Chapter 5

OPTIC DISK DETECTION AND ELIMINATION

The optic disc (OD) appears as the bright yellowish region in the color fundus image and is a normal feature of eye. Elimination of OD facilities detection of exudates because exudates appear in similar bright pattern, color and contrast as OD.This chapter describes the methods for detecting the boundary of OD and thereby eliminating OD. Three distinct methods are proposed to detect the boundary of OD. The detected boundary of OD is verified by the experts for its correctness.

5.1Introduction

Reliable and efficient optic disc localization and segmentation is an important task in automated screening system. The OD plays an important role in developing automated diagnosis expert systems for DR as its segmentation is prerequisite in identifying pathologies associated with DR. OD segmentation is also relevant for automated diagnosis of other ophthalmic pathologies like Glaucoma.

The OD can be distinguished in eye fundus images as an elliptical shape. Its size may vary significantly and different estimations have been made [90, 91].In color fundus images, the OD usually appears as a bright yellowish region. Besides the variations in OD shape, size, and color, contrast all around the OD boundary is usually not constant or high enough piecewise due to outgoing vessels that partially obscures portions of the rim producing shadows. This complicates the process of OD detection.

In [74], tracking blood vessels the presence of these vessels in the neighborhood of optic disc is used as a base. In [75], the constant distance between optic disc and macula is used as prior knowledge for locating macula. In [76, 77], optic disc removal is an important sub task to improve the lesion diagnosis and reduce false positive in extracting exudates. In [78, 79], an edge detection is performed after fitting the circle to optic disc using Hough transform to fit circle.

From the literature it is clear that there have been relatively few works on locating optic disc without user intervention. Most of the works are concentrated towards finding the optic disc centre. Very few authors have addressed the optic disc boundary localization. Reliable optic disc localization is difficult, due to its highly variable appearance in fundus images. Three efficient methods for locating the boundary of OD are presented in the following section. The experimental results show efficiency of the proposed algorithms.

Methodology

5.2 Masking Method

In this method the pixel intensity is used as centre of mask that is to be applied over optic disc in order to eliminate it. The brightest part in the fundus image is the optic disc centre. This point is obtained by first finding the pixel with highest intensity row wise. Next, the pixel with highest intensity from the resultant row matrix is obtained. Around this pixel the mask is created with radius 45 pixels.

5.2.1 Algorithm

Input: RGB color fundus image.

Output: Optic disc boundary located.

Method

Step 1: Extract green channel of fundus image.

Step 2: Complement the green channel image and then enhance the contrast by applying adaptive histogram equalization.

Step 3: Find the pixel with maximum intensity row wise.

Step 4: Find the pixel with maximum intensity column wise from the vector obtained in the previous step.

Step 5: Create a mask around the pixel obtained from step 3 with a radius of 45 pixels.

5.2.2 Experimental results

An optic disc extraction algorithm using mask is presented. A total of 100 images of dimension 4288X2848 are used to evaluate the performance of the proposed method. The performance has been evaluated by the experts. The method works well with images having complete or partial optic disc but fails when optic disc is absent or in cases where the exudates are more prominent than optic disc.

