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Detection of Glaucoma by the Use of Convolutional Neural Network

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Abstract- Glaucoma is a disease that affects human eyes and makes it difficult for people to see clearly. In recent years, the prevalence of this condition has increased significantly. The result of this illness is a permanent impairment of vision that cannot be reversed once it has taken place. In the past, the diagnosis of glaucoma was carried out with the assistance of a number of different deep learning (DL) algorithms. The results of our research on recognising glaucoma illness are presented in this journal. For the purpose of recognising the ailment, we used a deep learning model known as a Convolutional neural network (CNN). The convolutional neural network provides us with a distinct pattern for both eyes afflicted by glaucoma and eyes that are not impacted by glaucoma. This pattern may be used by us to diagnose glaucoma. When CNN is used, a hierarchical framework is provided for distinguishing between images of glaucoma-affected eyes and photographs of eyes that are not affected by glaucoma. This facilitates more accurate categorization. Using the method that we offer, it is possible to do a review in a total of six phases. The dropout mechanism is used in the study that is advised in order to improve the overall efficiency of the performance. This is done in the context of glaucoma disease detection. In order to carry out an analysis of the work that was intended, this study made use of the datasets provided by SCES and ORIGA. The values acquired for the ORIGA dataset come in at 92.3, while the SCES dataset has values that come in at 94.2.

Keywords- Deep Learning, Glaucoma Detection, Glaucoma Prediction, Convolutional Neural Network, Dropout Mechanism.

I. INTRODUCTION

Human vision can be lost in case of the glaucoma disease. It is one of the most harmful diseases that can happen to human as it takes the vision of the human eye and makes him blind [1]. This disease affects the human eye's optic nerve, a solid reason for human blindness [2]. Graefe in 1857 has performed very first operation for glaucoma disease on the human eye. Every person affected by glaucoma disease may lose their vision due to lack of the treatment and lack of a cure for such disease. An only specialized person can detect this disease for the suffering person. Internally glaucoma disease consists of various effects to the eye that may have similar characteristics.

Previously various methodologies have been applied for the proper detection of this disease. The detection in the early stage is necessary for the treatment of the disease [3]. Deep learning models are used in the detection of this disease. As discussed, the proper and early detection of glaucoma affected eyes can save people's vision [4].

Hence, we need to develop a proper model for the work of glaucoma detection. Previously a lot of algorithms have been applied for making glaucoma detection more accurate and effective. Our work also proposed a mechanism for glaucoma detection based on the patterns found for particular's eyes. The classification of glaucoma affection patterns in human eyes will be done with the convolutional neural network [5]. The various patterns seen in the given dataset will be classified with the use of the CNN model. We have worked in a total of 6 layers for accurate detection of the glaucoma disease. We also applied a dropout mechanism for improvement in the results for glaucoma detection.

1. **Glaucoma Detection:**
Glaucoma is a cure that can result in the blindness of human eyes which can be permanent blindness [6]. Such cases in treatment can be seen as typical, and for this proper detection is needed. In this disease, the earlier detection can be treated, and treatment is possible, but if the detection occurs late, there are chances of losing vision for the patient [7].

The earlier detection of single checkups cannot detect glaucoma disease in patients' eyes. In another case, regular checkup of eyes can detect some of the symptoms of glaucoma, and on these symptoms, we can provide treatment to the patient [8]. In a normal case, the doctor needs to check patient eyes a minimum of five times to confirm glaucoma. Below we have stated some of the health diagnoses needed to make disease confirm in the patient.

2. Optical Coherence Tomography:
It is one of the important checkups for the detection of the glaucoma disease. It is done for early glaucoma signs detection, damaging the retinal nerve fibre layer present around the optic nerve.

3. Tonometry:
This test gives the amount of pressure that is present in the eyes of the patient.

4. Ophthalmoscopy:
This test deals with the optic nerve of the eye. As the glaucoma disease mainly affects the eye's optic nerve, this test becomes an important test for glaucoma detection. This test is done by putting an eye drop in the patient eye for increasing the pupil's size so that the nerve cell loss can be seen in the eye for detection.

5. Perimetry:
Peripheral vision loss can happen in glaucoma disease at a very early stage. So perimetry test is done for detecting such vision loss in a human's eye. This test is also named as a visual field test.

