Classification and Localization of Eye Diseases using Convolutional Neural Network

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***Abstract*— The most common causes of vision loss in people worldwide are cataract, glaucoma, and retinal disorders. The rising prevalence of these diseases necessitates an immediate, accurate diagnosis. The suggested approach is created and designed to make it simple for individuals to diagnose illnesses of the retina, glaucoma, cataract and many more. Artificial neural networks and convolutional neural networks are used to classify and locate eye problems. The suggested approach will reduce the amount of brought-on blindness by enabling patients to receive the necessary care for the mentioned illnesses at an early stage. The chosen method also evaluates the effectiveness and safety of cataract surgery in eyes with age-related macular degeneration in addition to identifying glaucoma and retinal diseases. This study uses photos of the fundus from healthy eyes as well as eyes with glaucoma, cataracts, and retina to show the accuracy of algorithms. Nowadays, the concept of categorizing photographs based on their fundus and extracting features is well recognized, and it also plays a crucial role in the conclusion.**

Keywords— Artificial Neural Network, Convolutional Neural Network, 2D Images.

I. INTRODUCTION

Eye diseases, which can cause discomfort, vision loss, and occasionally even blindness, can affect the structure or function of the eye. These illnesses can strike at any age and may be brought on by a number of different things, including genetics, aging, trauma, infections, or environmental causes.

Cataracts, glaucoma, diabetic retinopathy, conjunctivitis, and other illnesses are just a few of the many distinct types of eye conditions that exist. Each condition has its own set of symptoms and treatment choices.

Eye conditions can be brought on by a number of things, including:

1. Genetics: Macular degeneration and glaucoma are two eye diseases that can be inherited from parents or other family members.
2. Age: Older persons are more likely to develop eye conditions such cataracts and age-related macular degeneration.
3. Environmental factors: Some eye illnesses can be made more likely by exposure to sunlight, pollution, and cigarette smoke.
4. Infections: Eye conditions like conjunctivitis or keratitis can be brought on by bacterial or viral infections.

In the science of ophthalmology [1], classification [2] and localization [3] of eye conditions are crucial areas of research. Different forms of eye illnesses are identified and categorized using these two methods before being treated with particular drugs or through surgery.

The classification of eye conditions entails classifying them according to their signs, root causes, and available therapies. Glaucoma [4], cataracts[5], macular degeneration[6], and diabetic retinopathy[7] are a few examples of frequent categories of eye problems. These illnesses each have distinctive traits that aid medical professionals in correctly diagnosing and treating them.

Finding the condition's precise location within the eye is known as localization of eye disorders. This is significant because it can assist doctors in selecting the most appropriate course of action. For instance, surgery might be required to remove a patient's lens cataract. However, medicine can be the best course of action if the same patient also has glaucoma.

II. RELATED WORK

Gauri Ramanathan, Divya Chakrabarti, Aarti Patil, Sakshi Rishipathak and Shubhangi Kharche [8] The suggested approach will reduce the quantity of brought-on blindness by enabling patients to receive the proper care for the rementioned illnesses at an early stage. The techniques we employ for detection are Support Vector Machine, Gradient Boosting, Random Forest, and Logistic Regression. Eye illnesses are detectable 90% of the time.

Akihiro Kuwahara, Rin Hirakawa, Hideki Kawano, Kenichi Nakashi and Yoshihisa Nakatoh[9] In this study, the noise caused by face movement was reduced and the blink detection system was enhanced using face image normalization. They discovered that, when using EARM, the suggested method outperformed all subject results for blink detection accuracy.

DShamia,Shajin Prince and DBini[10]In order to detect any concealed characteristics for this inquiry, fundus photos of both healthy and unwell individuals are obtained in well-lit settings. The fundus images are then processed utilizing power transform, grayscale, and resize techniques. The final step involves building a deep CNN, which consists of one hidden layer,16 input neurons, and either two healthy or two damaged output neurons. 91% of detections are correctly made.

AlaaDaher, Zennah Rammal[11] This project's objective is to develop a system that will let ophthalmologists identify, diagnose, and treat ocular strabismus without the use of eyeglasses, some harsh laser procedures, or drugs. The acquired findings show that our system is capable of differentiating between normal and abnormal patients, calculating deviation percentages and levels of abnormality, measuring ocular vibration levels, and treating a variety of eye diseases.

