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A Novel Study on Automated Diabetic Retinopathy: Detection and Grading

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Abstract:- Diabetic retinopathy (DR) is an ailment where the damage is caused to the retina because of diabetes mellitus. DR is a severe cause for blindness worldwide. Detection of DR is very prevailing nowadays as the number of patients with DR is increasing tremendously. The DR examinations done in Clinics exhibits a tremendous drawback in the low-resource availability on the grounds that there are only limited ophthalmologists, handy to consult for all patients with diabetes mellitus. The current ratio of ophthalmologist to patient is 1:1000 and it does not satisfy the requirement of ophthalmologist in the current situation. In this paper, we have rendered a comparative study of DR detection techniques to establish the outclass technique in detecting and grading diabetic retinopathy.

Keywords: Diabetic Retinopathy, Machine Learning, Deep Learning, Ensemble Learning, Transfer Learning. Convolutional Neural Network,

I. INTRODUCTION

Diabetic retinopathy (DR) is a dominant cause of blindness in humans worldwide. 80% of the people who possess diabetes mellitus for 20 years or more, have Diabetic Retinopathy [9].

Early screening of DR will slow-down the progress of this ailment [1]. The visual impairment evoked by DR can be controlled with the help of ordinary retinal fundus assessments [10]. A broad concurrence as for the advantages and cost-viability of evaluating for DR has developed among west European nations [11-13]. Diabetic Retinopathy are of two types, namely Proliferative Diabetic Retinopathy (PDR) and Non Proliferative Diabetic Retinopathy (NPDR). Out of which the Proliferative Diabetic Retinopathy or the PDR, is the most severe condition. Blood and liquid radiate from the breaks in the harmed retinal veins, and greasy material (called the exudates) get stored in the retina. This reasons for the enlargement of the retina.

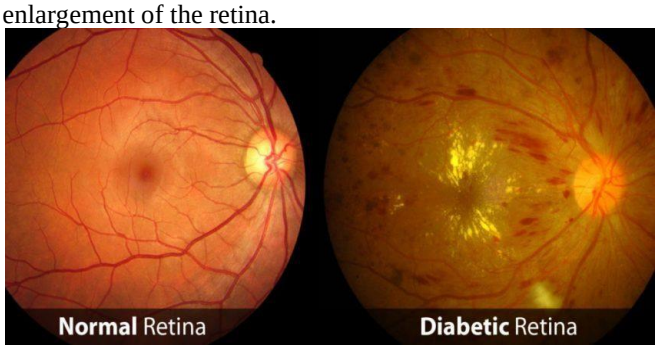

Figure 1: Healthy Eye vs DR affected Eye.

At the point when spillage happens and causes irritation in the focal aspect of the retina (the macula), it is called macular edema, and vision will be decreased or obscured. Spillage elsewhere in the retina will normally have no impact on vision. Diabetic Retinopathy if detected at an initial phase can be cured but if not, it may lead to vision loss.

NPDR doesn't lead to severe conditions. Proliferative Diabetic Retinopathy (PDR) is the growth of new blood vessels on your retina and these new blood vessels can ooze out in the eye. Automated DR detection and grading, undeviatingly distinguishes the nearness and seriousness of DR from fundus pictures. So this undertaking furnishes ophthalmologists with astuteness into the assessment process. The ordinary datasets utilized for Diabetic Retinopathy location could be retinal shading fundus photos or Fluorescein angiography fundus photos (pharmacological understudy expansion).

II. LITERATURE SURVEY

Based on the automated identification and grading system of healthcare data, the different techniques for identification and grading of Diabetic Retinopathy:

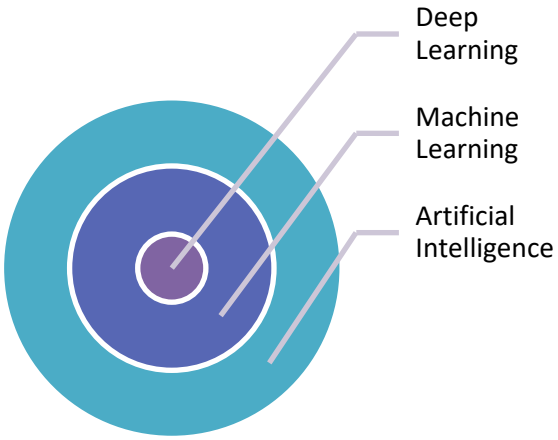

Figure 2 : AI Relationship

Deep neural networks (DNNs) are brain-inspired systems, they can naturally become familiar with various dynamic elevated level highlights or portrayals of characteristic classifications straightforwardly from unique huge information to find out an appropriated portrayal of information [1].

