A Survey on Exudate Detection in Fundus Images

Apurva M Shet
Department of Electronics and Communication, Sapthagiri College Of Engineering, Bengaluru.

Deepika U M
Department of Electronics and Communication, Sapthagiri College Of Engineering, Bengaluru.

Chandana V
Department of Electronics and Communication, Sapthagiri College Of Engineering, Bengaluru.

G Meghashree
Department of Electronics and Communication, Sapthagiri College Of Engineering, Bengaluru.

Dr. Sudha M S
Department of Electronics and Communication, Sapthagiri College Of Engineering, Bengaluru.

Abstract: Diabetic Retinopathy is often noticed in individuals suffering from diabetes since long time. Diabetic Retinopathy is a major disorder, which affects the patient's eye, when left untreated could lead to permanent blindness and its major characteristics is presence of Exudates. Exudates are the fluid that leaks out of blood vessels. Detecting exudates help the Ophthalmologist to diagnose the severity of the patient's condition and in turn help in better medication. Detection of the exudates in the retina is done by various methods developed by researchers. This paper focuses on surveying few of the works published in this regard.

Keywords: Diabetic Retinopathy; Exudates; Segmentation; Machine learning

I. INTRODUCTION

Diabetic retinopathy is a condition that may occur in people who have diabetes. According to American Optometric Association. Diabetic retinopathy is a serious sight-threatening complication of diabetes. Diabetes interferes with the body's ability to use and store sugar (glucose). The disease is characterized by too much sugar in the blood, which can cause damage throughout the body, including the eyes. Over time, diabetes damages small blood vessels throughout the body, including the retina. Diabetic retinopathy occurs when these tiny blood vessels leak blood and other fluids. This causes the retinal tissue to swell, resulting in cloudy or blurred vision. Diabetic retinopathy usually affects both eyes. The longer a person has diabetes, the more likely they will develop diabetic retinopathy. If left untreated, diabetic retinopathy can cause blindness. When people with diabetes experience long periods of high blood sugar, fluid can accumulate in the lens inside the eye that controls focusing. However, once blood sugar levels are controlled, usually the lens will return to its original shape and vision improves. Patients with diabetes who can better control their blood sugar levels will slow the onset and progression of diabetic retinopathy. At this stage, circulation problems deprive the retina of oxygen. As a result, new, fragile blood vessels can begin to grow in the retina and into the vitreous, the gel-like fluid that fills the back of the eye. The new blood vessels may leak blood into the vitreous, clouding vision. Other complications of PDR include detachment of the retina due to scar tissue formation and the development of glaucoma. The methods used by other researchers are computer vision and machine learning, U-net based network architecture, systematic computer aided model, segmentation using Frangi filter, adjusting contrast linearly, morphological operations, Marker based Watershed approach and Probabilistic Neural network (PNN) and Support vector machine (SVM).

II. LITERATURE SURVEY

Sudhir Rao Rupangudi et.al [1] summarizes a novel approach to identify the exudates in fundus images of the eye using computer vision and machine learning. A variance based method is used to segregate the high intensity optic disk from the bright exudates.

Yongshuo Zong et al. [2] proposes automatic hard exudates segmentation method is proposed in order to aid ophthalmologists to diagnose Diabetic Retinopathy in the early stage. Furthermore, U-net based network architecture with inception modules and residual connections is proposed to conduct end-to end hard exudate segmentation, and focal loss is utilized as the loss function.

Dhanshree Thulkar et al. [3] proposes systematic computer aided model for detection of exudates and automatic screening of healthy and diseased fundus image for prompt management and early detection of symptoms to prevent the onset of diabetic macular edema (DME). The fundus images undergo three steps: pre-processing, feature extraction and classification. In the pre-processing stage, the images go through contrast limited adaptive histogram equalization, alternate sequential filtering, and thresholding for extraction of the blood vessel.

