



DETECTION USING DYNAMIC SHAPE FEATURES RED LESION FOR DIABETIC RETINOPATHY SCREENING

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Abstract-Diabetic retinopathy does not show any symptom of the disease till the person is fully affected with it. The fundus of the eye opposite the lens and includes the retina, optic disc, macula and fovea and the posterior pole. This eye fundus must be examined periodically by ophthalmoscope or fundus photography. This fundus examination can easily denote any changes in the retina due to the very less number of ophthalmologists some automated screening process is need to be developed in order to cover all the diabetes affected people. This automation process can be done in two stages. The first stage involving the detection of patients affected with diabetic retinopathy. The second stage is evaluating to what extent the patient has been affected.

INTRODUCTION

Diabetic retinopathy is a health issue which often leads to improper vision and in some cases it can even cause blindness. Everyone in three people who is affected with diabetes [1] is subjected to possess signs of diabetic retinopathy and in recent surveys one in every 100 people suffers even more severe where they even lose their sight(Fig.1). This diabetic retinopathy can be diagnosed using the treatments that are present. If it is treated

at early stages loss of vision can be protected. Though this process more suitable treatment can be offered to the diabetic retinopathy affected patient. The research focuses on providing a computer aided telemedicine for diabetic retinopathy. The already adopted methods mainly focus on detecting micro aneurysms. These can be detected using morphological actions. This automation can be achieved by testing a group of people affected with diabetic retinopathy and sorting out the people with more severity. This helps human experts to reduce the examination time of the disease. The fundus images with diabetic retinopathy have a part of the eye tissues which would be damaged already [8]. This can be more accurately called as red lesions. These red lesions at sometimes cause swelling in the retina, blood vessels called as micro aneurysms and some time bleeding. In case of bright lesions a mass cell accumulation in the retina may occur and some fluffy patches may occur in the retina. The main aim is to differentiate micro aneurysms from stretched out structures [5]. Micro aneurysms are early signs of diabetic retinopathy however haemorrhages are even more valuable and useful to specify the severity of the disease. Haemorrhages are of different



types at different levels they can be classified as dot, blot and flame. This haemorrhages indicate either it is a moderate or a severe non-proliferative diabetic retinopathy. Dot haemorrhages are more commonly called as micro aneurysms [7] because human experts find it difficult to differentiate dot haemorrhages from normal fundus colour. In flame haemorrhages the blood oozes out into the nerve (outer layer) fibre and in a blot haemorrhages here the blood leaks out even deeper into the retinal layer. The blot haemorrhages is bigger than a dot haemorrhages its outer covers are not of uniform shape. Since these haemorrhages can have wide variety of shapes exact methods like pattern matching are done. The proposed method

here is primarily detecting all the haemorrhages and micro aneurysms which do not require the vessels to be split into multiple segments [1]. Instead we need to clarify the lesions and vessel segments. Once the image is captured it is processed after the pre-processing the affected lesions are identified. This idea mainly is focused on a set of different shapes which need not require earlier segmentation of the affected people. Since the newly proposed method mainly focuses on telemedicine system [2]. So factors such as image quality pixel clarity are taken into account [10].

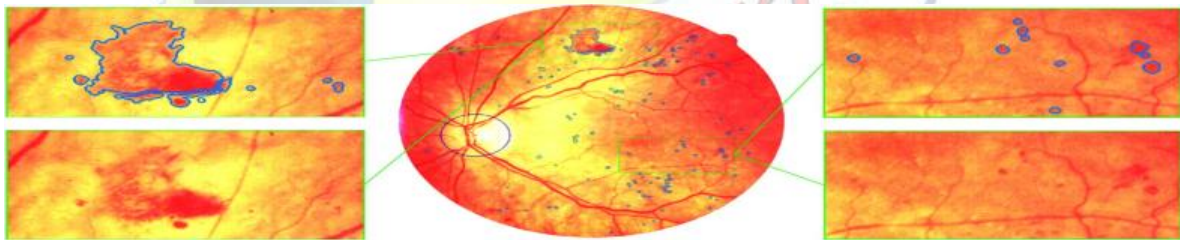


Fig1. Fundus images with red lesions

PROPOSED TECHNIQUE

In the newly proposed technique the colour of the fundus of the retina is given as an input. This method is split into 6 different steps [4]. The first step involves calibrating a single image against known values and the applying calibration to uncalibrated image. Second steps involves pre processing of the image by giving a flat regular surface to the image which can be more collectively called as smoothing

