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An Image Processing Algorithm to Detect Exudates in Fundus Images

Srujani J[1*], K. Pramilarani[2]

[1,2] Department of Computer Science, New Horizon College of Engineering, Karnataka, India

Corresponding Author: srujanijagannatha@gmail.com

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Abstract— Diabetes often leads to several secondary ailments related to different parts of the body. One such medical disorder is Diabetic Retinopathy. In this condition, the lipids accumulate in the retinal areas of the eye due to fragile blood vessels. These depositions are called Exudates. If exudates are not detected and treated well within the time, they can cause permanent blindness. This paper focuses on a method that can detect the presence of exudates.

Keywords— Diabetic Retinopathy, Exudates, Image Processing, Contrast Adjustment.

I. INTRODUCTION

During the initial two decades of DR eye disease, about all patients having diabetes type-1 and over 60% of patients having type-2 are suffering from diabetic retinopathy [1]. Comprehensively, the amount of people with diabetic retinopathy will develop from 126.6 million in the year 2010 to around 191 million by 2030. If immediate treatment is not provided for patients suffering from DR, [2] then the amount of patients may increase from 37.3 million to 56.3 million. In countries where income is too low as the access to eye-care experts is lacking, diabetic retinopathy is neglected in health-care research and planning.

A condition that is developed from the absence of hormone insulin in a human blood or if the body has an issue utilizing the insulin it produces, is known as Diabetes [3]. A person who is suffering from Diabetes Mellitus is called a diabetic patient. Diabetic Retinopathy (DR) is the most widely recognized eye infection that is brought about by diabetes, it harms the retina in the two eyes causing vision issues which leads to visual deficiency. It influences about 80% of all people who are suffering from diabetes for a long time or more. With early analysis and better treatment, at least 90% of people having exudates can be diagnosed before it reaches to the extreme level. [4] DR frequently has no early cautioning signs. The blood vessels formed behind the retina which belongs to proliferative DR bleed and results in blur vision. Exudates are formed from the liquid that has spilled out of blood veins and which looks like blood plasma. Then the liquid oozes out from the blood capillaries into the tissues. The liquid is made out of serum, fibrin and white platelets. Exudates seem to be waxy and glossy, situated in outer layer of retina at posterior poles of optic disc (OD).

This paper deals with extraction and detection of exudates using image processing algorithm along with machine learning. Various methods for exudates identification and evaluation are observed in the literature phase. The remaining paper will be arranged as shown below. Section II talks on a brief review of existing methods used for detection and extraction of exudates. Section III focuses on proposed system used for extraction and detection of exudates. Section IV presents results and discussions obtained. Section V discusses conclusions derived in the duration of experimentation manner.

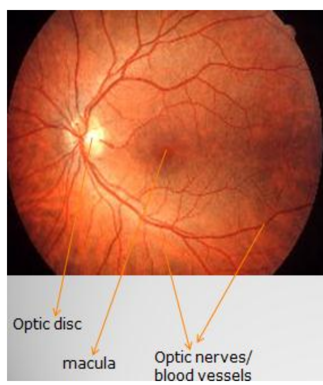

Figure 1: Normal Fundus Image

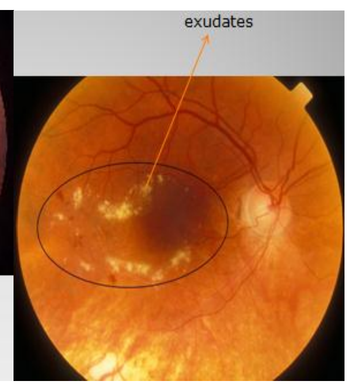

Figure 2: Exudate Image

II. RELATED WORK

In [5], Mohammed Shafeeq Ahmed and Baddam Indira used three sigma control method for automatic detection of exudates to process the colour intensity level of exudates pixel. It depends on limits of colour information. The upper and lower control limits of exudates are set using three sigma control limits. The fundus images are pre-processed to improve the colour intensity and elimination of OD is an important step in pre-processing layer as it shares same features with exudates. Hough transform method used here guarantees that OD is eliminated but not exudates and it is used to get great outcomes. The outcomes obtained are so promising and it encourages the specialists in treating the disease. This method resulted in 99.93% of sensitivity and 99.99% of specificity.

