An Optimized Method Using CNN, RF, Cuckoo Search and HOG for Early Detection of Eye Disease in Humans

Tian Jipeng, Manasa S., and T. C. Manjunath

Abstract—Glaucoma is a group of eye diseases that cause damage to the optic nerve, causing the successive narrowing of the visual field in affected patients due to increased intraocular pressure, which can lead the patient, at an advanced stage, to blindness without clinical reversal. As we have heard and seen from generations across that Glaucoma has been and is still one of the leading diseases that has permanent damage if untreated. As per the current research it says that 79Million are affected BY 2020 which are untreated. So, to make it easy for us humans, early detection is one of the best way to create awareness and treat the diseased. After having gone through the majority of the literatures, have seen that when LBP is given to HOG has accurate results for better feature extraction than other methods, also application of Cuckoo search (CS) algorithm, Random forest (for classifying) and Conventional Neural Network (for segmentation) have better outcome compared to the previously used hybrid algorithm methods to detected the diseased from the normal eye. So, to achieve this I will be using Matlab tool as it produces more accurate results than any other platform. In one of the paper LBP algorithm has been extensively used to obtain the desired results but when learnt about HOG, it looked as it has better properties to enhance the required results when combined along with LBP. CS is another unique method to analyze on aggregation of the image texture.

Index Terms—Glaucoma, Matlab, Simulation, Detection.

I. Introduction

Glaucoma is a 2nd leading eye disease in the world, it damages the optic nerve which leads to permanent blindness. It cannot be cured, so detecting the disease in time is very important.

Glaucoma is caused by many factors some of them are unknown, the biggest factor is intra-ocular pressure in the eye. This one single factor can be treated and controlled. It is one of the most severe eye diseases according to the number of blindness causes in India and western countries. Therefore, the early detection, long-term monitoring of the patients and the decision about the appropriate therapy at the correct time are the serious tasks for the ophthalmologist. This earlier detection of deadly diseases has been proposed using advanced image processing, analysis and recognition techniques. This state of art techniques had already been assisted doctors in various fields such as earlier detection and diagnosis of diseases, clinical decisions, remote sensing surgeries and so forth.

Published on April 13, 2020.

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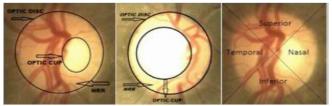


Fig. 1. Normal Disc, Glaucomatic Disc, ISNT Quadrants

Glaucoma cannot be cured, but its progression can be slowed down by treatment. Therefore, detecting glaucoma in time is critical. However, many glaucoma patients are unaware of the disease until it has reached its advanced stage. In India, there are now an estimated 15 million people affected by glaucoma, the majority of whom are undiagnosed. By 2020, this is expected to be 19 million. Since glaucoma progresses with few signs or symptoms and the vision loss from glaucoma is irreversible, screening of people at high risk for the disease is vital. The difference between the normal eye & the affected eye is shown in the Fig. 1 & 2 respectively. The Fig. 3 shows the enlarged view of the normal eye & the affected eye with glaucoma.

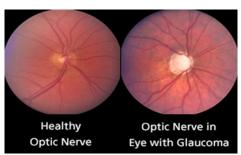


Fig. 2. Enlarged view of normal & affected eye with glaucoma

In the work considered, our ROI (Region of Interest) is the optic disc or optic nerve head, which is shown in in the Fig. 3. This is the location where ganglion cell axons exit the eye to form the optic nerve. There are no light sensitive rods or cones to respond to a light stimulus at this point. This causes a break in the visual field called "the blind spot" or the "physiological blind spot". The optic disc represents the beginning of the optic nerve and is the point where the axons of retinal ganglion cells come together. The optic disc is also the entry point for the major blood vessels that supply the retina. The optic nerve head in a normal human eye carries from 1 to 1.2 million neurons from the eye towards the brain.

