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A Glaucoma Detection using Convolutional Neural Network

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Abstract: Glaucoma is a disease that relates to the vision of the human eye. This disease is considered as the irreversible disease that results in the vision deterioration. Much deep learning (DL) models have been developed for the proper detection of glaucoma so far. So this paper presents architecture for the proper glaucoma detection based on the deep learning by making use of the convolutional neural network (CNN). The differentiation between the patterns formed for glaucoma and non-glaucoma can find out with the use of the CNN. The CNN provides a hierarchical structure of the images for differentiation. Proposed work can be evaluated with a total of six layers. Here the dropout mechanism is also used for achieving the adequate performance in the glaucoma detection. The datasets used for the experiments are the SCES and ORIGA. The analysis is performed for both the dataset and the obtained values are .822 and .882 for the ORIGA and SCES dataset respectively.

Keywords: Glaucoma Detection, Deep Learning, Convolutional Neural Network, Glaucoma Prediction.

I. INTRODUCTION

Glaucoma is one of the critical diseases that may lead to the blind vision of the person. Glaucoma is one of the cases in which the optic nerve of the eye gets affected, and this is the main reason for the vision loss. The first operation of glaucoma of human was done in 1856 by Graefe [1]. The whole population that is dealing with the problem of glaucoma may lose their vision without proper treatment and the care for that. The specialist in eye care can fine the patients who suffer from this disease[1]. Glaucoma internally contains various conditions that have similar characteristics. There are many works done in this field for the early detection of this disease. The system used various Deep learning Algorithms for proper detection. As stated that the early detection can prevent the blindness in human being and the vision can be saved. So the appropriate detecting model is required for the detection of this disease. There are many attempts taken for developing such a system. The approach is also presented to detect the glaucoma pattern in the patients. The presented method will make the use of CNN technique for the classification of the patterns found in patients. The differentiation of the trends in the founded data for the glaucoma detection will be carried out by making use of the CNN model. The overall architecture is having six layers for proper detection of the disease. In the presented mechanism, a dropout mechanism is also applied to improve the performance of the given approach. The major objective is to find the most similar patterns in between the normal human eye and the infected glaucoma eye.

1.1 Glaucoma Detection

Glaucoma is the disease that affects the human eye and results in a permanent blindness in the human eye. This situation is seen as the complex to deal with, so the proper detection is a must. This problem is detected at an early stage then it may be improved else it may lead to loss of vision. As per the previous evaluation, a single checkup cannot find the symptoms of glaucoma. The regular eye checks up may give the symptoms of glaucoma, and further treatment and check-up may be suggested. The eye

specialist checks five times at least for the confirmation of this disease in the human eye. Following are some health diagnosis that is analysed for the approval of glaucoma.

a. **Tonometry:** It determines pressure within the eye of a patient.

b. **Optical Coherence Tomography:** This scan is essential for the diagnosis of glaucoma. It is used to find an important sign of early glaucoma damage that is retinal nerve fibre layers around the optic nerve.

c. **Ophthalmoscopy:** The optic nerve is examined in this test. As glaucoma is a severe disease related to the optic nerve, so this is a very important test. Eye drops are used to enlarge the size of the pupil of the patient's eye to look optic nerve more clearly to find signs of disease-related nerve cell loss in the eye.

d. **Perimetry:** Glaucoma is a disease which causes peripheral vision loss at the initial stage. Therefore this test is done to detect vision loss. This test is also called a visual field test. It includes testing each eye distinctly with an automatic device that flashes lights in the periphery of the eye of the person.

e. **Gonioscopy:** It s the test related to intraocular fluid outflow drainage angle. The fluid is continuously being prepared in the eye & then it flows out at fixed angles. This test is done to find that whether the high eye pressure is caused by a blocked angle that is known as angle-closure glaucoma or if angle is open but not working properly then it is known to be as open-angle glaucoma.

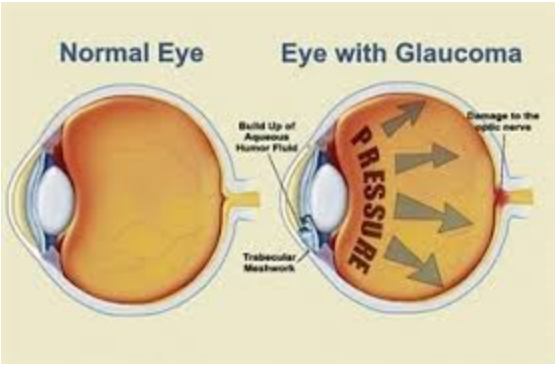

Figure 1. Image for the Infected Glaucoma Eye.[1]

II. LITERATURE REVIEW

Rashmi Panda et al. [2] put forward an automated model for Retinal nerve fibre layer defect detection. As it is an early proof of glaucoma condition in fundus images. Early detection & prevention are ways to stop loss of vision. The new method performs detection in fundus images using patch characteristics driven RNN. Fundus images dataset is used to evaluate performance. This system obtains high RNFLD detection and accurate boundary localisation.