C. Rekha and K. Jayashree [12] Using deep learning methods, this system seeks to predict the Hyphema sickness at an early stage. The suggested method comprises pre-processing of images using the image of the eye as the input.

Ayesha Kazi, Prerna Sukhija, Miloy Ajmera, and Kailas Devadkar [13] The authors suggest a method for identifying eye illnesses in which retinal blood vessels are extracted. Deep convolutional neural networks will be designed and subsequently put into use in order to detect the presence of an exudate and classify it as either diabetic retinopathy, glaucoma, or cataract. The implementation of a system for identifying diseases' likelihood of existing as well as their actual presence.

Dr.D.Selvathi,K.Suganya,[14]The suggested approach examines the application of machine learning to distinguish between diabetic eye illness and other eye conditions using thermography images of the eyes. The influence of temperature variation of anomalies in eye structure is also introduced as a diagnostic imaging technique that aids ophthalmologists in making clinical diagnoses.

SumitaWardani, Sawaluddin, PoltakSihombing [15] According to this study, the Support Vector Machine-K-Nearest Neighbor hybrid is more accurate than the Support Vector Machine alone at classifying eye diseases. The accuracy of the SVM and KNN method in combination is 94.67%.

Ai Ping Yow, Damon Wong, Huiying Liu, Hongyuan Zhu, Ivy Jing-Wen Ong, Augustinus Laude, Tock Han Lim[16] In this paper, we introduce AVIGA, an automated method for detecting vision impairment by gaze tracking. The Impulse Stimuli Response (ISR) test and the Pursuit Stimuli Response (PSR) test were implemented in the AVIGA system as two assessment kinds. The severity of visual impairment is classified using a Support Vector Regression (SVR)-based technique based on the exam results. The results show that the AVIGA system works better in identifying the presence of visual impairments in the eyes than Microperimetry and has a significant association to the visual acuity test (VA).

Vinay Nair, Savani Suranglikar, Sourabh Deshmukh, Yashraj Gavhane[17] The suggested computer vision model is capable of quickly recognizing a number of diseases and can be used to automate the identification of eye ailments on a large scale. The recommended approach may only partially detect diseases given the Hamming Losses offered, but even so, it is very fantastic because it can lessen the load on the ophthalmologists operating in these camps.

Abhijith Nuchin, Dr. TC Manjunath, Pavithra Govindaraiah[18] In the proposed study, Watershed is used to automatically identify glaucoma-affected eyes utilizing image processing techniques for filtering and modification, and to implement these techniques on hardware using an FPGA.

Y. Mao, Y. He, L. Liu and X. Chen [19] In this study, an illness discrimination model based on eye movement is established using a deep neural network (DNN) technique. In order to gather eye pictures, a number of eye-tracking studies are first designed. Second, the position and size of the pupil are retrieved, and from the normalized pupil information, the feature vectors of eye movement are obtained.

A. H. Vyas and V. Khanduja [20] This study discusses methods for detecting eye illnesses, such as ARMD, cataract, DR, and glaucoma, using machine learning and deep learning. It has been noted that the precision of AI-based.

III. METHODOLOGY

We propose a methodology for the classification and localization of eye diseases, which uses the fundusimages of retina as input data and artificial intelligence[21] for data processing and output generation. The suggested approach has a layered structure similar to a convolutional neural network[22].Each layer in this case has its own functions for supervised [23]training, and [24]dense network does the training.

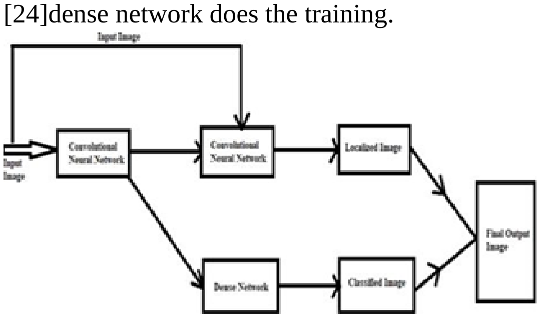

Fig.1: Block diagram of classification and localization of eye diseases using Convolutional Neural Network and Dense Network

The above block diagram shows the exact working of implemented model. The first Convolutional Neural Network block is used for feature extraction [26] and other is used for generating masks. After feature extraction the image goes for localization. By using dense network, it will classify eye data set into normal or abnormal eye. If the image is localized i.e. it will show where the exactly problem is in your retina then it is classified as abnormal eye and if there is no any localization in eye then it is normal eye. In this way the proposed idea will work.

