INTERNATIONAL RESEARCH JOURNAL IN ADVANCED ENGINEERING AND TECHNOLOGY (IRJAET) www.irjaet.com

ISSN (PRINT) : 2454-4744 | ISSN (ONLINE): 2454-4752

Vol. 1, Issue 4, pp.402 - 411, December, 2015

Detection of Glaucoma Based on CDR, CAR and Blood Vessel Extraction

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ARTICLE INFO

Article History:

Received 24th Dec, 2015

Received in revised form 27th Nov,15

Accepted 28th Dec, 2015

Published online 28th Dec, 2015

Keywords:

CDR, CAR, Glaucoma, IOP

ABSTRACT

Glaucoma is an eye disease which leads to vision loss when untreated, so detecting the disease in time is very important. This paper presents here the detection of glaucoma by calculating CDR (cup-to-disc ratio), CAR (cup-to-disc area ratio) by region-growing algorithm and the extraction of blood vessels also to be done by thresholding. Blood vessel extraction from the retinal fundus image is a vital and challenging task. This method comprises several basic image processing techniques. Region-growing algorithm takes advantage of spatial information of image object effectively.

INTRODUCTION

Glaucoma is the name for a group of eye conditions in which the optic nerve is damaged at the point where it leaves the eye. This never carries information from the retina (the light sensitive layer in the eye) to the brain where it is perceived as a picture. The damage to the optic never in glaucoma is usually caused by increased pressure within the eye. This squeezes the optic nerve and damages some of the nerve fibers which lead to sight loss. Peripheral Vision is the first area to be affected. But if glaucoma is left untreated, it damages the vision.

In some cases of glaucoma, eye pressure may be within normal limits but damage occurs because there is a weakness in the optic nerve. This is known as normal or low tension glaucoma. High pressure within the eye does not always result in glaucoma. A common condition is ocular hypertension, where eye pressure is above normal level but there is no detectable damage to the field of vision. This condition may simply be monitored or may be treated depending upon the consultant's view of the risk of developing glaucoma.

Types of Glaucoma:

There are two main types of glaucoma.

1. Chronic (Primary open angle glaucoma)

2. Acute (Primary angle closure glaucoma)

Chronic (Primary open angle glaucoma).

The most common is chronic, more formally known as primary open angle Glaucoma. In which the channels that drain fluid from the eye become blocked over many years. The pressure eye rises very slowly and there is no pain to indicate that there is a problem. However, the optic nerve is being damaged and the field of vision gradually becomes impaired. Usually the damage does not occur in the same part of the field of vision in both eyes. One eye compensates for the other and a great deal of damage will have been done before the person realizes there is a problem with their sight.

Acute (Primary closure angle glaucoma)

The second type of glaucoma, acute is much less common. More formally known as primary angle closure glaucoma, this develops when there is a sudden and more complete blockage of aqueous fluid within the eye and the pressure rises sharply. This tends to be very painful because the rise in pressure happens suddenly. It must be treated and in most cases a person's vision recovers completely. However, if treatment is delayed, there will usually be permanent damage to the eye.

Risk factors:

There are several factors that increase the risk of glaucoma and these tend to be cumulative in effect.

Age – Chronic glaucoma becomes much more common with increasing age.

Family History – There is a greatly increased risk of developing glaucoma if someone has a close relative (father, mother, brother and sister) with the condition. A recent study has estimated the lifetime risk of glaucoma at 20 percent if one has a sibling with open angle glaucoma.

Short Sight – People with very short sight(severe myopia) are at an increased risk of developing chronic glaucoma.

Diabetes - The abnormal blood vessels in proliferative diabetic retinopathy increase the likelihood of a type of glaucoma that is very difficult to treat.

Race – People of African origin are four times more at risk of developing chronic glaucoma compared to those of European origin. The condition also tends to develop at an earlier age and be more severe. People of Asian origin are at an increased risk of developing acute glaucoma.

Different Testing Methods For Glaucoma

Opthalmoscopy – an examination of the back of the eye including the optic nerve by shining a light from a special torch into the eye or by the use of special examination lens and a slit lens.

Tonometry – It measures the pressure within the eye. During tonometry, eye drops are used to numb the eye. Then a doctor uses a device called a tonometer to measure the inner pressure of the eye. A small amount of pressure is applied to the eye by a tiny device or by a warm puff of air.

