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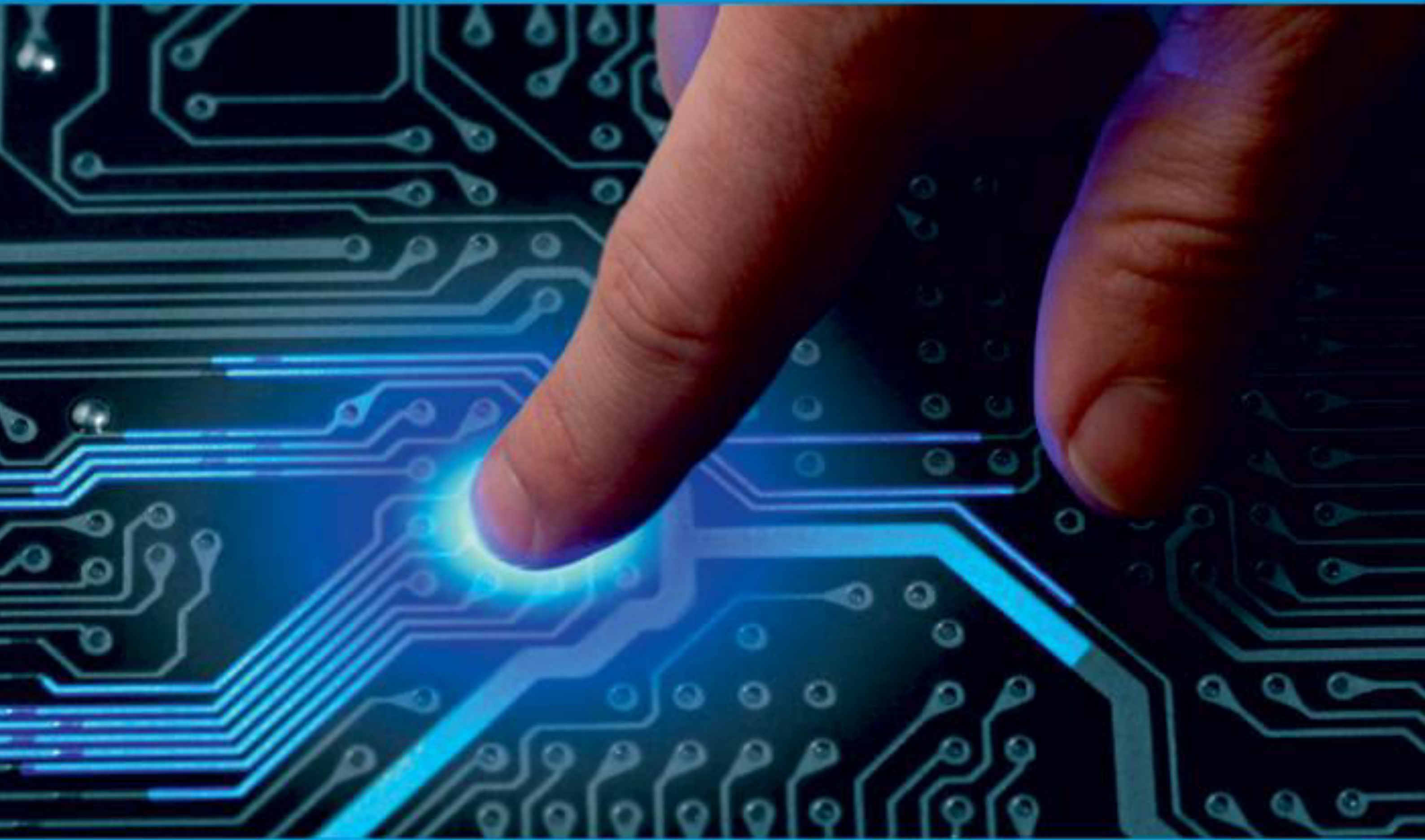

