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Different Techniques of Diabetic Retinopathy Detection

Suraj Gupta[1], Dr. Sneha Soni[2], Dr. Kalpana Rai[3]
[1]Mtech Scholar, SIRTE, surajgupta.bhopal@gmail.com, Bhopal, India
[2]Asso. Prof., SIRTE, Bhopal, India
[3] Prof. & HOD, SIRTE, Bhopal, India

Abstract *– Diabetes retinopathy (DR) is one of the most difficult problems that diabetic patients face, in which the retina becomes destroyed and causes blindness. It damages the blood vessels in the retina, causing full vision distortion due to fluid leakage. Diabetic Retinopathy (DR) is an eye disease caused by long-term diabetes. DR is the main cause of blindness among working-age adults worldwide, affecting an estimated 93 million people. Early detection and treatment of DR can help patients avoid losing their sight. Diagnosis of DR is a laborious process that entails a considerable quantity of clinical research, which takes a significant amount of time, money, and resources. The number of DR patients far outnumbers the number of practitioners. As a result, manual clinical diagnosis or screening takes a long time. To avoid such difficulties, follow-up screening is performed on a regular basis, and automatic DR detection and severity grading are required. Several strategies for detecting retinopathy and classifying its severity levels are presented here.*

Keywords*: Blood vessels, Diabetic retinopathy, Exudates, Hemorrhages, Microaneurysms, Non-proliferative diabetic retinopathy, Proliferative diabetic retinopathy,*

I. Introduction

Computer Science is the field of knowledge that deals with the study of computers and computational systems. Its principal areas include artificial intelligence & machine learning, computer systems & networks, security, databases, human-machine interaction, computer vision, numerical analysis, programming languages, software engineering, bioinformatics and theory of computing.

Computer vision is an interdisciplinary sub-field of Computer Science that deals with methods for understanding relevant information present in images. From an engineering perspective, its main purpose is developing methods and algorithms for automatically acquiring, processing, analyzing and understanding images. Typical problems addressed by computer vision include image classification, object detection, segmentation, semantic segmentation and text explanation generation.

DR is a complication caused by diabetes due to damage of the blood vessels of the light-sensitive tissue at the back of the eye [6]. Too much sugar in the blood leads to blockage of the tiny blood vessels, cutting off its blood supply and the eye attempts to grow new blood vessels. Early DR is called non-proliferative diabetic retinopathy where new blood vessels are not growing yet, but the walls in the blood vessels weakens resulting in tiny bulges protruding fromvessel walls and sometimes exudates due to leakages of fluid and blood into the retina. Larger vessels begin to dilate and results in irregular diameter. As the condition progresses, the blood vessel gets blocked and retina swells. This results in growth of abnormal new blood vessels in the retina. These new vessels can result in leakage and scar tissue formation in the eye, which can finally lead to retinal detachment and glaucoma. Figure 1 shows an image with various types of diabetic retinopathy conditions. Hence, detection of such exudates, scars and abnormal blood vessels are important diagnostic tasks in DR. Typical manual diagnosis takes 7 to 14 days as shown in Fig. 2 and needs specialized professionals input. The purpose of this study is to predict DR and do automated analysis by assigning a score of severity based on high-resolution retina images. This will save time in manual diagnosis as well as provide support where specialists are not available.

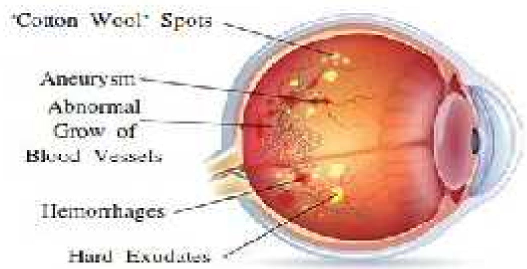

Figure 1: Diabetic retinopathy conditions

II. Literature Survey

The survey provides a comprehensive synopsis of diabetic eye disease detection approaches, including state of the art field approaches, which aim to provide valuable insight into research communities, healthcare professionals and patients with diabetes.

