Automatic Detection of Glaucoma Disease Using OCT and Fundus Images

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***Abstract*:- Retinal nerve fiber layer (RNFL), optic cup and optic disc are most important parts of human eye. The thickness of retinal nerve fiber layer and optic cup to disc ratio are used to diagnose the Glaucoma eye disease. The proposed work provides an automatic technique to estimate the RNFL thickness using statistical region merging algorithm and vertical cup to disc ratio using edge detection approach and a variational level-set approach to diagnose the Glaucoma through Optical Coherence Tomography (OCT) eye images and fundus images, which are captured from the OCT device and fundus camera respectively.**

Keywords:- ***Retinal nerve fiber layer(RNFL), Optical Coherence Tomography(OCT), Vertical cup to disc ratio(VCDR)***

1. INTRODUCTION

Glaucoma is a severe human eye disease. It is a type of chronic disease that damages the optic nerve and results in loss of vision. The main cause of glaucoma eye disease is the continuous loss of retinal nerve fiber layers due to the increase in the intra ocular pressure inside the eyes. The pressure of the fluid inside the ordinary eye is 21mm Hg. The pressure in eye increases with increase in fluid level causes damage in the optic nerves. Glaucoma has been called the "silent theft of sight". It is not a sudden effect, the loss of vision occurs slowly over a long period.
In healthy Eye, intraocular pressure is in normal condition and aqueous fluid continuously moves out of the Eye through drainage meshwork. Intraocular pressure is a pressure inside the eye caused by aqueous fluid of an Eye and aqueous fluid is water like fluid present in the Eye. Figure 1.1(a) shows the healthy eye image.

In case of Glaucoma Eye, Drainage meshwork is blocked. Hence aqueous fluid does not drain out of the Eye through meshwork. This aqueous fluid will circulate with in the Eye and increases continuously inside Eye. Increase of this aqueous fluid in terms increases the intraocular pressure. This cause damages to Retinal Nerve Fiber Layers and optic nerve. These damaged Retinal Nerve Fibers are usually does not carry the electrical signals to optic Nerve. Therefore loss of these signals creates the blind spots (Vision loss areas).This situation is called as glaucoma disease. Figure 1.1(b) shows the Glaucomatous eye image.

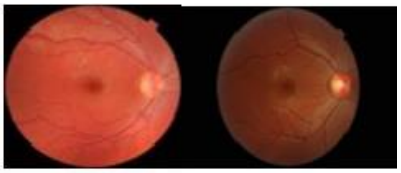

Fig 1.1(a) Healthy image Fig 1.1(b) Glaucomatous image

2. LITERATURE SURVEY

Literature survey is an important activity. It is used during gathering of information for the project. It will help full for us to get required information or ideas to do the project. The following paragraphs discuss the related work proposed by the different authors to detect the Glaucoma eye disease.

Fabian rathk et al [1]., presented novel approach to extract intra RNFL. Authors were used the three dimensional OCT images for extraction of RNFL. Here, global shape regularization method was used to extract different layers present in OCT images.

Gazarek J et al [2]., presented new system for segmentation of retinal nerve fibre layer in fundus eye images. Later extracted retinal nerve fibre layer from fundus eye images are compared with OCT eye images consisting retinal nerve fibre layer. Here, authors were used the four methods to detect retinal nerve fibre layer in fundus eye images.

Jost Bruno jomas et al [3]., proposed the new techniques to extract neuroretinal rim area of an eye, optic cup region and optic disc region in normal eyes. Here, authors were considered the 319 fundus image samples for analysis of cup, disc and rim areas. They were used magnification corrected morphometry method to extract and measure cup, disc and neuroretinal rim areas. Authors also calculated the cup to disc ratio.

U. Rajendra Acharya et al [4]., presented automatic approach to detect glaucoma. The texture features and high order spectra features were used in the glaucoma detection and analysis. Texture features and high order spectra features were extracted from fundus eye images.

Shijian lu et al [5]., presented automatic approach to segment different layers present in the OCT eye images. Initially OCT image is divided into several subparts. In the next step blood vessels are removed from each OCT sub-image using iterative polynomial smoothing procedure.

Jiri Gazarek et al [6]., developed the method to detect the retinal nerve fiber layer using the fundus eye images. Later results were compared with retinal nerve fiber layer extracted from OCT eye images. Fundus eye image was processed by using 2D matched filtering technique to remove blood vessels present in the fundus image.

Gearge kanpougeris et al [7]., developed the new approach for classification of Glaucoma eyes and normal eyes. In this work retinal nerve fiber layer thickness was considered to classify the Glaucoma eyes and normal eyes.