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Deep learning is part of a broad group of AI (ML) techniques dependent on Artificial Neural Networks (ANNs). This Learning can be of 3 types, to be specific supervised, semi-supervised or unsupervised. With respect to the quality of the spatial intelligibility of pictures, convolutional neural nets (CNNs) are more best since these are profoundly had some expertise in the reason for picture acknowledgment, investigation and grouping [1]. CNNs have given experiences into different clinical investigations. Capacities ruling those of clinical specialists, particularly when connected to skin malignancy order, bosom disease grouping, cellular breakdown in the lungs arrangement and retinopathy of rashness recognition. Convolutional Neural Networks (CNN) is the foremost well-known deep learning architecture. The latest surge of intrigued in deep learning (DL) is due to the gigantic notoriety and adequacy of conv- nets. The intrigued in CNN begun with AlexNet in 2012 and it has developed exponentially ever since. In fair three a long time, analysts advanced from 8 layer AlexNet to 152 layer ResNet.

A. Using CNN

Development of Hard exudates is a symptom for DR. So it is vital to find onerous exudates in early nursing stage. Image processing and Machine Learning techniques are used to find onerous exudates patients. Onerous exudates can be detected by using customized CNN which uses 8 layer convolutions with kernel sizes 2*2, 32, 64…256 layers. The dataset used for this model is the retinal fundus images and hard exudates are labelled corresponding to the ground truth images. The dataset have 54 images and those images are split into two, as training (40 images) and testing (14 images). The model has foretold the entire take a look at image patches with associate in nursing accuracy of 98.6%. It does not detect Soft exudates, haemorrhage and micro aneurysms. This system does not grade the severity of DR from segmented images.

B. Using Customized CNN and Decision Tree Classification

The algorithm processed colour structure pictures and classified the images as sound (DR not present) and not sound (presence of DR). For external validation MESSIDOR 2 and E-Ophtha databases are used. On 5-fold cross-validation using the local dataset, achieved an AUC of 0.97 with sensitivity of 94% and specificity of 98% [3]. While testing the above mentioned databases independently achieved an AUC score of 0.94 and 0.95 respectively [3]. This model does not consider different types of common patient metadata, such as genetic factors, patient history, diabetes history, haemoglobin A1C value, and some physical details that can lead the diseased to Diabetic retinopathy.

C. Using Convolutional Neural Network and Standard Deep Neural Network

A mechanized Diabetic Retinopathy recognizable proof and reviewing framework named DeepDR is executed. DeepDR identifies the nearness and seriousness of DR from fundus pictures utilizing move learning [7] and gathering learning [19]. Move learning utilize the information picked up while tackling one issue and applies it to an alternate yet related issue. For instance, information picked up while figuring out how to perceive vehicles can be utilized somewhat to perceive trucks as the two of them have a place with a similar class. It utilizes a lot of best in class neural systems dependent on blend of convolutional neural systems (CNNs) and tweaked standard profound neural systems (SDNNs) as in Figure 3.

