STUDY OF DIFFERENT APPROACHES FOR DETECTION OF DIABETIC RETINOPATHY IN RETINAL IMAGES

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= ***Abstract:*** Diabetic Retinopathy is a disease that damages retina of an eye. At the initial stage, it does not show any symptoms but eventually leads to blindness at advanced stage. Retinal fundus images which involves rear section of eye like optic disc, central or peripheral retina, macula is used for the analysis and detection of the disease. Detection of disease at early stage is crucial to reduce the possibility of blindness. This paper presents the various studies that have been carried out for automatic diagnosis of Diabetic Retinopathy.

Index Terms **- Diabetic Retinopathy, Optic Disc, Exudates, fundus images, bright lesions, eye disease, diabetes.**

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I. INTRODUCTION

The most significant organ of human being is the eyes without which the entire world will be dark due to lack of vision. Eye senses the light and allows us to see the world around us and gives the ability to distinguish between colors and depth. Main parts of eye are iris, retina, cornea, optic nerve etc. as shown in Fig. 1. There are various diseases related to eye such as Cataract, Diabetic Retinopathy, Edema, Glaucoma. There are various parameters that damages eyes one of which is Diabetes. Diabetes is a disease caused due to presence of high amount of glucose in the body. The diabetic population in India is close to hitting the alarming mark of 69.9 million by 2025 and 80 million by 2030 [1].

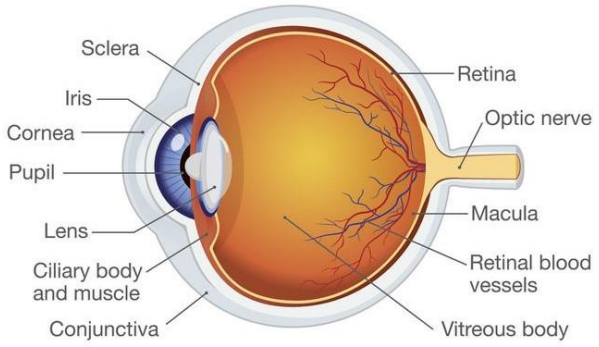

Fig. 1 Structure of Human Eye [19]

Diabetes is considered as the fifth leading cause of blindness. It especially harms the retina. Retina is the membrane which is sensitive to light and lines the inner side of back of eyeball. At the center of retina lies optic disc which is round to elliptical in shape. Optic disc is the bright point that acts like a blind spot since there is absence of rods and cones in that area.

Person who has diabetes for many years or aged diabetic patients are expected to get attacked by a disease known as Diabetic Retinopathy. Diabetic Retinopathy is an ailment in which blood veins or capillaries in retina are damaged because of presence of high glucose levels in the body. It is the major cause of sight loss in the developing countries. Indian diabetic population of about 18% is being affected by Diabetic Retinopathy.

Early stage of Diabetic Retinopathy is non-proliferative Diabetic Retinopathy (NPDR) and later stage is proliferative Diabetic Retinopathy (PDR) [2]. In the primary stage, the symptoms are not seen but becomes noticeable at the progressive stage where damage to retina is difficult or even impossible to treat. In the initial stages, the blood vessels become bulgy (Micro aneurysms), starts leaking fluid or lipids (exudates), and at the later stages new or abnormal blood vessels gets developed. Exudates are of two types: Hard exudates which are yellow in color and white or pale-yellow color deposits are called soft exudates.

Care needs to be taken to make sure that if infection occurs, it has to be treated at the primary stage. Continuous monitoring of people suffering from diabetes is to be done to save them from losing their vision. Diagnosis of Diabetic Retinopathy mostly relies on the observation and evaluation of fundus images. Fundus images as shown in Fig. 2 (Healthy Retina) and Fig. 3 (Diabetic Retina) contains the back portion of eye. Camera which is specific for fundus photography has intricate microscope affixed to flash enabled camera. Parts like optic disc, peripheral and central retina, macula are captured in these fundus images.

Fig. 2 Healthy Retina [20]

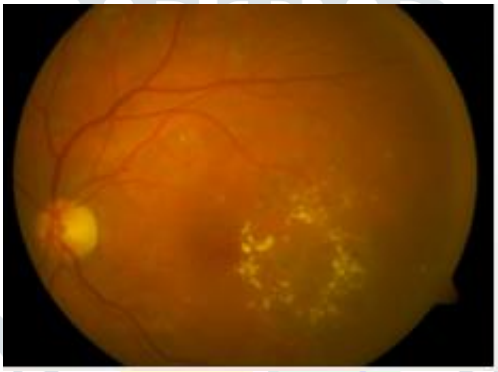

Fig. 3 Diabetic Retina [20]

Ophthalmology [3] is a branch of medicine and surgery which deals with the diagnosis and treatment of eye disorders. The specialist in this field of medicine is known as ophthalmologist. This eye disease can be treated with methods like Focal laser treatment, Scatter laser treatment and Vitrectomy [4] but it does not cure it completely.

Diabetic Retinopathy needs a very good assessment of fundus images to detect its presence accurately which is very difficult and time-consuming even for experienced experts. Computer-aided automated diagnosis system is essential that detects the lesions associated with the disease accurately and in less time. Efficient system that can detect symptoms at early stage so that people can be saved from losing vision is the need of an hour.

