A Novel Approach for Optic Disc Detection in RGB Retinal Fundus Images

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Abstract: ***Medical imaging of blood vessels helps assistant ophthalmologists see the interior parts easily, diagnose, treat diseases, and detect abnormalities, such as diabetic retinopathy, hypertension, macular and fovea, glaucoma etc. The early detection of these diseases is a main issue in today's' challenges. This is because it prevents the patient's status from being severe. In this paper, the method used helps perform morphological operators to segment the blood vessels, and detect the Optic Disc localization in RGB retinal fundus images based on blood vessels center and the largest intensity region using a circular mask approach. Input images are obtained from MISSIDOR dataset, and we have obtained a high accuracy results.***

Keywords: diabetic retinopathy, optic disc detection, image processing, blood vessel extraction, optic disc segmentation, fundus retinal images

1. Introduction

The optic disc is the most obvious part of the optic nerve head inside the retina. It is further brighter than the encompassing territory with a circular form. Variety in pigmentation inside typical eyes causes contrasts in the appearance of the disc. Numerous vessels crossing the optic disc can be commonly found in fundus images. Restriction of the optic disc is frequently important to separate the disc from different elements of the retina, like: exudates, cotton wool spots and as an essential historic point[1].Segmentation of vessels is an important step in the detection and recognition of many diseases. For instance, accurate vessel segmentation spatially plays a critical rolein the classification of diabetic retinopathy abnormalities. There are various troubles associated with it, such as: the presence of bleeding, hard and soft exudates extraction-created problems. Segmentation subdivides a retinal image into regions or objects. The goal of segmentation is to simplify the representation of an image and make it more meaningful and easier to analyze. Retinal image segmentation is typically used to locate blood vessels, optic disc, hemorrhages, exudates and cotton wool spots[2].The structural elements of the normal features of the retinal image are shown in Figure 1.

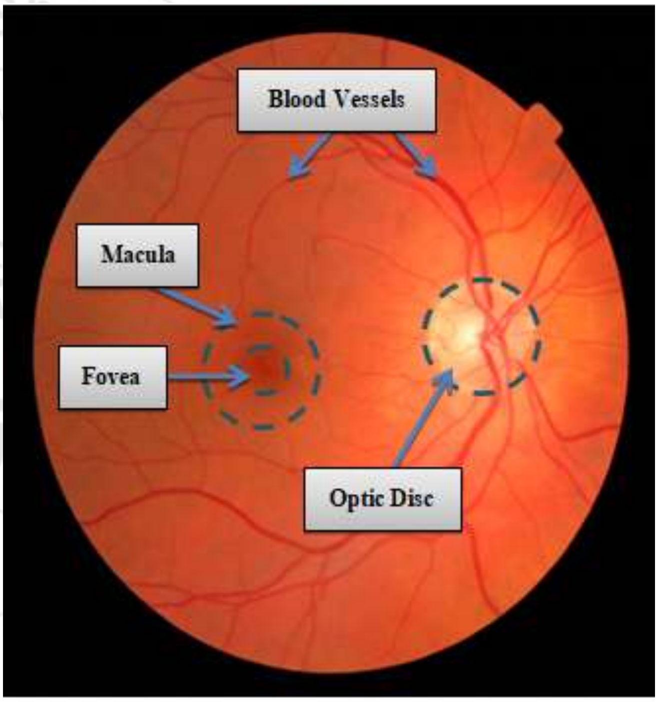


Figure 1

Blood vessels segmentation is essential since these vessels contain numerous valuable data about the patient's well-being. Precise segmentation of retinal veins is frequently a fundamental step in the recognizable proof of the retinal life circle and pathology. The retinal vasculature is made out of arterioles and veins; and the focal retinal conduit bifurcates at or on the optic disc into divisions that supply the four quadrants of the internal retinal layers. The vessels have a lower reflectance contrasted with other retinal layers. That is why; they seem darker in comparison to the background[1]. In case of blood vessels tracking algorithms, the location of optic disc becomes the starting point of vessel tracking. Detection and segmentation of optic disc is a vital step for an accurate exudate screening. The characteristics of optic disc are similar to that of hard exudates in terms of color and level of brightness. The optic disc is characterized by the largest area among circular shape areas. It is noticed to be in an oval shape with an average diameter reaching 1.5 to 1.7. Therefore it is located and removed during the hard exudates detection process, thereby avoiding false positive degree. In color fundus retinal image, the optic disc appears as a bright area of a broadside or elliptical shape, interrupted by the outgoing vessel. It can be seen how vessels emerge into the retina through the optic disc. The localization of the optic disc is important for two purposes: first, it serves as the service line for finding the exact boundary of the disc, and secondly, optic disc center and diameter are used to locate the macula in the image[3][4].The segmented fundus image is converted into a binary image, and then the high intensity pixel is converted into white and the other region into black. Color histogram equalization technique is independently applied for each extracted regions and a morphological operation is used to remove it from the image using the generated logical image. Optic disc and blood vessels are subtracted from the background of an image. This step is commonly used in the processing of fundus retinal images. It helps remove the irrelevant details and maintain only the pixels of interest. The enhanced retinal image is converted to a binary image by applying a proper threshold value[4].

