Combined Approach on Analysis of Retinal Blood Vessel Segmentation for Diabetic Retinopathy and Glaucoma Diagnosis

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Abstract— In Developing countries, Most of the working age populace are affected from eye diseases. Retinal image analysis plays an important role in medical diagnosis. Most common eye Diseases are Diabetic Retinopathy , Glaucoma, Retinal Detachment, Retinal Disorder, Age Related macular degeneration etc are of much significance today. Around 90% of the people are affected by Diabetic Retinopathy. In this paper, a novel approach is provided for diagnosis of Diabetic Retinopathy and Glaucoma. In Diabetic Retinopathy , retina gets damaged due to the results of diabetes. Finally Diabetic patients suffer from loss of vision and further causes blindness. For Diabetic patients, Blood vessels become swallow and starts to leak fluids in the retinal vessels. Exudates are detected and seen as yellow spots in the retinal layers. Glaucoma is one of the eye disease which affects the optic nerve. Glaucoma mainly affects the optic disc by increasing the cup to disc ratio. The blood vessels in optic disc region is detected by using component analysis method. The measuring of the blood vessels region in the optic disc, which is another parameter to detect glaucoma diagnosis. The better results obtained successfully with PSNR 32.9335 and ACCURACY 92.99%. A batches of Medical images are obtained from nearby Eye Hospital.

Index Terms— Diabetic Retinopathy, Exudates, Glaucoma , Optic Disc,Optic nerve, Retinal Disorder,Yellow spots.

1 INTRODUCTION

RETINA is the only location in the human eye, where blood vessels can be visualized. The retina receives images formed by the lens and transmits through the optic nerve to the brain. Retina is the light sensitive layer of tissue located in back of the eye. Retinal images play an important role in medical diagnosis. Some of the medical applications are Diabetic retinopathy, Aging related problems in Retina, Hypertension, Cardiovascular disease etc. The main aim of this work is to segment the blood vessels from retinal images for diagnosis of diabetic retinopathy and glaucoma.

Glaucoma: Glaucoma is one type of eye disease which affects optic nerve. The optic nerve is a light sensitive and it transmits images to the brain. In glaucoma, intra ocular eye pressure plays a significant role. It affects the optic nerve and due to which flow of blood in the optic nerve is reduced which lead to blindness. Glaucoma leading to second rank in common blindness across the world. Low awareness and high costs are reasons of glaucoma, which leads to improve the methods of screening and therapy. Based on morphological operations, Hough transform, and an anchored active contour model, Optic nerve head segmentation methods are proposed to improve validation retinal screening therapy in [1].

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Detection of optic disc is constrained to detect the blood vessels in the disc region and this helps to find the location of the optic disc. Cup to Disc ratio is calculated by using the threshold level set method and variation level set method to extricate the optic disc and optic cup from the normal images and Glaucoma image [2]. A robust and computationally efficient approach for the localization of the different features and lesions in a retinal image is presented in [3]. Here the method consists of morphological processing for isolating the brightest area in the image and Hough transform for detecting the main circular feature within the positive horizontal gradient image within the region of interest [4].

In Diabetic retinopathy [5], the major cause of blindness is due to the abnormal changes in blood vessel structure and new growth of blood vessels requires a proliferative diabetic retinopathy. DR causes haemorrhages , macular oedema, and in later stage retinal detachment. Diabetic retinopathy is the leading ophthalmic pathological cause of blindness among the people working in developed countries [6]. The estimated diabetes prevalence of all working age groups worldwide was 2.8% in 2000 and 4.5% in 2030. The total number of diabetes patients rise from 170 million in 2000 to 400 million in 2030[7]. Diabetes is one of the eye disease which are complicated is known as Diabetic Retinopathy. Due to some of the changes in the structure of the blood vessels and a new vessels are grown in abnormal region. Therefore the enhanced blood vessels are further segmented by using the modified entropy threshold algorithm [8].

This paper proposes a new approach which is organized as follows. In section 2, the proposed method is described. The experimental results are discussed in section 3 and conclusion and future work is discussed in section 4 .

