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Early Segmentation of Diabetic Retinopathy Images

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ABSTRACT
Retinal blood vessels segmentation and detection plays an important role for retinal image analysis. Diabetic retinopathy (DR) is a diabetes related eye disease which occurs when blood vessels in the retina become swelled and leaks fluid which ultimately leads to vision loss. Initially database images are considered for pre-processing and blood vessel segmentation process by Rough Fuzzy Clustering (RFC) technique. Once the particular region is segmented, feature information is extracted from the segmented DR fundus image. An extensive series of experiments were carried out and the results are validated on Messidor DR dataset. This essentially reduces the processing time involved in the process of detecting the disease and also the ophthalmologists can also have our graphical user interface as a backup that can be used for validating or assist in detecting the disease.
Keywords: Diabetic retinopathy (DR), Deep Learning, Optimization, Blood vessel Segmentation and clustering.

I. INTRODUCTION

Diabetic retinopathy is an infection that happens mostly in working populace for the most part experiencing diabetes. It for the most part includes a great deal of time in preparing the pictures of the fundus after a patient visits the ophthalmologist separately [1-5]. Proceeding with carelessness of not visiting an authority or not taking consideration can result doubtlessly in visual deficiency, making the patient be visually impaired for the remainder of their lives. The three fundamental segments of the human retina are vessels, optic circle and fovea. what's more, are for the most part utilized for a few applications, For instance, retinal picture selection, lighting up revision, similarly as pathology acknowledgment interior of the retina [6,7]. This disease is the commonest cause of blindness in people of working age, has an effective treatment available to prevent vision loss but is asymptomatic until late in the disease process [8]. The typical features of diabetic retinopathy are microaneurysms, small intra retinal dot hemorrhages, larger blot hemorrhages, all of which are red lesions, and whitish lesions for example lipid exudates, and cotton wool spots which are nerve fiber layer microinfarcts [9-12]. For example, a typical sequence may consist of one or more pre-processing procedures followed by image segmentation, feature extraction and classification stages. Pre-processing may be used to normalize image brightness, correct for image nonuniformity, reduce noise or reduce image artifacts. Segmentation decomposes an image into its constituent regions or objects, for example retinal blood vessels, optic nerve head or pathological lesions [13-16].

Furthermore, this method does not even require a circular in optic disc detection process that is able to apply the proposed method on others database of diabetic retinopathy. In the first of proposed method is detect and subtract the optic disk with morphological method to avoid noise in the exudate detection [17]. Retinal blood vessel segmentation is an imperative tool for the recognition of any changes that happen in the blood vessels, and it gives knowledge about the location of vessels. The automatic generation of the retinal map is used for age-related macular degeneration treatment [18]. Retinal blood vessel segmentation is the basic foundation for developing retinal screening systems since blood vessels serve as one of the main retinal landmark properties. The most common symptoms of diabetic retinopathy include cotton wool spots, hemorrhages, hard exudates and dilated retinal veins [19-24].

Hemorrhage occurs because of the massive quantity of blood released from the influenced part of the blood vessel. In addition, unusual development of blood vessels is said to be neovascularization. Here, venous beading is described as the expansion of veins which is placed nearby occluded arterioles [25-28]. The DR is classified as Non-Proliferative DR (NPDR) as well as Proliferative DR (PDR) [29] and the intensity of diabetes, NPDR is further divided into different stages, respectively [30]. To resolve the limitations, a novel technique is developed to detect and divide fundus images that are useful in preventing the vision loss as DR is used as main remedy. Different process has been used to derive précised identification of DR. The process of searching and classifying work of DR takes place by dividing the fundus images into tiny portions that tends to indentify existence of exudates, lesions, micro aneurysms and so on [31-35].

Severe DR occurs when the supply of blood to the retina is blocked causing the retina to grow new blood vessels, image representation shows in figure 1. The most critical state of DR is proliferative DR which causes new blood vessels to be formed and grown into the vitreous gel of the retina. [36]. Both of previous researches put forward the image analysis in each research, while this study will generate classification percentage of dataset in numerical form so that accuracy level obtained can be known [37]. Several studies proposed various techniques that facilitate the accurate identification of DR. The identification and categorization of DR take place through the segmentation of parts of the fundus image or the examination of the fundus image for the incidence of exudates, lesions, micro aneurysms, and so on [38].