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Prediction of Glaucoma Using Fundus Images

Mr V. Ramachandran[1], Navya Jammigumpula[2], Anusha Dosapathi[3], Lakshmi Chaitanya Alaparthi[4], Yasaswini Cheemalamarri[5]

Professor, Department of Information Technology, Vasireddy Venkatadri Institute of Technology, Nambur, Guntur, Andhra Pradesh, India[1]

U.G. Students, Department of Information Technology, Vasireddy Venkatadri Institute of Technology, Nambur, Guntur, Andhra Pradesh, India[2,3,4,5]

ABSTRACT: Glaucoma is a group of related eye disorders that cause damage to the optic nerve that carries information from the eye to the brain which can get worse over time and lead to blindness. It is very important that glaucoma is detected as early as possible for proper treatment. In this paper, we have proposed a Convolution Neural Network (CNN) system for early detection of Glaucoma. Initially, eye images are augmented to generate data for Deep learning. The eye images are then pre processed to remove noise using Gaussian Blur technique and make the image suitable for further processing. The system is trained using the pre-processed images and when new input images are given to the system it classifies them as normal eye or glaucoma eye based on the features extracted during training.

KEYWORDS: Convolution Neural Network, True Positive, True Negative, False Positive, False Negative.

I. INTRODUCTION

Glaucoma is often linked to a build-up of pressure inside the eyes. Glaucoma tends to run in families and one usually doesn’t get it until later in life. The increased pressure in eyes, called intraocular pressure, can damage the optic nerve, which sends images to the brain. If the damage worsens, glaucoma can cause permanent vision loss or even total blindness within a few years. Most people with glaucoma have no early symptoms or pain. One must visit the eye doctor regularly so they can diagnose and treat glaucoma before one has long-term vision loss. If a person loses his vision, it can’t be brought back. An optic disc and cup are present in all individuals but an abnormal size of the cup with respect to the optic disc is a characteristic of a glaucoma infected eye. Traditional methods detecting glaucoma include an eye doctor analyzing the images and finding the abnormalities in it. This method is very time consuming and not always accurate because the image contains noise and other factors which make it difficult for proper analysis. Also, if a machine is trained for analysis it becomes more accurate than human analysis. Most of the literature present mainly focus on optic cup and disk segmentation[4] and some focus on Cup/Disk ratio. Through our analysis we have found using the Convolution Neural Network[2] model to be better than other literature works proposed. Convolution neural networks are one of the most popular deep learning techniques for image analysis[3]. In this technique, training data sets of previously classified images are used to develop the system. This deep learning technique implies that computers can perform feature learning and classification simultaneously. In deep learning algorithms, a model is formed using many layers which transform the given input data to an output .

II. LITERATURE SURVEY

A lot of researchers have experimented with optic disc and optic cup based glaucoma detection in retinal images. Among them some of the works are analyzed here; Jun Cheng et al. [7] has presented super-pixel classification based optic cup segmentation for glaucoma detection. In optic disc segmentation, histograms, and center surround statistics were used to classify each superpixel as disc or non-disc. A self-assessment reliability score was computed to evaluate the quality of the automated optic disc segmentation. For optic cup segmentation, histograms and center surround statistics, the location information was also included in the feature space to boost the performance. but this method was given poor segmentation results. Moreover, Gopal Datt Joshi et al. has exhibited OD and OC Segmentation from monocular colour retinal images for glaucoma assessment. They introduced a OD segmentation method which integrates the local image information around each point of interest in multi-dimensional feature space. For cup segmentation, they used anatomical evidence such as vessel bends at the cup boundary. The method was evaluated on 138 images comprising 33 normal and 105 glaucomatous images against three glaucoma experts. Even though, in some cases the method produced irregular OD shapes. In Pardha Saradhi Mittapalli and Giri Babu Kande have presented a

