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Automatic Diabetic Retinopathy Detection

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Abstract - *Diabetic retinopathy is a disease generally found in diabetic patients that distresses eyes. When damage to the blood vessels of the light-sensitive tissue happens at the back of the eye then this disease occurs. In the beginning, this diabetic retinopathy disease may show no symptoms or only little problems in the vision. But with time it can also cause complete blindness. This situation can be developed in anyone who is patient of diabetes. This eye complication gets increased to the time you have diabetes and inversely proportional to the level of controlled blood sugar. The detection of DR is the application of image processing in the field of medicals. In order to diagnose the DR, we have to evaluate the retinal images. This is though, time taking and require lot of resource to physically evaluate the images so that the seriousness of DR can be cleared. This problem can be noticed only when the tiny blood vessels which are present inside the retina gets damaged. When from these tiny blood vessels, the blood starts flowing then the fluid will form the features that take place on the retina. There are three phases involved in the diabetes retinopathy detection technique. And these three phases are pre- processing, segmentation and classification. In this work, we have used the NN approach for the classifying the diabetic portion from the given images.*

***Key Words*: Diabetic retinopathy, fundus photography, lesions, haemorrhages, neural network**

1. INTRODUCTION

There are various parameters that affects the condition of human eyes. These parameters are diabetes, blood glucose, etc. It is consisting of retinopathy, edemas, cataracts, and many others. First of all, diabetic retinopathy, that is also known as the eye disease caused by diabetes, is a medical condition in which damage occurs to the retina of eye due to the diabetes mellitus. Diabetic retinopathy is a primary cause of blindness among people in most of the developed countries. It is found that if anyone have diabetes for 20 years or more then there are chances of up to 80 percent that they can have diabetic retinopathy. If proper treatment and monitoring can be provided to the diabetic patients then we can reduce at least 90% of new cases. The chances of developing diabetic retinopathy in a person is directly proportional to the time he or she had diabetes. Each year in the United States, it is observed that 12% of all new diabetic retinopathy cases is of blindness. Among people aged between 20 to 64 it is the leading cause of blindness. Generally diabetic retinopathy shows no early warning symptoms.

Similarly, it is found that the macular edema also does not show any symptoms in the beginning, which can cause rapid vision loss. It is observed that a person having macular edema is likely to have blurred vision which lead to difficulty in doing things like read or drive. However, in few cases, during the daytime vision can get better or worse.

The very first stage of diabetic retinopathy, known as non-proliferative diabetic retinopathy (NPDR), has no signs showing DR. It is found during the observation that patients may not notice the symptoms and may also have 20/20 eye-sight. Fundus photography is the only method to detect NPDR. In this microaneurysms can be seen. If fluorescein angiograph is showing narrow or blocked retinal blood vessels clearly, then there is reduced vision.

In an observation it is found that at any stage of NPDR Macular edema can happens due to which blood vessels outflow their contents into the macular region. Blurred vision and darkened or distorted images are the symptoms of it. Due to which images are not the same in both eyes. It is observed that vision loss associated to macular edema can be found in ten percent (10%) of diabetic patients. The areas of retinal thickening because of collection of fluid from macular edema can be shown in Optical Coherence Tomography.

In the next stage i.e. second stage, at the back of the eye abnormal new blood vessels (neovascularisation) are formed as the part of proliferative diabetic retinopathy (PDR); these abnormal new blood vessels can burst out bleed and blur the vision, as these new blood vessels are very delicate. It may not be very painful at the first time when this bleeding occurs. It is observed that in most cases, they just leave few specks of blood, or may be spots floating inside a person's visual field. Though these spots can go away within few hours.

After these spots formation it has been seen that within a few days or weeks a heavy leakage of blood takes place and this can lead to vision blur. If the condition is very much better even then a person may only be able to tell light from dark in that eye. It can take few days to months or even years to blood to clear from the inside of the eye, and also it is found that in some cases it did not clear. The chances of happening of these types of large hemorrhages is during sleep time.

(a) (b)

Fig -1 (a) Normal_Vision. (b) The same image with diabetic retinopathy.