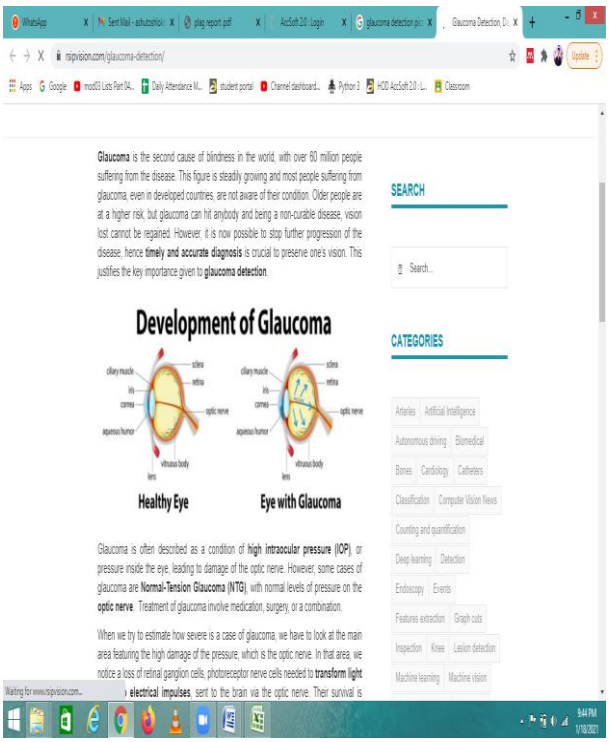

Fig 1. Glaucoma affected and non affected eyes.

II. LITERATURE REVIEW

Glaucoma results in irreversible blindness of the human eye. This paper gives an approach which makes use of CNN. Also, exploring the possibility of using the residual network to detect glaucoma at an early stage is done. The dataset here used for the experiment if ResNet50 and accuracy percentage obtained is 96.95 [9].

This paper states glaucoma detection work based on the cup to disc diameter ratio (CDR). The authors have presented a mechanism for calculation of CDR, which is based on a threshold. The overall results obtained for the proposed mechanism is more accurate and satisfactory [10].

Glaucoma disease has become a common issue nowadays. The pressure on the eye because of various gadgets used regularly is the main reason for this disease. The method implemented here uses image processing for extraction of CDR and RDR. 98% accuracy is obtained for k nearest neighbour algorithm, and VVG-16 model obtained 99.6% [11].

In this paper, authors have worked on the detection of glaucoma disease. Ophthalmologists' work has been stated in this paper and compared with the machine learning algorithms. The authors have stated that deep learning models can be used for glaucoma detection. A literature review is done in this paper and stated that 80% of the work could be better done with the deep learning algorithms [12].

Here in work of glaucoma detection, the authors have used cross-validation algorithm. Symptoms have been analyzed in the persons, and conclusive evidence has been made. The cross-validation and split validation algorithm have been implemented and analyzed. The conclusion was made that the people with age over 50 may be affected by glaucoma disease [13].

In this paper, a model for glaucoma detection has been implemented to use 3-D data colour images. CNN is used for evaluation, and fundus images are provided as input to the system. The AUC for the proposed system obtained is having a value of 0.96 [14].

As glaucoma detection is mostly done with fundus images, the authors have stated in their study that glaucoma detection can be done using OCT (Optical Coherence Tomography). They have concluded that glaucoma detection can dine in the early stage by using the proposed technique [15].

III. PROPOSED APPROACH

The work presented here uses a convolutional neural network which works in total six layers. The 4 of them are CNN layers. The remaining 2 of them are fully connected layers. The resulting output from the end layer is submitted into the classifier to classify glaucoma affected and non-affected eye.

Convolutional Layers: The images provided for detecting glaucoma affected eyes are analyzed to extract features in these layers. Patterns are analyzed from random images of glaucoma affected eye. Some features that may be

available at and location in the image can be calculated using it and detector for detection of feature and the image available on a particular location.Response Normalizing Layer: RNL works along with the first and second layers of the CNN in the architecture proposed in our work.

For calculation of the output

$$f(x)= \tanh(x)$$

in neural network,

here x represents input.

Overlapped Layers of Pooling: This particular layer for the Convolutional neural network architecture obtains the needed statistic for some particular region for the provided image of affected eyes. Max pooling layer is used for this task in glaucoma detection.