Jan Odstrcilika et al [8]., presented texture model to diagnose glaucoma eye disease. This approach monitors and detects the changes in retinal nerve fiber layer. This model based on two well know algorithms, Gaussian Markova random fields (GMRF) and least square error estimation algorithms. Gaussian Markova random fields(GMRF) return the texture features. These texture features were tested by least square error estimation and finally, these texture features were used to analyze the RNFL changes.

3. PROBLEM STATEMENT AND SOLUTION

3.1 Problem Statement

An early detection of glaucoma is particularly significant since it allows timely treatment to prevent major visual field loss and prolongs the effective years of usable vision. The diagnosis of glaucoma can be done through measurement of CDR (cup- to-disc ratio) and OCT images. Currently, CDR evaluation is manually performed by trained ophthalmologists. So it is subjective and in case of OCT devices, currently using techniques are not accurate. Thus, this work proposes an intuitive, efficient, accurate and objective method for automatically classifying digital fundus images and OCT images into either normal or glaucomatous types in order to facilitate ophthalmologists.

3.2 Solution

Retinal nerve fibre layer (RNFL), optic cup and optic disc are most important parts of human eye. The thickness of retinal nerve fibre layer and optic cup to disc ratio are used to diagnose the Glaucoma eye disease. First, Thickness of The Retinal nerve fiber layer is calculated by developed algorithm then estimated retinal nerve fiber layer thickness value is compared with gold standard value or the actual value obtained from hospital. At the end, the texture features are extracted from the OCT eye image such as Mean, Standard deviation, Skewness and Kurtosis and these texture features values are compared with RNFL thickness to develop the relationship and diagnose the glaucoma. On the other hand, Optic disc is the one of important factor used to detect the glaucoma. Optic disc is also referred as optic nerve head, it is area located at the back side of the eye. Optic disc is a small area in which all ganglion cell axons and retinal nerve fibers exit the eye and blood vessels are entering into the eye. It is connected to optic nerve and it consisting one small area is called the optic cup. Size of the optic cup is always constant but cup area varies from one person to another. Optic cup present inside the optic disc. Therefore area of optic cup is always smaller than the area of the optic disc. Vertical cup to disc ratio is used to detect the glaucoma eyes.

4. METHODOLOGY

4.1 Cup to disc ratio method:

To calculate the vertical cup to disc ratio (CDR), the optic cup and disc have to be segmented from the retinal images. The following figure shows depicts the framework for building the proposed detection system

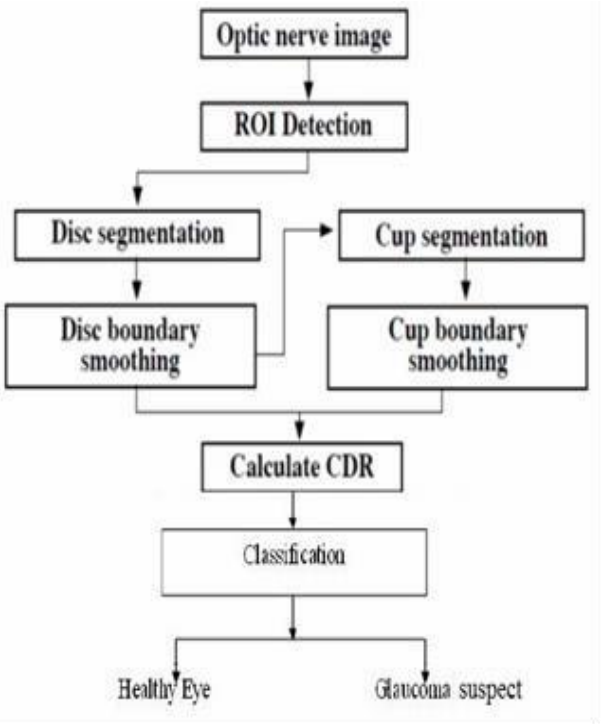

Figure 4.1: Retina image processing framework for cup-to- disc ratio (CDR) detection in glaucoma analysis.

In order to extract the optic disc and cup, each retinal fundus image has been captured using a high resolution retinal fundus camera and saved as a 3072 x 2048 high-resolution digital image. The fundus images with the highest intensity are selected as potential candidates for the optic disc center. The intensity-weighted centroid method [17] is proposed to find an approximate ROI center. The boundary of the ROI is defined as a rectangle around the Region of Interest (ROI) centre with dimensions of twice the typical optic disc diameter, and is used as the initial boundary for the optic disc segmentation, The ROI is returned as an image of size 480x750 pixels.