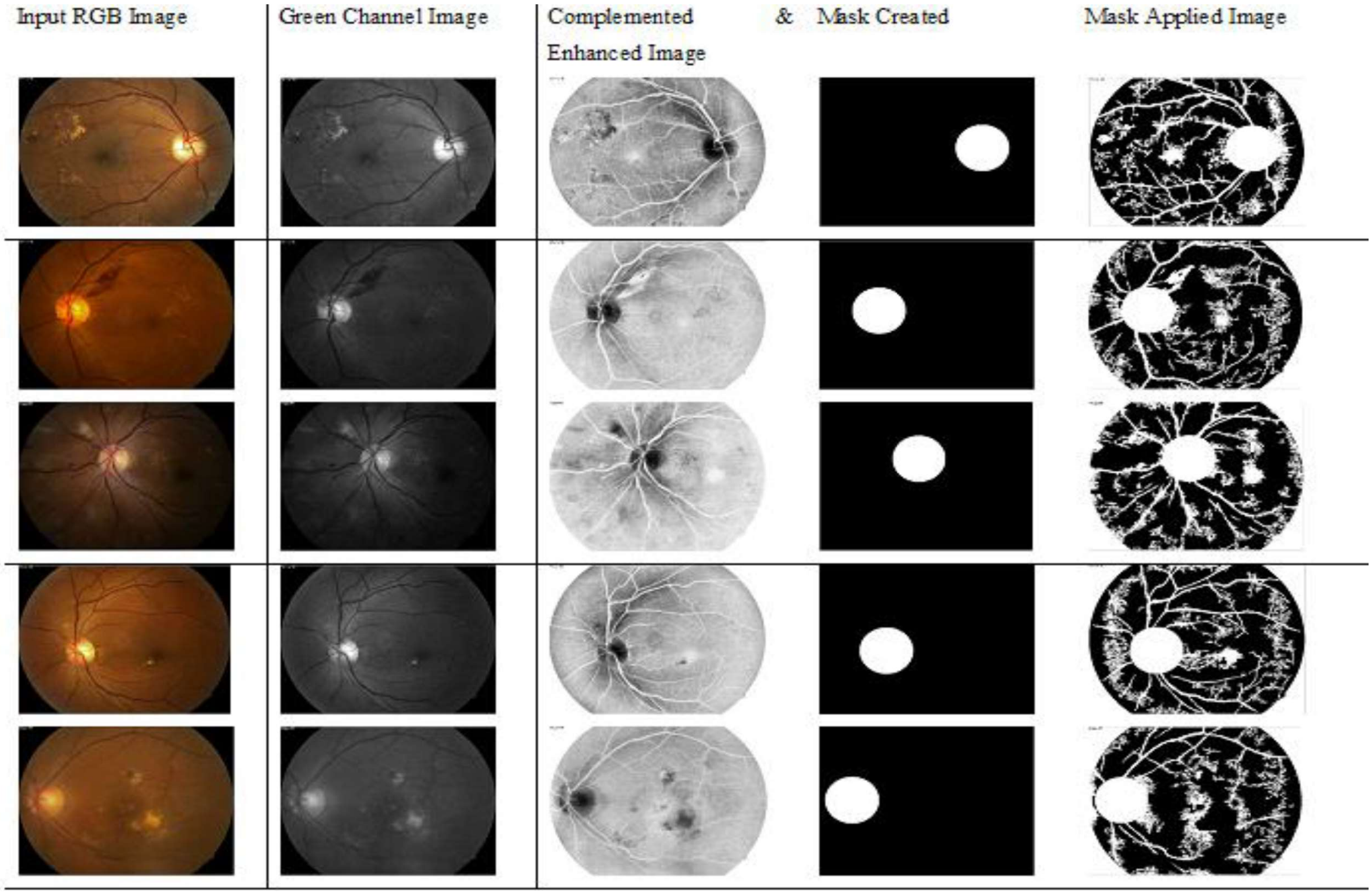

Figure 24: Results of Optic Disc Extraction Algorithm using Mask.

5.3 Active Contour Method

In this method chanvese algorithm [92] based active contour is used. Active contours are also known as snakes and are used to find the object boundaries. They are widely used in computer vision and image analysis to detect and locate objects. A snake may be semi automatic where user intervention is required or fully automatic where high level logical programming is written. Few authors have made an attempt to use semi automatic snakes to identify the optic disc boundary [93].

5.3.1 Algorithm

Input: RGB color fundus image.

Output: Optic disc marked using active contour

Method

Step 1: Pre Processing

- Normalize the image with respect to size.
- Extract green channel of fundus image.
- Apply un-sharp filters.

Step 2: Connected Component analysis is performed to extract the portion of the image containing optic disc.

Step 3: Apply bounding-box around the identified area & extract it as region of interest (ROI)

Step 4: Apply morphological closing operation to eliminate the blood vessel network.

Step 5: Apply chanvese active contour to detect the boundary based on the intensity of the pixel.

5.3.2 Experimental Results

A total of 100 images of dimension 4288X2848 are used to evaluate the performance of the proposed method. The performance has been evaluated by the experts. The novelty of the method is that it is fully automatic and no user intervention is required as in [83].

The method works well with images having complete or partial optic disc but fails when optic disc is absent or in cases where the exudates are more prominent than optic disc. The major disadvantage of this method is that it does not consider the size and shape of the optic disc rather it only concentrates on the intensity of the pixels on the boundary.

