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Review on Optic Disc Localization Techniques

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Abstract-The optic disc (OD) is one of the important part of the eye for detecting various diseases such as Diabetic Retinopathy and Glaucoma. The localization of optic disc is extremely important for determining hard exudates and lesions. Diagnosis of the disease can prevent people from vision loss. This paper analyzes various techniques which are proposed by different authors for the exact localization of optic disc to prevent vision loss.

Keywords: *Localization, Optic Disc (OD), Corner Detector, Vessel Convergence, Vessel Enhancement*

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I. INTRODUCTION

The retina is thin layer of tissue, in which the blood vessels are clearly visualized. Its purpose is to receive the light and convert it to neural signals and these signals are send to the brain for the visual recognition [16]. The brightest region in the retinal image is the optic disc. The blood vessels originate from the center of optic disc. It is classified according to its size. The slit lamp examination is done with fundocopic lens from which vertical and horizontal disc diameter are obtained. The Optic disc cup increase in size with the disc size, where large cups are obtained in healthy eyes. It is also called as optic nerve head and blind spot [3]. Optic disc is not sensitive to light because of the absence of light sensitive rods and cone in the retina, so it is called as blind spot. Optic disc is located in the vessel convergence region. The localization of optic disc is done mainly to save people from vision loss.

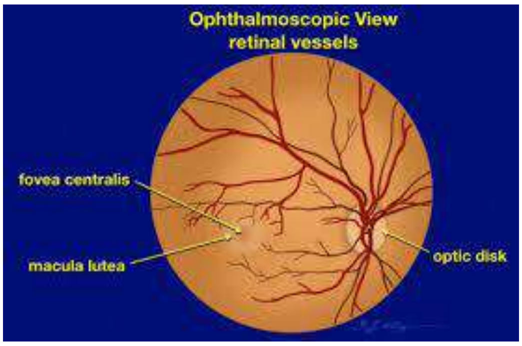

Fig 1. Optic Disc

Optic disc is mainly used for detecting various diseases such as diabetic retinopathy and glaucoma. It can also be used for the detection of other anatomical structures such as macula and retinal vessels [10].

The major health problem that has increased recently is the Diabetic retinopathy. It is an asymptomatic disease which can lead to loss of vision. About 10,000 people lose their vision due to diabetic retinopathy.

Retinal Treatment is the best method for reducing the vision loss. Regular eye examinations are required for detecting and treating the diabetic retinopathy [10].

The detection of optic disc in retinal image is very important for the exact localization of optic disc. To find the abnormal structures in the image it is to be mask out from the analysis. Optic disc detection is one of the important step for diabetic retinopathy and glaucoma for screening system. The optic disc boundary and the localization of macula is used for the detection of exudates and diabetic maculopathy. In diabetic maculopathy masking the false positive OD leads to improve in performance of lesion detection. The OD position is used as a reference length for measuring the distances in retinal images. The location of OD becomes the starting point for vessel tracking. Thus the optic disc localization is performed [4].

II. Techniques For Optic Disc Localization

Optic disc localization is extremely important for determining the hard exudate lesions or nonvascularization. By localizing the optic disc, blindness can be reduced. To localize Optic Disc various methods are available. In this survey some of the methods are discussed below.

2.1 Approximate nearest neighbor field based optic disc detection

A feature match ANNF algorithm Proposed in [14], to find the correspondence between the optic disc images. The correspondence between the images provides patches in the query image which are close to the reference image. This method uses only one retinal image which is used to extract the reference optic disc image. The given input image is preprocessed, in which reference optic disc is considered as an algorithm and the target image is considered as feature match. Then query image is preprocessed, i.e. it is equalized and converted to grayscale. ANNF searches the nearest patches

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with low dimension, but it does not produce exact match. Accuracy is improved by using image coherency. The ANNF map point out the location of patches in query image which is same as of the reference image. Using these patches, the likelihood map (L) is computed. By using this L map the maximum location is find out to localize the optic disc.

2.2 Feature match: A general ANNF estimation technique and its Applications

ANNF algorithm Proposed in [13], to estimate the mapping between image pairs. This generalization is achieved by spatial-range transforms and it enables to handle various vision applications, 1) optic disc detection- It mainly focus on medical images, for the localization of optic disc to produce as a target image. 2) super- resolution- It focus on synthetic images, which uses source image. The input is a reference image, which provides template for OD. It extracts the template from grayscale image, after histogram equalization. The optic disc which is extracted from the image forms a target image. The reference image is preprocessed as like query image. Likelihood map is initialized, to find the optic disc location in the image. After initialization of L map, it find out the number of times each patch is mapped in the query image. By using the L map it estimates the optic disc location.

