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Precision-Based Detection and Centralization of the Optic Disc in Color Retinal Fundus Images: A Novel Approach

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ABSTRACT

The detection of Optic Disc (OD) stands as the essential process in color retinal image analysis because it represents the main component of the human retina. The detection of Optic Disc along with its center enables healthcare providers to evaluate the severity of conditions like Diabetic Maculopathy (DM) and glaucoma. This document presents a fresh technique to discover optic disc regions while also determining their central areas. The first process enhances the input image through combination of Gaussian, Median, and Weiner filters to create the enhanced image. After image enhancement the morphological closing operation removes BVs as its next step. Adaptive Histogram Equalization is then applied before extracting Region of Interest using four co-ordinate points that are determined with the help of a drawn grid. The combination of Extended Maxima Transform and Morphological operation produces the OD region as well as its center point. The proposed method delivers evaluation results on MESSIDOR which achieve an accuracy rate of 96.21%. The proposed innovative approach detects OD without using Fovea or Macula while needing grid setup during the first run to obtain Region of Interest (RoI).

Keywords: Blood Vessels (BVs), Optic Disc (OD), Nerve Head (ONH), Optic Cup (OC), Diabetic Maculopathy (DM), Diabetic Retinopathy (DR)

INTRODUCTION

Vision relies on the human eye which serves as an essential component of the body structure. The multi-layered structure of retina exists at the back of human eyes. Photoreceptors numbering at the countless level in this structure transform light energy into electrical signals that travel to the brain through the optic nerve to create pictures. Figure 1 shows the design of the retina together with its fundamental elements. The optic nerve stands out as the brightest oval-shaped section of the retina that contains the Blood Vessels' origin point. The retina receives its nutritional supply through the Blood Vessels which also delivers oxygen. The correct functioning of retinal tissues depends on normal Blood Vessels together with the macula. People have one Fovea which holds the most vital position inside the macula.

The tiny fovea exists as a part of the macula which establishes inside the macula center. A retinal image displays fovea as a critical feature with 0.35 mm of diameter thus the fovea center maintains a distance equivalent to 2 times the optic disc diameter from the disc center. The position and distance relation between fovea and optic disc stays mostly steady. The cone cell population inside this small region produces sharp vision that operates within the central area. Bone marrow leakages from injured BVs in the fovea area trigger vision problems. The identification of fovea region serves as a critical factor for analyzing retinal images. A small elliptical shaped yellowish area named macula locates near the human retina focal point and is known scientifically as macula lutea. The macular region contains numerous light-sensing cells which deliver central and sharp vision but remains the most vulnerable area of the retina which lies towards the side of the optic

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Research Article

disc and lacks the presence of BVs. A human eye receives protection from excessive blue and ultra-violet light thanks to the sun-blocking property of this natural filter substance. Every individual has different macula placement thus researchers need to establish standard four-sided search parameters. The normal retinal image reveals that the diameter of macula measures about 1.5 mm or 0.059 inches. Hospital must envision light differently when macula suffers damage because this loss affects central viewing ability either by introducing darkness or visual distortion. Determination of fovea comes after the location of macula and results in better evaluation of maculopathy grading.

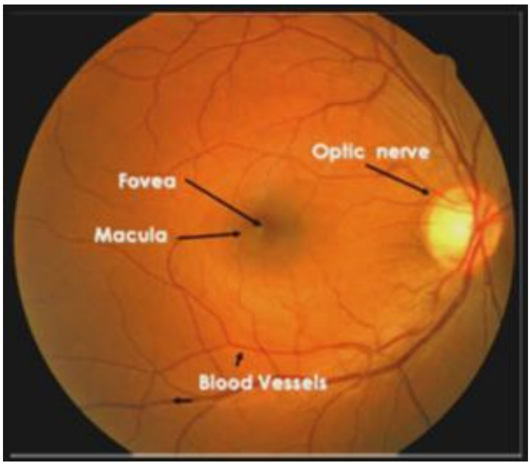

Figure 1: Retinal structure & its principal elements

The retina forms the multi-layered tissue structure which exists at the posterior position within the human eye. Among its millions of light-sensitive cells exists a network that receives light to produce electrical signals. Visual images emerge from brain processing of electrical signals that originate from the OD. This illustration in Figure 1 demonstrates how the human retina appears [1].