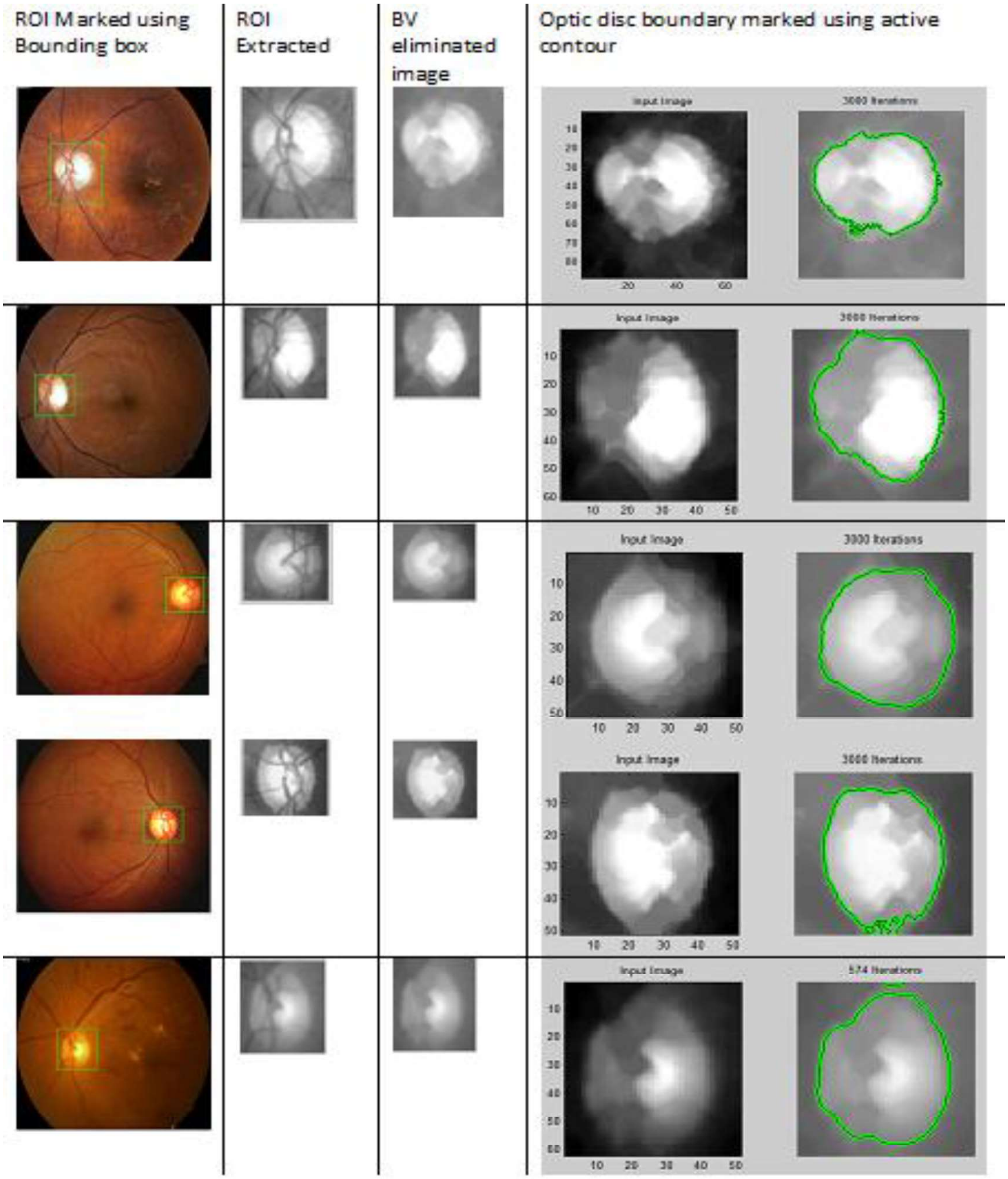

Figure 25: Results of Optic Disc Extraction Algorithm using Active Contour.

5.4 Hough Transform for Circle Fitting

The masking technique empirically removes the optic disc and does not ensure that the correct part of the image is eliminated and the active contour method does not consider the size and shape of the optic disc. Hence to overcome these drawbacks, Hough Transform to fit the circle to optic disc is used and this method also ensures that the area located in the image is optic disc by considering three features of the optic disc namely brightness, shape and size.

The circular Hough Transform relies on equations for circles. The equation of the circle is, $r^2 = (x-a)^2 + (y-b)^2$. Here a and b represent the coordinates for the center, and r is the radius of the circle.

5.4.1 Algorithm

In this algorithm to assign the values for a and b, first, extract the portion of image that contain the optic disk. This is achieved by performing optic disk localization using correlation coefficient. Now the size of the sub-image is assigned to a and b and radius is fixed to range between 45 to 55 pixels.

