A Novel Method for Automatic Optic Disc Elimination from Retinal Fundus Image

Hetal K[1]
[1]Department of Biomedical Engineering
[1]Government Engineering College, Gandhinagar

Abstract— Diabetic retinopathy has turned out to be one of the most common causes of vision loss in diabetic patients. Hence, it becomes inevitable for diagnosing it at an early stage. Various visual features like exudates, cotton wool spots, microanuerysms and hemorrhages are responsible for detecting diabetic retinopathy from retinal fundus image. Exudates are basically bright yellow lesions. Optic disc is normal feature of any retinal fundus image which is also highly illuminated region in the fundus image. So, when exudate detection is carried out, optic disc is also detected which gives incorrect output which implies the necessity of optic disc elimination at the preliminary stage of processing. The paper proposes and investigates a novel method for optic disc elimination which involves thresholding and morphological processing on the red channel of the image. The sensitivity of the methodology is found to be 75.02% for 'diaretdb' database and 80.95% for images from 'Bankers Retina Clinic & Laser Centre, Ahmedabad'.

Key words: diabetic patients, diabetic retinopathy, diagnosis, diaretdb, optic disc elimination, red channel, yellow lesions, retinal fundus image

I. Introduction

The growing incidences of diabetes, lack of specialists and high cost of examinations increases the work of ophthalmologists in diagnosing diabetic retinopathy and prevents patients from receiving effective treatment on time [1]. Automatic detection of Diabetic Retinopathy can help ophthalmologists diagnose the disease at an early stage with subsequent time and cost savings. Diabetic Retinopathy is the medical condition where the retina is damaged because of the fluid leaks from the blood vessels into the retina. The main function of the blood vessels is to nourish the retina; and when these blood vessels are damaged because of the uncontrolled glucose levels, the capillaries leak blood and other fluid that damages the retina. These leaks on the retina if prevails on it for a longer time, it can even cause severe impairments. Various visual features like exudates, cotton wool spots, microanuerysms and hemorrhages are responsible for detecting diabetic retinopathy from retinal fundus image. It has been found that during first 20 years of diabetes, all patients with type-I diabetes develop DR; whereas >60% patients with type-II diabetes have DR [2].

Optic disc is an elliptically shaped object in the eye which is approximately 1.5 mm in diameter. This means it is approximately one tenth of the image [3]. Optic disc is the portion of the eye where central retinal artery and vein are encased and enters the eye through optic disc [8].

II. Literature review

Various algorithms have been developed for detection and elimination of optic disc from the retinal fundus image. Some of them are developed using template matching approach, fuzzy c-means, k-means clustering, morphological operations and many more. In [5], optic disc were segmented using pyramidal decomposition and Hausdorff-based template matching. Firstly, potential regions for optic disc were determined by multi-resolution processing through pyramidal decomposition. Later, for each candidate region, canny edge detection, thresholding were calculated and Hausdorff distance was matched. Thereafter, compute confidence level was calculated for each candidate region. At final stage, the most likely position and radii for optic disc were determined with the one having highest confidence value.

Another morphological approach was mentioned in [3], where the RGB (Red, Green, Blue) image is converted into HIS (Hue, Saturation, Intensity) image. Further processing steps include median filtering, contrast limited adaptive histogram equalization (CLAHE), thresholding, morphological operations and finally binarization of the image. In region based segmentation, the segmentation is carried out by considering a pixel and its neighbors of similar gray levels as an individual region. Recently, region growing algorithm [6] was developed in which the optic disc is segmented by determining and seed point. Once this seed point was determined, the iterations were made to check the gray level of the neighborhood pixels. All these methods are complex, time consuming and have fair chances of giving false positives too.

III. Proposed methodology

A. *Image Acquisition:*

The image database used here is 'diaretdb' that has 89 images in .png (Portable Network Graphics) format. A set of 42 images was also collected from 'Bankers Retina Clinic & Laser Centre, Ahmedabad' in .jpg (Joint Photographic Expert group-JPEG) format. All images were taken from a retinal fundus image and were obtained in RGB form.

