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Analysis of Diabetic Retinopathy Diagnosis Using Learning Based Algorithm

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***Abstract*---**Diabetic Retinopathy is one of the most dangerous disease and should be identified and treated properly at the very early stage. This is usually diagnosed by scanning the interior structure of human eye with modality like optical coherence tomography and color fundus photography. Then the disease is been diagnosed manually by the respective experts which is a time-consuming process. This process should be automated so that the disease can be diagnosed in a faster and efficient way to reduce the human error. More number of researchers have been done based on automating the diagnosing of diabetic retinopathy disease using machine learning and deep learning approach. The most recent and robust techniques are been discussed in this paper.

***Keywords*---**diabetic retinopathy, deep learning, neural network.

Introduction

Human eye is one of the most essential and sensitive organs through which one can able to visualize the real world around them. The human eye can be very well compared with the camera device which operates in a similar fashion. Human eye is more special than other sensory organ since it helps the human being to understand the surrounding environment in a better way. There are some of the main components to be considered which are essentially helps in the functional operation of human eye and they are pupil, iris, retina and cornea. The pupil in the human eye can be compared with the f-stop of the camera device, the iris can also be compared with the aperture of the camera device, and operation of the

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cornea can be compared with the lens of the camera device. The disease in the eye is very common for the old age people but there are some other eye diseases which also affects the younger age people. Some of the common disease which affects the human eye are Refractive errors, Cataract, Diabetic Retinopathy, Glaucoma and Age-related macular degeneration.

Diabetic Retinopathy (DR) is one of the most dangerous eye diseases [28] which commonly occurs among the patient suffering from diabetes for a very long duration of time. This also affects the vision of the eye and even causes to the blindness of the eye. Some of the symptoms can be blurry vision, dark area spot visible in the eye region, vision getting fluctuating etc. There are two main stages or types of diabetic retinopathy and they are non-proliferative diabetic retinopathy and proliferative diabetic retinopathy. The non-proliferative diabetic retinopathy can be considered as the initial stage of the eye disease that occurred due to diabetes without controlling for longer period of time. This happens when the blood vessels inside the eye gets leaked and so the retinal area gets swell and the blood cannot able to reach the macula region. In this condition the patient can able to lose their own eye vision. Second stage is the proliferative diabetic retinopathy which is been considered as the most advanced stage of the diabetic eye disease. In this stage, new blood vessels get start growing in the retinal region. The new blood vessels formed might be bleeding and hence it may completely block the entire vision of the eye. Some of the tissue developed with new blood vessels can also detach the retinal region from the posterior region of the eye. Hence it is been considered as the most dangerous stage of the diabetic eye disease. Long term diabetic patient should be aware of such symptoms and get treatment accordingly.

Imaging modality of eye

There are two different and important modalities for scanning the eye region. They are Optical coherence tomography (OCT) and Colour Fundus imaging. These two different modalities are been described in briefly as below.

- *Optical Coherence Tomography (OCT)*
  The OCT is an imaging technology with non-invasive in nature and provides the cross-sectional retinal region in a high-resolution image quality. The OCT scan is been considered as a standard for determining the condition of retinal region. It uses some kind of light source which is not harmful to the eye while passing through it. The OCT scan can be used in multiple ways for determining the thickness of the retinal region, monitor the disease progress in the eye, determine the swelling area in the retinal region and so on. It provides sharper and high-quality clear resolution output image scan compared with other imaging technology.
- *Colour Fundus Photography*
  Colour fundus photography is another most popular imaging technology used to capture the interior surface of the human eye. It can able to capture the retinal region, fundus region, optic disc and also macula region in a high-quality resolution. The patient eye will be dilated before capturing with fundus photography. This process is done to widen the pupil region of patient so that it leads to increase in the area of observation. With the help

of colour fundus photography, the retinal region is been captured to determine any eye disease like diabetic retinopathy, age-related macular degeneration and other factors like detachment of retina.

Dataset details

There are multiple datasets been used for diabetic retinopathy detection for diagnosing the disease. Some are available as open access which can be accessed by the public for their research purpose and others cannot be accessed by public since it is privately maintained.