ARTIFICIAL NEURAL NETWORK:

Medical photographs like retinal scans or optical coherence tomography (OCT) [33] images can be analysed using Artificial Neural Networks (ANNs) [34] to identify eye illnesses. The artificial neural network (ANN) is trained using a sizable dataset of annotated images, where the labels denote the presence or absence of various eye conditions. During the testing phase, fresh images are put into the ANN, which then forecasts which diseases are present. Convolutional neural networks (CNNs), which have shown encouraging results in the detection of a range of eye diseases, including diabetic retinopathy, glaucoma, and age-related macular degeneration, can increase the accuracy of the predictions.

CONVOLUTIONAL NEURAL NETWORK:

Convolutional neural networks (CNNs), a subclass of deep learning neural networks, excel at tasks involving the classification of images, such as the identification of various eye problems. In the context of identifying eye illnesses, a CNN can be trained using a substantial collection of medical images, such as retinal scans or optical coherence tomography (OCT) images. CNN develops the capacity to spot patterns in the images that could indicate different eye conditions. The CNN is exposed to a wide variety of examples of healthy and diseased eyes during the training process, coupled with the labels indicating the presence or absence of particular eye disorders. Based on the patterns found in the photos, CNN gradually develops the ability to discern between various types of eye illnesses. Once trained, the CNN can be used to make predictions about brand-new, not viewed photos. The CNN analyses the image and generates a forecast of any eye disorders that might be present. The forecast is based on the training data's identified patterns. CNNs have demonstrated successful outcomes in the diagnosis of a number of eye diseases, including age-related macular degeneration, glaucoma, and diabetic retinopathy, with high precision rates.

IV. EXPERIMENTAL SET UP AND EXPECTED RESULTS

Python is used to build the system, and generic code that integrates with the system's utilities is used. The configuration uses a tensor flow (FP16) processor to process the photos. The system will support the GeForce RTX 3080, AMD Radon RX580, and 12GB NVIDIA RTX A6000 video cards. The necessary data collection can be retrieved from Kaggle.

F-MEASURE:

In 2D image classification tasks, where the objective is to place an input image into one of many defined categories or classes, the F-measure is a frequently used assessment metric. The F-measure combines the two crucial measures of precision and recall to provide a summary of a classification model's performance.

EPOCH:

When a machine learning model is being trained, a "epoch" is a whole iteration over the entire training dataset. When it comes to classification and localization of eye diseases using deep learning models, epochs play a crucial role in the training process.

- If you set a low number of epochs, the model may underfit because it doesn't have enough exposure to the data to learn the underlying patterns effectively.
- If you set a high number of epochs, the model may overfit the training data, meaning it learns to memorize the training examples rather than generalizing to new, unseen data. This can result in poor performance on the validation or test set.

Epoch 21/25
85/85
[==============================] - 81s 644ms/step - loss: 0.2430 - acc: 0.8987
Epoch 22/25
85/85
[==============================] - 80s 634ms/step - loss: 0.2672 - acc: 0.8823
Epoch 23/25
85/85
[==============================] - 80s 634ms/step - loss: 0.2128 - acc: 0.9059
Epoch 24/25
85/85
[==============================] - 80s 635ms/step - loss: 0.2058 - acc: 0.9204
Epoch 25/25
85/85
[==============================] - 80s 635ms/step - loss: 0.1997 - acc: 0.9224

F-measure for various eye diseases can be calculated as follows:

F-measure = 2 * (precision * recall) / (precision + recall)

Table 1: F-measure table for Glaucoma and Normal eye condition

F-Measure Calculation Table				
Eye Diseases	Disease Type Code	Precision	Recall	F-Score
Glaucoma	1	0.93	0.91	0.92
Normal	2	0.91	0.95	0.93

