Automatic Localization and Extraction of Optic Disc using Darwinian PSO and Morphological Operations

Remya K R, Giriprasad M N

***Abstract:** Locating and earmarking of the optic disc (OD) is a crucial step in the automatic identification of retinal diseases. In advanced stage of proliferative diabetic retinopathy on disk , the delicate blood vessels starts to grow in the disk and hence needs to be clearly identified for better grading of diabetic retinopathy . Furthermore exudates and optic disc share almost same intensity level and may lead to wrong classification if the latter is not identified and removed before the classification. In this paper, we propose an efficient automated system for OD detection and extraction so that exudates are extracted more effectively which will improve overall accuracy in diagnosis of Diabetic Retinopathy. A novel multilevel thresholding optimized by Darwinian Particle swarm Optimization is adopted to detect optic disc in the fundus image. Later Morphological operations are performed to extract the optic disc with precision. The suggested algorithm is tested on four publically available databases like MESSIDOR, DRIVE, and DIARETDB1. Performance of the algorithm is analyzed from the scatter plot. From the scatter plot, it is observed that manually labeled and automatically detected OD centers have a high positive correlation.*

***Keywords:** Darwinian particle swarm optimisation, Morphological Operations, Optic disk, Lesions.*

I. INTRODUCTION

Automatic detection and localization of OD has vital importance in Retinal image processing. OD is oval in shape and can be seen in the back of the eye. OD represents the beginning of the optic nerve having a diameter of 0.06 inch. Variations in anatomy of OD are an indication of various chronic retinal diseases that leads to loss of sight [1]. Evaluation of the optic nerve head is clinically an essential step in identification of optic abnormalities that may lead to vision loss [2]. Masking of OD has clinical importance as it helps in avoiding false diagnosis which can arise due to similarity of OD with bright lesions in color, brightness and intensity [3].

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Distance from macula to OD is 2.5 times OD's diameter. Hence detection of OD will aid in precise detection of macula as well [4]. Image segmentation, has a substantial role in fundus image processing. Commonly used image segmentation methods bring difficulty in real time application systems since they took more computational time [5].
The organization of this paper is as follows: Section II describes existing technologies for detection of optic disk. In Section III methodology to detect, locate and extract OD is proposed. Experimental results and performance analysis are presented in Section IV. Conclusions and future scopes are presented in Section V.

II. LITERATURE SURVEY

OD detection techniques covered in this literature utilizes various OD specific image features such as brightest region, highest image deviation, anatomical structure and distance between OD and macula. Abdullah et al. [6] applied circular Hough transform in order to locate Centre of optic disc followed by grow-cut algorithm to segment it's boundary. Huiqi Li et al.[7] applied PCA followed by modified active shape model to locate the OD from fundus image where edge of optic disk is weak or blocked by blood vessels. Hoover et al.[8] adopted multiple vessel segmentations for the same image in order to strengthen the detection of points where the vessels originates . Finally geometric relationship between the OD and blood vessels were effectively used to detect OD location. Walter et al.[9] proposed a method based on Optic disc has a brightest region by using morphological operations followed by filtering. Because the shape of OD is round or vertically slightly oval, S. Sekhar et al.[10] used circular Hough transform followed by morphological operations for detecting OD. Youssif et al. [11] detected the OD based on the anatomical structure that all blood vessels emanate from the OD in fundus image using directional filters matched with the outgoing vessels. Lu [12] proposed a shape based transformation to detect OD and estimate image discrepancy along numerous radial lines. Prabhu et al. [13] proposed Iterative thresholding and connected component analysis to localize Centre of the OD. Edges of the OD identified by active contour model. From the survey, we observed that many of the OD detection methods fail to produce accurate results if retinal abrasions like red lesion or white lesion are present in the fundus image, since the latter will produce brighter regions than OD. In this paper, we propose an automatic method for detecting and localizing the optic disk in a color fundus image having lesions using Darwinian particle swarm optimization and morphological operation by taking consideration of both Intensity and Size are candidate feature.

