Avoid Cataract- Machine Learning Based Approach for Diagnosis of Eye

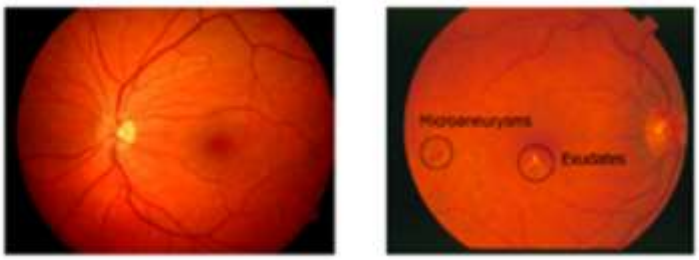
Tushar Sanjay Porje[1], Pagar Vinayak Uttam[2], Raikar Ankit Arun[3], Sinkar Dipeeka Ravindra[4]
prof. (Dr.) N.R.Wankhade[5], prof. (Dr.) N.R.Wankhade[6]
[1234] (Students, late G N Sapkal College of Engineering)
[56](Professor, late G N Sapkal College of Engineering)

Abstract- Diabetic retinopathy is a serious concern that affects the eyes and results in blindness. This paper presents an early detection system that can help to avert or decrease the spread of DR which otherwise might cause blindness. The proposed system detects the type of DR based on CNN classification. The algorithm can identify groups of injured pixels in the macula region and evaluates the total damaged area in the macula from the color retinal images. The system is proven effective in detecting diabetic retinopathy with higher detection accuracy.

Keywords: ***Diabetic retinopathy (DR), Vision Loss, Eye Disease Prediction, Age-Related Macular Degeneration (AMD),CNN classification, Local Binary Patterns (LBP)***

I. INTRODUCTION

Diabetic retinopathy (DR) [1] is a vasculopathy that affects the fine vessels in the eye and is a leading cause of preventable blindness globally. 40 to 45% of diabetic patients are likely to have DR at some point in their life; however, fewer than half of DR patients are unaware of their condition. Therefore, early recognition and cure of DR are essential to fighting this worldwide epidemic of avoidable vision loss. Even though DR is prevalent these days, its preclusion remains difficult. Ophthalmologists typically diagnose the presence and severity of DR through visual assessment of the fundus by direct examination and by evaluation of color photographs which is costly and time-consuming. Diabetic retinopathy severity analysis and early disease finding also remain somewhat subjective, with agreement statistics between trained specialists varying substantially, as recorded in previous studies. A fundus image with diabetic retinopathy is shown in Figure 1.



(a) (b)

In DR, the blood vessels in the retina are affected and which can be lost the visualization. If left untreated, it can lead to blindness. The excess growth of glucose and/or fructose damages the tiny blood vessels in the retina. The first lesions which occur most frequently as a consequence of DR are the Microaneurisms (MAs) [1][6us] that appear on the side of the blood vessels as small swellings. In the early stage, one does not observe any change in vision. A condition called macular- edema is developed by some which occur when the damaged blood vessels leak fluid and lipids onto the macula which is the part of the retina. Fluid makes the macula swell and causes blurred vision. As the disease progresses blood vessels start to proliferate. be short of oxygen in the retina causes delicate, new blood vessels to raise beside the retina and in the clear, gel-like vitreous humor that fills the inside of the eye. Lacking appropriate treatment may cause\ these new blood vessels to bleed, which can damage the retina.
The proposed system helps to analyze the Digital Retinal Fundus image and classify the DR into 5 different stages like No DR, Mild, Moderate, Severe and Proliferative DR.

II. LITERATURE REVIEW:

T. Suvathi Kannathal et al.[1] aims at finding the disease at the earliest possible stage by extracting two features from the retinal image namely Microaneurysms which is found to be the starting symptom showing feature and Hemorrhage which shows symptoms of the other stages. With the use of these two features system classify the stage of the disease as normal, beginning, mild and severe using a convolutional neural network. The system also locates the position of these features in the disease-affected retinal images to help the doctors offer better medical treatment.

