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Survey on Retinal Disease detection techniques

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***Abstract*—Retina is a thin membranous layer of tissue occupies at the back of eye which provides central vision needed for daily routines. Identifying disease as early as possible is a challenging task since healthy retina is required for central vision. Several retinal conditions are affected to our eye includes Age Related Macular Degeneration, Glaucoma, Diabetic Retinopathy, Retina Pigmentosa, retinoblastoma, retinal detachment etc. These diseases will experience a high growth in the future due to diabetes incidence increase and aging population in the current society. This paper surveys various methods used for detection of different retinal diseases.**

***Index Terms*— Feature extraction, Fundus image, Pre-processing, Retinal Diseases.**

I. INTRODUCTION

Eyes are one of the most significant parts that used to process the world around us. It will allow us to identify faces, colors, shapes, and depth by translating the light that reflects off of these things into signals that the brain recognizes as images. The eyes occupies in cone-shaped cavities in the skull called sockets and eyebrows, eyelids, eyelashes to protect eye. The eye is composed of cornea, pupil, iris, lens, sclera, retina, vitreous humor.

The eye is composed of light-sensitive cells associated with nerve fibers that allow light incoming the eye to be transformed to nerve impulses that arrive at the brain. The amount of light entering is prohibited by the iris and is then moves to the retina. The retina is a thin membranous coating at the back of the eye. It helps to focus images and converted to electrical impulses which are passed to the brain by the optic nerve. Early discovery and treatment of retinal eye diseases is critical to avoid escapable vision loss. Traditionally, retinal disease recognition techniques are based on manual interpretation. The World Health Organization or WHO finds that there were million people visually impaired in all over the world. The number of blindness cases has been extensively reduced in current years, it is estimated that 82%
of the cases of visual impairment are preventable or treatable. Retina is affected by several disorders which may be vision changes with aging. Many changes are common and can often be corrected.

Blindness prevention is an important challenge all over the world. Cataract, glaucoma and Age-related Macular Degeneration are the three major diseases to cause blindness. Vision 2020 pointed that there are about 285 million visually impaired people worldwide. So improving the eye care service especially the pre-detection is of great importance.

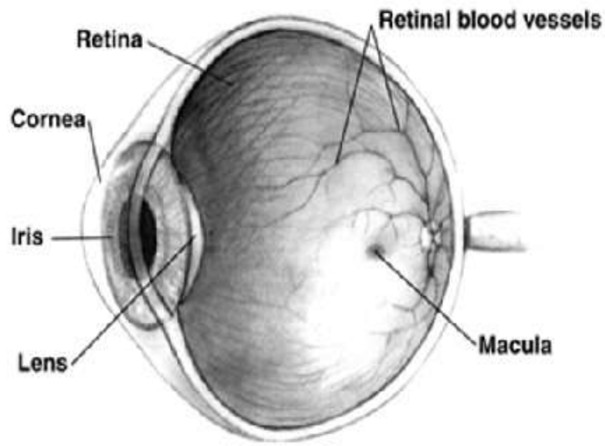

Fig 1: Human Eye Anatomy

This paper encounters different eye diseases and detection methodologies for efficient and timely manner diagnosis. Retinal images are widely used by ophthalmologists and primary care physicians for screening of eye diseases, because they are direct and no harm. For that fundus images of eye are used mostly.

II. RELATED WORKS

M. Usman Akram, Sundus Mujtaba, Anam Tariq [1] proposed the paper Automated drusen segmentation in fundus images for diagnosing age related macular degeneration. Age related macular degeneration (ARMD) is an eye disease due to presence of drusen on the retina and the disease may cause blindness. Early detection of ARMD using a computerized system can recover patient's foresight. The ophthalmologists can achieve this system useful for screening of ARMD. This paper presents a novel method for precise detection of drusen in colored retinal images. The system uses filter bank to extract all probable drusen parts form retinal image and eliminates false pixels which appear because of similarity of drusen with optic disc. System represents each region with a number of features and then applies support vector machine to categorize these regions as drusen and non-drusen. The performance is evaluated by testing it on STARE database using parameters such as specificity and accuracy.

