Segmentation and Enhancement of Retinal Images using Morphological Operations

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ABSTRACT
Different types of techniques are used to detect and segment the retinal diseases. Each technique gives a level of accuracy. Morphological methods have been extensively used in handling medical images. The goal of morphological operations is to remove imperfections by considering the structure of the image. This paper proposes an automated method to detect, (1) lesions in Diabetic retinopathy (2) pigment epithelial detachment in Wet age- related- macular-degeneration (3) soft drusen in Dry age- related- macular-degeneration and (4) haemorrhages in Central retinal vein and artery occlusion. A three-stage approach is developed to detect and enhance these retinal images. After pre-processing stage involving enhancement, otsu's method is applied to segment lesions, drusens and other affected parts. The third stage is to detect the concentrated and scattered patches using morphological operations.

1. INTRODUCTION
The medical imaging community is now able to probe into the structure, function, pathology of the human body with a diversity of imaging systems. To assist visual interpretation of medical images, the international imaging community has developed numerous automated techniques for processing and analyzing medical images after they have been generated or digitized. This paper proposes an automated method to analyse the retinal data sets. The sample retinal data sets are showed in Figure1.

There is a greater need for treatment of retinal diseases. The availability of this treatment is improving but still it is not cost effective for certain segments of the population. In spite of the advances in technology, equipment to detect retinal diseases is still expensive. Thus the main contribution of this work is the development of "an automated method to detect the retinal diseases". This will help for the screening purpose. After collecting sets of different types of retinal images, suitable image processing techniques were used to identify diseased parts.

The above procedure was applied to 50 fundus images [5]. Each retinal image was segmented using Otsu's method. As optic disk and some affected parts are of same luminance, Otsu's method segments the optic disk region also. To overcome this disadvantage, image smoothing was done.

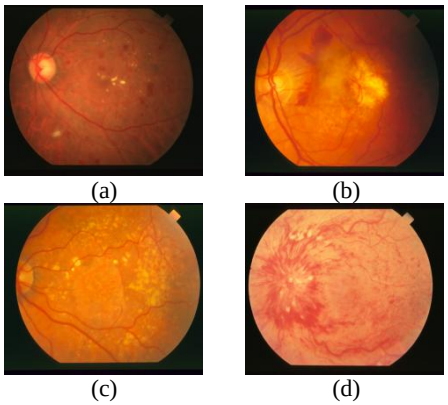


Figure 1. Example Retinal Images. (a) Lesions in Diabetic retinopathy (b) pigment epithelial detachment in Wet age-related- macular-degeneration (c) soft drusen in Dry age-related- macular- degeneration and (d) haemorrhages in Central retinal vein occlusion.

The method then uses morphological operations to find the major and minor affected parts. This paper is organized as follows. In section 2, treating materials are shown, and the algorithm outline is presented. In section 3, proposed system is explained, where subsection 3.1, 3.2, 3.3: describes the pre-processing, segmentation, morphological operations. In section 4, the results on the fundus images are presented, and the quality of the proposed method is analyzed. Conclusion and future work is made in section 5. In section 6 the vital persons are acknowledged. Finally, section 7, shows the references.

2. MATERIALS AND THE ALGORITHM OUTLINE
The retinal images were collected from different medical databases. The retinal images were collected from STARE database. The STARE database has retrieved the images from Shiley Eye Centre at the University of California, San Diego, and by the Veterans Administration Medical Center in San Diego. A digital retinal scan reveals both eye health issues and general health issues that relate to retinal changes. It uses optical technology which produces 30 to 45 degree photograph of retina, optic nerve and blood vessels. The scan was done by casting an unperceived beam of low energy infrared light into a person's eye as they look through the scanner's eyepiece. A digital retinal scan also provides an early warning of issues and abnormalities that may indicate poor eye health or early stages of eye diseases.

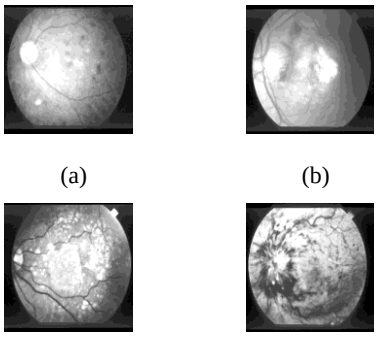
The method works as follows. The goal of first stage was to remove the background noises and to increase the contrast of

the image by histogram equalization. In the second stage, the Otsu's segmentation on the gray level image was done. Then, the over segmentation was removed by image smoothing. In the third stage, concentrated and scattered patches were detected using morphological operations.

