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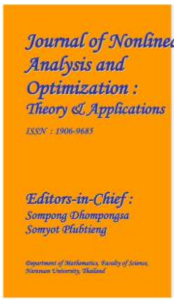

EYECHECK DIABSCAN: FEW-SHOT BRILLIANCE IN RETINOPATHY DIAGNOSIS

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***Abstract* - This project deals with the development of Diabetic Retinopathy Detection system using few-shot learning. Diabetic Retinopathy is one of the leading causes of vision loss within the age-group of 20-74, as per NEI (National Eye Institute), The United States report 2021, early detection and treatment are considered vital. NEI is a resource-based information centre related to eye health and diseases. The key focus of this project is to enhance the capabilities involved in detecting early-stage diabetic retinopathy with the help of few-shot learning technique. This proposed model can localise the required discriminative regions and work with a selective amount of data i.e., the amount of data handling will be reduced by increasing data optimization. It also allows the model to identify and trace patterns which are distinct and new within the given inputs. This model will also work with the recommendations analysis regarding economical and geographical barriers of patients. The application of Diabetic Retinopathy Detection is used in Medical & Healthcare fields. This allows us to work with the handling of risk of progression, predict treatment outcomes and reduce the effects and immediate impacts as well.**

***Keywords* – Diabetic retinopathy, Few-shot Learning, Fundus images, Machine learning, Ophthalmology, Recommendation system.**

I. INTRODUCTION

According to the American Academy of Ophthalmology the recently shared epidemics data on Diabetic Retinopathy describes the existence of the disease on the global populace as 387 million which is expected to increase to a value of 592 million by the year 2035. Based on the given report it is also concluded that the prevalence of DR is seen upto 77% in type-I and 25% in type-II diabetes. Diabetic retinopathy is a diabetic infuriated eye disease caused due to the deteriorated blood vessels in the retina resulting in blurry vision, blindness or glaucoma. It needs to be detected and treated in early stages to avoid sight threatening damages. It is an evasive microvascular issue in regard to diabetes leading midst the age group of 20-74. Hence, the need of detection of DR in the early stage arises for reducing the fatality.

This paper constitutes of several sections, the I-section gives a brief description of the project followed by II-section giving in the literature surveys conducted, III-section details the algorithm implemented in the model, IV-section showcases the results obtained, summed up with the conclusion in the V-section and future work, finishing with the final section VI designated for references.

Basic Concepts

Diabetic Retinopathy is caused due to the leading factor of diabetes known as diabetic mellitus. This diabetes infuriated eye disease is generally categorised as the second most leading cause of vision loss or blindness. DR is basically classified into two versions- i) Proliferate DR and ii)Non-Proliferate DR . According to the samples we take as Messidor dataset(Normal, Mild, Moderate and severe) or High resolution fundus images dataset(Healthy, Diabetic Retinopathy and Glaucomatous) are signified with their distinct attributes. If the DR detection is performed in the early stages, which is in non-proliferate stage leads to reduce the impact and cure with the help of either medications or laser treatment, if neglected can cause fatal issues like vision threatening diabetic retinopathy ultimately resulting blindness and vision loss. We have represented a pictorial representation of the types of Diabetic Retinopathy based on their severity for a brief understanding.

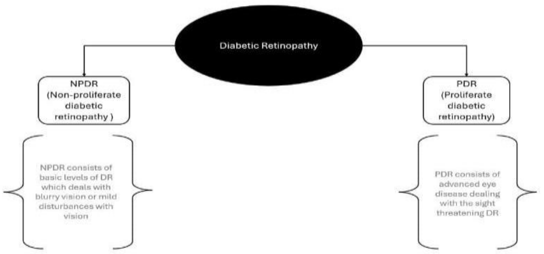

Fig.i. Types of DR

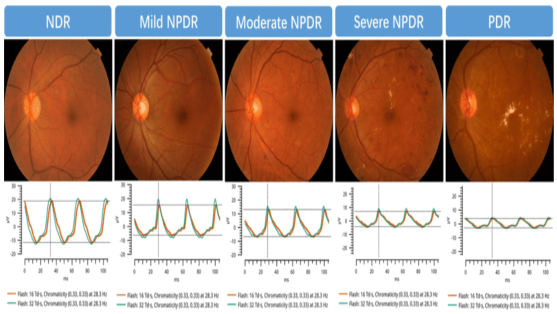

Fig.ii. Modularities in DR[1]