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glaucoma expert system based on the segmentation of OD and optic cup attained from color fundus images. Here, implicit region based active contour model was utilized for OD segmentation and structural and gray level properties of cup utilized for OC segmentation. Based on the precise information about the contours of OD and cup, different parameters were calculated for glaucoma assessment. Here, some patients have small CDR but significant visual field loss, whereas some have large CDR with little visual field loss. Similarly, Suman Sedai et al. [6] have presented a fully automatic regression-based method which accurately segments optic cup and disc in retinal color fundus image. A data augmentation approach was developed to improve the regressors' performance by generating synthetic training data. In [3], Artem Sevastopolsky et.al, have experimented glaucoma detection based on deep learning, namely, modification of U-Net convolutional neural network. Moreover, Muhammad Nauman Zahoor et al. [4] have presented a hierarchical technique for fast and accurate Optic Disc localization and segmentation. Retinal vasculature and pathologies were delineated and removed by using morphological operations at preprocessing stage followed by circular Hough transform for optic disc localization. The precise boundary of the optic disk was obtained by calculating the region of interest and applying a polar transform based adaptive thresholding. Similarly, Julian Zilly et al. [5] has presented a method to segment retinal images using ensemble learning based convolutional neural network (CNN) architectures. An entropy sampling technique was used to select informative points thus reducing computational complexity while performing superior to uniform sampling. The output of the classifier was subject to an unsupervised graph cut algorithm followed by a convex hull transformation to obtain the final segmentation.

III. PROPOSED SYSTEM

The main objective of the proposed methodology is to segment the optic disc and optic cup from the retinal image using convolution neural network for glaucoma detection. Glaucoma is a chronic eye disease which causes lasting vision loss. There are different methods applied to inquire about glaucoma such as enhanced Intraocular Pressure (IOP) measurement, assessment of abnormal visual field and damaged optic nerve head assessment. Out of which optic nerve head assessment is more reliable and sensitive. Therefore, in this paper, we suggest an efficient glaucoma detection technique established on optic nerve head assessment. The novelty of the proposed method is used to segment both optic disc and optic cup using CNN and MRG algorithm. These two segmentations lead to the accurate detection of glaucoma. The overall process of the suggested methodology is afforded in figure.

Algorithm:

A convolutional Neural Network (CNN) is a specific type of artificial neural network that uses perceptions, a machine learning unit algorithm, for super learning, to analyse data, CNNs apply to image processing, natural language processing and other kinds of cognitive tasks. A convolutional Neural Network is also known as a ConveNet

Implementation

For Optic Disc segmentation, the author of [3] uses a Fully Convolutional Neural network along with an "inception" module from Google Net. The author of the paper addresses the issue of detecting the boundaries of Optic Disc by segmenting the retinal nerve and optic disc using a Fully Convolutional Network. The Architecture consists of multiple convolutional layers, pooling layers and inception modules for generating optic Disc and retinal nerve segmentation maps. Let's briefly look at architecture developed by the author of Paper.

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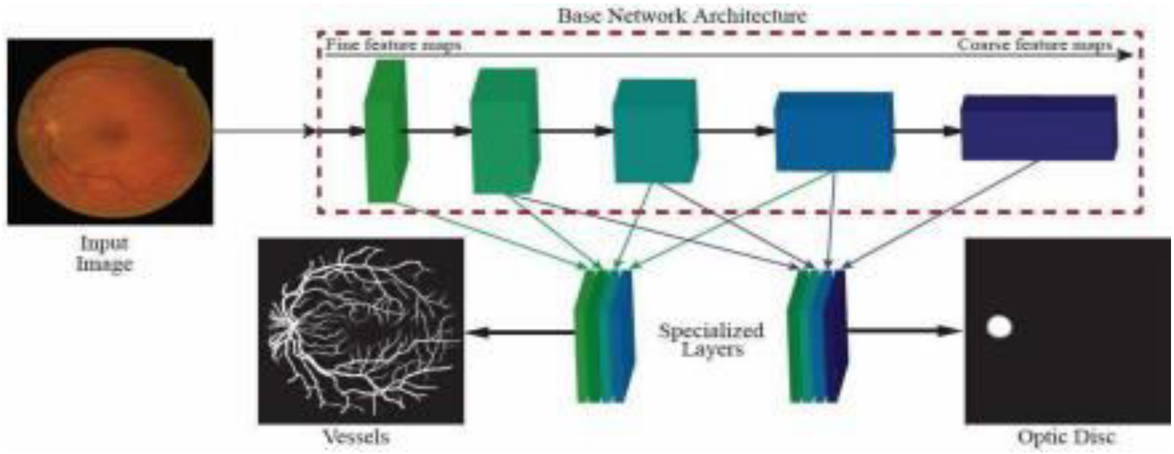
Figure 1: shows the Architecture and different modules in it.



