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Detection of Glaucoma Using Retinal Fundus Images with Gabor Filter

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Abstract — *Glaucoma is an eye disease which causes optic nerve damage. It is a primary cause of permanent blindness. It is a disease in which the intraocular pressure (IOP) becomes high. A liquid called "aqueous" is continuously flowing inside the eye. This liquid creates pressure on the internal surface of the eye. If this pressure increases to a great extent, the possibility of Glaucoma is high. Glaucoma mainly affects the optic disc by increasing the cup size. Glaucoma is one of the major causes which cause blindness but it can be cured if treated at early stages. Glaucoma is classified using Cup to Disc Ratio (CDR) of retinal fundus images. Hence an automated Glaucoma diagnosis is required to detect the abnormality so that when early signs are observed corrective treatments can be prescribed and vision loss can be prevented. Lots of research has been carried out in detecting the Glaucoma disease. In this paper, a new approach for detection and grading of Glaucoma by following three methods: (1) Gabor filter is used for detection of optic disc and cup (2) OTSU's method is used for thresholding (3) Artificial Neural Network (ANN) is used for classification of the disease.*

Keywords- Glaucoma, Cup to Disc Ratio (CDR), ISNT, Fundus Image, Optic Disc Segmentation, Optic Cup Segmentation

I. INTRODUCTION

In the modern era, there are lots of diseases that affect the normal life of a human. Lots of people in rural and semi-urban areas suffer from eye diseases such as Glaucoma, Diabetic Retinopathy, Age based Macular Degradation etc. Automatic retina image analysis is becoming an important screening tool for early detection of certain risks and diseases. Glaucoma is a second leading cause of permanent blindness. It is known as "silent thief of sight". Glaucoma usually causes no symptoms and warnings; it can only be diagnosed by regular eye examination. It is caused by an increase in intraocular pressure within eye (Fig. 1). The optic nerve carries image information to brain. A liquid called "aqueous" is continuously flowing inside the eye. This liquid creates pressure on the internal surface of the eye. In normal eye this pressure is between 14 to 20 mmHg. If it is between 20 to 24 mmHg, it shows the symptoms of glaucoma. If the pressure is greater than 24 mmHg, it is sure that glaucoma. Inter Ocular Pressure (IOP) within the eye constant but in glaucoma, the balance of fluids produced within the eye is not maintained properly. Due to this the optic nerve is damage. As For normal disc the CDR is considered to be less than 0.5 but in case of glaucoma, it is greater than 0.5.

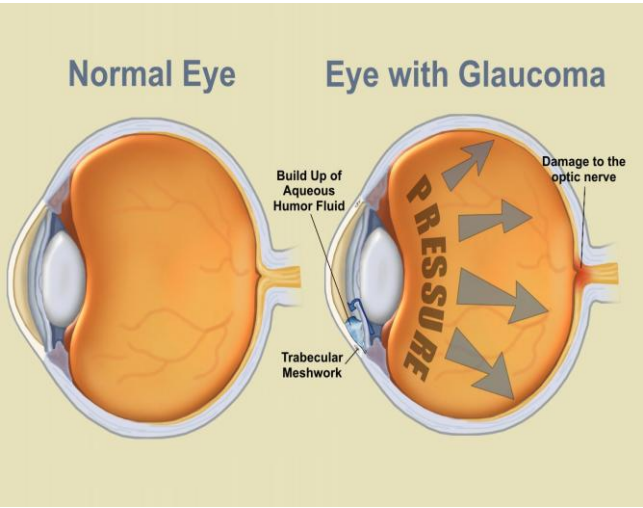

Fig 1: Comparison of Normal eye and eye with Glaucoma [5]

Glaucoma being the cause of blindness is 12.8 per cent of the total blindness in the country. In India, more than 90 per cent of Glaucoma in the community goes undiagnosed. In India, it is estimated that Glaucoma affects 12 million people

and by 2020, this is expected to be 16 million. Image processing technique helps in early diagnosis of glaucoma and other eye disease. Retinal fundus images are captured by using special devices called ophthalmoscopes.

Fig 2: Vision of Normal and Glaucoma [6]

The paper is organized as follows: Section II gives a review of different methods for detecting of optic cup and optic disc from retinal images. In Section III describes proposed algorithm for detection of glaucoma. Section IV shows the results obtained and Section V concludes the paper.

