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Review of different Image Processing Methods to Detect Glaucoma

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Abstract **- Glaucoma is one of the major causes of blindness in the world. It is due to the increase in intra ocular pressure within the eyes. The detection and diagnosis of glaucoma is very important. There are various manual and automatic detection methods available. This review paper analyzes the various methods of image processing to automatically detect the Glaucoma. This paper also reviews different approaches proposed by different researchers by using image processing techniques like image registration, image fusion, image segmentation, feature extraction, image enhancement, morphology, pattern matching, image classification, analysis and statistical measurements to detect glaucoma.**

Index Terms**— Glaucoma detection, image processing, segmentation, feature extraction, classification**

I. INTRODUCTION

Glaucoma is a condition that causes damage to your eye's optic nerve and gets worse over time. It's often associated with a buildup of pressure inside the eye. Glaucoma tends to be inherited and may not show up until later in life. High amount of intra-ocularpressure (IOP) is one of the major danger components ofglaucoma disease.Accusative of present medicament access is to reduce (IOP) inside eyes to preventstructural anthropology damage [1].
The increased pressure, called intraocular pressure, can damage the optic nerve, which transmits images to the brain. If damage to the optic nerve from high eye pressure continues, glaucoma will cause permanent loss of vision. Without treatment, glaucoma can cause total permanent blindness within a few years.

There are two main types of glaucoma:

Open-angle glaucoma: Also called wide-angle glaucoma, this is the most common type of glaucoma. The structures of the eye appear normal, but fluid in the eye does not flow properly through the drain of the eye, called the trabecular meshwork.

Angle-closure glaucoma: Also called acute or chronic angle-closure or narrow-angle glaucoma, this type of glaucoma is less common in the West than in Asia. Poor drainage is caused because the angle between the iris and the cornea is too narrow and is physically blocked by the iris. This condition leads to a sudden buildup of pressure in the eye.

Valuation of retinal nerve fiber layer (RNFL) heaviness and ocular field arguments are important for the detection of glaucoma [2]. A variety of various possibilities admitting mechanical and vessel frameworks has been utilized for pathological process of glaucoma [3]. Glaucoma is the diagnosis given to a group of ocular conditions that contribute to the loss of retinal nerve fibres with a corresponding loss of vision. Glaucoma is said to be one of the leading causes of blindness in people over the age of 40. Loss of peripheral vision is the earliest symptom. Left untreated the field of vision will continue to narrow leading to tunnel vision. If detected early, loss of vision can most often be prevented. Low awareness and high costs connected to glaucoma are reasons to improve methods of screening and therapy. However due to latest technology now it is possible to stop the progression of glaucoma in patients [4].Usually we measure the optic nerve head (ONH) from four sides of regions such as inferior, superior, nasal and temporal and particularly on nasal side ONH is less important for observing the optic nerve damage than the rest of other regions of ONH.

There are various approaches available for glaucoma diagnosis among which cup-to-disc ratio (CDR) measurement is one of the major essential psychological arguments for early diagnosis of glaucoma [5]. Depending upon the size and shape of optic disc boundary, it is possible to detect glaucoma. Once optic disc has been identified, other regions of retinal images like fovea and macula can be easily determined [6]. Glaucoma can be derogated by proper treatment and early detection in fundus images [7]. Retina is a component of eye which acquires images and sends pictures to the brain. Optic disc segmentation helps in the identification of exudates because the colour of optic disc and lustrous exudates are same [9]. Due to glaucoma optic cup shape enlarges and thus ophthalmologists can easily identify glaucoma from fundus images [8].

The rest of the paper is organized as follows; Section 2 discusses various image processing for the detection of

glaucoma whereas in Section 3 conclusion and future work is given.

