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Extraction Optic Disc of the Digital Image Eye Fundus using Deformable Model

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Abstract. In the medical world a proper diagnosis of the disease will help in the treatment of the disease itself. For example, the separation of optic disc features the eye fundus digital images, it has the objective to distinguish it from other features. Detection of the optic disc is required to distinguish the bright lesion (exudates), which have similar visual characteristics of the optic disc. To do that, we need a detector that features one eye to detect features of Optic Disc. In this study the detection features of Optic Disc using methods previously done Deformable Model preprocessing beforehand to eliminate noise features, vascular, image smoothing and edge detection. Research results are compared with the results extracted manually by humans. The proposed extraction method successfully detected Optic Disc with accuracy 99.63%, sensitivity 85.54% and specificity 99.66%.

Keywords: *diabetic retinopathy, optic disc, deformable model, and feature extraction.*

1. Introduction

In the world of medical treatment or the proper diagnosis of the disease will help in the treatment of the disease itself. Because a correct diagnosis can be performed medical acts the right time. For example, the separation of optic disc features the eye fundus digital images, this is done so that the features can be analyzed resemblance shape and get the proper medical treatment.

Optic disc is the area of the eye where the nerve enters the eye. Optic disc is also a reference of the other features in the fundus images. For successful detection of abnormalities, it is often necessary to separate the normal anatomy, see figure 1.

Detection of the optic disc is required to distinguish the bright lesion (exudate), which have similar visual characteristics of the optic disc. So that it can help in the proper diagnosis and get appropriate medical treatment as well.

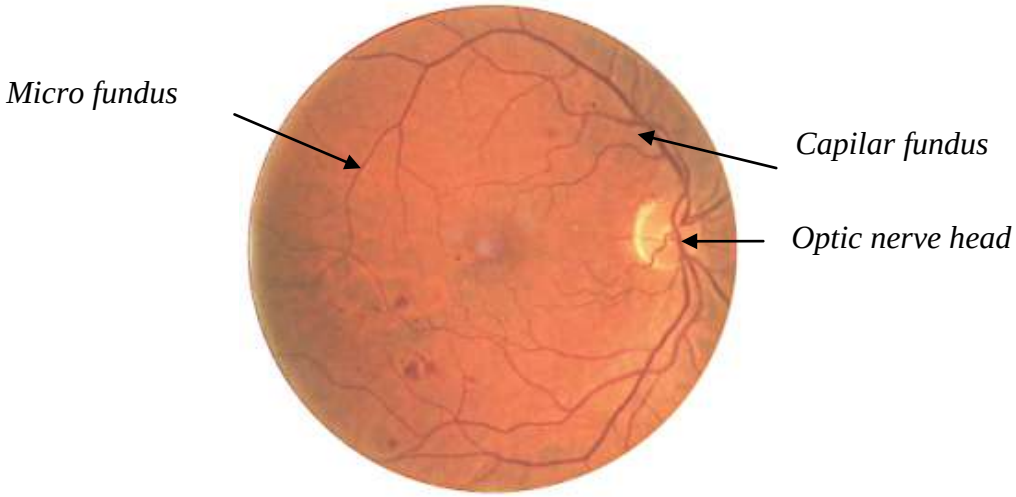

Figure: 1. Digital Retinal Fundus

Several methods have been used to detect optical discs such as Viranee Thongnuch and Bunyarit Uyyanonvara using circular Hough transform [1], and in subsequent studies using labeling connected.

Watershed transformation used by Thomas Walter and Jean-Claude Klein [2]. Akara Sopharak et.al has applied Otsu threshold applied after preprocessing. In research on exudate apply median filter on the channel I of the HSI image. Furthermore, applying Contrast-Limited Adaptive Histogram Equalization (CLAHE) before Otsu threshold, then eliminate the optic disc [3]. Joint entropy analysis of pixel intensity and connected components are used by Akara Sopharak et.al. Philips, S. King combines Fuzzy clustering with active contour. L [4]. Gagnon et.al. Using distance measurements Hausdorrf after her-wavelet transform and edge detection 'Canny' [5]. But of all the methods that have been applied, there is no single method that can detect the Optic Disc with 100% accuracy [6].

Optic Disc is useful for diabetic retinopathy detection. Diabetic Retinopathy, a disorder of retinal blood vessels resulting from diabetes mellitus, is one of the major cause of human vision abnormalities or even blindness. Thus, segmentation of this feature in the retinal images can provide a map of retinal vessels that can ease the assessment of the characteristics of the vessels [7].

