In this paper we place focus on Diabetic Retinopathy the former being a disorder in the retina of the eye caused mainly due to Diabetes leading to imperfect loss of vision and the latter being associated with elevated pressure in the eye causing damage to the optic nerve.

Eye Diseases [5]

1. Diabetic Retinopathy: Diabetes causes sight-threatening retinal degradation.
2. Glaucoma: Glaucoma damages the optic nerve and diminishes the field of vision. Learn about glaucoma causes, eye drops for glaucoma, narrow-angle glaucoma, primary open-angle glaucoma and glaucoma surgery.
3. Macular Dystrophy: Central vision loss can be associated with this inherited eye disease.

1.1 Diabetic Retinopathy

The type 2 diabetes is a familial disease, but also related to limited physical activity and lifestyle. The diabetes may cause abnormalities in the retina (diabetic retinopathy), kidneys (diabetic nephropathy), and nervous system (diabetic neuropathy). In DR the blood vessel becomes weak and the nerves burst leading to flow of yellow fluid called lipoproteins which leads to exudates generation and abnormalities in the eye.

1.2 Detection of Diabetic Retinopathy

1. Exudates: Exudates are accumulations of lipid and protein in the retina. Typically they are bright, reflective, white or cream colored lesions seen on the retina [9].
2. Hemorrhages: Rupture of weakened capillaries, appearing as small dots/larger blots or 'flame' haemorrhages that track along nerve-fibre bundles in superficial retinal layers [9].
3. Microaneurysms: Physical weakening of the capillary walls which predisposes them to leakages. These appear as small dark red dots between the larger vessels of the retina. Distensions (swell due to pressure from inside) in the capillary [9].

1.3 Data mining

There are various methods of classifying medical images and are mainly categorized into 3 parts namely Texture-based classification, Neural Network classification and the Data Mining Task as mentioned. Among them the Data Mining task is considered to be the best as it can not only be used effectively alone but can also be used to improve the accuracy of unsupervised techniques like the neural network classifier [2]. The organization of paper is as follows: section 2 describes the literature survey, section 3 defines problem Definition, section 4 provides proposed methodology. Finally in section 5, our conclusion is presented.

II. LITERATURE SURVEY

2.1. The author has proposed system applies median filter on the input image, it reduces noise making the edges brighter. Image subtraction is applied on the above image, Dynamic thresholding is further applied to convert the image in its binary form. Image addition is performed and features are extracted from the images. Performance evaluation is done based on these features [7].

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Table 1. Comparison of DR Detection Systems

2.2. The paper presents a morphology based exudates detection automated system to detect diabetic retinopathy from color fundus images. The proposed system has a series of steps where morphology operations of erosion and dilation are used to remove blood vessels and make the optic disk clear [8].
2.3. This paper presents an automatic detection of red lesions in retinal fundus image. Contrast adaptive histogram equalization is applied for adjusting illumination and brightness. Matched filter with two different sigma values is applied. Lesions are detected using morphological operations. Geometric and Intensity features are extracted and classified by using SVM classifier [10].

2.4 The author has proposed technique for extracting features for micro-aneurysms and exudates. In pre-processing stage, problems such as blurring, non-clarity are rectified and resizing of image is done. Hybrid median filter smoothens the image by reducing the noise like salt and pepper. Micro-aneurysms and Exudates are detected using candidate extraction, optical disc elimination, blood vessels extraction. Splat, GLCM (Gray Level Co-occurrence Matrix) are calculated and given as input to SVM and KNN classifier. The formulas for extracting above features are as follows:

\[
\text{Entropy} = \sum_i \sum_j G(i,j) \log(G(i,j)) \quad [11].
\]

2.5 The author has proposed technique for detecting Diabetic retinopathy automatically by employing morphology and edge detection. The various steps involved in first step are image compression, layer separation, equalization, morphological operation and feature extraction [12].

2.6. The author proposed an automated diabetic screening system by means of detecting the exudates, haemorrhages in retinal images. The changes in the blood glucose level affect the eyes and leads to breakage. Firstly, image enhancement and fovea localization is done and finally segmentation and detection of hemorrhages is obtained using classification. SVM classifier is applied [13].

