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# Exploring the Diagnostic Capabilities of Machine Learning in Glaucoma Detection

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**Abstract- This is a review of various image processing methods used in diagnosing glaucoma, an irreversible eye disorder of optic nerve results nerve cell damage. Glaucoma causes slow vision loss and is largely prevalent in rural and semi-urban populations, but people suffering from the disease can be found just about anywhere. The current method to diagnose retinal diseases mainly relies on the analysis of fundus images obtained from a retina through advanced image processing techniques. Image registration, fusion, segmentation, feature extraction, enhancement, morphological operations, medical image understanding are few of the standard methods used for detecting Glaucoma and different eye diseases along with GLCM based analysis and its pattern matching classification statistical techniques used. These methods play a critical role in increasing accurateness with early diagnosis and treatments results required for eye practices.**

**Index Terms- Image Processing, Glaucoma Diagnosis, Image Registration, Fusion, Segmentation, Statistical Measures, Morphology, Classification, Pattern Matching.**

## I. INTRODUCTION

Common eye diseases such diabetic retinopathy, glaucoma, age-related macular degeneration (AMD) and others strike a large number of people in the rural/ semi-urban areas. Glaucoma is a systemic disease that leads to damage of the optic nerve and is the second leading cause of blindness in the United States. It is often called as "the silent thief of vision". This is associated with a gradual loss of the optic nerve head (ONH) through high intraocular pressure inside the eye. The optic nerve sends image data to the brain. Damage to a large number of nerve fibres causes, eventually causing blindness in the feild. However, there are some signs which can be recognized visually such as changes in the appearance of the optic disc inducing suspicions that someone has glaucoma in their eye. The optic disc is ovoid and pink with a small central light area (literally:') When nerve fibres break down (degenerate), the orange-pink colour fades, so the habit is pale. i.e. enlargement of a depression: cup and thinning of the neuroretinal rim The central white portion of the diagram represented as cup does not have presence of neuroretinal tissue. A normal eye cup-to-disc ratio ranges anywhere from 0.3 to 0.5. The ratio is 0.8 when glaucomatous eye is included. In Deutschland gibt es ca. 5 Millionen Personen mit einem Risiko zur Entwicklung eines Glaukoms und etwa 800.000 Menschen, die glaukomatische Schädigungen vorweisen [1]. Morever, thanks to the capabilities of in-vivo optical imaging of the retina allowing an automated early detection for eye diseases is possible. This is done be performing various image processing techniques.

The recent advancement in the field of medical imaging led to better early detection of glaucoma and eye-other eye diseases with the help of Image processing techniques. Upon referral, experts trained in the interpretation of images of the retinal fundus evaluate them for evidence changes or abnormalities in the retina. Ophthalmoscopes: These are the Special type of Instruments with which we can take this imagess! In the area of non-invasive therapy and also clinical research, medical image analysis/processing is becoming a critical issue. This information will allow for part of glaucoma severity grading based on the appearance of an optic disc. One of the critical problem that should be considered in retinal image processing is due to key landmark feature, locality of optic disc. Figure 1 The fundus camera and the picture of the retinal fundus.

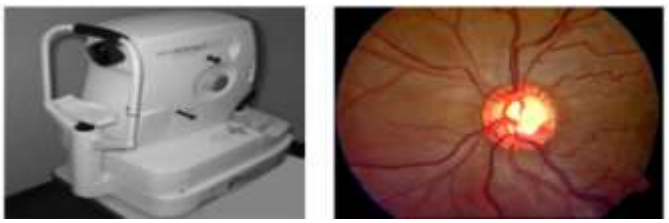


Figure 1: Digital fundus camera and acquired retinal fundus image

## II. IMAGE PROCESSING TECHNIQUE

Enhancement, Registration, Fusion, Segmentation, Feature extraction, Pattern matching, Classification, Morphology, Statistical measurements and Analysis are just some of the

various image processing techniques that are utilised in automated early diagnosis and analysis of various eye diseases. Other techniques include: [2][3].

Picture Improvement - Changing an image's brightness and contrast are two components of image enhancement. Filtering and histogram equalisation are also included in this process. It is part of the preprocessing procedure that is used to improve several aspects of the picture.