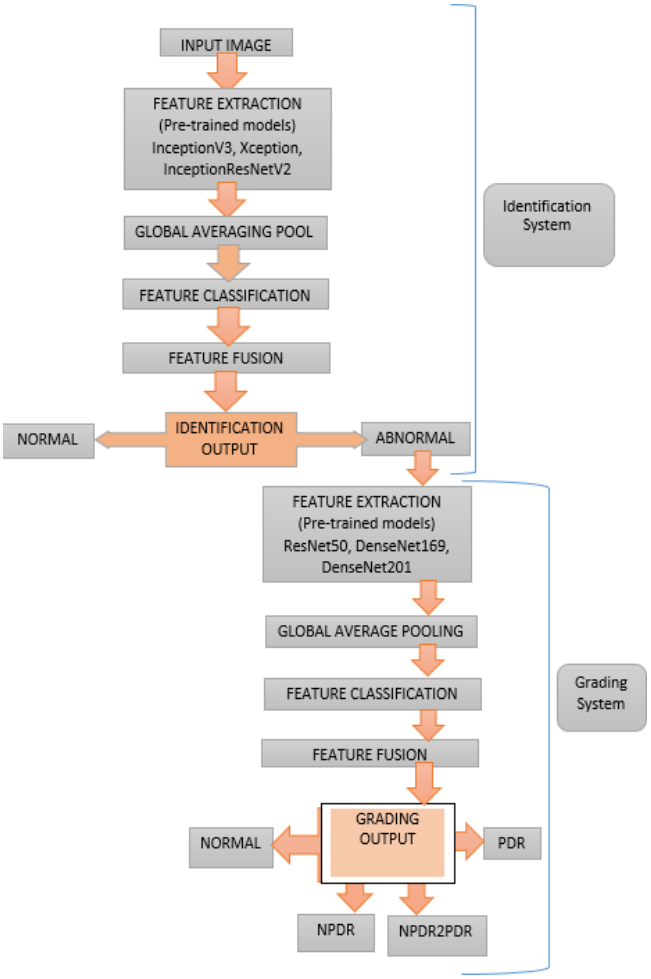

Figure 3: Diabetic Retinopathy detection using CNN and SDNN [1]

The framework is created by building an excellent dataset of DR clinical pictures and afterward marked by clinical ophthalmologists. Assessed the system on grounds of validity and reliability utilizing 9 measurements. Results show that the ID model beats best with a sensitivity of 97.5%, a specificity of 97.7% and a zone Area Under Curve (AUC) of 97.7% [1]. The reviewing model gains a sensitivity of 98.1% and a specificity of 98.9% [1].

Analysis continuations demonstrate the significance and viability of the ideal number and blend of part classifiers comparable to show execution. DeepDR furnishes reproducible and viable discovery results with high affectability and explicitness momentarily. This work give ophthalmologists with discernment in the indicative cycle [1].

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D. Using Fully Convolutional Neural Network

A deep learning model with fully convolutional neural network is developed to classify the DR, from fundus image of the victim. The proposed model comprises 6 convolutional layers which consist of rectified linear unit (ReLu) activation function and max pooling layer. As compared to the traditional CNN models, this system trains much more speedily, because of the absence of fully connected layer which can decrease the computational complexity [4]. An emblematic CNN models usually consist of the following set of layers *i.e.* convolution layer, pooling layer, rectified linear units (ReLUs) and fully connected layer. Its main dominance is that is learns the features and classifier weights directly from the image data i.e. the features need not be fed to the model (manual feature extraction). The architecture of the CNN confide on the types and numbers of layers used in the network. The ReLU layer alter any input value less than zero, to zero without changing the size of input. The pooling layers reduce the number of parameters to be learned *i.e.* used for down sampling. Max pooling or average pooling are used principally. Dropout Layer is a technique used to reduce over-fitting. Decisively, softmax layer is used as layer for the output layer activation function for classification. The considerable detriment of fully-connected layer is that it procrastinate the training operation process due to revision of rules while updating from that of convolution layer. The dataset used for this model is HRF dataset which contains fundus images of healthy person, DR Patient and glaucoma patient with 15 images respectively from each class. Training and testing dataset is split into 50:50 ratios. As an added advantage no feature extraction method is used. An accuracy of 91.66% is attained.

E. Using SVM, Decision Tree (in order to compare SVM)

The paper classifies the disease into 2 classes *i.e.* it has been splintered into two sections: DR detection and grading. Efficient algorithms for the recognition of veins, micro-aneurysms, the optic-disc, and burdensome exudates are bestowed. The proposed highlights show an extraordinary potential for DRNP detection and grading. Support Vector Machine can recognize DRNP with a sensibility of 95% [5], while DRNP can be characterized with a normal accuracy of 85% [5]. SVM reliably shows preferable result over other AI calculations. It doesn't distinguish delicate exudates, other than hard exudates, and the use of surface examination (regardless of whether it is smooth, or has a few knocks, and so forth.) so as to improve precision and reasonableness of the DR detector.[1]

F. Using Artificial Neural Network

Fundus pictures procured from fundus camera are frequently blemished, as a rule are in low difference and hazy. This causes trouble in precisely classifying diabetic retinopathy disease. This examination is based on classification of retinal fundus image and methods like artificial neural network (ANN) ,to be specific Multi-layered Perceptron (MLP) trained by Levenberg-Marquardt (LM) and Bayesian Regularization (BR) to group the data.19 features have been acquired from retinal fundus image and these are used as the input for neural network, for classification. Various quantities of shrouded hubs are utilized for analyzing. MLP trained with Bayesian Regulation provides a far outstrip classification performance with 72.11% for training and for testing, 67.47% as compared to the work of luminous flux unit [6]. This finding demonstrates the chance of using BR for other fake neural system model.