Table 2: Average of accuracy of Glaucoma and Normal eye condition dataset wise

	Glaucoma	Normal
Set 1	82.11	87.54
Set 2	93.13	82.71
Set 3	92.86	85.51
Set 4	95.52	85.27
Set 5	94.29	81.65
Set 6	84.51	85.67
Set 7	93.51	86.91
Set 8	89.31	89.74
Set 9	88.35	92.97
Set 10	96.73	95.56
Average of accuracy	91.032	87.35

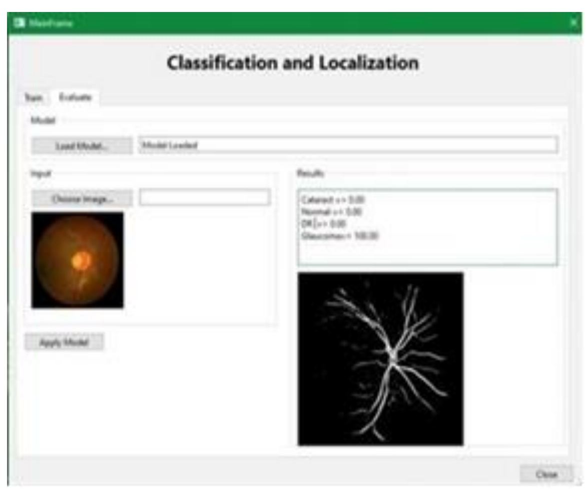

Fig 2: The eye is diagnosed of Glaucoma.

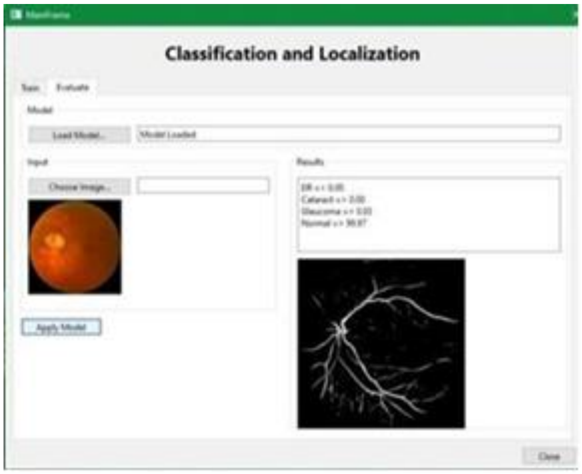

Fig 3: The eye is normal

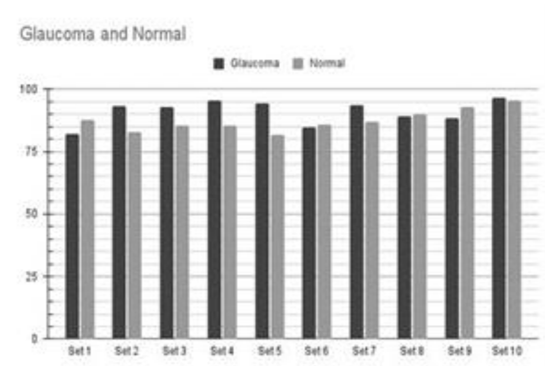

Fig 4: Accuracy of classification and localization of glaucoma and normal eye condition dataset wise.

V. CONCLUSION

Convolutional neural networks (CNNs), exponential linear units (ELUs), and backpropagation have all been shown to be efficient and promising techniques in the field of ophthalmology for the categorization and localization of eye disorders. In order to accurately classify and locate various eye illnesses, CNNs have shown extraordinary capabilities in learning and extracting significant information from eye images. By providing smoothness, capturing negative activation values, and limiting the loss of important information during training, ELUs, as activation functions within CNNs, overcomes the shortcomings of other activation functions, such as the dying ReLU problem.

Backpropagation is a fundamental deep learning method that is used to train CNNs. It enables the iterative modification of network weights based on the calculated gradients of the loss function in order to enhance the model's performance. The project has concluded the accuracy according to the following: Glaucoma has come to an average accuracy of 91.03 and Normal eye has given accuracy of 87.35, hence the total average accuracy of the model has driven as 91.45 resulting in providing 92% of correct results.

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