2.3 Retinal vessel segmentation by improved matched filtering-evaluation on a new high-resolution fundus image database

Segmentation of retinal vessels proposed in [12], to segment the blood vessels in the fundus images. The segmentation uses MF approach in the preprocessed image. The preprocessed image with five kernals, rotates into 12 orientations. The parametric image gets fused, so maximum responses are selected for each pixel. A blood vessel tree is obtained after threshold of fused image. The noise of the image structures are removed using morphological operators. A B-spline correction method is used to improve the accuracy of the proposed method. The two-dimensional MF exploits the correlation between image areas. The maximum response is selected from the set of parametric images for each pixel by using joint parametric image. The image is thresholded to obtain vascular tree. The blood vessels are considered as objects and remaining parts are considered as background of the image, where pixels inside the FOV are selected. The result of the thresholding algorithms are evaluated and compared using HRF database. Finally, morphological cleaning method is used to remove the artifacts, which are not connected to the vessel tree.

2.4 Teleophta: Machine learning and image processing methods for teleophthalmology

Diabetic retinopathy screening proposed in[2], is done by using teleopthalmology screening, in which image deals with the normalization technique, which uses FOV photographs as size invariant. The parameters are defined based on the size. Then segmentation is done for border reflections. The reflections appear as bright and moon shaped regions. Then segmentation carried out. Then detection takes place and vessels are segmented and OD is detected and finally the macula. The vessel masks are analyzed to extract the structures. The detection starts with threshold to select bright regions as like optic disc. The vessel mask which is previously computed is used to select the correct position of the optic disc. An exudates detection method is developed for a heterogeneous database. The exudates regions are extracted by using the morphological opening operation method. Finally each exudate region of 30 characteristics is extracted for the purpose of training a random forest model. A random forest classifier is used to compute the risk of each exudates region.

2.5 Fast Localization and Segmentation of Optic Disc in Retinal Images Using Directional Matched Filtering and Level Sets

The OD localization and segmentation algorithm proposed in [15], are used for the retinal disease screening. The OD locations are identified in the image using template matching. It is then designed to adapt various image resolutions. Then the patterns in OD determine the location. A hybrid levelset model is used to combine both the region and the local gradient information that is applied to the disc boundary segmentation. The blood vessels are removed using morphological filtering operation. The OD size can be calculated by FOV camera. Then the OD candidates are find out by using CIElab lightest image. Then the result is the normalized image. The optic disc candidates are selected according to the template responses. The segmentation uses morphological reconstruction to suppress the bright regions. At last the performance is evaluated by the combination of two test images.

2.6 Accurate and Efficient Optic Disc Detection and Segmentation by a Circular Transformation

OD detection and segmentation technique proposed in [7], is used for the circular transformation, which captures the shape of the optic disc and variation in the optic disc boundary. First a retinal image is derived by combining both the red and green components it determines the intensity of the image. Then preprocessing takes place. According to the shape of the OD and the variation in the OD boundary the circular transformation is designed. Finally retinal image is converted to the OD map. Then optic disc is localized.

2.7 Automatic Optic Disc Detection from Retinal Images by a Line Operator

An optic disc detection technique proposed in [8], is used to extract the lightness portion in the retinal image. The retinal images are preprocessed before the detection of optic disc. Then it is smoothed to enhance the brightest region associated with optic disc. Then the circular regions are detected using the line operator. The optic disc is located accurately using the orientation of the line segment. By using orientation map the optic disc is localized. The classification is done between the peak center and the surrounding of the peak center. By the combination of the peak amplitude and the image intensity the optic disc is detected.

2.8 Fast Localization of the Optic Disc Using Projection of Image Features

Optic Disc brightness and retinal vessel orientations features proposed in [9], based on two projections of image features that encode x coordinate and y coordinate of the optic disc. The one dimension projections determine the location of optic disc. It avoids two dimension image space and it improves the speed of the localization process. For the localization of OD, the process gets split into two steps. First the horizontal location of OD is determined using the image features that are projected to the horizontal axis. In Second step it determines the correct vertical location. Assume, if horizontal location is successfully identified, then the only aim is to find the correct vertical location. This can be found by feature_map_2 on the vertical axis. It is then find out as the maximum peak of the one dimensional signal.

2.9 Automated optic disc detection in retinal images of patients with diabetic retinopathy and risk of macular edema

The optic disc detection proposed in [1], based on two methodologies. On one side it belongs to the image contrast and the structure filtering techniques optic disc location and on other side edge detection technique and Hough transform are used for the circular approximation of the optic disc. For the localization of optic disc there are three detection methods they are, 1) Maximum difference method- which provide the difference between the maximum and minimum calculation of the images using filter. 2) Maximum variance method- The maximum pixels are selected which are located in the brightest region. 3) Low pass filter method- It returns highest grey pixel. The OD boundary provides a circular approximation of optic disc using segmentation. The original retinography are extracted using the pixel in the optic disc. The coordinates are provided using localization methodologies, 1) The blood vessels are eliminated using dilation and smoothing are done using filter. 2) The gradient magnitude is obtained using prewitt operator. 3) The noise of the image is reduced using morphological erosion. 4) Finally circular approximation of optic disc is obtained using Hough transform.