2 DIAGNOSIS OF GLAUCOMA AND DIABETIC RETINOPATHY

The block diagram for the proposed methodology is given in Fig 1. This schematic diagram enlightens about to find the Diabetic Retinopathy and glaucoma diagnosis.

Glaucoma is a disease which causes damages to the optic nerves. The retinal images were collected from Medical databases. The blood vessels gets multiple or narrow in glaucoma images.

Diabetic Retinopathy is a disease which causes damages to retina caused by diabetes. The blood vessels get swell or it starts to leak fluid in the retinal area.

2.1 Diagnosis of Glaucoma:

Glaucoma: Glaucoma is a complicated disease which mainly damages the optic nerve and it leads to blindness. The blood vessels get narrower for glaucoma diseased patients. Glaucoma is a disease which is characterized by an elevated Intra Ocular Pressure (IOP).

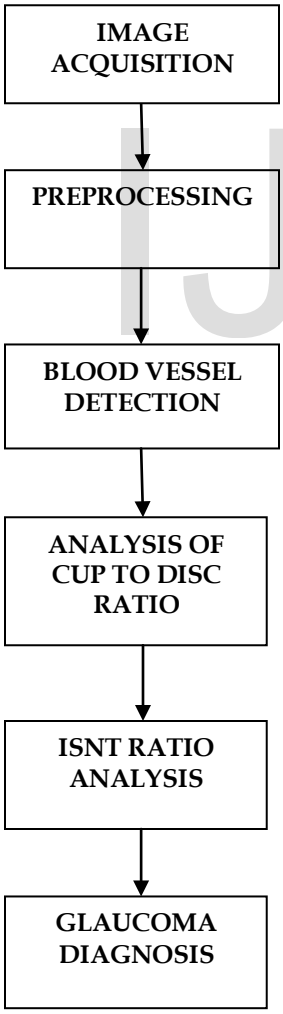
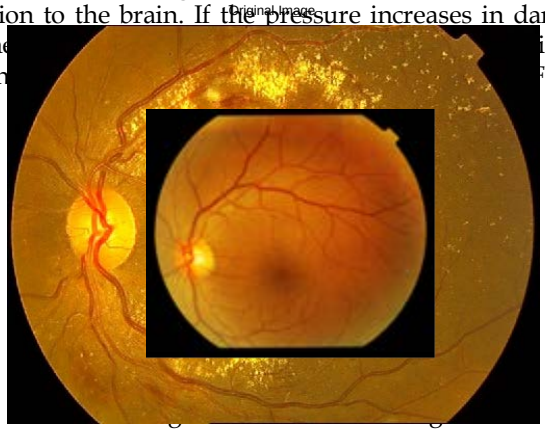


Fig. 1: Proposed Methodology for Glaucoma Diagnosis

This fluid within the eye is known as Aqueous Humour which flows in and out of the eye. The function of the Aqueous humour is to maintains the IOP and it inflates the globe of the eye. The flow inside the blood vessels gets obstruct and increase in pressure. This pressure is called Intra Ocular Pressure (IOP).The increased pressure called Intra Ocular Pressure damages the optic nerve which transmits information to the brain. If the pressure increases in damaging optic ne ion and perman Fig 4.



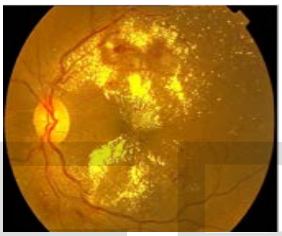


Fig 3: Diabetic Retinopathy Image

Fig 4: Glaucoma Image

Symptoms of Glaucoma: Increase in the cup to disc ratio is a symptom for glaucoma. Closed angle glaucoma affects eye one at a time. Some of the symptoms are blurred vision, vomiting , redness of eye, nausea and vomiting. Normal image have some of the blood vessels and in glaucoma image most of the blood vessels are located and gets narrower in glaucomatous eye.

2.2 Diagnosis of Diabetic Retinopathy

Diabetic Retinopathy is a complicated disease caused by Diabetes is given in Fig 3. Since Diabetic cause changes in the eye it leads to loss of vision. The blood vessels may swell or leakage of fluids into the retina.Dibetic may not happen suddenly it grows up later and finally it causes blindness.

