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# Study of Diabetic Retinopathy Detection Using Deep Learning Techniques

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***Abstract:***

*Diabetes or Diabetes Mellitus and its complications causing major and even life threatening problems in human being life across the world. Diabetic retinopathy is one of the complications of Diabetes Mellitus which causes deficiency in human eye and can cause loss of eye vision. In recent time, its diagnosis and classification is done by using machine learning techniques with acceptable results as Computer Vision and Image Processing techniques are being used effectively and efficiently on medical images like on retina images in modern medical science. Use of machine learning algorithms and deep learning algorithms have increased enormously in the medical image analysis and processing. Deep learning techniques like Deep Neural Networks, Convolution Neural Networks have been used to Diabetic Retinopathy detection by using retina images. This article presents the study of Diabetic Retinopathy and the review of deep learning techniques used in medical imaging especially for Diabetic Retinopathy diagnosis and classification by using publically available retina image datasets.*

***Keywords:*** *Diabetic Retinopathy, Deep Learning, Deep Neural Network, Convolution Neural Network*

## I. INTRODUCTION:

Diabetes Mellitus is life threatening and rapidly growing chronic disease. As the statistics of diabetics around world is growing enormously and its pervasiveness is growing anything like black night or pandemic, its complications also creating problems in large numbers for people suffering with Diabetes. The number of diabetes affected people will touch 650 million in upcoming few

decades. Around 65 million people of India are suffering with diabetes and likely to cross 130 million by 2045 [1].

Among many diabetes complications, Diabetes Retinopathy (DR) is one of the main complications which can cause vision loss. Its asymptomatic progress causes the deficiency in human eyes or visual impairment and it may remain undetected until permanent vision loss. Diabetes Retinopathy has become one of the main causes of vision loss or blindness in South Asian countries [2].

**Diabetic Retinopathy:**

Diabetic retinopathy is one of the common and mostly occurred microvascular complications of Diabetes Mellitus. Because of it, blood vessels damage occurs and it leaks blood and fluids to the retina which causes vision loss or blurry vision or swelling. Retina screening at some interval is one way to diagnose DR at its early stages. The presence of exudates in fundus images of retina is sign of developing Diabetic Retinopathy or eye with DR. The retina image with Diabetic Retinopathy is shown in Figure 1 [25].

**Signs, Symptoms and Risk Factors of Diabetic Retinopathy:**

Blurry vision, dark spots, impairment in vision with color identification problem, fluctuation problem, night vision problem, problem while driving and reading etc. are the few signs and symptoms of Diabetic Retinopathy.

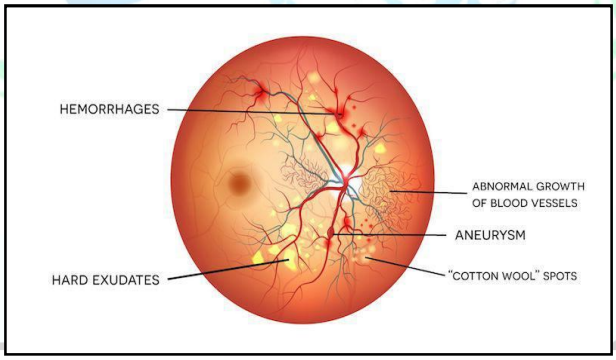


Figure 1- Diabetic Retinopathy

The prevalence of diabetes retinopathy is depended upon the diabetes types, its duration, glycemic control and the regions. Along with these, hyperglacemia, hypertension, nephropathy and dyslipidemia are the some risk factors which are associated with diabetic retinopathy. Optimizing the glycemic control, blood pressure control and serum lipid control are recommended for minimizing the risk or progression of diabetic retinopathy [2, 3].

Diabetic Retinopathy diagnosis is done with routine eye checkups with central vision testing, pupil testing, or checking eye pressures. Retina photography and fluorescein angiography can also be preferred in its detection. The ophthalmologists use color fundus images to diagnose and tre at the

DR. They may consider the features like hemorrhages, exudates (soft or hard), micro aneurysms, cotton wool spots and abnormal growth of blood vessels etc. in the process of DR detection and treatment [2, 4, 5].

**Classification of Diabetic Retinopathy:**

Diabetic Retinopathy is mainly categorized in two main stages; first is Non-proliferative Diabetic Retinopathy (NPDR) which is early stage of DR and second is Proliferative Diabetic Retinopathy which is more advanced stage of DR.

The international council of Ophthalmology has recommended Diabetic Retinopathy classification into five stages with its risk of progression. No apparent retinopathy, mild non-proliferative (Mild NPDR), moderate non-proliferative (Moderate NPDR), severe non-proliferative (Severe NPDR) and proliferative diabetic retinopathy (PDR) are the stages of Diabetic Retinopathy. These stages are shown with retina images in Figure 2a, 2b, 2c, 2d and 2e respectively [26]. Table-I shows the details of all the stages or classes of DR [2, 3, 4].