Figure 1: Stages of DR

II. LITERATURE REVIEW

In 2020 Hacisoftaoglu, R. E et al.[39], have proposed the Recent technological advances made smartphone-based retinal imaging systems available on the market to perform small-sized, low-powered, and affordable DR screening in diverse environments. However, the accuracy of DR detection depends on the field of view and image quality. Since smartphone-based retinal imaging systems have much more compact designs than a traditional fundus camera, captured images are likely to be the low quality with a smaller field of view [40]. Our motivation in this paper is to develop an automatic DR detection model for smartphone-based retinal images using the deep learning approach with the ResNet50 network. he proposed ResNet50 model is applied to smartphone-based synthetic images to explore the DR detection accuracy of smartphone-based retinal imaging systems. Based on the vision-threatening diabetic retinopathy detection results, the proposed approach achieved a high classification accuracy of 98.6%, with a 98.2% sensitivity and a 99.1% specificity while its AUC was 0.9978 on the independent test dataset. As the main contributions, DR detection accuracy was improved using the deep transfer learning approach for the ResNet50 network with publicly available datasets and the effect of the field of view in smartphone-based retinal imaging was studied [41].

Diabetic Retinopathy is a complication based on patients suffering from type-1 or type-2 diabetes. Early detection is essential as complication can lead to vision problems such as retinal detachment, vitreous hemorrhage and glaucoma by Samanta, A., et al.in 2020 [42-43]. a transfer learning based CNN architecture on colour fundus photography that performs relatively well on a much smaller dataset of skewed classes of 3050 training images and 419 validation images in recognizing classes of Diabetic Retinopathy from hard exudates, blood vessels and texture. This model is extremely robust and lightweight, garnering a potential to work considerably well in small real time applications with limited computing power to speed up the screening process.

In 2020 Kumar, S.,et al.[44],The proposed method consists of five stages- pre-processing, detection of blood vessels, segmentation of optic disc, localization of fovea, feature extraction and classification. Mathematical morphology operation is used for pre-processing and blood vessel detection. Watershed transform is used for optic disc segmentation. The main contribution of this model is to propose an improved blood vessel and optic disc segmentation methods. Radial basis function neural network is used for classification of thediseases. The parameters of radial basis function neural network are trained by the features of microaneurysm and hemorrhages [45].

In order for this disease to be detected early, an accurate classification method is required. Data mining concept is one alternative in conducting classification by Herliana, A. et al.2018 [46-47]. This study was conducting by applying particle swarm optimization (PSO) method to select the best Diabetic Retinopathy feature based on diabetic retinopathy dataset. Then, the selected feature is further classified using classification method of neural network. The study result show that there is an increase in result by applying neural network based particle swarm optimization (PSO) of 76.11%.

Diabetic Retinopathy is an eye disease caused in patients with diabetic which leads to blindness by Palani, D., et al.2019 [48]. an effective segmentation method that combines modified Fuzzy C Means (FCM) clustering with spatial features and Inertia Weight Particle Swarm Optimization (IWPSO) for detection of Diabetic Retinopathy. The input human retinal fundus images are filtered by a median filter to reduce speckle noise and then contrast enhancement is done by Adaptive Histogram Equalization. Then segmented by various methods like Chaotic Particle Swarm Optimization (CPSO), Inertia Weight Particle Swarm Optimization (IWPSO) and our proposed method.

In 2020 K. Shankar et al.[49], has been proposed the a deep learning-based automated detection and classification model for fundus DR images. The proposed method involves various processes namely pre-processing, segmentation and classification. The methods begins with pre-processing stage in which unnecessary noise that exists in the edges is removed. Next, histogram-based segmentation takes place to extract the useful regions from the image. Then, Synergic Deep Learning (SDL) model was applied to classify the DR fundus images to various severity levels. The justification for the presented SDL model was carried out on Messidor DR dataset. The experimentation results indicated that the presented SDL model offers better classification over the existing models.

III. PURPOSE OF DR DETECTION

- Early detection, which is critical for good prognosis, relies on skilled readers and is both labor and time-intensive. This poses a challenge in areas that traditionally lack access to skilled clinical facilities.
- The blood supply towards all layers of retina is done through micro blood vessels which are susceptible to unrestrained blood sugar level.
- The fluid causes the macula to swell, resulting in blurred vision. Diabetic retinopathy happens when high blood sugar levels damage blood vessels in the retina. People with diabetes can thus get attacked with the eye disease called as diabetic retinopathy.
- An algorithm to extract blood vessels from images. We used filtering methods to remove noise and environmental interference from image. Local entropy thresholding and alternative sequential filter methodology has been adopted in this system.
- In order to perform a screening of diabetic retinopathy, there are various tools available, such as the direct ophthalmoscope, PAN ophthalmoscope, binocular indirect ophthalmoscope, slit lamp and fundus camera [50-52].