II. DIFFERENT IMAGE PROCESSING METHODS TO DETECT GLAUCOMA

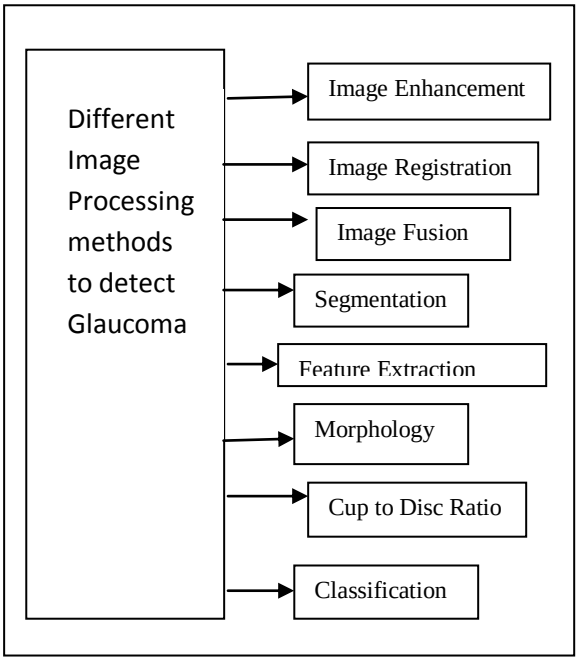

Fig. 1 Different Image Processing methods to detect Glaucoma

Various image processing techniques used in automated early diagnosis and analysis of various eye disease are Enhancement, Registration, Fusion, Segmentation, Feature extraction, Pattern matching, Classification, Morphology, Statistical measurements and Analysis.

Image Enhancement- Image enhancement includes varying brightness and contrast of image. It also includes filtering and histogram equalization. It comes under pre-processing step to enhance various features of image.

Image Registration- Image Registration is an important technique for change detection in retinal image diagnosis. In this process, two images are aligned onto a common coordinate system. Images may be taken at different times and with imaging devices In medical diagnosis, it is essential to combine data from different images and for better analysis and measurements images are aligned geometrically.

Image Fusion- Image fusion is a process of combining information acquired from number of imaging devices. Its goal is to integrate contemporary, multi sensor, multi-temporal or multi-view information into a single image, containing all the information so as to reduce the amount of information.

Feature Extraction- It is the process of identifying and extracting region of interest from the image.

Segmentation- Segmentation is the process of dividing an image into its constituent object and group of pixels which are homogenous according to some criteria. Segmentation algorithms are area-oriented instead of pixel oriented. The main objective of image segmentation is to extract various features of image which can be merged or split in order to build object of interest on which analysis and interpretation can be performed. It includes clustering, thresholding etc. .

Morphology - Morphology is the science of appearance, shape and organization. Mathematical morphology is a collection of non-linear processes which can be applied to an image to remove details smaller than a certain reference shape. Various morphological operations are erosion, dilation, opening and closing.

CDR (Cup to disc ratio) - The vertical cup-to-disc ratio (CDR) is one of the most important risk factors in the diagnosis of glaucoma [9].It is defined as the ratio of the vertical cup diameter over the vertical disc diameter. The optic disc is the location where the optic nerve connects to the retina. In a typical 2D fundus image, the optic disc is an elliptic region which is brighter than its surroundings. The disc has a deep excavation in the center called the optic cup. It is a cup-like area devoid of neural retinal tissues and normally white in color, OC of a glaucomatous eye tends to grow over time due to persistently increased intraocular pressure. As the OC grows, the neuroretinal rim located between the edge of the OD and the OC which contains optic nerve fibers becomes smaller in area. If the neuroretinal rim is too thin, vision will be deteriorated. Thus, quantitative analysis of the optic disc cupping can be used to evaluate the progression of glaucoma [10]. As more and more optic nerve fibers die, the OC becomes larger with respect to the OD, which corresponds to an increased CDR value. For a normal subject, the CDR value is typically around 0.2 to 0.3. Typically, subjects with CDR value greater than 0.6 or 0.7 are suspected of having glaucoma and further testing is often needed to make the diagnosis [11].

Neural Network for Classification

The Probabilistic Neural Network was developed by Donald Speech. Classification refers to the analysis of the properties of an image. Depending upon the analysis, the dataset is further referred into different classes. Input features are categorized as 0 and 1.The classification process is divided into two phases: training phase and testing phase . In the training phase, known data is given and in the testing phase, an unknown data is given. Classification is done by using classifier after the training phase [10].The Probabilistic Neural Network provides a general solution to pattern classification problems [11].