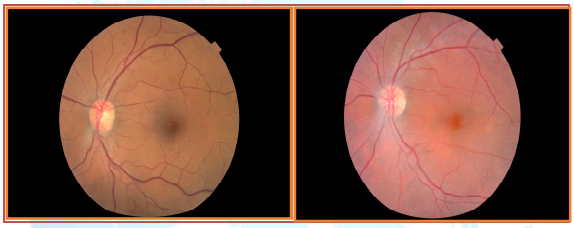

Figure 2a- No DR Figure 2b- Mild DR

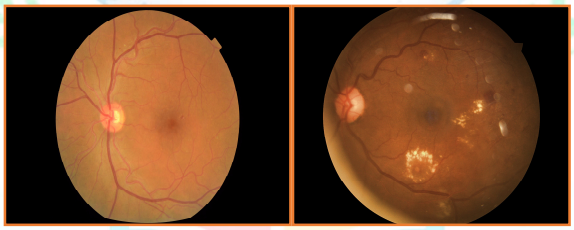

Figure 2c- Moderate DR Figure 2d- Severe DR

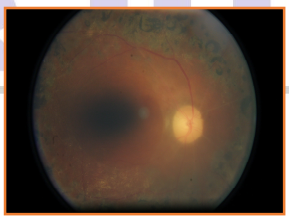

Figure 2e- Proliferative DR

**II. Machine learning techniques in medical imaging:**

Medical imaging is useful in gathering information about internal parts of human body. Once it is collected, medical processes like diagnosis, treatment and analysis become easier and these processes can be carried out efficiently. There are different ways for getting human body data in

image forms which may be depend on the body part or may be the treatment area of human body. Medical imaging has become the vital in disease assessment, confirmation and even in documentation of medical processes as it helps in early detection and diagnosis of diseases and doctors and experts use it for treatments, analysis and even in achieving the expertise in the diseases.

**TABLE-I**

| DR Class | Level | Details of DR Class |
|---|---|---|
| No apparent DR | Level 0 | Normal Retina (Healthy Eye) |
| Mild Non-proliferative DR | Level 1 | Retina with less micro aneurysms or |
| Moderate Non-proliferative DR | Level 2 | Retina with micro aneurysms or |
| Severe Non-proliferative DR | Level 3 | hemorrhages in ≥4 quadrants, or venous beading change in ≥2 |
| Proliferative DR | Level 4 | Abnormal growth of Blood vessels (Neovascularization) and |

Medical imaging is a crucial part of biological imaging and it includes radiography, magnetic resonance imaging (MRI), ultrasound, endoscopy, thermography and tomography etc. According to Zion market report, medical imaging market for products and medical applications is expected to cross the USD 48.6 billion by 2025. Developing countries like India, China, Brazil and South Africa etc. are investing more in medical imaging sector so the growth is expected and will continue globally [6].

Use of deep machine learning techniques in medical imaging has been growing rapidly as compared to traditional machine learning techniques. Traditional machine learning algorithms like support vector machine, linear-logistic regression, k-nearest neighbour etc., use raw image data for model creation, feature extraction from this image data mostly depends on experts, data variations exists while using these techniques because of data varies from person to person, location to location and experts to experts. So use of these techniques may create final model or application which may produce different results or results with comparatively less accuracies. And in the field medical

imaging, correct results with high accuracies are expected all the time [7, 8].

Deep learning algorithms like Convolution Neural Network (CNN) and Recurrent Neural Network (RNN) have shown their efficiency and usage in the field of medical especially in medical imaging as they do not require preprocessing of data in large extent or feature extraction is done smoothly. These techniques have been used in medical field for designing applications which help practitioners, doctors and experts for diagnostic purposes, designing treatment plans, timely observations, correct assessment and even in preparing documentations [8, 9, 10].

**III. Review on diabetic retinopathy detection using deep learning algorithms**

Comprehensive literature review has been done where number of research articles related to use and implementation of deep learning techniques in detection of Diabetic Retinopathy were studied and presented in brief. Extensive research work has been done for identification, detection, classification and severity measurement of Diabetic Retinopathy. Also enormous work has been carried out for same mentioned above by using many deep learning algorithms, especially for binary and multi-class classification in the process of DR diagnosis.

Dutta, Suvajit, et al. used back propagation neural network, deep neural network and convolutional neural network (VGGnet) on 1000 images of retina for retinopathy classification and they achieved 62.7%, 89.6%, 76.4% training and 42%, 86.3%, 78.3% testing accuracies respectively [11].