II. DIFFERENT METHODS FOR DETECTING OF OPTIC CUP AND OPTIC DISC FROM RETINAL IMAGE

In 2014, Hafsah Ahmad performed a work, "Detection of Glaucoma using Retinal Fundus Images" [1]. This paper explores an image processing technique for the detection of glaucoma which mainly affects the optic disc by increasing the cup size. In this paper, Glaucoma is classified by extracting two features using retinal fundus images. (i) Cup to Disc Ratio (CDR). (ii) Ratio of Neuroretinal Rim in ISNT quadrants. The novel method Morphological technique is used to extract above two features. The following methodology used in this paper:

1. Preprocessing of an image
2. Extraction of Optic Disc and Cup
3. Extraction of Neuroretinal Rim
4. Classification

In April 2013, Mei Hui Tan performed a work, "Automatic Notch Detection in Retinal Images" [2]. The proposed algorithm consists of four main steps:

1. Disc and vessel segmentation
2. Vessel bend computation
3. Feature points selection
4. Classification of the images using I and T values.

The proposed method is able to determine the presence of notching in the optic cup from color fundus images. Preliminary results show that the algorithm is automatic, efficient and accurate

In September 2013, DharmannaLamani performed a work," Cup-Disk Segmentation and Fractal Dimension to Detect Glaucomatous Eyes" [3]. It detects glaucoma in human eye through cup-disk segmentation & fractal dimension using image analysis using NRR. This paper uses:

(1) Semi variance method found to be more efficient.
(2) Fractal dimension feature could be used as a diagnostics parameter for earlier detection of glaucoma.
(3) The visualization of segmentation reveals that decrease in area of signifies attacking glaucoma neuroretinal rim by glaucoma.
(4) Fractal Dimension (FD) found to be in the range of 1.50-1.59 for the glaucoma affected eye.

In September 2011, Fengshou Yin performed a work," Model-based Optic Nerve Head Segmentation on Retinal Fundus Images" [4].The following method used in this paper:

1. Shape and Appearance Modeling
2. Pre-processing

3. Edge Detection and Circular Hough Transform
4. Optic Disc Boundary Extraction

III. PROPOSED ALGORITHM FOR DETECTION OF GLAUCOMA

Glaucoma is a very severe eye disease and it is dangerous for causing vision loss. For detection of cup and disc Gabor filter is used, for thresholding OUT'S method is used and for classification of Glaucoma disease Artificial Neural Network (ANN) is used. As shown in the flow chart the original fundus image is taken and Region of Interest (ROI) is derived. Original fundus image is converted into HSV plane. Optic disc is detected from V-plane. Extract Green plane from original image and optic cup is detected from G-plane. OTSU'S method is used for thresholding. Gabor filter is used for detection of optic cup and optic disc from fundus images. Then original image is converted into gray scale image and binary image. After that CDR is calculated. Then ANN classifier is applied on retinal images. At last, disease is diagnosed and classified as mild, moderate and severe.

