Blood Vessel Inpainting based Technique for Efficient Localization and Segmentation of Optic Disc in Digital Fundus Images

[1]Anushikha Singh, [1]Malay Kishore Dutta, [1]M. ParthaSarathi, [2]Vaclav Uher & [2]Radim Burget

[1]Department of ECE, Amity School of Engineering & Technology, Amity University, Noida, India

[2]Faculty of Electrical Engineering, Brno University of Technology, Czech Republic

सत्यमेव जयते
Department of Science and Technology
Government of India

Department of Science & Technology
Ministry of Science & Technology

AMITY UNIVERSITY

BRNO UNIVERSITY OF TECHNOLOGY

Abstract

The Optic disc (OD) nerve head region form basis for study and analysis of various eye pathologies. The shape, contour and size of OD is vital in classification and grading of retinal diseases like glaucoma. There is a need to develop fast and efficient algorithms for large scale retinal disease screening. With this in mind, this paper present a novel framework for fast and fully automatic detection of OD and its accurate segmentation in digital fundus images. The methodology involves optic disc centre localization followed by removal of vascular structure by accurate inpainting of blood vessels in the optic disc region. An adaptive threshold based Region Growing technique is then employed for reliable segmentation of fundus images. The proposed technique achieved significant results when tested on standard test databases like MESSIDOR and DRIVE with average overlapping ratio of 89% and 87% respectively. Validation experiments were done on a labeled dataset containing healthy and pathological images obtained from a local eye hospital achieving an appreciable 91% average OD segmentation accuracy

Proposed Algorithm

The proposed method of OD segmentation is divided into two subsections which deal with OD localization, and OD boundary detection as shown in the Fig. 1.

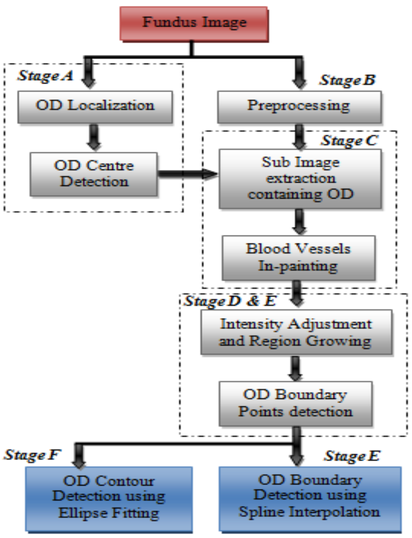

Fig.1. Flow Diagram of Proposed Algorithm

A. Optic Disc Localization:

Optic Disc comprises of a bright disc where the optic nerves terminate. In this work the strategy adopted is to detect the bright intensity regions in the fundus image. In the proposed work, OD is localized using double windowing based method. As shown in Fig 2(a), initially a Kaiser window was run along the rows, The row corresponding to maximum response is taken as the x-coordinate of OD centre. Another hat shaped window as shown in Fig 2 (b) is then passed through all the columns of the marked row. The maximum response thus obtained gives us the y-coordinate of the OD centre. Fig. 2(c) represents the output after passing the Kaiser and Hat shaped Kaiser window along all the rows and along all the columns of marked row of image respectively.

B. Preprocessing:

As a pre-processing step, a 8-bit image is created by combining red channel and green channel images with appropriate weightage.

I (x, y) = 0.75 × I_r (x, y) + 0.25 × I_g (x, y)

where I_r and I_g are the red and green channel of RGB fundus image respectively.

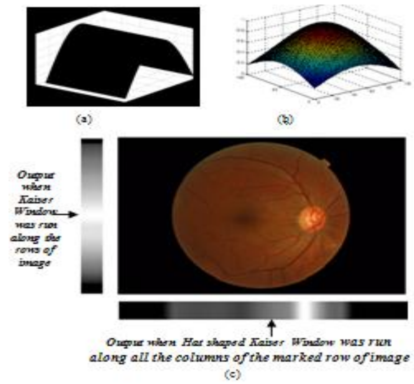

Fig.2: (a) Kaiser Window (b) Hat Shaped Kaiser Window (c) Output when Kaiser window and Hat shaped Kaiser window was run to detect OD centre.

C. In-painting of Blood Vessels.

The proposed algorithm is based on the premise that intensity of an OD pixel is a function of the distance from the optic disc centre. The gray level values decrease as the distance from the centre increases radially outwards.

