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Automatic Detection of Blood Vessels in Digital Retinal Images using Soft Computing Technique

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Abstract

Insulin-dependent mortals (humans) are attributed by blemished (defective) metabolism of glycogen (glucose) that leads to long lasting dysfunction and damage of an organ. The most prosaic (common) obstacle (complication) of diabetes is Diabetic Retinopathy, which is one of the predominant (primary) root of visual death and visual impairment in middle aged patient. The expeditious (rapid) mutation of diabetes patient thrust the limitations of the present Diabetic Retinopathy Screening potential for which the digital visualize of eye ball fundus can provide a potential solution by an automated image analysis algorithm. The present learning focus is developing the extraction of normal and isolated characteristics or marks in colour retinal images. The adaptive filters are tuned to match the lump (part) of vessel to be extracted in green channel images. To classify the pixels into vessels and non-vessels the Biogeography Based Optimization Algorithm is applied.

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Keywords: – Diabetic Retinopathy, Multilevel Image segmentation, Biogeography Based Optimization, Migration, Mutation, region growing, habitat.

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1.INTRODUCTION

The eye, gives impression of colour intensity, architecture and capacity to acquire images in the form of larger number of data, which is an integral channel of information bus to the brain. A perfused retina is blissful retina. The retina has multi-blanket layer fashion of neurons, photoreceptors and bedding cells [13]. But when abnormalities occur in the fundus of an eye may leads to casualty [4]. Fundus is positioned in the innermost facial of an eye, corresponding to the lens which carries retina, optic disk, macula and fovea and posterior pole [17]. The bodily structure of macula is the area focused within the temporal arcade computed about 5.5 mm. Fovea measure is about 1.5 mm with most sensitive area of retina and high resolution. Retinal blood vessels are crystalline and focal retinal artery was splited into four branches as super temporal, infero temporal, superonasal, and infronasal. Retinal capillaries are of endothelial cells with tight retinal barriers. Physiologically the optic disk represents the blind spot [22]. The pressure in innermost layer of eye is lower that 21mm/Hg and if it increases, the optic nerve is battered [17].There are several related diseases of an eye such as Glaucoma, Cataract and Diabetic Retinopathy which organizes the damages in the fundus [4].

Among this Diabetic Retinopathy is hackneyed (common) factor with diabetes mellitus and its popularity is travelling to 4.4% of the earthly population [8,1]. Diabetic Retinopathy is an ocular manifestation of diabetes which leads to blindness with no early warning signs. According to World Health Organization (WHO) the latest survey around 135 million people carry Diabetic Mellitus and the ratio may increase up to 300 million by 2025 [9]. Diabetic Retinopathy risk increases by age as middle and older level and it is non-communicable disease [12,23]. The possibility of grow up of Diabetic Retinopathy elaborate after teenage years [13]. The capital reason for alter conviction (changes) of blood vessels in retina by Diabetic Retinopathy [1]. The boss remedy to halt Diabetic Retinopathy and progression is with tight glucose control [13].

Micro aneurysms are central extension of retinal capillaries and intra retinal lipid exudates created from the crack-up of blood retinal enclosure [12]. Existence of exudates is a chief ratification (hallmark) of diabetic [15]. Hemorrhages are classified into flame and dot-blot hemorrhages. Flame hemorrhages crop up at nerve fibers and Dot-blot are circle shaped, bitty than micro aneurysms and seen at end of capillaries [12].

Development of Diabetic Retinopathy takes place in form of macula edema in after that phase [7]. Diabetic Retinopathy is bifurcated into non-proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR).

NPDR distinguish three levels mild, moderate and severe. Exudates are the chief gesture of Diabetic Retinopathy [10]. The debris (sediment) is make-up of lipid by product and bob up as waxy and yellow called hard Exudates. NPDR is auxiliary managed by optimizing the patient generic health [13]. NPDR will have 20/20 vision with no symptoms. Retinal ischemia is lack of blood flow in which narrowed or blocked vessels can be seen clearly [26].

Whereas PDR is the existence of neovascularization in the retina leads to new abnormal vessel growth [12]. PDR Diabetic retinopathy holds the central factor for authorized and operative blindness for the persons in their functioning years (ages 25 – 75) worldwide [6]. The fashionable vessels are cracked, flimsy and often misdirected. Whenever a lavish (enough) impulse (force) is created, a tractional retinal detachment may occur which leads to the acute vision death. First bleeding is not severe in PDR [26].