Circular Hough Transform Algorithm works as follows:

Step1: Turn the coloured image into gray scale.

Step2: Create a 3D Hough array (accumulator) with the first two dimensions representing the coordinates of the circle origin and the third dimension represents the radii.

Step3: Detect edges using the canny edge detector. For each edge pixel, increment the corresponding elements in the Hough array.

Step4: Collect candidate circles, and then delete similar circles.

Step5: Draw circles around the object.

5.4.2 Experimental Results

An optic disc extraction algorithm using active contour is presented. A total of 100 images of dimension 4288X2848 are used to evaluate the performance of the proposed method. The performance has been evaluated by the experts. The algorithm has yielded 100% results in image containing complete optic disc but fails when partial optic disc is present [figure 26].

Figure 26: Image with Partial Optic Disc.

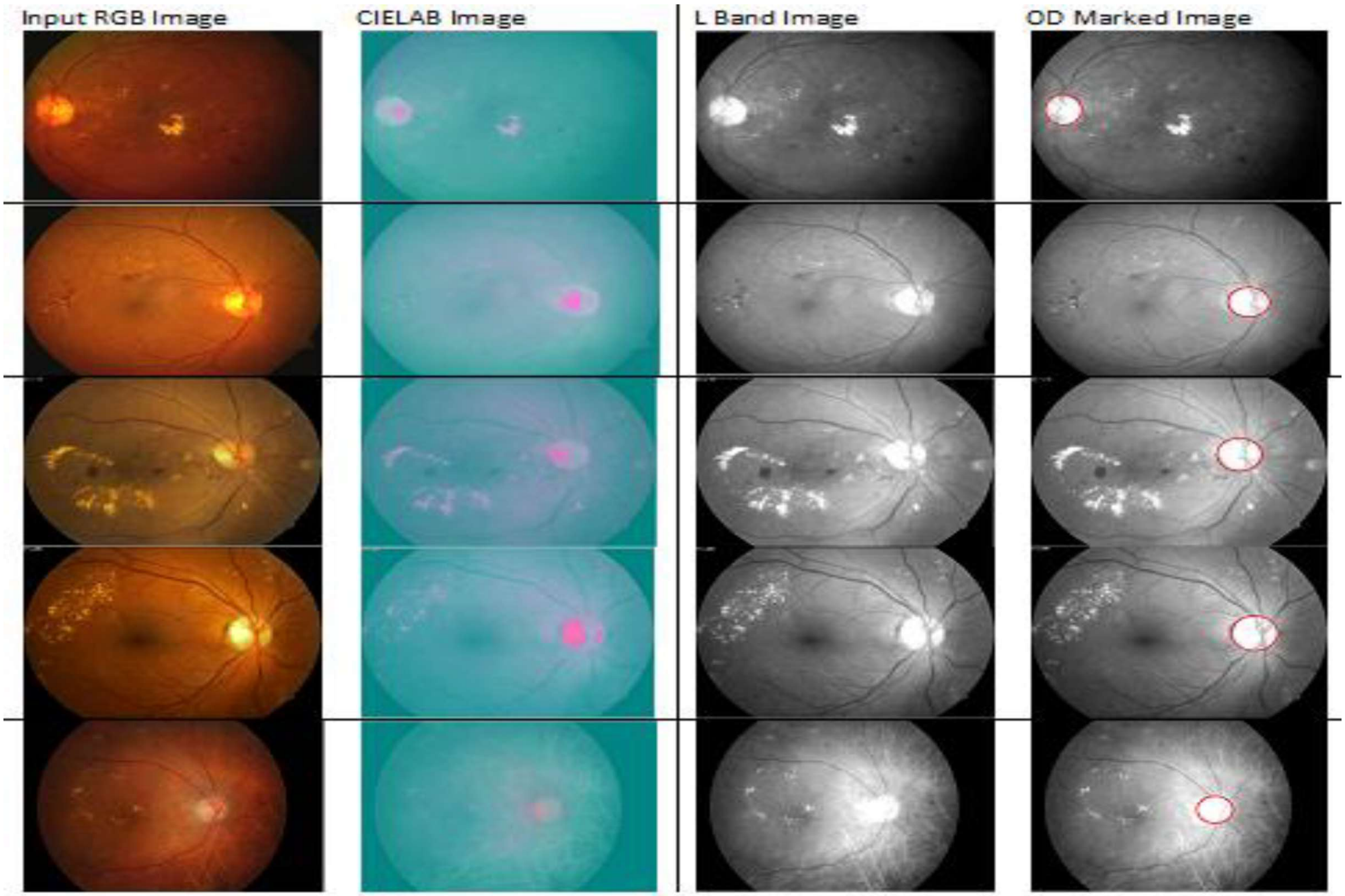

Figure 27: Results of Optic Disc Extraction Algorithm using Hough Transform.

