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Review Article

Automatic Detection of Optic Disc and Its Center in Color Retinal Images: A Review

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Abstract: Optic Disc (OD) is the most critical component of the human retina where blood vessels originate. In the normal retinal image OD appears as a round, bright yellowish region. An efficient localization of OD in color retinal fundus images is the most vital phase for the retinal image analysis and this information helps in finding severity of retinal diseases. Identification of OD accurately is a very difficult and challenging task because of various reasons, including the presence of lesions around the OD and variation in size, shape and color of the optic disc. In this review paper, a brief introduction about OD and some important properties of it are described. A literature survey on OD detection and the complications involved in OD detection are also discussed in this paper.

Keywords: Optic Disc (OD), Optic Nerve Head (ONH), Optic Cup (OC), Age Related Macular Degeneration (AMD), Diabetic Retinopathy (DR), Blood Vessels (BVs).

1. Introduction

Optic disc is also known as the Optic Nerve Head (ONH). It is one of the chief anatomical components of the human retina and it is the most acute retinal part to be identified in the retinal image analysis. In the normal retinal image OD appears as a slightly round yellowish circle brighter than its surroundings. The optic disc is recognized as the blind spot because of the absence of photoreceptors in the OD region. Optic nerve passes through the OD to connect to the brain that transmits visual information to the brain [1].

The OD is the initial point for origin of Blood Vessels BVs which carries oxygen and blood to the retina. The optic disc may look round in shape, but it is normally oval in shape with an approximate size of 1.76mm horizontally and 1.92mm vertically. Optic disc is located to the nasal side of the fovea with 3mm to 4mm distance. Since OD is a bright yellowish region in the retina, it appears clearer in the red and green plane than the blue plane of the RGB image. Therefore, identification of OD is performed only on the red and green plane of the RGB image [2] [3].

The central portion of the optic disc is called the Optic Cup (OC) where blood vessels are absent. Optic cup is the brightest section of the OD as shown in the Figure1. In the retinal image analysis, the most important job is to identify the OD accurately which is time consuming and prone to error. Because of this, more effort is needed to identify OD automatically in the color retinal fundus image.

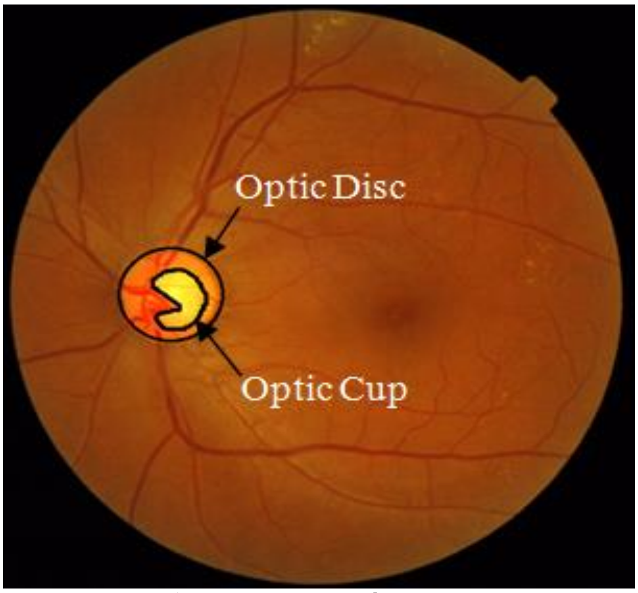

Figure 1: Optic Disc and Optic Cup.

The rest of the survey paper is structured as follows; section 2 describes a brief literature review on OD detection. Issues involved in OD detection are mentioned in section 3. The conclusion is presented in section 4.

2. Related Work

There are a number of methods for optic disc identification. Some of the methods/techniques are discussed in Table1.

Table 1: Literature review on optic disc identification.

Author's	Methods/Techniques	Database Used	Accuracy	Remarks
Kemal Akyol et.al [4] -2021	• Image Processing • Keypoint detection algorithm • LBP texture analysis • Error Distance • Jaccard Index metrics	DRIVE	92.5%	• The current work used a texture analysis on the region of interest in terms of observed keypoints in several color spaces to find the best potential optic disc region, with validation using the ED and JI on the DRIVE dataset. • The texture analysis samples employed in this study are limited, which is a restriction.
M.Elena Martinez-Perez et.al [5] -2019	• Pre processing • Multispectral analysis • Morphological analysis • Shannon entropy • Hough transform	SABRE (local database) DRIVE MESSIDOR	99.4%	• The findings confirm the premise that utilizing all of the color information is advantageous. • The goal of this research is to develop an algorithm that can help with the analysis of the retinal vasculature's quantitative properties for huge numbers of retinal pictures.
ThresiammaDevasia, Poulose Jacob et.al [6] -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.
Dilniu, PeiyuanXu et.al [7] – 2017	• Cascading Method uses Convolution Neural Network (CNN) • Saliency Map to determine the candidate region • Softmax regression model to predict the final class	ORIGA MESSIDOR	99.33% 99.04%	• Method failed to locate OD if a bright component is present in the image or brightness is low. • Proposed method is more accurate and promising to employ for mass screening of fundus image.
NamitaSengar, Malay Kishore dutta [8] -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.
Hanan S. Alghamdi, HongyingLilian Tang, et.al [9] - 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.
Manish Kumar Aggarwal, Vijay Khare [10] -2016	• Morphological Erosion Operation (Disk Shape) • Histogram specification • Count Labelling Method • Dictionary Matching Approach (template size of 80*80 pixels)	DRIVE DIARETDB1	95.00% 98.80%	• Method takes a computation time of 16 seconds. • Method ignores the blue channel of the retinal image because of highest noise and minimum information.

	• Median Filter			
Manish Kr. Aggarwal, Vijay Khare [11] -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.
Dan Popescu, Loretta Ichim et.al [12]- 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.
Behdad Dashtbozorg, Ana Maria Mendonca et.al [13] - 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 the camera field of view and size. • Method is robust to changes in illumination and contrast.
Murugan Raman, ReebaKorah, et.al [14] -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 [15]-2014	• Active Contour Segmentation • Morphological Operators • Hough Transform • Adaptive Histogram Equalization • Otsu's Automatic Thresholding	Local Database (30 Images)	93.00%	• Method not only depends on circular objects, but also it works on dissimilar structures of the OD. • OD is located correctly even though the 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.

3. Issues in Optic Disk Detection

- 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 on it 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.
- 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.

4. Conclusion

In retinal image analysis optic disc localization is the most important landmark for identifying the severity of retinal diseases. Since OD appears as the brightest spot in the color retinal fundus image, the localization may look simple but recent studies shows that tracing the OD boundary is a very difficult and challenging task when validation is done over a large dataset. This review paper discusses a brief introduction about OD and its key properties. It also discusses the recent method/techniques involved in OD detection with some issues that can be addressed with better techniques and methods.

We have tried to cover the most recent methods/techniques used to localize the OD. In this literature review most of the works present the identification of OD and its center accurately, but many works failed to trace the accurate boundary of the OD. To achieve more accuracy and tracing exact boundaries of the OD, machine learning and deep learning techniques such as Support Vector Machine (SVM), Neural Network (NN), Deep Convolution Neural Network (DCNN), five layers CNN with drop out mechanism can be used.

Conflict of Interest
The author declares no conflict of interest.

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Author's Contributions
We, conceptualized the research idea, designed the methodology, and wrote the entire manuscript as the
sole authors of this study. The authors were responsible for all aspects of this research review, including data collection, preprocessing, model development and documentation.

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