The above CNN Architecture draws inspiration from the VGG net [2] and the inception module concept from GoogleNet [4]. The architecture consists of a base network and specialized layers. The Base network consists of a series of convolutional layers with different filter sizes along with the REctified Linear Unit (RELU) Activation Function. And these convolutional layers are followed by max-pooling layers to downsample the input image when we go further deep into the network so the model retains only the necessary information. There are two specialized layers, one for generating an optic nerve segmentation map and the other for generating an optic disc segmentation map. The specialized layers are formed by the input feature map from the convolutional layers of the base network based on the inception module concept. The specialized layer which generates the optic nerve segmentation map takes the input feature from the first four layers because when the input goes further deep into the network only the coarser information is retrained. So other information like small retinal nerves is removed from featuresmaps. The feature maps from each convolutional layer are then resized to image size and are concatenated to the final layers of each stage to form a retinal nerve segmentation map. In the same way, the features maps from the last four layers are resized to image size and concatenated to form a segmentation map containing the optic disc information. The majority of the convolutional layers employ 3x3 convolutional filters for efficiency except the ones used for combining the output (1x1 filter).
The model uses a class-balancing cross-entropy loss function for the training network. The loss function is defined as:

$$\mathcal{L}(\mathbf{W}) = -\beta \sum_{j \in Y_+} \log P(y_j = 1 | X; \mathbf{W}) - (1-\beta) \sum_{j \in Y_-} \log P(y_j = 0 | X; \mathbf{W})$$

The Advantage of this architecture compared to the other methods which use morphological techniques or energy-based models is that it produces better results in the segmentation of the optic disc from the digital fundus image. And the current model does not require any form of initialization in the success segmentation of the optic disc. And also requires less time for training the model.The Disadvantage of this architecture is that it only addresses the issue of extracting the optic disc from the digital fundus image whereas it fails to address the issue of extraction of the optic cup which is difficult and necessary information to predict the presence of glaucoma in the fundus image.The author of the paper [3] addresses the issue of detecting the optic cup and optic disc from the fundus image using a Deep Convolutional Neural Network. In this paper, the author detects the boundaries of both optic cup and disc from the Digital Fundus Image (DFI). The input Fundus image is first pre-processed before it is given to the model. The pre-processing step involves finding the ROI (Optic Disc and Optic Cup) in the fundus image by dividing the image into a grid and locating the region of more brightest pixel values in the fundus image.