2. LITERATURE SURVEY

In this field, lots of work has been done. Since 1982, studies related to the detection of features such as exudates and blood vessels on fundus images have been done In order to diagnose the DR we have to evaluate the retinal images. This is though, time taking and require lot of resource to physically evaluate the images so that the seriousness of DR can be cleared.

Niemeijer et.al.,(2010) [1] describe the recognition of microaneurysms in digital color fundus snapshot that is considered to be a very serious form of detection for automated viewing of diabetic retinopathy. To complete the process of recognition, frequent mechanisms are available in the global microaneurysm recognition for Retinopathy Online Challenge. The results have been compared with the various sets to produce a similar set of data for further evaluation. The evaluation is performed with consistent behavior for the data set in the training images.

Jaafar et al. [2] proposed an automated algorithm, which mainly consist of two part: the top-down segmentation to segment the exudates legion and a polar coordinate system centered at the fovea to grade the severity of hard exudates. Based on a small dataset of 236 fundus images, it reaches a sensitivity of 93.2%.

Pardeep Singh Sodhu and Kirtu Khatkar., (2014) [3] proposed a method using color fundus images to detect diabetic retinopathy. Using Image processing techniques, the features from raw images after extracting are then fed into Support Vector Machine (SVM) using Fuzzy C-means clustering. [4] This Fuzzy C-Means Clustering is a combination of _SVM technique and pre-processing to improve the blood vessels and optic disk detection.

Diabetic retinopathy is analyzed and removed with the help of hybrid approach.

In diabetic retinopathy retina got scratched due to some blood vessels from which fluid leaks into the retina. For diabetic retinopathy the preliminary indication is the existence of hemorrhages. Parisut Jitpakdee., et. al., [5] overview the techniques, algorithms, and methodologies used for the discovery of hemorrhage from diabetic retinopathy retinal images.

3. DETECTION OF EXUDATES IN DIABETIC RETINOPATHY

Anitha Somasundari and Janardhana Prabhu., (2013) [6] suggested an algorithm to detect and confine the presence of exudates from low distinction digital images collected from patients having diabetic retinopathy. [7] To segment exudates in the retinal fundus images, retinal fundus images are pre-processed and Mask Technique and Score Computation Technique are used. This procedure helps in early detection of disease as it can detect exudates in less time. A system known as Eye Art has revealed_potential in beforehand studies. [8] This system was used at 15 different medical locations to screen 893 patients with diabetes. Licensed graders then revised the results for clinical accuracy.

At present, it is efficient in precisely uncovering diabetic retinopathy 95.5 % of the times.

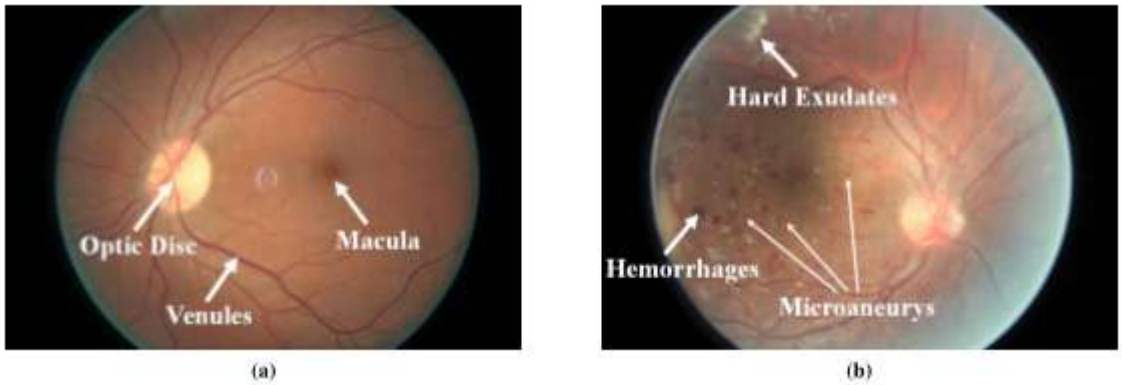

Fig -2: Typical _fundus photos. (a) Photograph of fine fundus, indicating the ordinary optic disk, venules and macula. (b) Photograph of fundus with serious DR, in which three normal sores (hemorrhages, microaneurysms and hard exudates) are brought up [9].