The cup-to-disc ratio is a measurement used in ophthalmology to assess the progression of glaucoma. It is the area where the optic nerve and blood vessels enter the retina. The optic disc is the anatomical location of the eye's blind spot. The optic disc can be flat or it can have a certain amount of normal cupping. But glaucoma, which is due to

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an increase in intra-ocular 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. The cup-to-disc ratio compares the diameter of the 'cup' portion of the optic disc with the total diameter of the optic disc. The hole represents the cup and the surrounding area the disc. If the cup fills 1/10 of the disc, the ratio will be 0.1. If it fills 7/10 of the disc, the ratio is 0.7. The normal optic disc cup-to-disc ratio if less than 0.3 and greater than 0.3 cup-to-disc ratio also implies glaucoma. However, cupping by itself is not indicative of glaucoma; rather, an increase in cupping as the patient ages also is an indicator for the cause of glaucoma.

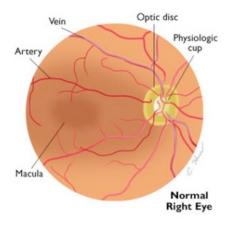


Fig. 3. Enlarged view of retina with optic disc.

Secondary glaucoma refers to any form of glaucoma in which there is an identifiable cause of increased eye pressure, resulting in optic nerve damage and vision loss. As with primary glaucoma, secondary glaucoma can be of the open-angle or angle-closure type and it can occur in one or both eyes. Secondary glaucoma may be caused by an eye injury, inflammation, certain drugs such as steroids and advanced cases of cataract or diabetes. The type of treatment will depend on the underlying cause, but usually includes medications, laser surgery, or conventional surgery.

II. CONVENTIONAL METHODS

The methods adopted by ophthalmologists to detect glaucoma are:

- Intra Ocular Pressure (IOP) measurement
- Visual Field Test.
- Optic nerve at back of the eye.
- Assessment of the Retinal Nerve Fiber Layer (RNFL) loss.

All together these methods give information on both structural and functional deficits. It involves trabeculectomy where bulb may be formed under the upper eyelid, which is not visible.

A. Drawbacks of the Conventional Methods

Cup Disk Ratio (CDR) is also a parameter for the glaucoma detection. Specified range of CDR for healthy retina is within the range of 0.1-0.5, whereas for glaucomatous (Unhealthy) retina, the CDR is in the range of 0.6-1.0. Sometimes glaucoma was found within the normal range of CDR. This contributes to the failure of existing clinical (conventional) method.

The quantification of Retinal Nerve Fiber Layer (RNFL) thickness is also an efficient parameter for the detection of glaucoma. The specified thickness of RNFL for healthy retina is in the range of 70-140 μm , whereas for glaucomatous retina, the thickness is below 70 μm . This approach demands the usage of costly equipment's like Optical Coherence Tomography (OCT). Also, the availability of such image acquisition systems is limited to only corporate hospitals. Common people are deprived of these facilities.

IOP is measured using a Tonometer. For a healthy eye, the IOP range is 10 20 mmHg, whereas for the unhealthy eye the range exceeds the upper limit. In some cases, even though the IOP is within the healthy range, the eye might be affected with glaucoma (Normal tension glaucoma). This is a failure of the conventional existing method.

It should be noted that we are using both the CDR & the RNFL methods for detection of higher order glaucoma in the human beings. Moreover the glaucoma disease is detected through this procedure only after 40% of the progression. The accuracy of these methods are still in question.

III. MODERN GLAUCOMA DETECTION TECHNOLOGIES EMPLOYED

Optic nerve assessment is thus able to detect glaucoma early and is currently performed by a trained glaucoma specialist, or using specialized expensive equipment such as the OCT (Optical coherence tomography) and HRT (Heidelberg Retinal Tomography) systems. However, optic disc assessment by an ophthalmologist is subjective and the availability of OCT/HRT is limited because of the cost involved. The 2D fundus digital image is taken by a fundus camera, which photographs the retinal surface of the eye. In comparison with OCT/HRT machines, the fundus camera is easier to operate, less costly, and is able to assess multiple eye conditions.