Based on the background of problems that arise, this study is focused to perform feature extraction in digital images optic disc in the eye fundus. The image used is the input digital image eye fundus. This study will focus on how to get the optic disc area on eye fundus digital images. This research provides benefits include Contribute to the development of digital image processing of medical images in particular the extraction of fundus and Optic Disc Assist ophthalmologist in detecting features of Optic Disc in eye fundus digital images.

2. Review of References

2.1 Optic Disc

Optic disc or optic nerve head is the location where ganglion cell axons exit the eye to form the optic nerve. At no point in optic disc that is sensitive to light in response to a light stimulus. This causes a visual point of so-called "blind spot" or "physiological blind spot". Optic disc is the beginning point where the optic nerve and retinal ganglion cell axons boils. Optic disc also as entry point to the major blood vessels that supply the retina. Optic disc in normal human eyes carry 1-1.2 million neurons from the eye to the brain. The reason why normally people are not aware of blind spots in both eyes is because the human eye is open when the blind spot of one eye corresponds to the retina in the eye to see them. A normal optic discs are colored orange pink. A pale disc is an optical disc color varies from pale pink to orange to white. A pale disc is an indication of the condition of the sick. Normally there is a small shallow hole visible on the front of optic disc. The hole is called a shallow cup. Smaller diameter than the diameter of the optic nerve. When an ophthalmologist looks into using a magnifying Monocular nerve, optic disc was seen as a cup on a plate (or like a disc). Then it started many names to describe the optic nerve (cup to disc ratio, cupping, cupped, etc.).

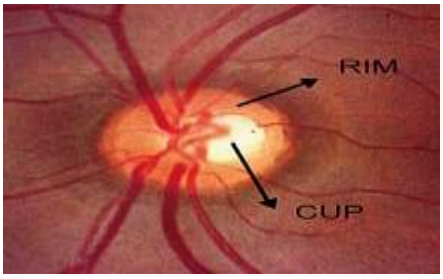

Figure 2. Optic disc under normal conditions

2.2 Deformable Models

Deformable models are a framework for describing the shape of the object from a 2D image. So-called because of the way sliding Deformable contour models are accompanied by energy minimization. Deformable models are a collection of dots moving closer to the limits of an object, the concept of Deformable model is similar to using a balloon to get the shape of the object.

An object is inserted into the balloon, by reducing the air inside the balloon so the balloon becomes increasingly smaller. Limitation of the object is found when the balloon is no longer shrinking. Here's a simple overview of the work Deformable models: an initialization curve is placed outside of the object to be segmented, and then through a process of iterative curve will be moved closer to the boundary of the object until it stops after finding the object boundaries.

This framework tries to minimize the energy associated with the image of a form as a number of internal and external energy. External energy must be minimum when Deformable models have been in the position of the outer limits of an object. The simplest approach is to provide a low gradient value at around the contour until

it reaches a minimum value. While the internal energy must be minimum when Deformable models have a form corresponding to the shape of the object.
Deformable models are represented as a set of n points in an image. Representation of the position of Deformable models: v (s) = (x (s), y (s))

$$E_{snake} = \int_0^1 (E_{internal}(v(s)) + E_{image}(v(s)) + E_{con}(v(s)))ds \quad (1)$$

Where is the internal energy of Deformable models, this energy affects the movement of Deformable curve model. The energy of the input digital image's. The high level of information that affects the movement of Deformable curve model. v(s) is a set of x and y coordinates of Deformable curve model.
The internal energy of the curve Deformable models that affect the movement of the curve itself. It can be explained by the following formula:

$$\begin{aligned} E_{int} &= E_{cont} + E_{curv} \\ &= (\alpha(s)|v_s|^2 + \beta(s)|v_{ss}(s)|^s)/2 \\ &= \left(\alpha(s)\left\|\frac{dv}{ds}(s)\right\|^2 + \beta(s)\left\|\frac{d^2v}{ds^2}\right\|^2\right)/2 \end{aligned} \quad (2)$$

Where:

- The first derivative dv (s) / ds, calculate the energy that governs the elasticity of Deformable curve model.
- α (s) is a parameter that governs the elasticity of the curve
- The second derivative, calculate the energy that governs the curvature of the curve.
- β (s) is a parameter governing the curvature of the curve

The value of α (alpha) has the following effect, a small value of α will cause the distance of each point of the curve is irregular, while a large value of α will cause the distance of each point is maintained. The value of β (beta) has the following effect, a small β value will cause the curve becomes smooth (curve can be at an angle), a large value of β will lead to a smooth curve.