IV. GLAUCOMA CLASSIFICATION BY CNN

1. Extraction of ROI (Region of Interest):
The proposed work takes input from the ROI if the image creates a small image and takes the input to the system for glaucoma detection. As compared to the disc or cup provided ROI will take lesser time for the processing. By ROI, the execution becomes faster, and the proposed approach's overall performance will be improved. ARGALI method is used here for the detection which works on the division of the fundus's image in grids, and the detection of the optic nerve based on another patient gives

ROI for the image. So for the detection of the ROI, this method will be used. Removal of bright fringe is done in the preprocessing stage of ARGALI method, and this will give centre for trimming of the circle and obtain the radius of the trimming section. 256*256 resolution will be used for the ROI of the image. At last, Illumination in the image will be reduced by subtracting the mean value from every pixel.

2. Dropout:
The proposed approach implements the dropout mechanism in both of the stages of fully connected layers. For .5 value of neuron, the dropout value is set to be 0. Once the neurons are dropped in CNN, they will not be part of the forward passing and backpropagation. In the implementation phase, the multiplication of the 0.5 value is done with the neurons' outputs.

3. Data Augmentation:
If the data augmentation is not performed in the glaucoma detection mechanism, the fitting problem can be seen. Horizontal reflections and translations for the images are done through data augmentation process. 224*224 patches are provided in the training phase for random values, making 256*256 images. Training of the network is done for these patches. Five patches of 224*224 are obtained from CNN's testing work that involves four corners and one in the centre. Horizontal reflection for the following five patches will also be obtained. The average of this overall prediction given by softmax layer for the ten patches is taken.

V. EXPERIMENTS PERFORMED

Two datasets that are ORIGA and SCES are used for the evaluation of the proposed approach. This both datasets have images of glaucoma fundus for testing the presented approach.

1. Evaluation Parameters:
The receiver operation characteristics (ROC) curve, which measures the area under the curve (AUC), is used to evaluate the performance of the models employed in glaucoma detection and to make comparisons between them. The relationship between the sensitivity TPR and specificity TNR is shown as a ROC curve, which is illustrated in the following way:

$$\mathbf{TPR=TPTP+FN,\ TNR=TNTN+FP}$$

2. Experiment Setup:
The ORIGA dataset contains clinical glaucoma diagnosis in which it has 1434 glaucoma images and 3871 normal fundus images in number. Simultaneously, 1386 images for glaucoma in 2103 images of the fundus are present in the SCES dataset.

VI. RESULT EVALUATION

The proposed approach for detecting glaucoma by using CNN is evaluated in terms of accuracy and comparison is done with the state of the art reconstruction method. In the training of the model, 2700 images have been provided from a total of 3100 images. The remaining 400 images are used for the testing purpose. For the SCES dataset full of the images used to test the proposed mechanism and the training is kept the same as the ORIGA dataset.

Table 1. The values of AUC for proposed and earlier methods.

Dataset used	State of Art Method (%)	Proposed CNN method (%)
ORIGA Dataset	81.2	92.3
SCES Dataset	86.3	94.2

The results obtained are satisfactory in comparison with the other methods. The detected value with the proposed approach has more accuracy.
The graphical representation is shown below for the obtained values of the AUC:

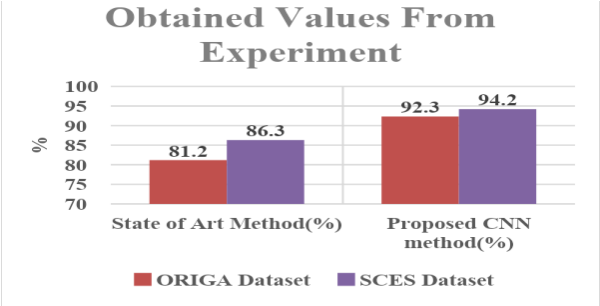

Fig 2. Obtained Values From Experiment.

VII. CONCLUSION

Glaucoma disease is seen as a very typical problem that is related to the human eye. This disease can lead to the loss of vision in the human eye. If glaucoma detection is done in the earlier stage, only the treatment can be done. Otherwise, the loss of vision can occur. Hence the detection of glaucoma is to be done accurately, for which we have presented a methodology that uses deep learning CNN for analysis purpose.

Six layered architecture is presented in which four are of CNN, and two are fully connected. ORIGA and SCES datasets were used for experiments. Results obtained are 92.3 for ORIGA and 94.2 for SCES. The methodology proposed here can be implemented for the detection of glaucoma.

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