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Detection of Glaucoma Eye Disease Using Deep Learning

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***Abstract*—The motivation behind developing the "Glaucoma Eye Disease System' is that glaucoma disease does not have symptoms. Today, glaucoma is the leading cause of blindness. It damages optic nerve of eye. Glaucoma changes the thickness of the retinal nerve fiber layer. An increase in pressure inside the optic nerve head causes glaucoma. Glaucoma is an eye disease that is incurable. Manual glaucoma diagnosis is a time-consuming process. Also, this process is less accurate. Early-stage glaucoma disease detection may prevent complete eye vision loss. The deep learning process is useful in terms of image segmentation and classification. A convolutional neural network can extract features from an image to classify it as having glaucoma or being healthy. This system reduces manpower and complexity in glaucoma diagnosis. We trained our model using the ORIGA dataset and performed cross-validation on the same dataset. The model was tested on 65 images and achieved an accuracy of 89%.**

Keywords—computer vision, deep learning, glaucoma, SVM, and convolutional neural networks.

I. INTRODUCTION

Glaucoma is a eye disease caused by internal pressure. This pressure is named as intraocular pressure [1]. For detecting glaucoma, observation of the optic nerve head and optic cup to disc ratio is important [2]. It is called 'Silent Thief of Sight' as advanced stage of glaucoma can cause complete vision loss and it has no symptoms [3]. Early screening and corresponding treatment is needed since existing medical technology cannot cure glaucoma completely. Glaucoma detection is a time consuming job due to variation in orientation, size and shape of lesions [6-7]. The deep learning techniques allows computer to perform task automatically, without being explicitly programmed. In 1988, a type of neural network called 'Convolutional Neural Network' (CNN) was suggested by Yan LeCun [8-10]. The architecture of CNN is inspired by human brain, where each biological neuron is analogous to perceptron or node [11-13]. Feature extraction has significant role in entire deep learning process [14]. Hence, we need to build the deep learning based model for automatic detection of glaucoma for population screening.

II. RELATED WORK

Authors in their paper,"An Efficient Approach To Glaucoma Detection using Deep Learning"(2022) presented Approach EfficientDet-D0 network for glaucoma classification which was found to be robust. A challenging dataset (named Origa) in terms of variations in glaucoma lesion size and shapes achieved large accuracy. The limitation of this paper is that the dataset used is an unbalanced dataset. This has a negative impact on the outcome because the model's tendency is more biassed towards the majority of the population[6]. Shubham Joshi, B. Partibane, Wesam Atef Hatamleh, in paper,"Glaucoma

Detection Using Image Processing and Supervised Learning for Classification**"**,2022 proposed an ensemble model. The performance of the proposed algorithm (ensemble model) was better than the three ConvNet architectures. The ensemble method combines predictions from two or more models. Hence, accuracy is at its maximum. This model yielded the highest accuracy,sensitivity and specificity.

The training dataset used contained fewer images, resulting in a less accurate model[7]. P. Aruna Priya and G. Latha (2022) proposed neural networks (NN), support vector machines (SVM), and adaptive neurofuzzy inference systems (ANFIS) as machine learning classifiers to analyze glaucoma retinal image classification system performance. Using SVM, more accuracy was achieved [8]. Nanditha Krishna and K Nagamani at 4th International Conference on Intelligent

Circuits and Systems Journal of Physics presented one model based on CNN .The model extracted features such as shape, texture, and haar.

This approach increased the percentage of accuracy. There are fewer CNN layers used. This leads to a degradation in information extraction[14]. Ajitha S. and M.V. Judy, in their paper "Faster R-CNN classification for the recognition of

glaucoma" (2020), presented an R-CNN approach to detect glaucoma in fundus images. It also increased accuracy in terms of extraction. The limitation of the RCNN is that it cannot be trained end-to-end because it is a multi-stage model. It uses the extracted features from the pre-trained CNN to improve the classifier's training[16].In this paper, author experimented on softmax classifier and SVM Classifier. SoftMax Classifier achieved highest accuracy, sensitivity, specificity and precision. The performance of the support vector machine classifier algorithm is not optimum when: 1) dataset size is more.2) dataset contains noisy images [17]. Authors [19] in their paper used Canny Edge Detection for accurate depth and geometry of frame. Dataset consisting of hand action gesture and three dimensional body scan were used to achieve desired result. Authors [20] in their paper, "Effective and efficient approach for gesture detection in video through monocular RGB frames" highlighted the transformation journey of 2D video to 3D video. A comparative study of all techniques with pros and cons was done, and it was concluded that 3D video processing is emerging technology.