Symptoms of Diabetic Retinopathy:

There are two stages in the Diabetic Retinopathy are, Non-Proliferative Diabetic Retinopathy (NPDR) and Proliferative Diabetic Retinopathy (PDR).

In NPDR, Mild DR is affected by the presence of micro aneurysm. Moderate DR detects by the haemorrhage, microaneurysm. Severe DR indicates by the new abnormal blood vessels. In PDR , Severe stage occurs by ref [9].

A. Non-proliferative diabetic retinopathy (NPDR)

1. Micro aneurysms
2. Dot and blot haemorrhages
3. Hard (intra-retinal) exudates

4. Cotton-wool spots

B. Proliferative diabetic retinopathy(PDR)

1. Neo-vascularisation of the retina, optic disc or iris
2. Fibrous tissue adherent to vitreous face of retina
3. Vitreous haemorrhage
4. Pre retinal haemorrhage.

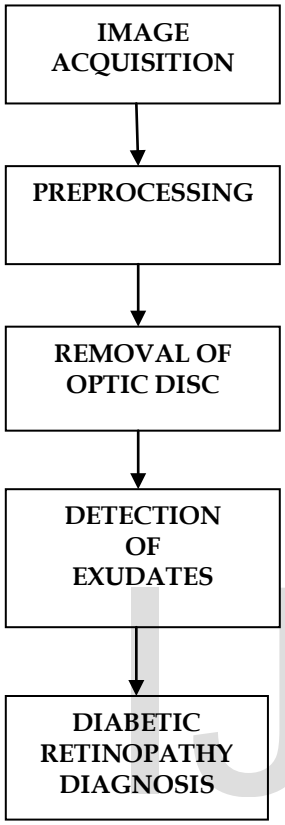


Fig. 5: Proposed Methodology forDiabetic Retinopathy Diagnosis

2.3 Modules Description

Image Acquisition: Collection of retinal images from Medical Databases such as STARE (Structured Analysis of the Retina) Database and DRIVE (Digital Retinal Images for Vessel Extraction) Database [8]. It consists of 20 images (ten with pathologies) captured by a TopCon TRV-50 fundus camera at 35 FOV. The slides were digitized to 700 605 pixels with 8 bits per colour channel. The FOV in the images is approximately 650 550 pixels.

A batch of Medical images from nearby Anilkumar Eye Hospital , sivakasi.

Preprocessing: RGB refers to Red Green Blue channel in retinal images. The images are converted into Red component , Green component. The Green channel have higher contrast than background.Red channel is mainly used to extract the optic disc and cup areas for detecting Glaucoma.

Blood vessel Detection: The blood vessels in the segmented optic disc region are detected by using the connected component analysis method.

Curvelet transform are used to enhance the blood vessels in the retinal images. Curvelet transform can efficiently represent edges along the curves. Contrasting images are converted into binary images. A Binary image is a digital image that contains only two values for possible values for each pixel. Binary images are also called as two-level or bi-level. The binary image replaces all the pixels in the input image with greater than the values 1 (white) and 0 (black). As a result of binary images such operations as morphological operations etc. Finally the segmentation is done by using the Connected component analysis method and the blood vessels detection is done.

Remove small objects:

```
L = labelmatrix(CC);
BW2 = ismember(L, find([S.Area] >= P));        (1)
```

Morphological processing: Blood vessels in the image is removed so as to achieve the accurately measure the optic disc and the cup areas. Morphological operation such as erosion, dilation, opening and closing are implemented on the image.

The Morphological erosion operation erodes away the regions of foreground pixels and for dilation was to gradually enlarge the regions of the foreground pixel, therefore this techniques help to remove unwanted bright spots or boundaries present in the image.

A disc shaped structuring element of size 15 was created and a closing and opening operation was performed on both the red and green component images. A value of 1 (white) was obtain for the region that contains the optic disc and cup, whereas a value of 0 (black) for the background.