G. Detection of DR based on Transfer Learning

The long-established manual characterization strategy requires information and time. So it is hard to get a goal and incorporated clinical analysis. So proposes a method for diabetic retinopathy recognition which is incorporated with transfer learning [7]. The dataset is downloaded from Kaggle's legitimate site, at that point performs information improvement strategies which incorporate information enhancement, flipping, collapsing, and contrast modification. At that point, utilized pre-prepared model, for example, VGG19, InceptionV3, Resnet50,etc. Once in the past, every one of the neural systems has been prepared by ImageNet dataset. At that point immigrate the DR pictures to those models. Unavoidably, the pictures are fragmented into 5 sorts, by the conscious level of diabetic retinopathy. This paper actualizes a technique for relocation learning (move learning) by Keras worked in model. The test results shows that the characterization exactness of this strategy at 0.60, which is superior to the conventional direct preparing technique and has improved robustness [7].

H. Using Particle Swarm Optimization and Neural Network

This paper adopts the techniques like the ensemble learning which uses the machine learning classifiers. Forthwith, there are disparate doctors who faces dispute in managing early location for diabetic retinopathy. This happen in light of the fact that it is hard to perceive the early indications of this illness. All together for this illness to be recognized early, an exact grouping technique is required. Information mining idea is one option in overseeing arrangement. This investigation was conducted by applying particle swarm optimization (PSO) strategy to choose the best Diabetic Retinopathy highlight dependent on diabetic retinopathy dataset [8]. At that point, the chose include is additionally characterized utilizing grouping technique for neural system. The result display that there is an expansion in result by applying neural system based particle swarm optimization (PSO) of 76.11% [8]. By applying neural system alone, the characterization result is 71.76% and when including highlight choice with neural system there is an expansion of 4.35% [8].

I. Using Ensemble learning approach

DR has quintuple stages: normal, mild, moderate, severe and PDR. Massively trained specialists look at the loured fundus pictures to analyze this deadly ailment. Modest determination of this condition, by clinicians is

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monotonous and blunder inclined. So various automated vision-based methods have been portrayed to consequently distinguish DR and its various phases from retinal pictures. Withal, these strategies can't encode the fundamental ardous includes and can just arrange DR's exceptional stages with low exactness especially, for the beginning phases. Kaggle dataset of retina pictures was utilized to prepare an outfit of quinary profound Convolution Neural Network (CNN) models (Resnet50, Inceptionv3, Xception, Dense121, Dense169) to encode the rich lineaments and patch up the characterization for unique phases of DR [19]. The test result show that the proposed model distinguishes all the phases of DR dissimilar to the current techniques and performs outperforming contrasted with best in class strategies on the equivalent Kaggle dataset.

J. Using weighted path for convolutional neural network

In this paper, an unused strategy, which incorporates various weighted ways into convolutional neural system, called the WP-CNN, prodded by the outfit learning. In WP-CNN, diverse way weight coefficients are improved by back proliferation, and the yield features are discovered the center estimation of excess diminishment and speedy intermingling. The trial results show that with the productive preparing intermingling rate WP-CNN accomplishes a precision of 94.23% with affectability of 90.94%, explicitness of 95.74%, a zone under the beneficiary working bend of 0.9823 and F1-score of 0.9087[24]. By exploiting the multipath instrument, the proposed WP-CNN had all the earmarks of being exact and convincing for referable DR recognizing proof contrasted with the condition of-workmanship computations. In this paper, the weighted way component procures all the highlights and joins it with different open fields secures all the highlights and consolidates it with different responsive fields.

K. Using soft margin SVM

Diabetic retinopathy could be a retinal contamination brought about by diabetes mellitus. Earnestness of diabetic retinopathy may prompt visual lack (Blindness). One of diabetic retinopathy signs is the nearness of hard exudates. So hard exudates in retinal fundus pictures are used to order the moderate and serious non-proliferative diabetic retinopathy (NPDR). The hard exudates are divided using logical morphology and the removed features are arranged by using delicate edge SVM. The order result achieves exactness of 90.54% for 75 preparing information and 74 testing information of retinal pictures [25].

L. Based on Area and Number of Micro aneurysm extracted from Colour Fundus Image using SVM

Extemporized diabetic retinopathy location by removing exact area and number of miniaturized scale aneurysm from shading fundus pictures has been introduced in this paper.