Standards like HEVC are effective for multiview video coding. It leads to increase in coding efficiency. Authors in their paper [21] presented a three- module pipeline for effective hand gesture detection at a speed of 100 frames per second. 2D and 3D annotations of hand gestures are merged to form a 3D mesh around the skeletal hand. 3D animated hand gestures presented using neural network ensured the greater understanding of depth ambiguity problem. Main aim of the work is to develop the system that predicts glaucoma disease with maximum accuracy and minimum time.

III. METHODOLOGY

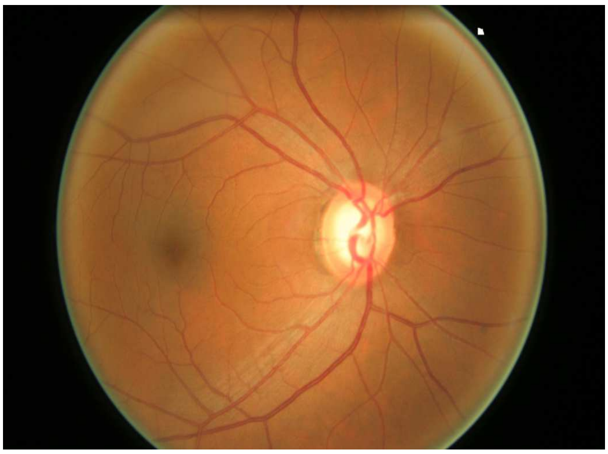

Figure 1. (a)Normal Eye

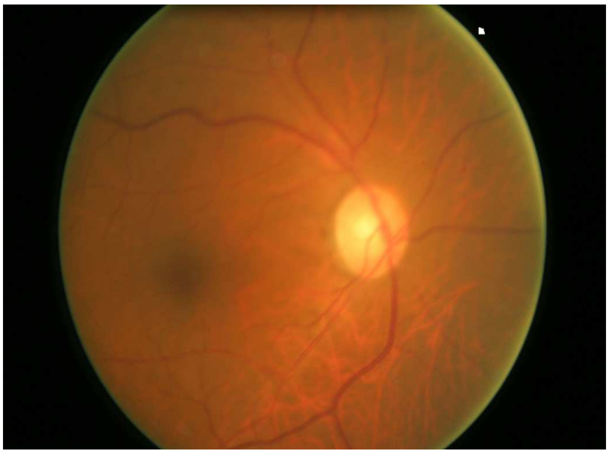

Figure 1.(b) Glaucoma Diseased Eye

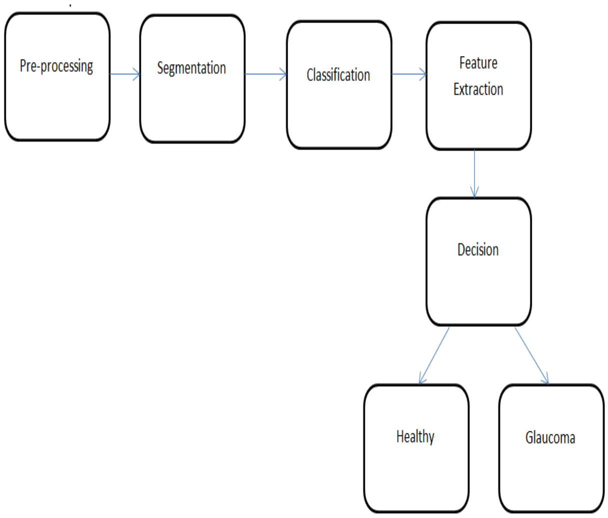

Figure 2. Block Diagram

The convolutional neural network is made up of convolutional layers that are followed by a pooling layer and a flattering layer. Images are stored in the form of a matrix of pixels. CNN is significant in its work in image classification. A convolutional neural network consists of four layers: a fully connected layer, a subsampling layer, a ReLU layer, and a convolution layer. The convolution layer is the first layer in CNN. It performs the mathematical operation of multiplication between the input image and the kernel matrix or filter matrix. The ReLU activation function equates negative pixel values to zero. The output is a rectified feature map. This activation function makes the model more predictive. It also causes a reduction in the likelihood of a vanishing gradient. It is used for developing nonlinearity. The pooling layer down samples the feature maps. The supreme element features are chosen by the max pooling layer. Max pooling reduces the image's dimension. By flattening, the pooled feature map matrix is transformed into a single-column vector. The feature map of the last layer (which may be a convolutional layer or a pooling layer) is connected to the fully connected layer. Full connected