3. PROPOSED SYSTEM

3.1 Pre-processing Stage Involving Enhancement

Initially the color fundus images were converted to gray images. Different color filters were used Red, Green and Blue to locate the lesions and haemorrhages in the image. Then on these, median filter was applied, in order to remove the noises. The median filter returns the median value of the pixels in a neighbourhood. Hence it is non-linear. It is similar to a uniform blurring filter which returns the mean value of the pixels in a neighbourhood of a pixel. Unlike a mean value filter the median tends to preserve step edges. Thus the median filter reduces the noises in the image and produced an enhanced image. Finally, histogram equalization [7] is used for local contrast enhancement. Figure2 shows the enhanced images of figure 1.The colors of fundus images will differ widely.



(a) (b)

(c) (d)

Figure 2. Enhanced Images of Figure 1

Histogram specification was applied to normalize different colors of fundus images. Histogram of a digital image with gray values r_0, r_1 ... r_{L-1} is the discrete function,

$$P(r_k)=n_k/n \qquad (1)$$

Where,

P (r_k) is the fraction of the total number of pixels with gray value r_k.

n_k is the number of pixels with gray value r_k

n is the total number of pixels in the image

Histogram provides a global description of the appearance of the image

3.2 Otsu's Segmentation

The extraction of diseased part is done with the help of segmentation algorithms. Selection of suitable segmentation algorithms is essential, so that exudates, drusens and other retinal lesions can have clear distinct characteristics from other objects and background. The following are the algorithms used.

3.2.1 Otsu's Method

This method automatically performs clustering-based image segmentation [6]. The gray level image is reduced to binary image. The algorithm assumes that the image to be threshold contains two classes of pixels or bi-modal histogram. It then calculates the optimum threshold by separating those two classes so that their combined spread is minimal. Thus with the separability measure and threshold the exudates, drusens and other types of lesions are successfully segmented. Figure4. shows the Otsu's segmentation and smoothing results.

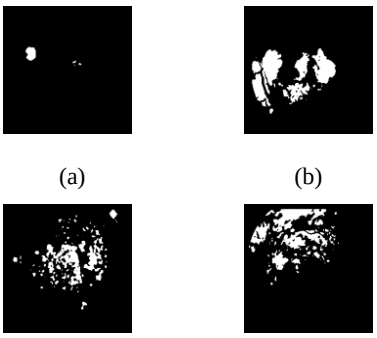
3.2.2 Image Smoothing

As optic disk and exudates are of same luminance, the otsu's method will segment optic disk space along with the exudates. Hence in order to overcome this problem, the segmented image is smoothed. Thus, in order to reduce noise, smoothing is done. It uses non-linear filter (median filter).

Image smoothing is used in two ways,

a) By being able to extract more information from the data as long as the assumption of smoothing is reasonable.
b) By being able to provide analysis that is both flexible and robust.

Thus image smoothing successfully smoothens the optic disk region and gives the exact result of affected region.



(a) (b)

(c) (d)

Figure 3. Otsu's results of Figure 2.

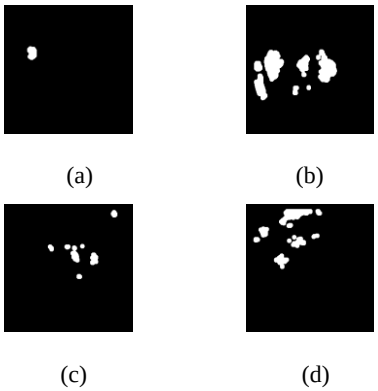
3.2 Morphological Operations

3.2.1 Morphological Open

The morphological opening of A by B, denoted as A· B. It is defined as the erosion of A by B, followed by a dilation of the result B.

$$A\cdot B = (A \ominus B) \oplus B \qquad (2)$$

Morphological opening removes completely regions of an abject that cannot contain the structuring element; smoothes object contours, breaks thin connections and removes thin protrusions. Thus in this work, with this morphological open, the concentrated portions of retina are detected, by giving the structuring element. Figure 4 shows the morphological open results.