For recognizing the red lesions, generally, the green channel of RGB fundus images is utilized as it reflects the best difference between the background and red lesions. These lesions appear brighter and have a more extensive scope in a red channel. Accordingly, it is used in the recognition of brightness or yellowish lesions, such as that of the optic disc and hard exudates. However, this channel has less difference between the foreground and background of red lesions detection. Consequently, to obtain high results and strong data, both the green and red channels of a similar fundus image are utilized for recognizing the red injuries [5].The objective of preprocessing is to attenuate the noise, improve the contrast and to correct the non-uniform illumination. Hence, putting medical images in a gray level is used for further processing. Such a conversion is a common scale level that is used in images. Since all features, like blood vessels and other lesions are not clearly visible, a contrast adjustment is performed to improve the image quality. Normalization step is performed by subtracting an approximate background from the gray image[6][7].Median filtering is a nonlinear filter, which can reduce the impulsive straining in an image and without too much distortion. It is an effective method in noise isolation since it produces no blurring sharp edges. Median filtering operation replaces image pixels with the neighborhood of small sliding window, and completes the image. It is characterized as being very robust and leads efficient results.[8]Adaptive Histogram Equalization is applied for contrast enhancement and in the process of transforming the intensity values of an image. A case in point is the histogram of the output image that matches approximately the specified histogram [6] [9]. Non-adaptive histogram equalization method increases the global line of the image as the adaptive histogram equalization is capable of improving the image’s local contrast[9].For such images, a local contrast enhancement method is applied as a second preprocessing step. Finally, it is required to create a fundus mask for each image to facilitate the segmentation of wound and the anatomical structures in later phase[10].The last phase is the simplest organization used for effectively partitioning the foreground from the background [11]. A correct threshold value induces more noise whereas the higher threshold value causes loss of some information [6].The proposed approach uses mathematical filters, edge detection operators and morphological operations to obtain the retinal blood vessels segmentation and optic disc detection.

2. Related Works

Neera Singh, Ramesh Chandra Tripathi in [12]proposed a method for automated optic disc detection by Hausdorff’s Distances method. Genetic algorithm-based location of the optic disc was used. To form only one region, the nearby pixels are grouped into regions, and then these regions are assembled. The centroid of the largest region is considered the optic disc center; genetic algorithm is generated by an initial population and its fitness is calculated. Optic disc boundaries are optimized using geometric active contours technique. J.Ramya and others in [13]proposed an approach uses the circular Hough transform method to detect the optic based on a circular shape. Such a technique takes two parameters x,y as a center of the circle and another variable, r, as the radius of the circle. A. Biran in[14]proposed a method to detect the optic disc using CHT by finding a high and large intensity region in the retinal fundus images. S. Letishia Mary and others in [15] produced the BBB method (Blood Vessel removal, Bright region removal, Brighter region removal). The proposed approach focuses on segmenting OD Cup formed from cues such as Gradient method, Connected component and Adaptive Threshold value.

3. Proposed Optic Disc Detection Approach

A. Blood Vessels Extraction

Mathematical morphological operations on image are utilized to decide and distinguish the blood vessels from the RGB fundus retinal images. The blood vessels are mostly unmistakable in the green channel. The following algorithm steps are required to identifying the location of blood vessels as shown below in Table1.