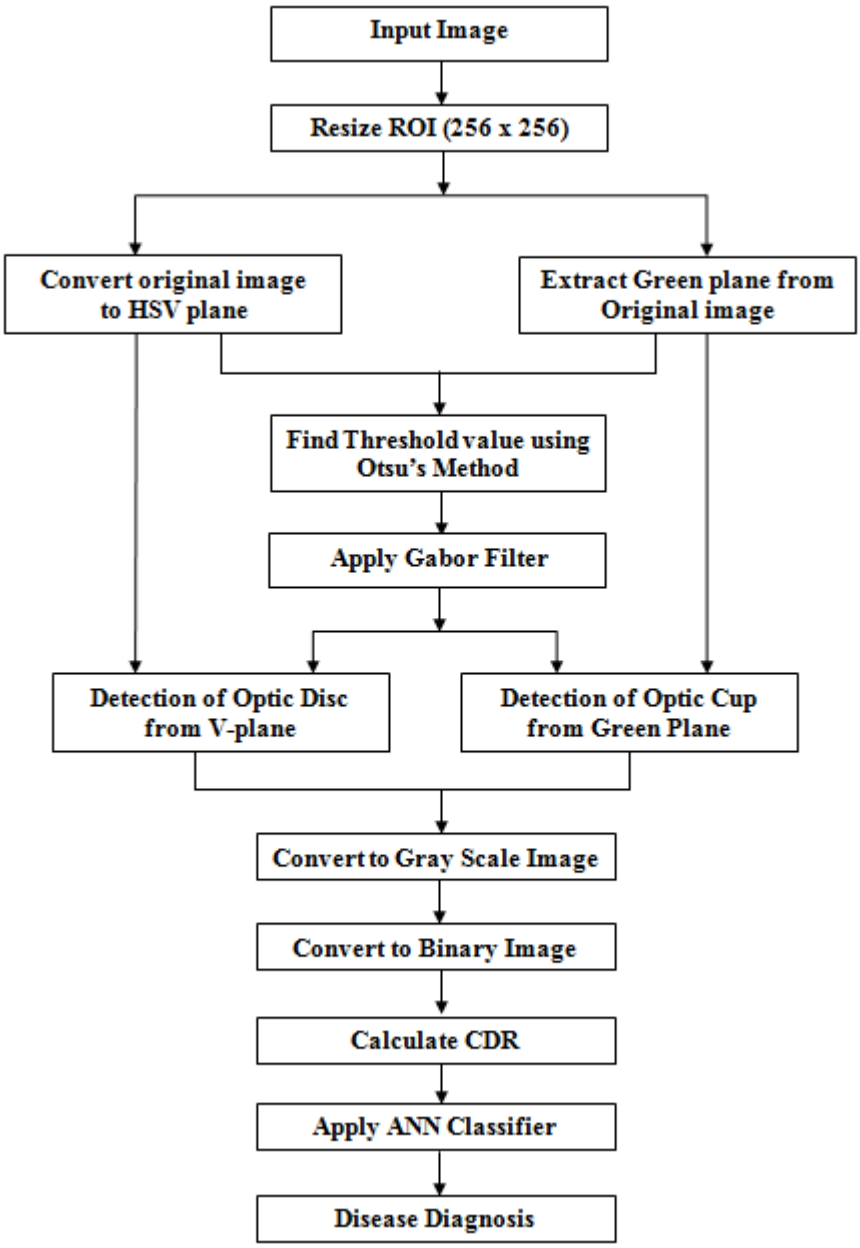

Fig 3: Flow chart for propose algorithm for detection of Glaucoma

IV. RESULTS

The proposed algorithm for Glaucoma detection was implemented on Retinal Fundus Images. The main database is consisting of 136 fundus images [7]. Out of these datasets, 24 images are taken for training and 27 images are taken for testing phase. The clinical CDR provided by ophthalmologist for training and testing images. Detection of optic disc and optic cup using the propose algorithm is shown in fig 4. Magnitude of Gabor filter and Real part of Gabor filter are shown in fig 5 and fig 6. The result of ANN is shown in fig. 7.

Cup to Disc Ratio (CDR) is calculated by following equation.