2.10 Fast detection of the optic disc and fovea in color fundus photographs

KNN regressor technique proposed in [11], used to predict the pixel distance, based on several features. The lowest distance in the fovea is selected as fovea location. First the image is preprocessed. Then the gradient magnitude is calculated by the detection of FOV in the red plane of the image. The optic disc and fovea localization uses green plane. The green plane image is blurred using a Gaussian filter to remove the low frequency gradients. The anatomical structure problems are defined as a regression problem. The goal is to find the dependent variable. The threshold is applied to get a vessel map. This method combines the cues that is measured directly and the segmentation of retinal vasculature. The optic disc center is selected according to the lowest predicted distance of optic disc. Using this, fovea is defined and it is selected as the fovea location in the fovea search area.

2.11Feature extraction in digital fundus images

An exudate segmentation algorithm proposed in [5], used to enhance the exudates regions. First the image is preprocessed to improve the contrast of the lesions. Next optic disc is eliminated using entropy. A Fuzzy c-means clustering algorithm is used to extract the exudates regions. The FCM algorithm changes to standard FCM using spatial neighborhood information. Then vessel skeleton map is obtained. The neighbor pixels are obtained for each skeleton pixel. The vessels are detected by identifying the pixels with one neighbor vessel pixel. The disc boundary is detected using contour model. First image is preprocessed, then dilation carried out and OD boundary is determined. Then FCM algorithm is used to segment the exudates. Finally SVM classification is used to provide the exact lesion from non-lesion.

TABLE 1: COMPARATIVE ANALYSIS OF OPTIC DISC LOCALIZATION TECHNIQUES

PAPER TITLE	ALGORITHMS/ METHODS	FEATUR ES	BENEFITS	DRAWBACKS
Approximate Nearest Neighbor Field based optic disc detection [14]	• Optic Disc Location- Approximate Nearest Neighbour.	Shape, Colour, Brightness	• Performance is good. • Less computation time.	• Less accuracy. • Dislocation of optic disc.
Feature match: A general ANNF estimation technique and its Applications [13]	• Feature Extraction- Walsh Hadamard Transformation. • K-NN Search- KD-tree algorithm.	Colour, Gradient	• Accuracy is good. • Coherency is good.	• Regeneration of color information becomes a difficult problem. • Differences in image intensities.
Retinal vessel segmentation by improved matched filtering-evaluation on a new high-resolution fundus image database [12]	• Preprocessing- B-Spline- based illumination correction. • Correlation detection between images- 2D Match Filtering.	Shape, Intensity	• Reduces the false-positive detections. • High Resolution.	• Poor Performance. • Evaluation is performed on low-resolution images.
Teleophta: Machine learning and image processing methods for teleophthalmology [2]	• Preprocessing- Field of View. • Anatomical detection- Morphological filter.	Size, Shape, Contrast	• Small vessels can be detected. • Help in rising of new population health challenges.	• Lowers the specificity. • Poor Performance.

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Fast Localization and Segmentation of Optic Disc in Retinal Images Using Directional Matched Filtering and Level Sets [15]	• OD Size Estimation- Field Of View and image resolution. • OD Segmentation- morphological processing. • OD Localization- Template Matching.	Size, Shape, Brightness	• Increase robustness. • Accuracy of Optic Disc detection.	• It is expensive. • Optic Disc detection is difficult.
Accurate and Efficient Optic Disc Detection and Segmentation by a Circular Transformation [7]	• Preprocessing- Down-Sampling. • OD Segmentation and Detection- B-Spline Filtering.	Shape, Brightness	• Algorithm runs faster. • Accuracy gets improved.	• OD segmentation may introduce error. • Optic Disc boundary pixels cannot be determined based on symmetry.
Automatic Optic Disc Detection from Retinal Images by a Line Operator [8]	• Preprocessing- Bilateral smoothing Filter. • Circular Detection- Line Operator. • OD Detection- 2D Circular convolution Mask.	Brightness, Image Variation	• High Detection speed. • Retinal lesions can be tolerated.	• Poor Performance. • Various types of imaging artifacts cannot be handled.
Fast Localization of the Optic Disc Using Projection of Image Features [9]	• OD Localization- Model based method.	Space, Intensity	• Less computation time. • Search-space dimensionality is reduced.	• It is expensive. • Robustness for localization of OD is difficult.
Automated OD detection in retinal images of patients with diabetic retinopathy and risk of macular edema [1]	• OD Localization- Maximum difference and variance method, Low-pass filter method. • Segmentation of OD- Dilation, Prewitt operator, Erosion, Circular Hough Transform.	Shape, Colour, Depth	• Accuracy is increased. • Robustness is increased.	• Poor Computation time. • High Megabytes images are not accepted.
Fast detection of the optic disc and fovea in color fundus photographs [11]	• Preprocessing- Field Of View. • Position Regression – Regression	Size, Space	• Performance is increased. • Increase in robustness.	• Poor contrast. • Does not make strong assumption

III. Conclusion

This paper analyzes various techniques which are proposed by different authors for localizing the optic disc. Diabetic retinopathy leads to vision loss, where various preventive measures are taken to save people from vision loss. It focuses on the localization of optic disc. Various approaches are used for OD localization they are, Approximate Nearest Neighbour Field (ANNF), optic disc detection technique and Match filtering methods. These techniques are used to localize the exact optic disc. The performance is decreased due to optic disc dislocation. In future advanced algorithm can be used to improve the performance.

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