Meimei Yang, Ji-Jiang YANG, Qinyan Zhang, Yu Niu Jianqiang Li [2] proposed Classification of retinal image for Automatic cataract detection. This paper proposes to use a neural network classifier that is used for automatic cataract detection based on the classification of retinal images. The methodology is constructed as pre-processing, feature extraction, and classifier construction. In the pre-processing part, an improved Top-bottom hat transformation is used to improve the contrast between the foreground and the object, and a trilateral filter is used to decrease the noise in the image. The classifier is constructed by back propagation (BP) neural network which has two layers. Cataracts are differentiated into normal, mild, medium or severe ones.

Muhammad Salman Haleem, Liangxiu Hana, Jano van Hemertb, Baihua Li [3] proposed the paper Automatic extraction of retinal features from color retinal images for Glaucoma Diagnosis. The techniques used for detecting Glaucoma include measurement of Intra-Ocular Pressure or IOP using Gonioscopy, Tonometer which are prepare manually by the clinicians. Tests are usually followed by Optic Nerve Head (ONH) Appearance examination for the complete diagnosis of Glaucoma and this require usual monitoring and this is expensive and time inefficient. The accuracy and consistency of diagnosis is restricted by the domain knowledge of ophthalmologists.

Xinting Gao, Stephen Lin and Tien Yin Wong [4] proposed the paper Automatic Feature Learning to Grade Nuclear Cataracts Based on Deep Learning. This paper proposes a new method for nuclear cataract grading based on automatic feature learning. It is difficult to find the right features and this study makes a new approach that directly addresses this problem in a systematic and general manner, in differ to resorting to heuristic features. In deep learning, discriminative features that describe high level semantic information are effectively extracted. This approach has the potential to be applied to other eye diseases; different handcrafted features are used in optic cup or disc segmentation to evaluate the succession of glaucoma and to detect drusen for measurement of AMD. Features extracted through this type of deep learning approach may potentially lead to improved performance in these cases.

Dharitri Deka, Jyoti Prakash Medhi, S. R. Nirmala [5] proposed the paper Detection of Macula and Fovea for Disease Analysis in Color Fundus Images. Macula and fovea plays an important role for the detection of various retinal diseases. If any irregularity falls over the macular region it affects the central vision and slowly it leads to blindness. Here they presented a good method for detection of macula and fovea. Macula was localized using the property of BV structure and fovea is detected as the center of macula. They tested on both normal and diseased images using DRIVE, MESSIDOR, DIARETDB1, HRF, STARE databases.

D Huiying Liu, Yanwu Xu, Damon W.K. Wong, and Jiang Liu [6] proposed the paper Grow cut-based Drusen Segmentation for Age-related Macular Degeneration Detection. This paper proposed a novel drusen segmentation method. The major characteristic of this method is using Grow cut to track the boundaries of drusen. The initial seeds for Grow cut are determined automatically. This method first detects the local maximum and minimum points. The maximum points, which are potential drusen, are then classified as drusen or non-drusen.

Weiming Fan, Ruifang Shen, Qinyan Zhang, Ji-Jiang Yang, Jianqiang Li [7] proposed Principal Component Analysis Based Cataract Grading and Classification. On the basis of traditional classification system of cataract grading and classification, they add a step (PCA) into the system and make it more perfect especially considering the computation cost and training time of a classifier. Even though there is slightly decrease in accuracy ratio, the computation speed get improved to a large degree. With the number of images involving in the building of a classifier increases, the significance of PCA transformation will be more significant. The classification system of automatic cataract detection based on retinal fundus images having three steps fundus image preprocessing, feature extraction and the building of classifier.

III. RETINAL DISEASES AND DETECTION METHODS

A. Age-Related Macular Degeneration

Age-related macular degeneration or AMD is a eye disorder and a most important source of vision loss among people age 50 and older and it causes hurt to the macula which is small spot near the center of the retina and the part of the eye desired for sharp, central vision.