3. Extraction Flow Optic Disc in Retinal Image

The software starts with the process of opening an image once the image is opened to read the specifications, then enter the preprocessing stage, and then made the Optic Disc detection initialization way around the optic disc by using the algorithm Deformable model. The General process flow of the system can be seen in the following figure**.**

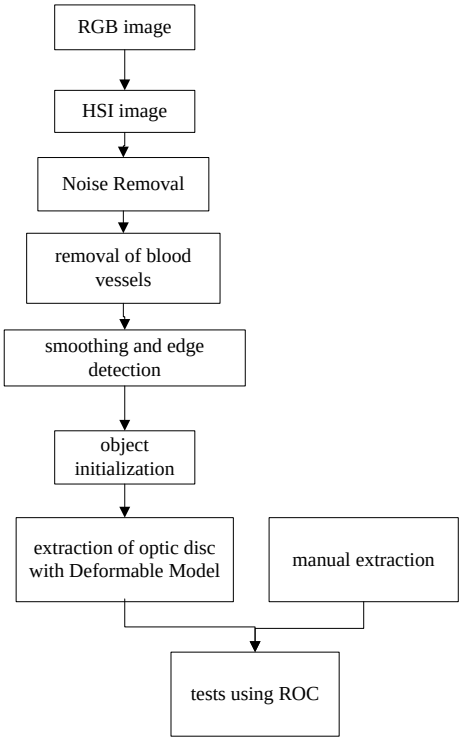

Figure 3. Block diagram of the preprocessing and extraction of optic disc using the method Deformable Model

3.1 Preprocessing

There are several stages of pre-processing is done starting with the image conversion RGB to HSI. The input image is still an RGB image or a color image that still needs to be converted into HSI image. Since HSI color is another form that can be used to interpret the characteristics of the natural color. In the alteration or conversion of RGB images to HSI (Hue, Saturation Intensity) using equations 3,4,5,6.

- Calculate θ

$$\theta = cos^{-1}\{\frac{(R-G)+(R-B)}{\sqrt[2]{(R-G)^2+(R-B)(G-B)}}\} \quad (3)$$

- Calculate H (Hue)

$$\begin{cases} \theta \\ 360-\theta \end{cases} \text{ if } B \leq G, \text{ if } B > G \quad (4)$$

- Calculate S (Saturation)

$$S = 1 - 3\frac{\min(R,G,B)}{(R+G+B)} \quad (5)$$

- Count I (Intensity)

$$I = I = \frac{1}{3}(R + G + B) \quad (6)$$

Assuming that the RGB values are normalized value in the range (0,1), and θ angle measured by the degree the red axis of the HSI space. Hue can be normalized in the range (0,1) with the division by 360° all the value generated from the above equation hue. Two other HSI components already available within this range if the RGB values are given in the interval (0,1) [8].

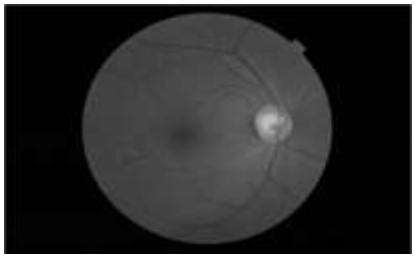

Figure 4. RGB to HSI conversion results

Elimination of noise or noise in the images is the process of reducing the noise or spots in the image so that the image gets a more clean and good quality. This noise removal process using techniques medfilt or median filtering is a technique that focuses on the value of the median or the mean of the total value of the overall pixels around him. This technique works by filling the value of each pixel with the median value of neighbors. The selection process begins by sorting the median values of neighboring pixels newly selected value center. In the process of the removal of noise or noise using a median filtering technique using the following equation 7.

$$y\,[\mathrm{m,n}] = median\,\{x\,[i,j]\,[i,j] \in w\} \tag{7}$$

Where *w* is a neighborhood centered around the location *m, n* in the figure.