4.2 RNFL thickness method

The figure 4.2 shows steps involved in detection of glaucoma disease using OCT images.

4.2.1 Image Pre-Processing

This phase takes the original OCT image, generates the red channel image, green channel image and blue channel images. Red channel image consisting only red components presents in original OCT image. Green channel image consisting only green components presents in original OCT image and blue channel image consisting only blue components presents in original OCT image. Later de-noised image is obtained by applying the median filter algorithm to red, green and blue channel images and combining red, green and blue channel images.

4.2.2 Image Enhancement

This phase takes de-noised color OCT image generated by pre- processing phase and produces the enhanced OCT image using image adjustment method. Image adjustment method adjusts pixels values. So, contrast of image will increases.

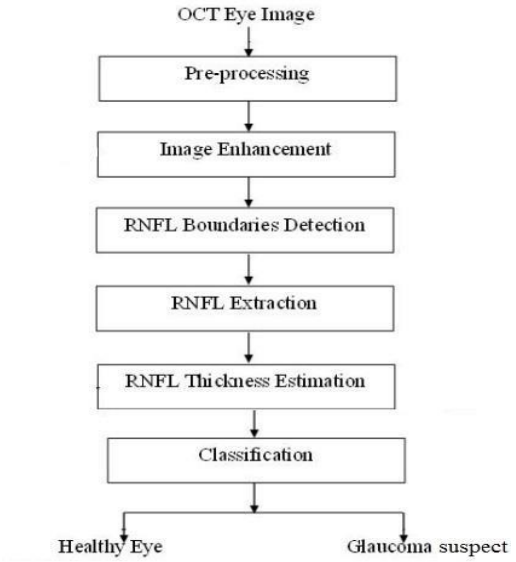

Figure 4.2: System Architecture for detection of glaucoma disease using OCT images.

4.2.3 RNFL Boundaries Detection

Here, boundaries of retinal nerve fiber layer are detected by using statistical region merging algorithm. It also detect the boundaries of others layers present in the OCT image.

4.2.4 RNFL Extraction

An algorithm is developed to segment the RNFL from the texture segmentation output. Since it is the first layer in the image, the algorithm first searches for any change in the pixel value. This process will continue until an abrupt change in the pixel value is obtained.

4.2.5 RNFL Thickness Estimation

Thickness of RNFL can be obtained by calculating the number of white pixels in the RNFL. First the number of white pixels in each column is calculated. Then the number of white pixels in each column is multiplied with the resolution factor respectively. The resolution factor for OCT is normally 8μ/pixel. Finally the average of all the values is taken as the thickness of RNFL. This thickness measurement (T) is given by following equation.by using T we can easily classify image into either normal or glaucoma suspect.

$$T = \frac{\text{Resolution factor* No. of pixels in each column}}{\text{No. of columns}}$$