II. LITERATURE SURVEY

Yunlei Sun,[2] developed a model for DR diagnosis by using BNCNN model avoiding the complicated compliances of one-dimensional data by inculcating implicit data learning from disbanding artificial feature extraction.The paper describes the processing of model and diagnosis of DR along with various other diseases likewise, chronic kidney diseases, cardiovascular diseases and cerebrovascular diseases. It has achieved accuracy with the use of three models i.e, Logistic Regression, MLP and CNN with training and testing accuracies determined to LR(97.57-93.02), MLP(96.857-86.04) and CNN(99.85-97.56).

Sehrish Qummar, et.al,[3] worked on achieving the accuracy for detection of DR with the help of five deep CNN models(Resnet50, Inceptionv3, Xception, Dense121, Dense169) with respect to state-of-art models. In their paper they have clarified that they focused on accurate detection of DR at all stages and have obtained results accordingly and have improved the classification of stages ensembled in it.They have used the popular fundus image dataset from kaggle to achieve the results.

Mohammed Ghazal, et.al,[4] proposed a system to develop optical coherence tomography with the help of transfer learning in computer aided diagnostics.They have delivered the output results with two pre-trained models one of which is independently fed by nasal retina patches and the other by temporal retina patches using the CNNs. Their CAD system has achieved an accuracy of 94% .

Rubina Sarki, et.al[5] Conducted a survey on diabetic retinopathy keeping in view metrics based on the working and deployment of any model related to DR detection.These metrics are available datasets, image pre-processing techniques, deep learning models and performance evaluation metrics. They have observed the need of various inputs regarding data, algorithms to be used and have given insights regarding it likewise as in developing improvised DL models, training with minimal amount of data, similar DL architecture for image context in medical field, optimum values for DL architectures with respect to the hidden layers, or else modules in various layers and integration of various other fields like DL , telehealth and cloud computing to ease the use of analysing data correction and significant usage for the provision of input. This paper reviews a provision on state-of-art description of Diabetic Eye Disease(DED) including DR.

Adaptive fine tuned CNN model suggested by Fahman Saeed, et.al,[6] where the predefined layers of CNN model will try to model the data with local structures of lesion and normal regions wherein advancing to the fully connected DR detection system would indulge the required components basing on the global nature and domain specific traits. It outperforms the state-of-art methods by a 10 fold cross-validation steps along with the challenging datasets which are EyePACS and Messidor. This model adds to a final layer of gradient boosting-based classification. This system has developed automatic suggestions of a DR patient based on their detection to an ophthalmologist at an early stage avoiding effects and more complications. This model has adapted to work with accuracy in a specified amount of data handling to overcome overfitting and reduction in model complexity.

Suggested the VGG-NIN deep learning architecture by Zubair Khan, et.al,[7] which focuses on lowest possible learnable parameters for DR detection to improve the training and model convergence.This proposed model has resultantly performed way better in accuracy, computational resource utilisation with respect to the previously held state-of-art models. It is an extension of their work where they have built and deployed the model with ensemble approaches, and have clarified that the proposed model has surpassed the already established ensemble and non-ensemble model which they have been working with already.

Hybrid CNN-SVD Based Prominent Feature Extraction and Selection for Grading Diabetic Retinopathy Using Extreme Learning Machine Algorithm by MD. Nahiduzzaman, et.al,[8] where the paper exploits the usage of extreme learning machine(ELM) approach where the dataset is described using Ben Graham's approach, contrast limited adaptive histogram equalization (CLAHE) for contrast-enhanced images. This methodology has driven DR detection more precisely. Involving detecting DR for binary class and multiclass classification based on datasets APTOS-2019 and Messidor Dataset.