III. PROPOSED METHODOLOGY

The proposed method composed of five phases. In the first phase pre-processing is applied to the fundus image. In the second phase histogram of the pre-processed image is calculated and number of thresholds also defined. In the third phase the Darwinian particle swarm optimization technique (DPSO) is applied to find the optimized threshold that maximizes the variance between different classes. In the next phase morphological operations are done to detect and extract OD. In the fifth phase performance of the proposed algorithm is evaluated in various data bases available. Block diagram of the proposed algorithm is shown in Fig.1

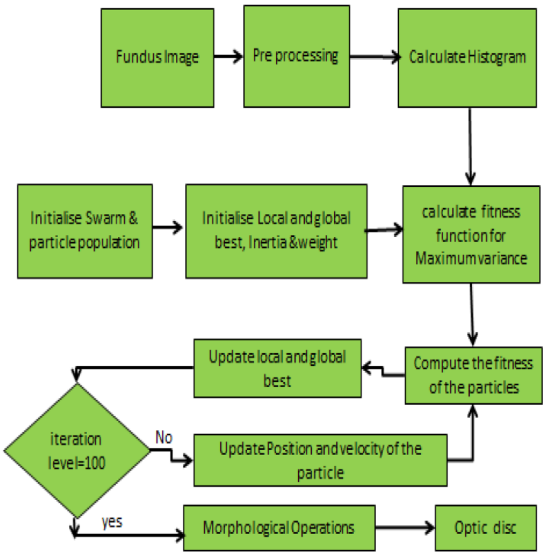

Fig. 1 Block diagram of the Proposed Method

A. Pre Processing

Resizing

Fundus images from various databases having different resolution. Fundus image have 1440 X 960, 2240 X 1488, 2304 X 1536 are the three type of resolution present in the MESSIDOR data base. Size of Fundus Image in DRIVE, and DIARETDB1 are 564X584 and 1152 X 4500 respectively. Processing of this fundus image will take more time. In order to standardize, input images are resized to 500 x 700 x 3 pixels. That will considerably reduce the computational time.

Contrast Enhancement

Fundus images show high variation in contrast level from database to database. Here we are using clipped adaptive histogram [14] equalization to improve the overall contrast of the image. Histogram of input image as well as enhanced image is shown in Fig. 2

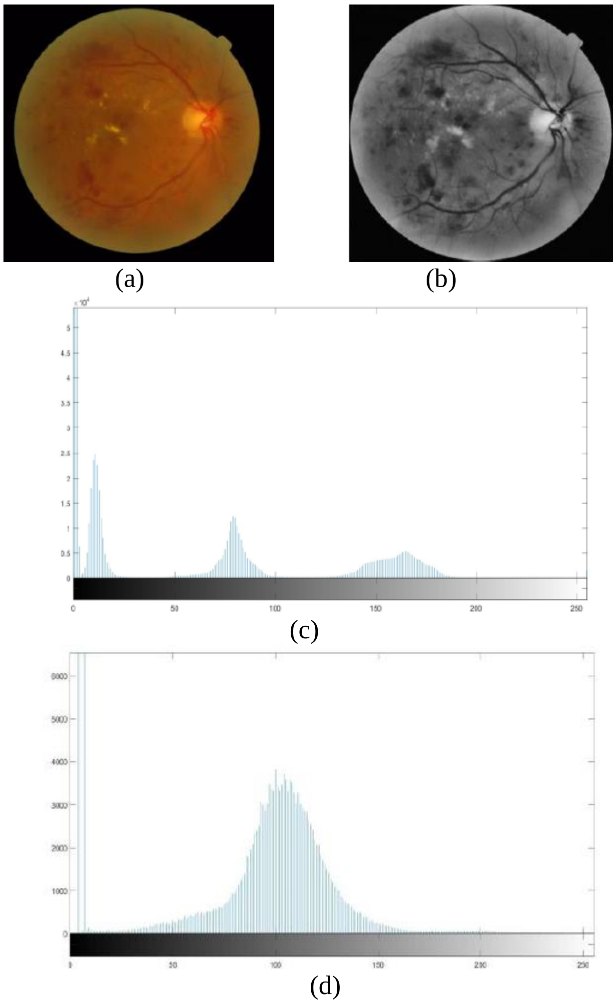

Fig. 2 Clipped adaptive contrast enhancement. (a) Fundus image (b) histogram of input (c) Enhanced gray Image (d) histogram of Enhanced Image

B. OD Localization and Removal

Intensity of optic disk is much higher than the surrounding retinal background, the largest cluster of pixels with the highest gray level represent the candidate region. It is the part with highest intensity of the histogram and to get this portion, the histogram of the pre-processed image is divided into n regions, where the last region with highest intensity represents the optic disc. Fitness function is calculated by the function that maximizes the class variance. Threshold for n regions are optimized using Darwinian PSO (DPSO).

