DETECTION OF OPTIC DISK IN RETINAL IMAGES - A COMPARISON

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Abstract: In retinal image analysis, the detection of optic disk is of paramount importance. It facilitates the tracking of various anatomical features and also in the extraction of exudates, drusens etc., present in the retina of human eye. The health of retina crumbles with age in some people during the presence of exudates causing Diabetic Retinopathy. The existence of exudates increases the risk for age related macular Degeneration (AMRD) and it is the leading cause for blindness in people above the age of 50.A prompt diagnosis when the disease is at the early stage can help to prevent irreversible damages to the diabetic eye. Screening to detect diabetic retinopathy helps to prevent the visual loss. The optic disk detection is the rudimentary requirement for the screening. In this paper few methods for optic disk detection were compared which uses both the properties of optic disk and model based approaches. They are uniquely used to give accurate results in the retinal images.

Key words: Diabetic Retinopathy, optic disk, exudates, retina, macular degeneration.

I. INTRODUCTION

Diabetic Retinopathy (DR) is a result of long term diabetes mellitus. It has been noted as a significant growing public health problem. It is one of the predominant causes of blindness. It causes pathological changes of the retina such as microaneurysms, intraretinal microvascular abnormalities, venous bleeding and neovascularities as well as haemorrhages, exudates and retinal oedema. Regular screening of Diabetic Retinopathy is indispensable so that appropriate and timely treatment can be given which thereby reduces the incidence of impaired vision and blindness from this condition. Current methods of detection and assessment of diabetic retinopathy are manual, expensive and require highly trained personnel to read large number of fundus images. The efficiency can be improved by automating the initial task of analyzing the huge amount of retinal fundus images.

The optic disk is the brightest part in fundus images that can be seen as a pale, round or slightly oval disk. It is the entrance region of blood vessels and also acts as a landmark and reference for the other features in the fundus image. There are several methods for optic disk detection.In the Principal Component analysis method (PCA), the minimum distance between the original retinal image and its projection onto disk space is located as the center of Optic disk[1]. This detection is accurate but more time consuming. In the next method PCA and active shape model [2] is used, where the shape of the OD is obtained by an active shape method. Here the affine transformation is used to transform the shape from shape space to the image space. This algorithm takes the advantage of top down processing that increases the robustness yet it is time consuming. In lab color morphology[3],the location of optic disk was by both the automatic initialization of snake and the application of morphology in color space[4].In Sobel edge detection and least square regression[5], the detection is performed in the red component in three steps-candidate area identification, sobel edge detection and estimation step[6]. Lalonde et.al used a Hausdorff-based template matching technique on edge map, guided by a pyramidal decomposition [7]for large scale object tracking .The cholesky algorithm[8] was used but the snake had failed to locate the boundary in the upper right quadrant. In this paper, the detection of optic disk is done using combination of various concepts. Initially the candidate regions are selected and by using different methods such as iteration, binary imaging, clustering and PCA, propagation through radii, the location of optic disk is detected and compared.

II. METHODS

2.1 CLUSTERING

This is a distance based method. The calculation of threshold is done by simple mean estimation method and multiplying the mean image by a scaling factor. A scaling factor of 0.85 is appropriate. The gray scale image is initially scanned pixel by pixel. For every pixel exceeding the threshold a box of size (5 x 5) is constructed. This box is called a cluster. The x and y co-

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ordinates of the pixel is updated into two vectors row and column. Starting from the first entry in the vectors a box with coordinate lying in an acceptable level of distance is searched. To compute the distance basic mathematical formula

$$\sqrt{(x2-x1)^2+(y2-y1)^2} \quad \text{---------- (1)}$$

is used. Once found the boxes are joined. The boxes are joined based on their location.