II. LITERATURE SURVEY

A lot of study has taken place for automatic detection of diabetic retinopathy by analysing retinal fundus images.

Amin Dehghani et al. [5] presented a method to locate the optic disc using histogram matching. Histogram of each color component of each optic disc was obtained and mean histogram for each color component was used as template. For each retinal image, correlation between histogram for each color component under window of size 80 x 80 and the histogram of corresponding channel in the template is obtained. The correlation result ranges between 0 to 1. The result of histogram matching is the weighted sum of correlation values calculated for each channel.

A. Aquino et al. [6] proposed a template-based technique for optic disc segmentation. To find out the pixels that fall under optic disc voting type algorithm was used. Morphological and edge detection methods succeeded by circular Hough transform were used to find out the circular boundary of the optic disc. It achieved more accuracy in identifying elliptical shaped optic disc than the circular shaped optic disc.

A. Elbalaoui et al. [7] offered a method for automatic exudate detection in fundus images. Image in the HSI colorspace was median filtered and enhanced using CLAHE. Hough transform was used for optic disc detection. For segmentation of exudates graph cut technique was used with the help of alpha expansion algorithm. Classification was carried out using Neural network classifier.

Javeria Amin et al. [8] performed classification of diabetic retinopathy based on structural predictors of lesions. Grayscale image was enhanced using Gabor filter. Mathematical morphology was used for lesion segmentation. Feature set consisted of area, perimeter, circularity and diameter. The method was analysed using four classification families: probabilistic, geometrical, k-nearest neighbour and tree based.

Shaohua Wan et al. [9] studied performance of different CNN models in DR image classification. Non-Local Means Denoising technique was used for noise removal. AlexNet, VggNet, GoogleNet and ResNet were the CNN models used for classification. To handle overfitting problem occurred in training phase, transfer learning and hyperparameter-tuning techniques were used. VggNet-s model showed good accuracy of 95.68%.

S. Lu [10] presented efficient technique for detection and segmentation of optic disc. The intensity component of image was derived followed by down sampling to reduce cost of computation. Optic disc probability map which is based upon Mahfouz's method was used to decrease the optic disc search space. Later, circular transformation was used to detect the disc which takes into account the shape of the optic disc along with the variation across optic disc boundary. The number of radial line segments and length of radial line segment were the two parameters which resulted from circular transformation were used for evaluation. STARE, ARIA and MESSIDOR databases were used for the study

Win et al. [11] proposed system to detect exudates using Histogram analysis. The average filter was used to remove noise. First, the optic disc was removed using histogram matching. Image was converted into green channel as this channel has higher contrast and then median filter and CLAHE was used for noise removal and contrast enhancement respectively. Using histogram-based thresholding technique exudates were detected. Otsu thresholding technique was used to decide the threshold. DRIVE, DIARETDB1, STARE and local database consisting of 325 images was used to carry out the experiment.

Kemal Adem [12] proposed a new method for detection of exudates of Diabetic Retinopathy. The study was carried on DIARETDB0, DIARETDB1 and DrimDB. For the detection of optic disc, adaptive histogram equalization, canny edge detection and circular hough transform techniques were used. CNN was later used for automatic detection of exudates. It was found that results of this method were better than using CNN alone on the images.

A. Rao M. et al. [13] proposed automated diagnosis of DR using Hurst Exponent to determine fractal dimension. 3D image obtained from the DRIVE, STARE, MESSIDOR, CMIF databases was converted to 2D. After pre-processing of image, green channel was selected as it has good contrast. Properties like fractal dimension, contrast, correlation, energy, homogeneity and entropy were derived from co-occurrence matrix of image. It was found that fractal dimension falls in the range 2.0700 to 2.2300 for DR image and lies between 2.000 to 2.0690 for non-DR image

Bannigidad et al. [14] presented a system for exudate detection using GLCM features with Decision Tree Classifier. Canny edge detection technique was used to highlight edges. Morphological opening and closing were performed to increase size of exudates and to delete the small components like blood vessels. Circular mask was used to eliminate optic disc. GLCM features like energy, contrast, homogeneity and correlation were extracted. Supervised learning classifiers such as SVM, K-NN and Decision tree were used to analyse retinal images.

Lama Seoud et al. [15] introduced a novel method for automatic detection of microaneurysms and haemorrhages. Spatial calibration is used to support different image resolution. Pre-processing steps include illumination equalization, denoising using mean filter and adaptive contrast equalization and color normalization. Entropy based technique is used to locate optic disc. Candidate areas are selected depending upon intensity and contrast. Dynamic shape features such as elongation, relative area, eccentricity, circularity, rectangularity and solidity were extracted and classified using Random Forest classifier. The experiment was carried on six databases.

Piotr Chudzik, et al. [16] discussed an automatic method for detection of microaneurysms. Green channel is used for pre-processing where noise was removed using opening and closing with the help of window of size 5. Patches are generated using sliding window technique. Pixel-wise classification was carried out using CNN where Dice coefficient loss function and batch normalization was used. Datasets used for analysis were E-Ophtha, DIARETDB1 and ROC.