IV. PROPOSED RESEARCH METHODOLOGY: A DL MODEL

The propounded design deals with various image processing techniques and machine learning methods so as to segment the fundus input image properly, and are explained in the upcoming subsection respectively. In our research work also Deep Learning Model (DLM) with optimization techniques utilized to DR classification process. Initially, the database images are considered to pre-processing steps to increase the quality of the images, and segmentation process carried out by adaptive histogram equalization used. With the help of finding the best thresholds, a successful segmentation process can be reached when compared with other methods which are relied on Rough Fuzzy Clustering (RFC) Approach.

4.1 Image Acquisition

The retina images were collected from MIMESSIDOR dataset. The image data were converted in the JPEG file format with size 813x499, 60 images in totals, 15 images as a normal retina images and 45 images as an abnormal retina image. The foregrounds image contains the vasculature, optic disk and any visible lesions. The background image contains all illumination variation due to the transformation function or the original background. This is the ideal image of the retina without any visible vascular structure or lesions.

4.3 Blood vessel Segmentation

In the first level, the main colours present in the image are recognized and the segmented image regions are constructed where the pixel in each portion is colour to one between the colors over other colors. The looks of eroded images depended on the structuring element used to scan on the image by bringing the expanded image through dilation process to the Erosion process to eliminate the exudates, leaving only the retina. After the closing process, the images would be brought through dilation again to increase the retina size. A class of popular approaches for vessel segmentation is based on filtering methods, which work by maximizing response as ship-structures. The mean value for a normal fundus image is far higher than that for a diabetic image by RFC [53]. merging process occurs based on the sizes of the segmentation region to minimize the number of regions in the segmented image.

4.3.1 Vessel Enhancement

The problem with vessel segmentation is that the visibility of vascular pattern is usually not good especially for thin and invisible vessels. So, it is necessary to enhance the vessels. his gives us the enhanced vascular pattern for the retinal image. Histogram for the enhanced retinal image is calculated. Maximum values occur for the grayish background while the vessel corresponds to values a slight greater than the background values as they are of bright color. An FC technique is used that selects this point which separates the vessels from the rest of image.

Procedure Involved in RFC

The clustering is achieved by iteratively minimizing the cost function that is reliant on the distance of the pixels to the cluster centers in the feature domain. The pixels on an image are highly correlated. The pixels in the immediate neighborhood possess nearly the same feature data. Therefore, the spatial relationship of neighboring pixels is an important trademark of an extraordinary guide in imaging segmentation, the block diagram shows in figure 3. To begin with, the starting fuzzy partition network is made and introductory fuzzy cluster centers are evaluated. In each movement of the iteration, the cluster centers and the membership grade point are re-designed and the objective function is minimized to find the best domain for the clusters.

Rough sets

The rough set hypothesis is as yet another way to deal with vagueness. Correspondingly to the fuzzy set hypothesis, it is to traditional set hypothesis however it is inserted in it. The rough set hypothesis can be seen as a particular usage of thought vagueness, i.e., imprecision in this approach is communicated by a boundary area of a set, and not by a fractional membership, as in fuzzy set hypothesis.

Objective Function: Proposed RFC partitions into clusters by minimizing objective Equation (1).

$$O_b(X,Y) = \sum_{j=1}^{n}\sum_{i=1}^{k} \alpha_{ij}^{b} dis^2 \quad (1)$$

Membership Function: For solving the objective condition, the membership function is analyzed, shown in equation (2).

$$\alpha_{ij} = 1 \Big/ \sum_{i=1}^{k}\left(dis_{ij}^2 \Big/ dis_{ij}^2 \right)^{1/b-1} \quad (2)$$

Similarity Evaluation: Minkowski Distance is generally called the summed up distance metric. In condition (3) given underneath, observe that when m=2, the distance transforms into the Euclidean distance. This distance metric is a variety of Minkowski distance metric where m=∞ (taking a state of repression).

$$Dis = \left(\sum_{k=1}^{d} \left| R1_{ik} - R2_{jk} \right|^{\frac{1}{m}} \right)^{b} \quad (3)$$

Centroid: The objective function is minimized when the pixel close to the centroid of their clusters is assigned with high membership values. The low membership value is assigned to pixels which are far away from the centroid. The membership function represents the probability that a pixel belongs to a specific cluster.

$$Cen = \sum_{j=1}^{n} \alpha_{ij}^{b} R_j \Big/ \sum_{j=1}^{n} \alpha_{ij}^{b} \quad (4)$$

In above equations (1) to (4), the representation as $O_b(X,Y)$ is an objective function, b, i and k are Fuzziness Index $b \in [1,\infty]$, cen is centroid, dis as minimum distance calculation. Rough set theory creates the set of rules this way. If the set of rule is created next the rule is enduring the optimization process.

Rule Generation

The rules are effectively developed once reduce has been figured, by overlying diminish over the starting decision and reading of the value. This investigates ontology-based e start data utilized for the rule generation process. For Example, the input considers as R1, R2, and R3, its range from [0, 5] and the output cluster taken as C1, C2, C3, and C4. This investigation utilizing AND, OR work for input blend to group the data.