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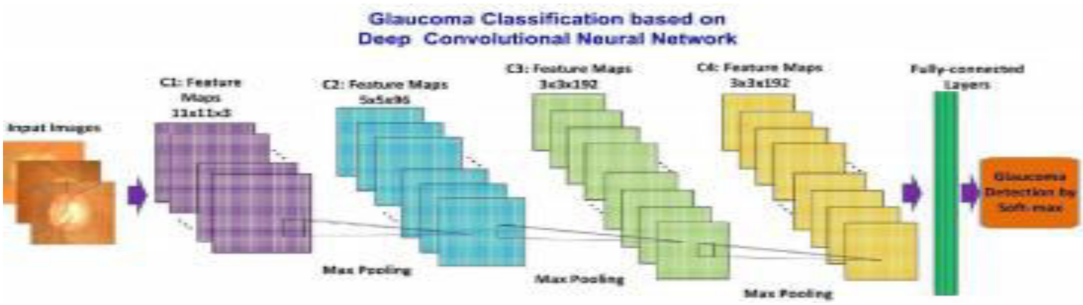
Figure 2: CNN Architecture



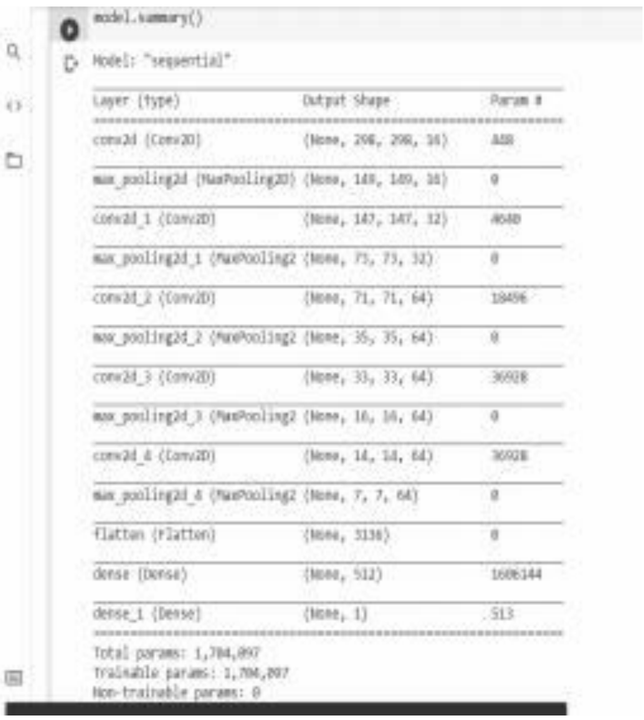
After detecting the region of brightest pixels in the fundus image. We have successfully extracted the ROI which is optic Disc and optic cup from the image. Then we resize the image into 256x256 pixel size to make the model trainer faster. After resizing the image into 256x256 size we give the image to the model as an input. The CNN architecture proposed in Paper [2] consists of 4 layers. Each layer has 5 convolutional blocks followed by the max-pooling operation. The final layer is a dense layer with a softmax activation function for classifying whether the given image has Glaucoma or not. The model used (ROC) Region under the Curve has the evaluation metric to evaluate the performance of the model. The ROC is plotted to show the tradeoff between the sensitivity TPR (True Positive Rate) and specificity TNR (True Negative Rate), defined as:

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

Where TP and TN are the number of True Positives and True Negatives respectively, and FP and FN are the numbers of False Positive and False Negative respectively.

IV. RESULT

Figure 3 :**CNN Algorithm**



```
model.summary()

Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 298, 298, 16)      448
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 149, 149, 16)      0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 147, 147, 32)      4640
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 73, 73, 32)        0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 71, 71, 64)        18496
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 35, 35, 64)        0
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 33, 33, 64)        36928
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 16, 16, 64)        0
_________________________________________________________________
conv2d_4 (Conv2D)            (None, 14, 14, 64)        36928
_________________________________________________________________
max_pooling2d_4 (MaxPooling2 (None, 7, 7, 64)          0
_________________________________________________________________
flatten (Flatten)            (None, 3136)              0
_________________________________________________________________
dense (Dense)                (None, 512)               1606144
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 513
=================================================================
Total params: 1,704,897
Trainable params: 1,704,897
Non-trainable params: 0
```