Image Registration is a critical step in the process of retinal image diagnosis, since it is used to identify any changes that may have occurred. During this step, both of the pictures are brought into alignment on the same coordinate system. There are a variety of timings and imaging tools that may be used to capture an image. When making a medical diagnosis, it is vital to integrate data obtained from a variety of pictures, and geometric alignment of the images is performed so that the results of the analysis and measurements may be improved. [4]

Image Fusion is the process of merging information that was obtained from a variety of imaging equipment. Image fusion is also known as "image stitching." It seeks to do this by incorporating modern information that is multi-sensory, multi-temporal, or multi-view into a single picture that contains all of the information in an effort to limit the quantity of information that is available.

The process of determining and then extracting certain regions of interest from a picture is referred to as "Feature Extraction." The process of splitting a picture into its component parts, each of which consists of a group of pixels that are identical to one another in accordance with a set of criteria, is known as segmentation. The focus of segmentation algorithms is on the region rather than the individual pixels. The primary purpose of image segmentation is to extract distinct aspects of a picture, which can then be merged or separated in order to produce an object of interest on which analysis and interpretation may be conducted. This is accomplished via a process known as "feature extraction." It involves things like clustering and thresholding, among other things.

Morphology is the study of form, structure, and organisation. It is also known as the science of appearance. Mathematical morphology refers to a group of non-linear operations that may be carried out on a picture in order to eliminate any features that are smaller than a certain reference form. Erosion, dilation, opening and shutting are all examples of different morphological operations. Image analysis relies heavily on classification as a method for estimating statistical parameters according to the grey level intensities of pixels. Classification is an essential component of image analysis. Labeling a pixel or group of pixels based on the grey values and other statistical characteristics is included in this process. Picture analysis functions are used in order to get a comprehension of the contents of an image. [5].

## III. LITERATURE REVIEW

In the published research, there are several studies that report on the identification of optic disc as well as the detection and categorization of glaucoma. The work may be summarised as follows:

Enhancement of retinal fundus image to emphasise characteristics for abnormal eye identification was a project that Kevin Noronha worked on in the year 2006 [6]. This study details the procedures that were carried out in order to identify the primary characteristics of retinal fundus pictures. These characteristics include the optic disc, the fovea, exudates, and blood vessels. Find the brightest portion of the fundus and apply the Hough transform so the author may figure out where the optic disc is and where its centre is.

Sangyeol Lee completed the paper titled "Validation of Retinal Image Registration Algorithms by a Projective Imaging Distortion Model"[4] in the year 2007. There have been many different suggestions made for approaches to retinal image registration. In addition to this, the authors propose a validation tool that can be used with any retinal image registration approach. This tool works by retracing the course of the distortion and obtaining the geometric misalignment from the coordinate system of the reference standard.

S. Sekhar carried out the work "Automated localization of retinal optic disc using hough transform"[7] in the year 2008. The picture of the retinal fundus is used extensively in the diagnostic and therapeutic processes for a broad variety of eye illnesses, including diabetic retinopathy and glaucoma. The approach that has been developed includes two stages: in the first stage, a region of interest (ROI) is located in an image via the use of morphological processing, and in the second stage, an optic disc is identified through the use of the Hough transform.

Zhuo Zhang completed the work "ORIGA-light: An Online Retinal Fundus Image Database for Glaucoma Analysis and Research"[8] in the year 2010. The authors provide an online dataset known as ORIGA-light with the intention of providing the general public with access to clinical retinal pictures. The author maintained a steady stream of system updates that included further clinical ground-truth photos. The segmentation of the optic disc and cup is the primary emphasis of the suggested approach.

Vahabi Z presented "The novel technique to Automatic identification of Optic Disc from non-dilated retinal

images"[9] in the year 2010. The author offers a novel filtering methodology to identify Optic Discs, which includes methods such as Sobel edge detection, Texture Analysis, Intensity, and Template matching. The wavelet domain is used to apply the suggested technique to each of the 150 photos in the Messidor dataset.

Zafer Yavuz completed the work "Retinal Blood Vessel Segmentation Using Gabor Filter And Tophat Transform"[10] in the year 2011. The author presented a technique for the segmentation of retinal blood vessels in this work. The approach involves first using a Gabor filter to emphasise the blood vessels, and then using a top-hat transform. At a later stage, the result will be transformed into a binary picture using p-tile thresholding.

Nilan jan Dey carried out the research for the paper "Optical Cup to Disc Ratio Measurement for Glaucoma Diagnosis Using Harris Corner"[11] in the year 2012. In this study, the CDR was calculated using the Harris Corner method. The Harris comer detector [12,13] determines the regional variations of the signal by comparing patches that have been moved in a variety of directions by a negligible amount. The local autocorrelation function of a signal is used as the foundation for this method.