A. Advantages of the modern technology methods

Here, I am trying to develop a low cost strategy for the detection of glaucoma using the combination of various parameters. Also making use of improved techniques to obtain the accuracy of the results. To help common people to detect the eye disease in early stages that would be useful to cure or treat the eye in initial stages.

IV. LITERATURE SURVEY

Glaucoma disease in human beings is considered as one of the important diseases which affects the nervous systems & may lead to the loss of vision. Glaucoma damages the optic nerve which carries visual information to the brain. The brain can recognize the objects in the foreground and in the background or at a certain distance with the help of eyes. The damage to the optic nerve leads to permanent blindness or to loss of vision. So, detection of glaucoma plays an important role in order to prevent the loss of vision.

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Tatijana Stosic and Borko D. Stosic showed that vascular structures of the human retina represented geometrical multi-fractals which were characterized by a hierarchy of exponents rather than a single fractal dimension. Multi-fractal behavior w.r.t. the human retina was observed, where capacity dimension (CD) was found to be larger than the information dimension (ID). The ID obtained in turn was found to be larger than the correlation dimension (COD). Finally, all the three dimensions were found to be significantly lower than the diffusion limited aggregation (DLA) fractal dimension method. However, they did not attempt for classification of healthy and glaucoma retinal images.

Madhusudhan Mishra et.al., proposed a method to detect the glaucoma of the retinal color funds image by calculating the Cup-to-Disk Ratio (CDR). In order to estimate the CDR, the authors had employed active counter algorithm & they tested their algorithm for 25 images, which yielded excellent results. However, they didn't attempt for loss of retinal nerve fiber layer, which was a high risk factor in glaucoma as this would have led to diabetics and myopia (these problems were not dealt with here).

Balasubramanian T, Krishnan S, Mohanakrishnan M, Ramnarayan Rao K, Vinoth Kumar C and Nirmala K paper says that, the image's texture are used for accurate and efficient glaucoma classification. The image is then given to a HOG feature descriptor. The statistical features are then extracted from the HOG Features that are they have used for SVM classification of glaucomatous images. Also, here they have used it under features extraction wherein I'm making use of this algorithm for pre-processing of the original image for better output.

Swathi Ramachandran, Dr. T.C.Manjunath, in this paper they have mentioned that when calculating a LBP code for an image, the edges are ignored as they do not have enough information and this would lead to produce false information. The feature vector can now be processed using the Support vector machine, extreme learning machines, or some other machine-learning algorithm to classify images.

TABLE I: COMPARISION OF THE ALGORITHMS

No	Proposed Algorithms	Drawbacks
1	LBP and LMBP combined Algorithm	It lacks in improving the convergence speed of the network, ie. Training sequence.
2	KNN Algorithm	Does not work well with large dataset and higher dimensions. Mildly sensitive to noise.
3	SVM Classifier	Must use huge number of different parameter settings in order to achieve a satisfactory result.

Mahendran Gandhi and Dr. R. Dhanasekaran have conveyed that -The major symptom of diabetic retinopathy is the exudates. Exudate is a fluid that filters from the circulatory system into lesions or area of inflammation. Detecting retinal fundus diseases in an early stage, helps the ophthalmologists apply proper treatments that might

eliminate the disease or decrease the severity of it. This segmented image shows the location of exudates confirming the disease diabetic retinopathy.

Inference based on the papers studied, so as to overcome then with better algorithms and results.

V. OBJECTIVES OF THE PROJECT WORK

The main objective of the M.Tech. Dissertation work is to develop a method which would give higher accuracy result based algorithm

- To design algorithms for detection Neo-vascular and pigmentary Glaucoma.
- To optimize the obtained results using ML with AI algorithms like CS, RF.
- As I am using CNN, and HOG methods, which intend to give out better results in detection of this eye disease for both OCT and fundus images.