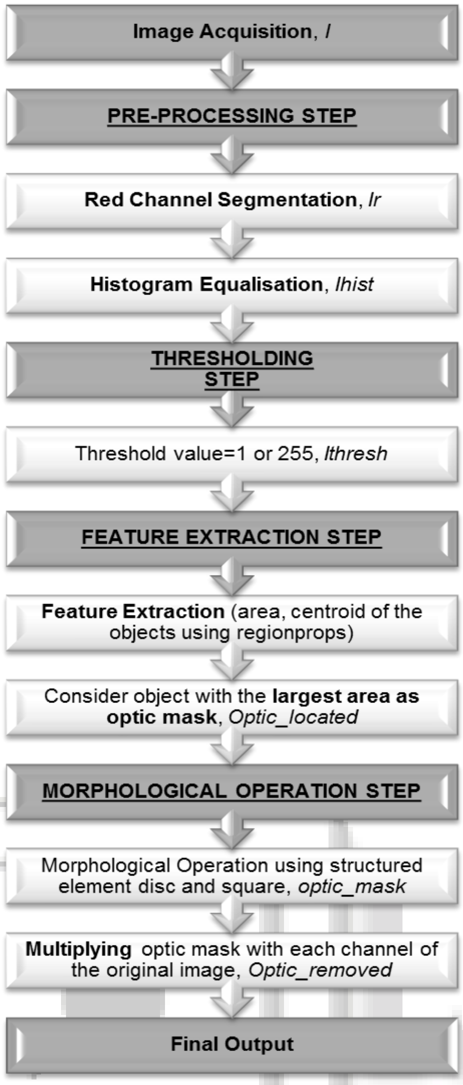

Fig. 1: Flow of Proposed Methodology for Optic Disc Elimination

Fig. 2: RGB Image [9]

B. Pre-Processing Step:

RGB image is composed of three color channels that are red channel, green channel and blue channel [7]. When looked at all the images into detail, it seemed that green channel has the maximum information that can be retrieved from it. For segmentation of only optic disc, red channel of the image is considered so that there are have fewer features to deal with.

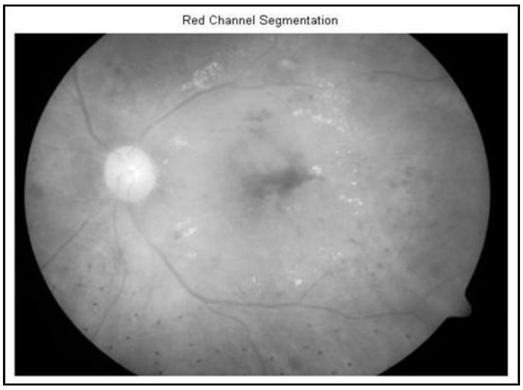

Fig. 3: Red Channel of the Image

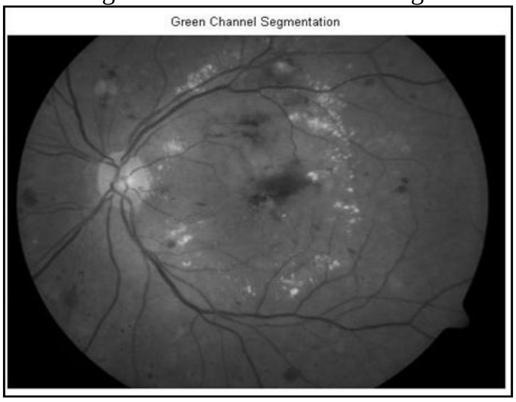

Fig. 4: Green Channel of the image

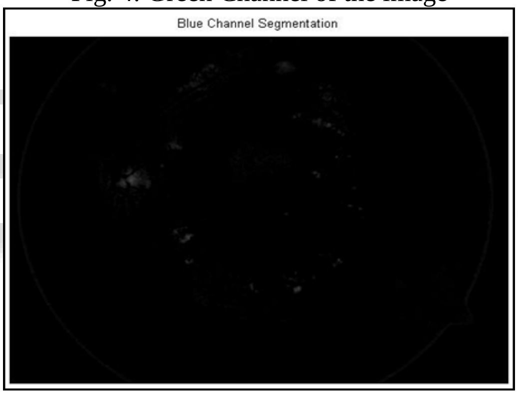

Fig. 5: Blue Channel of the Image

Histograms are visual representation of occurrence of particular gray level in the image. Histogram equalization is the process in which the gray levels of the uniformly over the entire range of 0 to 255. This is called histogram equalization [7]. After the red channel of the RGB image has been extracted, histogram equalization is done on the image.