Darwinian PSO (DPSO)

Multiple swarms are present at any time in Darwinian PSO [15]. The basic operating principle of DPSO is to execute multiple simultaneous PSO algorithms with some rules for killing and spawning of swarms also included in DPSO. PSO [16] is initialized with a group of random particles. Each particle is represented as $P_i=(P_{i1},P_{i2},\ldots,P_{iN})$, i =1,2,...,N, where N is the swarm size. Thus, each particle is randomly placed in the n dimensional places as a candidate solution. The best solution a particle has reached so far is known as local best (pbest). Global best (gbest) preserves only a single best solution . Finally all particles will converge to gbest. In every iteration, each particle is updated its gbest as well as pbest. $pbest_i$ at a time step t is updated as equation (1)

$$p_i(t+1) = p_i(t),\ \text{if } f(x_i(t+1)) \Rightarrow f(p_i(t)) \quad (1)$$

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$p_i(t+1) = x_i(t+1)$, if $f(x_i(t+1)) < f(p_i(t))$

Velocity and position of each particle is updated after every iteration as equation (2) and (3) respectively.

$$v_i(t+1) = I * v_i(t) + a_{c1} z_1 [l_{best} - x_i(t)] + a_{c2} z_2 [g_{best} - x_i(t)] \quad (2)$$

$$p_i(t+1) = p_i(t) + v_i(t+1) \quad (3)$$

Where $v_i(t)$ and $p_i(t)$ are the velocity and position of the particle i at time t. I is the inertia weight .ac_1 and ac_2 are the acceleration constants, z_1 and z_2 are random numbers bounded between 0 and 1. Entire process will continue until the predefined iteration level is reached.

Algorithm of DPSO includes rules for Deleting as well as spawns of particles and swarm. Numbers of particles in a swarm are bounded. When a swarm's population drops below minimum, that swarm has to be removed. A search counter will keep on advancing by checking the fitness levels of the particles in a swarm. As it moves forward, the search counter removes the worst performing particles whose fitness has not shown any improvement, once the threshold is breached. A new swarm get formed when lot of particles are deleted and replaced with particles which have incremental change in the fitness over a period. If this condition is met and the maximum number of swarms will not be exceeded, the swarm spawns a new swarm. A particle is produced whenever a swarm achieves a new global best fitness.

Thresholding

Number of thresholds defined in this proposed method is three. Hence the output of DPSO contains only four intensity level. OD belongs to the fourth region since it represents highest intensity level. In order to extract that particular intensity region thersholding is used.

C. Morphological Operations

In order to eliminate the presences of bright lesion from the segmented image, region with highest area is selected as the candidate region. The binary equivalent of this extracted region, processed through various morphological operations represents the mask for the optic disc of the fundus image. In order to reserve correct circular shape, centroid of the mask is calculated. Using the centroid and radius a circular mask of optic disc is generated

IV. RESULT AND DISCUSSION

We tested our proposed technique in three publically available datasets. MESSIDOR [17] DIARETDB1 [18], DRIVE [19]. Each of these datasets are composed of 1200, 89 and 40 retinal images respectively .Proposed method is tested for both normal as well as fundus images with abrasions. Fundus Images with different contrast level and brightness also checked. Simulation is done using MATLAB 2017 Images from different database having varying contrast, illumination and brightness are also tested. Fundus images of different histogram profile will also give accurate results as shown in the Fig. 4. Table I shows the variation of centroid values for manually detected OD with our proposed algorithm. Scatter plot obtained for manually labeled OD and automatically detected OD as shown in figure (5) is linear indicate detection the accuracy of the proposed method. Deviation is represented in pixel values.

Outputs obtained for strings of steps in the proposed algorithm are shown in Fig.3.