and this can also be done by decomposing the image (Fig.2). Then the raised disc of the retina at the point of the entry of optic nerve, lacking visual receptor which creates a blind spot is also detected to eliminate this portion during the detection of lesions [9]. The fourth step comprises of identifying the people with diabetic retinopathy with corresponding lesions that are identified in the image pre processing phase. The fifth step comprises of the dynamic shape features extraction.

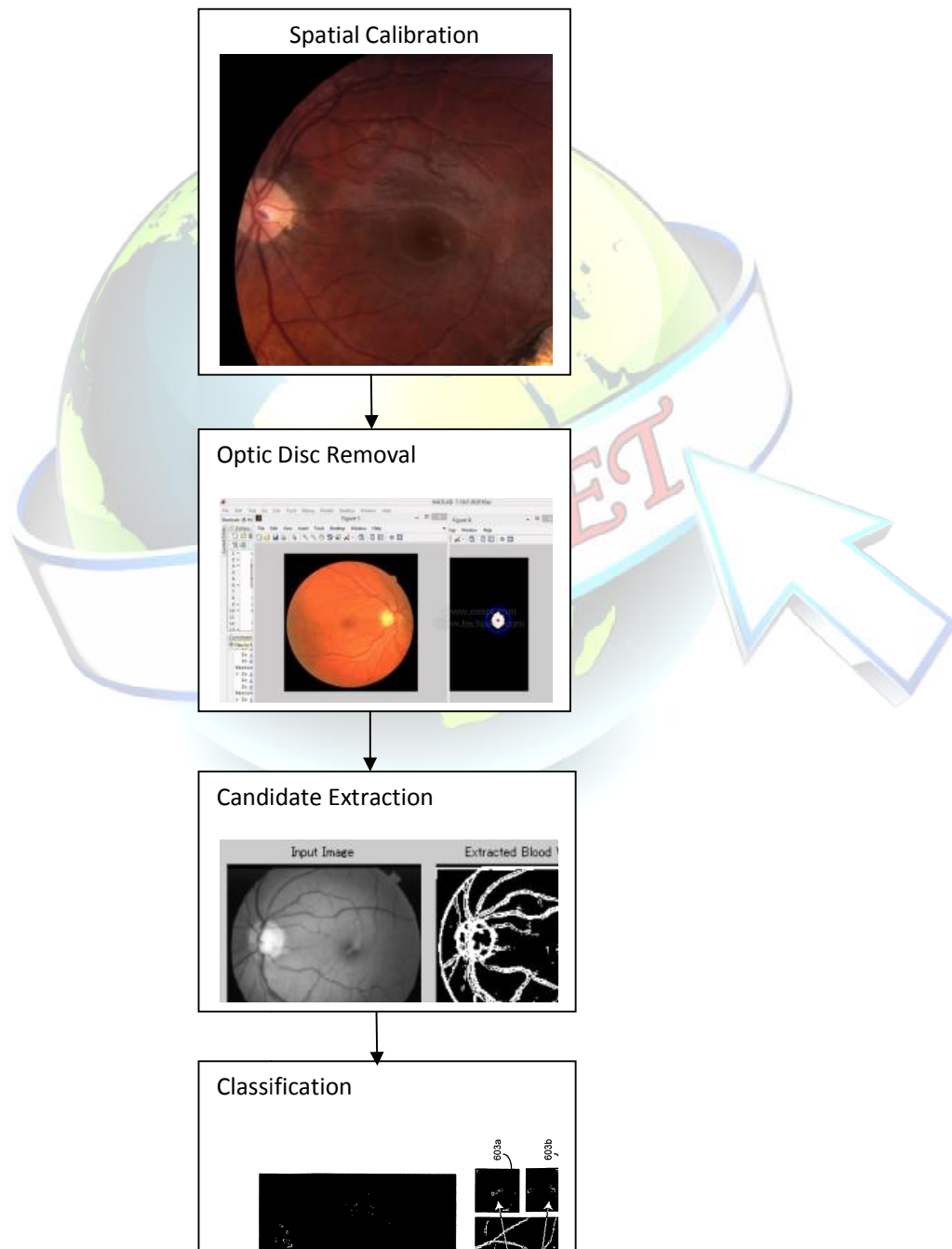


The final step is where the people gets affects with diabetic retinopathy are classified based on their red lesions [6]. Detailed description of the above steps is elaborated in the below diagram (Fig.3):



Fig 2: Severe Red Lesions

Fig3: Red Lesions Screening Process





1. SPATIAL CALIBRATION

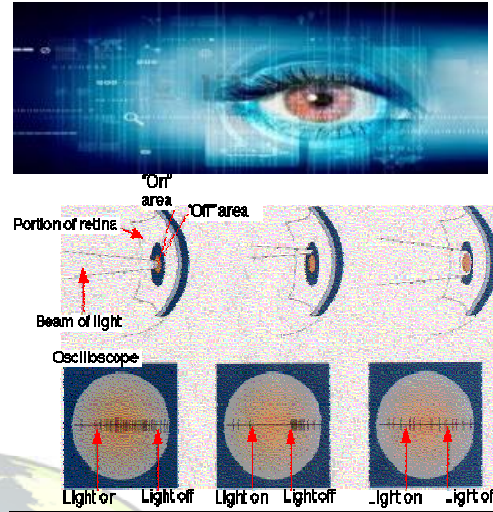
This method is very useful because it can adopt various resolutions of images. Here the image is neither increased nor decreased. Instead the diameter of the circular area surrounded by the black background i.e. the region of interest is taken with variation in their size[11]. The diabetic retinopathy screening is obtained with a field of view at 45 where the diameter D is used to set different filter sizes. There are three parameters that are considered in this method they are

- d1 is the average radius of the optical disc
- d2 is the size of the smallest microaneurysms
- d3 is the largest haemorrhage's size

In the obtained fundus we can set these parameters as

- $d1 = D/10$
- $d2 = D/360$
- $d3 = D/28$