CDR = (Cup area / Disc area)*2

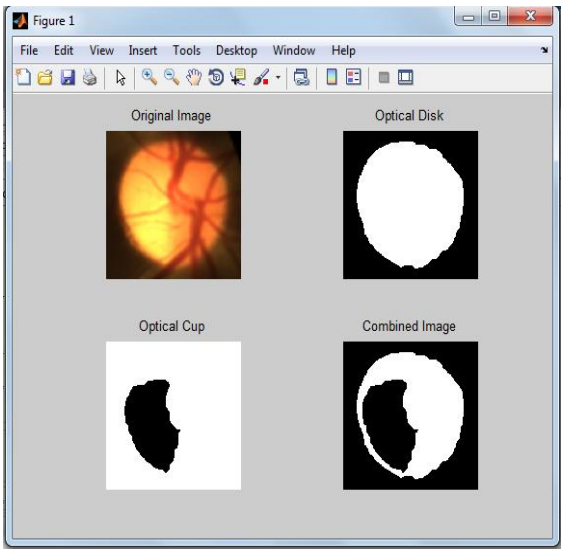

Fig 4: Detection of Optic Cup and Optic Disc

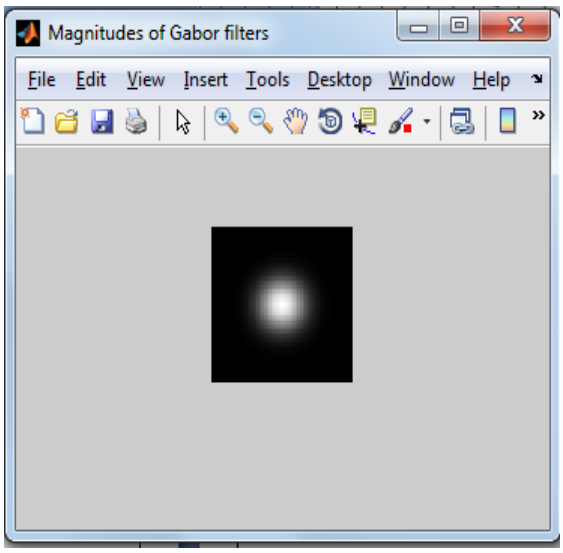

Fig 5: Magnitude of Gabor Filter

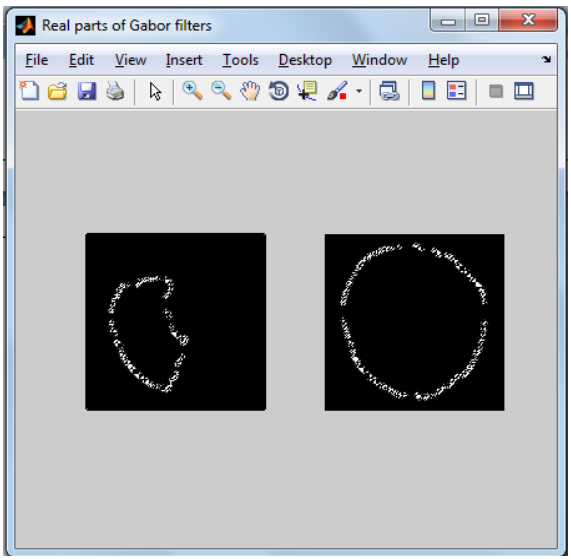

Fig 6: Real parts of Gabor Filter

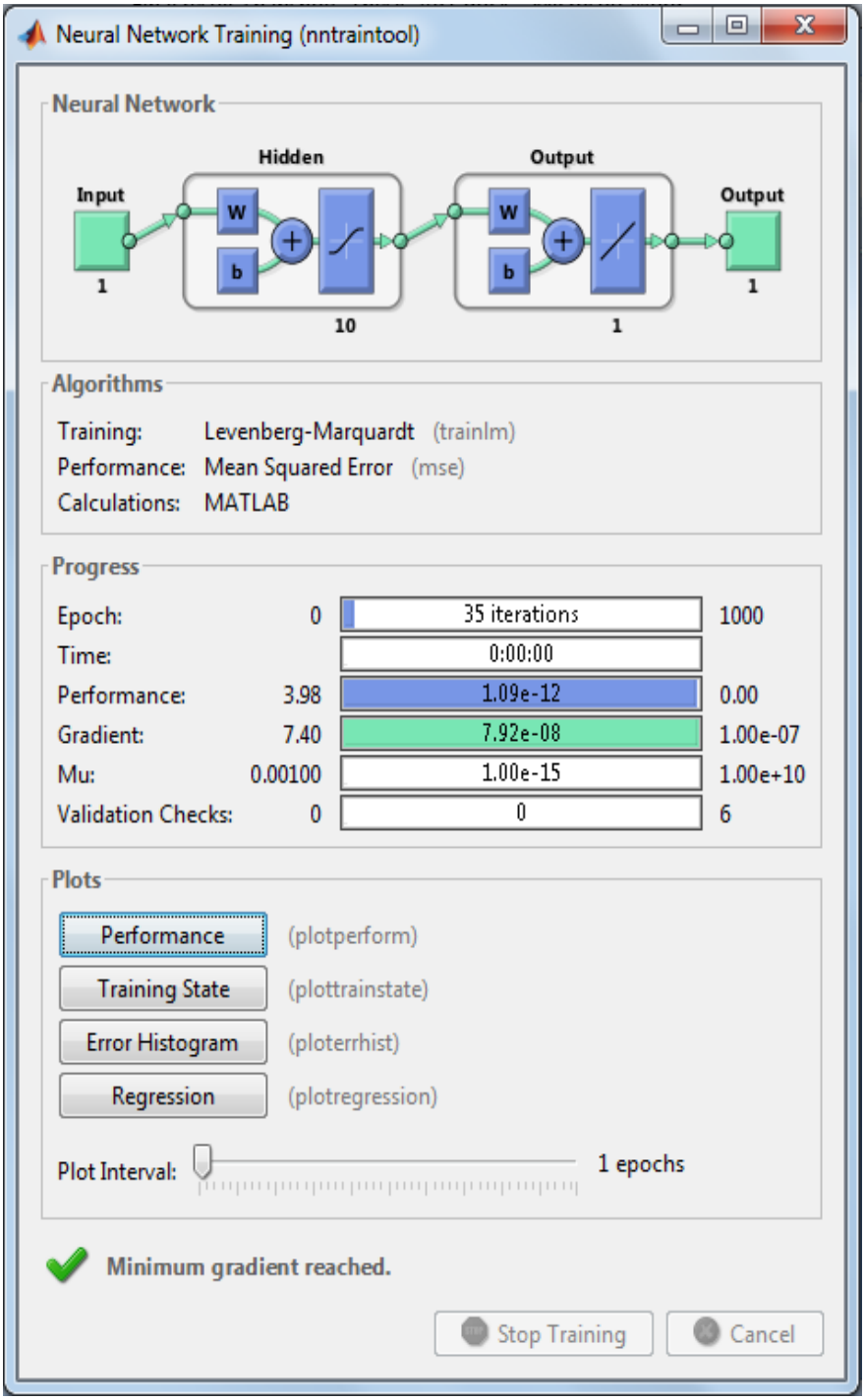

Fig 7: ANN Result

❖ **CDR Ratio in tabular form:**

Table 1: CDR Ratio of Fundus Images

Images	Clinical CDR (Ophthalmologist)	CDR by Existing Method[1]	CDR by Proposed Method	Grading / Classification
15_training.jpg	0.8	0.7998	0.8421	Severe
16_training.jpg	0.3	0.4708	0.3008	Mild
20_training.jpg	0.4	0.0741	0.4190	Moderate
23_training.jpg	0.8	0.7998	0.8421	Severe
24_training.jpg	0.4	0.4946	0.3965	Mild
04_test.jpg	0.5	0.5243	0.5767	Moderate
08_test.jpg	0.7	0.5796	0.6948	Severe
13_test.jpg	0.3	0.6227	0.3305	Mild
14_test.jpg	0.6	0.2952	0.5733	Moderate
15_test.jpg	0.6	0.5297	0.6548	Severe

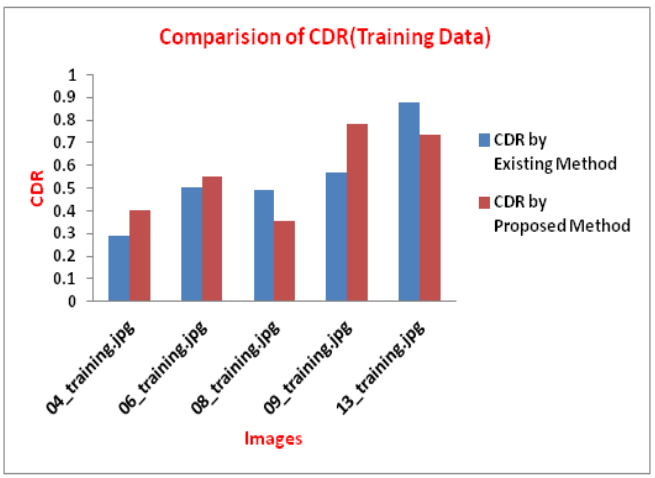