Say for example, (x1, y1) be the centroid of first cluster and (x2, y2) be the centroid of second cluster. After this the basic mathematical formula to evaluate the distance between two points is applied to find out the distance between the clusters. Keeping (x1, y1) as the reference point the distance between this reference and the center point of every other cluster is determined. The clusters having centroids within a specified distance from this reference centroid point are combined. The north-west point of the reference cluster and the South-east point of the cluster which is closer to it are merged to form a single cluster. Then subsequently these centroids are removed from the list of centroids to be evaluated. This phenomenon is repeated for every other centroid and the clusters are regrouped. This method is repeated above for certain time which gives certain candidate regions. For every candidate, number of pixels exceeding the threshold is found. If it is below a certain level determined by the size of the candidate region the candidates are discarded. Finally we have an image in which the candidate region completely encloses the optic disc though it may not exactly square it.

This is suitable for normal healthy fundus images where in optic disc is alone the brightest region of the image. But our images contain exudates and lesions. The exudates' intensity value is similar to that of optic disc. If it is small in size then it can be characterized by the intense pixels density. But in some images the exudates are as large and dense as exudates. In such cases it is difficult to find which of the candidate contains the optic disc.

2.2 PRINCIPAL COMPONENT ANALYSIS BETWEEN CLUSTERS:

PCA is a statistical method. For every pixel a window is constructed around it with the pixel as the centre .For every box PCA is applied and the one having minimum Euclidian distance contains optic disc. Our test image size is 240 x 180.So the PCA process has to be applied 43200 times. So it is very time consuming and the method is not accurate enough to wait so long. Clustering does not produces correct output for images with exudates. The advantage of the PCA and clustering can be combined. The main extract of this method is that, the candidate regions are first determined by clustering the brightest pixels in intensity image. Principal Component Analysis is then applied to these candidate regions. The candidate region having the least Euclidian distance contains the optic disc. Though the centre of the candidate region and centre of the optic disc does not coincide, the region encloses the optic disc.

Candidate region is determined by clustering method. The clustering method produces candidate regions of varying dimensions. But for applying PCA we need the candidate regions to be of fixed predetermined size. (40 x 40) in our case, so the candidates are resized. For every fixed size cluster we find the brightest pixel and construct a 40 x 40 box. The fixed size clusters and these boxes are the entries for PCA. Hence if there are n candidates we will have 2n PCA entries. Now we apply PCA only to these entries rather than to every box centered around every pixels of the image.The training set can be extracted individually by moving a window of size 40 x40 over this single image. These extracted sub images are stored in a three dimensional matrix. So the third dimension of this matrix represents a page and each page contains a individual sub image. By doing this the access of the individual sub images becomes easy as they have the same name and only differs in the index of the third dimension which is a numerical value. By incrementing this numerical value in a for loop, the consecutive sub images which form the training dataset can be accessed.

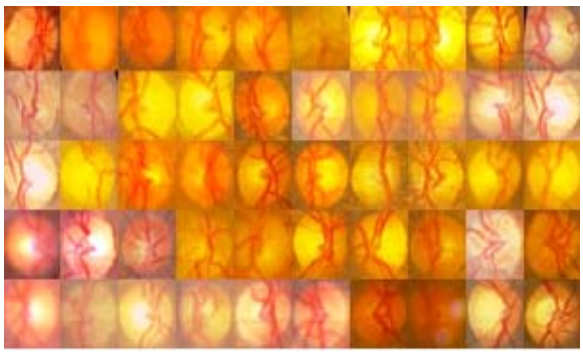

Figure 2.1 TRAINING IMAGE

2.3 PROPAGATION THROUGH RADII

PCA between clusters produces output such that the optic disc is enclosed in a square box of size (40 x 40). For fixed size boxes 1600 pixels are extracted considering it to be containing the optic disc. But in many images the optic disc occupies only around 1000 pixels. If any exudates lie within proximity of the optic disc then it may also be extracted. This may increase the risk of abnormal retina being reported normal. In few images the optic disc is too large to completely fit within the (40 x 40) box. So few of the optic disc pixels may remain unextracted. This may intervene in exudate detection. So in either case extracting pixels under a fixed size area is not efficient. To avoid this we tried to define a circle (circle of best fit) that encloses the optic disc with minimum number of pixels that does not belong to the optic

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disc. The original fundus image is subjected to contrast limited Adaptive Histogram Equalization.