Pradip Dhal et.al [4] paper proposes a blood vessel segmentation method on retinal images. The segmentation is done, by using the Frangi filter with the enhancement of contrast, using morphological bottom hat transform in an integrated platform that uses the fuzzy C-Means clustering, and to handle the pathological cases it uses the Laplacian of Gaussian (LOG) filter also.

Aishwarya.K.Dixit et.al. [5] This paper presents a novel method that adjusts the contrast of the image linearly, which in turn, helps detect the hard exudates.

Dulanji Lokuarachchi et. al. [6] paper proposes a method for the automated detection of exudates by using retinal images. We have used different morphological operations for the exudates detection from the retinal images and the developed algorithm has a sensitivity and specificity 94.59% and 88.46% respectively.

Vasanthi Satyananda et. al [7] paper concentrates on extraction of hard exudates and optic disc from the retinal images of eyes using Marker based Watershed approach, which uses the minima imposition method to create mask and marker. Though software systems are easy to install, they prove to be expensive in terms of time and cost; thus, this method has also been implemented on FPGA for an on-chip solution.

P. R. Asha, et.al. [8] proposes work that detect the presence or absence of retinal exudates are detected using machine learning (ML) techniques. A total of 100 images were used, out of which 80 images were used for training and 20 images were used for testing. The classification task carried out with classifiers like Naive bayes (NB), Multilayer Perceptron (MLP) and Extreme Learning Machine (ELM).

Mohammed Shafeeq Ahmed, et, al. [9] proposes a method to detect the exudates from fundus images in RGB color space, thereby facilitate a realistic diagnosis close to the method adopted by ophthalmologist. A Statistical measure-three sigma is used to compute the color intensity range of exudates pixels. The retinal images are preprocessed to enhance the color intensity and optic disk (OD) is eliminated because, it shares similar features with exudates.

R.Priya et. al [10] In this paper, to diagnose diabetic retinopathy, two models like Probabilistic Neural network (PNN) and Support vector machine (SVM) are described and their performances are compared. Experimental results show that PNN has an accuracy of 89.60%.

III. RELATED WORK

During the recent years, there have been many studies on automatic detection of exudates using several techniques. Sudhir Rao Rupanagudi [1], has proposed a machine learning approach which utilizes quadratic regression coupled with a novel computer vision based optic disk extraction technique is proposed. The steps involved in the algorithm can be seen in Fig. 1 and have further elaborated below.

A. Resizing the fundus image

The paper has worked on images from datasets such as DiaRetDB0, DiaRetDB1, IDRiD and, MESSIDOR. Green model was selected for further processing. Regression technique is applied for contrast correction. Least pixel values were identified for templates of exudates and from the same the threshold for contrast enhancement is performed. Later, manual threshold is applied to perform segmentation to obtain both exudate and optic disk. Variance based analysis is applied for optic disk elimination.

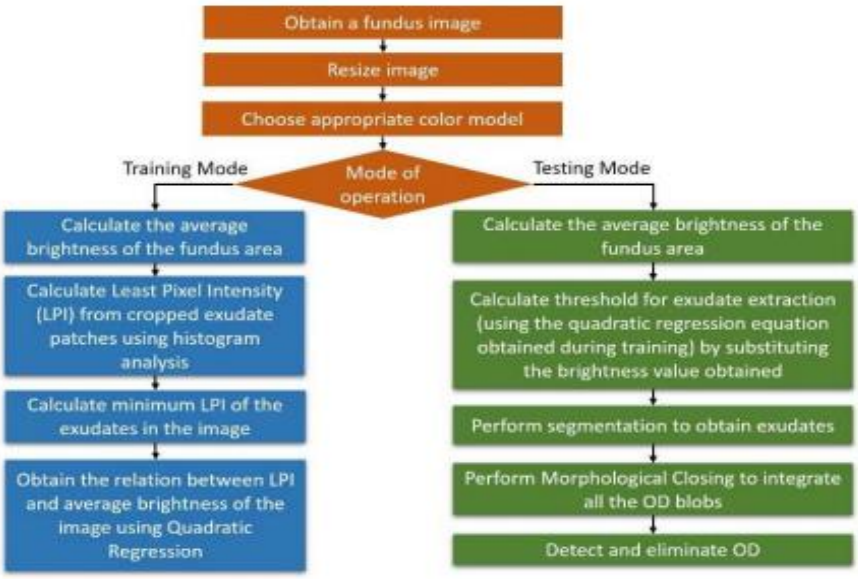

Fig 1. Flow chart showcasing the algorithm proposed in [1]