5.5Summary

Three efficient methods for extracting optic disc from fundus images are presented. The experiments have been carried out on 100 fundus images per algorithm collected from Karnataka Institute of Diabetology, Bangalore.

The mask method fail in situations where optic disc is partially visible or absent or not as bright as exudates [figure 28(a)] and also for in images where exudates cover larger area then optic disc [figure 28(c)]. In such cases, the brightest and largest exudates group will be misclassified as optic disc [figure 28(b) and figure 28(d) respectively]. Red box represents the optic disc area misclassified as exudates and yellow box represents exudates area eliminated as optic disc. The failure of the methods in these cases may be attributed to the fact that methods consider the color intensity feature alone and do not ensure that the eliminated area is an OD as shown in figure [29].

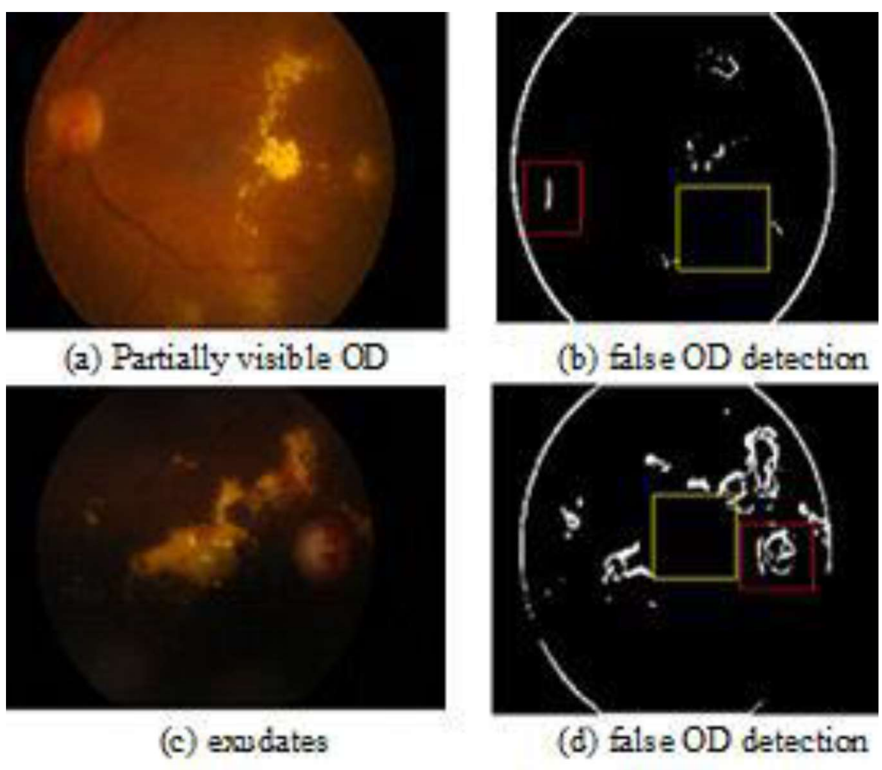

Figure 28: Example Images of False OD Detection

