Segmentation of SD-OCT Images: A Comparative Study

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Abstract

Spectral Domain -Optical Coherence Tomography (SD-OCT), a non-invasive diagnostic tool which can assist ophthalmologist in deep examination of retina. Segmentation is a substantial task of image processing in medical images. Automated segmentation of SD-OCT images helps to quantify the pathological changes in the region of Optic Nerve Head (ONH). This article analyses three segmentation algorithms such as Otsu thresholding, Fuzzy C means, Region growing. The experimental results are demonstrated in terms of Performance ratio, Mean Square Error (MSE) and Peak signal to Noise Ratio (PSNR) values. Fuzzy C means algorithm provides more PSNR value of 13.89 and PR value of 5566.37.

Keywords - *SD-OCT, ONH, Otsu, Fuzzy C means, Region growing*

I. INTRODUCTION

Having the competence of acquiring 27,000 A-scans/seconds approximately, SD-OCT can effectively quantify the cross-sectional region of retinal layers and ONH.SD-OCT is an adaptive imaging modality having better resolution of 6 micrometre[1, 2]as depicted in figure1, comprises of more than one million nerve fibres which is responsible for peripheral vision. Structural changes to ONH may leads to different retinal disorder[1].

Segmentation is the process of extracting the essential information for further processing of image. Recognition and delineation are the two major tasks of image segmentation. Recognition is used to determine the location of region whereas delineation refers to extract the feature of interest[8]. Segmentation of ONH region is the forefront for delineating the different retinal layers to diagnose the ocular disease like retinopathy, glaucomaetc [4].

Various segmentation approaches are being in use. This paper focuses on three segmentation algorithms like Otsu, Region Growing and Fuzzy C means for analysing the best one.

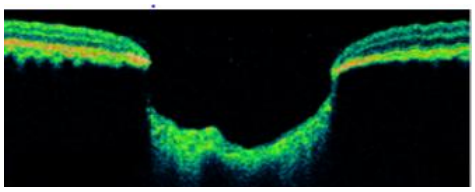


Figure 1. Region of Optic Nerve Head in SD-OCT image

A.Motivation and Justification

Several approaches have been developed to detect the structural changes of ONH.Segmentation of the interest region is effectively useful to delineate the inner and outer retinal boundaries more accurately. Considering this need, three different segmentation algorithms are analysed in this article to justify the optimal one.

B.Outline of the paper

The outline of the paper is presented in Figure2.

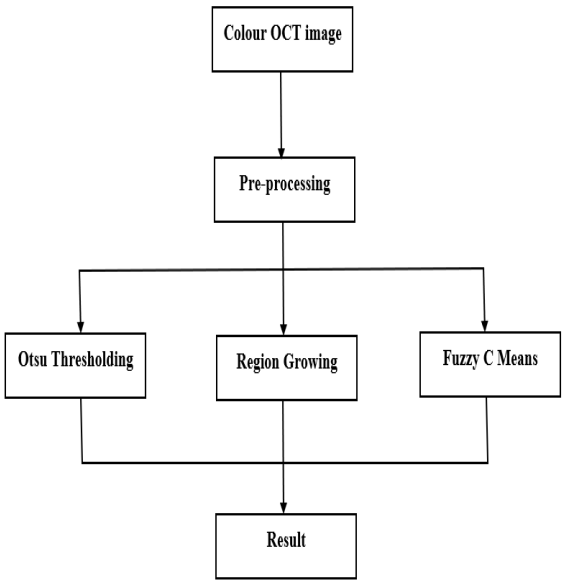


Figure 2. Outline of the proposed work

C. Organisation of the Paper

The remaining portion is structured as follows. Section II includes literature review, Section III comprises methodologies, Section IV comprises Performance analysis, Section V narrates conclusions.

II. RELATED WORK

[10]Tehmina Khalil proposed a method of calculating cup to disc ratio for glaucoma diagnosis. Multilevel Otsu Thresholding techniques are implemented to segment the ILM and RPE layer. Optimal results are achieved when comparing with fundus and clinical CDR values.

[5]R. Nithya compared four different types of segmentation algorithm such as Otsu, Regiongrowing, Hill Climbing and Fuzzy C Means in fundus images. Results reveal that Fuzzy C Means yield less performance error than others.

[9] NoorElaiza Abdul Khalid implemented Fuzzy C Means algorithm for optic cup and disc segmentation. Deployment of morphological operations improves the accuracy of segmented image.

III.METHODOLOGY

A. Pre-processing

Primarily, the colour OCT image is converted into grey scale image (GSI) as there is complexity in processing colour images. Then the contrast of the image is enhanced to achieve fine segmentation[11]. Finally, three segmentation algorithms are implemented to discover the ideal one. Thepre-processed output image is depicted in Figure.3 (b, c).