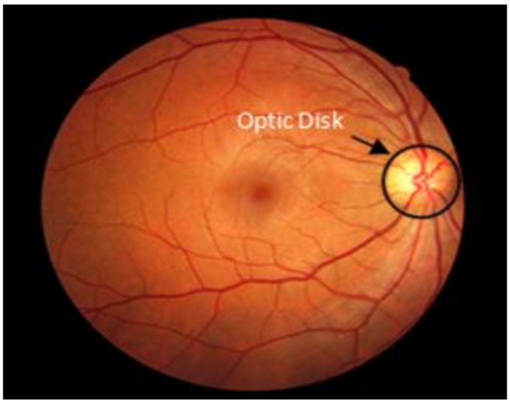

Figure1: (a) Human Retina

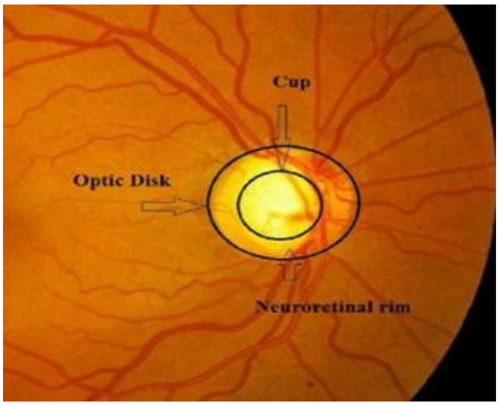

Figure1: (b) Optic Disc and its Appearance

The Optic Disc (OD) or Optic Nerve Head (ONH) represents a principal anatomical element of human retinal structure from which blood vessels arise according to Figure 1(a). Analysts focus on detecting the OD because it stands as the essential feature in retinal image assessment. The precise detection of Optic Disc alongside its center location enables the identification of Fovea and Macula components within the retina. In healthy retinal image OD appears as slightly round yellowish circle brighter than its surroundings and it is recognized as the blind spot since the nonappearance of photoreceptors. Thus, if any light falls on OD region will not be transformed into electrical signals nor sent to the brain for understanding [2,3].

As depicted in Figure1(b) the Optic Cup (OC) stands as the brightest portion of the optic disc since it contains no blood vessels within its central region. The automated detection of Optic Disc boundaries including their core area within retinal images requires much time and frequently leads to misidentification during analysis. Detection methods for optic disc in color retinal fundus images require additional research development.

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Research Article

The OD is the initial point for the origin of BVs which carries oxygen and blood to the retina. The optic disc is oval in shape and measures 1.76mm horizontally and 1.92mm vertically, despite its appearance of being circular. On the nasal side, it's 3 to 4mm distant from the fovea. OD appears clearer in red and green plane than in the blue plane of the RGB image. Therefore, the OD detection method is performed on the red and the green plane of the RGB image to segment more accurately [4,5].

Research about optic disc detection appears in Section 2 of this paper. Section 3 presents every material that enables the proposed process to function. The explanation of this proposed approach appears within Section 4. Section 5 addresses the findings and interpretation, and section 6 wraps up the study by concluding remarks.

1. LITERATURE REVIEW

The detection of OD is crucial in the analysis of retinal images, as it aids in determining the seriousness of retinal diseases such as DM and glaucoma. OD identification can be done in a multitude of ways; Table 1 shows some of the most prominent methods/techniques.

Table 1: Literature Review of Optic Detection Identification

Author’s	Methods/Techniques	Database Used	Accuracy	Remarks
Zahraa Jabbar Hussein, Enas Hamood Al-Saadi [6] -2024	You Only Look Once (YOLO)	Messidor-1 Messidor-2 IDRID	Messidor-1: 99.5%, Precision: 99.9%, Recall: 100%, Messidor-2: 99.1%, IDRID: 98.7%	• This approach is a deep learning-based technique for segmenting and detecting optic discs. • The approach compares Intersection over Union (IOU) values and retains boxes with highest reliability.
Bharkad et al. [7] - 2023	Grayscale morphological dilation followed by median filtering	DiaretDB0	96.92%	• The technique is effective for enhancing image features and reducing noise. • Its effectiveness relies heavily on the input image resolution

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Research Article

Zaaboub, Nihal et.al [8] - 2022	OD Localization: • Preprocessing step using saliency masks • morphological operations • Geometric analysis for OD location utilizing the Circular Hough Transform OD Segmentation • Compute a set of candidates using the region growing algorithm • Combine candidates to form a completed contour of the OD using the Active Contour Model	RimOne IDRID Chase DRIVE HRF Drishti Drions Bin Rushed Magrabia Messidor Local database	RimOne: 98.06% IDRID: 99.71% Chase, Drive, HRF, Drishti, Drions, Bin Rushed, Magrabia, Messidor, LocalDB: 100% Overall success rate: 99.80%	• Employs saliency masks for optic disc detection and region expansion using the Active Contour Model. • Achieves 99.80% success rate across multiple databases, demonstrating high accuracy and robustness. • May have limitations in generalizability to more diverse retinal image datasets.
Kemal Akyol et.al[9] -2021	• Image Processing • Keypoint detection algorithm • LBP texture analysis • Error Distance • Jaccard Index metrics	DRIVE	92.5%	• The research investigated observed key points from various color spaces for texture analysis in order to identify optimal optic disc regions while performing-validation using DRIVE dataset ED and JI metrics. • The texture analysis samples employed in this study are limited, which is a restriction.

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Research Article

Kumar, Shailesh, Abhinav Adarsh et.al[10] -2020	• Pre processing • A morphological iterative procedure detects blood vessels within images. • Optic disc localization byWatershed segmentation method • Fovea localization • Feature extraction of micoaneurysm and hemorrhages • An RBF NN system classifies diabetic retinopathy conditions.	DIABET DB1	93%	• Improved microaneurysm and haemorrhage detection methods are suggested, which will result in a greater number of diabetic retinopathy cases being detected early. • In the DR-affected retinal fundus image, you can discern nearly ringed bright spots like haemorrhages and MAs, as well as some blood vessel remnants.. Just a few vascular residues are visible in a healthy eye fundus picture. • The proposed diagnostic system is more effective at detecting non-proliferative diabetic retinopathy. • system robust and accurate.
Wang, Lei, Han Liu et.al [11] - 2019	• U-net model uses Convolution Neural Network(CNN) • Vessel destiny maps	DIARET DB0 DIARET DB1 DRIONS DB DRIVE MESSIDOR	93.7% 93.2% 85.9% 87.4% 93.5%	• The fundamental part of the proposed method consisted of unifying pixel intensity and vessel density mapping for OD detection and segmentation. • The designed vessel density map served to reveal spatial connections between OD and retinal vessels so researchers could recognize the OD better while removing potential false results from the imaging area. • The proposed system has the potential to provide reasonably accurate segmentation results.