The above mentioned objective of my dissertation work is achieved using the following steps:

- 1. Collecting OCT and fundus images of human eyes (Both healthy and unhealthy) using appropriate image capturing devices (data base of image collection) from various sources from hospitals.
- 2. Preparation of desired image data bases using required techniques.
- 3. Performing Image pre-processing (segmentation, enhancement), processing, and Feature extraction, analysis and application of mathematically developed equations in spatial & frequency domains.
- 4. Extracting and preparing features vector, for query eye image as followed in step 3, and Preparation of optimized method for further analysis.
- 5. Diagnosis of eye glaucoma by comparing of data base feature vector (step 3) and currently obtained feature vector (step 4).

VI. TOOLS USED FOR THE PROJECT WORK

The software tool that is going to be used for the project work is Matlab with Simulink modeling. Reason for choosing Matlab is such that the accuracy of this is much higher than compared to other software tools

VII. MOTIVATION / PROBLEM STATEMENT DEFINITION

The motivation for carrying out the project work should be depicted in this section along with the problem statement. Specialists are discovering issues in the prior location of contaminated district in the event of eye as the glaucoma illness as it is the second most influenced malady on the planet to which many individuals are falling casualties. In the meantime it is an exceptionally costly procedure to distinguish the ailment utilizing the cutting edge devices, so as a result of which we are developing a methodology for detection such that it is affordable by all the sections of the society, also it can be detected at the early stage & prevention can be taken.

VIII. PROPOSED METHODOLOGY

The proposed methodology that is going to be used in

our project work is presented in this section. The proposed methodology adopted in the present project work is depicted in the Fig. 4 in a very highly abstracted manner with various blocks numbered as 1 through 7, which are explained as follows.

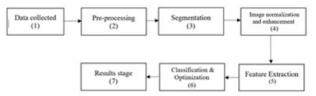


Fig. 4. Block-diagram of the proposed methodology

- 1. Block 1 gives the information about the data samples being collected from various hospitals including normal and diseased eye image samples.
- 2. Block 2 gives the information about pre-processing where image involves normalizing the image where the purpose of analysis and to increase the overall performance of the system, have used general procedure, this helps in emphasizing on removing the irrelevant sections from the images.
- 3. Block 3 gives the information about segmentation as it is a process of partitioning a digital image into individual multiple segments so as to ease the analysis of the image, which is done using Convolutional Neural Networks (CNN). Here the objects and the image boundaries can be located easily. CNN segmentation is a task in order to remove the effects of eyelids etc to get better view of ROI.
- 4. Block 4 gives the information about image normalization and enhancement where after all the previous processes we have to remove noises and again enhance the image texture, quality and clarity for further blocks.
- 5. Block 5 gives the information about feature extraction Random Forest (RF) here the forest of trees splitting with oblique hyper planes can gain accuracy as they grow without suffering from overtraining, as long as the forests are randomly restricted to be sensitive to only selected feature dimensions.
- 6. Block 6 gives the information about concept that is being used to classify and optimize the extracted features of the retina part into normal & diseased cases. In our proposed methodology of classification & optimization, the Cuckoo Search (CS) type of classifiers have been used in order to obtain a better accuracy of the diseased retina (Glaucoma) recognition system.

IX. Possible outcome / Expected-Simulation Results

The possible outcome of this project work has to be presented in this section.

The expected results or the outcome of the project work could be summarized as follows -

- To detect Glaucomatic eyes in its early stages for better treatment.
- Also it can be used in near future for creating an automatic system for better identification of the diseased eyes.

X. APPLICATIONS OF THE PROJECT WORK

The project work can be developed using AI/ML for further implementation in years to come. It can also be used in hospitals so that early detection of these eye diseases could be checked and treated immediately, precaution could be considered that the proper diagnosis can be done.

XI. CONCLUSIONS

In this section, a brief conclusions of the work that is going to be done / undertaken has been presented.

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