Roychowdhury, Sohini, et al. [17] proposed system based on machine learning that generates severity grade for Diabetic Retinopathy. The pre-processing step includes histogram equalization and contrast enhancement of the green plane image. A minimum-intensity maximum-solidity (MinIMaS) algorithm was used to identify optic disc regions. Lesion classification was carried out in two steps. In the first step, bright candidate regions were categorized into bright and non-bright lesions and red candidate regions into true red and non-red lesions. In the second step, the true bright lesions were classified further into cotton wool spots and hard exudates and the true red lesions were classified into microaneurysms and haemorrhages. Thirty features were extracted to carry out the analysis. Gaussian Mixture Model, k-nearest neighbour, support vector machine and AdaBoost were the classifiers used for evaluation.

III. RESULT

The summary of various proposed methods is given in Table 1. It provides information of the various methods used in the detection of the disease and the results obtained using those techniques in terms of accuracy, specificity, sensitivity or success rate.

Table 1. Summary of different proposed methods

Authors	Methodology	Conclusion
A. Dehghani et al. [5]	Histogram Matching: (Filter, Template and Correlation)	Success rate: 100%, 91.36% and 98.9% for DRIVE, STARE and a local dataset respectively.
A. Aquino et al. [6]	OD detection: Morphological and edge detection techniques followed by Circular Hough Transform	Accuracy: 90% (MESSIDOR database) Accuracy: 97% and 92% for elliptical and circular OD respectively.
A. Elbalaoui et al. [7]	RGB to HSI, Median filtering, CLAHE, Hough Transform. Segmentation using graph cuts and alpha expansion. Classification using SVM.	Sensitivity: 95%, Specificity: 96.65%, Precision: 95%, Accuracy: 95.15%.
Amin et al. [8]	Gabor filter for lesion enhancement, Gaussian filter for noise removal, Histogram equalization for image enhancement, Morphological operators for OD detection and four classification families: probabilistic, geometric, k-nearest neighbour (KNN) and tree-based.	SVM and Naïve bayes classifiers showed good accuracy.
Wan et al. [9]	Non local means denoising for noise removal, CNN models such as AlexNet, VggNet, GoogleNet, ResNet for classification, Transfer learning and hyperparameter-tuning to overcome over-fitting problem.	The accuracy of VggNet-s model: 95.68%.
S. Lu. [10]	Circular transformation for detection of OD center and boundary.	Accuracy: 99.75% STARE, 97.5% ARIA and 98.77% MESSIDOR respectively.
Win et al. [11]	Average filter for denoising, CLAHE, Median filtering, Histogram analysis (Filter, Template and Correlation) for OD detection.	Success rate of OD detection: 100%, 96%, 93%, and 97% for DRIVE, DIARECTDB1, STARE and local dataset respectively. Accuracy of Exudate detection: 92%.
Adem, Kemal. [12]	Adaptive histogram equalization, canny edge detection algorithm and circular hough transform for OD detection and CNN for classification.	Accuracy: 99.17% in DiaretDB0, 98.53% in DiaretDB1 and 99.18% in DrimDB.
A. Rao M., et al. [13]	Hurst Exponent to determine Fractal Dimension (FD), Properties: Fractal Dimension (FD), Contrast, Correlation, Energy, Entropy and Homogeneity using GLCM.	FD: 2.0700 to 2.2300 for DR images, FD: 2.0000 to 2.0690 for non-DR images.
Bannigidad, et al. [14]	Canny edge detection, morphological opening and closing, circular mask for OD detection, GLCM features.	Decision tree classifier showed good accuracy of 96.4% and 95.5% on DIARETDB0, DIARETDB1 respectively.
Lama Seoud et al. [15]	Illumination equalization, mean filter, adaptive contrast equalization, color normalization, OD detection using entropy-based technique, Dynamic shape features like elongation, relative area, circularity, solidity, rectangularity and eccentricity.	On Retinopathy Online Challenge's database, the method achieves a FROC score of 0.420. On the Messidor database, the method achieves an area under the ROC curve of 0.899.

Piotr Chudzik, et al. [16]	Patch generation using sliding window technique, Dice coefficient loss function, batch normalization, CNN	Achieved good results using FROC metric and highest sensitivities for low false positive rates.
Roychowdhury, Sohini, et al. [17]	Minimum-intensity maximum-solidity (MinIMaS) algorithm to identify optic disc region, thirty features like area, major axis and minor axis length, orientation, Euler number etc.	Achieved 100% sensitivity, 53.16% specificity and 0.904 AUC.

IV. CONCLUSION

Diabetic Retinopathy is a disease that leads to sight loss which is mainly seen in the patients suffering from diabetes for many years. Early diagnosis can help the person from losing his eyesight. Many studies have been carried out for segmentation of different pathological regions in the retinal fundus images. Using various features like color, texture and shape of lesions related to the disease, different systems have been proposed. The efficient technique is needed to help Ophthalmologists to detect the presence of the lesions corresponding to the disease accurately to prevent blindness in the people.

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