B. Otsu Thresholding

Segmentation based on thresholding is an effective technique to segment the object from the background's peaks(i.e.) maximum and minimum grey value is considered from the histogram of the image. Optimum threshold value that minimizes the interclass is obtained by iterative process. The pixel below the T value refers to the background and the above value refers to the foreground[7]. It can be expressed mathematically as

$$g(x,y) = \begin{cases} 1 \; iff(x,y) > T \\ 0 \; iff(x,y) \leq T \end{cases}$$

Where g(x, y) is the output.
The segmented output is shown in Figure 4(a)

C. Region Growing Method

Region Growing Method can be otherwise known as pixel-based segmentation. On the basis of pre-defined criteria such as colour, intensity or object, this techniques groups the pixels of the entire image into sub -regions. It involves four step process
(i)Selecting an arbitrary seed pixel from original image
(ii)Selecting a group of similar criterion pixels
(iii)Grow regions by start with seed pixel and append the similar neighbouring pixels
(iv)Stop the process until no pixels achieves the criteria[6].
The Segmented output is shown in Figure 4(b)

D. Fuzzy C means algorithm

This algorithm considers the feature vectors based on intensity. Each vector fits to any number of clusters. Grouping is based on distinctive membership weightage function. Segmentation is based on minimizing the function J (U, V) as follows

$$J(U,V) = \sum_{i} \sum_{k} (u_{ik})^{q} d^{2}(X_j - V_i); k \leq N$$

Where, N-number of vector features;
K=clusters;
q-weighing exponent;
uik-membership I on vector k;
Vi-prototype of the cluster;
J (U, V)-objective function [5].
The Segmented output is shown in Figure 4(c)

IV.PERFORMANCE ANALYSIS

A. Performance Metrics

The performance metrics like Accuracy, Mean Squared Error (MSE), Peak Signal to Noise Ratio (PSNR) are estimated to recognize the optimum one.

1) Mean Square Error (MSE)

MSE is the measure of squared error which calculates the loss of accurate information to be depicted [3]. The mathematical formula to calculate MSE can be given as

$$MSE = \frac{1}{m \times n} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2$$

Where m X n represents the image size;
I (i, j) denotes the original image;
K (i, j) specifies the segmented image.

2) Peak Signal to Noise Ratio (PSNR)

PSNR is the ratio between signal power and noise power. It is used to evaluate the quality of restructured image [3].

$$PSNR = 10 \; log_{10} \left(\frac{255^2}{MSE} \right)$$

Where MSE is the Mean Square Error.

3) Performance ratio (PR)

Performance ratio measures the quality of the estimator [3].

$$\text{PR} = \frac{\text{True edge pixel}}{\text{False edge pixels identified as non edges}}$$

B. Performance Evaluation

Three segmentation algorithms such as Otsu thresholding, Region Growing and Fuzzy C means are implemented in a SD-OCT image. As an outcome, the performance ratio of Fuzzy C means algorithm is relatively higher than the other. The result of the segmented algorithms is summarized as follows.

Table1.Value of MSE and PSNR

	MSE	PSNR	PR
Otsu	5922.21	10.4400	4536.82
Region Growing	5920.38	10.4413	5054.77
Fuzzy C Means	2670.09	13.8995	5566.37

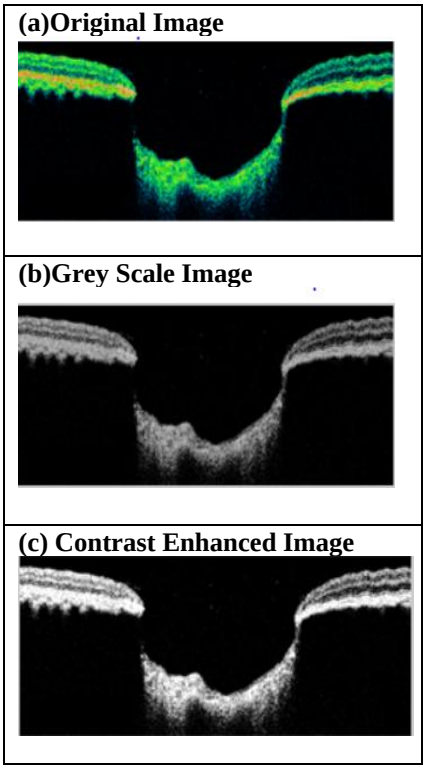
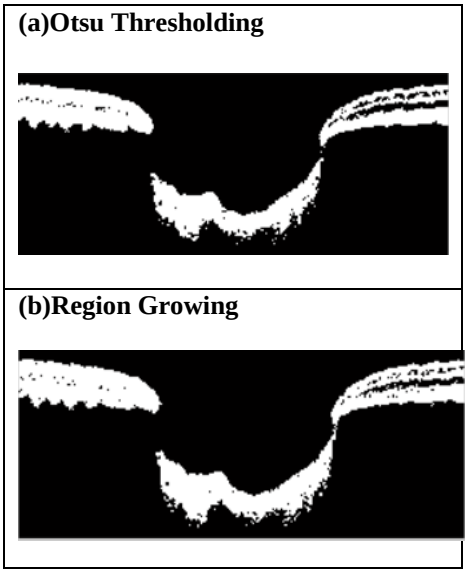


Figure 3. Pre-processing of input image



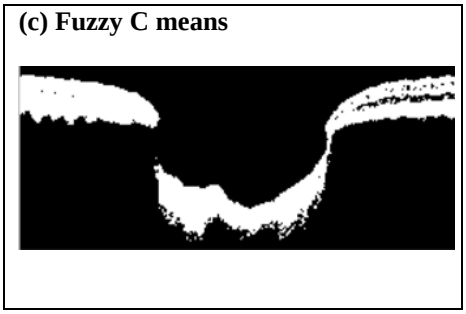


Figure 4. Implementation of Segmentation Algorithms

V. CONCLUSION

The segmentation Algorithms like Otsu, Region Growing and Fuzzy C Means are analysed in this paper. Quality Assessment metrics like MSE, PSNR, PR are calculated. The result conceals that Fuzzy C Means algorithm has better performance than the other. Moreover, the Peak Signal to Noise ratio is relatively higher in Fuzzy C Means**.**

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