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Research Article

ThresiammaDevasia, Poulose Jacob et.al - [12] 2018	• Morphological Operation • Edge Detection Technique • Circular Hough Transform • Canny Edge Detection	Local Database (587 Images)	97.27%	• Method works well even in an image with low contrast. • Takes less processing time with increase in efficiency and reduction of cost • Improves the processing consistency for each patient's fundus image
Niu, Di, Peiyuan Xu et.al- [13] 2017	-Cascading Method uses Convolution Neural Network (CNN) -Saliency Map to determine the candidate region	ORIGA MESSIDOR	99.33% 99.04%	-When the image brightness is poor or there is a bright component in the image, the method fails to locate OD. -Proposed method is more accurate and promising to employ for mass screening of fundus image
Sengar, Namita, Malay Kishore Dutta [14] -2016	-Region based segmentation -Mathematical & morphological operations	DRIVE MESSIDOR	95.00% 90.00%	- Proposed method is robust to uneven illumination in images. -Method is computationally fast.
Alghamdi, Hanan S et.al [15] - 2016	-Cascade classifier for object detection using Convolution Neural Network (CNN). -Adaboost Classifier -Image is normalized by subtracting the mean image and dividing by the standard deviation.	DRIVE DIARETDB1 MESSIDOR STARE KENYA HAPIEE PAMDI KSSH	100.0% 98.88% 99.20% 86.71% 99.53% 98.36% 98.13% 92.00%	-Proposed method is fully supervised -Method is fast and more accurate
Aggarwal, Manish Kumar [16] -2016	-Morphological Erosion Operation (Disc Shape) -Histogram specification -Count Labelling Method -Dictionary Matching Approach (template size of 80*80 pixels) -Median Filter	DRIVE DIARETDB1	95.00% 98.80%	-Method takes computation time of 16 seconds. -Method ignores the blue channel of the retinal image because of highest noise and minimum information

Journal of Information Systems Engineering and Management
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Research Article

Aggarwal, Manish Kr, Vijay Khare [17] - 2015	-Mean Filter by Size 5*5 -Median filter of size varies from 10*10 to 60*60 -Histogram Matching using KL divergence method (window size of 80*80)	DRIVE STARE	100% 90%	-Method identifies a non OD point as OD point in poor contrast images. -proposed method detects OD with significant accuracy in both normal and pathological images
Popescu Dan, Loretta Ichim et.al [18]- 2015	-Gliding Box Algorithm(Two box-counting method) -Median filter	STARE	96.66%	-Method is simple and efficient in OD localization -Method is less sensitive to input image variation.
Dashtbozorg, Behdad, Ana Maria Mendonça et.al [19] - 2015	-Multiresolution Sliding band Filters (SBF) -Maximal Filter -Smoothing Algorithm	MESSIDOR ONHSD INSPIR-AVR	89.00% 83.00% 85.00%	-Proposed method is independent of camera field of view and size. -Method is robust to changes in illumination and contrast.
Murugan Raman, ReebaKorah, et.al [20] -2015	- Adaptive Histogram Equalization -Contrast Limited Adaptive Histogram Equalization (CLAHE) -Directional Matched Filter	ONHSD	96.96%	-Efficient in detection of OD in low resolution retinal images. -Proposed method takes less time. -Method is tested on a small local database containing 99 images only.
Rama Prasanth. A, M.M. Ramya [21]- 2014	-Active Contour Segmentation -Morphological Operators -Hough Transform -Adaptive Histogram Equalization -Otsu's Automatic Thresholding	Local Database (30 Images)	93.00%	-Method not only dependson circular object, but also it works on dissimilar structures of the OD. -OD is located correctly even though surrounding region of the OD is unclear. - Robustness of the method is tested by taking dissimilar images of the patients at different phases of the DR.

The detection of Optic Disc plays a major role in the detection of abnormalities of the retinal image. After an comprehensive survey as listed in section 2 some of the understandings drawn are mentioned below:

- Exact localization of OD is difficult since the boundary of the OD is not clearly visible.
- Optic disc location is challenging because some part of it is covered by BVs as they originate from OD.
- Variation of OD size, shape and color from one image to the other due to factors such as severity of disease, illumination etc. makes OD detection difficult.
- In case of Age-Related Macular Degeneration (AMD), OD detection may fail since the intensity of OD region and drusen are found to be similar.
- The intensity variation of OD and influence of its surroundings makes it difficult in OD detection.
- Presence of bright areas outside the OD makes detection difficult.
- OD detection becomes difficult when the quality of the image is low and if lesions are present around the optic disc.

Journal of Information Systems Engineering and Management
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https://www.jisem-journal.com/
Research Article

- In the severe stage of Diabetic Retinopathy (DR) and Diabetic Maculopathy (DM), OD detection may fail because of similarity in brightness of the hard exudates and optic disc.