Quang H. Nguyen et al. have tested with VGG-16 and VGG-19 CNN models and observed that the accuracy always ranges from 71 to 73%. We then tested with Keras sequential CNN models by adding customized convolutional layer, optimiser, dense, merge etc. and obtained improved accuracies ranging from 80 to 83%. Due to the limitation of image label counts for 3 and 4 labels, the training model accuracy is impacted in labels 3 and 4. This can be improved if there is more samples with better distribution on each labels.[1]

Kaouthar Manar Fellah et al. have interested to propose a new convolutional neural network (CNN) for color fundus images. These images are pre-processed with various filters before being fed into the training model. Experimental results, in this work, are very encouraging and they outperform results of similar works in literature.[2]

Muhammad Mohsin Butt et al. have Diabetic Retinopathy (DR) is a medical condition present in patients suffering from longterm diabetes. If a diagnosis is not carried out at an early stage, it can lead to vision impairment. High blood sugar in diabetic patients is the main source of DR. This affects the blood vessels within the retina. Manual detection of DR is a difficult task since it can affect the retina, causing structural changes such as Microaneurysms (MAs), Exudates (EXs), Hemorrhages (HMs), and extra blood vessel growth. In this work, a hybrid technique for the detection and classification of Diabetic Retinopathy in fundus images of the eye is proposed. Transfer learning (TL) is used on pre-trained Convolutional Neural Network (CNN) models to extract features that are combined to generate a hybrid feature vector. This feature vector is passed on to various classifiers for binary and multiclass classification of fundus images. System performance is measured using various metrics and results are compared with recent approaches for DR detection. The proposed method provides significant performance improvement in DR detection for fundus images. For binary classification, the proposed modified method achieved the highest accuracy of 97.8% and 89.29% for multiclass classification.[3]

G. U. Parthasharathi et al. have Diabetic retinopathy is a disorder induced by long-term diabetes that can result in total blindness if not addressed. As a result, early detection of diabetic retinopathy is critical, as is the medical treatment to prevent its adverse effects. Manual ophthalmologist detection takes longer and produces considerable discomfort during examination. Machine learning has recently become one of the most popular strategies for improving performance in a variety of sectors, including medical picture analysis and classification. As a result, an automated system aids in the early detection of diabetic retinopathy. Using a combination of neural networks, this research offers the extraction of exudates, haemorrhages, and micro-aneurysms and classification by machine learning.[4]

Anas Bilal et al. have suggested a two-stage novel approach for automated DR classification in this research. Due to the low fraction of positive instances in the asymmetric Optic Disk (OD) and blood vessels (BV) detection system, preprocessing and data augmentation techniques are used to enhance the image quality and quantity. The first step uses two independent U-Net models for OD (optic disc) and BV (blood vessel) segmentation. In the second stage, the symmetric hybrid CNN-SVD model was created after preprocessing to extract and choose the most discriminant features following OD and BV extraction using Inception-V3 based on transfer learning, and detects DR by recognizing retinal biomarkers such as MA (microaneurysms), HM (hemorrhages), and exudates (EX). On EyePACS-1, Messidor-2, and DIARETDB0, the proposed methodology demonstrated state-of-the-art performance, with an average accuracy of 97.92%, 94.59%, and 93.52%, respectively. Extensive testing and comparisons with baseline approaches indicate the efficacy of the suggested methodology.[5]

Deepak Mane et al. have adhere to traditional strategies mainly containing input Data acquisition, pre-data processing, segmentation and data preparation, feature measurement, feature extraction, model creation, model training, model testing on testing data, and outcome and analysis of the model. We have reviewed various algorithms and their challenges that help in the diagnosis of methods used in the detection of diabetic retinopathy.[6]