2. IMAGE PROCESSING



The lighting of the retina is not uniform which often leads to local luminosity

And variation in contrast. This image pre-processing can be done in 4 steps

And they are

2.1 Illumination equalization

To overcome the reduction of an image brightness or saturation we use the illumination equalization method. A mean h_{m1} filter of diameter (d_1) is applied on each colour component

That is present in the original image (I) to calculate the illumination of the image after this the produced image which is a colour image is subtracted from the original image[9]. Then the intensity of the original image μ is also added

$$I_{ie} = I + \mu - I * h_{m1}$$

2.2 Demonising

In this method a small mean filter (h_{m2}) of diameter (d_2) is applied to each channel in the produced image I_{ie} in order to reduce



the noise that results from the steps which does not involve the smoothing of lesions

2.3 Adaptive Contrast Equalization

The contrast continuous slow movement from one place to another is approximated by using a local standard deviation which is used to compute each pixel in the neighbourhood which is of diameter (d) for different colour channel (I_{Ad}) places which have low standard deviation indirectly denote that they are areas which have less contrast or which have smooth background to improve the low contrast area we sharpen the details in each portion using the below equation for each colour channel

$$I_{ce} = I_{dn} + 1/I_{std}(I_{dn} * (1 - h_{m3}))$$

The details of the image produced in the phase are added to the image where the noise is removed