Table 1
Open access dataset for diabetic retinopathy

Dataset Name	Capture device	Total images	Modality type	Image format
AGAR300	45 Deg. FOV	300	Fundus	JPEG
ODIR – 2019	Fundus Camera (Canon, Zeiss)	8000	Fundus	JPEG
APTOS	DFC	5590	Fundus	PNG
OCTID	Cirrus HD, Zeiss	500 +	OCT	JPEG
JICHI DR	AFC-230 fundus camera	9939	Fundus	JPEG
DR HAGIS	TRC-NW6s	39	Fundus	JPEG
Rabbani	Heidelberg spectralis	24	OCT	TIFF
EyePacs	Centervue DRS	88702	Fundus	JPEG
MESSIDOR 1	Topcon TRC NW6	1200	Fundus	TIFF
DR 1	TRC – 50X	1077	Fundus	TIFF
DRIVE	3CCD	40	Fundus	JPEG
STARE	Topcon TRV	20	Fundus	JPEG

The Table I represent some of the open access common dataset used for diabetic retinopathy detection. There is also other dataset available in private and cannot be accessed in public.

Table 2
Private dataset for diabetic retinopathy

Dataset name	Capture device	Total images	Modality type	Image format
DriDB	Zeiss 200	50	Fundus	BMP
UoA-DR	45 Deg DFC	200	Fundus	JPEG
CSME	AFC 330	1445	Fundus	JPEG
OCTAGON	DRI OCT Triton	213	OCTA	JPEG, TIFF

OPTOS	200 Tx ultrawide	13047	Fundus	JPEG
MESSIDOR 2	Topcon TRC NW6	1748	Fundus	TIFF

The DR dataset mentioned in Table II cannot be accessed by public, but some of the dataset can be used after an agreement with the dataset owner to get their permission for usage.

Implementation approach

Deep learning approach

The approach for solving the detection of diabetic retinopathy disease is a highly computational process. But the prediction results are more robust and accurate than another traditional algorithm for diabetic retinopathy detection. Recent researchers involved in the automation of diagnosing the diabetic retinopathy disease is processed based on latest deep learning algorithm techniques. Now a day deep learning algorithms plays important role in all research areas such as metal purity prediction [30], noise removal [31], sign language understanding[32], medicine [33] and food adulteration detection [29, 34].

Wang et al [1], has proposed semi supervised multichannel generative adversarial network for detecting the diabetic retinopathy disease in an efficient way. The GAN algorithm will develop some of the sub fundus image in order to limit the labelled data and determine diabetic retinopathy from a high-resolution image. Obtains accuracy of 84.23 % in MESSIDOR dataset. Elswah et al [2], has proposed a deep learning method for diagnosing the diabetic retinopathy disease. Before feeding the input fundus image to the model, it is been pre-processed using some of the augmentation technique and intensity normalization. The pre-processed image is been sent to the Residual neural network for extracting the unique features for detecting the diabetic retinopathy disease. Achieved overall accuracy for classification is 86.67% for diagnosing DR disease.

Alver et al [3], has proposed a method for diagnosing the DR disease through a deep learning approach solution. Initially some pre-treatments were made to the input dataset for standardize them. A custom based convolutional neural network is been processed as a deep learning model to diagnose the diabetic retinopathy disease. The model trained achieved 98.5% of overall accuracy in diagnosing the diabetic retinopathy disease. Jiang et al [4], has proposed a method for diagnosing the DR disease with a multi label model for classification with the technique of Gradient weighted class activation map. The deep learning model used is a modified version of residual neural network which attains the performance metrics goal of sensitivity as 93.9% and specificity as 94.4% for diabetic retinopathy classification.

Patel et al [5], has proposed a method for faster diagnosing of diabetic retinopathy disease using the transfer learning approach for classifying five different variation of DR disease. The model used for training is pretrained MobileNetv2 with some fine tuning of parameters. The weights of some of the top layers is been fine tuned

to improve the performance and then achieved training accuracy of 91% for diagnosing the DR disease classification. Jiang et al [6], has proposed an ensemble method for diagnosing the diabetic retinopathy disease in an efficient way. Some of the image transformation-based augmentation techniques been used as a pre-processing step. To reduce the bias of the model, multiple deep learning model are integrated with the AdaBoost algorithm technique ensembled for better performance. It also describes about the weighted class activation map for determining the position of the lesion been present in the input image dataset.

Thota et al [7], has proposed a deep learning method for diagnosing the diabetic retinopathy disease using transfer learning techniques. The model training is done by using the pretrained neural network of VGG-16 for classifying the severity of the diabetic retinopathy disease. Some additional techniques like normalizing the batch, augmenting the input image data and learning rate adjustment is been carried out for improving the performance of the model to detect the DR disease with better accuracy. The performance of the model achieved for average class accuracy of 74% and the sensitivity with 80% for DR disease diagnosis.

