Glaucoma Detection Using Support Vector Machine Algorithm

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Abstract: ***Glaucoma is an eye disorder that is not curable, so early diagnosis is needed to prevent it from developing further. This condition contributes to complete blindness. Various automated systems have been developed to address the disease. In this paper, we explain the calculation of the cup to disc ratio (CDR) using a fuzzy algorithm. One of the major factors in the diagnosis of glaucoma is the cup to disc ratio (CDR). In the proposed process, using the support vector machine and thresholding, the optic disc and optic cup are segmented. The primary identifier to confirm glaucoma for a patient is the Cup to Disc Ratio (CDR) of the image. This classifies the given input image as normal or diseased and if recognised as diseased, classifies the stage of the patient affected by glaucoma based on the CDR ratio, whether mild, extreme or normal. In this paper, we include a range of screenshots that display the effects of various techniques of image processing applied to input images.***

Keywords: Image, Optic disc, Optic cup, Cup-to-disc ratio, Support vector machine, Thresholding

1. Introduction

Glaucoma is a chronic eye condition that is permanent and leads to loss of vision. This damages the optic nerve and is primarily due to the rise in pressure inside the eye, known as intraocular pressure (IOP). If left untreated, it inevitably leads to blindness. The human eye drainage system is capable of functioning properly for normal eyes. The intraocular fluid in our eyes has natural flow and prevents high pressure within the eyes from building up. The normal drainage system becomes blocked when a person is affected by glaucoma and the intraocular fluid faces blockage and does not come out. This phenomenon increases the degree of IOP, which in turn damages the fibres of the optic nerve [1]. The optic disc forms a hollow structure over time and expands to a cup shape. The Optic Cup is the name of this newly created structure.The disease slowly progresses forward and triggers blocks of peripheral vision. It is virtually difficult to diagnose the disease glaucoma at an early stage, but its early detection is necessary to prevent further growth. Manual glaucoma detection used by ophthalmologists is a time-consuming procedure and we need an automated process of detection. Fundus photography is the simplest and most powerful method of early detection of glaucoma among the different methods used for image processing. In this area of research, several trials are going on, but more precision is required for early detection of glaucoma in the human eye, which is curable if diagnosed at an early stage.

Symptoms and classification

The first and foremost difference is in the intraocular pressure of the eye due to glaucoma. Glaucoma is actually said to be a disorder because of an elevation of eye pressure. The usual intraocular pressure value ranges from 10 to 20 mmHg. But it may increase in patients with glaucoma (but not always). The nerve fibres start to die due to this rise in strain. The light that falls on these regions will not cause any sense of vision when these fibres die. The spot therefore becomes blind. The blind spot is simply called the cup [2]. The cup area can increase because of glaucoma, correspondingly reducing the area of the disc. It is a long process that can take years for a slight change to take place. The side vision of the patient progressively decreases as a result of these changes. The rise in the blind region raises the size of the cup, assuming that the size of the disc remains constant. The eye's vertical cup to disc ratio is defined as the ratio of the cup's diameter to the optic disc's diameter.

$$\text{Cup to disc ratio} = \frac{\textit{Diameter of the cup}}{\textit{Diameter of the disc}}$$

Figure 1: Cup to disc ratio formula

The cup extends due to glaucoma, so the cup-to-disk ratio rises in glaucoma patients. The cup can not rise evenly in all directions. This can cause abnormalities in Inferior (I), Superior (S), Nasal (N), and Temporal (T) thickness. Another parameter that can be taken into account is the neuro retinal rim region (NRR). The area between the cup and the disc is the Neuro Retinal Rim. The area of the NRR is diminished as the cup enlarges as a result of glaucoma. As nerve fibre loss becomes more severe, the patient's peripheral vision decreases. The various phases of the disease are categorised as moderate, normal and severe.

2. Methodology

According to science, this condition arises due to the presence of glaucoma when IOP rises and the cup region often increases slowly. The CDR value is used to analyse the cup area's elevation. There are various ways to calculate the[3] CDR. In terms of area, perpendicular and horizontal lengths of both OD and OC, CDR can be described. Clinically, the Vertical Cup Diameter (VCD) to Vertical Disc Diameter ratio is the CDR (VDD). The normal image is provided by CDR with a value lower than 0.45, while the glaucomatous images are given by CDR with a value greater than 0.45.