The Origin of a Structuring Element:

The morphological functions use this code to get the coordinates of the origin of structuring elements of any size and dimension.

```
Origin = floor ((size (nhood) +1)/2)        (2)
```

Erosion:

The erosion of the binary image A by the structuring element B is defined by:

$$A \oplus B = \{Z \in E \mid B \subseteq A\} \quad (3)$$

Dilation:

The dilation of A by the structuring element B is defined by:

$$A \oplus B = UA \quad (4)$$

Opening:

The opening of A by B is obtained by the erosion of A by B, followed by dilation of the resulting image by B:

$$A \circ B = (A \theta B) \oplus B \quad (5)$$

Closing:

The closing of A by B is obtained by the dilation of A by B, followed by erosion of the resulting structure by B:

$$A \bullet B = (A \oplus B) \Theta B \quad (6)$$

The closing can also be obtained by,

$$A \bullet B = (A \circ B) \quad (7)$$

Adjunctions (Dilation and Erosion):

Let {Xi} be a collection of elements from $L \to L$

Dilation is any operator $\delta : L \to L$ that distributes over the supremum, and preserves the least element. i.e

$$\vee \delta Xi = \delta(\vee Xi)$$
$$\delta(\phi) = \phi \quad (8)$$

Erosion is any operator $\xi : L \to L$ that distributes over the infimum, and preserves the universe. i.e.

$$\wedge i\xi(Xi) = \xi(\wedge iXi)$$
$$\xi(U) = U \quad (9)$$

Analysis of Cup to Disc ratio: In glaucoma, due to increase in intra ocular pressure IOP, the optic cup area increases and occupy the disc area. Cup to Disc Ratio is measured by area of the optic disc to the optic cup.
This paper obtained CDR Ratio of 0.6647.

Glaucoma is diagnosed by measuring cup to disc ratio. If the CDR value below 0.3 it is normal image and CDR exceeds above 0.3 then the glaucoma is diagnosed.

ISNT Ratio: A mask image (360×360) is used to measure the area of the blood vessels in the ISNT quadrant. At each time the mask is rotated by 90° and is used to obtain the area covered by blood vessels in each quadrant.

TABLE 1
ANALYSIS OF ISNT RATIO

I_S Value	602312
N_T Value	582440
ISNT _ Ratio	1.0431

Exudates Detection: The Exudates are detected by using the Feature Extraction and Blob Detection.

Exudates: In the retinal blood vessels, the fluids and bloods are starts to leak from retina. This leakages gets deposits in the retinal area and this substance is known as the exudates.

The optic disk is the only brightest part in retinal images and next to it comes the exudates. The optic disk centre is found and propagation through radii method is employed and the entire optic disk region is blackened and removed. Now the image is left with exudates as the brightest region. Binary Imaging method is used and proper threshold value is set and the exudates can be easily identified from the image [9].

Performance metrics: Performance metrics plays a significant role in diagnosis of images in medical applications where performance is generally evaluated in terms of

Sensitivity : (Ratio of the number of true positives and the number of positive instances)

Specificity : (Ratio of the number of true negatives and the number of negative instances).

The performance measures are evaluated by this classification of vessels. The perfor mance measures are given in the Table II which evaluates the performance of the methods used in the systems.

TABLE 2
PERFORMANCE METRICS FOR RETINAL BLOOD VESSEL SEGMENTATION

Measure	Description
Specificity	TP/(TP+FN)
Sensitivity	TN/(TN+FP)
Accuracy	(TP+TN)/(TP+TN+FP+FN)

TP=True Positive, TN= True Negative, FP=False Positive, FN=False Negative.

TABLE 3
ACCURACY VALUE FOR BLOOD VESSEL DETECTION

True Positive	False Positive	Accuracy
0.9557	0.0086	0.9299

Performance Measurement for Glaucoma Diagnosis :

In Glaucoma, the CDR Ratio and the area of blood vessels are larger for glaucoma, due to the increase in pressure ie., IOP (Intra Ocular Pressure). These are two parameters to find the Glaucoma diagnosis.

The CDR ratio is 0.343 ± 0.245 for a normal eye and 0.503 ± 0.221 for a glaucoma eye.