Figure 4:**Accuracy and Loss**

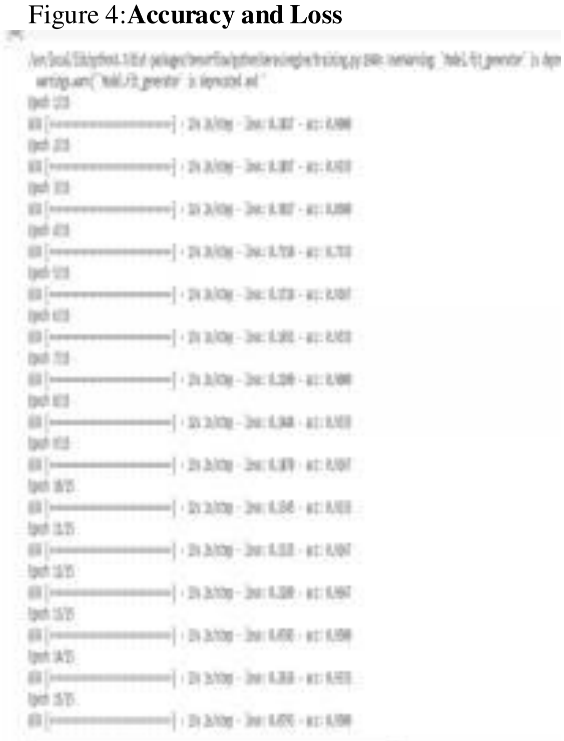


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Figure 5 :**Graph for Accuracy And Loss**