Standard screening of eye is significant for identifying and making do with diabetic retinopathy. Diabetic retinopathy (DR) is an eye malady which occurs because of, the mischief of retina because of long disease of diabetic mellitus. Miniaturized scale aneurysms (MA) are minimal rosy spots on retina, framed by exploding out of fragile bit of the veins. An arrangement of methodologies have been proposed for area and assurance of DR.

In this paper, there are two features explicitly; number and zone of MA have been chosen [22]. From the start, pre-preparing techniques like green channel extraction, histogram evening out and morphological handle have been used. For disclosure of small scale aneurysms, Principal Component Analysis (PCA), contrast restricted Adaptive Histogram Equalization (CLAHE), morphological cycle, averaging filtering have been used. Grouping of DR has been finished by straight Support vector machine (SVM). It yields a sensitivity of 96% [22] and specificity of 92% [22] exclusively.

M. Symptom Analysis of Diabetic Retinopathy by Micro aneurysm Detection Using NPRTOOL

Diabetic retinopathy is known to be an unsafe eye illness which can cause vision misfortune or visual impairment in the long run. As of late, this illness has spread hazardously among individuals who are enduring from diabetes. In this paper, a diabetic retinopathy identification technique has been proposed by utilizing fundus image from the retina of the patient [23]. This strategy includes advanced digital image processing on fundus image. Fig.4 depicts the architecture of this model.

Diabetic retinopathy is known to be a dangerous eye ailment which can cause vision mishap or visual disability over the long haul. Starting late, this disease has spread perilously among people who are suffering from diabetes. In this paper, a diabetic retinopathy ID procedure has been proposed by using fundus picture from the retina of the patient [23]. This procedure incorporates progressed computerized picture preparing on fundus picture. Fig. 4 delineates the design of this model. Small scale aneurysm, which is considered as the underlying phase of diabetic retinopathy has been examined using MATLAB Neural Network Pattern Recognition Tool (NPRTOOL).

The proposed technique has been contrasted with two other existing procedures Naive Bayes strategy and SVM classifier strategy [23]. NPRTOOL has been used for estimation and exploratory work. The proposed technique has an affectability of 61.6%.And precision of 26.3% with NPRTOOL. Basic progression has been found regarding affectability and precision contrasted with the recently referenced existing techniques. Micro-aneurysm, which is considered as the initial stage of diabetic retinopathy has been analysed utilizing MATLAB Neural Network Pattern Recognition Tool (NPRTOOL).

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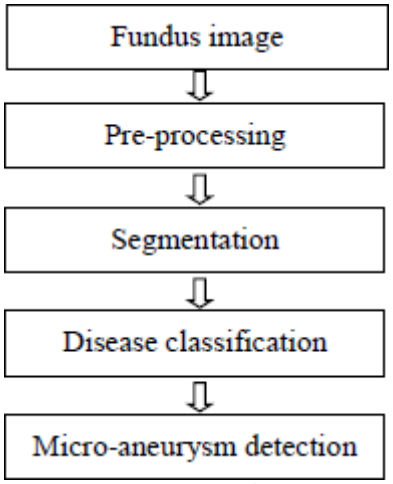

Figure 4: Block Diagram of proposed system

The proposed strategy has been compared to two other existing strategies- Naive Bayes method and SVM classifier method [23]. NPRTOOL has been utilized for calculation and experimental work. The proposed method has a sensitivity of 61.6%.And accuracy of 26.3% with NPRTOOL. Critical advancement has been found in terms of sensitivity and accuracy compared to the previously mentioned existing methods.

III. CONCLUSION

In this paper, we have compared and rendered various machine learning models, deep learning models, transfer learning technique, ensemble learning technique for detecting and grading Diabetic- Retinopathy. The classification of Diabetic- Retinopathy using machine learning algorithms, does not cause any overhead. But the identification and grading of DR is tedious and time consuming, especially for a large data. So the ensemble learning and transfer learning techniques supports DR detection and grading to a large extent. Identification and grading of DR outperforms with deep neural networks. From the review rendered, a system with a Learning technique (Transfer Learning, Ensemble Learning) and combination of deep neural network (CNN, SDNN) yields a surpass result with a sensitivity of 97.5%, a specificity of 97.7%, an area under the curve (AUC) of 97.7% for the identification system & attains a sensitivity of 98.1%, specificity of 98.9% for the grading system.

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