Photo acquired by high resolution laser fundus camera are used to analyse Diabetic Retinopathy which were collected from databases [15, 17]. Automated blood vessel segmentation technique can be applicable in determining dissimilarity in the blood vessels based on the patterns, tortuosity, width and density. Automated analysis will lead research towards diagnosing

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hypertension, difference in retinal vessel diameter due to history of icy limbs and flicker response [21]. Vessels which breed out in the focal plane of the fundus photo almost challenging task such as presence of noise, lower contrast among vessels and background [16].

To avoid the hazard of blindness, diabetic patients should have screening test every year [8]. Screening can decrease the hazard of blindness by 50% in the patients [11]. The ambition of Diabetic Retinopathy Screening is to determine whether the patient is desired for outlying rehabilitation or not [2]. Screening is essential as frequent humans do not evidence of Diabetic Retinopathy until leading grade of disease and the recommendation for screening are deviating for Type 1 and Type 2 diabetics [13].

The international clinical Diabetic Retinopathy determined the disease harshness gradation by Wilkinson and others. The gradation of fundus images fawn on (based on) categorical retinal aspects. Diabetic Retinopathy scaling is test threat for computational systems as well as medical practice [2]. Self-regulated blood vessel diagnosis in the fundus images can increase rapidity and boost the analysing. Different algorithms have been developed for retinal imagining [5].

This work is concerned to establish blood vessel segmentation and eliminating other patches using Bio-Geography Based Optimization using optimization tool box in MATLAB which is newest to optimize retinal abnormalities with less time. This path of optimization to be expressed by retinal fundus images with desire to bring different approach to pronounce Diabetic Retinopathy and check the level of disease severity. The colour fundus image consists of three layers red, green and blue [12]. Mapping of the colour fundus image with the databases of fundus images contains healthy fundus images as well as images of fundus affected from Diabetic Retinopathy [17].

2. MATERIALS AND METHODS

The emphasis of this work is to automate the detection of diabetic retinopathy using feature extraction from digital fundus images. The entire automation of the proposed algorithm has been implemented using MATLAB. The main features extracted in this studied are micro-aneurysms, optic disc, exudates, levels of Cataract and blood vessels. Also provision is made to provide other category of visual disorders.

3. DATABASE

Fundus images are used for diagnosis by trained clinicians to check for any abnormalities or any change in the retina. They are captured by using special devices called ophthalmoscopes. A typical fundus image with its features marked is shown in the Figure 1.

The images of retinal fundus used in this work are from the open source data from databases such as DRIVE, DIARETDB1 and MESSIDOR. The DRIVE database [6] contains 30 color images of the retina, with 565 x 584 pixels and 8 bits per colour channel, represented in LZW compressed TIFF format. These images were originally captured from Canon CR5 non mydriatic 3 charge-coupled-device (CCD) cameras at 45o field of view (FOV), and were initially saved in JPEG format. Besides the colour images, the database includes masks with the delimitation of a FOV of approximately 540 pixels in diameter for each image, and binary images with the results of manual segmentation. The existing 30 images were sub divided into 20 images for training set and 10 images for testing set. 70 retinal fundus colour images from the DIARETDB1 database [7] were also used to test our algorithm. Images were captured using the 50 degree Field-Of-View digital fundus camera with varying imaging settings. The data correspond to a good practical situation where the images are comparable and can be used to evaluate the general performance of diagnostic methods. This data set is referred to as "calibration level 1 fundus images". Few images from the MESSIDOR database [8] also been used. The images captured using a colour video 3CCD camera on a Topcon TRC NW6 non-mydriatic retinograph with a 45 degree field of view. The images were captured using 8 bits per colour plane at 1440 x 960, 2240 x 1488 or 2304 x 1536 pixels.

The proposed method implements the following sequence of operation. The image pre-processing comprises of Edge enhancement, Grayscale conversion, Average filtering and histogram equalization. The area of interest includes the Binarization, Morphological operation, Object classification, and Optical disk and border subtraction.

From the processing of retinal fundus image the statistical analysis also performed to find out the severity of diseases. The Figure 1 shows the actual image from the data base.

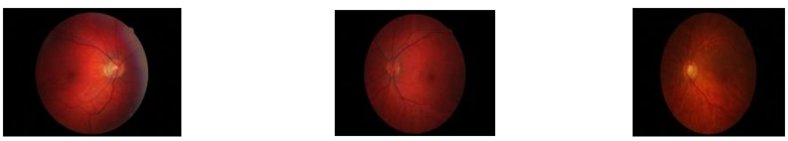


Figure 1. Actual Retinal FUNDUS image from Data base

The actual fundus image is processed to identify different abnormalities levels as per the flowchart given below in Figure 2.

