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Multiple Retinal Disease Detection Using Convolution Neural Network

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I. Abstract:

In todays generation, issues related to retinal diseases and eye diseases are increasing due to digitized world. The major resons of visual impairment around the world are Cataract, Glaucoma, Myopia and other retinal diseases among patients. The alarming instances of these illnesses name for a pressing intervention by early diagnosis. Artificial Intelligence has provided a platform through which the early detection of diseases is possible and on basis of that proper treatment can be made available.

One of the valuable sources available for opthalmologists in diagosing retinal issues is 'Retinal Fundus' images.Medical professionals utilise theses retinal fundus images to diagnose numerous retinal problems like diabetic retinopathy, hypertensive retinopathy, glaucoma etc. In recent times, machine learning research has focused on diagnosing diseases like diabetic retinopathy by extracting features and then classifying the image.

In this project, we use machine learning to develop a program which collects the related data from the provided dataset and detect the retinal diseases such as 'Cataract', 'Glaucoma', 'Hypertension', 'Myopia' and 'Diabetic Retinopathy'(Diabetes). Software used in this project is 'PyCharm' software editor which uses 'Python' programming language. The algorithm used in this project is 'Convolution Neural Network' (CNN). We also made use of 'TKinter' which provides a Graphical User Interface (GUI) for the project and the dataset is collected from 'Kaggle' which is an internet network of data scientists and machine learning engineers and allows customers to locate datasets they want to use in building AI models.

Deep learning methods (mainly CNNs) which are introduced for the automated detection, diagnosis, and staging of retinal diseases are achieving improved performance. Hence this project facilitates the assistance to the clinicians in early detection of various retinal diseases and this can improve chances of cure and also prevent blindness.

Keywords: - Machine Learning, Retinal disease, Convolution Neural Network (CNN), PyCharm, TKinter (GUI), Kaggle.

II. Introduction:

To investigate the human eye, many imaging modalities have been developed over the years, out of which, 'Fundus Imaging' has gained in popularity due to its non-invasive and cost-effective nature. Fundus photography involves capturing the projection of the fundus (the rear portion of an eye) onto a two-dimensional plane using a monocular camera. Several ocular structures and biomarkers including various abnormalities can be identified from a captured 2D fundus image. Many of these visual markers play an important role in identifying retinal diseases.

Diabetic retinopathy (DR), Glaucoma, age-related macular degeneration (AMD), Diabetic macular edema (DME), retinopathy of prematurity (ROP),Myopia, hypertensive retinopathy and Cataract are some of the major eye diseases that can cause blindness if not treated appropriately. The screening process for such retinal diseases generally requires expert attention and substantial skill .

In densely populated countries like India, there is a severe lack of trained ophthalmologists, who can perform such time-consuming tasks . Due to recent exponential growth in digital processors and data-driven technologies, artificial intelligence (AI) based medical screening systems have become extra popular and provide viable and cost-effective solutiond for automated analysis of retinal diseases. In particular, computer vision and deep learning (DL) techniques have shown immense growth and promise in fundus image analysis.

