Detection of Retinal &Eye Diseases by using Convolutional Neural Network

D.O.I - 10.51201/12489

https://doi.org/10.51201/12489

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Abstract: *In todays generation, issues related to retinal diseases and eye diseases are increas-ing due to digitized world. Artificial Intelligence has provided a platform through which the early detection of diseases is possible and on the basis of that proper treatment can be made available. CNV (Choroidal revascularization), DME (Diabetic macular edema), Drusen (retinal diseases), Cataract and Glaucoma (eye diseases) are the diseases considered for the pro- posed system. Cataract and Glaucoma are very common eye diseases leading to blindness. Cataract can only be diagnosed with Torch light examination, slit lamp examination etc. those required for Anterior Segment examination. Above diseases must be diagnosed at early stage to prevent complications. OCT (Optical coherence tomography) is an imaging technique which provides micrometer resolution images of retina The objective of this system is to improve the accuracy of the diseases detection like Cataract and Glaucoma along with retinal diseases CNV (Choroidal revascularization), DME (Diabetic macular edema) and Drusen using the similar model as used for OCT images. Along with OCT images for detection of retinal diseases, eye scans are used for detection of Cataract and Glaucoma. Dataset of around 86,000 OCT, Cata- ract, Glaucoma and normal images was used. OCT, Cataract, Glaucoma and normal images were pre-processed and around 95% accuracy was achieved.*

Keywords: Convolution neural network, Artificial Intelligence, Dataset, Optical Coherence tomography (OCT), Machine learning algorithms.

1. Introduction

Artificial Intelligence (AI) has wide applications in fields like medical, entertainment, education etc. Eye related diseases are common nowadays due to the smart phones, computers and TV. If the diagnosis of these diseases not done at an early stage it may cause blindness. Proposed System does detection of retinal and eye diseases. DME (Diabetic Macular endema) Drusen and CNV (Choroidal neovascularization) are some major retinal diseases [1] and Cataract, Glaucoma are eye diseases. DME is Diabetic Macular Edema which causes accumulation of fluid in the macula part of the eye. Drusen is the yellow spots on the retina. CNV (Choroidal neovascularization) is the growth of new blood vessels. Glaucoma is a condition that causes damage to the optic nerves. Cataract causes blurry vision. Dataset of around 86,000 OCT and scanned images were used for both training and testing purposes and 1000 images of patients were used for validation of the system. CNN [4][5] is trained on this data and prediction of disease is done. Proposed system is an automated diagnosis tool which will help different hospitals and doctors to detect and analyze the patient data so early treatment can be provided to patients. It will also minimize the manual work per- formed by doctors and will help in providing efficient diagnosis.

2. Related Work

Suhail Najeeb *et al.* [1] proposed a system which focuses on detection and classifica-tion of issues related to retinal diseases. This system uses OCT scans for retinal detec-tion and classification and helps to detect the issues related to retina by using the part that is interested through which different disease can be diagnosed.95.66% accuracy is achieved by this proposed system.

Jiahuan Zhou et al. [2] proposed correlation layer and computed the correlation coef-ficient matrix. It is specially designed to optimize the weights distribution. MINIST and CIFAR-10 dataset were used in the given methodology.

Abhishek Verma et al. [3] proposed Venturi Architecture. The comparison is done between the proposed Venturi Architecture and existing deep neural network architec-tures.The comparison parameters were accuracy and loss for both training and testing phases. The Karolinska Directed Emotional Faces dataset of 4900 images was used. The proposed architecture showed greater accuracy than existing architectures.

Teppei Matsubara and Jose C. Nacher et al. [4] made use of Convolutional Neural Network for classification of lung cancer. The developed method succeeded in inte- gration of protein interaction network data and gene expression profiles for classifica- tion purposes.

Tianmei Guo and Jiwen Dong et al. [5] built a Convolutional Neural Network to clas-sify images of the MINIST and CIFAR-10 dataset. The feature extraction capability of conventional neural networks is scarce which affects their performance.

Saad ALBAWI and Tareq Abed MOHAMMED *et al.* [6] gives the deep understand- ing of Convolutional neural network. Discussion is done on the important elements of CNN and their working, drawbacks and parameters affecting efficiency.

Partha Pratim Banik *et al.* [7] proposed classified White Blood Cells (WBC) images for medical diagnosis system. The proposed fused-CNN model trained faster than conventional models and achieved an accuracy of 90%.