4. PROPOSED WORK

This work depends on the diabetes retinopathy detection. The diabetes retinopathy detection has the different stages which are the image pre-processing, segmentation, feature extraction and classification [10]. Various stages are described below: -

4.1 Data Pre-Processing

In preprocessing technique, the raw records are converted into useful and significant format. In this phase, the input image wherein diabetic retinopathy must be detected is taken in the RGB format which is then converted into the grey scale format. The grey scale image is then more processed for the detection.

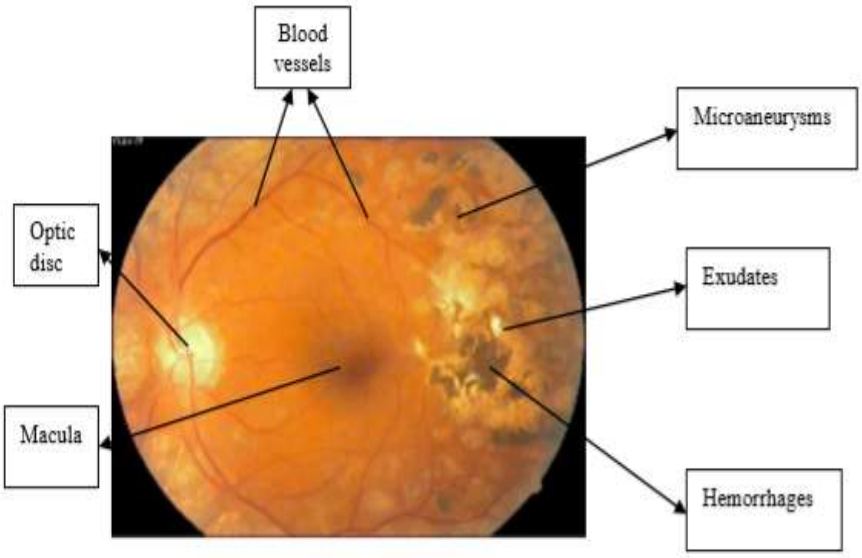

Fig -3: Various lesions of retina

4.2 Optical Disk Segmentation

The optic disc is the intense yellowish or white area in the colored fundus images. Exudates have excessive and comparable intensity values as the optic disc. Therefore, it is very important to remove optic disc from the retinal image. For masking and removal of this brighter optic disc, region properties and area identification are used. After preprocessing edge detection algorithm is applied to detect optic disc and blood vessels. The counter detection is performed using canny edge detection algorithm [11]. All the local maxima referred to as the gradient is preserved for enhancing the blurred edges by the means of the canny edge detection algorithm.

4.3 Blood Vessel Extraction

This is because of the way that their concentration levels are alike. Dilation operation is applied on the intensity image to put off the high ranges of contrasts vessels. And dilation also then used to fill the small gaps existing within the images

alongside with the help_of structuring_ element. The optical disc and blood vessels are eliminated here using the flat disc shaped structure [10].

4.4 Classification

It is a datamining feature that assigns objects in a group to goal categories or classes. The goal of classification is to efficiently predict the goal class for each case within the information. The last stage is the classification phase which is implemented with the Neural networks. [10] The NN method is the unsupervised method for the diabetes retinopathy detection. Depending on the input image's color features, training set is organized. The system is trained till error gets minimized within the network. System is taken into account as most skilled at a stage where it gets minimum error. The test image is then used as input for diabetes retinopathy detection. The test image are going to be matched with the training image and it generate very last classified image.