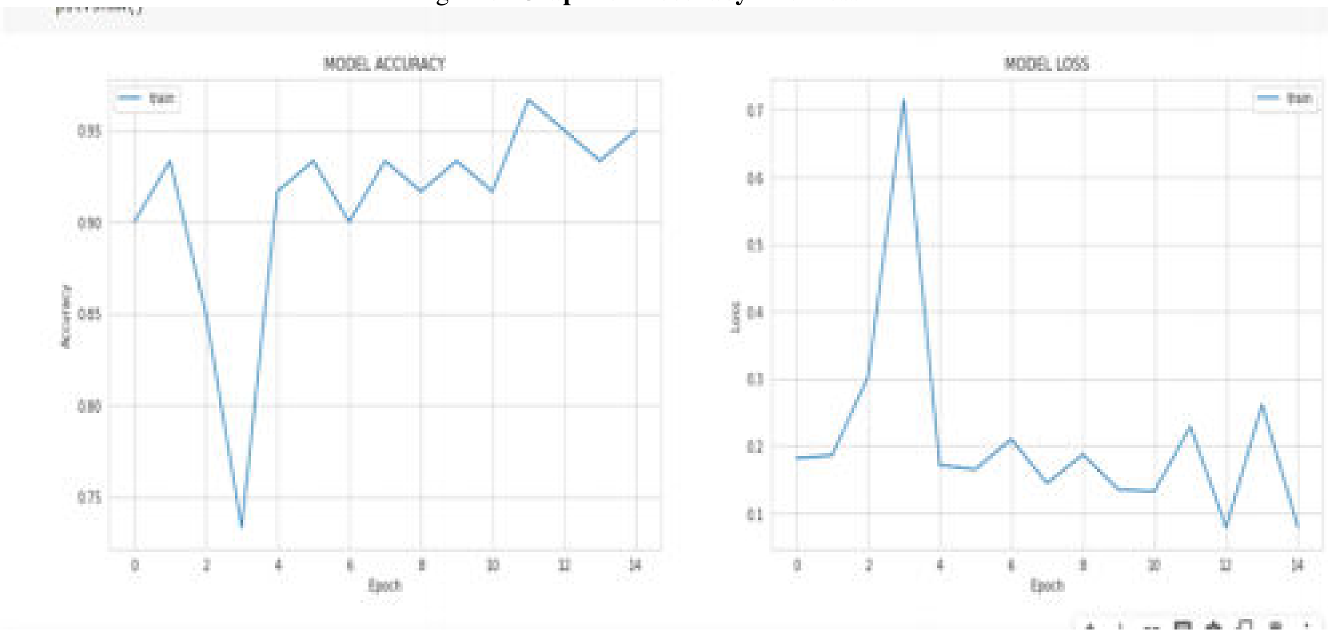


Figure 6 **:Testcase-1:**

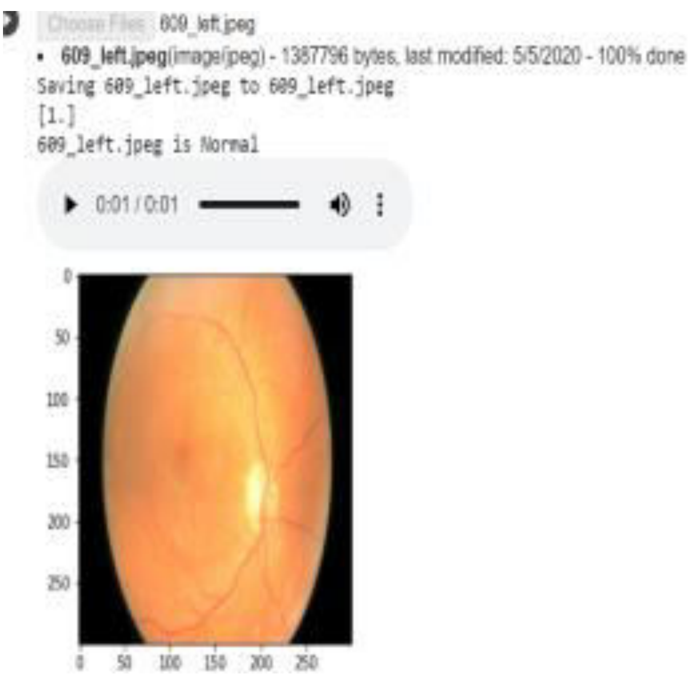
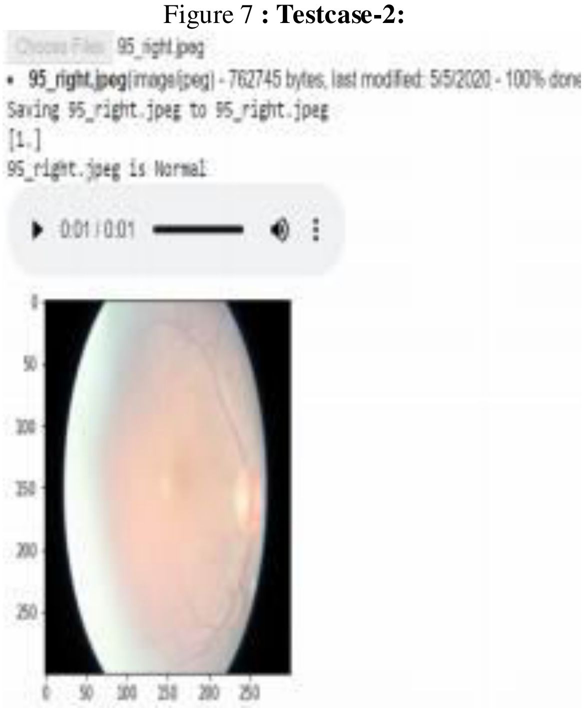


Figure 7 **: Testcase-2:**



V. CONCLUSION

In this paper, we have designed and implemented the project using Convolutional Neural Network. Our system will provide a better solution for detecting Glaucoma in the earlier phase in less time which will save the vision of many people. To implement this project we have used the Region of Interest (ROI) to take the only region of the image in which Glaucoma can be detected, also we have used Gaussian blur to remove noise from the image and then the preprocessed image is given to CNN. Our system gave 0.9607 and 0.98 values of precision and recall respectively. In the future, we will try to increase Accuracy of our project by using different technologies.

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