III. PROBLEM DEFINITION

Diabetes is one of the major diseases affecting the world, leading to deaths. A lot of research work is carried out in all the countries including developing and developed countries to detect and cure diabetes. Diabetes may cause abnormalities in retina (diabetic retinopathy), nervous system, and kidneys. Detection of these abnormalities can help to prevent diabetes and eventually prevent the body part from being damaged. Type 1 diabetes leads to damage of pancreas which are responsible for insulin production. Type 2 diabetes is a step ahead where person suffers from resistance to insulin which affects the physical activity and lifestyle of the person. Detection of type 2 diabetes through retinal analysis is difficult as it shows minor changes in the retina. Diabetic retinopathy first generates micro aneurysms in the retinal capillary, this is not easily detected. Next stage is generation of hard exudates which clearly indicate the level of severity of DR. Many systems have been proposed for detection of both micro aneurysms and hard exudates. Blood vessels get damaged and leaks fluid into the eye resulting in yellow spots called as exudates. Exudates are of two types depending on the severity, hard and soft exudates. The systems proposed for DR detection use many spatial domain methods and frequency domain methods. The systems extract single features from the retinal fundus images and use them for detection for DR. Most of the system work on contrast enhancement through CLAHE to make retinal image more clears for feature extraction. Use of morphological operations aids in better feature extraction so has been used widely. Combination of multiple features for detection of DR has not been suggested till date. Data mining for performance evaluation has been used rarely. The proposed system will extract multiple features from the retinal fundus images, evaluation of the extracted features will be done by applying data mining.

IV. PROPOSED SYSTEM

The survey of the Diabetic retinopathy detection shows that multi feature system can improve the detection of DR and aid for prevention of type 2 diabetes. The proposed system can be described in following figure i.e. fig 1.

The Proposed system is as follows:
1. Input Image:
Color Fundus Image of retina taken as input to find out the severity of DR present in it. The image is taken by using digital fundus camera with 50 degree field of view. The standard database DIARETDB1 and HRF are used. It consists of DR images and normal images. 1500*1152 is resolution of color fundus image.

2. Pre-processing:
The pre-processing stage includes many stages through which the image has to go. The stages of pre-processing for proposed system include:
   a. Resizing image and Use Green Channel:
The Databases used are DIARETDB1 and HRF which consist of images of varying size so they have to resize to specific dimension before using them further. Images are resized to 512*512. After resizing the image, we will use only the green channel as it contains a lot of information regarding exudates and optic disc along with the nerves of the eye.
   b. Image Sharpening:
Image sharpening is performed where the exudates and other image components will become more sharper for extracting the features. Image sharpening sharpens the edges as well as in the interior of the image increasing the brightness of the optic disc, nerves and exudates.
   c. Laplace Edge Detection:
Laplace edge detection is a second order derivative which makes the foreground edges more bright and background edges hidden.
   d. Histogram Thresholding:
In Histogram thresholding the image will be converted to binary form making the exudates and optic disc available for feature extraction.

3. DWT Transform and GLCM:
The obtained binary image is then given to DWT for extracting the frequency domain features. The DWT gives four sub bands as output HH LL HL LH, out of this LL band is the best band where the exact information of image is obtained. The binary image is also given to GLCM to extract texture features.

Figure 1. DWT and GLCM based proposed system flow

1. Input Image:
2. Pre-processing:
   a. Resizing image and Use Green Channel:
   b. Image Sharpening:
   c. Laplace Edge Detection:
   d. Histogram Thresholding:
3. DWT Transform and GLCM:
4. KNN Classifier:
KNN classifier classifies input image as normal or abnormal by calculating the Euclidean Distance between the images. The performance parameters are Sensitivity, Specificity and PSNR.

PSNR can be obtained using below equation:

\[ \text{PSNR}=20\log_{10}\left(\frac{\text{MAXf}}{\sqrt{\text{MSE}}}\right) \]

where, \( \text{MAXf} \) = higher grey value 255 and \( \text{MSE} \) = Mean square error between test image and enhanced image.

Sensitivity:
Sensitivity is the percentage of abnormal classified as abnormal by applying the detection technique. For obtaining Sensitivity refer equation

\[ \text{Sensitivity} = \frac{\text{TP}}{\text{TP} + \text{FN}} \]

where, \( \text{TP} \) - True Positive and \( \text{FN} \) - False Negative

Specificity:
Specificity is the percentage of normal classified as normal by applying the detection technique. For obtaining Specificity refer equation (17)

\[ \text{Specificity} = \frac{\text{TN}}{\text{TN} + \text{FP}} \]

where, \( \text{TN} \) - True Negative and \( \text{FP} \) - False Positive

V. CONCLUSION
Type 2 diabetes is one of type of diabetes which affects various parts of human body and leads to loss of it. Diabetic retinopathy is one of the symptoms of type 2 diabetes, which if detected properly can be prevented and hence reduce the deaths due to diabetes. We have proposed an automated eye screening system based on multi feature extraction which can detect Diabetic retinopathy based on the exudates extraction. Combination of DWT and GLCM features is used for evaluation using sensitivity, specificity parameters. The proposed system has an improved pre-processing stage which will eliminate the noise completely and thus improve overall efficiency of the system. The automated system will extract the exudates and based on the ratio of exudates to total pixels in the image will define the severity of the DR.

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