The number of blood vessels for a normal eye is 29254.3±10775.5. The number of blood vessels increases in glaucoma eye is 35746± 11443.2.

The ISNT ratio for normal eye is (1.024±0.02) and ISNT ratio is greater for glaucoma eye (1.037±0.021).

TABLE 4
ANALYSIS OF CUP TO DISC RATIO

Image	Cup To Disc Ratio
Normal	0.2183
Glaucoma	0.6647

3 RESULTS AND DISCUSSION

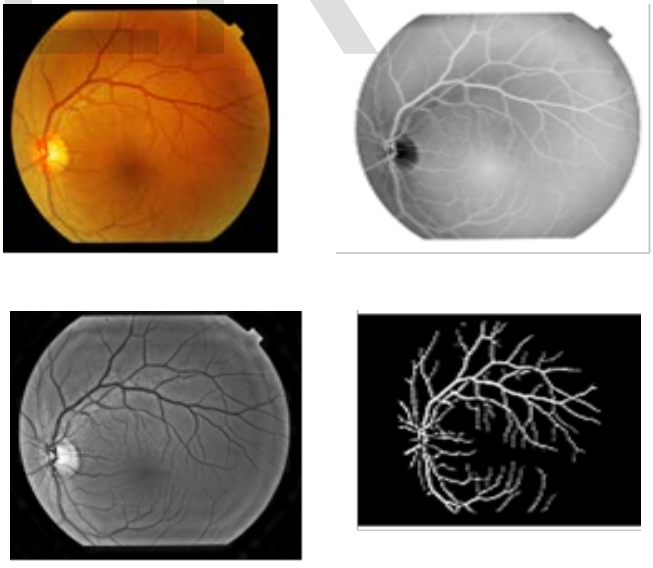


Fig 6. Result for Detection of Blood vessels for Connected component Analysis method a.) Input Image b.) Complement Image c.) Enhanced Image d.) Blood vessel Detection.

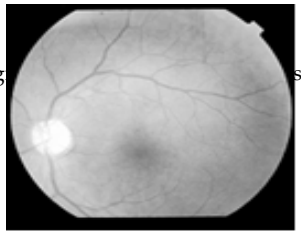



Fig 7: Result of Glaucoma Image a.)Input images b.)Preproceesed image.


Fig 8: Result for Extricated of Optic Disc and Optic Cup a.)Optic Disc b.)Optic Cup

Cup To Disc Ratio For Normal Eye : 0.2183
Cup To Disc Ratio For Glaucoma Eye : 0.6647

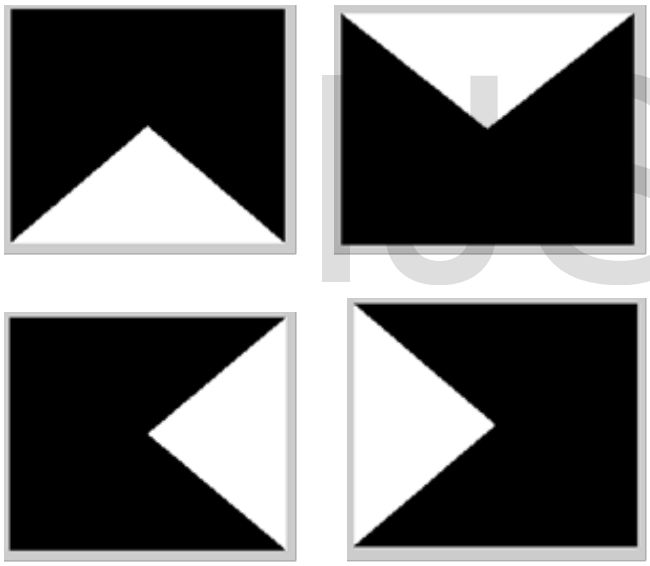


Fig 9. Result for Masking for glaucoma Diagnosis a.)Masking Inferior b.)Masking Superior c.)Masking Nasal d.)Masking Temporal.