Shankar et al [8], has proposed a method for diagnosing the diabetic retinopathy disease using a modified version of Inception v4 with automated hyperparameter tuning model for classification. Some of the pre-processing techniques like contrast limited adaptive histogram equalization is been performed to improve the model performance along with hyperparameter tuning. The experiment is carried out for MESSIDOR dataset and compared the resultant output with other methods.

Chetoui et al [9], has proposed a method for diagnosing the diabetic retinopathy disease using a deep learning architecture called EfficientNet. The aim is to detect referable DR and vision threatening DR disease. Two different dataset such as EyePACS and APTOS is been used for the study. The proposed method achieves state of the art result performing higher classification accuracy. An explainability technique is been implemented for showcasing the progress and performance of the model.

Lands et al [10], has proposed a deep learning method for diagnosing the different stages or types of diabetic retinopathy disease in an efficient way. As a pre-processing step, some of the techniques such as Gaussian blur subtraction and augmenting of image data is been performed. Two different deep learning architectures like ResNet and DenseNet is been used for training the model. The model will be deployed only after training and testing the model. The models used for training is been considered as an efficient architecture among the deep learning model. The abnormalities detected can be classified as different stages of diabetic retinopathy disease.

Shintu et al [16], has proposed ensemble based deep learning model to identify the diabetic retinopathy disease. Different neural architecture are been considered for automatically identifying and perform the grading for the diagnosis. Various variants of inception architecture is taken for diabetic retinopathy detection and other architecture like resnet and densenet are used for

grading of diabetic retinopathy. Accuracy score of 99.5 % obtained for identification and 99.6% obtained for grading method. Ensemble of multiple architecture shows robust performance in this approach.

Deepa et al [17], has proposed a method for diagnosing the diabetic retinopathy disease by comparing multiple pretrained models using deep learning algorithm. The research shows that the Xception model has given better performance than other pretrained model architecture with an accuracy of 99.3% overall score in classification of diabetic retinopathy disease in fundus images. Ramya et al [18], has proposed a method to understand the severity of the diabetic retinopathy detection disease using multi stage implementation. With modified version of Unet architecture, some important features like different stages of diabetic retinopathy are extracted and then fed into a convolutional neural network architecture to classify the severity score. This research work has got kappa score value of 0.925 for detecting the severity method in diabetic retinopathy disease.

Yash et al [19], has proposed a method for diagnosing the diabetic retinopathy disease in a robust way. Neural network architecture called inceptionv3 algorithm is used for extracting the features from the input fundus images. With the power of transfer learning the model is been used. The support vector machine algorithm is been used as a final classification technique. With this combination of a hybrid neural network the diabetic retinopathy disease is been diagnosed. Anik et al [20], has proposed a method for classifying diabetic retinopathy disease using few shot learning technique from an unbalance dataset. The researcher has done pre-processing technique to improve the performance of the algorithm such as automatic thresholding based on Otsu and histogram equalization technique. The pretrained architecture of vgg16 and alexnet is used for model classification and seems that vgg16 performs good result with deep feature exploitation. Alexnet showed improved result with batch normalization method.

Harshit et al [21], has proposed a novel method for diagnosing the diabetic retinopathy disease. As a pre-processing the image quality is been improved and evaluated. Stacked method of convolutional neural network is been used in the proposed method. With three custom weights and three sub neural network, the model gives good prediction result with accuracy score of 97.92% for binary classification of diabetic retinopathy disease.

Machine learning approach

Dharmana et al [11], has proposed a method for diagnosing the diabetic retinopathy disease using machine learning algorithm. As a pre-processing step, input image dataset size normalization and histogram equalization are been performed. Then the pre-processed image is been diagnosed for extracting the feature from the input using blob detection technique. For this, Laplacian of gaussian algorithm is been used. The extracted feature is been sent to different classifier like support vector machine and Naïve bayes. The Naïve bayes classifier produces good result than other method.

Reddy et al [12], has proposed a method for diagnosing the diabetic retinopathy disease using the ensemble techniques of different machine learning algorithms

been used. The machine learning algorithm used for this implementation are Adaboost classifier, Random Forest classifier, K-Nearest neighbour classifier, Decision tree classifier and Logistic regression classifier. As a pre-processing step, a min-max normalization method is been implemented in the entire diabetic retinopathy dataset. Then the pre-processed dataset is been fed to the different machine learning algorithm through ensemble method. The implementation prove that the ensemble machine learning model performs well and seems more robust than the other individual machine learning algorithm.

Liu et al [13], has proposed a machine learning model for diagnosing the diabetic retinopathy disease by deploying four different machine learning models. They are logistic regression, support vector machine, logistic regularized with elastic-net and XGBoost tree. This implementation yields good result by fine tuning of different hyper parameters and the good model optimization technique. The machine learning model achieve the accuracy of 82% for determining and diagnosing the diabetic retinopathy disease using machine learning method.