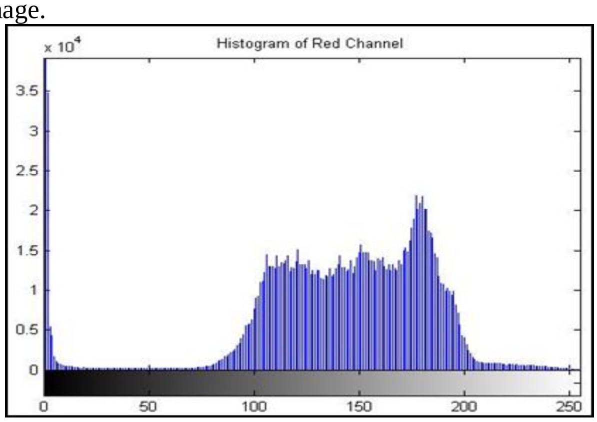

Fig. 6: Histogram of Red Channel

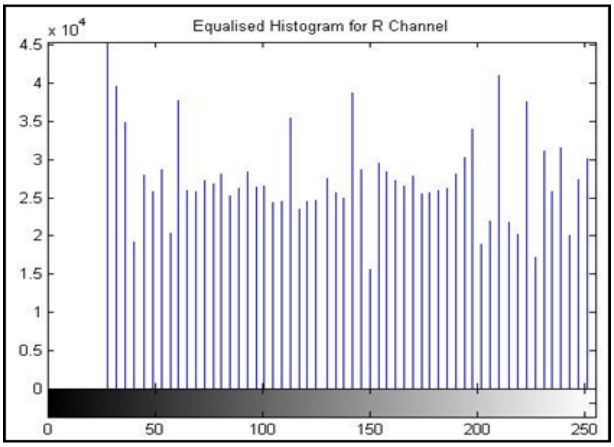

Fig. 7: Histogram of histogram equalized image of red channel

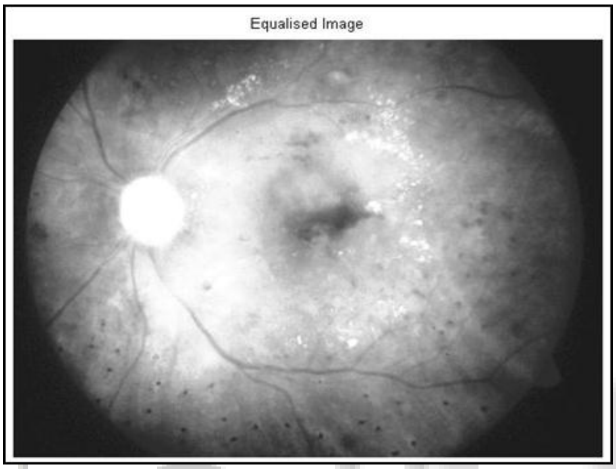

Fig. 8: Image obtained after histogram equalization

C. Thresholding Step:

As seen in figure 7, after performing histogram equalization on the image; optic disc, the brightest is also seen bright after processing. Observing the value, it was found approximately equal to the intensity as that of white which is 1 or 255. This value would be used as threshold value. Figure 8 is obtained when the threshold value is set to 255.