2.4 Colour Normalization

This step is necessary to obtain image of a standard colour range

3. OPTIC DISC REMOVAL

The optic disc removal is a phase where the false positive in the red lesions need to be removed. In the pre processed image we apply an entropy based technique to locate the centre of the optic disc. Usually the optic disc is present in the region where there is high intensity where the vessels possess maximum entropy

4. CANDIDATE EXTRACTION

Usually the blood vessels and lesions which are dark possess high contrast in the

green channel. The red channel and the blue channel are used in the latter part for the extraction of certain colour features .Especially in the green channel Micro aneurysms and haemorrhages appear as shapes which contain local minimal intensity .Less fortunately this method is very sensitive to noise[6] .To overcome this disadvantage we go for the dynamic transformation technique. In this technique the minimal regions are rated to their appropriate local contrast. The regions which are noisy usually have low contrast and lesions present .The extract and pre-processed image which is denoted as G_p . The main advantage of this method is that the out coming contrast measurement does not depend upon the size and shape of the regional minimum. Contrast and illumination equalization are very important because if these steps are not applied the global contrast and intensity thresholding will be difficult to calculate[7] and the candidates whose distance to the optical disc's centre are smaller than the optical disc radius are removed.

5. DYANIMIC SHAPE FEATURES

In the diabetic retinopathy affected patients several regions correspond to non lesion region such as segments of vessels the flooding level in the topographic representation at each flooding level (i) for each person affected with diabetic retinopathy and catchment basin B_i^{sj} .

- Relative area(Rarea):number of pixels in B_i^{sj} , divided by total number of pixels in the region of interest



- Elongation(Elong): $1-W/L$ where W is the width and L is the length of the bounding box of B^{sj}_i present along the major axis
- Eccentricity(Ecc): $(L^2-W^2)/L^2$ with W and L the width and length of the bounding box B^{sj}_i present along the major axis
- Circularity(Circ): ratio of the area of B^{sj}_i over its squared perimeter and multiplied by 4π
- Rectangularity(Rect): ratio of the area B^{sj}_i over the area of the bounding box along the major axis
- Solidity(Sol): ratio of the area B^{sj}_i over the area of its convex hull.

CLASSIFICATION

To differentiate between lesions and non-lesions we can use a Random forest classifier (RF). This classification is the most powerful technique in the recent years since it has number of advantages this technique can be applied to high dimensional and noisy data. [3] proposed a method in which the minimization is performed in a sequential manner by the fusion move algorithm that uses the QPBO min-cut algorithm. Multi-shape GCs are proven to be more beneficial than single-shape GCs. Hence, the segmentation methods are validated by calculating statistical measures. The false positive (FP) is reduced and sensitivity and specificity improved by multiple MTANN.

EXPERIMENTAL SETUP

To check the performance of the proposed method we use 6 different databases which helps us to evaluate our technique with

respect to image resolution field of view (fov) and image compression technique

Per Lesion Evaluation

To detect the red lesion we need to perform free response receiver operating characteristic (FROC) analysis. This is a process where the per lesion sensitivity and the average number of false positives per image (FPI) are calculated for different threshold probabilities $P(S_j)$. The sensitivity are taken at 7 specific points in a FROC [10]. The points are $1/8, 1/4, 1/2, 1, 2, 4$ and false positives per image. For this technique the lesions need to be divided into segments so that they can act as a reference for this process we make use of 3 independent databases.

1. Retinopathy online challenge (ROCh) Database

This database consists of 2 types of images 50 training images and 50 testing images. In this the annotated images of the training set alone are publically provided. The evaluation of the testing image is done via a challenge website which gives a FROC curve with an associated score. In this database only micro aneurysms are annotated. This method is also important because it is used in the literature and allows comparisons [5]. The RF built images using the ROCh training images and are denoted as RF_{ROCh} .