From the above literature review and inference, we came to know that exact identification of OD and tracing its boundary is difficult because of its boundary is not clearly visible and some part it is covered by BV's. Variation in size, contrast around OD region, shape and color are also affects the OD identification. By considering these issues, we have developed a novel method which detects OD and its center with clear boundary[5].

2. METHODOLOGY

The proposed method is divided into three stages, (1) Pre-processing, (2) Segmentation, (3) Detection of OD and its center.

2.1 Pre-Processing

The color retinal image taken from fundus camera may have illumination and other problems so pre-processing is necessary in OD detection. In the retina OD is the brightest part; because of this tracing its boundary is difficult, so that the normalization of illumination helps in tracing OD boundary clearly. The block diagram for the pre-processing is shown in Figure 2.

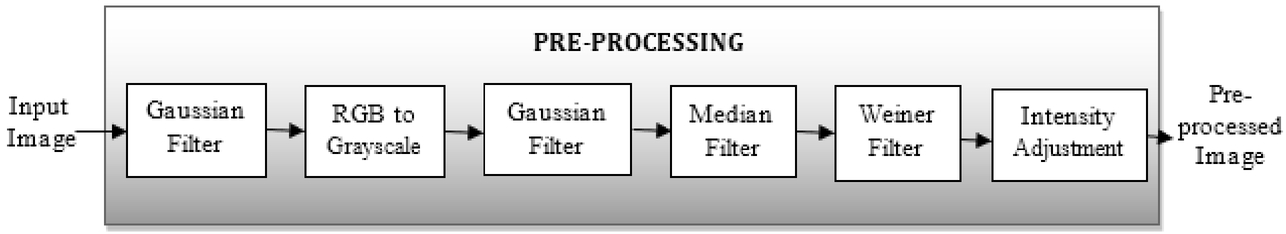

Figure 2: Block Diagram of Pre-Processing Stage

In pre-processing stage initially, an input color image is given to Gaussian filter with increasing in gamma value to correct the illumination, then illumination corrected image is converted into a grayscale image. The grayscale image is again passed through Gaussian filter and then the noise is removed using median with size 3*3 and Weiner filter with size 5*5 . Finally, intensity is adjusted to get pre-processed image.

2.2 Segmentation

In this stage, the grid is first drawn over the pre-processed image. Looking over the grid, select four co-ordinates' points are chosen manually based on the resolution of the data set in such a way that the OD region appears in that specified field for all photos in the MESSIDOR database(it is one time initialization). Finally, create a ROI from a selected area of the pre-processed image.

2.3 Detection of OD

The Extended Maxima Transform [23] generates the whole intensity field after which the disc-shaped structuring morphological operation performs both an open and close function to eliminate erroneous positions. The external border of the object needs tracing for subsequent centroid calculation in a binary image. You can identify both the location and the centre of the OD within the input image by placing this binary data set on top of the original image as depicted in Figure 3.

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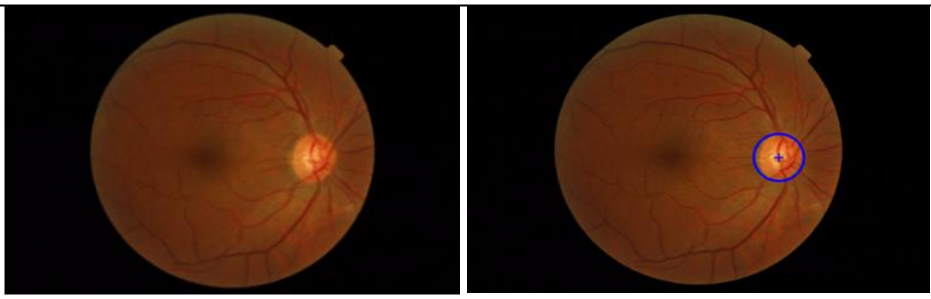

Figure 3: (a) Image of the retinal fundus in colour, taken from the original (b) The centroid of the detected OD area is labelled and superimposed on the original image.

Proposed Model for Optic Disc (OD) Detection:

This model uses a series of image processing and morphological operations, combined with techniques such as median filtering, gamma correction, CLAHE, and extended maxima transform, to detect the optic disc in retinal fundus images. The process ensures noise reduction, contrast enhancement, and accurate detection of the OD boundary and its center.

Input: Color retinal fundus image

Output: Color image with OD boundary and its center

The following steps provide a detailed mathematical model for automatic optic disc (OD) detection in a color retinal fundus image:

Step 1: Input Image

Let $I_{RGB}(x, y)$ be the color retinal fundus image, where x and y represent the pixel coordinates.

$$I_{\{RGB\}}(x, y) \in R^3(Red, Green, Blue\ channels)$$

Step 2: Apply Gaussian Filter

To reduce illumination variations and smooth the image, apply a Gaussian filter $G_\sigma(x, y)$:

$$I_{smooth}(x, y) = I_{RGB}(x, y) * G_\sigma(x, y)$$

Where $G_\sigma(x, y)$ is the Gaussian kernel and $*$ denotes convolution. This step helps in illumination correction.

Step 3: Convert RGB to Grayscale

Convert the color image $I_{RGB}(x, y)$ to a grayscale image $I_{gray}(x, y)$ by calculating the weighted sum of the color channels:

$$I_{gray}(x, y) = 0.2989 \cdot I_R(x, y) + 0.5870 \cdot I_G(x, y) + 0.1140 \cdot I_B(x, y)$$

Where $I_R(x, y)$, $I_G(x, y)$, $I_B(x, y)$ are the red, green, and blue channels, respectively.