Let a set of pixels, s_i be at a equal distance, R from the optic disc centre where i=1,2,3…q….k.

Calculate τ_1 = min (s) + $\frac{\{max\ (s) - min\ (s)\}}{2}$

If $s_q < \tau_1$ Then s_q is assumed to be a blood vessel pixel.

To remove the blood vessel pixels$_q$, the pixel value s_q is replaced by the median of these k pixels of s.

$s_{q\ (\text{new})}$ = median $\{s_1, s_2, \ldots.. s_k\}$

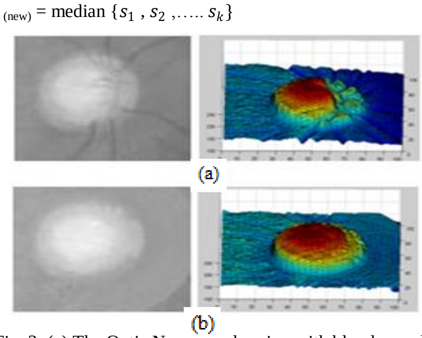

Fig. 3: (a) The Optic Nerve head region with blood vessels and its 3-D surface representation. (b) The Optic Nerve head region with blood vessels inpainted and its 3-D surface representation.

E. Adaptive Threshold Selection

As optic disc is the brighter object so changes in the intensity values can be a consideration to decide the threshold automatically. A 1-Dimensional plot of intensity values along the row containing the OD centre is shown in Fig. 4. Threshold value, τ_2 is thus calculated as

τ_2 = mean { T_i }, where i=1 to n

where T_i is the set of neighboring pixels along the row and n is total number of pixels used for threshold selection.

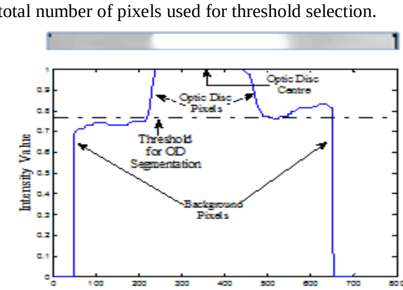

Fig. 4: 1-D plot of gray levels in the optic disc region

Experimental Results

The experiments and validation of the proposed method has been carried out on three different Database of fundus images like MESSIODR, DRIVE and local database. Fig. 5 presents the results of the OD contour detection using the region growing method. Average overlapping scores reported in the Table 1 shows that proposed method performs well for different data sets.

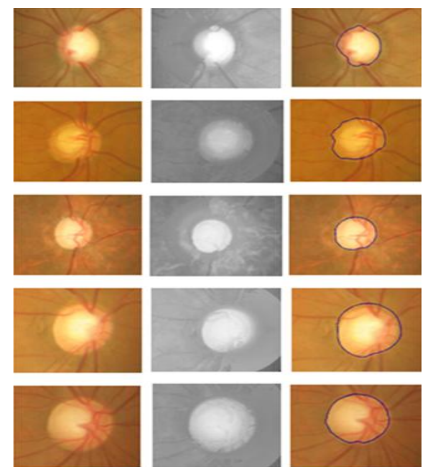

Fig.5: Results of Optic Disc segmentation (a) optic disc appearance (b) in-painted optic disc region (c) OD contour detection

S. No.	Data Base Used	Expert Validation	Average overlapping Score
1.	MESSIDOR-1200 images	Standard Database. Expert Segmented Information Available	0.89
2.	DRIVE – 40 Images	Standard Database Segmented by 2 Expert Ophthalmologist	0.87
3.	Local Data base – 144 Images	2544×1496 Size & JPEG Format Image Segmented by 2 Expert Ophthalmologist	0.91

Table 1: Average overlapping score for OD segmentation.

Conclusions

In this paper, a complete framework is presented for fast, full and automatic localization of OD and its accurate segmentation. The blood vessel inpainitng, region growing method and ellipse fitting is used to segment the OD. The results obtained indicate that the proposed set of algorithms fare well on varied databases, both local and standard test databases. The paper compares the OD detection algorithm performance with existing state of art methods. The proposed OD segmentation algorithm fared well on MESSIDOR database with an overall average overlapping ration of 89% . On the DRIVE database, the results obtained are encouraging average overlapping ratio of 87%. Future work may aim to design algorithms to perform reasonably well on failure cases as well for example, fundus images with high peri-papillary atrophy.

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