An Efficient Grading Algorithm for Non-Proliferative Diabetic Retinopathy using Region Based Detection

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1. Introduction

The paper proposes an image processing algorithm to grade the severity of Non Proliferative Diabetic Retinopathy. This method is based on the approach of how an ophthalmologist looks at different regions of the fundus image and grades the severity of the disease. The distance of the abnormality from the centre of macula is a measure of the intensity of the damage caused to vision. Medically it has been established that in Non-Proliferative Diabetic Retinopathy (NPDR), damage to macula is a major reason for vision loss and hence regions around macula are of prime concern. The proposed algorithm provides an efficient grading technique by segmenting the fundus image into specific regions of interest and avoids redundancy in computation. Instead of detecting abnormalities for the whole fundus image, the proposed method emphasizes on the segmented regions for the abnormalities, thereby reducing the computation time significantly. Furthermore, this approach provides a simple and direct method to measure the severity of the disease. This region based segmentation also has the advantage of a much lesser computational load making this process suitable for real time applications. The accuracy of this region based segmentation method is more than 80 % when tested in a database.

2. Proposed Algorithm

In the proposed block diagram as shown in Fig 1, various stages have been shown wherein detection of optic disk and macula is followed by three processes padding, cropping and masking. Once the masked images for different regions are obtained, region wise detection of abnormalities is performed to determine the severity of Diabetic Retinopathy (DR).

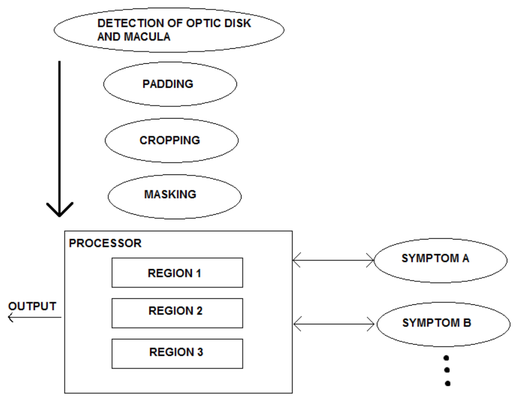

Figure 1: *Block Diagram of the proposed method*

Optic Disk (OD) and Macula are two principle components present in a fundus image of a human eye. OD is characteristically bright, circular and large in size, whereas, macula is dark and relatively a smaller circle, but located in a fixed region with respect to the OD, as shown in Fig 2.

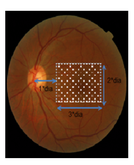

Figure 2: *Search region for Macula*

A window based search has been employed to locate the centre of OD and macula. Using windows as in Fig 3 and Fig 4, the required coordinates are found. On first sliding the window in Fig 3 vertically over the whole image, the row with maxima is found. Then, sliding the window in Fig 4 across all the pixels in that row, the pixel with maxima is the centre of OD.

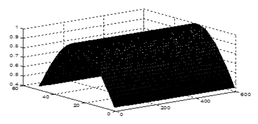

Figure 3: *Window 1*

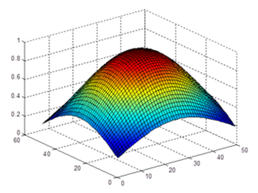

Figure 4: *Window 2*

Using the same concept inside the macula search region defined in Fig 2, the minima instead of maxima, gives the centre of macula. In the next step the fundus image is cropped into three regions. Region 1 is the circular region around the centre of macula with the radius of D/3. Region 2 is the circular region of radius D excluding region 1, from the centre of macula. Region 3 is the circular region of radius 2D excluding regions 1 and 2, around the centre of macula (where D=diameter of optic disk). A pictorial representation of the regions has been given in Fig 5.

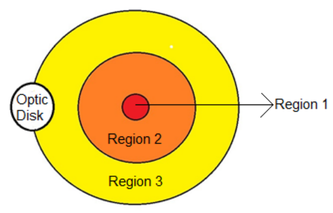

Figure 5: *Region wise segmentation around the macula*

As in the proposed block diagram in Fig.1, classification of images into various stages of DR is based on the presence of various abnormalities in different regions as shown in Fig. 5. In the beginning, Region 1 is selected and detection algorithms are run in this region to detect the presence of exudates and micro-aneurysms. If any of these abnormalities are found in Region 1 then the image is classified as Severe NPDR and no further execution is carried out. But if no abnormality is detected in Region 1 then Region 2 is selected and the process is repeated for the detection of abnormalities. If any of the abnormalities are found in this region then the image is classified as Moderate NPDR and the execution is stopped. The same process is repeated for Region 3 and if the abnormalities are present then the image is classified as Mild NPDR. In the end if abnormalities are not found in any of the regions then the image is classified as a NORMAL image.

3. Results and Discussion

The proposed method has been tested on a set of fundus images graded by the doctors into four categories, severe, moderate, mild and normal. The results, which have been verified by the doctor, have an overall accuracy of 80 % in classifying the fundus image into the predefined categories. The primary source of error is due to uneven illumination and varying quality of fundus images. The accuracy of detection is tabulated in Table 1.

Table 1: *Accuracy of Detection*

Sl. No.	Type of Fundus Image	Identification Accuracy
1	Normal images	70 %
2	Severe NPDR	100 %
3	Moderate NPDR	80 %
4	Mild NPDR	80 %

Table 2: *Comparison of Computation Time*

Stage of DR	Average time with Region-based approach (seconds)	Average time without Region-based approach (seconds)
Severe	15.590681	95.725638
Moderate	16.432230	99.625927
Mild	16.423637	92.288933
Normal	15.966857	103.499852

Table 2 shows the comparison of computation time between the proposed method of region based computation versus execution for the entire fundus image. Huge difference in the computation time can be observed, verifying the potency of the proposed methodology.
Figure 6 shows the results for exudates detected in the region 1 for a given fundus image.

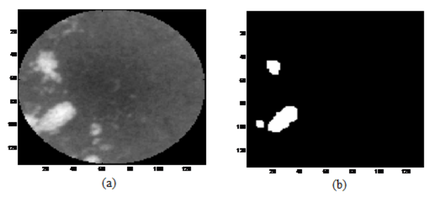

Figure 6: *(a) Region 1 of a Fundus image, (b) Detected exudates*

4. Conclusion

The proposed methodology to determine the severity of the fundus image has two major advantages. First is the simplicity in classification of Diabetic Retinopathy as per severity. The region wise segmentation of the abnormalities in itself is a measure of the severity of the disease. The second advantage is that instead of implementing the algorithm for the whole image, following a region wise implementation of the detection algorithms reduce the computation time significantly. Moreover, unnecessary or redundant computation is not carried out. Therefore, it facilitates the concept of stopping the execution whenever some abnormality is detected. In other words if some abnormality is detected in region 1, then the proposed algorithm would not go for any further computation. So, a normal eye is scrutinized the most and a severely affected eye will be graded the quickest. The proposed algorithm holds good for classifying Non-Proliferative Diabetic Retinopathy.

5. Acknowledgement

This work was supported in part by the Grants from Department of Science and Technology, No. DST/TSG/ICT/2013/37, Government of India and by SIX CZ.1.05/2.1.00/03.0072, OPVK EE.2.3.20.0094, MPO FR-TI4/151, and VUT BD18116001, Czech Republic.