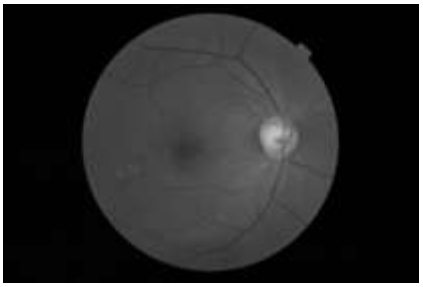

Figure 5. The image after the noise is removed

For the removal of blood vessels, here using morphological operations. Morphological type used is closing operations. Closing operation is a merger between erosion and dilation operations. Only dilation surgery done first. Then it is followed by a process of erosion. Dilation function serves to expand the area of optic disc while the erosion function is useful for removing blood vessels. Closing operation can be expressed by equation 8.

$$C\,(A,B) = AoB = E(D(A,-B), -B) \tag{8}$$

The results of operations closing almost like dilation of operating results that extend beyond the boundary of the foreground object and also close the small hole located in the center of the object, but the results are not as big as the result of closing operations dilation. Results dilation will cause swelling of the overall shape of the object. This effect can be reduced by applying the process of erosion after the dilation process.

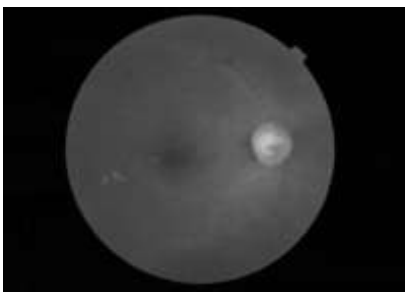

Figure 6. Image after a blood vessel is removed

Smoothing and edge detection has a goal to smooth the image and display that image to detect the edge boundary, on the edge detection algorithm uses a Canny edge detection algorithm is one of the popular edge detection technique of its use in image processing. One reason is the thickness of the edge of the pixel value that is intended to localize the position of the edge in the image.

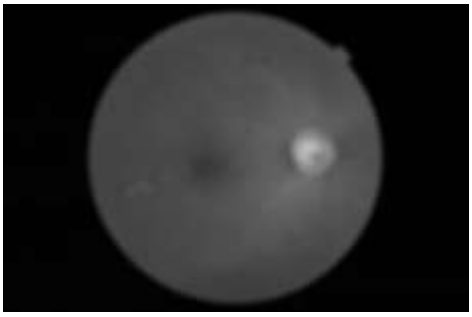

Figure 7. Image after smoothing

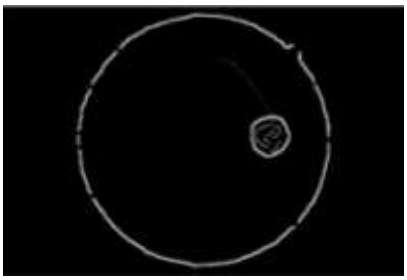

Figure 8. Image after edge detection

3.2 Extraction of Optic Disc

Optic disc extraction process using image preprocessing results as input. The process of detection of optic disc initialization by using a mouse that uses the principle of minimizing the energy of detecting certain features in the image, a curve (surface) that can flexibly adapt to the dynamic leading edge (border) or the object in the desired image (can be used for automatic object segmentation). This system consists of a set of points that are interconnected and controlled by a straight line. Determination of the object in the image via Deformable Model an interactive process.

The user must estimate the initial contour, contour defined nearing the target object shape features. Furthermore, the contour will be attracted towards the features in the image or the edges of the optic disc due to the influence of the internal energy that produces an image. The optic disc extraction process is shown in the picture below.

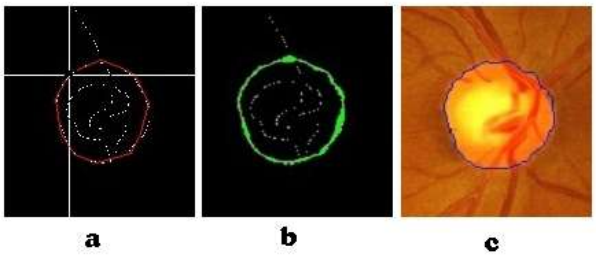

Figure 9. (a) Initial contour (b) Iteration (c) Extraction Results

3.3 Verification

In the verification phase, 100 images extracted from the optic disc applications compared with 200 images extracted manually by humans. So 100 image extraction results first applications compared with 100 images manually extracted the A, followed by 100 images of the application compared to 100 images manually extracted the B.