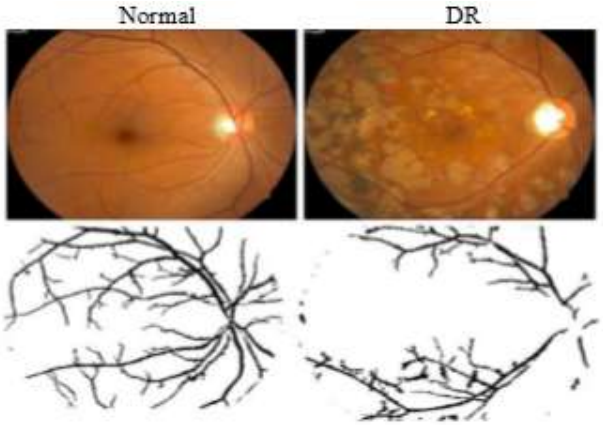

Fig -4: Normal retina and retina having_DR

5. RESULT

5.1 DATA SET

The images are used as the dataset in our work, EyePACS organized this competition on Kaggle platform [10] and provided the dataset which includes 35126 high-resolution fundus photographs taken under a range of imaging conditions. Fundus photographs are labeled clinician with a scale of 0 to 4 which depend on the seriousness of DR, by the trained clinicians. The 5_classes of DR and their individual extent are appeared in Table 1. According to the International Clinical Diabetic Retinopathy Scale [11], defined PDR as the presence of moderate and worse DR and/or referable diabetic macular edema. "Without PDR" is classified as 0 and 1. The other labels exhibit the severity of PDR in a growing order. Table 2 represents the organization of relabeled dataset. The problem of category imbalance can be seen in the dataset. In order to reduce this problem, the groups of binocular fundus images are created into 4_bunches_in_pairs: PDR in both eyes, both eyes are without, PDR only in left _eye and PDR only on right eye. Then training set stores the 80% images in each bunch and test set will contain the remaining 20% of each bunch, this guarantees the similar extent of images with various labels in both training set and test set [9].

Table -1: The original data

Label	Class	Number	0.5"
0	No DR	25810	73.5%
1	Mild	2443	6.9%
2	Moderate	5292	15.1%
3	Severe	873	2.5%
4	Proliferative DR	708	2.0%

Table -1: The relabeled data

Label	Class	Number	Percentage
0	No DR	28253	80.4%
1	RDR	6873	19.6%

5.2 PRE-PROCESSING AND AUGMENTATION

We have two instances of the unprocessed fundus images, along with the corresponding processed image obtained after pre-processing and augmentation as given in Fig.5.The of fundus zone Fig.5(c) is of good quality, but the fundus zone in Fig. 5(a) is insufficient and there is some dazzle around its edges. The next process is the clipping of the borderline region of fundus image in Fig.5(a), as it removes the artifacts and the full circle is obtained in left over fundus region shown in Fig.5(b). Apart from this, the fundus area in Fig.5(b) is revolved around by a small angle and Fig.5(b) is upturned compared with Fig.5(a). The revolving including flipping, developed from augmentation, are carried out randomly on fundus images. It is clear from the Fig.5(b) and Fig. 5(d), that fundus regions are normalized to be circular areas to have a equal size, containing the optic disk, macula and main vessels. Additionally, the color surrounding retina is blanched, while the features are emphasized. Features are hard exudates, hemorrhages, venules etc.

