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Diagnosis of Diabetic Retinopathy Using Machine Learning Techniques and Embedded Systems

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Abstract: The complication of diabetes causes blindness known as Diabetic Retinopathy (DR). It is very widespread among middle-aged and elderly people. To overcome DR, an early detection is needed. DR can be divided into two groups; one is non-proliferative (NPDR) while the other is proliferative (PDR). In this study, machine learning (ML) techniques are used to diagnose DR at an early stage which uses PNN, SVM, Bayesian Classification and K-Means Clustering. Techniques will be evaluated and compared with each other to choose the best methodology. A total of 300 fundus photographs are processed for training and testing. The features are extracted from these raw images using the image processing techniques. After an experiment, it is concluded that PNN has an accuracy of about 89%, Bayes Classifications 94%, SVM 97% and K-Means Clustering 87%. The preliminary results prove that SVM is the best technique for early detection of DR.

Keywords: Diabetic Retinopathy, Non-proliferative (NPDR) Diabetic Retinopathy, proliferative (PDR) Diabetic Retinopathy, optic disc, Support vector machine, Exudates, microneurysms, ATmega328 microcontroller.

I. INTRODUCTION

Diabetes has become one of the rapidly increasing health threats worldwide. Proper and early treatment of diabetes is cost effective, since the implications of poor or late treatment are very expensive. Fundus imaging has an important role in diabetes monitoring since occurrences of retinal abnormalities are common and their consequences are serious. However, since the eye fundus is sensitive to vascular diseases, fundus imaging is also considered as a candidate for non-invasive screening. The success of this type of screening approach depends on accurate fundus image capture, and especially on accurate and reliable image processing algorithms for detecting the abnormalities. Numerous algorithms have been proposed for fundus image analysis by many research groups. However, it is impossible to judge the accuracy and reliability of the approaches because; there exists no commonly accepted and representative fundus image database and evaluation protocol. With a widely accepted protocol, it would be possible to evaluate the maturity and state-of-the-art of the current methods, i.e., produce the achieved sensitivity and selectivity rates. In the type 1 diabetes, the insulin production in pancreas is permanently damaged, whereas in the type 2 diabetes, the person suffers from increased resistance to insulin. 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). The diabetes is also a major risk factor in cardiovascular diseases.

II. LITERATURE SURVEY

Jothi. R., et al., [1] follows the Diabetic Retinopathy (DR) is characterized by the progressive deterioration of retina with the appearance of different types of lesions that include micro aneurysms, hemorrhages, exudates etc. Detection of these lesions plays significant role for early diagnosis of DR. Extensive simulations on different publicly available databases highlight an improved performance over the existing methods with an average accuracy of 97% and robustness in detecting the various types of DR lesions irrespective of their intrinsic properties. However, classification of different stages of diabetic retinopathy hasn't been done as part of this research

Enrique V. Carrera., et al., [2] say the main goal of their paper is to classify the grade of non-proliferative diabetic retinopathy at any retinal image and an initial image processing stage. They isolate blood vessels, microaneurysms and hard exudates in order to extract features that can be used by a support vector machine to figure out the retinopathy grade of each retinal image. The method explained in this paper has obtained a maximum sensitivity of 95% and a predictive capacity of 94%. Proliferative diabetic retinopathy is not discussed in this paper.

Deepali D. Rathod., et al., [3] have performed the extraction of non-proliferative diabetic retinopathy. They have extracted microaneurysms and exudates using new designed wavelet (DR), and classification is done using KNN classifier. The technique procured 99.03% accuracy for detection of NPDR. Though KN classifier is used, SVM classifier could have been used as it yields better accuracy.

Anila V M ., et al., [4] explain standard image processing techniques that may be found in any good text on general image processing that is detecting certain features and lesion in retinal images and it produces good result compared to previous paper. The proposed method detects the microneurysms from the fundus image without doing fluorescence angiography, and this method is simple, flexible and robust. The automated detection method used is neural network, and the major advantage of this method is that it takes less computation method.