Salman Sayed et al., [2] have compared the detection of Diabetic Retinopathy in the fundus images using the models Probabilistic Neural Network (PNN) and Support vector machines (SVM). Initially through the preprocessing followed by machine learning techniques. Preprocessing techniques such as Grayscale conversion, Adaptive Histogram Equalization, Discrete Wavelet Transform, Matched filter, and Fuzzy C-means segmentation are used to treat the poor image quality. Further, the yielded result of both the techniques are compared and analyzed. The detection accuracy of Support Vector Machine (SVM) outperformed than Probabilistic Neural Network PNN).

Kanika Verma et al., [3] have proposed a system to detect blood vessels, identify hemorrhages and classify different stages of diabetic retinopathy into normal, moderate, and non-proliferative diabetic retinopathy (NPDR). The retinal vascular were segmented using density analysis and bounding box techniques. Finally classified by using the area and perimeter of blood vessels and hemorrhages by Random Forests technique.

Nikita Kashyap et al.[4] present a low price and compact mobile phone-based result finding system for early detection of diabetic retinopathy using an artificial neural network (ANN) Algorithm. The mobile phone will take the retina images with the help of condensing lens then implement a detection program of ANN to decide for the initial screening of DR.

Ankita Gupta, Rita Chhikara [5] have compared the various machine learning algorithm's experimental results. The parameters focused on are sensitivity, specificity, Area under Curve (AUC), Accuracy. The review detects DR approaching Blood vessels segmentation and Identification of lesions. The obtained results were also compared with the deep neural network. Out of the various analyses, the best technique is provided. Moreover has provided high efficiency in the detection of the desired features.

Shailesh Kumar et al.[6] used two features namely; number and area of MA. Initially, pre-processing techniques like green channel extraction, histogram equalization, and morphological process have been used. For detection of microaneurysms, principal component analysis (PCA), contrast limited adaptive histogram equalization (CLAHE), morphological process, averaging filtering has been used. Classification of DR has been done by linear Support vector machine (SVM).

Rishab Gargeya [7] proposed a robust diagnostic technology to automate DR screening. Referral of eyes with DR to an ophthalmologist for more assessment and treatment would help in reducing the rate of vision loss, enabling timely and accurate diagnoses.

Mike Voets, et al [8] provide a deep study, essential for validation of new methods, and to Development and validation of a deep learning algorithm for detection of diabetic retinopathy in retinal fundus photographs. Deep learning can be used to automatically identify diabetic retinopathy. They implemented the method since the source code is not available, and used publicly available data sets. The Kaggle Eye PACS test dataset is used for this work.

III. PROPOSED DESIGN

The proposed system uses fundus camera images to avoid vision loss and blindness as part of early disease diagnosis for elderly patients.

A. System Architecture

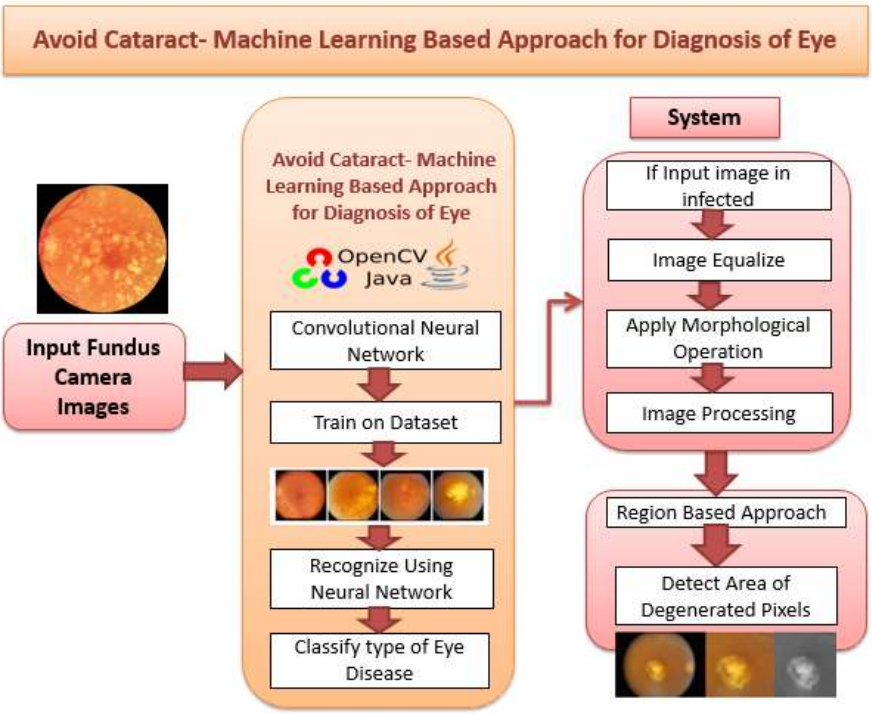
1. Original AMD Retinal image:

a. The original retinal image is cropped to select the region of interest (ROI).

b. A Region of Interest (ROI) is an area of an image, which is graphically selected from a window displaying that image. Any ROI is used as a mask o remove pixels from the image.

c. Removing pixels means setting their intensity to zero.

d. When dealing with logic operations on gray scale images pixel values are processed as string of binary numbers. The AND and OR operations are used for masking, that is for selecting sub-images in a main image.



2. Pre-processing

a) Selecting the Region of Interest (ROI):

a. The original retinal image is cropped to select the region of interest (ROI).

b. A Region of Interest (ROI) is an area of an image, which is graphically selected from a window displaying that image. Any ROI is used as a mask o remove pixels from the image.

c. Removing pixels means setting their intensity to zero.

d. When dealing with logic operations on gray scale images pixel values are processed as string of binary numbers. The AND and OR operations are used for masking, that is for selecting sub-images in a main image.

3. Detection of degenerated pixels (Particle analysis to detect non-zero pixels):

a. To detect the degenerated region (dark pixels) particle analysis is performed.

b. A particle is a contiguous region of non-zero pixels.

c. These particles are extracted from a gray scale image by thresholding the image into background and foreground states.

d. Zero- valued pixels are placed in the background state, and all non-zero valued pixels are place in the foreground. Particle analysis consists of a series of processing operations.

e. Geometric features of the degenerated area are calculated such as area, volume.

4. Measurement of degenerated pixels area (Histogram area calculation):

To calculate the total degenerated area, histogram is calculated, which gives the number of non-zero pixels and zero-pixels. The number of non-zero pixels represents the degenerated area.

5. Identification of type of eye Disease Using CNN

Input for CNN is taken from Kaggle website

https://www.kaggle.com/c/diabetic-retinopathy-detection/data

0 - No DR

1 - Mild

2 - Moderate

3 - Severe

4 - Proliferative DR

Output is - A clinician has rated the presence of diabetic retinopathy in each image on a scale of 0 to 4, according to the mentioned scale.

5 ALGORITHM USED

A. Convolutional Neural Networks (CNN):-

A CNN consists of an input and an output layer, as well as multiple hidden layers. The hidden layers of a CNN typically consist of Convolutional layers, pooling layers, fully connected layers and normalization layers. CNN will be used to train the images analytics engine for recognizing important data from images.