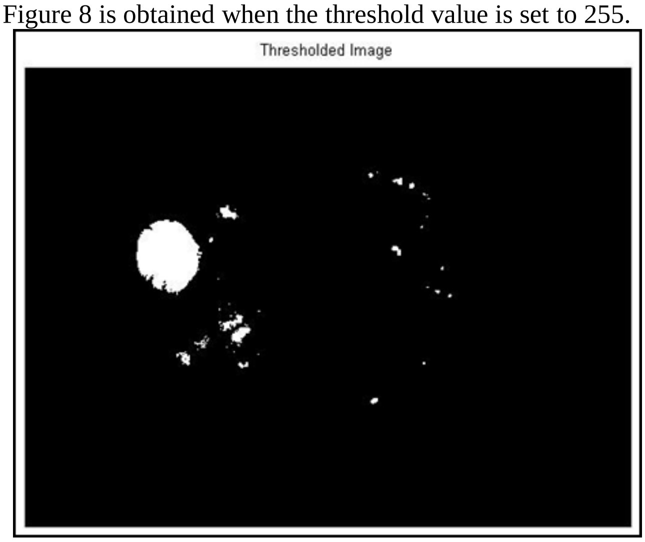

Fig. 9: Thresholded Image; threshold value=255

D. Feature Extraction Step:

In feature extraction step, statistical features of the regions in the logical image as shown in figure 8 are determined. For this purpose, 'regionprops' function in MATLAB is used and features like area, centroid and boundingBox of the image are found. The result obtained would be a structure and have a series of values for each of the properties. Each element in the structure would point to a single region and would hold values for area, centroid and boundingBox. From figure 8, it can be inferred that optic disc has the largest area. On the basis of this approach, the region with the largest area is extracted and all the other regions are been removed.

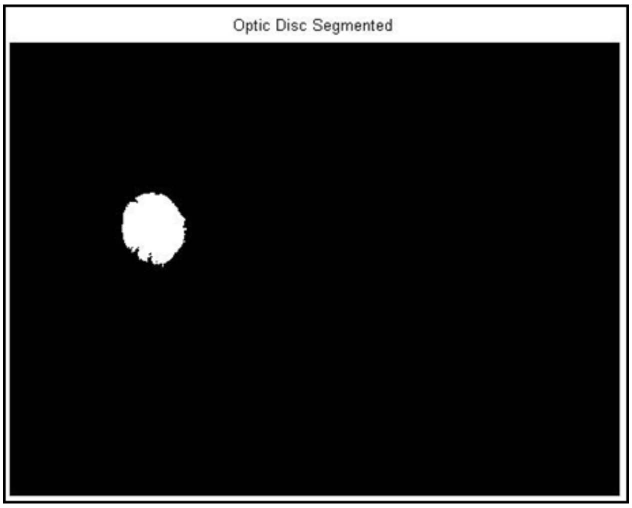

Fig. 10: Optic Disc Segmented

E. Morphological Operation Step:

The major morphological operations that are used are dilation and erosion. Dilation is the smoothening of the edges or it can also be said thickening of the edges; whereas erosion is thinning of the edges. Opening and closing are other two important morphological operators. Opening is dilation followed by erosion and closing is erosion followed by dilation. For applying morphological operators, structured elements are formed. Here, for dilating the edges of the optic, 'disk' and 'square' structured elements of size thirty are used. The image is then complemented as to remove the optic disc from the original image, that region has to be zero. The optic mask is then multiplied with each channel of the image and the result obtained has the optic disc removed from the image.

