A Review of Retina Blood Vessel Detection using Image Segmentation Techniques

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Abstract

Early diagnosis of this disease is very crucial for the treatment becomes effective. In emerging medical field the analysis, diagnosis and treatment is necessary. In this review the importance is given to cancer in retinal part. Normally cancer is defined as when a cell grows out of control. In eye, due to blood vessels changes the cancer formed and it is termed as Retinoblastoma (RB). In children, during early stages of development, the eyes having a cell called retinoblasts, this cells are divided into new cells and fills the retina. It causes several changes in eye and also affect the vision. The existing methods directly witnessed better understanding of genetics of Retinoblastoma. Initially the classification and genetics are listed based on clinical view. Hence this review is concentrated on retinoblastoma detection and several processing techniques are reviewed.

Keywords: Blood Vessel Detection, Image Segmentation, Fundus Image Classification, Feature Selection

I. INTRODUCTION

In developing tropical and subtropical countries the unilateral non-heritable disease are increasing. Several observations are made based on retinoblastoma in developed countries. Almost this disease is found only in young children’s. Once this cancer affect then they may lose their vision or need to remove the eye. It also deals with mutation process in chromosome. The retinoblastoma may occur at any age. The disease may be classified into two forms, such as heritable and non-heritable form. The bilateral retinoblastomas are commonly heritable and unilateral retinoblastomas are commonly known as non-heritable.

Retina is one of the light sensitive layer consists of tissues covered with rods and cones to convert the light into signals, which is in the form of neural signal related to brain signals. Normally, blood removes the waste generated by retina. Hence, if any blood stream affected from any disease then the retinal process affected (i.e.,) light filtering process is affected.

A. Heritable Retinoblastoma

Heritable is also called as hereditary, familial, or germ line. It is due to the mutation that occur in reproductive cells in the retinoblastoma (RB1) gene. The term “Heritable retinoblastoma” includes with multifocal disease, hose with a positive family history. Some of the unilateral retinoblastoma are heritable due to germ line mutations.

B. Non-Heritable Retinoblastoma

Non-heritable is also called nonhereditary, non-familial, or sporadic. The retinoblastoma results from somatic mutations that occur in non-reproductive cells in the RB1 gene. When comparing this with heritable the disease is identified at a later age.

The size of tumors may vary according to the effect in each eye. In some cases the parasellar region gets affected it is termed as trilateral retinoblastoma. The size, position and quantity of tumors are considered when preparing for treatment.

The symptoms and signs for this disease are abnormal appearance of the retina while viewed through the pupil, an irritated eye with glaucoma and deterioration of vision. Beyond that the faltering growth or delayed development is also a signs for Retinoblastoma. A white eye reflection is not always an indication of retinoblastoma. The main cause is indicated that the mutation of genes found in chromosomes and the way in which cells grow and develop within the body. The diagnosis of retinoblastoma is given by means of eye examination for checking any structural abnormalities. Need to check for symmetrical reflection of beam light on an eye within a same spot, it helps to identify the eyes are crossed or not. And finally the checking will be in normal reddish orange reflection from the retina. Apart from these diagnosis there are several methods are used here to development such as Persistent hyperplastic primary vitreous (PHPV) [18], Coats disease and Retinopathy of Prematurity (ROP) [19]. If the eye examination is nonsufficient then further some imaging studies were analyzed such as Ultrasound, Magnetic Resonance Imaging (MRI) and Computerized Tomography (CT). In this the CT and MRI helps to identify the structure abnormalities and shows any calcium depoositions. In ultrasound the height and thickness of the tumors were defined.

The treatment of retinoblastoma is must even after diagnosis, it preserve the life of the child in early, then preserve the vision to minimize the side effects. The treatment is based on the exact course of the individual and it will be depends on ophthalmologist decision taken after discussed with oncologist. The various treatment methods are Enucleation of the eye, External Beam Radiotherapy (EBR), Brachytherapy, Thermotherapy, Laser photocoagulation and so on. The surgery is also taken place by oncologist if other treatment is not possible. This process is also called as enucleation. Radiation therapy uses high energy X rays to kill the cancer cells. Due to this therapy, fatigue, nausea, vomitting and headache are the side effects may occur. Other types of
therapy is cry therapy uses extreme cold to destroy cancer cells. Laser therapy uses heat in the form of a laser to shrink smaller tumours. Chemotherapy uses drugs to destroy the cancer cells.