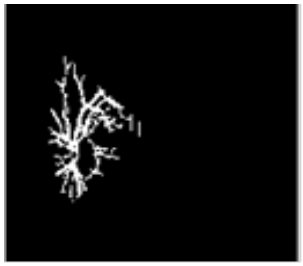


Fig 10. Result for ISNT Ratio calculation a.) Inferior b.) Superior c.) Nasal d.) Temporal

Results for Diabetic Retinopathy

Input image which is affected by DiabeticRetinopathy.Here, Exudates are going to detect is reffered as major symptoms.

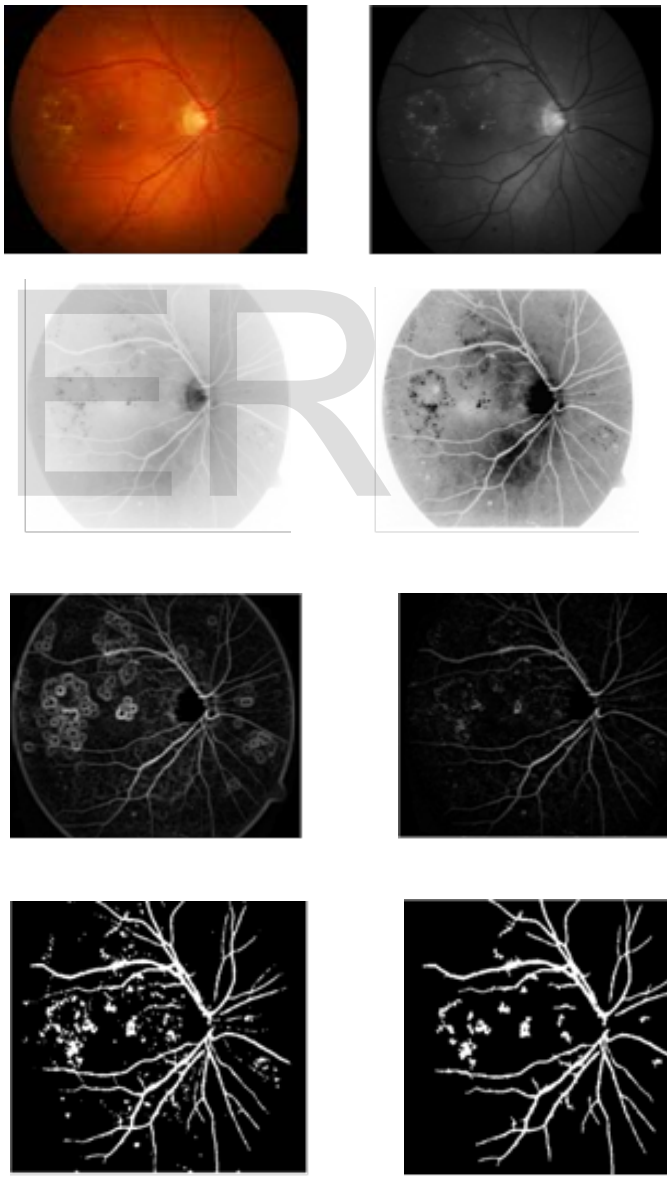


Fig 11. Results for Diabetic Retinopathy Diagnosis a.)Diabetic Retinopathy image b.) Green channel image c.) Complement imaged.) Histogram Equalization e.) Optic Disc Removal region. f.)closing operation g.) Binary image h.) Removing small area with Exudates i.) Exudates detection.

4 Conclusion and Future work

The retinal images used in this method are collected from the publicly available STARE and DRIVE databases. A new approach is used for the detection of glaucoma diagnosis and Diabetic Retinopathy diagnosis. In Diabetic Retinopathy the blood vessels starts to swell or leak fluids in the retina or in multiple. Finally the yellow spots are detected ie., is known as exudates. Glaucoma is mainly based on two parameters i.e., CDR calculation and ISNT Ratio measurement. This work provides better results with PSNR of 32.9335 and accuracy of 92.99%. Normal eye consist most of the blood vessels and for glaucoma the blood vessels get narrower to differentiate normal from glaucoma eye. This future work is extended to detect Retinal Detachment.

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