Step 4: Apply Gaussian Filter to Grayscale Image

Apply a Gaussian filter to the grayscale image to smooth the image and reduce noise:

$$I_{gray_{smooth}(x,y)} = I_{gray}(x, y) * G_\sigma(x, y)$$

This helps further reduce noise and preserve edges in the grayscale image.

Step 5: Noise Removal Using Median and Wiener Filters

A Median Filter with a 3×3 window is applied:

Journal of Information Systems Engineering and Management
2025, 10(41s)
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https://www.jisem-journal.com/
Research Article

$$I_{median}(x,y) = Median(I\_gray_{smooth}(x,y), 3 \times 3)$$

A Wiener Filter with a 5×5 window is applied

$$I_{wiener}(x,y) = WienerFilter(I\_gray_{smooth}(x,y), 5 \times 5)$$

These filters reduce salt-and-pepper noise and random noise, respectively.

Step 6: Intensity Adjustment Using Gamma Correction

Gamma correction is applied to adjust the intensity of the image. The transformation equation is:

$$I_{\gamma}(x,y) = I_{wiener}(x,y)^{\gamma}$$

Where γ is varied between 0.1 and 0.5 to enhance the contrast of the image.

Step 7: Morphological Closing to Remove Blood Vessels (BVs)

Perform morphological closing to remove blood vessels by applying a disc-shaped structuring element BB:

$$I_{closed}(x,y) = (I_{\gamma}(x,y) \oplus B) \odot B$$

Where $\oplus$ represents the dilation operation and $\odot$represents the erosion operation. This step eliminates small objects like blood vessels.

Step 8: Adjust Intensity Using Default Gamma Value

Re-apply gamma correction using a default value (e.g., $\gamma = 1.0$) for further intensity adjustments:

$$I_{adjusted}(x,y) = I_{closed}(x,y)^{\gamma}$$

Where $\gamma = 1.0$ to normalize intensity.

Step 9: Apply Contrast Limited Adaptive Histogram Equalization (CLAHE)

CLAHE is applied to enhance the local contrast of the image:

$$I_{CLAHE}(x,y) = CLAHE(I_{adjusted}(x,y))$$

This improves the visibility of the optic disc by adjusting the local contrast, particularly in darker regions.

Step 10: Intensity Adjustment Using Gamma Correction

Apply additional intensity adjustment with a modified gamma value (increased from the previous step):

$$I_{\gamma 2}(x,y) = I_{CLAHE}(x,y)^{\gamma}$$

Where the value of γ is fine-tuned for optimal detection.

Step 11: Draw a Rectangular Grid and Select ROI

Overlay a rectangular grid on the image to define a Region of Interest (ROI). The grid consists of four coordinate points that define the boundaries of the ROI. Define the ROI as a region where the optic disc is likely to be found.

Step 12: Extended Maxima Transform for ROI Selection

Use the **extended maxima transform** to identify regions with the highest intensity values within the ROI:

$$I_{maxima}(x,y) = ext\_max(I_{\gamma 2}(x,y), threshold)$$

Where ext_max identifies the local maxima, and the threshold ensures only regions with the brightest intensity (i.e., the optic disc) are selected.

Journal of Information Systems Engineering and Management
2025, 10(41s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

Step 13: Morphological Operation to Remove Incorrectly Placed Regions

Apply a morphological operation using a disc-shaped structuring element to clean up the incorrectly detected regions:

$$I_{clean}(x,y) = (I_{maxima}(x,y) \oplus B) \odot B$$

This step removes regions that do not correspond to the optic disc.

Step 14: Trace Peripheral Border and Calculate Centroid

In the binary image, trace the peripheral border of the detected object and calculate its centroid:

$$Centroid = \left(\frac{1}{N}\sum_{i=1}^{N} x_i\,, \frac{1}{N}\sum_{i=1}^{N} y_i\right)$$

Where N is the number of pixels on the boundary of the optic disc, and (x_i, y_i) are the pixel coordinates.

Step 15: Superimpose Binary Image Over Input Image

Superimpose the detected binary image of the optic disc over the original color retinal fundus image to display the detected OD boundary and its center:

$$I_{final}(x,y) = I_{RGB}(x,y) \oplus I_{binary}(x,y)$$

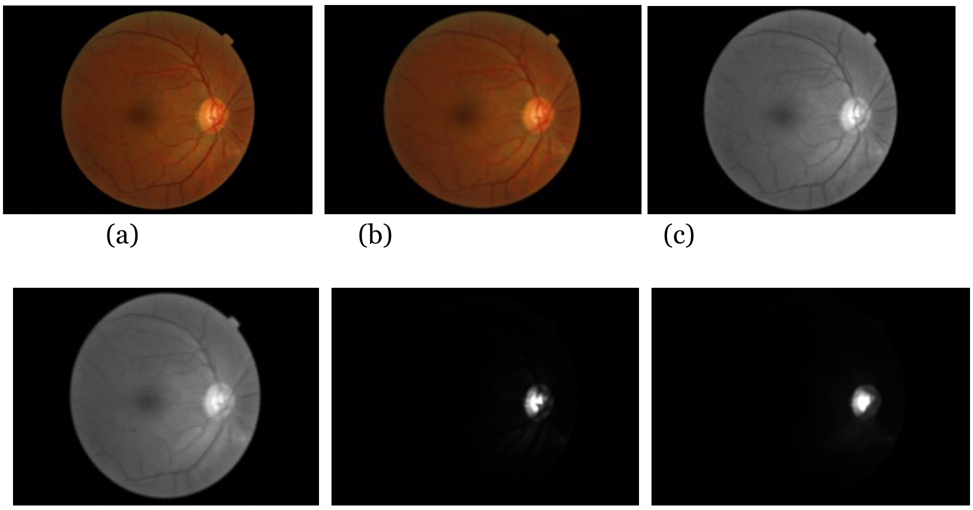
Where $I_{binary}(x,y)$ is the final binary image with the OD boundary detected.