AMD affects so slowly that vision loss does not take place for a long time. Sometimes disease progresses faster and may lead to a loss of vision in one or both eyes. AMD progresses, an unclear area near the center of vision are a common indication. Over time, the unclear area may rise larger or may enlarge blank spots in vision. AMD by itself does not lead to complete blindness, with no ability to see but the loss of central vision in AMD can interfere with simple day by day actions, such as the ability to see faces, drive, read, write.

A comprehensive dilated eye exam can detect AMD. For examination of eye, eye care professional places drops in your eyes to widen or dilate the pupils. It will provide a better view of the back of the eye. Using magnifying lens, clinicians can looks at retina and optic nerve for symbol of AMD or other eye disorders. Other method is Amsler grid and eye care professional also may ask to look at an Amsler grid. Changes in your central vision may cause the lines in the grid to disappear or appear curvy, a sign of AMD. Fluorescein angiogram is a test, which is performed by an ophthalmologist; a fluorescent dye is injected into arm. Pictures are taken as the dye passes through the blood vessels in your eye. Optical coherence tomography has probably heard of ultrasound, which uses sound waves to capture images of living tissues. It is categorized by the presence of specific structures like drusen which is yellow bright lesions that are formed at the retinal portion. Drusen are said to be the early sign of AMD which is the main cause of loss of sight.

AMD can be detected using three phases. In the first phase, retinal image preprocessing and contrast enhancement is done for improving the contrast of the retinal image for easy detection of lesions. The second phase consists of candidate drusen region detection along with removal of OD pixels so that the false regions get eliminated. In the last phase, Feature vector for drusen is formulated and classification is done to separate the regions as drusen or non drusen.

A.A Pre-processing and Contrast Enhancement

To enhance the contrast and quality of image, preprocessing and contrast enhancement is applied to the retinal image. Background estimation is done by using mean and variance based method while HSI (Hue, saturation and intensity) channels are utilized for noise removal. Drusen are the bright regions so in order to highlight the bright regions, the dark regions are suppressed using morphological closing. This gives us smoothed fundus image containing bright regions only. To improve the contrast, contrast limited adaptive histogram equalization is used.

A.B Drusen Region Detection

For finding all probable bright regions, used Gabor Filter Banks. These filters are popular due to their fine frequency tuning and directional selectiveness. Gabor Filter is represented by Gaussian kernel function and that can be modeled with wide range of shapes by changing its parameter making them suitable for drusen detection.