Table 1: Vessel Segmentation Algorithm

Input:	RGB retinal fundus image (*I*)
Output:	Blood vessels extracted image (I_v)
Step 1	Inversion of gray image (I_g) to ($-I_g$)
Step 2	CLAHE applied on inverted image (I_{ahe})
Step 3	Morphological opening operation with ball shaped structuring element (8, 8)
Step 4	2D Median filter and subtracting morphological image from (I_{ahe})
Step 5	Image adjustment and thresholding to obtained a binarization image
Step 6	Morphological operation with disk (15)
Step 7	Plot image boundaries from **Step 6** on the original image (*I*) and blood vessel extraction (I_v)

The green channel form RGB image is used and inverted then a ball structure element of span 8 is made with a morphological opening operation. Next, the previous stage image is subtracted with the first image to remove the background. Adaptive histogram equalization (CLAHE) is performed to enhance the differentiation of an image. From the subtracted image, the new image is converted from a gray scale to a binary stage by performing a threshold value. Structure element with a disk shape of span 15 is made, and then the pixel estimations of the image are modified to get just the veins with a dark background in zeros pixels. Figure2 shows blood vessels extraction.

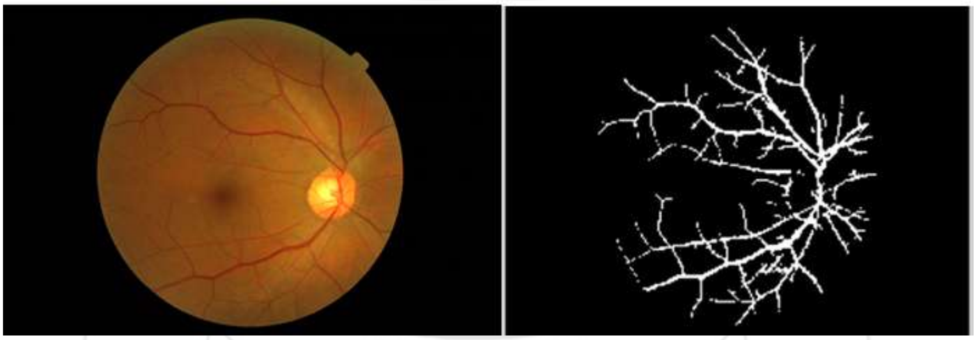


Figure 2: (a) Original image. (b)Blood vessels extraction

B. Optic Disc Segmentation

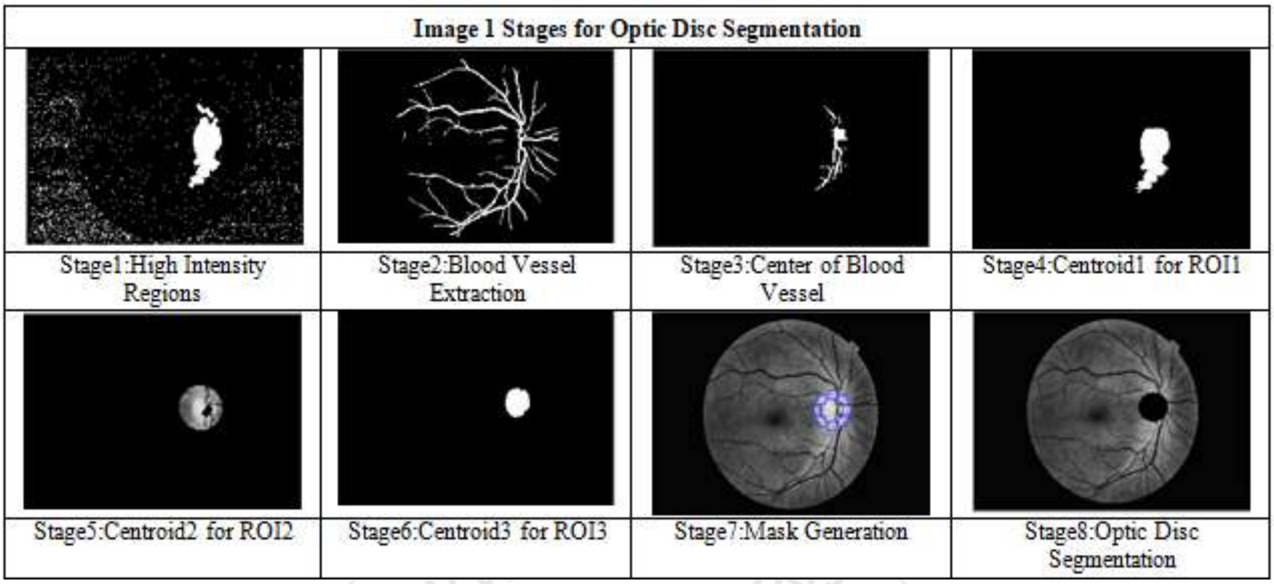
Optic disc is the brightest retinal structure; this component makes the recognition less demanding and puts the brightest lesions in misclassification recognition. In any case, certain injuries, for example, hard exudates additionally have an appearance similar to the optic disc. Therefore, these abnormalities have lesser range in contrast with the optic disc. Accordingly, the optic disc is mostly obvious in the green channel of the image that contains blood vessels and that is in a circular shape. The algorithm steps to optic disc detection are shown below in Table 2.