Li, Yung-Hui, et al. presented work for retinopathy diagnosis by proposing algorithm using deep convolutional network with fractional max pooling, support vector machine and teaching learning based optimization. They used 1000 retina images and achieved 86.17% accuracy for five class classification and 91.05% binary classification accuracy [12].

A segment level retinopathy identification using CNN is presented by Math, Laxmi and Ruksar Fatima in their work. They achieved 96.97% accuracy with 20% retina image data and 98.46% accuracy with 30% retina image data collected from Kaggle [13].

Bora, Ashish, et al. presented work for diabetic retinopathy risk assessment using deep learning. They used two datasets, one is Eye PACK, second dataset created from 13 hospitals of Thailand. In 3-field DL system produced 79% under the AUC for the internal validation dataset. With 1-field DL system produced 70% under the AUC for external validation dataset [14].

Gadekallu, Thippa Reddy, et al. presented hybrid approach with PCA-Firefly and DNN. They achieved 97% accuracy which better one as compared with DNN (96%), DNN-PCA (90.07%) and others [15].

Gulshan, Varun, et al. presented deep learning algorithm for detection of diabetic retinopathy using fundus images of retina. For detecting referable diabetic retinopathy with Eye PACS, 99.10%

area under ROC and 99% area under ROC with Messidor-2 accuracy was achieved where as 90.30% sensitivity for Eye PACS and 87% sensitivity for Messidor-2 was achieved [16].

Li, Feng, et al. presented deep transfer learning approach with Inception-v3 network for automatic detection of diabetic retinopathy using color fundus images of retina. They achieved 93.49% classification accuracy with 96.93% sensitivity and 93.45% specificity [17].

Samanta, Abhishek, et al. proposed CNN approach for retinopathy detection on small datasets. They used DENSENET121 trained on Imagenet . 0.97 was F1 score for healthy eye achieved by them [18].

The work presented in [19] used Messidor dataset with 1200 color fundus images for classification of diabetic retinopathy images and used pre-trained CNN networks like Alex Net, VGG-16 and Squeeze Net and achieved 92.38%, 93.74% and 94.47% accuracies respectively.

The work proposed at [20] used Alex Net, VGG16 and Inception Net V3 pre-trained architectures of CNN with 166 images dataset collected from Kaggle and achieved 37.43%, 50.03% and 63.23% accuracies respectively.

Gargeya Rishab, and Theodore Leng presented data driven tool based on DNN which can be used for automated DR identification. The model presented by them has achieved 0.97 AUC with a 94% and 98% sensitivity and specificity using local dataset respectively and achieved 0.94 and 0.95 AUC score, against MESSIDOR 2 and E-Ophtha datasets respectively [21].

Pratt, Harry, et al. presented the research work for Diabetic Retinopathy using CNN. The model trained with SGD and learning rate 0.0001, 0.0003 and achieved accuracy over 70% on full dataset. Finally, 75%, 95% and 30% accuracy, specificity and sensitivity respectively was achieved by the trained network [22].

The automated detection of DR using Deep CNN is presented in [23]. CNN with gradient boosting tree based classification method and CNN based classification method is used for DR classification. Hard exudates, red lesions, micro-aneurysms and blood vessels detection are the features extracted and used in the network. Finally, 89.4%, 88.7%, 86.2%, 79.1%, 91.5% and 94.5% accuracies were achieved for Hard exudates + GBM, red lesions + GBM, micro-aneurysms + GBM , blood vessels + GBM, CNN without data augmentation and CNN with data augmentation methods respectively.

Bellemo, Valentina, et al presented the research work for screening the diabetic retinopathy in Africa. They used two CNN architectures: VGGNet and ResNet. The public dataset with 4504 retina images were used in the experiment carried out by them and achieved area under curve (AUC) 0.973 with 92.25% sensitivity and 89.04% specificity for referral DR, for vision threatening DR they achieved 99.42% sensitivity and for diabetic macular oedema they achieved 97.19% sensitivity [24].

## IV. Conclusion

Automated detection at early stage of Diabetic Retinopathy and at its screening offers chances to detect, prevent and diagnose the DR and can be useful in avoiding vision loss for people suffering with it. In recent time, many researchers have added use of CNN with set of algorithms in this endeavor. The use of deep learning algorithms gives huge opportunities for the physician for interpretation, screening and drawing conclusions from the retina image datasets. This study presents the work carried out by number of researchers in this front which will help as soft tools for the practitioners, doctors and experts. Enormous work has been done for Diabetic Retinopathy detection, stages identification and its classification. Still there are opportunities to extend these practices to use live retina image datasets and to enhance the accuracies by using various deep machine learning algorithm.

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