Dhanshree Thulkar [3] presents a systematic computer aided model for detection of exudates which can be illustrated by the steps shown in Fig.2.

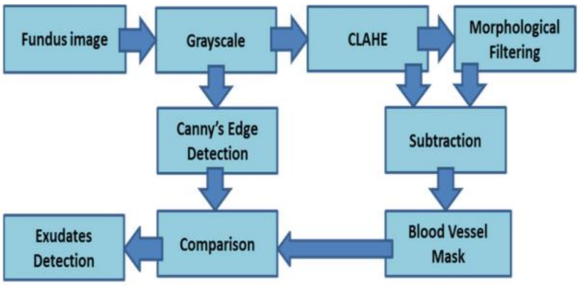

Fig 2. Process Flow

The aim of the processing is to extract the abnormalities in the image and separate them from the other anatomical structures like blood vessels and optic disk in the retinal image. The fundus image is first pre-processed by resizing it using a mask of 800 x 615 dimensions. The image was split in RGB channels. Green channel exhibits maximum contrast with prominent details in the fundus image. This channel is used for further processing by applying contrast limited adaptive histogram equalization (CLAHE). Histogram equalization is applied locally on the medical image with respect to the contextual region. To remove over amplification the bins above a certain clip limit are redistributed in the histogram bin. Then for smoothing the image morphological filter are applied. Sequential filtering is done using opening and closing operation alternately on the image along with elliptical kernel function of increasing size. The enhanced image and morphological filtered image is subtracted leaving faint traces of blood vessels. This image is again contrast enhanced and thresholding is applied to convert grayscale to a black and white image. Close contours in the image are found and removed. Only the contours representing continuous linear line corresponding to blood vessels are retained in the image. Thus, the blood vessel mask is obtained. To extract the exudates in the image the grey scale fundus image is applied with Canny's edge detection technique. All the edges of exudates and blood vessels above the threshold value are prominent in the image. The image obtained is compared with the image of the blood vessel. The pixels corresponding to the blood vessels are removed after comparing, to obtain the image that has the edges corresponding to the exudates alone. The region corresponding to optic disk is masked.

The final image will consist of edges of exudates. Dilation is applied on image to fill in the exudates. Informative features extraction from processed data is done to find the area of the exudates, entropy, contrast, correlation in the pixel, mean, standard deviation and skewness to enable analysis and prediction. For classification, ANN is applied as it classified the images with high accuracy.

IV. PROPOSED WORK - METHODOLOGY

The general procedure includes pre-processing of fundus image, segmentation, optic disc removal and area estimations of exudates to detect the abnormalities.

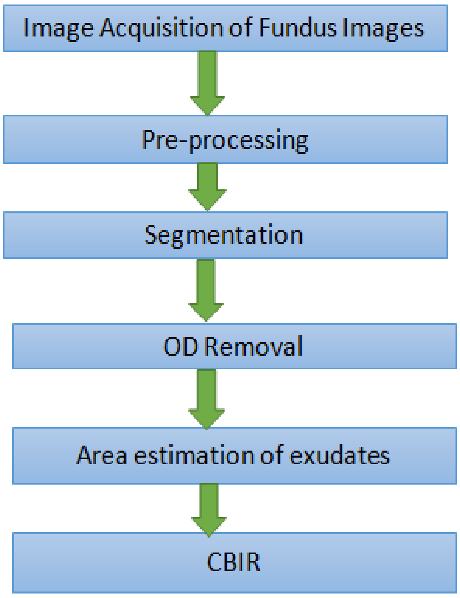

Fig 3. Steps involved in the implementation.