Kavita Choudhary et al. [3] presented a paper with the aim of detection of glaucoma at early stages using cross-validation algorithm. Authors analysed symptoms prevailing in persons & computed & generalised those symptoms to reach conclusive evidence. It was found that measures such as blood pressure, Age, Sugar level, & myopia were combined for various datasets are related to changes of a person suffering from glaucoma. Authors in their study have done an analysis of glaucoma disease by Classification method such as cross-validation algorithm & split validation algorithm. The outcome reveals that patients who have high blood pressure, high sugar level, myopia & with the family history of this disease can suffer from glaucoma. It is also observed that the patients with age more than 50 have higher chances of glaucoma.

Seong Jae Kim et al. [4] in this paper studied and attempted to design machine learning models that have robust power of predicting& interpretability for glaucoma diagnosis based on RNFL thickness & visual field. Different features were collected after examination of RNFL thickness & visual field. Authors used 4 machine learning algorithms like C5.0, random forest, SVM & K- nearest neighbour to design a glaucoma prediction model. Learning models are constructed using training dataset & their performance was evaluated by using validation data set. Finally, the authors observed that the random forest model gives the best performance & remaining other models show similar accuracy.

Shwetha C. Shetty et al. [5] disused and analysed that Glaucoma is an ocular disorder and its identification includes measuring the shapes and also the optic cup sizes. Pre-processing of data is then clustered using K-means clustering, which is used for segmenting the optic curves. It is again executed to find its various dimension. Since the fractional dimension is used to determining the various dimension of non-regular identities, the authors presented a new method for detection of glaucoma using method of the perimeter for the fractional

analysis. The outcome reveals the new approach is accurate in detecting glaucoma.

Liuli et al. [6] in this paper presented attention-based convolutional neural network for detecting glaucoma, known as AGCNN. Approaches which were proposed in the past for automatic detection system based on fundus images are insufficient to remove high redundancy, which may lead to reduced reliability & accuracy of detection. To overcome this shortcoming, the newly proposed method establishes a large-scale data set, which includes fundus images labelled as (+) ve or (–) ve. The attention maps of some images are taken from ophthalmologists through a simulated experiment. Then a new AG-CNN structure is constructed which includes a subnet, a pathological area localisation subnet and a glaucoma classification subnet. Experiment on LAG database& other available datasets reveals that the proposed method gives a detection performance superior to previous models.

Jin Mo Ahn et al. [7] here, they have presented a method for the detection of the glaucoma disease which utilises fundus photography and uses deep learning. The author discussed that advanced & early glaucoma both could be correctly identified using machine learning along with fundus images. Dataset of 1,542 images was used and divided into training, validation & test datasets. The newly put forward model that is trained using CNN is more effective and accurate in the detection of early glaucoma.

Annan Li et al. [8] suggest that automatic detection of disease is important for retinal image analysis. When studied and compared with segmentation based approaches, it is found that image classification based approaches perform better. But challenges are always there due to improper sample, effective features and also shape variations of the optic disc. To overcome these, a new classification based model for detection of glaucoma is put forward by authors in this papers, in which deep convolutional networks are used to represent visual appearance, holistic & local characteristics are combined to reduce or remove misalignment.

Ali Serener et al. [9] discussed Open-angle glaucoma as it is one of the basic kind of disease & slowly, a person tends to lose his sight. Diagnosis of this disease manually by experts is possible, but it either takes a huge time or cost. Authors in this paper presented a method for the detection of both early & advanced glaucoma automatically. 'ResNet-50' & 'GoogLeNet' deep CNN algorithms are trained & tuned using transfer learning. It is found that 'GoogLeNet' model is better than 'ResNet-50' for detecting both early & advanced glaucoma in the eye of the patient.

Ramin Daneshvar et al. [10] analysed that baseline OCT measures predict VF progression in patients with suspicious or established glaucoma & also authors compared performance with semi-quantitative optic disc measures. It is observed that baseline pRNFL & macular OCT parameters can be used for checking the risk of glaucoma progression in future. People abnormal OCT findings require better care to prevent progression of functional damage.

