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A Survey on Detection of Glaucoma using Fundus Images

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ABSTRACT

Glaucoma, an eye disease, is often referred to as the silent thief of sight. The damage done by glaucoma is irreversible. There are many types of glaucoma. Early detection and treatment of glaucoma is the only solution. Till date, many works have been done towards automatic glaucoma detection using Fundus Images (FI) by extracting structural features. Structural features can be extracted from optic nerve head (ONH) analysis, cup to disc ratio (CDR) and Inferior, Superior, Nasal, Temporal (ISNT) rule in Fundus Image for glaucoma assessment. But unfortunately, the works till date fall short of expected accuracy in this regard. A review of automated glaucoma detection techniques is presented in this paper.

Keywords: *Glaucoma, Fundus images, Optic nerve head, Cup to disc ratio (CDR), ISNT rule.*

1. INTRODUCTION

Glaucoma is a disease that progresses damaging the optic nerve with loss of retinal neurons and the nerve fiber layer, resulting in blindness if not treated on time. It is caused by elevated Intraocular Pressure (IOP). Blind spots develop due to damage to the optic nerve fibers which usually go undetected until optic nerve is significantly damaged. Glaucoma is a standout amongst the most serious eye sicknesses as indicated by the quantity of visual impairment causes in India and western nations and is the second most driving eye illness. Thusly, the early recognition, long-haul observing of the patients and the choice of the suitable treatment at the right time are the genuine assignments for the ophthalmologist. Glaucoma is the leading cause of blindness in the world with around 80 million likely to be afflicted with glaucoma by the year 2020. The need for early glaucoma detection is due to the facts: 1) No noticeable symptoms in its early stages 2) Damage caused by it is irreversible 3) Leads to permanent loss of vision if not treated on time. Although the damage caused by glaucoma is irreversible, detection at an early stage and subsequent treatment help in slowing down the progression of the disease.

In its early stages, there is no pain and patients often have no symptoms. Over time glaucoma starts to affect your side/peripheral vision and slowly works its way to the middle if left undetected. To date, there is no cure for glaucoma. Fortunately, it is usually a slowly progressing condition, and if it is detected early, it can be treated successfully. Early detection is the key to preventing sight loss. It is described by the dynamic degeneration of optic nerve strands and prompts auxiliary changes of the optic nerve head, which is known as an optic plate, the nerve fiber layer and a synchronous practical disappointment of the visual field. Movement of the infection prompts loss of vision, which happens step by step over a drawn-out stretch of time. Glaucoma can't be cured, however, its movement can be backed off by treatment. Hence, recognizing glaucoma in time is basic.

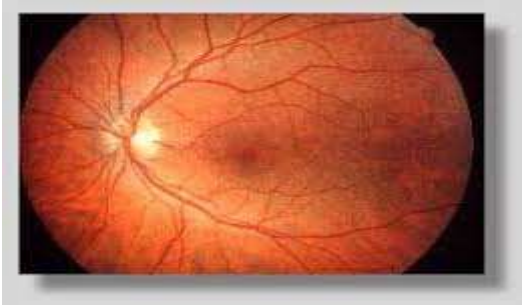

Fig.1. Fundus image of the eye.

Fundoscopy (Ophthalmoscopy) and OCT have emerged as a preferred imaging modality for glaucoma screening as well as automated glaucoma assessment due to its noninvasive nature. Automated glaucoma detection using Fundoscopy involves analyzing optic nerve head (ONH) and detecting structural changes in ONH. An important feature of interest in Optic cup segmentation is that the vessel bends at cup boundary. Apart from CDR, the thickness of the NRR is also an important structural feature for differentiating between a nonglaucomatous and a glaucomatous eye. Also, a normal eye should satisfy Inferior, Superior, Nasal, Temporal (ISNT) rule. In a healthy eye, the inferior rim thickness is more than that of superior, which in turn is more than the nasal rim. The temporal rim is thinnest. In a glaucomatous eye, the ISNT rule will not remain intact.

OCT is the most advanced optical imaging modality for glaucoma assessment. OCT aids in detecting structural changes in the retinal layers due to glaucoma progression. Due to glaucoma progression, the retinal layers (Retinal Nerve Fiber Layer (RNFL) and Macular Layer (ML)) thickness reduces due to the destruction of ganglion cells. Hence RNFL and ML thickness are the major structural features for differentiating between a nonglaucomatous and a glaucomatous eye. In this paper, the survey of detection of glaucoma from the fundus image is presented.