- The fundus images from the dataset are fed to the processor.
- This processor houses an algorithm that can detect exudates. Steps involved in detection of exudates is as shown in Fig 3.
- The algorithm consists of the following steps:
  a) Image acquisition
  b) Selecting suitable color model and contrast adjustment as a part of processing.
  c) Performing segmentation to extract exudates.
  d) The texture and pixel characteristics of optic disc (OD) are similar to that of exudates. Thus optic disc removal must be carried out.
  e) Once the exudates are retrieved, area of spread of exudates must be carried out.
  f) Perform Content based image retrieval (CBIR) to prescribe medication.

V. CONCLUSION

The work generates a novel algorithm which utilizes a combination of computer vision and machine learning in order to identify exudates and optic disc in a fundus image. Not only the algorithm proposed increases efficiency, but also shows promising results in terms of speed in comparison with a majority of other methods as well. Due to these reasons, the algorithm proposed in this project can be employed by ophthalmologists for faster screening and also early identification of eye diseases, especially in those individuals suffering from pre-diabetic and diabetic conditions.

REFERENCES

[1] Sudhir Rao Rupanangudi, Varsha G Bhat, Bharath kumar Revana, Jeevitha Gowda Chandramouli, Sheetal Devegowda, Darshan G, Kaushik Kumaran, Niyatha Malepati, Laveena Manjunath, Shwetha N, Vaishnavi Ramsali "Optic Disk Extraction and Hard Exudate identification in fundus images using computer vision and Machine learning", IEEE 11th Annual computing and communication workshop, pp 655-661, 2021.

[2] Yongshuo Zong, Jinling Chen, Lvquig Yang, siyi Tao, Cieryouzhen Aoma, Jiangsheng Zhao, And Shui-Hua Wang,"U-net Based Method For Automatic Hard Exudates Segementation in Fundus Images Using Inception Module And Residual Connection", IEEE 2020.

[3] Dhanshree Thulkar, Rohin Daruwala "Detection of Exudates for Diabetic Macular Edema classification", 5th International conference on science and technology (ICST), Yogyakarta, Indonesia 2019.

[4] Pradip Dhal, Chandrashekhar Azad "A Novel approach for blood vessel segmentation with Exudate detection in diabetic retinopathy", International Conference on Artificial intelligence and signal processing (AISP), 2020.

[5] Aishwarya K Dixit, Dr. Parimala Prabhakar "Hard Exudates detection using linear brightness method", 2019 4th International Conference On Recent Trends On Electronics, Information, Communication & Technology (RTEICT-2019), MAY 17th & 18th 2019.

[6] Dulanji Lokuarachchi, Kasun Gunarathna, Lahiru Muthumal, Tharindu Gamage, "Automated Detection of Exudates in Retinal Images", IEEE 15th International Colloquium on Signal Processing and its applications (CSPA 2019), Penang, Malaysia, 8-9 March 2019.

[7] Vasanthi Satyananda, K V Narayanaswamy, Karibasappa "Hard Exudate Extraction from fundus images using Watershed Transform", Indonesian Journal of Electrical Engineering and Information (IJEEI).

[8] P.R. Asha, S. Karpagavalli "Diabetic Retinal Exudates Detection using Machine Learning techniques", 2015 International Conference on Advanced Computing and Communication Systems (ICACCS-2015), Coimbatore, INDIA Jan ,05-07, 2015.

[9] Mohammed Shafeeq Ahmed, Baddam Indira "Detection of Exuadates from RGB Fundus Images Using 3σ Control Method", IEEE WISPNET conference 2017.

[10] R.Priya, P.Aruna "SVM and Neural Network based Diagnosis of Diabetic Retinopathy", International Journal of Computer Applications(0975-8887)March2012.