6. RESULTS

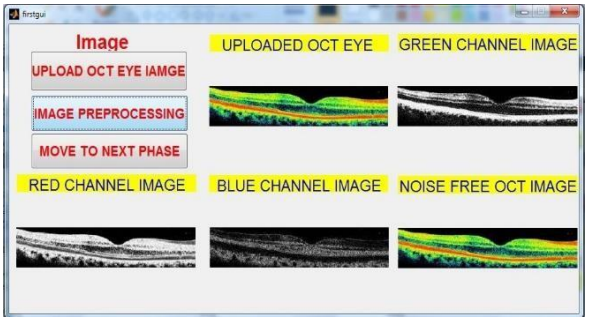

Figure 6.1: Image preprocessing of OCT

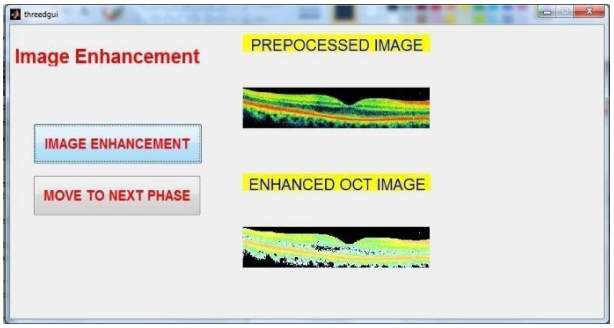

Figure 6.2: Image Enhancement

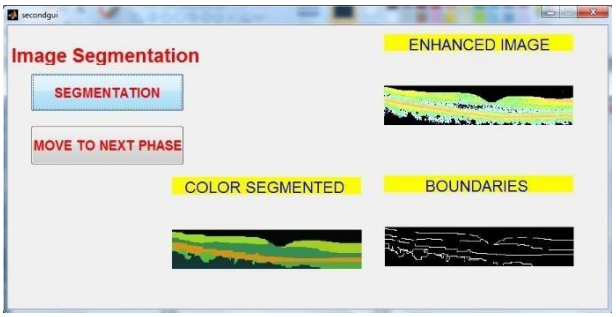

Figure 6.2: Color Segmentation and OCT boundaries

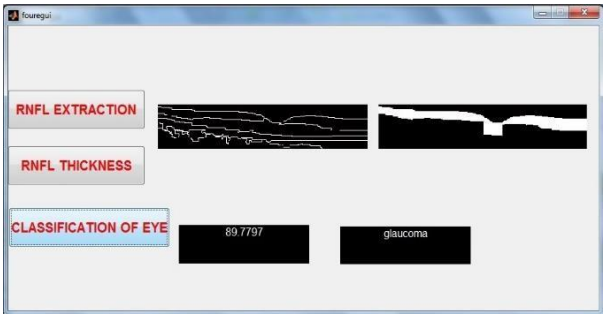

Figure 6.3: RFNL Thickness and Glaucoma analysis

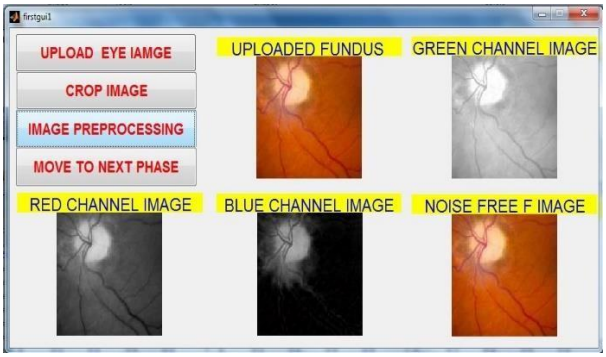

Figure 6.4: Image preprocessing of FUNDUS

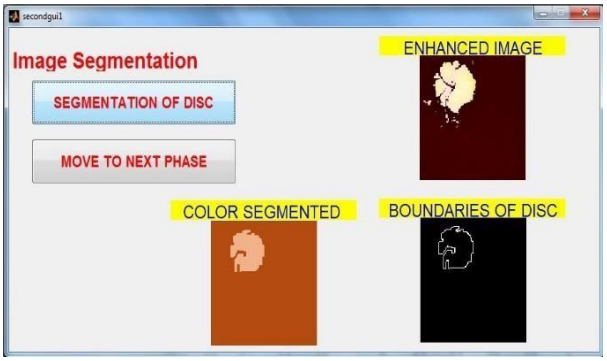

Figure 6.5: Color Segmentation and Disc boundaries

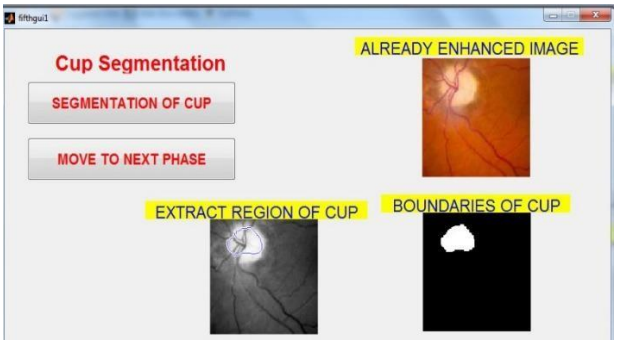

Figure 6.6: Color Segmentation and Cup boundaries

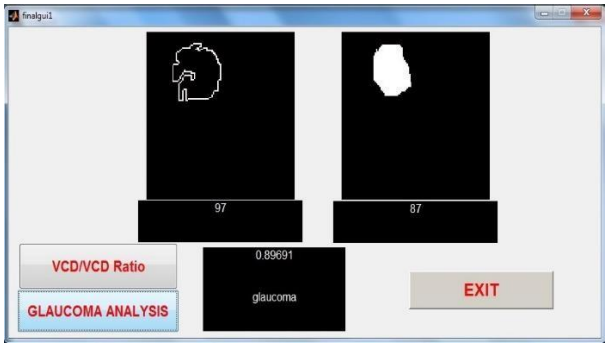

Figure 6.7: VCD ratio and Glaucoma analysis

7. CONCLUSION

Proposed work presents techniques for segmentation of retinal nerve fiber from OCT images, estimation of thickness of RNFL, calculation of CDR from fundus eye images and detection of glaucoma eye disease based on the thickness value of nerve fiber layer, CDR extracted from OCT and fundus images.

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