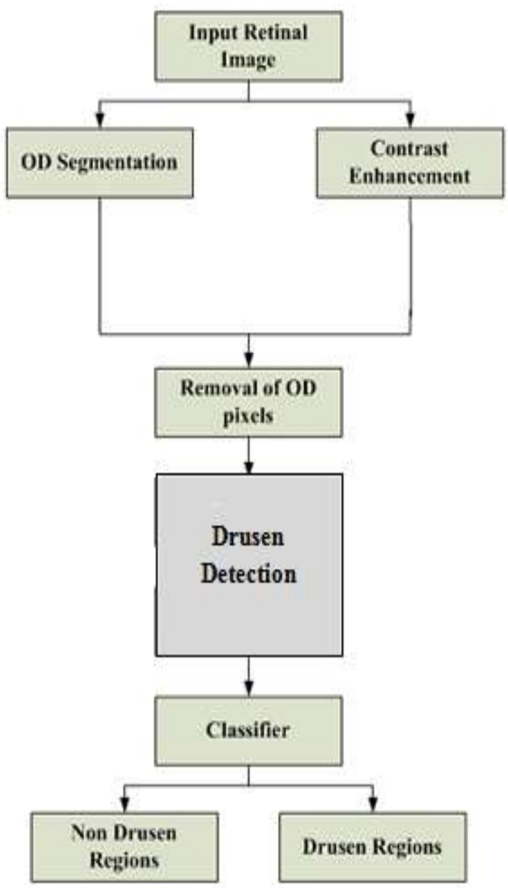

Fig 2: AMD detection technique

A.C Classification

The binary map created after removing OD pixels contains possible candidate drusen regions. A feature set is created for each binary map. The feature vector is composed of area, compactness, average boundary intensity, minimum boundary intensity, maximum boundary intensity, mean hue, mean saturation, mean intensity value, mean gradient magnitude, energy and entropy. These features are selected based upon the properties of drusen and they help in finding true drusen regions. We have used SVM classifier to grade the region. The complete feature vector is fed to SVM and it grades the region as drusen or non-drusen.

B. Cataract

Cataract is one of the leading causes of blindness in the world. It is the clouding of the lens that causes loss of vision. Most cataracts are related to aging. Other risk factors diabetes, smoking, exposure to sunlight. The retina mainly contains three parts: optic disc, macular and blood vessel. Optic disc is the highest round disc in the middle of the retina and binds with brain nerves. Macular is the optical center of the eye and it is high in lutein which makes it become visible yellow. The blood vessel is separated into artery and vein. All of the blood vessels converge at the optic disc and vein is darker as well as wider than the artery. Artery and vein are known as big vessel. There are some capillaries which append to the big vessel. They are known as small vessels. Cataract is classified into four different grades: normal, mild, medium and severe. If the optic disc, big vessel and small vessel are clear, the retina image is a normal one. Whether small vessel isn’t clear, it is defined as a mild. If the small vessel and big vessel are un clear, it is said to be medium cataract. If the optic disc is not clear, it is known as a severe cataract.
To implement this technique it contains three parts which are pre-processing, feature extraction, and classifier shown in Fig 3.

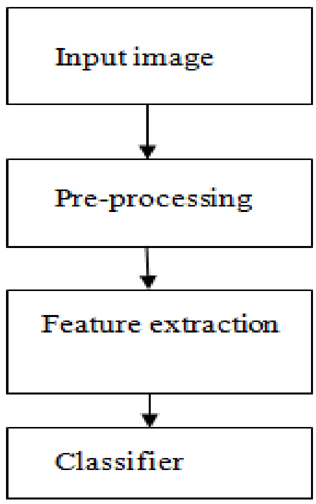

Fig 3: Cataract detection technique

B.A Pre-processing

The pre-processing can increase the quality of the retinal image, and formulate it better for succeeding actions. Top-bottom hat transformation and a trilateral filter can be used to enhance the quality of the retinal image. To boost contrast between the foreground and blood vessel, improved top-bottom hat transformation is used. Trilateral filter is used to remove the noise in the image after the improved top-bottom hat transformation.

B.B Feature Extraction

To avoid the problem of the dimension disaster, feature extraction is essential. The clearness of the retinal image is the standard for cataract classification, so the lumiance is selected as a feature for classification. Then the image is converted to a binary image and the threshold is set to 0.6. The lumiance feature is how much the white pixel share in the image. The differences between four classes are very big. So gray co-occurrence matrix is selected to do the job of feature extraction. Gray-gradient co-occurrence matrix concerns the associated statistic distribution of the gray and the edge gradient. From the gray-gradient co-occurrence matrix, the features extracted are gray heterogeneity, little gradient dominance, large gradient dominance, inverse difference moment, gradient heterogeneity, gray mean square error, gradient average, gradient mean square error, gray entropy, hybrid entropy, correlation, inertia and energy. These features can be extracted from the same images with gray co-occurrence.

B.C Back Propagation neural network classifier

The classifier is constructed by back propagation (BP) neural network which has two layers used for classification.