In [6], P.R.Asha and S.Karpagavalli used machine learning (ML) techniques to detect the presence or absence of exudates. After segmentation process, features such as Mean, SD and Centroid are extracted which detects the presence of exudates. The quality of retinal images gets improved after applying the pre-processing step which includes Local Contrast Enhancement, Fuzzy c-means and Histogram Equalization. The exudates and non-exudates are categorized with the help of Naive Bayes (NB), MLP and ELM, where ELM technique is much efficient than MLP and NB. As a result, successful exudates detection process is achieved which diagnose the eye disease in early level and reduce human intervention. This method resulted in 82% of accuracy (NB), 81% of accuracy (MLP) and 90% of accuracy (ELM), which proves that ELM technique have more accuracy than remaining two classifiers.

In [7], Ravitej Singh Rekhi, Ashish Isaac, Malay Kishore Dutta and Carlos.M.Travieso used a robust method which segments hard exudates from fundus images using Anisotropic Diffusion noise removal technique, Adaptive Thresholding segmentation method and SVM technique for classification. The proposed method results in more specificity and accuracy which exactly generates very few false pixels that is useful in real-time diagnostic applications. The segmentation process considers shape and orientation features to categorize the objects as exudates or non-exudates. This method resulted in 92.13% of accuracy and also 90% of accuracy respectively.

III. METHODOLOGY

The proposed system is divided into five parts namely Image Acquisition, Selection of suitable Color Model, Segmentation to extract only exudates, Optic Disc (OD) removal using machine [8] learning and measure of area of spread of exudates.

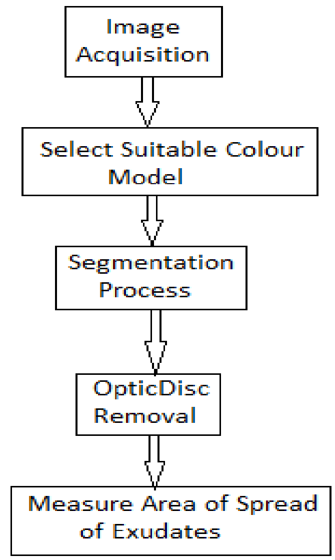

Figure 3: Flowchart of Proposed System

A. Image Acquisition

In this phase, a set of RGB fundus images are downloaded from the database DiaretDB0 and DiaretDB1 which are affected by exudates eye infection. The RGB fundus image is first fed to the image processor for further process.

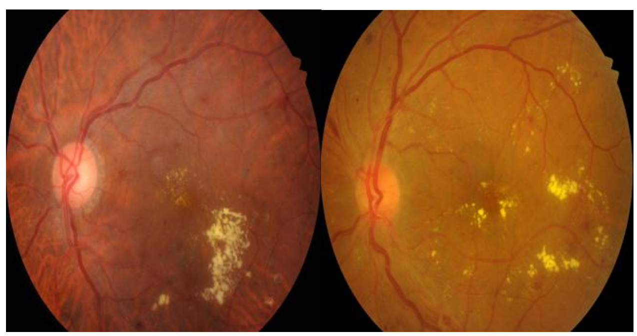

Figure 4: RGB Images

B. Select suitable color model

In this phase, a suitable color model has to be selected for the RGB fundus image that is fed to the image processor. Color processing is done because it clearly differentiates the exudates from the background of fundus image. There are three types of color models namely YCBCR color model (Brightness, Chroma-Blue, Chroma-Red), Grayscale color model and HSV (Hue, Saturation and Value) color model.

The [9] formula used to convert RGB image to YCBCR color model is:

$$Y = 0.299 \cdot R + 0.587 \cdot G + 0.114 \cdot B \quad (1)$$

$$Cb = -0.169 \cdot R - 0.331 \cdot G + 0.500 \cdot B \quad (2)$$

$$Cr = 0.500 \cdot R - 0.419 \cdot G - 0.081 \cdot B \quad (3)$$

The [10] formula used to convert RGB image to HSV colour model is:

$$H=\begin{cases}0 & \Delta=0\\ 60^{*}(G'-B'/\Delta\ {}^{*}\mathrm{mod}\ 6), & Cmax=R'\\ 60^{*}(B'-R'/\Delta+2), & Cmax=G'\\ 60^{*}(R'-G'/\Delta+4), & Cmax=B'\end{cases} \quad (4)$$

$$S=\begin{cases}0, & Cmax=0\\ \Delta/Cmax, & Cmax!=0\end{cases} \quad (5)$$

$$V = Cmax \quad (6)$$

The RGB fundus image has to be converted to these following color models. The color model which clearly differs exudates from the background is chosen for the entire process. As a result, the green component of RGB color model was selected as a suitable color model.