Automatic Severity Classification of Diabetic Retinopathy Based on DenseNet and Convolutional Block Attention Module developed by Mohamed M. Farag, et.al,[9] in which the model uses a single color fundus photograph(CFP). This system uses DenseNet169 for the visual embedding process, on top of which to reinforce the discriminative power they have used a convolutional block attention module (CBAM). The dataset used for this model is obtained from kaggle which is Asia Pacific Tele-Ophthalmology Society(APTOS). The network related to this model has significantly shown higher competency with respect to severity grading. It also reduces time and space complexity in autonomous diagnosis.

Hamza Mustafa, et.al,[10] worked on multi-stream deep neural networks for DR severity classification under a Boosting Framework, where the proposed model approaches to take advantage of deep networks and PCA for inter and intra-class images extracting features from raw images. These work on pre-trained architectures of deep learning like ResNet-50 and DenseNet-121 as main feature extractors for the computation of the model. Datasets used for this model are Messidor and EyePACS resulting in working with a robust and accurate detection and classification. This model has proposed a revolutionary statement declaring that with the increase of dataset size the accuracy size is also expected to increase and vice-versa.

Ghulam Ali, et.al,[11] has proposed a model where fundus images are used along with hybrid CNN inorder to attain automatic DR detection. They have used Resnet50 and Inceptionv3 models of Deep learning architecture. It is an end-to-end mechanism used as feature extraction of diabetic fundus image. Tasks such as image enhancement and data augmentation have been included to perform the proposed model.

Waleed Nazih, et.al,[12] developed the Vision Transformer Model for Predicting the Severity of Diabetic Retinopathy in Fundus Photography-Based Retina Images. In the given paper novel ViT based extension of DL with the help of a suitable dataset specifically modelled for this problem is termed as fine-grained annotated diabetic retinopathy (FGADR) dataset. The role of Vit plays a crucial role in exploring various aspects and features of retinal images used to detect DR. This model is expected to provide accurate, precise and timely decision making.

Huma Naz, et.al,[13] proposed Ensembled Deep Convolutional Generative Adversarial Network for Grading Imbalanced Diabetic Retinopathy Recognition, where synthetic images along with actual images are used against the algorithm Deep Convolutional Generative Adversarial Network

(DCGAN). This model is evaluated on EyePACS and DDR datasets. This model obtained an accuracy level of 97%, and has optimised parameters for performance enhancement. Data augmentation is a revolutionary work in this field and is specially worked with an algorithm with respect to it.

Anik Ghosh, et.al,[14] together described in their research paper the validity and existence of various CNN models with the help of few-shot learning along with the similar problem domain giving an exquisite report of the usage of various models like AlexNet and VGG16.

Minghao Yan [15] studied briefly on Adaptive Learning Knowledge Networks for Few-shot learning where the data collected is determined to be labelled with the help of this methodology, where the feature extraction helps the model to be built on a descriptive learning basis involving lesser data redundancy and allowing clear and distinct data understanding.

W. K Wong et.al,[16] deployed TL based model derived from messidor and EyePac dataset with the help of ResNet-18 along with ShuffleNet models with the help of ADE algorithm to derive the Error Correction Output Code (ECOC). This model has succeeded at achieving an accuracy of 75%, 82% and 96%.

III. METHODOLOGY

In this proposed model we have opted for **FEW-SHOT LEARNING** technique which strongly approves of giving accuracy in a limited amount of data. This is a newly emerging technique consisting of two main internal separation namely on the basis of meta learning and prototypical networks. We'll be working with meta-learning in this problem. Few- shot learning approves us to receive an accurate amount of results within a specified or regulated amount of dataset. This Algorithm can be applied to a limited amount of datasets and problems which are new and cannot have vivid data requirements. It helps to be utilized in case sensitive areas or dry regions with less data.