Example Rules

If R1=4 AND R2=3.5 OR R3= 2 then cluster as C1
If R1=2 AND R3=3.5 then cluster as C2
If R2=3 AND R3= 0.8 then cluster as C1
If R1=1.69 then cluster as C3
If R3=2.4 then cluster as C3
If R2=3.9 AND R1=4 then cluster as C2

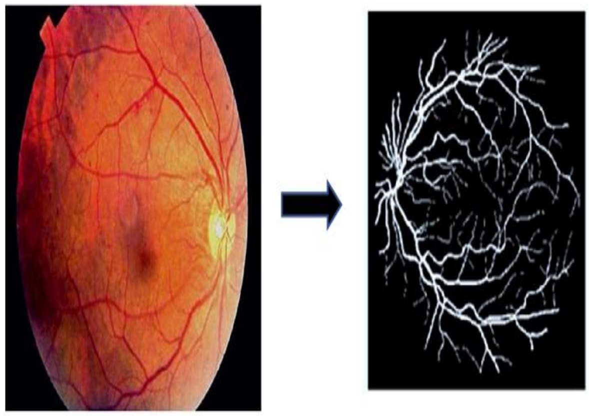

Figure 2: Segmented Region of Fundus Image

Important terms by segmentation

- Select the underlying mask of the input segmented image and apply region-based active contour to obtain the mask of the retinal image.
- Subtract the mask from the input image which will result in a new mask
- Then subtract the new mask from the old mask, the resulting image will be the non-masked segmented image and its shows in figure 2.
- The membership function in RFC only describes the similarity measure between the intensity feature and the cluster center and does not consider the spatial feature among the pixel points.

V. DR DETECTION RESULTS ANALYSIS

In this result analysis section, the implementation settings and the effectiveness of our proposed ANDLM with DALO model, this innovative proposed work implemented in MATLAB 2018, i3 processor and 4GB RAM, this performance analysis is fully based on different quality measures. For experimentation, the parameter used are batch size:8, learning rate: 0.02, epoch or step size: 10000, score threshold:0.7, minimum dimension: 600 and maximum dimension: 1500. This Proposed DR detection model compared with recent segmentation and classifier techniques.

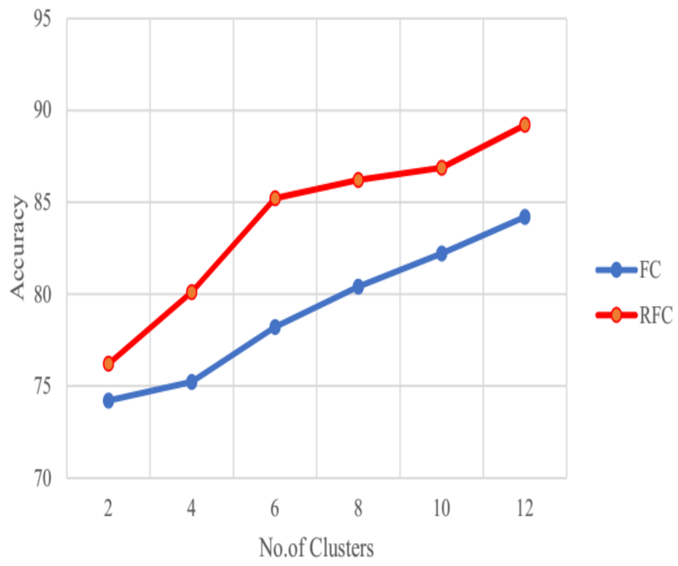

Figure 3: Accuracy analysis for Segmentation technique

Blood vessel segmentation results shows in figure 3, If increasing the cluster size, the accuracy also varying. For example, if the cluster size is 6 the accuracy of proposed RFC is 86.21 and FC is 80.41, Similarly for all clusters. Increasing sensitivity tends to reduce the specificity and in turn, may change the overall accuracy. In reality, the tiny vessels have very low contrast compared with the background, thus if the algorithm is especially intended for tiny vessel elements extraction to increase the accuracy of segmentation.

VI. CONCLUSION

This paper analyses the DL model with DALO optimization for DR detection along with the fuzzy segmentation and feature weighting process. This study intends to classify the DR fundus images with maximum detection rate. An extensive series of experiments were carried out and the results are validated on Messidor DR dataset. Our proposed model produced the accuracy as 99.19%, sensitivity as 98% and finally specificity as 99.5% in ANDLM with DALO model. This work can be extended by quantification of tortuosity and fractal blood vessel dimension in chronic obstructive fundus images. In future work , real time database images are considered for evaluation along with convolution based detection techniques.

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