Counted the number of pixels that are detected. Furthermore, the pixels are classified into 4 groups: TP (true positive), TN (true negative), FP (false positive) and FN (false negative). TP is the optic disc pixels detected correctly. TN is a non optic disc pixels that is detected correctly. FP is non optic disc pixels detected as optical disks. While FN pixels optic disk is not detected. This grouping is illustrated in table 1.

Table 1. Grouping pixels

	Pixel OD	Not Pixel OD
Detected as OD	TP	FP
Not Detected as OD	FN	TN

3.4 Tests with ROC

To test the ability of the application, it is necessary to test for the test application, the test uses the technique of ROC (Receiver Operating Characteristic) is a technique for visualizing, organizing and selecting classifiers based on their performance. In this test, which is calculated accuracy, sensitivity, and specificity. Accuracy indicates the performance of this method. Sensitivity indicates the proportion of pixels that are detected optic disc correctly. While specificity indicates the proportion of non optic disc pixels that are not detected as optical disks. Equation of accuracy, sensitivity and specificity is as follows.

$$accuracy = \frac{TP + TN}{P + N}$$

$$Sensitivity = \frac{TP}{TP + FN}$$

$$specificity = \frac{TN}{FP + TN}$$

3.5 Result

Deformable Model Method applied by using 100 pieces of digital images of the eye fundus Messidor database, which is a research program funded by the TECHNO-VISION French Ministry of Research and Defense in 2004 to concentrate on his studies of diabetic retinopathy. The data used is a retinal fundus image data of high resolution (2240 x 1488 pixels) with up to 100 images tiff format. Data from experimental results obtained accuracy of 99.63%, sensitivity of 85.54% and a specificity of 99.66%. Test results can be seen in Table 2.

Table 2. Accuracy, sensitivity and specificity

Image	Specif	Sensi	Acc
1	0.9928	0.5856	0.9896
2	0.9933	0.7004	0.9907
3	0.9935	0.7552	0.9912
4	0.9935	0.6879	0.9908
5	0.9928	0.6029	0.9901
6	0.9958	0.5916	0.9940
7	0.9943	0.5888	0.9916
8	0.9949	0.6335	0.9925
9	0.9950	0.6576	0.9920
10	0.9956	0.6007	0.9928

4. Discussion

Extraction is the process of separation of optic disc features of the retinal optic disc so it can be determined where the area where the optic disc and optic disc area besides. So with optic disc area-determined accurately, it will be found also to appropriate medical treatment in the treatment of eye disease related to the retina and optic disc. The core of this research model is the separation of optic disc of the retina by way relieve certain features in addition to optical disc, and then applies the algorithm Deformable models in the determination of the optic disc area. These features are removed include the removal of the blood vessels, and eliminating the noise in the retinal image. Deformable model algorithms work with affected internal and external forces force the draw contour lines near the edge of the optic disc boundary. Overview of the algorithm is that we insert an object into a balloon filled with air, and then we open up the balloon so the air inside the balloon out and finally found the shape of the object in the balloon. In this study tested using some test parameters such as sensitivity, specificity and accuracy. Specificities and accuracy of the parameters obtained very good results are above 90%, but the sensitivity parameter values obtained are not so good which has an average value of 70%. Although the sensitivity values obtained were not so good, but this application can be categorized as an Ophthalmological application that can help in the early detection and treatment of diabetic rethinopaty.

5. Conclusion & Further Direction

Based on 100 fundus image data of the test or in the extraction by manual application of paint that is obtained using the optic disc area that does not match the actual form of the optic disc or inaccurate, while using the program obtained optic disc area of real or accurate, it's because the program Deformable models using the style of the border who are looking for a color automatically. The percentage level of compliance of the testing program has been carried out has a high value, it can be seen from the high specifity and accuracy that is at the highest value obtained specifity 0.9966 and 0.9899, while the lowest value on the accuracy obtained the highest value and the lowest value 0.9843 and 0.9963, but the sensitivity values get a not so good but it could be categorized as an application that can help the work of someone who works in an ophthalmologist in the detection of the optic disc. The proposed extraction method successfully detected Optic Disc with accuracy 99.63%, sensitivity 85.54% and specificity 99.66%.

Based on the conclusions obtained, the system can be developed further. Not only is an application of the detection of optical discs in the digital fundus eye but can be added or combined with another application which is a line of research on retinal image as the detection of exudates in eye fundus digital images. Also needs more development on the application of the results obtained due to the not so good on the part of his sensitivity testing. It's necessary to find the causes of and solutions to be applied to that part.

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