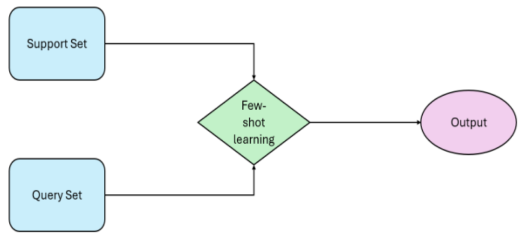

Fig.iii. Working with Few-shot technique

This refined algorithm is a part of three types of learning techniques namely (i)zero-shot learning, (ii)one-shot learning and (iii)few-shot learning. The Few-shot learning technique is also classified as N-shot learning technique as it depicts and derives regarding the amount of data required or the attributes and classes to be taken in accordance with to fulfil the the dataset requirements. It is feasible to work with few-shot learning in any real world problems as attaining huge amounts of datasets can be troublesome and it helps to overcome the same. It does not require more time and is able to adapt to new changes and modifications regarding the tasks and their usage.

The FEW-SHOT learning technique trains the model on two types of training and testing methodologies namely the support set and query set. Support set encapsulates a few samples of each attribute with their labelled data derived from a pre-trained model. The support set is used for training the model whereas the query set can be applied for training the given model. In the query set model the testing phase is done with the model. The testing phase involves allowing pre-trained model data labels along with new unlabeled data which could be deprived from previous layers of the modelled algorithm. This involves working with new and old categories of data based on the information gained from the support set.

These query and support sets help the model to be tested and trained with the given dataset, the query set helps the model to predict accurate data from the given iterative labelled data along with new patterns to check whether the before enacted layers can help build the model with accuracy and checks for any discrepancies if available. The support set embeds the data labels for the given tasks divided among them whereas in the query set the unseen data patterns and tasks are foreseen to check the efficiency of the model.

We can understand it better with the figure given below where it depicts the epochs required to train a model using meta learning followed by two major vectors involved with the algorithm i.e, the support set and query set to study the labeled data with distinct classes and a few number of examples for each class which helps the model to categorise data in a precised and clear manner.

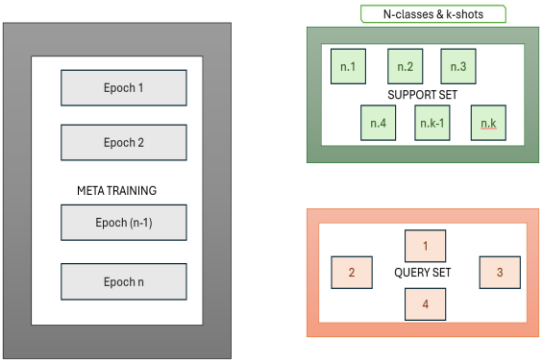

Fig.iv Query set and Support set in Meta training

This methodology provides us with distinct graphs and textual outputs. We will be generating both of them to generalise the problem more efficiently. Henceforth we have tried to represent the test and train accuracy of the given model and verify accordingly.

FRONTEND - In this model we have created a web- UI along with the detection system which gives recommendations based on the treatment analysis to achieve goals and motives for a friendly patient use. This involves database requirements involving geo-location access, consultation facilities, amenities and rating of the ophthalmologist details and feedback of previous consultants for guidance.

The model has tried to work on fast detection using limited access to any specified dataset given for easy detection and to start treatment in advance as it is very necessary to eliminate the issue and its cause in the initial stage, the treatment involves various methodologies starting from eye drops to laser treatment based on the necessity and severity in the disease. Using this algorithm we will not require a whole bunch of bulk data instead a limited amount of data will be even sufficient to work with the problem and shows positive impacts and accuracy. It mainly focuses on the image classification which is very relevant to the problem statement that we have opted for.