The output is a color retinal fundus image with the OD boundary and its center marked. The centroid of the optic disc (OD) provides a precise location of the OD center, which is useful for further analysis, such as glaucoma detection or optic cup segmentation.

3. RESULTS AND ANALYSIS

The entire coding was done in MATLAB 15 (Release R2015a) on a laptop running Microsoft Windows 8.1 with an Intel(R) CoreTM i7-3520M CPU operating at 2.90GHz and 8GB of RAM.

Both ophthalmologists and non-ophthalmologists can benefit from the proposed method, which is simple and successful in locating the OD centre and its boundary. The method was tested on 400 photographs from the MESSIDOR database, 30 of which were removed owing to lighting concerns, leaving the algorithm with 370 images to test. Complete one instance of the OD detection method is shown in Figure 3.



(a) (b) (c)

(d) (e) (f)

Journal of Information Systems Engineering and Management
2025, 10(41s)
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https://www.jisem-journal.com/ **Research Article**

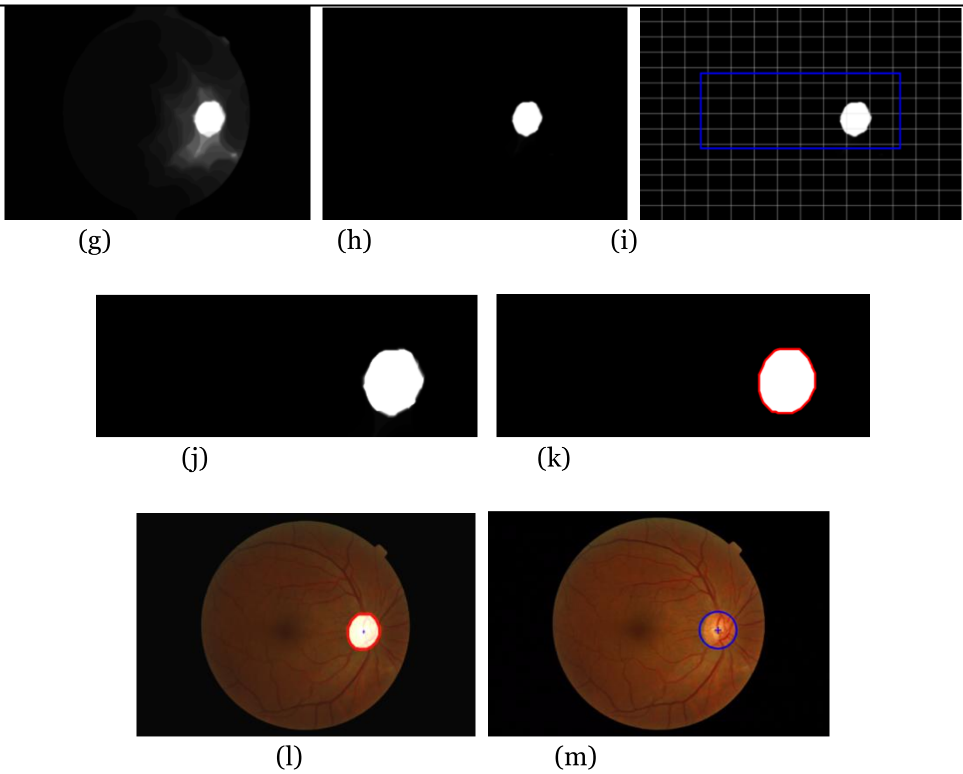

Figure 3: (a) Image of the retinal fundus in colour, taken from the original. (b) After gaussian filter is applied, (c) Converted to gray scale image, (d) Enhanced gray scale image, (e) After adjusting intensity value with increasing 'gamma' value, (f) After removing BVs, (g) After adjusting intensity value with default 'gamma' value, (h)After adjusting intensity value with increasing 'gamma' value, (i) Selected ROI over grid, (j) Detected OD region after applying extended maxima and Morphological operation, (k) (l) The centroid of the detected OD area is labelled and superimposed on the original image.

True Positive (TP), True Negative (TN), False Positive (FP), and False Negative (FN) are the four main concepts used to define accuracy, as illustrated in Eq-1. [21]. The proposed method is detected OD and its center correctly in 356 images out of 370 images so that the TP becomes 356 (i.e. OD is present and proposed method also detected the same) and the method is not detected the OD and its center correctly in 14 images so that FN becomes 14 (i.e. OD is present, but proposed method is not detected). Since the OD is present in all the retinal images, the TN and FP becomes 0. The proposed method's confusion matrix is illustrated in Table 1.