Haiying Xia *et al.* [8] proposed a cascaded architecture CTF-Net for early detection and treatment for diseases related to rear eye which is also called as fundus. They achieved an overall accuracy of 96.85% for their architecture.

M. Miyagawa *et al.* [9] evaluated and trained networks of CNN based on lumen seg- mentation. Polar coordinate system provided accuracy of 99%, Dice index of 98%, Jaccard index of 97% with the help of small sized images.

Reza Rasti *et al.*

[10] proposed MCME model to detect multiple scale sub image faster with the help of CNN. Model was used to identify normal retina and macular patholo- gies. This model achieved 98.86% of precision rate.

Yibiao Rong *et al.*
[11] did classification of surrogate retinal OCT images using Con- volutional Neural Network. Promising results were achieved when performed on dif- ferent databases. Muhammad Awais et al.
[12] by using pre-trained CNN, classified normal and ab- normal images for Diabetic Macular Edema (DME). Accuracy of 87.5% was achieved.

The following fig.1 depicts the advancements in the field of Ophthalmology from 800BC till date

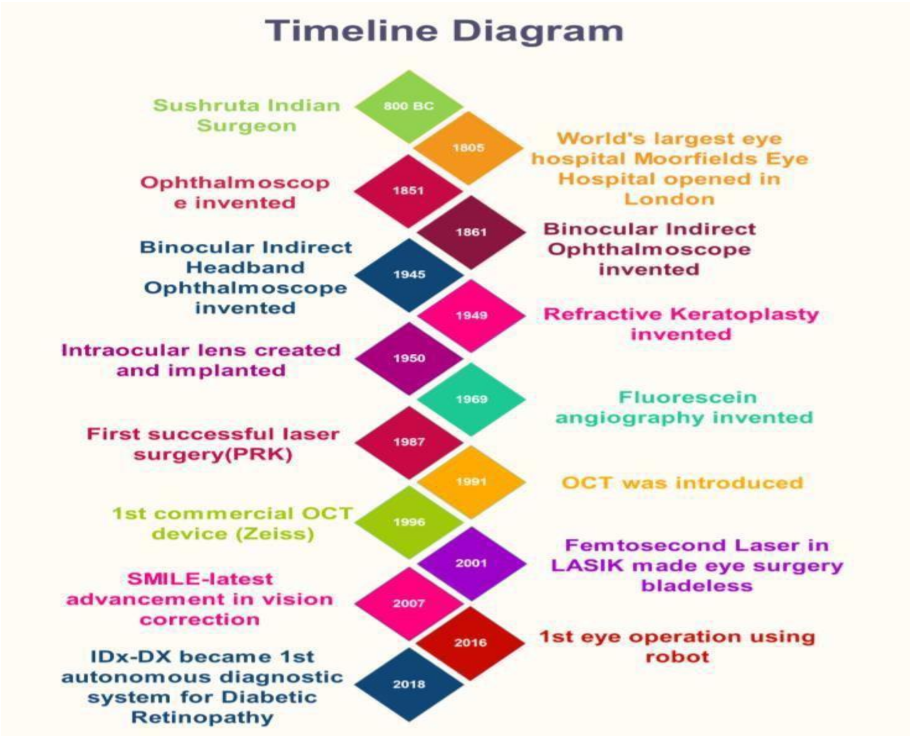

Figure 1:Timeline diagram

3.Methodology

The following fig. 2 shows our proposed system architecture.