Perimetry – It is a visual field test that produces a map of the complete field of vision. This test will help a doctor determine whether the vision has been affected by glaucoma. During this test, the patient will be asked to look straight ahead and then indicate when a moving light passes the peripheral vision. This helps to draw a map of the vision.

Gonioscopy – This diagnostic exam helps to determine whether the angle where the iris meets the cornea is open and wide or narrow and closed. During the exam, eye drops are used to numb the eye. A hand-held contact lens is gently placed on the eye. This contact lens has a mirror that shows the doctor if the angle between the iris and cornea is closed and blocked or wide and open.

Pachymetry – It is a simple, painless test to measure the thickness of the cornea the clear window at the front of the eye. A probe called a pachymeter is gently placed on the front of the eye to measure cornea's thickness. Pachymetry can help the diagnosis, because corneal thickness has the potential to influence eye pressure readings. With this measurement, the doctor can better understand the IOP reading and develop a treatment plan.

Risk Parameters of Glaucoma

Some of the risk parameters of Glaucoma are listed below:

Cup-to-Disc Ratio

The cup-to-disc ratio is a measurement used in ophthalmology and optometry to assess the progression of glaucoma. The optic disc is the anatomical location of the eye's blind spot the area where the optic nerve and blood vessels enter the retina.The optic disc can be flat or it can have a certain amount of normal cupping. But glaucoma, which is due to an increase in intraocular pressure, produces additional pathological cupping of the optic disc.The pink rim of disc contains nerve fibers.The white cup is a pit with no nerve fibers.As glaucoma advances,the cup enlarges until it occupies most of the disc area.

Disc Haemorrhage

Disc haemorrhages are common in eyes with glaucoma. These small, often flame-shaped lesions at or near the margin of the optic nerve are generally considered a sign of uncontrolled glaucoma. In clinical trials of ocular hypertension and both low and high-pressure glaucoma, the presence of disc haemorrhage has been identified as a poor prognostic factor.

Focal Notching

Notching is due to loss of axons pertaining to large diameter cells or magnocellular ganglion cells. Focal notching is typical of normal IOP glaucoma, it has been demonstrated that there is a fracture of the lamina cribrosa at that location and the glaucomatous damage tends to be symmetrical in both eyes.

Intereye Asymmetry

Asymmetry of IOP can arise due to real differences in IOP between the eyes or due to measurement error, asymmetry of central corneal thickness, or other structural differences.

Peripapillary Atrophy

Peripapillary choroidal atrophy is widely found to exist simply as an age-related degeneration similar to that seen at the macula and peripapillary with advancing years. In many cases, the area directly around the optic nerve, known as the peripapillary area,is contributory and diagnostically significant in terms of the patient's ocular health. Peripapillary atrophy is primary linked to advanced age, but is also seen glaucoma and myopia where they are associated with optic heamorrhages, peripapillary atrophy and optic pits.

Retinal Nerve Fiber Layer Defect

Retinal nerve fiber layer defect(NFLD)is a major sign of glaucoma, which is the second leading cause of blindness in the world. Early detection of NFLDs is critical for improved prognosis of this progressive, blinding disease. Band like regions darker than the surroundings pixels were detected as candidates of NFLDs.For each candidate, image features were determined and the likelihood of a true NFLD was determined by using the linear discriminate analysis and an artificial neural network (ANN).

Neuro Retinal Rim Thinning

In normal subjects neuro-retinal rim appeared wider in the lower pole, followed by the upper, nasal and temporal aspects. Optic nerve fiber layer showed a decreased thickness in hypertensive and glaucoma patients, particularly in sectors of the temporal aspect of the optic nerve.

Symptoms of Glaucoma

The most common types of glaucoma-primary open-angle glaucoma and angle-closure glaucoma have completely different symptoms.

Primary open-angle glaucoma signs and symptoms include:

Gradual loss of peripheral vision, usually in both eyes.

Tunnel vision in the advanced stages.

Acute angle-closure glaucoma signs and symptoms include:

Eye pain.

Nausea and Vomiting.

Sudden onset of visual disturbances, often in low light.

Blurred vision.

Halos around lights.

Reddening of eyes.