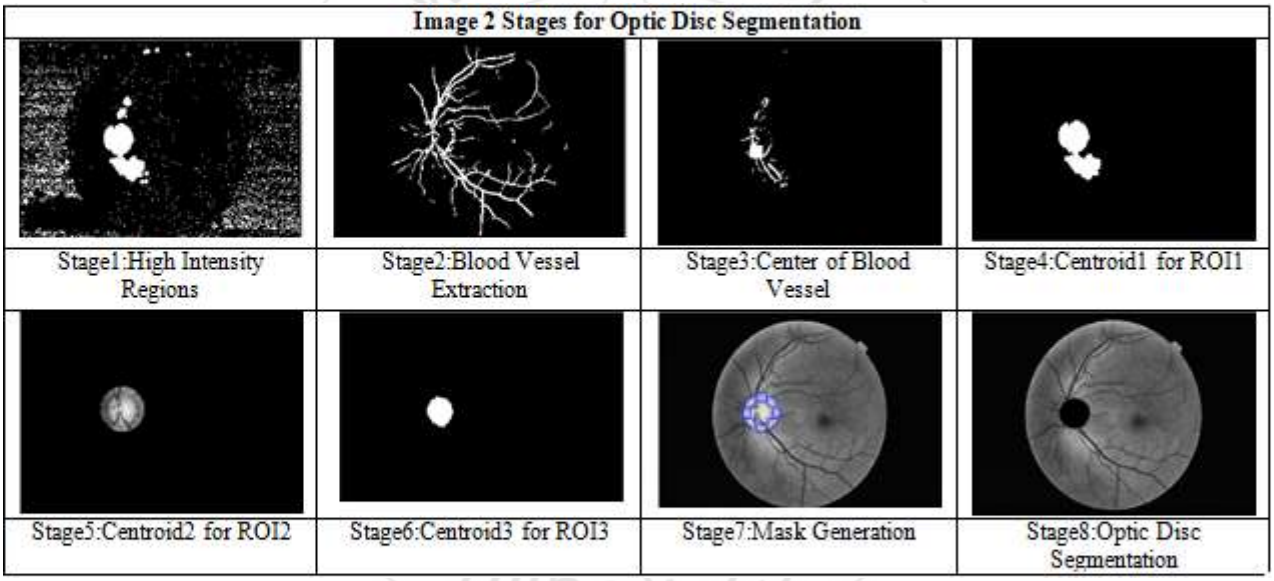
The first step in optic disc segmentation algorithm is the preprocessing phase that is performed using median filter in the green channel obtained from RGB fundus retinal image. CLAHE is applied to the preprocessed image that is obtained from the previous step to enhance the retinal image. It further helps sharpen the edges using Prewitt edge detection. The image is then converted to a binarization form with high intensity regions. The image and the optic disc contain more than one bright region or edge. A blood vessel extraction algorithm is then applied and a small mask discovers the center of the blood vessel applied to obtain an image that contains the largest intensity region and a blood vessel. This step plays an important role in ignoring edges and other regions that appear in the brightest and largest areas.

Table 2: Optic Disc Segmentation Algorithm

Input:	RGB retinal fundus image (*I*)
Output:	Optic disc segmentation image (*OD*)
Step 1	Pre-processing by using median filter on (I)
Step 2	CLAHE applied on Pre-processed image (I_{ahe})
Step 3	Intensity regions extraction (I_i) using Prewitt edge detection applied to (I_{ahe})
Step 4	Blood Vessel Extraction and center detection of optic disc (I_b)
Step 5	Maximum region from ROI for identification a centroid (C_1, C_2, C_3) from ROI_1, ROI_2, ROI_3
Step 6	Using (I_b) and a ROI_2, ROI_3 for more accuracy
Step 7	Optic Disc Detection and Segmentation (OD) $OD=I_b+C_2+C_3$