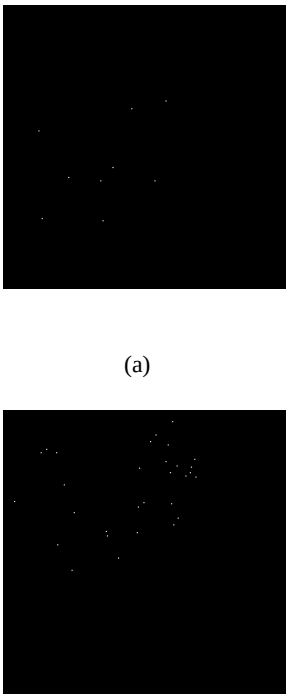
(a) (b)

(c) (d)

Figure 4. Major Affected Parts of Figure 1

3.2.2 Hit or Miss Transformation

This is one of the morphological operations. It is useful to be able to match specified configurations of pixels in an image, such as isolated foreground pixels or pixels that are endpoints of line segments. Thus this operation is very helpful in this proposed work, which helps to detect scattered areas of retina.



(a)

(b)

Figure 5. Minor Affected Parts of (a) Wet-age-related macular degeneration, (b) Central retinal vein occlusion

The hit-or-miss transformation of A by B is denoted as AϴB, where B is a structuring element pair, $B = (B_1,B_2)$, rather than single element. The hit-or-miss transformation is defined in terms of these two structuring elements as,

$$A \circledcirc B = (A \ominus B_1) \cap (A^c \ominus B_2) \qquad (3)$$

4. EXPERIMENTAL RESULTS

Proposed a step towards, a standardized method for detecting findings of diabetic retinopathy [16], wet and dry-age-related macular degeneration, central retinal vein and artery occlusion. Fifty retinal data sets were used. Out of that 40 correspond to abnormal case and remaining normal. The thresholding employed in the method to distinguish normal and abnormal images was chosen in such a way that the possibility of an abnormal image being identified as normal was practically zero; whereas the converse, that is a normal image being detected as abnormal was permitted with few probability. Table 1. illustrates the accuracy results and Figure 6. shows the results graphically.

Table 1. Sample Dataset Accuracy Results

S.No	Retinal Datasets	Concentrated Patches Accuracy	Scattered Patches Accuracy
1	Diabetic Retinopathy	98%	75%
2	Wet-age-related macular degeneration	95.4%	80%
3	Dry-age-related macular degeneration	96%	88.6%
4	Central Retinal Vein Occlusion	94.3%	82.2%

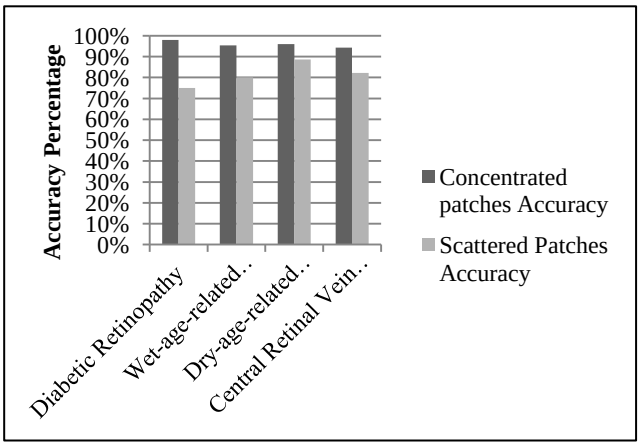


Figure 6. Graphical Accuracy Results

5. CONCLUSION & FUTURE WORK

This paper presented an application of morphological operations to retinal datasets. The proposed method was applied to 10 retinal datasets in order to quantitatively evaluate the accuracy. The average classification accuracy is 90%. Then, the method was applied to another 40 data sets in order to qualitatively evaluate the quality of the whole procedure. The evaluation by a physician was done to check

the quality of the method. The evaluations showed that the method successfully segmented the diseases parts and finds the concentrated and scattered patches of the affected area using morphological operators.

This paper has proposed a method which could be used both as a screening device and also as a diagnostic tool. The actual implementation of this in a clinical/hospital environment will call for several graphical user interfaces to be developed as well as rigorous beta testing.

6. ACKNOWLEDGEMENTS

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