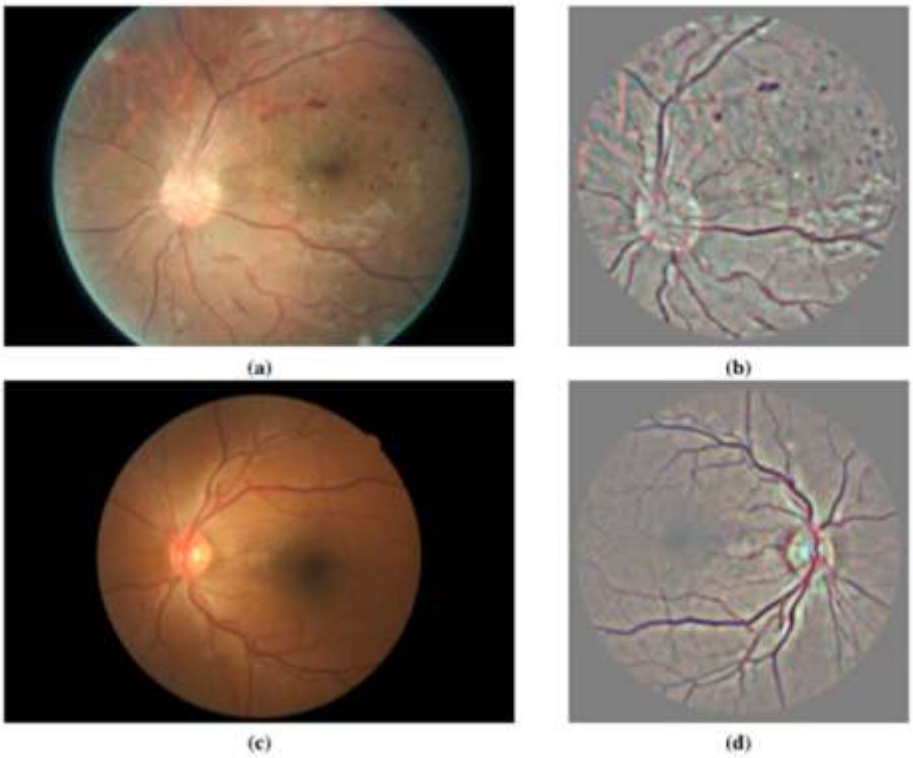

Fig -5 Instances of original fundus images and the respective processed images. (a), (c) Original images. (b), (d) Processed images.

6. EVALUATION

NVIDIA GeForce GTX1080TI graphics cards are used here for the training of the presented binocular model for Diabetic Retinopathy detection, and alike model for the classification of DR into 5 stages. They are evaluated with different metrics in the following two subsections. It is to be pointed out that binocular model is based on the fundus images of both eyes and paired fundus images are sent into the network for training and evaluation. The training of the presented model took more than 24 hours. The comparison between monocular_inception_V3 model and the presented model using transfer learning method [12]. The potential of the best versions of the compared models is evaluated by the Area Under the receiver operating Curve (AUC). The results of the binary classification model typically have probability values from 0 to

1. This is noted that "If different thresholds are selected, classification results will be contrasting, this will result in the model having district sensitivities and specificities" [9].

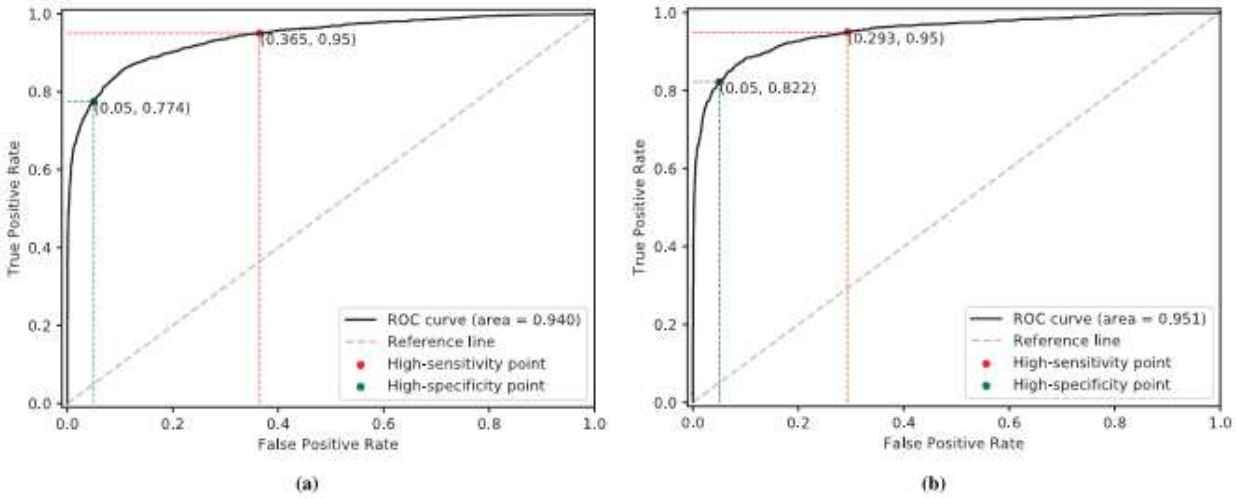

Fig -6: Receiver Operating Curve.