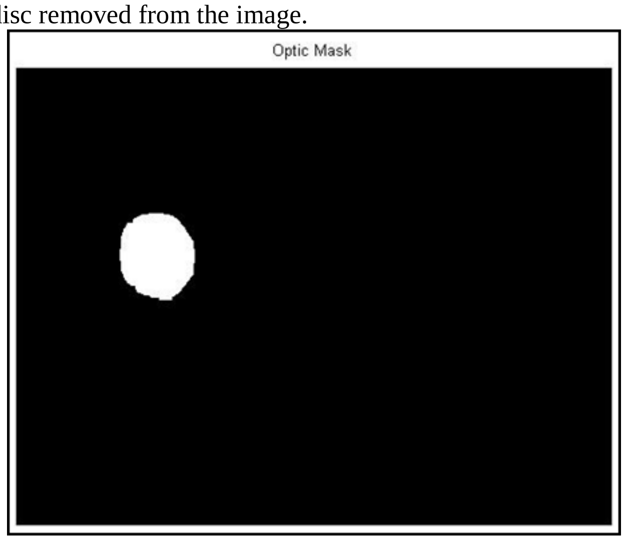

Fig. 11: Morphological Operators applied

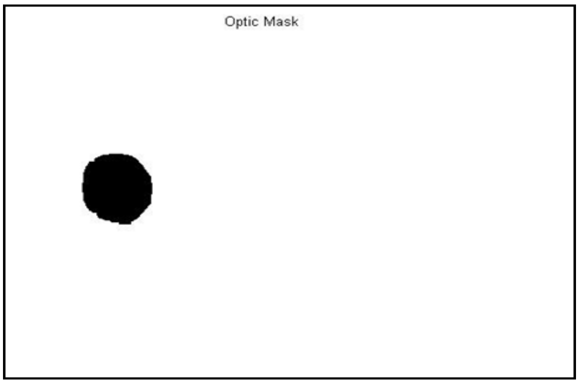

Fig. 12: Complement of the Image, Optic Mask Formed

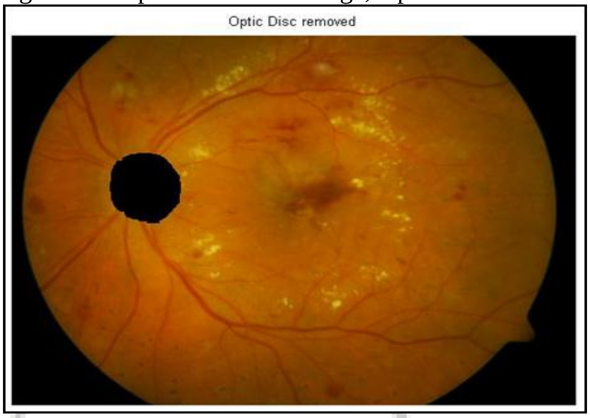

Fig. 13: Optic Disc is removed from the image

IV. RESULTS & DISCUSSION

Fig. 14: Algorithm applied on 'image015.png' from 'diaretdb' database

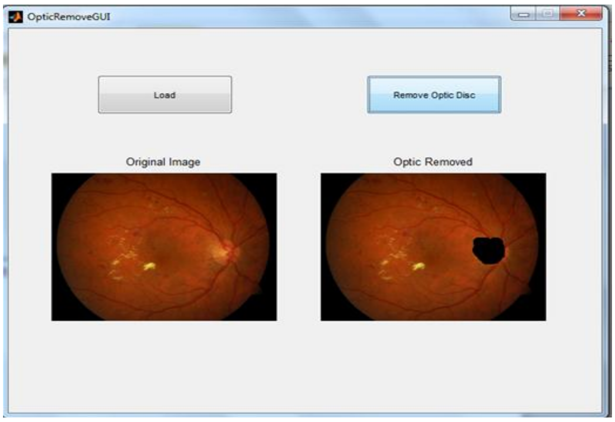

Fig. 15: Algorithm applied on 'image014.png' from 'diaretdb' database

Figure 14, 15 and 16 shows the output of three different images taken from databases. Figure 14 and 15 are outputs of image015.png and image014.png respectively; whereas figure 16 is output for an image taken from 'Bankers Retina Clinic & Laser Centre, Ahmedabad'.

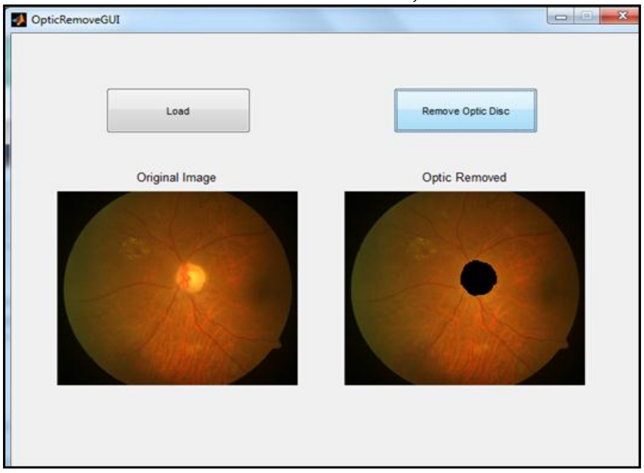

Fig. 16: Algorithm applied on an image obtained from 'Bankers Retina Clinic & Laser Centre, Ahmedabad