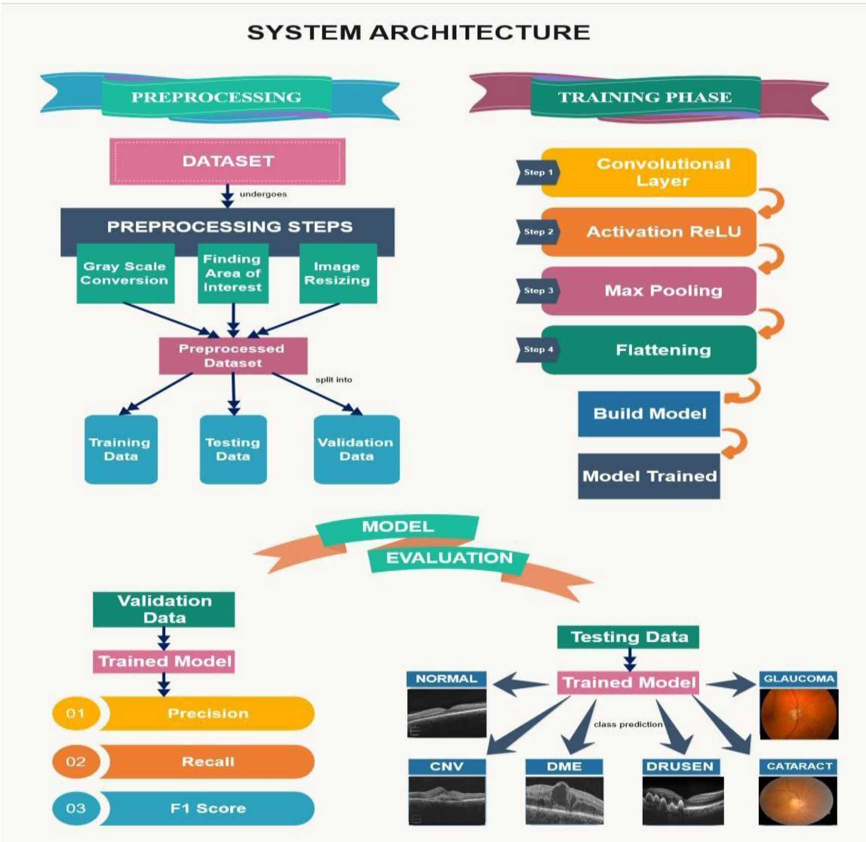

Figure 2: System Architecture

Collecting the Dataset:

For training the model, thousands of images are required so that the model can learn from the dataset by identifying relations and common features from the images. An open source dataset of OCT scans of CNV (Choroidal neovascularization), DME (Diabetic Macular Endema), Drusen combined with Glaucoma and Cataract images was used for training and testing purposes. The dataset contains a total of around 86000 images [1]. For validation 1000 images of these diseases were obtained from an Ophthalmology Institute in Pune. The images in the dataset were used directly without making any changes in them.

Segmentation/Finding Area of Interest: This is the pre-processing step. CNV (Choroidal neovascularization), DME (Diabetic macular endema), Drusen, Cataract, Glaucoma and normal images have a particular area of focus in the entire image. This region is called the Region of Interest (ROI) [10]. Hence this ROI is cropped out using Python's OpenCV library. First all the white pixels present in the border region are replaced with black pixels. Then Binary Thresholding is applied which uses Otsu's inverted Binarizaton algorithm.The result of this step is a cropped image of the disease.

Building the Convolutional Neural Network (CNN)

The layers of CNN areas follow.

Convolution2D Layer:

The input layer is followed by a 2D convolution layer. This layer consists of 32 filters having 3X3 kernels. This layer slides the convolutional filter of input and convolves the input in two directions vertically and horizontally. Further it computes the dot product of weights and input and then adds a bias term.

Activation Relu Function:

ReLu (Rectified Linear Unit) activation function is used in this layer. Relu is the well- liked activation function. Relu is half rectified from bottom.

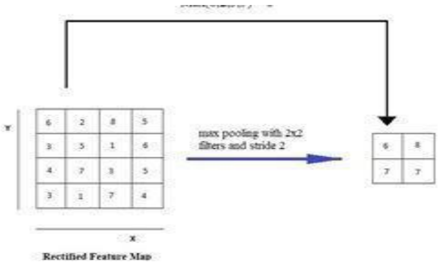

Figure 3. Max Pooling

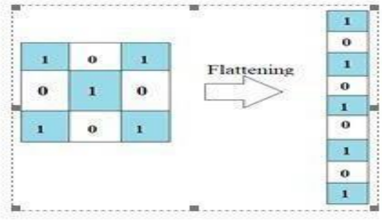

Figure 4. Flattern

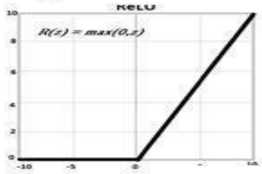

Figure 5. Relu function

MaxPolling:
In the third layer of the CNN 2X2 max pooling (See Fig 4.) operation is carried out. Max pooling reduces the contiguous proportion of the representation. The amount of criteria’s used for computation is also minimized. In this operation we take the largest element in the window and replace it with the window.