Guangzhou An et al. [11] presented a model for the detection of glaucoma within the patients by making the use of the open-angle for glaucoma that is based on the 3-D data colour images. Various fundus pictures as input provide the CNN architecture. After getting output form every CNN model, the outputs have been combined. And the random forest method is used for the classification of the fundus pictures. This classification is done with healthy and glaucoma infected eyes. At the result obtained for the AUC is of .96.

Juan Carrillo et al. [12] The authors have provided the glaucoma detection method as the glaucoma is the irreversible cure of eyes. They have provided a tool for computing the glaucoma symptoms in eyes. They have used this tool for the detection, and the detection is observed by the sizes of the cup and the disc. Also, they have used the fundus images for the evaluation.

Tehmina Khalil et al. [13] have presented an overview of the glaucoma detection, and they have stated that most of the detection schemes for glaucoma use the fundus images. They stated that the detection of glaucoma could be done efficiently by making the use of the Optical Coherence Tomography. By using the OCT, the detection can be done at an early stage is concluded by them.

Namita Sengar et al. [14] have stated that the image processing for glaucoma detection can be done by using the fundus images. They have presented a deciding parameter for the detection of glaucoma. The work proposed by them performed well, and their presented mechanism has achieved an accuracy of 93.57%.

Abdul basher et al. [15] presented a survey on the deep learning neural networks. They stated that the neural networks do the training to the system. They stated about the CNN that the feature extraction in CNN is done automatically that it reduces the extra work of feature extraction.

T. Vijayakumar et al. [16] have presented a capsule neural network. This study compared the drawbacks of CNN with the capsule neural network. The study is done on various applications.

Limitations Found in our Survey:

1. Glaucoma is seen as a major crisis for the vision of a person.
2. There is a need for a proper glaucoma detection method.
3. The previously applied methods need more improvements.
4. As stated, the doctor needs at least 5 check-up reports to confirm the glaucoma affection, so it becomes essential to design a system to detect this disease accurately in one attempt.

III. PROPOSED APPROACH

The presented approach works in six layers. The four layers are the convolutional layers, and the last two layers are connected fully. The output obtained from the very last layer is given to the classifier for the detection of the glaucoma disease.

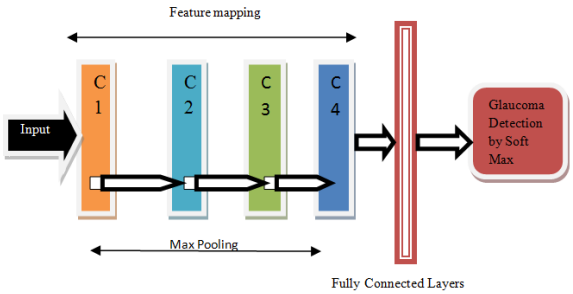

Figure 2. Block Diagram of The Proposed Model

Convolutional layers: This is used as the feature learners at a small scale that is taken randomly from any image. Any feature that is present in the image at any point of location will be calculated by using it with the detector that detects the elements and the image that is present at that location itself.

Response Normalization layer: This layer works in following with the 1st and 2nd layer of convolution in the presented architecture. For a neural network to calculate the output f(x)= tanh(x), where x is the input.

Overlapped pooling layers: This layer for the CNN architecture gets the overall statistics for a particular region inside the given image. Here the max-pooling layer is used.

CNN Based Classification for Glaucoma

3.1 Region of Interest (ROI) Extraction:

Here in our presented CNN to get the input, the ROI of the image that forms a short image as an input is used. The ROI provided will take a concise time for the processing in comparison with the disc or cup. To get the proper ROI will make the execution very faster, and the detection of glaucoma will be much faster, and the performance will be improved. Here, the ARGALI approach is used, where they divided the image of the fundus into grids, and the ROI will be detected where the optic nerve is detected as per the same of any user or patient. So here, the algorithm will be used for ROI detection.

In ARGALI method, the preprocessing is used for the removal of the bright fringe, which will help in getting the centre for the trimming circle and the radius of the trim. The obtained ROI will be fixed to 256*256 resolution. In the end, for all the pixels of the disc image, the mean value is subtracted from every pixel for the removal of the illumination in the pictures.