Table1: Confusion Matrix of the Proposed Method

Existence of Fovea	Anticipated (No)	Anticipated (Yes)
Actual-No	TN=0	FP=0
Actual-Yes	FN=14	TP=356

$$Accuracy = \left[\frac{TN + TP}{TN + TP + FN + FP}\right] * 100$$

$$Accuracy = \left[\frac{0 + 356}{0 + 356 + 14 + 0}\right] * 100$$

$$Accuracy = 96.21\%$$

Overlap Coefficient: Overlap coefficient measures the similarity between two objects. The equation for calculating overlap score is given in Eq-2. The result of the proposed method is compared with the ground truth images, where ground truth images are generated manually using original color retinal images of MESSIDOR database.

Journal of Information Systems Engineering and Management
2025, 10(41s)
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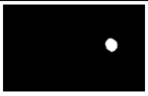
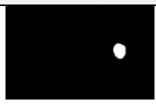
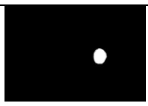
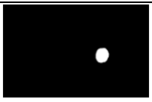
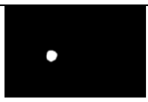
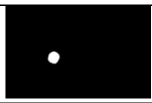
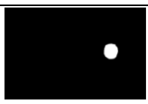
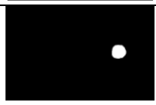
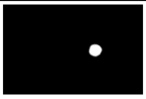
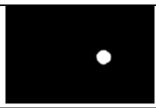
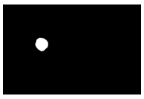
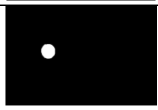
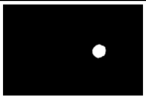
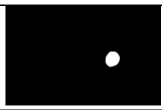
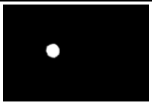
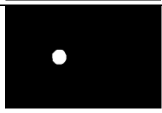
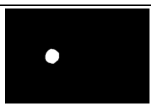
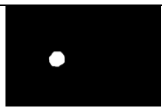
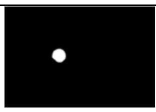
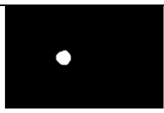
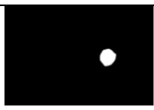
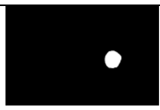
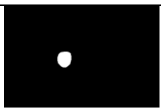
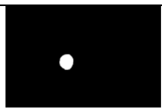
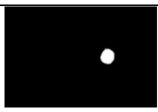
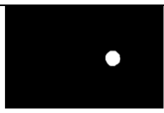
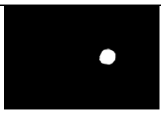
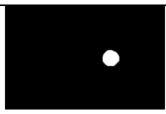
https://www.jisem-journal.com/
Research Article

$$Overlap\ (X, Y) = \frac{|X \cap Y|}{|XUY|}$$

The result of the proposed method is tested against ground truth images and overlapping score is recorded. The result of such 5 instances is given in Table 2.

Table 2: Overlapping Score

Image No.	Ground Truth OD Region	Detected OD Region	Overlap Score	Diameter Difference
1			0.9974	0.1293
2			0.9960	0.4748
3			0.9976	0.0057
4			0.9939	0.3120
5			0.9961	0.1165
6			0.9963	0.7057
7			0.9968	0.2970
8			0.9971	0.1443
9			0.9958	0.1437
10			0.9946	0.2198
11			0.9960	0.3701
12			0.9957	0.2116
13			0.9961	0.7554
14			0.9964	0.1222

Journal of Information Systems Engineering and Management
2025, 10(41s)
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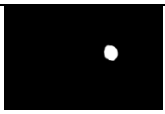
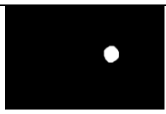
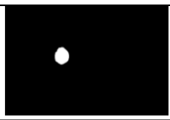
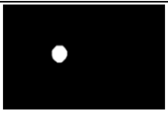
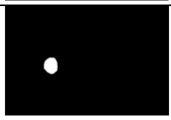
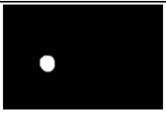
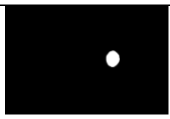
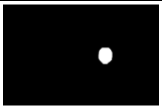
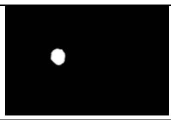
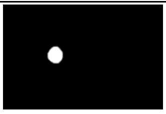
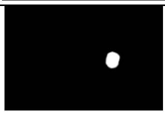
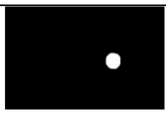
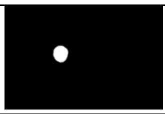
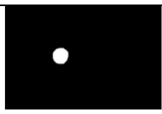
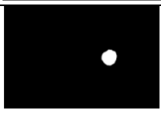
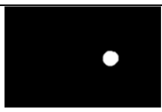
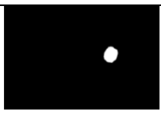
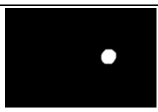
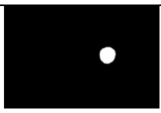
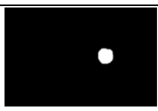
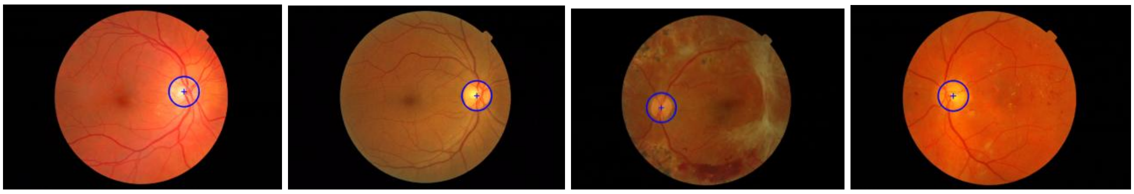
15			0.9966	0.1820
16			0.9948	0.1367
17			0.9963	0.6189
18			0.9949	0.0424
19			0.9968	0.5962
20			0.9973	0.6193
21			0.9966	0.6936
22			0.9966	0.5547
23			0.9975	0.2895
24			0.9967	0.2435
25			0.9980	0.1431