International Classification of Intraocular Retinoblastoma (ICRB) [20] was developed to predict those with intraocular retinoblastoma. Without enucleation or any external beam radiation treatment who are ready to be cured and the eye be saved. The ICRB classifies tumors from A through E:

- Small tumors (3 mm or less across) that are only in the retina and are located > 3 mm from foveola > 1.5 mm from the disc.
- Tumors larger than 3 mm or in a macular location. There can be a cuff of sub retinal fluid < 3 mm from the tumor without associated sub retinal seeding.
- Tumor with localized sub retinal seeding within 3 mm of the tumor and up to 1 quadrant of sub retinal fluid
- Tumors with diffuse vitreous seeding > 3 mm from tumor.

Image processing plays a major advances in the field of medical and it is contribute towards improving the clinical outcome. For accurate diagnosis and staging of RB image processing helping to identify it. In advanced radiotherapy techniques include improved radiation delivery to the target. The main purpose of this article is to review the literature on various key developments in the field of retinoblastoma. A brief overview of these recent advances carried over imaging, chemotherapy and radiotherapy (RT).

![Flow Chart for Processing a Samples](image)

**Fig. 1:** Flow Chart for Processing a Samples

Figure 1 shows the sequence of operations to extract the information about the problem in the given image. The image is taken from the digital fundus camera. The original image consists of RGB component. In preprocessing the image which is in RGB is converted into gray scale image. Pre-processing involves Image resampling to reduce or increase the number of pixels of the dataset and greyscale contrast enhancement is used to improve the visualization by brightening the dataset. This step minimize the noises and enhance the image to improve the image quality. The following steps are mentioned about this process in detail.

- Initially convert image into gray scale.
- Enhance the image by applying transformation technique.
- To improve the quality of the image median filter is used here.

For non-stationary signals the wavelet transform [21] is used and haar wavelet transform [22] is one of the simplest wavelet transforms. Gaussian filter [23] is used for smoothen the image. Mostly in signal and image processing gaussian filters used for effective function and it is simple and computation is very easy. The each transformation is has some steps such as divide the information into detailed information. Thresholding is used here to get black and white version of RGB image. Apply filtering operation on both operations. And finally get the details of the given image.

Post processing plays a major role to achieve the best quality of images. In both diagnosis and therapy the post processing of bi directional and three dimensional images plays a major role. The histogram equalization is one of the method used to improve the intensities to enhance contrast. The histogram function of given image is f, it will be represented as m, by m, matrix of integer pixel ranging from 0 to L-1. Where, L is the possible integer value often 256. Let p denotes the normalized histogram of “f” with a possible intensity.

\[
P_n = \frac{\text{number of pixels with intensity } n}{\text{total numbers of pixels}} \quad \text{where } n = 0,1,2, \ldots , L - 1.
\]
Tests and procedure for examine the retina are two types: Physical exam and history: A total checkup of the body in terms of
signs of disease, lumps or anything else seems unusual.

The blood vessel detection helps to diagnosis the eye by extracting the normal and abnormal features in retinal images. Eye
exam with dilated pupil: it is type of examine the eye in which the pupil is opened wider with a medicated eye drops to allow
the doctor to view over a lens. Several types of eye exams are done with pupil dilated such as ophthalmoscopy, slit lamp bio microscopy
and fluorescein angiography. The chance of recovery and treatment options depends upon the size of tumors or number of tumors,
whether the cancer is in one or both eyes, there are symptoms at the time of diagnosis. Depends upon the age of patient, viewing
type and cancer is forming in second type or initial. In Optical coherence tomography (OCT) image segmentation algorithms may
be categorized in to 4 steps described by Kafieh et al., (2013) [59] Determining a particular range of OCT datasets (e.g., 2D, 3D,
Time Domain, Spectral Domain, macular, etc.), Lee (2009) based on Segmentations of the intraretinal surfaces, optic disc and retinal
blood vessels in 3D-OCT scans.

This brief introduces about the retinal disease and sampling process of the captured retinal image. This paper is organized as
follows: section 2 describes the survey about Retinoblastoma with its methods and algorithms in detail, section 3 follows the
problem statement and finally the studied analyze is concluded.