Both open-angle and angle-closure glaucoma can be primary or secondary conditions. They are called primary when the cause is unknown and secondary when the condition can be traced to a known cause, such as eye injury, medications, certain eye conditions, inflammation, tumor, advanced cataract or diabetes. In secondary glaucoma, the signs and symptoms can include those of the primary condition as well as typical symptoms.

Image Processing

Introduction

In recent year's image processing techniques have got immense attention of research particularly in medical image processing. The transforms like discrete cosine, Hough transform, deformable models, contour, thresholding, histogram etc., are used for detecting disease by analyzing the retinal images.

Medical imaging technology in medicine made the doctors to see the interior portions of the body for easy diagnosis. It also helped doctors to make key hole surgeries for reaching the interior parts without really opening too much of the body.CT scanner, Ultrasound and Magnetic Resonance Imaging took over X-ray imaging by making the doctors to look at the body's elusive third dimension. With the CT scanner, body's interior can be bared with ease and the disease areas can be identified without causing either discomfort or pain to the patient.MRI picks up signals from the body's magnetic particles spinning to its magnetic tune and with the help of its powerful computer, converts scanner data into revealing pictures of internal organs. Image processing techniques developed for analyzing remote sensing data may be modified to analyze the outputs of medical imaging systems to get best advantage to analyze symptoms of the patients with ease.

Image processing basically includes the following three steps:

Step-1 Importing the image with optical scanner or by digital photography.

Step-2 Analyzing and manipulating the image which includes data compression and image enhancement and spotting patterns that are not to human eyes like satellite photographs.

Step-3 Output is the last stage in which result can be altered image or reported that is based on image analysis.

Image Segmentation

Introduction

Image segmentation is the process of partitioning a digital image into multiple regions(sets of pixels, also known as super pixels).Image segmentation is the process of dividing an image into multiple parts. This is typically used to identify objects or other relevant information in digital images. There are many different ways to perform image segmentation. Some of them are listed below:

Clustering based methods.

Histogram based methods.

Edge detection methods.

Morphological operation.,etc.

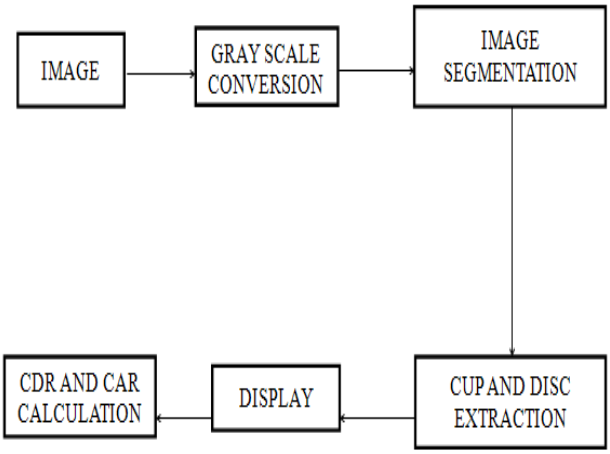
Proposed Methods

Region Growing Method

Region Growing Algorithm takes advantage of spatial information of image object effectively. Region Growing algorithm is used for extracting optic cup and optic disc from retinal fundus images. First, the input image is converted into gray scale image, after this conversion it undergoes into segmentation i.e., subdividing an image

into multiple regions. By using region growing algorithm the optic cup and disc are extracted images are displayed. Finally, by using this extracted images the CDR and CAR values are calculated manually.