T Chandrakumar.,et al., [5] proposes to use Deep Convolution Neural Network for all level of diabetic retinopathy stages. True Positive rate are also improved. Additionally used Augmentations are needed for the images to taken from different cameras with different field of views. The advantage of this method is to find the better and optimized way to classifying the fundus images. It has less accuracy because it uses the Convolutional Neural Network .

According to Raju Maher., et al., [6] the method developed has to detect the blood vessels and optic disc and identify abnormalities in the retina like exudates and microaneurysms that cause diabetic retinopathy. This method has resulted with sensitivity and specificity for Microaneurysm detection as 80% and 99.5%, respectively. Advantage of this paper is the use of morphological operators to be using the Microaneurysm detection on diabetic retinopathy low-contrast images. This paper explains detection in low contrast images and has very high specificity.

C. P. Reshma Chand., et al., [7] use the histogram specification to equalize the level of original image by changing its intensity values. They also perform optic disc removal with the help of edge detection. SVM based classifier is used here to detect abnormal images. Advantage of this paper is the use of preprocessing method to enhance the contrast of the low quality images. And Optic disc removal is used to give the better result and avoid the noise. However, SVM was used to detect abnormal images only.

Madhura Jagannath Paranjpe., et al., [8] explained preprocessing using the matched filter to remove the noise and adaptive contrast enhancement techniques to improve the image quality. Advantage of this paper is using the match filter that removes the noise and edge detection. This results in less accuracy.

B. Ramasubramanian.,et al., [9] explains that the knowledge of digital image processing can be used to diagnose exudates from images of retina. Colour fundus images often show important lighting variation, poor contrast and noise. Preprocessing is done to eliminate any imperfection of images. To classify exudates, K-Nearest Neighbor (KNN) Classifiers are used which have less accuracy.

III. PROPOSED METHODOLOGY

The approach of diabetic retinopathy consists of digital image studies with an aim of providing ways to diagnose diabetic retinopathy and identifying the severity of the disease. It typically includes application of Image processing on digital images of the retinal structures. This section deals with the steps to diagnose exudates. We propose the following steps to be performed for diagnosis of DR.

A. Image Pre-processing

The aim of pre-processing is to improve the image data by suppresses unwanted distortions or enhance some image features important for further processing. Image preprocessing is the initial step in automated retinal pathology diagnosis. It includes techniques such as RGB to Grayscale conversion, noise removal/filter, contrast enhancement etc.

- RGB to Gray conversion: The colour image to be converted into gray image. Gray image has the range 0 to 255.
- Noise removal: Median filter to be used to remove the noise from an image.
- Contrast enhancement: This is to be applied to improve the quality of the image.
- Optic Disc elimination: Optic disc elimination is to be used to eliminate the yellowish regions in the color image.

B. Feature Extraction

The features such as blood vessels, exudates, micro-aneurysms are to be extracted for further analysis.

- Exudates: Small yellow white patches with sharp margins and different shapes. Exudates are one of the early occurring lesions. Soft exudates are often called “cotton wool spots” and are more often seen in advanced retinopathy.
- Microaneurysms: These are the first clinical abnormality to be noticed in the eye. They may appear in isolation or in clusters as tiny, dark red spots or looking like tiny haemorrhages within the light sensitive retina.

C. Classification

The goal is to predict presence of exudates in discrete values like 1 or 0 and true or false. These are used to check the diabetics stage, whether it is normal or abnormal. Whatever the result of the SVM is, it is to be fed to ATmegha328 controller via UART to display result on LCD as well as to send to the patient through Wi-Fi.

IV. ADVANTAGES

- Retinal image can be used in patient education
- Hard copy can be incorporated into patient record
- Accessible, convenient service

V. APPLICATIONS

- Hospitals
- Diabetic patient Treatments

– Research student's unit

VI. CONCLUSION

In this research work, we studied and compared several ML techniques for DR detection, edge detection and adaptive contrast enhancement. It is found that the early detection of DR can reduce the risk of vision loss up to 76%. Also, this work presents a novel model to diagnose DR based on ML techniques. Among of all of these techniques it can be said that SVM is the best with a percentage of 97.3%, Naive Bayes Classification 86.4% and PNN with a percentage of 78% K-Means Clustering is 81%. It can be concluded from the study that results are promising.

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