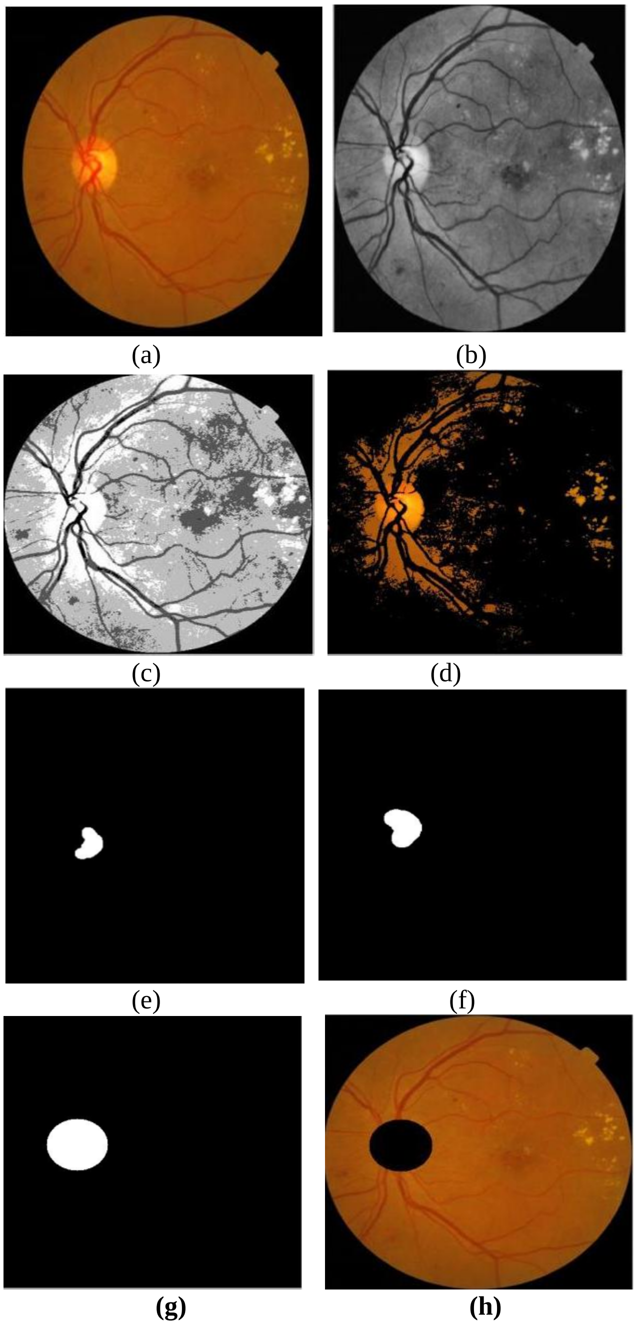


Fig. 3 Strings of steps carried out to perform OD Extraction (a)Fundus Image (b) Enhanced Image (c)DPSO output(d) Intensity mapping(e) Binary image generated after thresholding (f) image after morphological Operations(g) generated mask.(h) Fundus image with extracted OD

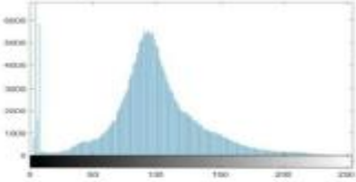
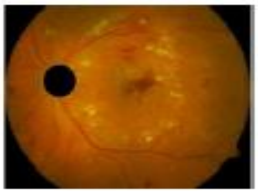
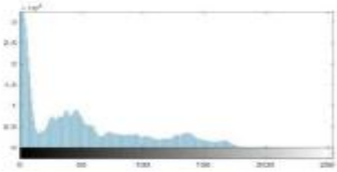
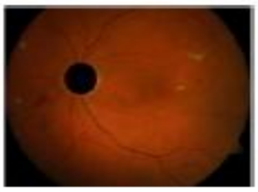
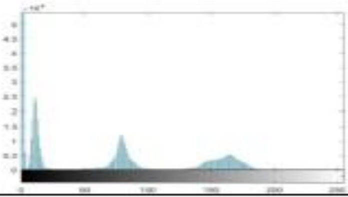
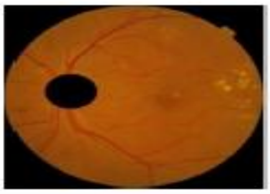
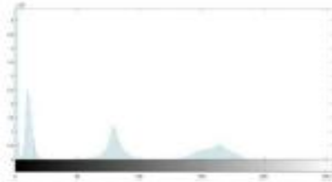
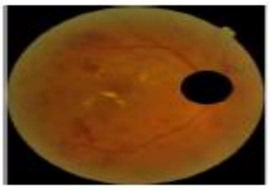
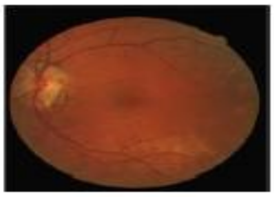
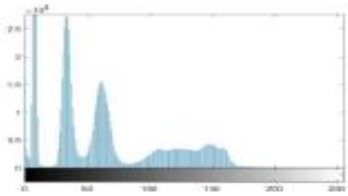
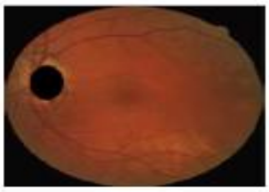
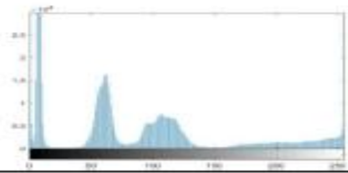
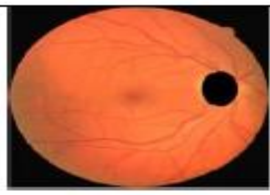
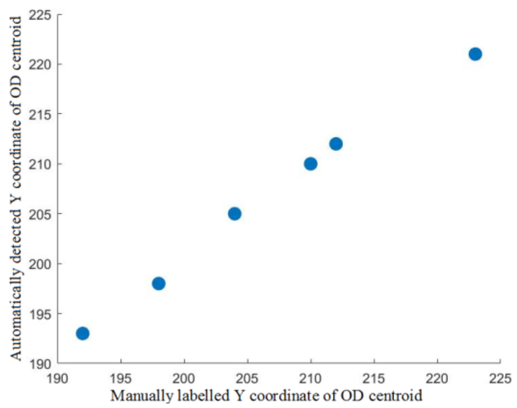
Sl. No	Database	Input Fundus Image	Histogram	OD removed Fundus Image
1	DIARETDB1 IMAGE1			
2	DIARETDB1 IMAGE2			
3	MESSIDOR IMAGE3			
4	MESSIDOR IMAGE4			
5	DRIVE IMAGE5			
6	DRIVE IMAGE6			