R. Geetha Ramani published her paper "Automatic Prediction of Diabetic Retinopathy and Glaucoma via Retinal Image Analysis and Data Mining Techniques"[5] in the year 2012 [citation needed]. In this study, an innovative method for the automated diagnosis of illness was suggested. Analysis of the retinal pictures and various data mining methods are used so that the retinal images may be reliably classified as either normal, diabetic retinopathy impacted, or glaucoma affected.
Review of Image Processing Techniques for Automatic Detection of Eye Diseases was a proposal that was made by ManjulaSri Rayudu in the year 2012 [14]. This review article explains how image processing methods may be used to automatically diagnose eye disorders. Image registration, fusion, segmentation, feature extraction, enhancement, pattern matching, image classification, statistical measures, and analysis are some of the essential image processing methods for diagnosing eye illnesses.

## IV. GLAUCOMA DETECTION ALGORITHM

For assessment of glaucoma, cup-to-disc ratio is most widely accepted index. Early research was done for detection and localization of optic disk. The various algorithms used in this direction are vessel's direction matched filter, curvelet transform, active contour model, fuzzy c-mean clustering, artificial neural networks, k-NN regressor, pyramidal decomposition, edge detection, entropy filter and feature vector[15-21].

Other techniques include averaging filter, template matching technique and canny edge detector. S.Sekhar et al. [22] applied Hough transform to detect Optic Disk. After preprocessing a binary image is obtained which can be used to find the contours of OD. Morphological closing is performed on ROI to calculate the magnitude gradient of edge detection and fill the vessels according to (1).

$$f \bullet B = ( f \oplus B) \Theta B . \quad (1)$$

For removing any peaks, morphological opening is applied according to (2).

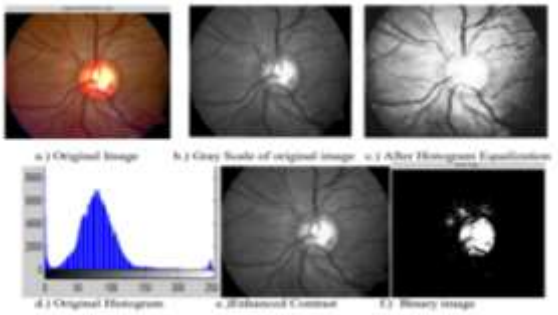
$$f \circ B = ( f \Theta B) \oplus B \quad (2)$$

Where f is the grayscale image, B is binary structuring element; $\oplus$ is dilation $\Theta$ is erosion operators

In their study [23], Gopal Dat Joshi and colleagues revealed how to calculate the cup-to-disc ratio (CDR) for the purpose of diagnosing glaucoma by using morphological operations and the Hough transformation. Cup is segmented inside the optic area utilising vessel bends (r-bends for designating cup boundaries), as well as pollar information. These r-bends are scattered in a manner that is not consistent over the OD area. Therefore, a local interpolating spline is used for the purpose of cup border detection. The matched filter strategy was suggested by Aliaa Abdel and colleagues [15]. During the preprocessing stage, the illumination equalisation technique and the adaptive histogram equalisation approach are used to respectively normalise the luminance and contrast of the image. A two-dimensional Gaussian-matched filter is used in order to segment the retinal vessels. R. Chrastek and colleagues [24] presented a technique for segmenting the head of the optic nerve and validated their approach. Morphological procedures, the Hough transform, and an active contour model are all components of this technique.

## V. RESULTS

As a part of survey of various image processing techniques, the author has implemented some of the techniques like preprocessing; histogram equalization morphological operation etc. and result are as follows:



## V. CONCLUSION

In order to begin the process of glaucoma detection and diagnosis, the author of this study came to the realisation that the optic disc has to be segmented as the very first stage in the procedure. After the phase of capturing images has been finished, the preprocessing stage will start with the application of thresholding, lighting, and histogram equalisation. The optic disc and cup are segmented using a variety of techniques, such as the Hough transform, k-means clustering, fuzzy c-means clustering, active contour method, matching filter approach, vascular bends, and morphological processes. After that, the CDR is calculated, and classification is conducted so that it may be determined whether or not the patient's eye condition is normal or glaucomatous.

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