IV. RESULTS

In the proposed problem we have come across various similar solutions regulating state-of-art methodologies. These solutions and algorithms, built to overcome this problem of Diabetic Retinopathy Detection as its detection and treatment are often neglected in the initial stages as it might develop major vision threatening issues moving on further with it. Let us provide this with a comparison of a few such examples beginning with a fully connected CNN architecture with a Mobilenet_v2 backbone which took a precise amount of dataset equivalent to 440 images and proposed accuracy of 68%. We came across another model which is also a CNN with resnet architecture indulged in training, this model gave in an accuracy of 73% from the specified dataset.Continuing further with a CNN model followed by an application of Tensorflow to predict the expected outcomes. In this model the accuracy is calculated to be 82% which doesn't provide the ultimate results required for the modelling of the data as diabetic retinopathy detection is very sensitive within the initial stages and highly negligible compared to mild and moderate phases. We continued our model comparison with a CNN based resnet152 architecture which worked with over 100 epochs within 4 layers of training resulting in a phenomenal accuracy of 97%, this model required an excess amount of dataset to train the deep learning algorithm to obtain such a premium accuracy level. We encountered some classifications including data augmentation and data visualization supporting the algorithms like res-blocks deep neural network with an accuracy of 84%, this model has a distinct precision, f1-score, recall and support for each messidor dataset label involving mild, moderate, no_dr, proliferate and severe.

MODEL	ACCURACY
Mobilenet_v2 CNN	68%
Resnet CNN	73%
TensorFlow CNN	82%
Resnet152 CNN	97%
Few-shot Learning	98%

Table i. Comparisons

Our model has tried to achieve approximately 98% of accuracy with a restrictive amount of data which emphasizes more on the working efficacy of the algorithm. In this technique of applying meta training to few shot learning we have come across on the learning of how building and modelling each layer has given us equivalent amount of accuracy and exposure to initial state to the final state of the model i.e, each layer gets more trained based on the adaptability of the previous models. It has developed a mean dev along with the model accuracy with respect to model count and test accuracy.

In this model we have also associated transfer learning with the help of pre-training the model with both AlexNet and VGG16 on messidor dataset. Both the datasets have successfully provided an accuracy of near approx 98% in which AlexNet along with messidor dataset has yielded a result of 98.36% whereas the VGG16 model has attained an accuracy of 98.92%. Therefore, it shows astonishing results in accordance with the model.

We have trained the models with the existing AlexNet and VGG16 model which involves 80% of the overall data for training purposes and 20% of the rest used for testing which gives us distinct entities.

	AlexNet	**VGG16**
Accuracy	98.387097	98.924731
Recall	98.797909	99.024390
FScore	97.850989	98.447368
Precision	97.142857	98.000000

Table ii. Results

V. CONCLUSION AND FUTURE WORK

In this paper we have gone through the perpetual neglection of diabetic retinopathy by diabetic patients and have incorporated the need of DR detection in regular check-ups in moulding the treatment and preventive measures in the initial stages with the help of few-shot learning technique, which deploys layer by layer trained meta learning model to provide improvised detection mechanism in the procedure with limited amount of dataset. In this project we came across building a model which will be providing an advantageous amount of accuracy in detection of diabetic retinopathy within limited parameters. We would also like to add revolutionary ideology of transfer learning mechanisms to inculcate the problem on a pre-trained model to reduce complexity and involve a better accuracy to the model.

VI.REFERENCES

[1]Zeng, Yunkao & Cao, Dan & Yang, Dawei & Zhuang, Xuenan & Yu, Honghua & Hu, Yunyan & Zhang, Yan & Yang, Cheng & He, Miao & Zhang, Liang. (2020). Screening for diabetic retinopathy in diabetic patients with a mydriasis-free, full-field flicker electroretinogram recording device. Documenta Ophthalmologica. 140. 10.1007/s10633-019-09734-2.

[2]Y. Sun, "The Neural Network of One-Dimensional Convolution-An Example of the Diagnosis of Diabetic Retinopathy," in IEEE Access, vol. 7, pp. 69657-69666, 2019, doi: 10.1109/ACCESS.2019.2916922.

[3]S. Qummar et al., "A Deep Learning Ensemble Approach for Diabetic Retinopathy Detection," in IEEE Access, vol. 7, pp. 150530-150539, 2019, doi: 10.1109/ACCESS.2019.2947484.

[4]M. Ghazal, S. S. Ali, A. H. Mahmoud, A. M. Shalaby and A. El-Baz, "Accurate Detection of Non-Proliferative Diabetic Retinopathy in Optical Coherence Tomography Images Using Convolutional Neural Networks," in IEEE Access, vol. 8, pp. 34387-34397, 2020, doi: 10.1109/ACCESS.2020.2974158.