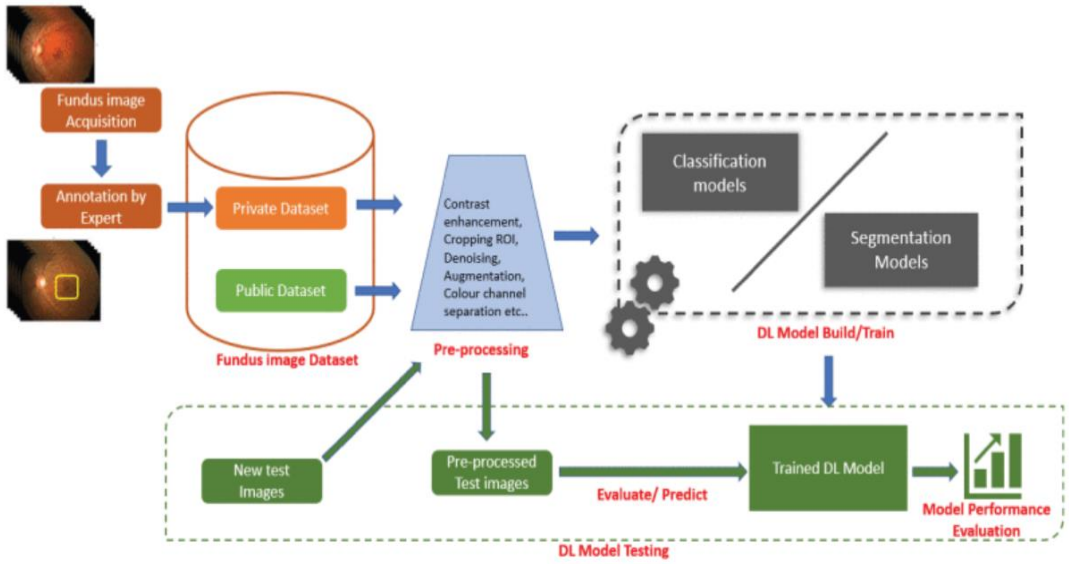
Deep Learning is a subset of Machine Learning that is based on artificial neural networks (ANNs) with multiple layers, also known as deep neural networks (DNNs). These neural networks are stimulated with the aid of using shape and feature of the human brain, and they are designed to learn from large amounts of data in an unsupervised or semi-supervised manner. Deep Learning models are capable of automatically learn features from the data, which makes them well-ideal for tasks such as image recognition, speech recognition, and natural language processing. The architectures which are most commonly used by the data scientists in deep learning are feed forward neural networks, convolutional neural networks (CNNs), and recurrent neural networks (RNNs).

The simplest form of ANN is the Feed Forward Neural Network (FNN) which have a linear flow of information with thw aid of the network. FNNs have been broadly used for tasks which includes image classification, speech recognition, and natural language processing.

Convolutional Neural Networks (CNNs) are a special type of FNNs designed specifically for image and video recognition tasks. CNNs are capable of automatically learning features from the images, which makes them well-suited for tasks such as image classification, object detection, and image segmentation.

Deep Learning models are trained using large amounts of labeled data and require significant computational resources. With the increasing availability of large amounts of data and computational resources, deep learning has been able to achieve state-of-the-art performance in a wide range of applications such as image and speech recognition, natural language processing, and more. We create an artificial structure called an artificial neural net where we have nodes or neurons. We have some neurons for input value and some for output value and in between, there may be lots of neurons interconnected in the hidden layer.

DL tasks in retinal disease diagnosis mainly fall into two categories - classification and segmentation tasks. The classification task refers to a direct classification of input images into various disease categories. Similarly, identifying important biomarkers and crucial lesions through segmentation tasks from a given fundus image of the patient can reveal many details about the nature and type of retinal diseases.



III. Literature Survey:

There has been a lot of research work done on our topic and we studied some of them for our reference.

Sadikul Alim Toki, Sohanoor Rahman, SM Mohtasim Billah Fahim, Abdullah Al Mostakim and Md. Khalilur Rhaman**[1]** in their paper mentioned about the diagnosis of the different types of eye diseases like Cataracts, Diabetic Retinopathy, Glaucoma etc using fundus images.They aim to automatically classify healthy and diseased retinal fundus images using deep neural networks and used convolutional neural networks(CNN) to classify the retinal images whether they are healthy or not.

S. Karthikeyan, P. Sanjay Kumar , R.J. Madhusudan , S.K. Sundaramoorthy and P.K. Krishnan Namboori**[2]** proposed 'Deep Convolution Neural Networks (Deep CNN) based machine learning approach which has been used for the detection of the twelve foremost retinal issues from the minimal set of fundus images.Real-time fundus images were used for the further cross-validation of the model.The efficiency, specifity and ability of the model to minimize the misclassification are proved to be excellent. The "multi-class retinal disease" model on further cross-validation with real-time fundus images gave an accuracy of 95.63 %, validation accuracy of 92.99 % and F1 score of 91.96 %. The multi-class modelis found to be a theranostic clinical support system for the ophthalmologist for diagnosing different kinds of retinal problems, especially BRAO, BRVO, CRAO, CD, DR, HRVO, HP, HR, and CN.