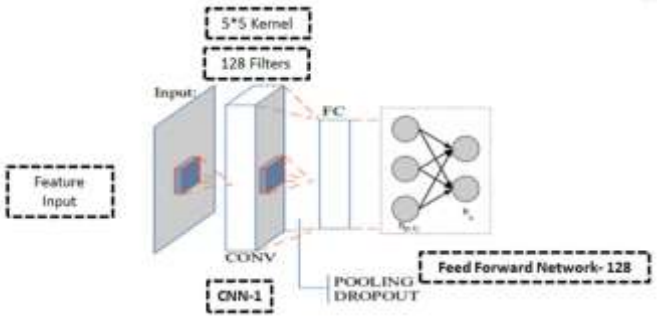


Figure: - Working of CNN

CNN is a technique that is used for classification of images. CNN is also a main part of deep learning. It stands isolated from traditional machine learning algorithms. Convolutional Neural Networks (CNN) fundamentally differentiates classes with combination of algorithms.
Following algorithm is used to train the video analytics engine for recognizing important frames in the video.
1) Accepts a volume of size W1* H1 *D1
2) Requires four hyper parameters:
a) Number of filters K
b) Their spatial extent F
c) The stride S
d) The amount of zero padding P
3) Produces a volume of size W2*H2 *D2 where:
a) W2=(W1-F+2P)/S+1
b) H2=(H1-F+2P)/S+1
With parameter sharing, it introduces F*F*D1 weights per filter, for a total of (F*F*D1)*K weights and K biases.
4) In the output volume, the d-th depth slice (of size W2 _H2) is the result of performing a valid convolution of the d-th filter over the input volume with a stride of S, and then offset by d-th bias.
5) A common setting of the hyper parameters is F=3, S=1,P=1 However, there are common conventions and rules of thumb that motivate these hyper parameters.

B. Contrast Limited Adaptive Histogram Equalization Algorithm(CLAHE):

Implementation Steps Involved in the Algorithm:
Step 1: Read the input image.
Step 2: Convert input image into gray scale image if it is color image.
Step 3: Select the control parameter K1 and K2.
Step 4: Calculate fmin and fmax. These are calculated as follows:

fmin= min(min(f)) and fmax= max(max(f)).

Step 5: Determine f=f-fmin and also Calculate f=f/fmax.
Step 6: Calculate output of modified sigmoid function.
Step 7: Output image of modified sigmoid function(i.e., o) is further passes through contrast limited adaptive histogram equalization.
Step 8: Repeat steps 6 to 7 for entire image.

IV. RESULT EVALUATIONS

A. Dataset Used

Large data set of Fundus Images from the below link is used for experimentation.

https://www.kaggle.com/c/diabetic-retinopathy-detection/data

B. Experimental Evaluation

In our proposed system we used a large dataset of the fundus image. Where accuracy and precision are calculated based on false positives images, i.e. which are items incorrectly labeled as belonging to the class and false negatives, which are items which were not labeled as belonging to the positive class but should have been.

	TP	TN	FP	FN
CLASS 0	1971	6331	26	28
CLASS 1	1129	7173	71	50
CLASS 2	1891	6411	166	148
CLASS 3	1789	6516	126	202
CLASS 4	1525	6777	75	36

Figure: Class wise Distribution of Images

We are considering 5 classes in which we have classified the DR stages i.e.
0 - No DR
1 - Mild
2 - Moderate
3 – Severe
4 – Proliferative DR
For the mentioned classes the accuracy and precision is calculated by using the below formula.

$$Precision = \frac{TP}{TP \times FP}$$

$$Recall = \frac{TP}{TP \times FN}$$

We tested the data set of 2000 images for the class 0, 2 and 3, 1200 image for class .

	ACCURACY	PRECISION	SENSITIVITY	SPECIFICITY
CLASS 0	99.35	98.7	98.6	99.59
CLASS 1	98.56	94.08	95.76	99.02
CLASS 2	96.36	91.93	92.74	97.48
CLASS 3	96.2	93.41	89.84	98.1
CLASS 4	98.68	95.31	97.69	98.91

The graphical representation of the above table is represented in following graph;