The centre of the box containing optic disc is defined by coordinates (x, y). In general to represent a circle in discrete space we use x+rcosθ, y+rsinθ. θ lies from 0 to 360. The arbitrary initial value of r is 10. Thus we have ({x+10cos0, y+10sin0}, {x+10c0s1, y+10sin1}… {x+10cos360,y+10sin360}). Each of them representing a point in the circumference of the circle. Now the first point (corresponding to θ=0) on the circumference is taken. Keeping it as the centre point and a pixel is chosen above (x+(r+1)cosθ, y+(r+1)sinθ) and below(x+(r-1)cosθ, y+(r-1)sinθ) that. The difference of pixel intensity value between the upper point and center point and also between lower point and center point is computed. A threshold is set (5 in our case) and if the difference value is greater than the threshold make the center point is made black. This procedure is repeated until the difference value becomes greater than the threshold, each time shifting the centre point upward along the radius by incrementing the initial r value .The final r value is the radius corresponding to that θ. This is done for all the points present in the circumference of the circle i.e., for θ ranging from 0 to 360. Hence we get radius for all 360 degrees, and then the mean radius is found. Our next step is to find mean centre. This is done by finding midpoint of line joining circum points of supplementary angles for θ=0 to 180.The mean of these x and y co-ordinates of the midpoints gives us the mean centre. The circle of best fit is drawn with mean centre as the centre and mean radius as the radius. As error margin can be added to the mean radius, this ensures that the optic disc is completely enclosed.

III. RESULTS

Figure 3.1 ABNORMAL INPUT IMAGE

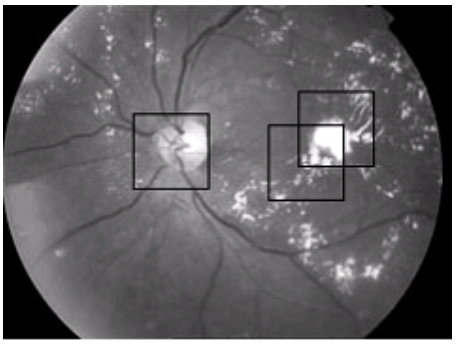

Figure 3.2 CLUSTERING OUTPUT

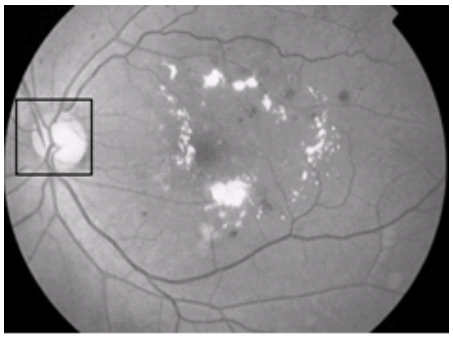

Figure 3.3 PCA OUTPUT

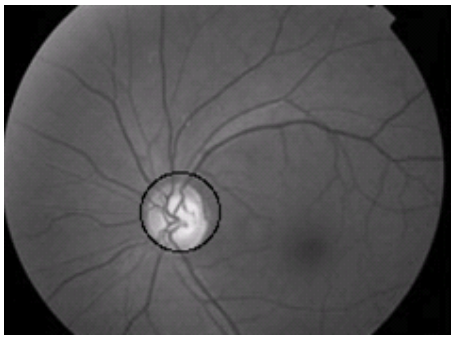

Figure 3.4 PROPAGATION THROUGH RADII OUTPUT

IV. CONCLUSION

Scaling factor of 0.85 is appropriate in clustering method and is suitable for normal healthy images where optic disk alone is the brightest region in the image. Using PCA between clusters, out of 50 images, accurate results are obtained for 44 images. The detection of exudates involves the removal of optic disk. Under these circumstances propagation through radii method can be employed. The various methods for optic disk detection is given in which the time consumption of PCA is overcome by

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applying PCA only to the clusters. The propagation through radii method is suitable for removing optic disk in the detection of exudates since it does not require the exact center of optic disk.

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