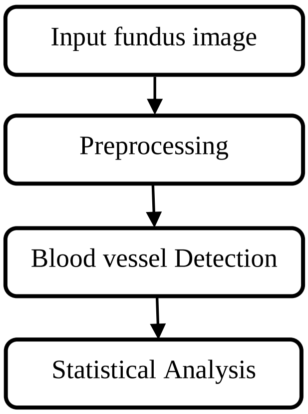


Figure 2: Proposed Algorithm

3.1 Detection of Blood Vessels and pre-processing

There are different image-processing methods that can be used for capturing variations in the fundus image. Some of the methods namely, image segmentation, edge or boundary detection, shape and texture analysis. The detection process can be carried out either on the original image or in the transform domain. In this work the blood vessel detection is carried out on the original image. Some of the transforms that are used in image processing are wavelet transform, Fourier transform, and discrete cosine transforms (DCT). This work utilizes adaptive filter for automated detection and classification of retinal images.

3.2 Image Segmentation

Image segmentation is a process of partitioning an image into regions such that each region is homogeneous and the union of two adjacent regions is not homogeneous. Thresholding based methods can be classified according to global or local thresholding and also as either bi-level thresholding or multi thresholding. The gravy level based on the statistical histogram ranges from 0 to L Between 0 and L, threshold K is chosen to segment the image into two classes: the background whose gray level is from 0 to K and the target whose grey level is from K+1 to L. If a certain threshold K can make the value of interclass variance σB the highest among all the possible values.

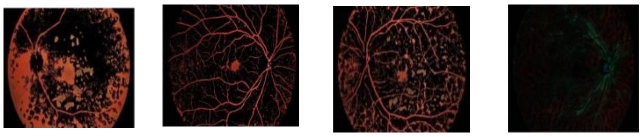
The blood vessel obtained from binarization process is not satisfactory because of noise and many small unwanted objects. The edge enhancement has been performed; however, it also enhances the noise as well. As a result, the final binary output contains noise/unwanted small objects as well as some black vein going through the detected blood vessel. To eliminate or reduce these noises, we applied an operation based on calculating the area of each object in an image. This is a simple method to eliminate the unwanted species from the binary image.

In pattern recognition and in image processing, feature extraction is a special form of dimensionality reduction. When the input data to an algorithm is too large to be processed and it is suspected to be notoriously redundant (much data, but not much information) then the input data will be transformed into a reduced representation set of features (also named features vector). Transforming the input data into the set of features is called feature extraction. If the features extracted are carefully chosen it is expected that the features set will extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full size input. Feature extraction involves simplifying the amount of resources required to describe a large set of data accurately. Analysis with a large number of variables generally requires a large amount of memory and computation power or a classification algorithm which over fits the training sample and generalizes poorly to new samples. Feature extraction is a general term for methods of constructing combinations of the variables to get around these problems while still describing the data with sufficient accuracy. The input data should be transformed into a reduced representation of set of features such as Area Bounding box, Centroid, Eccentricity, Euler number and Diameter.

4. RESULT

The retinal images from the data bases DRIVE and STARE database are used for evaluating the performance of the proposed method. The standard segmentation images are taken as manual segmented images from both the databases. All algorithms have been tested using MATLAB coding. The results are summarized in the following section.

Adaptive filtering is mainly used to enhance the multi-oriented vessels. For each of the images a corresponding manually segmented image is provided. It is binary image with pixels that are determined to be part of a blood vessel by a human observer under the instruction of an ophthalmologist are coloured white. Quantitative evaluation of the segmentation algorithm is done by comparing the output image with the corresponding manually segmented image. The comparison yields statistical measures that can be summarized using contingency table, as shown in Table. True positives are pixels marked as vessel in both the segmentation given by a method and the manual segmentation used as ground truth. False positives are pixels marked as vessel by the method, but that are actually negatives in the ground truth. True negatives are pixels marked as background in both images. And false negatives are pixels marked as background by the method, but actually are vessel pixels



(a) (b) (c) (d)

Adaptive Filter outputs (a) Original Image as an Input, (b) Haemorrhages detected image, (c) Retinal Nerve Identification, (d) Retinal Nerve Identification with Exudates, (e) Colour Patch Identification

(a) **(b)**

Figure (4) (a) Original image from DRIVE data based (b) Segmented image by the proposed algorithm

Two performance measures are measured namely Sensitivity and Specificity. Sensitivity gives the percentage of pixels correctly classified as vessels by the method and specificity gives the percentage of non-vessels pixels classified as non-vessels by the method as follows

Sensitivity = $T_p/(T_p + F_n)$

Specificity = $Tn/(T_n+F_p)$

Where T_p is true positive, T_n is true negative, F_p is false positive and F_n is false negative at each pixel. The method is compared with the matched filter based method of [14] using the DRIVE database. Table shows that Morphological filter is better in classifications of vessels with less false positive fraction rate. Method

The features obtained by the above algorithms are not satisfactory. It is found that the accuracy of above methods is only 75%. Hence, the BBO algorithms have been implemented for all the images. In this method, the 3 level segmentation has been performed. The results obtained by this method are given as following snapshots for three set of images.