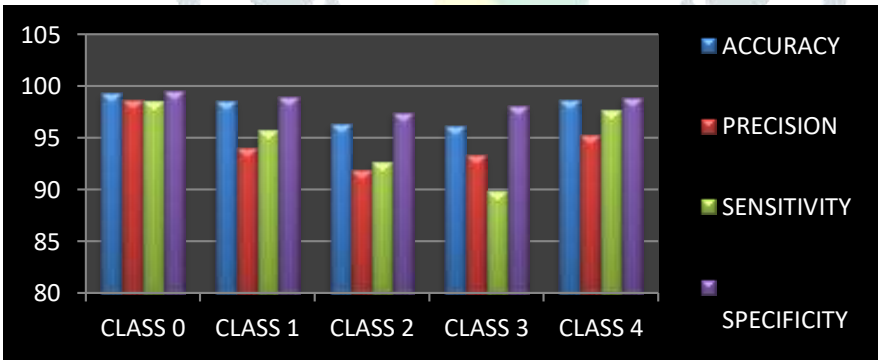


Figure: - Class wise Accuracy and Precision Comparative graph

The proposed system gives an overall 94.35% accuracy for detection of DR using CNN algorithm.

VI. CONCLUSION

The proposed framework make use of Convolutional Neural Networks (CNNs), for detection of DR with 94.35% accuracy , that have proven to be most powerful for the diagnosis of eye fundus images. The system detects groups of damaged pixels in the macula region and evaluates the total damaged area in the macula from the colour retinal images.

REFERENCES:

[1] Sudha, K. Priyanka, T. Suvathi Kannathal, S. Monisha,"Diabetic Retinopathy Detection",International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-9 Issue-4, April 2020.

[2] M.Kamaladevi , S.SnehaRupa, T.Sowmya "Automatic Detection of Diabetic Retinopathy in Large Scale Retinal images", International Journal of Pure and Applied Mathematics 2018 (IJPAM) Volume119.

[3] Prabhjot Kaur, Somsirsa Chatterjee, Dilbag Singh "Neural Network Technique for Diabetic Retinopathy Detection", International Journal of Engineering and Advanced Technology (IJEAT) 2019 Volume-8.

[4] Nikita Kashyap ,Dr. Dharmendra Kumar Singh"Mobile phone based diabetic retinopathy detection system using ANN-DWT",2017 4th IEEE Uttar Pradesh Section International Conference on Electrical, Computer and Electronics (UPCON) GLA University, Mathura, Oct 26-28, 2017.

[5] Ankita Guptaa, Rita Chhikara " Diabetic Retinopathy: Present and Past" , International Conference on Computational Intelligence and Data Science 2018 (ICCIDS).

[6] Shailesh Kumar,Basant Kumar,"Diabetic Retinopathy Detection by Extracting Area and Number of Microaneurysm from Colour Fundus Image ",February 2018 DOI:10.1109/SPIN.2018.8474264 Conference: 2018 5th International Conference on Signal Processing and Integrated Networks (SPIN).

[7] Rishab Gargeya,Theodore Leng, MD, "Automated Identification of Diabeti Retinopathy Using Deep Learning", 2017 by the American Academy of Ophthalmology 1 Published by Elsevier Inc.

[8] Gegundez-Arias, M.E., Ortega, C., Garrido, J., Ponte, B., Alvarez, F. and Marin, D., 2016, April. Inter-observer reliability and agreement study on early diagnosis of diabetic retinopathy and diabetic macular edema risk. In International Conference on Bioinformatics and Biomedical Engineering (pp. 369-379). Springer, Cham.

[9] Arisha Roy ; Debasmita Dutta ; Pratyusha Bhattacharya ; Sabarna Choudhury ,"Filter and fuzzy c means based feature extraction and classification of diabetic retinopathy using support vector machines", 2017 International Conference on Communication and Signal Processing (ICCSP).

[10] Xiyang Liu, Jiewei Jiang, Kai Zhang, Erping Long, Jiangtao Cui, Mingmin Zhu, Yingying An, Jia Zhang, Zhenzhen Liu, Zhuoling Lin, Xiaoyan Li, Jingjing Chen, Qianzhong Cao, Jing Li, Xiaohang Wu, Dongni Wang, Haotian Lin, Localization and diagnosis framework for pediatric cataracts based on slit-lamp images using deep features of a convolutional neural network, PLOS ONE — DOI:10.1371/journal.pone.0168606 March 17,2017.