Fig. 4 OD Extraction from fundus Images of different Intensity profile

Table 1: Comparison of Manually labeled and automatically detected centroid of OD

Image no & database	Manually labelled centroid		Automatically Obtained centroid		Deviation of manually coordinates and obtained coordinates	
	X coordinate	Y coordinate	X coordinate	Y co ordinate	X coordinate	Y coordinate
Image1 DIARETDB1	208	198	206	198	2	0
Image2 DIARETDB1	152	204	150	205	2	1
Image3 MESSIDOR	108	223	110	221	2	2
Image4 MESSIDOR	335	212	335	212	0	0
Image5 DRIVE	100	192	109	193	9	1
Image6 DRIVE	546	210	546	210	0	0



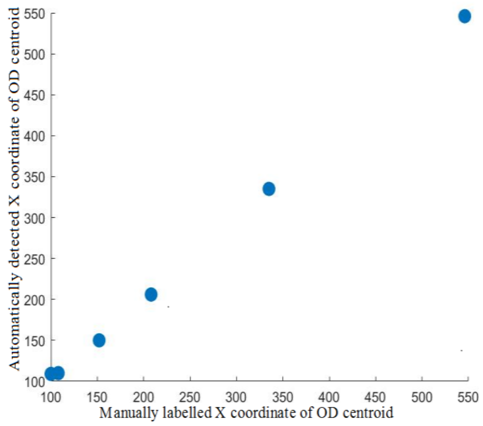


Fig. 5 Scatter plot for manually labeled and automatically detected centroid of OD

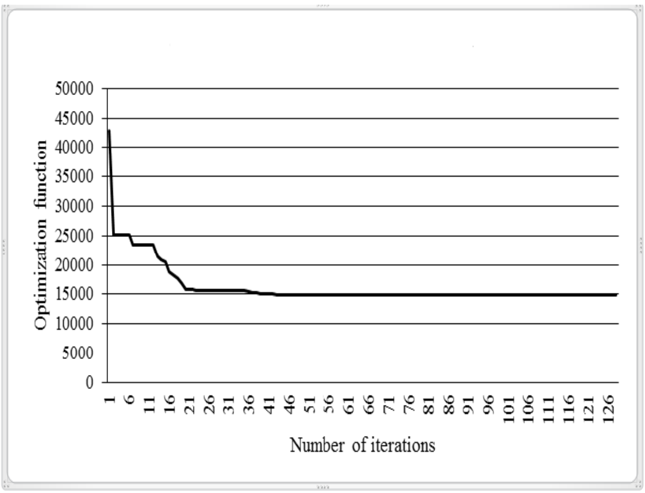


Fig.6 Convergence of DPSO

In each iteration, the objective function in DPSO evaluates the summation of pixel values in various clusters. Cluster centroids do change in each iteration that leads to change in pixel values of clusters. In this work, algorithm reaches very close to convergence in 18th iteration and subsequently converges around 42nd iteration. This is evident in Fig.6.

V. CONCLUSION

The work has focused on enhancing existing automatic systems for DR detection. The proposed method for Extraction of OD can be seen as a first step towards the development of automatic DR detecting systems. In this paper, OD is detected, localized and removed using Darwinian particle swarm optimization techniques followed by Morphological processing. Method is verified on publicly available three databases. The experimental results demonstrated that the new method performs well in extracting optic disk in color fundus images exhibiting different intensity and resolution characteristics. Proposed algorithm precisely detects and extracts OD from fundus images having bright lesions. Results of the experiments are promising and faster in processing compare to other prevailing conventional methods.

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