3.2 Dropout and Data Augmentation

Dropout: It is implemented in two stages of the fully connected layers as presented in our approach. The Dropout will set 0 for every value of neuron, which is having a value of .5. When the dropping of the neurons is done in the CNN, then they will not take part in the passing forward and will not be a part of the backpropagation. While experimenting with the multiplication for all the outputs of the neurons by .5 is done.

Data Augmentation: The overfitting suffering will be seen if the data augmentation is not done in the model. DA will generate translations for the images and the reflections that are horizontal. For the training period 224*224 patch is done for random values with the inclusion of the 256* 256 models, and train the network for these patches that are extracted. In testing five 224*224 patches are obtained from CNN, which include four corners and one centre. The horizontal reflections are also obtained for these five patches. The average of this prediction that is given by the network softmax layer for this 10 patches is taken.

IV. EXPERIMENTS PERFORMED

The proposed model of two datasets that are ORIGA and SCES, which is having the images of glaucoma fundus are experimented here.

4.1 Criteria for the Evaluation

The area under the curve () AUC is utilised of the receiver operating characteristics (ROC) curve for the evaluation of glaucoma detecting performance of the model. The curve between the sensitive TPR and the specificity TNR is plotted as the ROC and is defined as:

$$TPR = \frac{TP}{TP + FN}, \quad TNR = \frac{TN}{TN + FP}$$

4.2 Setup for the Experiment:

The ORIGA dataset consists of clinical glaucoma diagnoses and having 168 glaucoma and 482 images of the normal fundus. The dataset of the SCES has 46 images for glaucoma and 1676 images for the fundus. The experiment carried out has the following configurations:

- **In Hardware:** 4 GB RAM, 140 Gb SSD Harddisk, Intel core i3 and intel motherboard.
- **In Software:** 64-bit windows 10 and Python 3.8.
- **Python packages** like NumPy, pandas, tenserflow and Keras Library etc.
- **Data Set:** ORIGA dataset consists of clinical glaucoma diagnoses and having 168 glaucoma and 482 images of the normal fundus.

V. RESULT EVALUATION

For the validation of our proposed approach using CNN for the detection of the glaucoma accuracy, the given model is compared to the state of the art reconstruction based method. The training dataset will consist of 90 images out of 600 images, and the left image is used in the testing of the results. And in the SCES dataset, the same training set as of ORIGA is used, and the overall images in SCES are used for the testing.

The obtained AUC for the proposed method are .0822 for the ORIGA dataset, and for the SCES it is having the value of .882. For comparison, the state of the art mechanism is used to give the value of the AUC as .809 for ORIGA and .859 for the SCES dataset.

Table1. The values of AUC for proposed and earlier methods.

Dataset used	State of Art Method	Proposed CNN method
ORIGA Dataset	.809	.822
SCES Dataset	.859	.882

The graphical representation is shown below for the obtained values of the AUC:

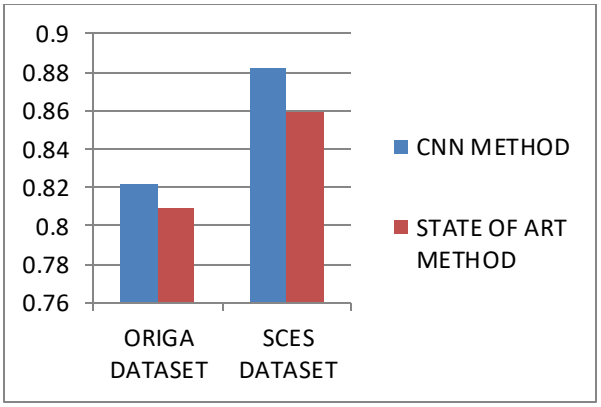

Figure 3. Graph for the Obtained Values.

The results are providing satisfaction in the results obtained. The detection capability of the proposed systemseems higher than other methods.

VI. CONCLUSION

Glaucoma is one of the primary concern for the human eye. The vision of the eye can be lost; the glaucoma symptoms are seen in the human eye. The glaucoma is a significant defect that may result in blindness if pre-stage detection is not done. So to detect this disease, a mechanism that uses the deep learning CNN is proposed for the analysis. The proposed mechanism is based on the six-layer architecture, and CNN will classify the patterns observed for the glaucoma detection in the patient's eye images. Two datasets are used here; they are ORIGA and the SCES dataset. The proposed method worked very well and the results obtained are satisfactory. The AUC values are carried out from our experiment. The values are obtained for both the datasets and compared with the existing state of the art algorithm. The earned value is .882 and .822 for the SCES and the ORIGA dataset respectively. The proposed method can be used for glaucoma detection.

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