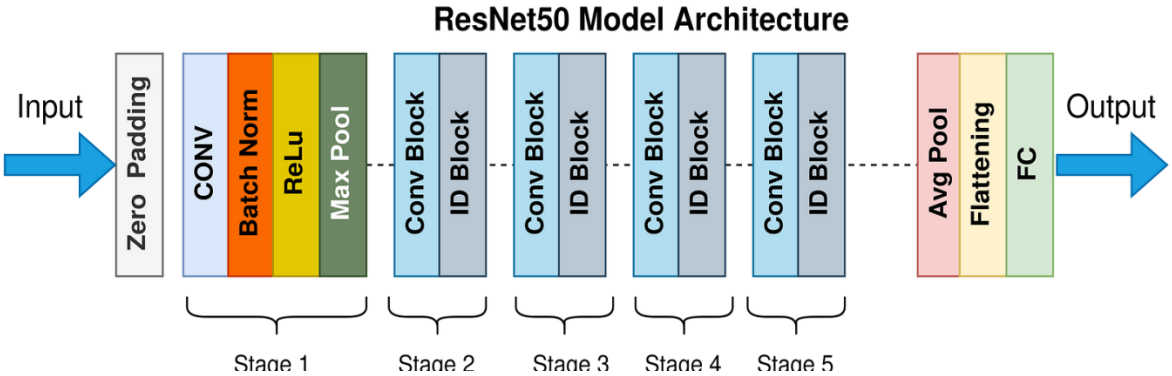
Abu Kowshir Bitto, Imran Mahmud**[3]** in their work used visual geometry group (VGG16), ResNet-50, and Inception-v3 architectures of convolutional neural networks (CNNs) to differentiate among normal eyes, conjunctivitis eyes, and cataract eyes throughout this paper. Inception-v3 is the most accurate at detecting eye disease with a detection time of 485 seconds and 97.08% accuracy, ResNet-50 performs the second-highest accuracy with 95.68% with 1090 seconds and lastly, VGG-16 performs 95.48% accurately taking the highest time of 2510 seconds to detect eye diseases.

IV. Methodology:

- **Pre-trained Model:** A pre-trained model refers to a model or a saved network created with the aid of a person and trained on a huge dataset to resolve a comparable problem. We can use a pre-trained model as a starting point, instead of building a model from scratch.

- **Transfer Learning:** Transfer learning means taking a pre-trained machine learning model and repurposing it for another related task for faster development. It facilitates in attaining better overall performance even if the model is trained on a smaller dataset.
- **Convolution Neural Network(CNN):** A convolutional neural network (CNN or convnet) is a subset of machine learning. It is one of the diverse sorts of artificial neural networks that are used for different extraordinary applications and data types. A CNN is a type of network architecture for deep learning algorithms and is specifically used for image recognition and tasks that involve the processing of pixel data.

  A deep learning CNN includes 3 layers: a convolutional layer, a pooling layer and a fully connected (FC) layer. The convolutional layer is the primary layer while the FC layer is the last. The complexity of the CNN increases from the convolutional layer to the FC layer. It is this growing complexity that allows the CNN to successively identify large quantities and greater complicated features of an image until it subsequently identifies the object in its entirety.
- **ResNet50:** ResNet stands for Residual Network and is a specific type of convolutional neural network (CNN). ResNet-50 is a 50-layer convolutional neural network (48 convolutional layers, one Max Pool layer, and one average pool layer). Residual neural networks are a type of artificial neural network (ANN) which forms networks via way of means of stacking residual blocks.



It is clearly observed that after starting off with a single Convolutional layer and Max Pooling, there are 4 similar layers with just varying filter sizes – all of them using 3 * 3 convolution operation. Also, after every 2 convolutions, we are bypassing/skipping the layer in-between. This is the primary idea of ResNet models. These skipped connections are called “identity shortcut connections” and uses what is called residual blocks.

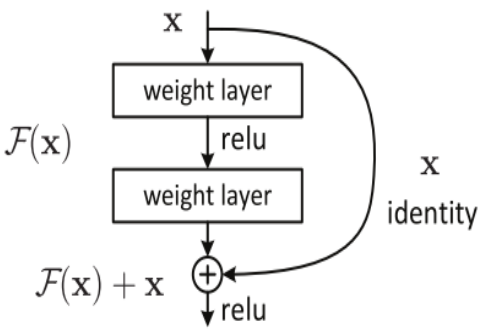


Fig: Residual blocks of ResNet Network

- **Retinal disease detection:**The following steps are to be followed to detect the retinal disease of the given input image:

  Step1: Import required Libraries and Dataset

  Step2: Partition and Visualize Data

  We need to divide the dataset into two parts: one for training and the other for validation. The model gets trained on the training subset as each epoch passes. Then, it assesses its overall performance and accuracy on the validation subset simultaneously.