To discuss regarding the sensitivity of the algorithm, it was applied on all the images of both the fundus databases. It is found that the algorithm holds true for 67 out of 89 images from 'diaretdb' database and 34 out of 42 retinal images obtained from 'Bankers Retina & Laser Clinic'.

$$Sensitivity = \frac{TP}{Total} \times 100\ (\%)$$

Where TP=True Positives

Database Name	Sensitivity
diaretdb	75.02%
Images from 'Banker's Retina & Laser Clinic, Ahmedabad'	80.95%

Table 1: Sensitivity values for two different databases

While performing this algorithm, it was noted that the time elapsed for removing optic disc from a single image can range from 3 seconds to 25 seconds depending on the size and resolution of the image. time elapsed for images from 'diaretdb' was found to be approximately 19 seconds; whereas for images obtained from 'Bankers Retina Clinic & Laser Centre, Ahmedabad', the processing time was approximately 20 seconds. Another advantage of this algorithm is that it does not really need an explicit thresholding algorithm. This leads to the conclusion that the algorithm is quite efficient and time saving to perform without needing too much of coding or actually converting RGB image to any other form.

V. CONCLUSION

Automatic optic disc segmentation from the fundus image might not seem so important; but it turns out that it is crucial when exudate detection is being carried out because of the fact that both exudates and optic disc seem to have high intensity values. In this paper, the proposed method is applied on the red channel of the image unlike other methods that require either conversion of RGB image into HSI image, complex to implement or time consuming. The proposed algorithm might fail to implement on non-uniformly illuminated and improperly acquired image; however, it still gives fairly good output for further analysis.

The main advantage of this system is the ease of implementation irrespective of the system performance and gives output within 20 seconds for most of the images. This application can be used where there are rare ophthalmologists and system performance is poor.

VI. ACKNOWLEDGMENT

The author shows deepest gratitude to guide, Prof. Bhavin Mehta, Assistant Professor, Biomedical Department, Government Engineering College, Gandhinagar for his constant support, encouragement and co-operation throughout the progress of the work. The author also acknowledges Dr. Dhaval Modi, Ophthalmologist at 'Modi Eye Care' for his constant guidance related to the field of Ophthalmology. The author would also like to thank Dr. Alay Banker of 'Bankers Retina Clinic & Laser Centre, Ahmedabad' for providing good quality retinal fundus image for forming a dataset of non-standard database.

REFERENCES

[1] Maria Garcia, Roberto Hornero, Clara I. Sánches, Maria I. López and Ana Diez, " Feature Extraction and Selection for the Automatic Detetcion of Hard Exudtaes in Retinal Images", 29th International Conference of IEEE EMBS, 1-4244-0788-5/07, August 23-26, 2007.
[2] Watkins, J. P., "ABC of diabetes retinopathy", British Medical Journal, 326:924–926, 2003.
[3] Oakar Phyo, AungSoe Khaing, "Automatic Detection of Optic Disc and Blood Vessels from Retinal Images using Image Processing Techniques", IJRET, eISSN: 2319-1163 ,Volume 03 Issue 03, March 2014.
[4] Giri Baby Kande, P. Venkata Subbaiah, T. Satya Savithri, "Segmentation of Exudates and Optic Disc in Retinal Images", Sixth Indian Conference on Computer Vision, Graphics & Image Processing, IEEE, 978-0-7695-3476-3/08, 2008.
[5] M. Lalonde, M. Beaulieu and Langis Gagnon, "Fast and robust optic disk detection using pyramidal decomposition and Hausorff-based template matching", IEEE Transactions on Medical Imaging, Volume 20 Issue 11,pp. 1193-1200, November 2001.
[6] Lydia Glory Priyadarshini M., J. Anitha, "A Region Growing Method of Optic Disc Segmentation in Retinal Images", 2014 International Conference on Electronics and Communication Systems (ICECS-2014), February 13-14, 2014.
[7] Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing, 2nd Edition
[8] Anne Waugh and Allison Grant, "Anatomy and Physiology in Health and Illness", Ross and Wilson, Ninth Edition.
[9] diaretdb – Standard retinal image database for diabetic retinopathy http://www.it.lut.fi/project/imageret/diaretdb1/