[5]R. Sarki, K. Ahmed, H. Wang and Y. Zhang, "Automatic Detection of Diabetic Eye Disease Through Deep Learning Using Fundus Images: A Survey," in *IEEE Access*, vol. 8, pp. 151133-151149, 2020, doi: 10.1109/ACCESS.2020.3015258.

[6]F. Saeed, M. Hussain and H. A. Aboalsamh, "Automatic Diabetic Retinopathy Diagnosis Using Adaptive Fine-Tuned Convolutional Neural Network," in *IEEE Access*, vol. 9, pp. 41344-41359, 2021, doi: 10.1109/ACCESS.2021.3065273.

[7]Z. Khan *et al*., "Diabetic Retinopathy Detection Using VGG-NIN a Deep Learning Architecture," in *IEEE Access*, vol. 9, pp. 61408-61416, 2021, doi: 10.1109/ACCESS.2021.3074422.

[8]M. Nahiduzzaman, M. R. Islam, S. M. R. Islam, M. O. F. Goni, M. S. Anower and K. -S. Kwak, "Hybrid CNN-SVD Based Prominent Feature Extraction and Selection for Grading Diabetic Retinopathy Using Extreme Learning Machine Algorithm," in *IEEE Access*, vol. 9, pp. 152261-152274, 2021, doi: 10.1109/ACCESS.2021.3125791.

[9]M. M. Farag, M. Fouad and A. T. Abdel-Hamid, "Automatic Severity Classification of Diabetic Retinopathy Based on DenseNet and Convolutional Block Attention Module," in *IEEE Access*, vol. 10, pp. 38299-38308, 2022, doi: 10.1109/ACCESS.2022.3165193.

[10]H. Mustafa, S. F. Ali, M. Bilal and M. S. Hanif, "Multi-Stream Deep Neural Network for Diabetic Retinopathy Severity Classification Under a Boosting Framework," in *IEEE Access*, vol. 10, pp. 113172-113183, 2022, doi: 10.1109/ACCESS.2022.3217216.

[11]G. Ali, A. Dastgir, M. W. Iqbal, M. Anwar and M. Faheem, "A Hybrid Convolutional Neural Network Model for Automatic Diabetic Retinopathy Classification From Fundus Images," in

IEEE Journal of Translational Engineering in Health and Medicine, vol. 11, pp. 341-350, 2023, doi: 10.1109/JTEHM.2023.3282104.

[12]W. Nazih, A. O. Aseeri, O. Y. Atallah and S. El-Sappagh, "Vision Transformer Model for Predicting the Severity of Diabetic Retinopathy in Fundus Photography-Based Retina Images," in *IEEE Access*, vol. 11, pp. 117546-117561, 2023, doi: 10.1109/ACCESS.2023.3326528.

[13]H. Naz *et al.*, "Ensembled Deep Convolutional Generative Adversarial Network for Grading Imbalanced Diabetic Retinopathy Recognition," in *IEEE Access*, vol. 11, pp. 120554-120568, 2023, doi: 10.1109/ACCESS.2023.3327900.

[14]A. Ghosh, A. B. M. Aowlad Hossain and S. M. Taslim Uddin Raju, "Classification of Diabetic Retinopathy Using Few-Shot Transfer Learning from Imbalanced Data," *2021 7th International Conference on Advanced Computing and Communication Systems (ICACCS)*, Coimbatore, India, 2021, pp. 78-83, doi: 10.1109/ICACCS51430.2021.9442024.

[15]M. Yan, "Adaptive Learning Knowledge Networks for Few-Shot Learning," in *IEEE Access*, vol. 7, pp. 119041-119051, 2019, doi: 10.1109/ACCESS.2019.2934694

[16]W. K. Wong, F. H. Juwono and C. Apriono, "Diabetic Retinopathy Detection and Grading: A Transfer Learning Approach Using Simultaneous Parameter Optimization and Feature-Weighted ECOC Ensemble," in *IEEE Access*, vol. 11, pp. 83004-83016, 2023, doi: 10.1109/ACCESS.2023.3301618.