  Step3: Import the Pre-trained Model

  The keras library comes with many modern machine learning algorithms that customers can pick to solve a problem. At the time of usage of resnet50, we have to apply the keras which is an open-source library which was written in python for neural networks.

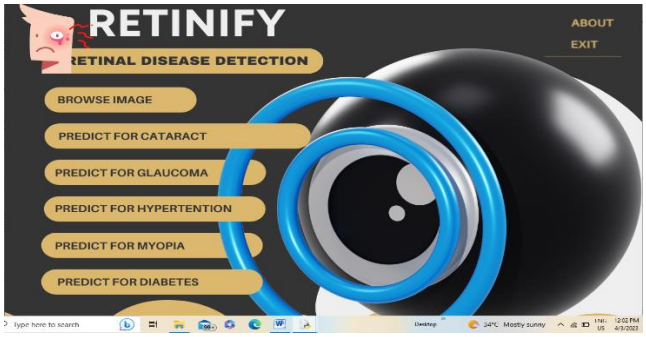
  Step4: Train and Evaluate Model

  Step5: Model Inference

  The images must be preprocessed using few steps before running the model on the given dataset. These steps make sure that every image's dimensions correspond to what the model trained on. In our work we used 224*224 dimension.

  Once our model is trained and ready we will give the input image which is a retinal fundus image and check for the type of disease from the given mentioned options such as Cataract, Glaucoma, Hypertension, Myopia and Diabetes.

V. Results:



The 'retinal fundus images' of the eye are to be given as an input in our program in order to detect the type of retinal disease of the patient.

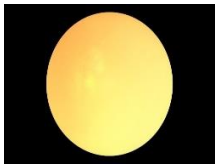


Fig1: Input image

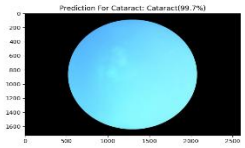


Fig2: Predicted result for cataract

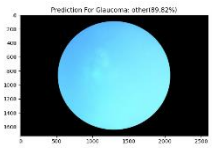


Fig3:Result for glaucoma

Fig1 shows one of the given input retinal fundus image in our project and Fig2 and Fig3 describes the predicted result for cataract and glaucoma for that input respectively.From the above results it is proved that the detected disease from the given input is cataract and it doesn't have glaucoma.

A person might suffer from more than one disease. By giving different input images we observed that our model detected multiple diseases for a given input such as an image sometimes has both cataract and myopia or both glaucoma and diabetes etc.

VI. Conclusion:

Our paper demonstrates the use of Transfer Learning(TL) and deep feature extraction to diagnose multiple retinal diseases from the given input retinal fundus images. Deep feature extraction and Transfer Learning (TL) are performed using the Convolution Neural Network (CNN) architecture ResNet-50. Here we used the pre-trained models of ResNet-50 architecture for the different retinal diseases mentioned in our project such as 'Cataract', 'Glaucoma', 'Myopia, 'Hypertension' and 'Diabetes' (Diabetic Retinopathy) which are trained using 'Kaggle' dataset are imported into our program using 'keras tenserflow' and 'numpy' libraries. In this paper we achieved good accuracy with 50 Epochs. This will aid the medical department in using the technology and detecting eye problems as fast as possible.

VII. Acknowledgement:

We are very much delighted to express our sincere thanks to our Head of the Departmrnt (ECE) **Dr. S. Aruna** for her extended encouragement. It is our privilege to acknowledge with deep sense of gratitude to our project guide Assistant Professor, **Mrs. Rama Devi** whose motivation, supervision and valuable suggestions has helped us significantly to successfully complete our project. Their guidance proved to be very much significant and valuable to overcome all the troubles in the fulfillment of this mega project on **"Multiple Retinal Disease Detection Using Convolution Neural Network"**.

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