C. Glaucoma

Glaucoma is a chronic eye disease in which the optic nerve is progressively damaged. There are two main types of Glaucoma Primary Open Angle Glaucoma (POAG) and Angle Closure Glaucoma (ACG) [8]. The Intra-Ocular Pressure (IOP), which maintains a permanent shape of the human eye and protects it from warp, rises because the correct amount of fluid cannot drain out of the eye. A clogging problem occurs inside the drainage canals even the entry to the drainage canals work properly. This type of Glaucoma develops gradually and sometimes without obvious sight loss for many years and it can be treated with medications if diagnosed at the earlier stage. Angle Closure Glaucoma happens when the drainage canals get blocked. Iris is not as wide and open as in the standard case. The outer edge of the iris bunches up over the drainage canals, when the pupil enlarges too much or too rapidly. The changes in the retinal structures which are associated with Glaucoma are Optic Nerve Head (ONH) variance, Neuroretinal Rim Loss Determination, Retinal Nerve Fiber Layer (RNFL) defects, Peripapillary Atrophy (PPA) [9].

C.A. Segmentation based Automatic Feature Detection

Most of segmentation based need Optic Nerve Head (ONH) analysis. So, methods for analysis of the Glaucoma are correlated to extraction of ONH and its anatomical structures. The localization of ONH is the first step in order to locate other anatomical structures, vessel tracking and registering changes inside Optic Disc region. Whether any pixel within the Optic Disc boundary is located, then it can ease the extraction of the Optic Disc boundary. There are three main categories for the localization methods of the Optic Disc boundary. They are Optic Disc Detection as the Brightest Region, Center Localization by Matching of the Optic Disc Template and ONH center as Convergence Point of Retinal Blood Vessels. Second step is Optic disc extraction and different methods are done in two main parts: Non-Model based approaches and Model based approaches.

- Non-Model Based approaches:

Morphological Operations, Pixel Clustering etc are used for extracting Optic Disc using different image processing algorithms. The Optic Disc was either segmented out using different thresholding techniques or morphological operations or approximated as an circular or elliptical area.

- Model based approaches:

Optic Disc boundary is represented in the form of mathematical model. The model based approaches were characterized as either freeform modelling or statistical shape modelling. In the freeform modelling, there is no explicit structure of template except some constraints. In this category, Active Contour Modelling (ACM) has been widely investigated for extraction of Optic Disc boundaries. ACM is fundamentally a deformable contour. It changes its shape corresponding to the properties of an image based contour properties and knowledge based constraints. Statistical shape modelling involves an offline training process in order to determine a shape model parameterizing the diverse of characteristics of the shape.

After the segmentation of Optic Disc boundary, the next step is to find out the boundary of Optic Cup in order to determine the features such as Cup to Disc Ratio, Neuro-retinal Rim Loss etc for the diagnosis of Glaucoma. Morphology based Cup Segmentation used morphological operations in the green channel of RGB images to segment Optic Cup.

C.B. Non-Segmentation based Classification

In non-segmentation based methods, Bock has major Contribution. Initially they used Pixel Intensity Values on which they applied Principal Component Analysis (PCA) for dimensionality reduction. Features such as image texture, FFT Coefficients, Histogram Models, B-Spline coefficients etc are added. Based on these features they calculated Glaucoma Risk Index (GRI). Classifiers used such as Naive Based Classifier, k-Nearest Neighbor Classifier and Support Vector Machines (SVM) which will helps to categorize between healthy and Glaucomatous images.

IV. CONCLUSION

There are many retinal diseases which cause harm to our human eye and leads to vision loss. This paper proposes an empirical study on different methods used for detection of retinal diseases. Many of them use fundus images of retina as the input and preprocessing was done for normalization or noise removal. After that relevant features are extracted. Different types of classification techniques are reviewed. This paper encounters three major retinal diseases Age-related Macular Degeneration (AMD), cataract and glaucoma.

Different properties of drusen are used for constructing proper feature vector whereas SVM provides accurate classification of AMD. A neural network classifier is used to automatically classify the severity of cataract. Methods to diagnose Glaucoma, and the methods based on automatic detection of retinal features which can be in use to support analysis of Glaucoma at an early stage are reviewed.

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