2. Diaretdb1 Database

This is also a public database which consists of 28 training images and 61 testing images. This database by itself produces segments of both micro



aneurysms and haemorrhages. This RF built images are denoted here as RF_{drb1}

3. Cora 143 Database

This database is a private database which has a collection of 143 images which were collected by telemedicine platform. Based on the client images are obtained using different retinal camera devices with different resolutions. The picture once captured is analysed by 2 human experts this method does lesion annotation. Here 1384 lesions are annotated, the first human expert checks for the presence/absence of diabetic retinopathy. Then the second expert validates with the result produced by previous one

Per Image Evaluation

There must be at least one lesion in the retina to indicate the presence of diabetic retinopathy. If no such lesions are present then the retina is a healthy one. Therefore the people with red lesions have the high probability of having Diabetic retinopathy. This can also be evaluated using 3 different databases

1. Messidor Database

This database contains 1200 fundus images. Grading is done for each image .

2. Erlangen Database

This database possesses 15 images of a healthy retina and 15 images of people affected with glaucoma and 15 images of people affected with diabetic retinopathy.

3. Cara1006 Database

This is a private database and it contains 1006 images of telemedicine screening project.

DSF Parameters

The dynamic shape feature (DSF) parameters are evaluated .The parameters are

- K: order of the inner fit
- I_{stop} : last flooding level

We use,

1st ($y=ax+b$)

2nd ($y=ax^2+bx+c$)

3rd ($y=ax^3+bx^2+cx+d$)

These are linear order regression which help in modeling the shape attributes.

RESULTS

DSF PARAMETERS

In consideration of the order of linear fit there is notable difference between the different regression results. As far as the flooding level I_{stop} is concerned .The regression results of first order $\mu-\sigma_{noise}$ are better than μ .This estimate tells us that $\mu-\sigma_{noise}$ is a better result of the retinal background.

PER LESION EVALUATION

This method make use of 3 different databases the best detection accuracy is provided by RF_{ROch} .The total estimate of scores achieved by this database RF_{Roch} , RF_{drb1} and RF_{cara} are 0.146,0.354,0.217.



PER IMAGE EVALUATION

This helps to classify the images with and without diabetic retinopathy using the lesion classifiers which also helps to classify the images according to the stages of diabetic retinopathy.

Discussion

1. Performance in detecting lesions

This method is ranked 4th based on the ROCh dataset and is highly accurate since both micro aneurysms and haemorrhages have been segmented. In this case the database Diaretdb1 achieves even more better results than the RF.

2. Performance in Detecting images with DR

Lesions are mainly the indicators which tell whether the person has diabetic retinopathy or not. In this the Messidor database achieves even better results and performs well. These Messidor can be classified into referable and non-referable images.

3. Computation time

The total computation time can be calculated only with reference to the image resolution on an average it may take upto 98 seconds to process an image in the range 2000-3000 pixels.

The extension process for detection of red lesions demonstrates its potential to be used in telemedicine DR Screening process (Fig.4).

Classification between lesions and non lesions has to be listed first and based on that the severity can be detected.

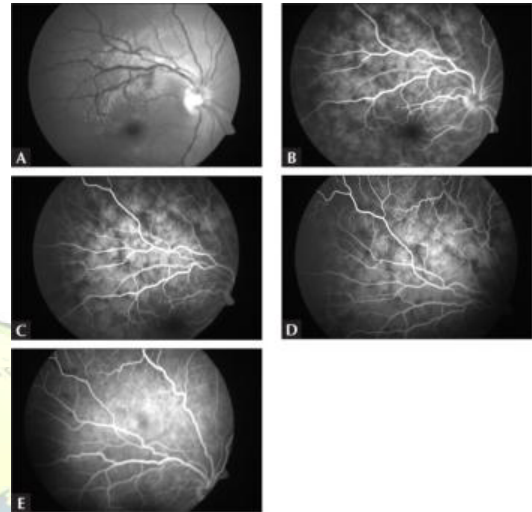


Fig 4: Red Lesions Detection

CONCLUSION

This method has strong performance in detecting both haemorrhages and micro aneurysms in the fundus for different image resolution. The results demonstrate its strong performance. Further the comparison between other techniques will be proposed as a future work.

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