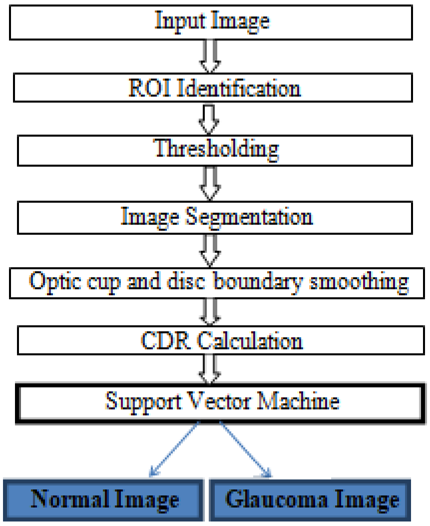


Figure 2: Methodology flow chart

a) Pre-processing

Pre-processing phase performs two tasks, these are evaluation of Region of Interest (ROI) and colour channel analysis. ROI involves cropping the fundus image before processing.

- Region of Interest (ROI) For the segmentation of OD, a simple yet vigorous process is suggested. For correct segmentation, the [4] pre-processing phase is very critical. Since the image of the fundus is both high in resolution and wide in size, the image should be cropped before processing. The ROI in the optic cup and disc area is seen as a run.
- RGB to channel conversion (Color Channel Analysis) Color channel analysis is necessary for next image processing phases. After ROI extraction retinal color image is set as input for channel analysis where outputs are red, green and blue channel images.

b) Thresholding

As a segmentation technique, thresholding is used and transforms a grey scale image and gives a black and white image. The best way to transform grey scale images to binary images is thresholding in general. It is based on a threshold level and substitutes white for all pixels larger than this value and black for all pixels smaller than this value. The entire image[5] can be transformed to a binary image in this way. Each pixel in the binary image can hold either 0 or 1. The mean value of all the image pixels is calculated and then zero or one value can be assigned to other pixels based on this mean value. This method simply transforms a precious grey image to a binary image.

c) Image Enhancement

Noise presents and noise reduction are often performed in digital image via image enhancement. To improve the image, Histogram equalisation is used. Normalization of the disc is done after enhancement, which helps to find the average value from the measured mean values. In disc normalisation, the pixel intensity range is modified, which means that subtraction from the specified input image is finished.

d) OD and OC

Human eye segmentation accepts lights and transmits them through the optic nerves to the brain. OD is known as one of the key components of glaucoma detection. OD appears brighter than the surroundings in the case of fundus pictures. Segmentation is important to describe the characteristics of the optic disc, such as macula, optic cup, fovea, etc. Glaucoma can be identified by identifying changes in shape, size and colour produced in OD.
CDR (Cup to Disk Ratio)

The basic element for the diagnosis of glaucoma is CDR. Using the techniques above, OD and OC are segmented. CDR is computed then. CDR is measured as CDR = area of cup / area of disc based on the area occupied by segmented cup and segmented disc CDR The greater CDR value gives more chance of glaucoma. A normal eye without glaucoma is CDR [7] with a value less than .45; a glaucoma-affected eye gives more than .45**.**

Support vector machine

Normally, a classification task requires separating knowledge into training and testing sets. Every instance includes one target value (i.e. class labels) and several attributes in the training set (i.e. the features or observed variables). We have used a supervised learning model, the support vector machine (SVM) classifier, to distinguish normal eye fundus from glaucoma-affected eye fundus. The objective of [8]SVM is to generate a model (based on training data) that predicts the target values of test data on the basis of only the attributes of the test data.

One of the most popular Supervised Learning algorithms, which is used for classification and regression issues, is Support Vector Machine or SVM. It is however, mainly used in Machine Learning for classification problems.

The SVM algorithm's goal is to build the best line or decision boundary that can segregate n-dimensional space into classes so that in the future we can easily place the new data point in the right category. This boundary of best judgement is called a hyper plane.

The extreme points/vectors which help to construct the hyper plane are chosen by SVM. Such extreme cases are referred to as support vectors, and the algorithm is thus referred to as the Support Vector Machine.