4.1 DISEASE SEVERITY:

The severity of the disease is measured depending on the area calculated from the pre-processing and feature extraction and also from the BBO algorithm, Depending on the severity, there are four categories such as mild, moderate, severe and cataract stage. A treatment can also be based on the severity. Certain known treatments are Vitrectomy, Scatter laser treatment, Focal laser treatment and Laser photocoagulation.

The disease severity is computed as = $\frac{\boldsymbol{Affected\ area}}{\boldsymbol{Total\ area\ of\ retina}}$

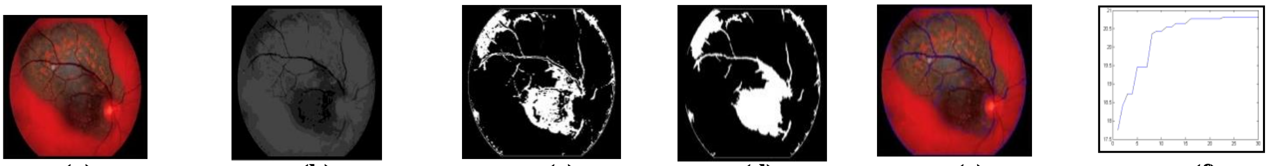
Table 1. Diagnosis of Stages of Disorder

LEVEL	PERCENT	PRESENCE
MILD	Less than 12 %	Haemorrhages
MODERATE	12 – 30 %	Presence Of Macula Edema
SEVERE	31 – 55 %	Presence Of Exudates
CATARACT	Greater than 55 %	Loss of Vision and Cataract Stages is Developing

Table 2. Output Percentage of Affected Image of Fundus

Patient Details	Diseased Area in %
Image 1	9.67
Image 2	62.34
Image 3	17.96
Image 4	24.21
Image 5	30.07
Image 6	43.83
Image 7	71.88
Image 8	12.88
Image 9	31.87
Image 10	38.34

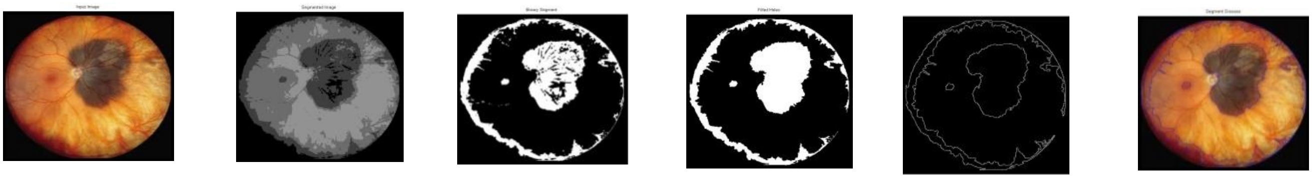
1. Input image 1.



(a) (b) (c) (d) (e) (f)

Processing of Image 1 (a) Input image, (b) Segmented image, (c) Binary Segmentation, (d) Filled Holes image, (e) Segmented Disease, (f) Optimization of Infected Area

2. Input Image 2



(a) (b) (c) (d) (e) (f)

Processing of Image 2 (a) Input Image, (b) Segmented Image, (c) Binary Image, (d) Filed Holes Image, (e) Scar Detected Image, (f) Segmented Image

3.Input Image 3

(a) (b) (c) (d) (e) (f)

Processing of Image 3 (a) Input Image, (b) Segmented Image, (c) Scar Detected Image, (d) Binary Image, (e) Filed Holes Image, (f) Segmented Disease Image

CONCLUSION

The intent of this research is to develop algorithm to identify non-identical lesions associated with Diabetic Retinopathy. The lesions breed of interest was micro aneurysms, haemorrhages, hard exudates, soft exudates and neovascularization. An approach for neovascularization identification is still to be fixed.

The soft exudates colour and intensity were close to fundus colour. The precision of exudates perception appears to be good since exudate pixels were accurately classified as exudates and further pixels as non-exudates by Biogeography Based Optimization Algorithm.

DISCUSSION

The image processing of colour fundus images has a significant role in the early diagnosis of Diabetic Retinopathy. In this work, a novel method is presented for the detection of abnormal new blood vessels from the colour fundus images. Finally the images are classified as normal and abnormal and disease severity also categorized.

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