II. LITERATURE SURVEY

A brief overview of segmentation and imaging process for retinal diseases is reviewed in this section. It discussed about various
frameworks, segmentation process, and over all image processing applied for retinal detection. A Probabilistic framework for
content-based diagnosis of retinal disease is discussed by Tobin et al., (2007) [2] and they also stated about the Content Based
Image Retrieval (CBIR) method to verify the hypothesis, that the retinal pathology can be quantified and identified from visually
similar retinal images. The diagnostic results based on specificity and sensitivity on a population of fundus image. Finally the
probabilistic framework used to estimate the disease state is reviewed. The results using CBIR framework for diagnosing
retinopathy were reviewed. In retinal database the patient’s age, gender, ethnicity and medical history are recorded. Hence by
comparing with age it is useful evidence to process to posterior estimation and analysis.

Ravindraiah et al., (2011) [1] presented a qualitative and quantitative analysis of Segmentation of Human Retinal Images. They
have made in terms of color, texture and luminance of an image by using the spatial domain edge detection approach. For edge
detection the gray scale image is needed and to analyze the feature extraction and highly prone to noise. To find the X derivative
and Y derivative two dimensional filters are used with edge detection. These process is done by MATLAB coding and total
analyzed report is discussed with statistical analysis (for retinoblastoma) and statistical analysis (for exudative maculopathy).
Hence it provides the segmentation for optimizing and diagnosing the pathologies through a simple and effective logic.

aims to detect the leukocoria or the white eye reflections, in recreational photography. Retinoblastoma symptom is identified in
the presents of leukocoria, then the comparisons are made by analyzing the classification of eye images taken from flickr and
achieved low error rates. The types are normal, Leukocoric and Pseudo leukocoric rates. Finally, concluded as CNN provides better
results than the traditional three layer fully connected neural networks. The achieved results are made due to the local connectivity
and replicated neurons to produce trainable filters. By comparing with small networks i.e., one with few free parameters the results
are perfect.

Rivas-Pereat et al., (2014) [4] discussed the finding in Smallest Circle Containing the Iris in the Denoised Wavelet Domain. The
system consists of image processing unit and a part of wavelet transform, Median filtering, Hough transform and two-dimensional
discrete stationary wavelet (2D SWT) are analyzed by Antoine et al., (2008) [8]. The main aim of this system is to detect the exact
location and radius of the smallest circle presented in the eye image. Here both median filter and two dimensional wavelet
transforms are used to achieve the low error rates. 2DSWT is used to de-noising the input images with high signal to noise ratio.
The Hough transform is used to detect the circle of the eye pattern. This research indicates median filter and wavelet is used to
find the smallest circle containing the iris. Finally results shows the median filter approach provides the more robust in finding the
radius of the image.

region information with application to retinal images. Here a new infinite active model is proposed that uses hybrid region
information of the image to approach this blood vessel problem. The designs provides better segmentation by using different types
of region information such as combination of local phase and intensity information based on enhancement map. The proposed
design focused in this work is compared with other widely used supervised and unsupervised methods. A vessel segmentation
problem can be solved by means of datasets and demonstrate that it outperforms most of the methods in terms of accuracy. The
evaluation of this designed model on retinal images is well suited and to address segmentation problem in images. These images
were taken from MRI, CT or X-ray. The overall estimation done in MATLAB tool and its performance is compared with effective
code optimization. They concluded that the designed tool will be helpful for analyzing vascular related diseases [6].

Tak Chien [7] proposed a review Age Classification from Facial Images for Detecting Retinoblastoma. The main theme of
this is to find the age by means of analyzing the facial image. It is one of the complex task such as variations of image such as
illumination, pose and expression may vary even if a same person character. Initially they classify the age into two types less than
the N value and greater than the N value to find out the retinoblastoma. Based on growth patterns the systems is built. In general,
the system consists of face detector, age classifier, eye detector and leukocoria detector. The reason for defining child and adult by means of defining is to detect leukocoria, where it is only significant if the subject in the image is age 5 or less.

Lewicki and Olshausen (1999) [9] presented a bayesian network to find the problems in the images. The framework is used here to compare the coding efficiency by calculating the probability of the given function. In [10] Coifman and Wickerhauser (1992) presented an algorithm which is totally based on entropy for processing selection. The major idea is to build the library functions to an orthonormal basis relative. The comparison were made by using binary tree and the complexity is noticed. González-López et al (2015) [11] made an assessment on retina which is based on web oriented framework. The design is based on several ophthalmology-support systems that request the data from the application server via HTTP. Web interface is made to analyze and process the image. Some of the limitations that occurs during the web interface listed as data is computed and stored in the user’s computer. Several applications are dependent due to the user’s platforms such as Linux, Mac, etc, in case of updating the software it is necessary to update all the software.