Meera Ghaskadvi et al. have Diseases knock on a man’s door when he least expects it. One such disease is Pneumonia. It occurs due to the inefficiency of lungs and can lead to major health threats in not just young adults but also children if not detected timely. Diabetic Retinopathy, a disease commonly seen in diabetic patients can be lethal and make a person lose their eyesight. To diagnose these diseases timely, the amalgamation of health with technology is inevitable. With the medical circle of our country being consistently under a great deal of pressure particularly in these difficult times of the pandemic, we have made a one-stop site that can test the presence of different illnesses like diabetic retinopathy and pneumonia by using a deep learning algorithm called convolutional neural networks.[7]

Saif Hameed Abbood et al. have presents an Algorithm for improving the quality of images to strengthen the standard of color fundus images by reducing the noise and improving the contrast. The approach includes two main stages: cropping the images to remove insignificant content, and then applying the shape crop and gaussian blurring for noise reduction and contrast improvement. The experimental results are evaluated using two standard datasets Eye PACS and MESSIDOR. It’s clearly shown that the outcomes of feature extraction and classification of enhanced images is outperforming the results without applying the enhancement approach. The improved algorithm is also tested in smart hospitals as an IoMT application.[8]

III. Detection Methods

III.1 Computer based detection

A novel approach to detect DR from the retina image. First diseased regions were found and features were extracted by applying Discrete Wavelet Transform. The feature number was reduced by Principal Component Analysis and for classification Naïve Bayes was used. The proposed system achieved an accuracy of 95% in the detection of the disease. An automated method to detect Diabetic Retinopathy.

III.2 Convolutional Neural Network

In preliminary image processing was carried out after converting the RGB images into gray scale images. Deep Learning Approach was applied to these gray scale images. The processed images were fed to CNN which predict the presence of diabetic retinopathy and achieved 100% accuracy and sensitivity. In initial vessel segmentation was finished by changing image into binary image. Then vessel and nonvessel half was separated. The morphological operations square measure taken for different orientations. Morphological cutting is employed to skinny the new vessels. Feature extraction was finished by windowing image into 50X50 so as to measure range of pixels in every window. If threshold price is smaller than vessel pixels range then PDR has been detected.

III.3 Artificial neural network (ANN)

An algorithm for DR detection was done using ANN. Decision for screening DR was done using ANN by taking retinal images using condensing lens. The procedure obtained 63% precision and 57% recall rate with a reduced analysis time. Features of horizontal and vertical Video Oculography (VOG) signals from non-proliferative and proliferative patients were used for classification. Discrete wavelet transform was used for feature extraction. For classification feed forward ANN were used. In training process, performance analysis was done. The highest performance for classification was observed when the dataset was divided into 80% &20% for training & test respectively. For detection of exudates a novel wavelet based method was used.

III.4 Fuzzy C-Means (FCM) clustering

A DR detection method using FCM clustering and morphological image processing. The image resizing, CLAHE, contrast adjustment, gray and green channel extraction are included in preprocessing. The SVM classifier was used for classification by using selected features. Accuracy obtained was 96.67%, sensitivity was 100% and specificity recorded was 95.83%. In different image preprocessing techniques were implemented. Performance was compared by performance metrics. Image obtained after the pre-processing was then given as input to the deep neural network. Preprocessing helps to improve the quality of images by averaging. The CNN model used was MobileNets having 28 convolutional layers. Each layer includes batch norm and ReLU nonlinear function except final layer.

III.5 Based on thresholding

a mixture of global & adaptive thresholding for exudates segmentation on color images. Each image was normalized and a set of attributes were extracted. The subset discriminate exudates. Surrounding of images was selected by logistic regression (LR). A radial basis function (RBF) network was used for detection of exudates. For lesion based rule, sensitivity was 92.1% and positive predictive value was 86.4% and for image based specification, sensitivity was 100%, specificity was 70.4% and 88.1% accuracy were obtained. To extract the brighter region on 8 bit gray level images a histogram based multilevel thresholding. For blood vessel segmentation convergent Median filtering was used. Points in blood vessels were determined using least square regression technique. By using convergent point the optic disk (OD) in the brighter regions was determined and it is extracted by thresholding.