layer classifies the images. The number of exit nodes in the fully connected layer is the same as the number of classes. Here, we have two classes (glaucoma and healthy). So, only two exit nodes are present. Each neuron in the fully connected layer receives those weights, which prioritize the most appropriate label. In this way, based on the majority of votes, a classification decision is made.

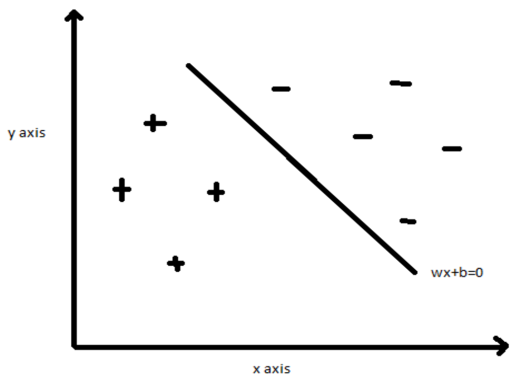

Figure 3.Support Vector Machine

The equation of hyper plane is as: y=wx+b=0
Where w=vector normal to hyperplane
b=offset
If y>0, then we say it is positive point otherwise it is negative point.

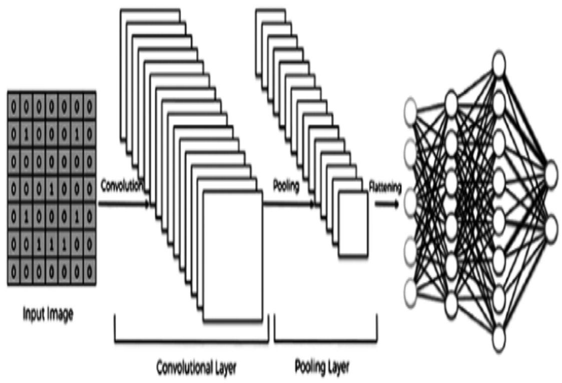

Figure4. CNN structure

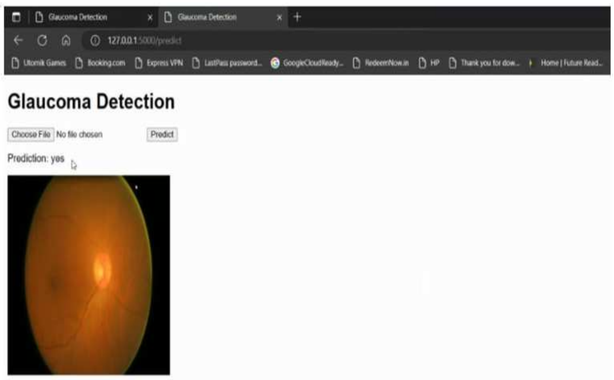

Figure 5.Desktop Application Front End

IV. Experimentation

The datasets used to train the model are ORIGA and Drishti. The dataset consists of 585 images. The images in the dataset are of dimensions 3072 x 2048. We converted images to 256 x 256 dimensions during the data pre-processing stage. The training dataset is used to help CNN learn and extract features. The convolutional neural network (CNN) architecture used is illustrated in figure 2. It consists of four convolutional layers, two pooling layers, and a flattening layer. The pre-processed image is fed as input to CNN. Many layers of CNN were used to further process this image. An image is convolved with a kernel or filter. Maxpooling reduces the size of the image by downsampling. The feature map obtained is pooled. Pooled feature map matrixes are converted to a single-column vector by flattening layer. Fully connected layers process a single-column vector. The last fully connected layer evaluates the probability of each class and classified image. We use the "sigmoid" activation function in the fully connected layer and the "ReLU" activation function in the hidden layer of CNN. We trained our model using the Adam optimizer. "Binary cross entropy" was used as a loss function to calculate error.