The active contour traditional model were extended by Mishra et al (2009) [12] to conform the two step optimization process to segment the image as soon as possible. A detailed description of the high resolution optical coherence tomography (OCT) system can be found in Puhanathasan et al., (2008) [13]. Abramoff et al., (2010) [14] presented a Computer-aided diagnosis with an internal population screening in retina. The work concentrates in quantitative approaches to retinal image analysis two dimensional and three dimensional retinal imaging are made first. Zhang et al., (2001) [15] determined how to process the raw image with spatial objects, pixel levels, and object level. The framework describes the first step towards capturing and processing the image. Secondly the useful patterns were processed for each patterns. The various levels of image driven is made such that the pixel level comprises the raw images, object levels based on the pixel level is noticed and the semantic concept level considered from the objects. To support the flow of information the high dimensional indexing scheme is included in the frame work.

Rousson and Deriche (2002) [16] discussed a framework for active and adaptive segmentation of vector valued images to minimize the energy consumption. The complex formats are also analyzed by Gaussian model to represent the regions. Lankton and Tannenbaum (2008) [17] presented a natural framework that uses region based segmentation to formulate it in local way. The region based segmentation helps to improve the accuracy and provide background regions statistically.

Rivas-Perea et al (2014) [25] includes two approaches such as median filter-based approach and a wavelet approach for detecting the smallest circle in iris. It creates an automatic system for detecting leukocoria. Quellec et al (2008) [26] described the Overall learning procedure that utilize the template-matching based algorithm to detect the Microaneurysms. Images are then enhanced and normalized to overcome the lighting variations, by median filtering[27],[28], histogram or retina specific treatments [29]. In some cases the detection of lesions made by using extracted features mentioned in [30-32]. The preprocessed images are directly classified by a neural network in [33]. Matched filters widely used on retinal images to extract the blood vessels in particular [34-37]. In [38], Sum and Cheung minimize the global energy and a local energy based on image contrast. In order to overcome the difficulties caused by intensity in homogeneities the region-based active contour model is designed by Li et al (2008) [39].

Table - 1

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Citation</th>
<th>Methodology</th>
<th>Merit</th>
<th>Limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chaudhuri et al(1989)[43]</td>
<td>Introduced a sobel operator for feature extraction based on the optical and spatial properties of objects to be recognized.</td>
<td>Salt-and-pepper Noise factor is highly reduced. Accuracy is high Edge Continuity is good</td>
<td>For real time capturing images it is not efficient</td>
</tr>
<tr>
<td>2</td>
<td>Gardner et al(1996) [42]</td>
<td>A back propagation neural network is modeled to recognize features in the retinal image</td>
<td>Sensitivity and a specificity for the detection of diabetic retinopathy were improved</td>
<td>The filtering process is limited due to the factor noise.</td>
</tr>
<tr>
<td>3</td>
<td>Osareh et al 2002 [46]</td>
<td>Grey level morphology is used to remove the interference of blood vessels</td>
<td>Accuracy in localizing is high.</td>
<td>It suits only for characteristics of our optic disc images</td>
</tr>
<tr>
<td>4</td>
<td>Osareh et al (2003) [41]</td>
<td>The color retinal images were segmented using fuzzy C-means clustering and classify the segmented regions into exudates and non-exudates by artificial neural network classifier.</td>
<td>Tradeoff between sensitivity and specificity was balanced</td>
<td>Timing mismatch between objects occurs due to pixel by pixel based lesion classification</td>
</tr>
<tr>
<td>5</td>
<td>Lankton et al (2008) [17]</td>
<td>Localizing region-based active contours and modeled a natural framework that allows any region-based segmentation</td>
<td>Segmenting Heterogeneous images with high accuracy</td>
<td>Capturing and Processing speed is very low</td>
</tr>
<tr>
<td>6</td>
<td>Quellec et al.,(2008) [26]</td>
<td>Wavelet transform used to detect microaneurysms in retina photographs. The optimization process is based on a genetic algorithm followed by Powell’s direction set descent</td>
<td>Highly tunable, easier and more efficient</td>
<td>Some Microaneurysms problems are not completely solved</td>
</tr>
<tr>
<td>7</td>
<td>Xu et al(2007) [45]</td>
<td>A deformable-model based approach is presented for robust detection of optic disk and cup boundaries.</td>
<td>This method results in accurate and robust to blood vessel occlusions.</td>
<td>The resulted image creates some non-uniform edges.</td>
</tr>
</tbody>
</table>