Fig 8: Graphical comparison of CDR for Training Images

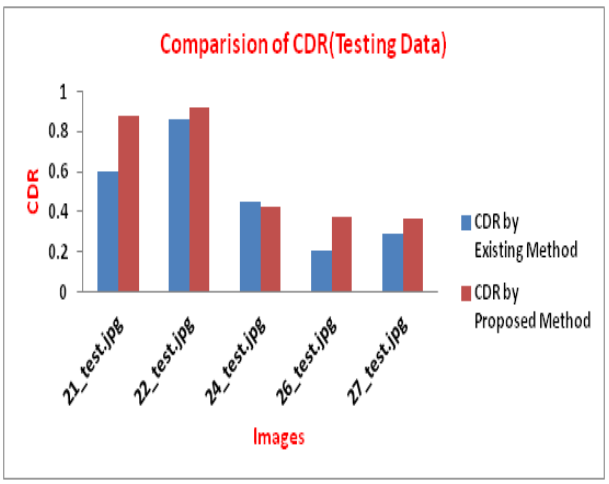

Fig 9: Graphical comparison of CDR for Testing Images

V. CONCLUSION

Glaucoma is a fast growing disease in today's modern world. There are many symptoms on the basis of which the glaucoma disease can be classified. Different techniques are used by different authors and it is noted that there is a constant research happening in this field. Here an attempt is done to learn and understand some of the techniques used till now for detection and extraction of the features. After successful understanding of the disease and the technique, a unique method is proposed to extract the relevant features. A unique method is proposed to identify the stages of Glaucoma by classifying the features extracted according to their significance.

VI. REFERENCES

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[6] http://www.vistaeyecareco.com/glaucoma

[7] http://barodaeye.com