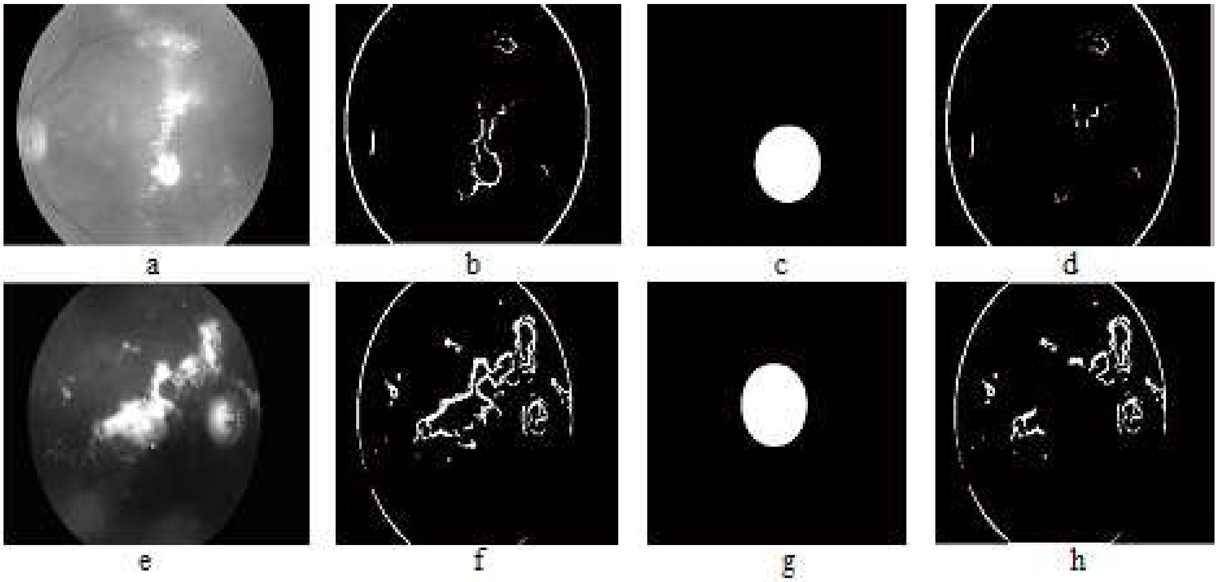

Figure 29: (a, e) Intensity Images (b, f) Result of Segmentation (c, g) Mask (d, h) OD Eliminated Images**.**

The problem of false optic disc detection is over come by the third method ie, using Hough Transform to fit a circle. The results obtained by performing experiments on such images using Hough Transform provide the evidences [figure 30]. The group of bright exudates, almost circular, is rejected from being a candidate optic disc [figure 30 (b)] because radius of the area covered by the exudates group is smaller than the radius of optic disc [41]. Similarly, the group of large bright exudates, is rejected from being a candidate optic disc [figure 30 (f)] because of the non circular / oval shape. Hence, for successful optic disc elimination three features of optic namely, brightness, shape and size need to be considered.

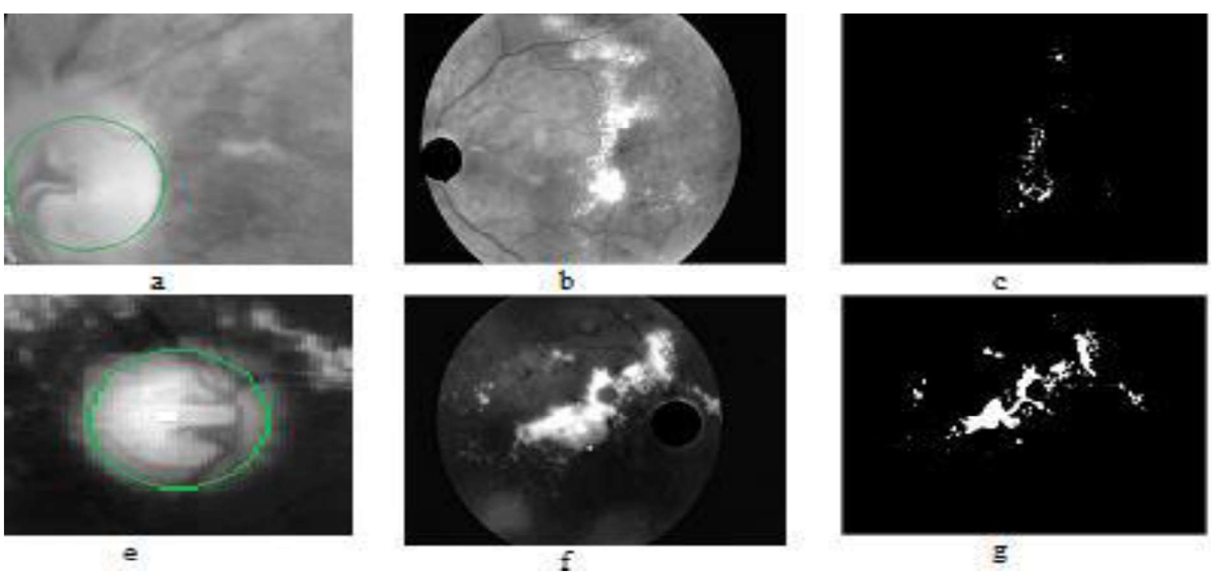

Figure 30: (a, e) OD marked image (b, f) OD pixels set to background (c, g) OD eliminated images.