TABLE 1. Dataset Images

Dataset	Normal	Glaucoma	Resolution	Total
Origa	482	168	3072 x 2048	605

TABLE 2. Training performance of model

Epochs	Model Training Loss	Model Training Accuracy	Model Validation Loss	Model Validation Accuracy
1/30	0.64	0.72	0.24	1
10/30	0.54	0.76	0.18	1
20/30	0.59	0.71	0.41	0.93
30/30	0.46	0.79	0.29	0.89

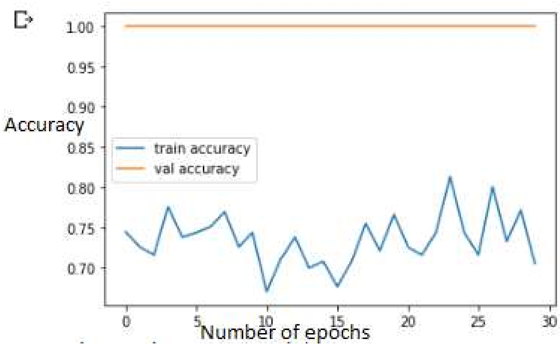

Figure6 (a)

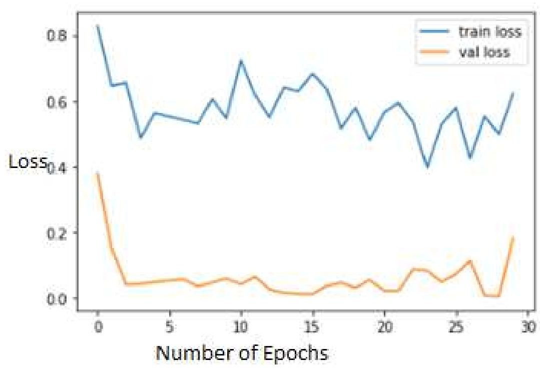

Figure6. (b)

Figure6. (a) Model accuracy curve ,(b) Model loss curve for training and testing dataset with respect to epoch

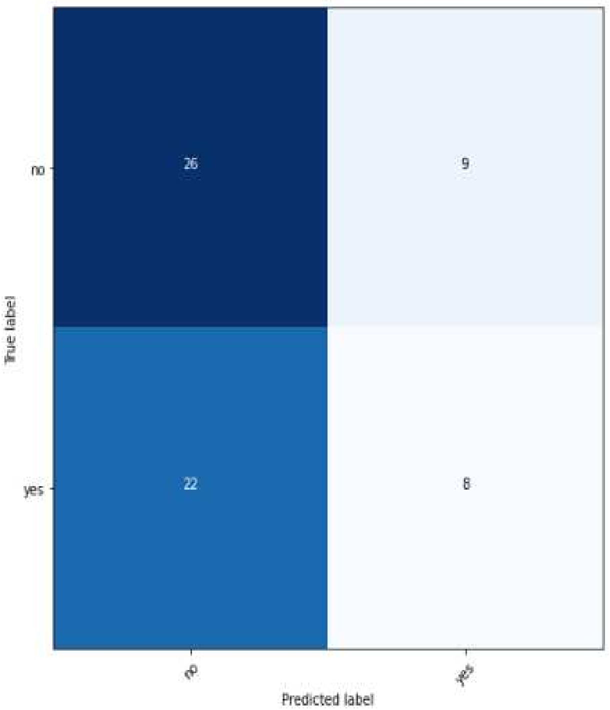

Figure 7.Confusion Matrix with SVM Classifier

V. CONCLUISON

We proposed a new glaucoma screening algorithm with an SVM classifier. The developed system assists ophthalmologists in the fast and accurate diagnosis of glaucoma. Image-based features are extracted by a neural network. The parameters such as accuracy, sensitivity, and recall confirm that our model is more robust for glaucoma classification. In the future, we may work on an ensemble-based model to increase detection accuracy. In addition, to extract a large number of features, more layers can be added to the convolutional neural network.

VI. DISCUSSION

We used KERAS to train our model over 30 epochs. As we go on training model with number of epochs, the training loss decreases from 0.64 to 0.46, and the training accuracy increases from 72% to 79%. The validation loss decreases and the validation accuracy increases as the epoch length increases. In total, 65 images were used for testing. Out of them, 48 images are of a healthy eye and 17 images are of a glaucomatous eye.

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