This is to be noted that sensitivity is true positive rate and specificity is false positive rate numerically it is 1. The reference line is shown as the gray dotted line, it is denoting the ROC with an AUC of 0.5 emerged from random guessing. (a) ROC of monocular_Inception_V3_model, 77.4% sensitivity when high specificity operating point and a specificity of 63.5% when high sensitivity operating point. (b) ROC of presented binocular model, 82.2% sensitivity when high specificity operating point and a specificity of 70.7% when high sensitivity operating point.

The classification model is better to the extent of the curve closer to the top left corner and AUC value near to 1. As shown in Fig.6(a) and Fig.6(b) respectively, 0.940 is the AUC of monocular model and 0.951 is the AUC of the presented model. To compare the performance of two models in detail, two operating points on the ROC are selected with reference to [9]. As interpreted in the Fig.6(a) and Fig.6(b), for the high specificity operating points, 0.80 is the sensitivity of presented model whereas 77.4% is the sensitivity of monocular model. For the high-sensitivity operating points, 82.2% is the specificity of presented model whereas 70.7% is the specificity of monocular model. It demonstrates that presented binocular model achieves higher performance than monocular_Inception_V3_model on both operating points, this manner we found that binocular model has greater performance in clinical application.

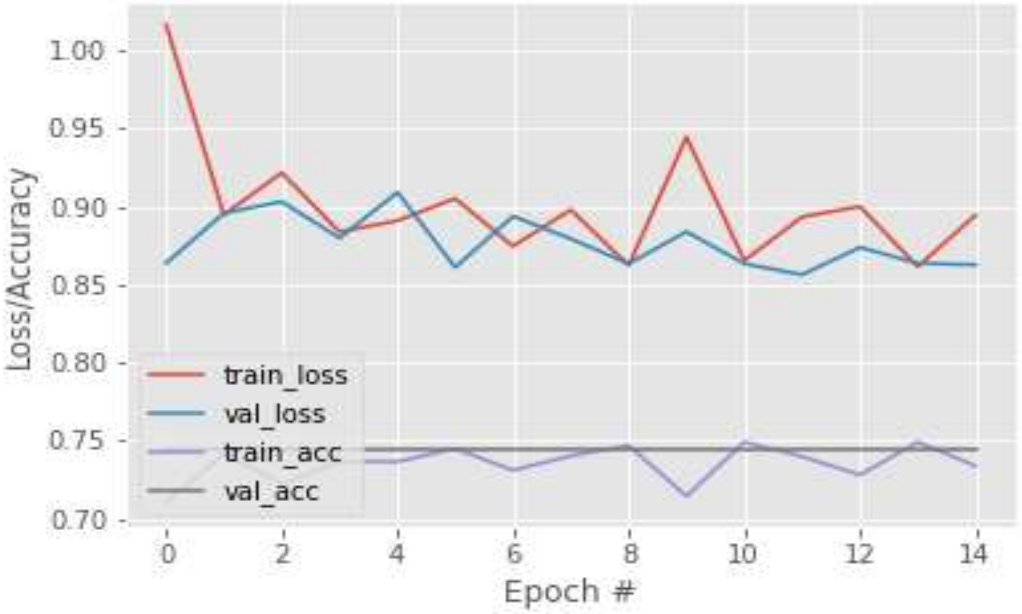

Fig -7: Plot between loss and epoch

7. CONCLUSIONS

Novel CNN model is being used to detect RDR automatically based on the deep learning method. The model presented has a Siamese like architecture, it takes binocular fundus images as inputs and the possibility of RDR for each eye is given by utilizing the physiological and pathological correlation of both eyes. The outcome of evaluation indicate that high performance is achieved by binocular model with an AUC of 0.951 and a sensitivity of 82.2% on the high specificity operating point and a specificity of 70.7% on the high sensitivity operating point, which outshines than existing monocular model based on Inception_V3 network [9].

Moreover, the modifications can be done on the presented binocular model and can be applied to the auto-detection of other ophthalmic diseases in a jiffy. But there is still much space for presented model to get improvement. For example, the training and testing with the dataset in which paired fundus images are unavailable is difficult in the presented binocular model. Some proceedings will be assessed in the hereinafter work, e.g., model to recognize a pair of fundus images from the same patient, and if single fundus image is available then using an evenly shaped image replacing the missing image.

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