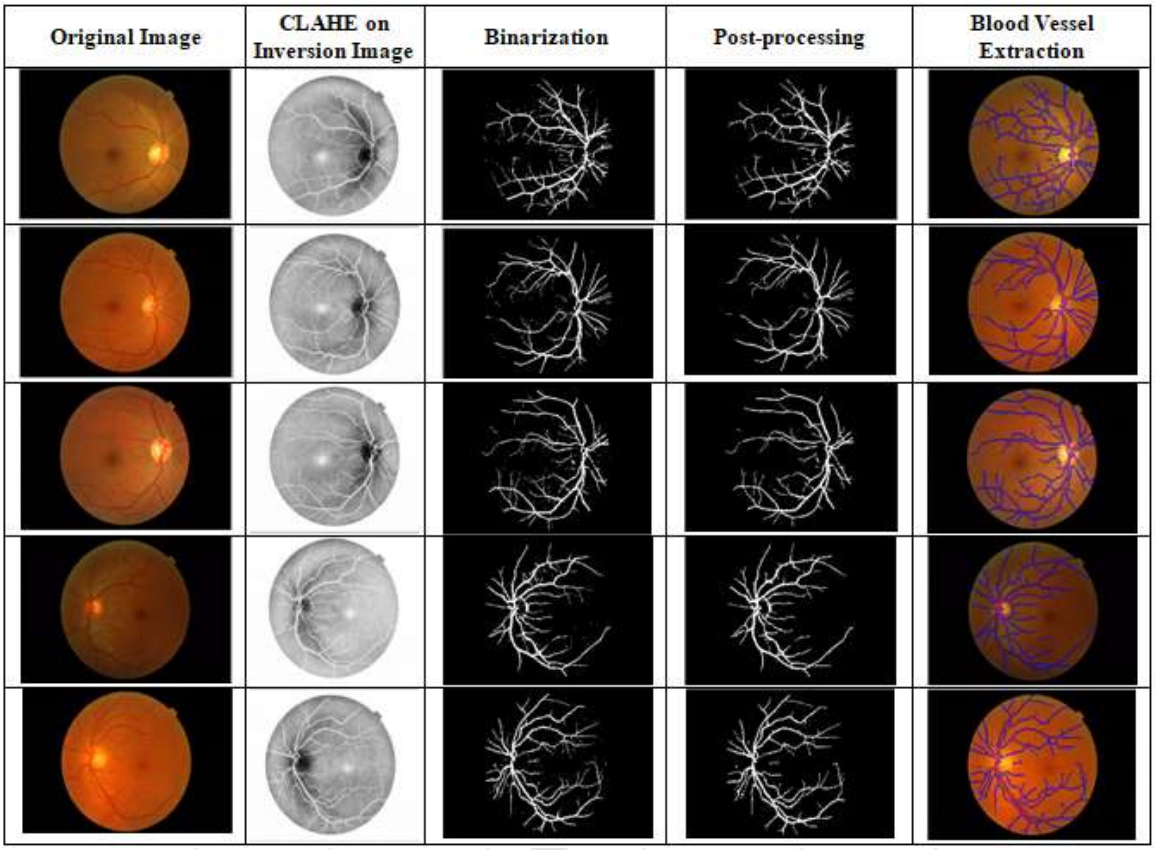
The maximum region that contains the blood vessels extracted and a centroid are computed to mask the region in question. Then, some morphological operations applied to this region to obtain more regions in the optic disc. The previous step is repeated even if the optic disc appears with a full circular region after a third step. Finally, the second and third regions are combined with the center of the blood vessel to obtain an accurate result for the detection of optic disc location. Then, a mask identifies this region to obtain the optic disc segmentation. These steps are shown in Figure3, Figure 4, and Figure 5 below:

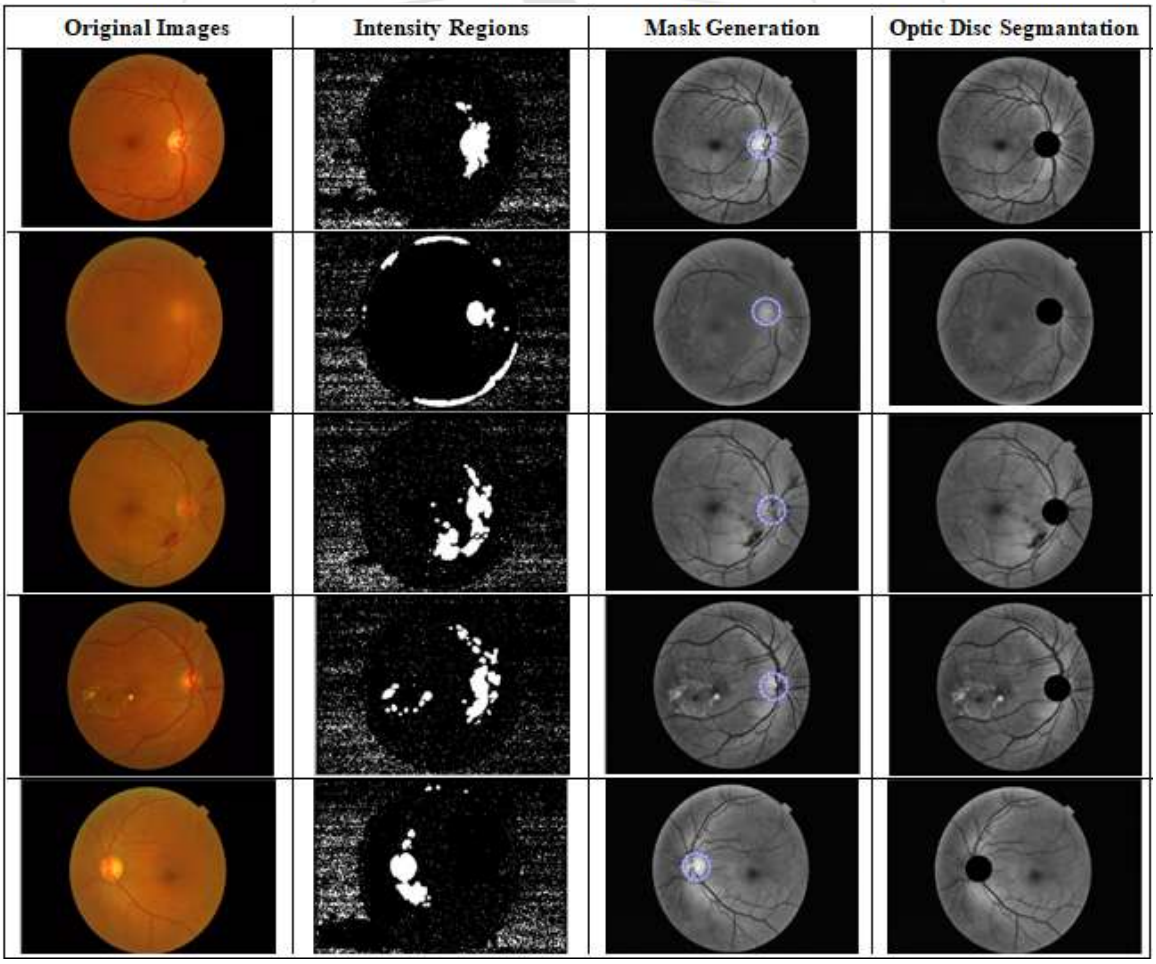




4. Results and Discussion

Experimentation has been done on 100 different images. Results have shown that the proposed method is well suited for the segmentation of retinal blood vessels and for optic disc detection. The proposed approach works well for standard MISSIDOR dataset as shown below. Figure (6) and figure (7) show the result of blood vessel and optic disc segmentation.





In the analysis of diabetic retinopathy, image processing of color fundus images has an important part. In this paper, a methodology is presented for automatic detection of optic disc from the colored fundus retinal image. The paper methodology is based on the morphological techniques and circular mask technique on the center of blood vessels. Robustness and accuracy of this approach have been evaluated on a MISSIDOR database that contains form 100 images. There are only two images that diagnosed as incorrect optic disc detection which is due to two reasons; first image contains corrupted area which is similar to optic disc. The second reason is in an image that is a region detected as optic disc because it is contained a high intensity and blood vessels but it isan exudates. These uncorrected results may have not affected on the overall system since the correct results that detected is 98% form these 100 images. However, the performance of the algorithm can be improved if these two remained images can be detected.

5. Conclusion

Optic Disc localization and segmentation methodology for RGB retinal fundus image screening has been developed and investigated. The proposed method is an efficient method for blood vessel extraction and for the detection of optic disc. This proposed algorithm has a high accuracy, specificity and sensitivity; it also works with lower quality retinal images.

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