Narayanan et al [14], has proposed a hybrid machine learning method for diagnosing the diabetic retinopathy disease. Principal component analysis (PCA) is been used for dimensionality reduction and support vector machine is been used for classifying the detected or extracted features. With pre-processing of input images, the model achieves the accuracy of 85.7% for determining the diabetic retinopathy disease classification. Huda et al [15], has proposed a feature importance machine learning algorithm for diagnosing the diabetic retinopathy disease. The implementation extracts several features like diameter of optical disk, presence of abnormalities and so on, It uses classifier like Decision tree, Support vector machine and Logistic regression for the machine learning model prediction. The performance achieved for the proposed method receives 88% of accuracy.

Table 3
Paper based on learning model

Author	Year	Methodology	Performance Metric
Harshit et al [21]	2021	Stacked generalization of CNN	Accuracy: 97.92%
Wang et al [1]	2021	Multi-channel semi supervised GAN	Accuracy: 93.2% Sensitivity: 92.6% Specificity: 91.5%
Yash et al [19]	2021	Inception V3 and SVM	Accuracy: 98.88% Sensitivity: 97.77% Specificity: 100%
Deepa et al [17]	2021	Xception	Accuracy: 99.3%
Shintu et al [16]	2021	Inception	Accuracy: 99.5%
Saeed et al [22]	2021	ResNet	Accuracy: 99.73% Sensitivity: 96.04% Specificity: 81%
He et al [23]	2021	MobileNet with attention blocks	Accuracy: 92.1% Sensitivity: 89.2%

			Specificity: 91%
Abdelmaksoud et al [24]	2021	UNet + SVM	Accuracy: 95.1% Sensitivity: 86.1% Specificity: 86.8%
Hsieh et al [25]	2021	Inception v4	Accuracy: 90.7% Sensitivity: 92.2% Specificity: 89.5%
Thota et al [7]	2020	VGG 16	Accuracy: 74% Sensitivity: 80% Specificity: 65%
Shaban et al [26]	2020	DCNN	Accuracy: 88% Sensitivity: 87% Specificity: 94%
Pao et al [27]	2020	Custom bichannel CNN	Accuracy: 87.83% Sensitivity: 77.81% Specificity: 93.88%

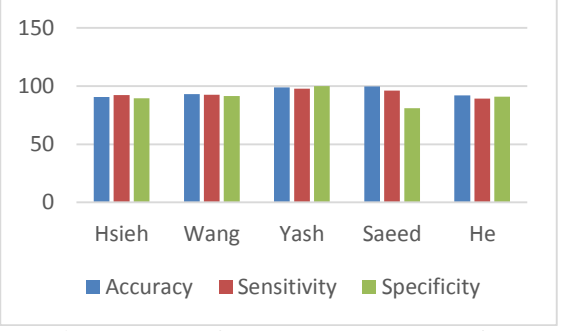

Figure 1. Performance Measure Plot

Performance metrics

Every proposed method has a evaluation metric that helps to understand the performance of the proposed model. For diagnosing diabetic retinopathy disease, there are three main performance metric is been used for evaluating the trained model by all the researchers. They are Accuracy, Sensitivity and Specificity.

Accuracy

The Accuracy is the measurement which tells the overall performance of the trained model and how good the model will work. The Accuracy metric can be calculated as in (1),

$$Accuracy = \frac{(TP+TN)}{(TP+FP+TN+FN)} \qquad (1)$$

Sensitivity

The Sensitivity is the proportion that tells how much of the patient with the disease is been diagnosed properly. The Sensitivity metric is been calculated as in (2),

$$Sensitivity = \frac{(TP)}{(TP+FN)} \quad (2)$$

Specificity

The Specificity is the proportion that tells how much of the patient without the disease is been diagnosed properly. The Specificity metric is been calculated as in (3),

$$Specificity = \frac{(TN)}{(TN+FP)} \quad (3)$$

These listed different performance metrics are more popularly used in the evaluation of trained model.

Conclusion and future work

Automating the diagnosing of diabetic retinopathy disease using various techniques are been discussed in this paper. Popular open access dataset for diabetic retinopathy is been listed. Implementation using both machine learning and deep learning techniques are been discussed. Evaluation metric for the implemented model is been captured and presented. As a future work, need to analysis all the conventional techniques that are been used for diagnosing the diabetic retinopathy disease and how it can be used efficiently by combining with the recent robust algorithms.

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