3. Results and Discussion

1) Take image 1.jpg from databases.---------No Glaucoma detected

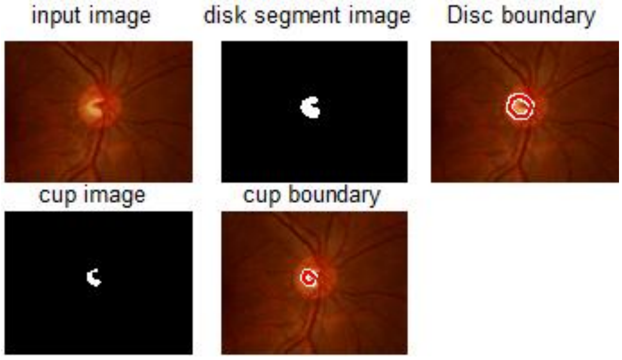


Figure 3: 1. jpg Image processing

2) Take image 2.jpg from database------------------No glaucoma detected

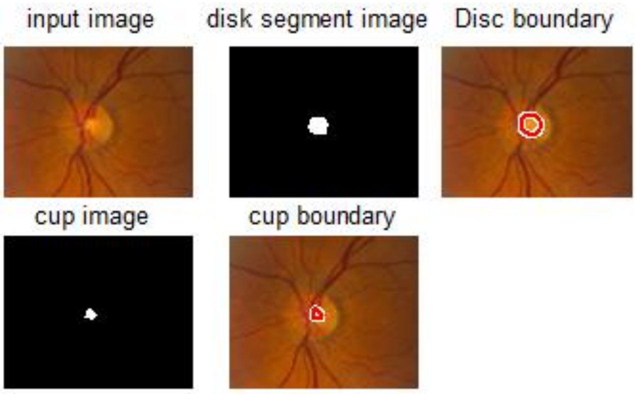


Figure 4: 2.jpg Image processing

3) Take image 9.jpg from database.--------- Glaucoma Detected

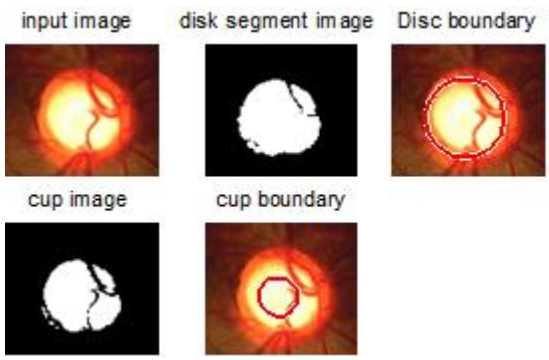


Figure 5: 9.jpg Image processing

4) Take image 12.jpg from database---------------------- Glaucoma Detected

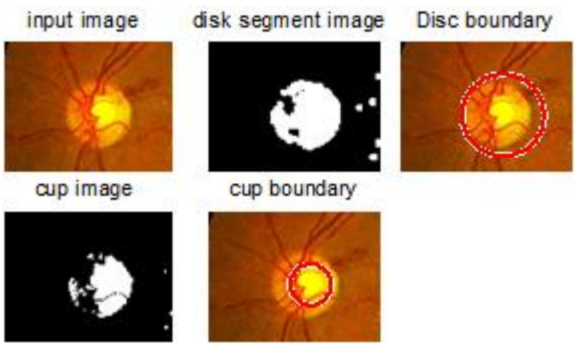
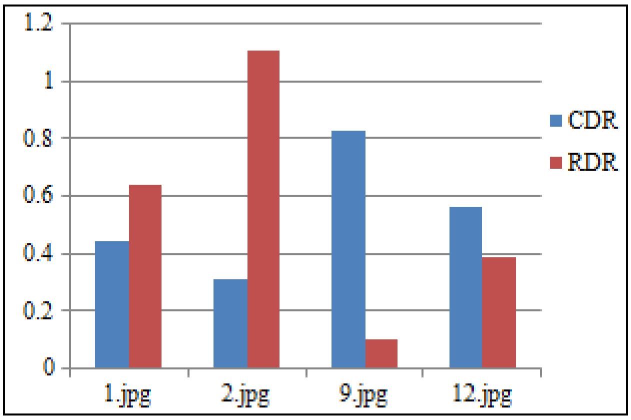


Figure 6: 12.jpg Image processing

Comparison Table

S. No.	Image	CDR	RDR	GLAUCOMA
1.	1.jpg	0.4436	0.64	no
2.	2.jpg	0.3152	1.1061	no
3.	9.jpg	0.8268	0.1063	yes
4.	12.jpg	0.568	0.39	yes



Glaucoma detected if CDR > 0.45

4. Conclusion and Future Work

Glaucoma is an eye condition that if not diagnosed and treated at the right time, can lead to blindness. Often, glaucoma is caused by elevated intraocular pressure (IOP) of the fluid in the eye. Glaucoma is the world's second leading cause of blindness and is referred to as the' Secret Thief of Sight.' Glaucoma is one of the primary causes of blindness, but early diagnosis is difficult. In this work, we used different image processing techniques for the early detection of glaucoma. Our approach is based on the use of cup to disc ratio (CDR) in photos to distinguish conditions of glaucoma affected patients. The image with CDR> 0.45 shows glaucoma detected and no glaucoma detected with CDR<0.45.

By using machine learning methods such as CNN, the proposed framework can be further expanded in the future by obtaining more robust datasets.

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