Flatten:
The output of max pooling undergoes flattening operation (See Fig 5.). Flattening operation transforms the resultant 2dimensional matrix of the Max Pooling into a one dimensional vector. This 1D vector is then fed to the dense layers. This layer provides probabilities for each class of diseases to the output layer. The class with the highest probability is activated in the output layer of the neural network.

Training the Model

The CNN build during step 3 was trained using around 86000 images [1] of the training dataset. Apart from this 1000 images of live patients from the hospital were used for validation of the model. Since the training data is very large 15 epochs were required to train the model completely. Adam optimizer was used for training purpos- es.

Load Model

A .h5 file is generated after successful training of the model. This .h5 file can be used to predict the disease of the input image. For the prediction we need to first load the model i.e. load the .h5 file which can be done as follows in python: model = load_model('f1.h5')

Class Prediction

There are 6 classes of images i.e. CNV (Choroidal neovascularization), DME (Diabet- ic macular edema), Drusen, Cataract, Glaucoma and Normal. The Model successfully predicts which class does the input image belongs to from these 6 classes.

4. Result and Analysis

Training Phase of Convolutional Neural Network provided accuracy matrices which were further substantiated by calculating precision, recall and specificity.
Table 1 contains the Accuracy matrices [1] for classes such as Normal, CNV, DME, Drusen, Cataract and Glaucoma. The results achieved are further extended by drawing a confusion matrix in Fig. 6.
DME (Diabetic macular edema) shows poor performance which misclassified Normal and CNV as DME. CNV demonstrated best classification amongst all the classes. Cataract and Glaucoma showed high accuracy. Except for a few images the results from other classes were convincing.

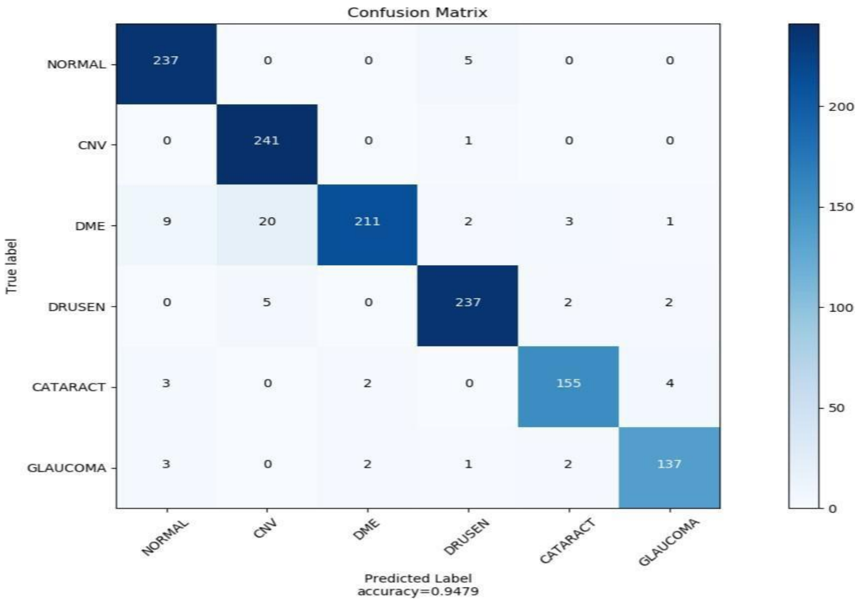

Figure 6. Confusion Matrix

Table 1. Accuracy Metric of our proposed system

	Precision	Recall	Specifici-ty
Normal	0.94	0.97	0.98
CNV	0.90	0.99	0.96
DME	0.98	0.85	0.99
Drusen	0.96	0.96	0.98
Cataract	0.95	0.94	0.99
Glaucoma	0.95	0.94	0.99
Average	0.94	0.94	0.98

5. Acknowledgement

\We are thankful to Dr. Abhijit Agre of Insight Institute of Ophthalmology and Laser Center for support and guidance regarding the dataset and different types of diseases.

6. Conclusion

Retinal diseases diagnosis system analyzed various retinal diseases such as CNV, DME, Drusen and various eye diseases such as Cataract, Glaucoma and also detected. Images can be uploaded to this system and through this system above diseases can be detected at an early stage and treatment can be provided as per one's need. Proposed system demonstrated good performance with an accuracy of 95% by CNV, DME, Drusen and 95% by cataract and glaucoma. Accuracy of Glaucoma and Cataract De- tection can be increased by increasing the size of data for cataract and glaucoma.

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