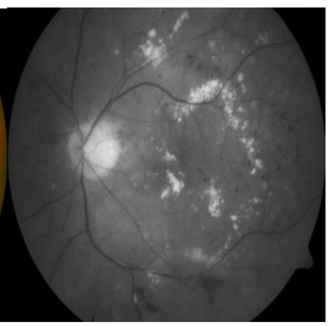

Figure 5: RGB Image Figure 6: Green Image

C. Segmentation

In this phase, after a suitable color model is selected, segmentation process is applied on that particular color model image to extract the exudates. The exudates and the optic disc (OD) both share same features so along with exudates even the OD also gets extracted. The segmentation process here is based on thresholding technique. Thresholding [11] is a simple technique used for image segmentation. In this technique, each pixel of fundus image is replaced by a black pixel, if the intensity of image is less than some fixed constant or is replaced by a white pixel if the intensity of image is greater than some fixed constant.

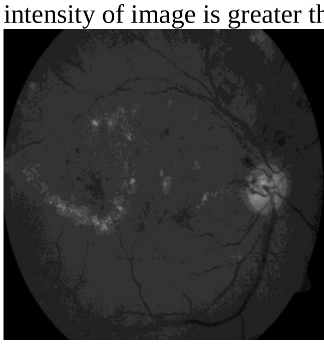
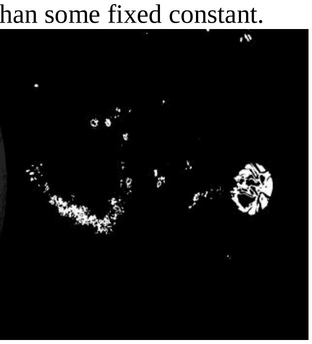

Figure 7: Green Image Figure 8: Segmentation Image

D. Optic Disc Removal

In this phase, the optic disc which is also extracted along with the exudates in the segmentation phase is removed. Here the removal of OD is done using morphological operations. Morphology based noise removal contains two things: erosion (the removal of white pixels) and dilation (the removal of black pixels. These two operations are performed based on the structuring element technique where the image will be divided into parts.

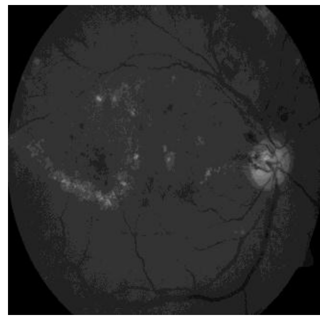
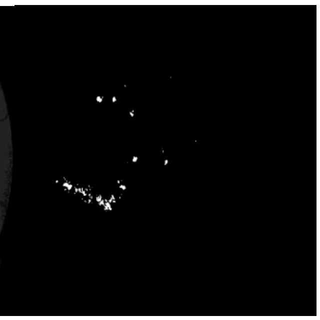

Figure 9: Green Image Figure 10: Optic Disc Removal Image

E. Measure of area of spread of exudates

In this phase, after the removal of OD only the exudates will be left out. The spread of exudates is measured which gives the area of spread of exudates using which the stage of eye disease can be observed and the proper diagnosis can be given to the patient based on the stage of disease the patient is suffering currently.

IV. Results and Discussion

The results obtained for our methodology is discussed in this section. The proposed work has been tested and evaluated on 60 images of DIARETDB0 and DIARETDB1 database. DIARETDB series is a public database that is freely available which benchmarks the diabetic retinopathy (DR) detection from fundus images.

Among 60 images, 52 images gave better results in extracting the exudates where remaining 8 images failed in OD removal technique and segmentation process. DIARETDB series database is maintained by Kuopio University, Finland. It resulted in 86.88% of accuracy. The accuracy achieved is due to the simple and faster method used in our project for detection of exudates.

V. Conclusion

In this paper, our proposed method was successful in detection of eye disease by extracting the exudates in fundus images. It is simple and faster technique which helps in early diagnosis of eye disease and prevents blur vision. The regression machine learning technique distinguishes exudates and the optic disc correctly, which results in efficient removal of optic disc.

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