IV. Diabetic Retinopathy

Eyes are globular organs of sight present in humans and vertebrates with the function of capturing the light coming from the environment and convert it into signals that are interpreted by the brain as images. From these images the brain is able to extract information and construct abstractions from the external world. Eyes are composed of different parts, each one having a differentiated function (see figure 2). Light coming from the environment travels through the cornea, iris and lens, reaching the retina, situated in the internal back side of the eyeball. Retina is continuous with the optic nerve, and consists of several layers, one of which contains the rods and cones that are sensitive to light. Activated rods and cones transfer information through the optic nerve that is interpreted by the brain as an image.

Diabetes is a disorder of the body due to its inability of producing or responding to the hormone insulin, resulting in abnormal metabolism of carbohydrates and elevated levels of glucose in the blood. Such high blood glucose levels can damage blood vessels and nerves, increasing the probability in diabetic patients of developing other derived diseases, like Diabetic Retinopathy.

Diabetes can be of two different types: type 1 and 2. Type 1 is an autoimmune disease that causes the insulin producing beta cells in the pancreas to be destroyed, preventing the body from being able to produce enough insulin to adequately regulate blood glucose levels. Because type 1 diabetes causes the loss of insulin production, it therefore requires regular insulin administration. Type 2 is a metabolic disorder that results in hyperglycemia, ie. High blood glucose levels, due to the body either being ineffective at using the insulin it has produced or being unable to produce enough insulin. Type 2 diabetes is characterized by the body being unable to metabolize glucose, leading to high levels of blood glucose, which over time, may damage the organs of the body.

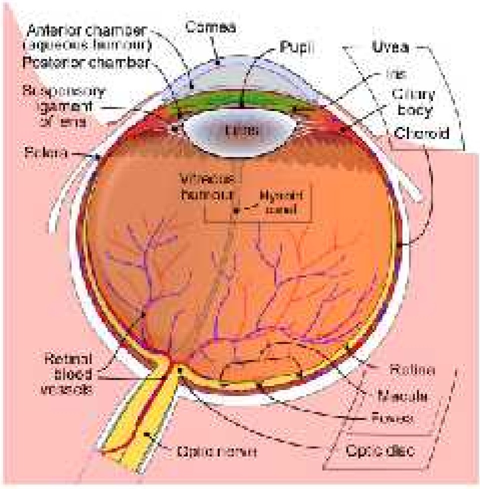

Figure 2: Schematic diagram of the human eye

Diabetic Retinopathy is an associated disease derived from diabetes. It is caused by the damage of the small blood vessels of the retina. Due to diabetes disease related secondary effects, retinal blood vessels can break down, leak or become blocked; affecting the transport of nutrients and oxygen to parts of the retina, causing impaired vision over time. Due to the blockages, abnormal blood vessels can grow on the retina surface, causing an increment of the probability of bleeding and liquid leakages. Such structural changes can result initially in vision blurring and in last stages, even in retinal detachment and/or glaucoma.

During the first two decades of the diabetes disease, nearly all patients with type 1 and more than 60% of patients with type 2 diabetes, will develop a retinopathy.

Figure 3 - Stages of diabetic retinopathy

V. Conclusion

This research examines various ways for screening retinopathy and classifying its severity degree. In conclusion, this study provides a comprehensive overview of the onset and progression of diabetic retinopathy. In our study we found that even well-developed nations lack data on progression of diabetic retinopathy. Also data on incidence of diabetic retinopathy in type 1 diabetes is lacking. Our study suggest that more in depth high quality studies based on data stratified by sex, age and severity of disease are essential to summarize the evidence base.

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