2. AUTOMATED GLAUCOMA DETECTION

The retinal images used are fundus image. Preprocessing of retinal image leads to improvement of image data by suppressing unwanted distortions and by enhancing some image features for further processing. Feature extraction from retinal image incorporates algorithms designed and developed to detect various desired features (shapes) from the retinal images. Retinal image classification analyzes various image features extracted and organizes the data into categories: NonGlaucomatous or Glaucomatous. The following papers used different methods on the fundus images to detect glaucoma.

2.1 Investigation of Primary Glaucoma by CDR in fundus images [7]

In this paper, the primary glaucoma is detected by calculating CDR from the input image. The proposed work is used to develop the relation between CDR and RNFL, and the relation between age of humans and the CDR. The segmentation is done by some novel segmentation algorithm. The application of this project work is it can also be used in public places so that the human being who is affected with glaucoma can be detected immediately, precaution could be given so that the proper diagnosis can be done.

2.2 Automated Detection of Suspected Glaucoma in Digital Fundus Images [8]

In this paper, an algorithm is proposed to detect suspected glaucoma by using the presence or absence of hemorrhages in a particular region, near the optic disc, in fundus image. The method proposed in this paper helps to diagnose the case of suspected glaucoma efficiently. The optic disc and hemorrhages are segmented automatically by using adaptive thresholding and some geometrical features. The proposed method is used to diagnose the cases of suspected glaucoma. The method proposed for detection of suspected glaucoma is divided into two sections: Segmentation of region of interest (ROI) and detection of suspected glaucoma using hemorrhages detection. The ROI segmentation is used for hemorrhages detection. In this project, a total of 140 fundus images are tested to check the reliability of the method and the proposed algorithm has an accuracy of 93.57% in the detection of glaucoma.

2.3 Automatic Glaucoma Detection by Using Funduscopic Images [9]

In this paper, the funduscopic images are used to identify glaucoma automatically using digital image processing. Here the glaucoma is detected by CDR ratio and blood vessel orientation. Here first the cup and disc are extracted by using average and maximum grey level pixels respectively with the use of the histogram and then find the radius of cup and disc. Then the CDR is calculated and by if CDR is exceeded the threshold value then the image is abnormal. The system extracts the blood vessels and through their orientation glaucoma is identified.

According to the experiment it proved that if the CDR value is between 0.0 and 0.3, then the image is normal and if it is greater than 0.3, then it is glaucomatous. Blood vessel orientation is identified by the distribution of the extracted blood vessels in four equal quarter circles. If most of the blood vessels belong to only one or two-quarter circles then it is advanced glaucomatous and if the blood vessels spread into three or all four quarter circles, then it is early glaucomatous or normal.

2.4 Detection of Glaucoma Using Retinal Fundus Images [10]

In this paper glaucoma is classified by extracting two features) Cup to Disc Ratio (CDR) and Ratio of Neuroretinal Rim in inferior, superior, temporal and nasal quadrants i.e. (ISNT quadrants) using retinal fundus to check whether it obeys or violates the ISNT rule. Two features are extracted by Mean Threshold Morphological method in order to evaluate CDR and to find NRR ratio in ISNT quadrants. For CDR evaluation, optic disc and cup is required and to find NRR ratio in ISNT quadrants, NRR itself is required. The developed methods are tested on three different data base i.e., DMED, FAU, and MESSIDOR. The proposed method achieves an average accuracy of 94% having the average computational cost of 1.42 seconds.

2.5 Glaucoma Detection by Segmenting the Super Pixels from Fundus Colour Retinal Images [11]

This paper proposes an automated image processing approach for detection of glaucoma which may be a diagnostic tool to help ophthalmologist in mass screening of glaucoma suspects. The proposed approach is based on the segmentation of optic disk and the optic cup and computing the cup-to-disc ratio. For segmentation of optic cup and optic disk, a double threshold method is used, one for removing blood vessels and background and second threshold for segmenting the super intensity pixels contained by the optic disk and optic cup. Further, Hough Transform is used to calculate the radius of optic disk and optic cup. The vertical cup to disk ratio is used as a parameter for identification of glaucoma symptoms in the fundus image. To know the effectiveness of the proposed

method, the results obtained from the proposed method is compared with the diagnosis results of expert medical professionals. The comparison of the results indicates that the proposed method has high accuracy in detecting Glaucoma using retinal fundus images. The proposed algorithm is tested over a large data set of retinal fundus images and a detection accuracy of above 90% is attained. The simplicity of the algorithm with low computational cost has good potential in glaucoma diagnosis.

3. CONCLUSION

This paper presents briefly about the various methods used to detect glaucoma from the fundus images. Each method has its own merits and demerits. The future work can be done by using different images like anterior segment optical coherence tomography (AS-OCT) images and using different algorithms

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