Classification - Classification is an important technique of image analysis for estimation of statistical parameter according to the gray level intensities of pixels. It includes

labeling of a pixel or group of pixels based on the grey values and other statistical parameters. For understanding the contents of an image, image analysis functions are used [4]. The proposed method focuses on optic disk and cup segmentation.

III. LITERATURE REVIEW

Many researchers proposed their work by using above mentioned image processing methods to detect Glaucoma. Review of few is as below –

Mary et al. [12] implemented a technique for glaucoma detection where optic disc segmentation via pyramidal decomposition is carried out on the retinal images which gives a better performance than other algorithms. It is important to note that although Pyramidal decomposition method with the help of Hough transform is guaranteed to converge though it is very sensitive to noise. So, multiple initializations are being used to yield a better performance. Finally, they have proposed a model approach using discriminant analysis which has shown an improvement over the rest.

L´aszl´o G. Ny´ul [13] devised a novel automated glaucoma classification technique, depending on image features from fundus photographs. In this study, data-driven technique does not need any manual assistance. The system does not depend on explicit structure segmentation and measurements. First of all size differences, non uniform illumination and blood vessels are eliminated from the images. They then extracted the high dimensional feature vectors. Finally compression is done using PCA and the combination before classification with SVMs takes place. The Glaucoma Risk Index (GRI) produced by the proposed system with a 2-stage SVM classification scheme achieved 86% success rate. This is comparable to the performance of medical experts in detecting glaucomatous eyes from such images. Since GRI is computed automatically from fundus images acquired by an inexpensive and widely available camera it is suggested that the system could be used in glaucoma mass screenings.

Grau et al. [14] developed a new segmentation algorithm, depending on the expectation-maximization. This algorithm used an anisotropic Markov random field (MRF). In this study, structure tensor had been used to characterize the predominant structure direction as well as spatial coherence at each point. This algorithm had been tested on an artificial validation dataset that is similar to ONH datasets. It has shown significant improvement over an isotropic MRF. This algorithm provides an accurate, spatially consistent segmentation of this structure.

Bock et al. [15] developed an automated glaucoma classification system that does not at all depend on the segmentation measurements. They had taken a purely data-driven approach which is very useful in large-scale screening. This algorithm undertakes a standard pattern recognition approach with a 2-stage classification step. In this study, various image-based features were analyzed and integrated to capture glaucomatous structures. There are certain disease independent variations such as size differences, illumination in homogeneities and vessel structures which are removed in the preprocessing phase. This system got 86% success rate on a data set of 200 real images of healthy and glaucomatous eyes.

Sr. No.	**Paper Title**	**Author**	**Method Used**	**Remark**
1	Automatic Optic Nerve Head Segmentation for Glaucomatous Detection using Hough Transform and Pyramidal Decomposition	M. Caroline Viola Stella Mary, B. Jainudhin Sudar Marri	Segmentation	Use of discriminant analysis improves the result
2	Retinal image analysis for automated glaucoma risk evaluation	L´aszl´o G. Ny´ul	Classification, Feature Extraction, Compression	Does not need manual assistance
3	Segmentation Of Trabeculated Structures Using An Anisotropic Markov Random Field: Application To The Study Of The Optic Nerve Head In Glaucoma	Vicente Grau, J. Crawford Downs, and Claude F. Burgoyne	Segmentation	More accurate and spatially consistent
4	Classifying Glaucoma with Image-Based Features from Fundus Photographs	R¨udiger Bock, J¨org Meier, Georg ichelson, L´aszl´o G. Ny´ul, Joachim	Classification, Data-Driven approach	Useful in large scale screening

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Table 1 Literature Review

IV. CONCLUSION

In this review paper we have overviewed basics of Glaucoma and various image processing methods to detect it. Also, we have reviewed work done by different researchers to detect Glaucoma using automated systems. These techniques will be of great help in medical field to detect glaucoma at early stages as it requires very less data and expertise to test. Early detection of glaucoma can save person from blindness.

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