The average overlapping score and diameter difference between ground truth and detected OD of the proposed method are 0.9963 and 0.3251, respectively. The proposed method was tested on 370 images and correctly detected OD in 356 of them. Table 3 shows a comparison of the proposed approach to the current methods.

Results of some images are shown in Figure5. But the proposed method is failed to detect OD in 14 images because of the OD boundary is not clearly visible, some part of it is covered by BVs as they originate from OD, presence of bright and dark areas outside the OD and variation in size, shape and color of the OD from one image to the other due to factors such as severity of disease, illumination etc. The images where method is failed to detect OD are shown in Figure6.



Journal of Information Systems Engineering and Management
2025, 10(41s)
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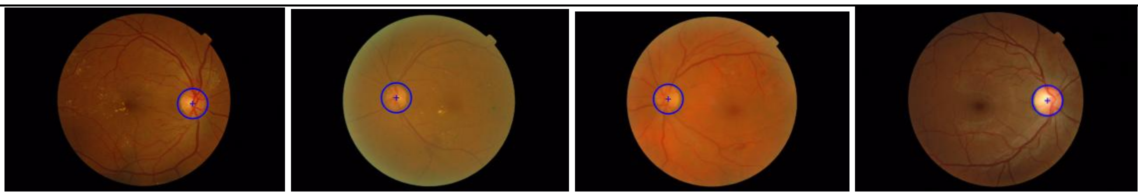

Figure 5: OD detection result of some images

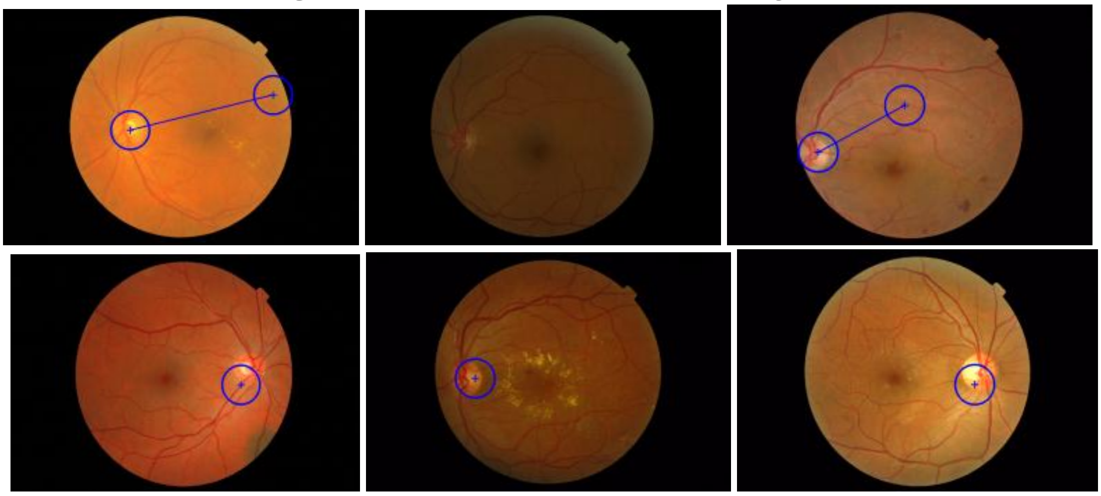

Figure 6: Images where OD detection failed

Table 3: Using the MESSIDOR database, a comparison of OD detection methods was made.

Paper	Method	Accuracy
Namita Sengar, Malay Kishore dutta [14]	Region based segmentation and morphological operations	90.00%
Behadad Dashtbozorg, Ana Maria Mendonca et.al [19]	Multiresolution Sliding band Filters, Maximal Filter, Smoothing Algorithm	89.00%
Proposed Method	*Grid based region Segmentation, Morphological operations*	*96.21%*

4. CONCLUSION

The automatic identification and boundary identification of the optic disc represents the main task within retinal image analysis systems. The optic disc boundary remains unclear because Volatile veiny structures partially cover it which creates difficulties for automatic detection systems. The proposed simple method in this paper successfully detected optic disc center while achieving an overlapping score of 0.9963. The method demonstrates both speed and effectiveness for determining the optic disc center and its boundary area. The proposed detection method functions to define OD boundary with clarity which enhances the detection of both retinal components and diseases. The proposed method achieves 96.21 % successful detection accuracy based on MESSIDOR database evaluation results from 370 images.

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Journal of Information Systems Engineering and Management
2025, 10(41s)
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