A Review of Retina Blood Vessel Detection using Image Segmentation Techniques

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Osareh et al (2003) [41], Fuzzy C-means clustering is used to classify the segmented image. Its main objective is to identify the exudates automatically from the retinal images. The artificial neural network is investigated to classify the segmented regions into exudates and non-exudates. Chrästek et al. (2005) [62] made a system that acquires and analyzes the surface topography of the optic nerve head. Anarim et al. (1994) [44] considered for edge detection, the model is named as Decision Based Directional Edge Detector (DBDED). Based on the standard deviation and local directional averages are constructed. Xu et al (2007) [45] presented a robust detection for glaucoma analysis. Andersson et al., (2009) described a Level set methods to solve the image segmentation. The main aim is to minimize the cost function. Dua et al., (2005) [48] andAbramoff et al., (2008) [51] made an evaluation of a system for automatic detection of diabetic retinopathy. Hann et al., (2009) analyzed a color channels and segmentation methods to separate the fundus images. The system is used to detect, diagnose and monitor the image and diagnostic outcome made the resulting positive and negative prediction values. Ege et al., (2000) [53] concentrated on Diabetic retinopathy by using the technique Statistical classification. Several statistical classifiers such as Bayesian [54], a Mahalanobis, and a K-nearest neighbor(KNN) classifier [55] were tested. Mostly KNN is used for soft computation. The main advantages of KNN is robust to noisy and it suits for large datasets. The retinopathy detection is made with the retinal image dataset with the classification of Macular Ischemia made by Patil and Daigavane (2015) [56]. Chaudhuri et al., (1989) concentrates on edge detection algorithms with matched filters. Weller et al., (2010) made a segmentation process by using adaptive morphological approach.

This section discussed the previous research method based on detection and processing steps in retinoblastoma. The table I shows the work contribution made from 1989 to 2013. The major work contribution is based on the accuracy but several drawback is analyzed such as noise, filtering efficiency and provide the clarity of images which is going to diagnosis.

### III. Problem statement

Blood vessel detection is necessary because it is important to detect diabetes and hypertension. Based on the literature it is analyzed that the segmentation accuracy is depending upon the diagnostic value. For segmentation several traditional methods are used such as tracking, thresholding and machine trained classifiers. These process is based on the selection of filters, some cases the contrast between vessel and background will be enhanced, while enhancing these process the complication will be reduced but still the radius and exact location of a cells are not identified. The retinal images normally varies in gray level contrast, in these cases the large blood vessels displays in good contrast and vice versa. Hence, there is a need to extract the large and thin vessels. In traditional methods, the process is extracted by different types of algorithms, but still it is necessary to improve the efficiency in detecting the retinal blood vessels. The retinoblastoma is discussed with the normal process and analyzed based on two-dimensional discrete stationary wavelet in order to identify the exact location and radius of the smallest circle presented in the eye image. Initially, an effective preprocessing technique is necessary because the problem faced by preprocessing is, in gray level image the blood vessels appear darker, to make it is normalize and eliminate the gray level deformation. The pre-processed image is given for classification by reducing the dimensionality of feature vectors. The problem identified in this process is dimensionality of feature vectors is high. In some cases treatment method become more complex in nature, because it provides some side effects, to overcome this demerit the upcoming design need to be made efficient.

### IV. Conclusion

The retinal vessel process in computer vision is reviewed with several methodologies and processing steps. It is important to segment the blood vessels in the form of image that can be used to identify the correct disease. Although lot of research were made in segmentation field, but still it has some limitations and there is a need to enhance the techniques effectively. This paper reviewed, analyzed and categorized by several retinal vessel extraction algorithms with various techniques and methodologies.
The study is summarized with the problem on constraints such as brightness and contrast of outcome in a resulting image. Hence, it is necessary to improve the overall performance in pre-processing, extraction and concentrate up to outcome of the result. For future directions, the algorithm must process the blood vessel detection without user interaction in analyzing different retinal images because of its good behavior against images of different conditions.

REFERENCES