BLOCK DIAGRAM OF REGION GROWING ALGORITHM

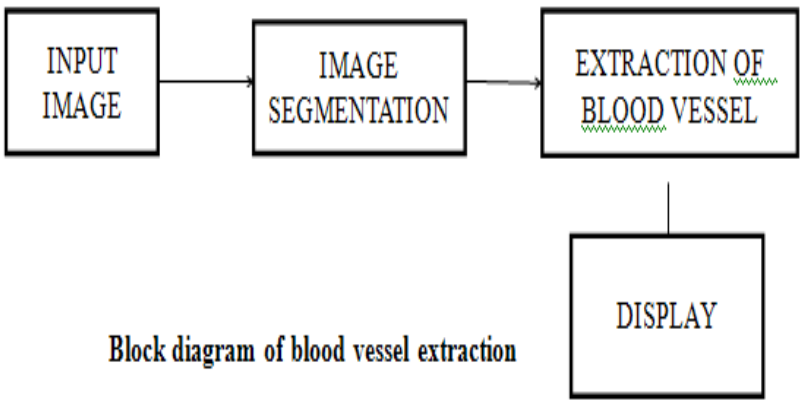


The block diagram of region growing method

Thresholding Method

Image segmentation by thresholding is a simple but powerful approach for segmenting images having light objects on dark background. Thresholding technique is based on image space regions i.e. on characteristics of image. Thresholding operation converts a multilevel image into a binary image. By using this method, the blood vessels are extracted. In this the blood vessel of the optic nerve head looks thinner and less bright. It indicates that the extracted blood vessel has healthy retina. Otherwise it is glaucoma affected eye.

BLOCK DIAGRAM OF BLOOD VESSEL EXTRACTION



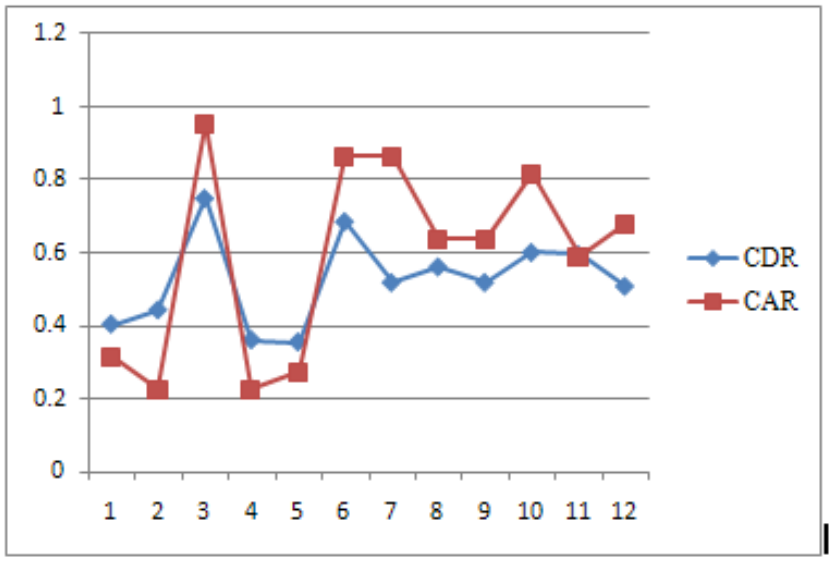
Block diagram of blood vessel extraction

Performance Analysis of CDR,CAR and Blood Vessel Extraction

We have taken 25 sample images and we analyzed 12 images for CDR and CAR calculation and also we done blood vessel extraction. The following table shows that the CDR value for healthy retina has the criteria CDR<0.5 and if it exceeds beyond 0.5 indicates that the taken image is considered as glaucoma. For CAR calculation, the healthy eye has<0.55 and it goes beyond 0.55,it is considered to be as glaucoma.

IMAGE	CDR	CAR	BLOOD VESSEL	RESULT
1	0.4045	0.3180	Thinner	Healthy retina
2	0.4436	0.2272	Thinner	Healthy retina
3	0.7498	0.9542	Thicker and also bright	Glaucoma
4	0.3610	0.2272	Thinner	Healthy retina
5	0.3550	0.2726	Thinner	Healthy retina
6	0.6861	0.8633	Thicker and also bright	Glaucoma
7	0.5186	0.8633	Thicker and also bright	Glaucoma
8	0.5614	0.6361	Thicker and also bright	Glaucoma
9	0.5186	0.6361	Thicker and also bright	Glaucoma
10	0.6014	0.8179	Thicker and also bright	Glaucoma
11	0.5952	0.5907	Thicker and also bright	Glaucoma
12	0.5085	0.6816	Thicker and also bright	Glaucoma

By using the measurement, we made a performance analysis to provide the best result. From this we noticed that the CDR value exceeds 0.5 it is said to be as high risk of glaucoma and the CAR value exceeds 0.55 it is considered as glaucoma affected eye.



Conclusion

Thus our project shows an efficient result to extract the blood vessel using thresholding and we calculated CDR and CAR values manually using region growing method. Based on the ratio value the images are classified as normal or glaucomatous. The blood vessel detection and region growing is an important for glaucoma diagnosis at earlier stage.

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