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A Deep Learning Based Diabetic Retinopathy Detection from Retinal Images

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***Abstract*— Diabetes is increased tremendously due to metabolism. Lack of early detection, prolonged diabetics might lead to medical complications such as heart problems, eye vision problems, skin issues etc. Diabetic retinopathy (DR) is a frequent abnormality of diabetics. In this paper, we propose computer vision based technique to analyze and predict diabetes from the retinal input images. This helps in an early stage detection of DR. In this image processing steps such as pre-processing, segmentation, feature extraction steps are applied. After the image processing steps, machine learning based classification step is performed. For experimental results, we used python programming language for better results. For experimental results platform, we use jupyter for developing the coding. The framework developed was evaluated on open access public repository datasets, achieving an accuracy of 98.50% using CNN as compared to the accuracy of 87.40% achieved by SVM. These results perform better than several advanced unsupervised ML techniques. It results in decrease of procedural complexity and improved assessment metrics, hence making it suitable to be used in the diagnosis of DR using retinal image analysis.**

Keywords — Diabetic retinopathy, pre-processing, segmentation, feature extraction, machine learning algorithm

I. INTRODUCTION

Diabetes is one of the important cause for eye vision loss. Early detection of diabetes is important, delayed inspection will have a greater impact on the eye retinal region. As WHO predicts because of the food habitats, lack of physical activities approx. 347 million individuals would be suffering from diabetic issues by the year 2030. In the recent couple of years, many diabetes patients are getting retinal problems which is termed as diabetic retinopathy (DR) [1] .Now a days adults with age of 30 are very much affected by diabetic retinopathy and mostly common with working individuals. Thus this motivates that early detection of DR is very demanding and essential to save human lives.

In delayed inspection or analysis of diabetic retinopathy would lead to severe complications such as stroke, heart problems, vision problems, neuro issues etc. DR means prolonged diabetes mellitus in individual body leading to blood vessel abnormality like blockage, blood vessel getting thinner etc. This can be experience only at the advanced stage leading to medical complications. Thus early detection of DR is essential. This early detection can be performed using computer vision techniques applied on the retinal image inputs. The retinal images are obtained with the help of ophthalmoscope photography, IRIS scanner. Also this proposed computer vision based approach eliminates the dependency of skilled physicians to analyze, recommend diagnosis in a reduced time. Also this proposed approach would assist the physicians in decision making. Diabetes is majorly caused and increased because of metabolism. Eating habitat also plays an important role in balancing the insulin level in the body. During diabetes abnormality, the insulin won't be produced in the right level leading to complications. The insulin level produced would be less or sometime no insulin. People suffering from DR cannot feel the vision problems at the early stages at all. Thus it would be getting worse each day leading to a greater impact to the vision. The medical diagnosis would be recommended based on the current stage of diabetics and impact of DR.

II. RELATED WORK (LITERATURE SURVEY)

The authors [2] have proposed a research analyzing the preprocessing techniques towards detection of diabetic retinopathy. Also they have performed comparison of preprocessing algorithms with regard to diabetic retinopathy. The methodologies proposed for performing the comparison are HE, ADHE, CLAHE, and ESIHE. Finally the research proved that HE was user friendly with easy implementation.

This paper [3] performs the comparative analysis of classifiers with regard to diabetic based detection using retinal images. Also this paper provides the accuracy level comparison of classifiers using mathematical equations. Finally the classifier comparative e study states that support vector machine algorithm render promising results.

This research paper [4] explains certain feature extraction algorithms which are used for extraction of the features from the input images of the retina. The features such as blood vessel extracted values are extracted and different algorithms are been compared.

This paper [5] in depth briefs about the Diabetic Retinopathy stages. It states the DR can be classified into 4 stages, Mild, Moderate, Severe and Proliferative DR. The main parameter which differentiates and identifies the stage is by

analyzing the thinness, weak walls of the blood vessels. Thus the advanced stage would lead to vision loss and sometime blindness.[5]

This paper [6] proposes a model named AlexNet to predict the diabetic detection and its respective stage identification. This model can able to predict only few class of diabetic as the trained model has certain limitations. This model can able to render a accuracy of 69% only. Thus accuracy is constant though the input dataset is been increased.

This paper [7] briefs about few classifiers and their performance. Few classifier's which was considered in this paper are naïve bayes, svm, convolutional neural network. With 15 features been extracted, naïve bayes algorithm renders a predictive accuracy of 64.67%. From the retinal input fundus image with 10 feature been extracted, the support vector machine algorithm renders a predictive accuracy of 72.67%. Both the classifiers are time consuming as training model needs much improvisation.

This paper [8] explains how convolutional neural network can be utilized for detecting the diabetics from retinal images. Thus CNN provides better accuracy, validation and training model. During experiment analysis CNN outperforms when compared with other classifier. The CNN classifier has the ability to obtain the spatial, temporal values in the input retinal images and analyses increased weights from the input image. Thus CNN has the capability to train the model efficiently and predict, address the complexity involved in the training model in an efficient manner.

III. PURPOSE

Diabetic retinopathy (DR) is a medical condition in which a patient's retina is affected and leaks in the blood are caused due to diabetes mellitus. Thus the purpose of the project is to develop an automation solution saving time and human efforts to detect diabetic stage from the retinal images. Also our purpose is to provide an accurate result based application invoking best suitable and effective machine learning algorithm.

IV. PROPOSED ARCHITECTURE

The proposed architecture is shown in **Fig. 1.**

A. Data Pre-Processing

In this part, the retinal image captured by fundus photography is used for the detection. RGB format image needs to be converted to gray scale format. An image of a gray scale format is further used.

B. Optical Disk Segmentation

The OD is a bright yellowish or whitish space in the colored fundus images. For the optic disc, large and same intensity values are provided for exudates. Hence, the removal of optic disc from the retinal image is extremely necessary and is an important step. The region properties and space identification are used for the process of masking and to remove the brighter optic disc. Detection of the optic disc and blood vessels are done by applying edge detection algorithm after correction. Objective detection was performed using a canny edge detection algorithm. The local maxima also known as gradient is further saved for refining the blurred edges by the canny edge detection algorithm.

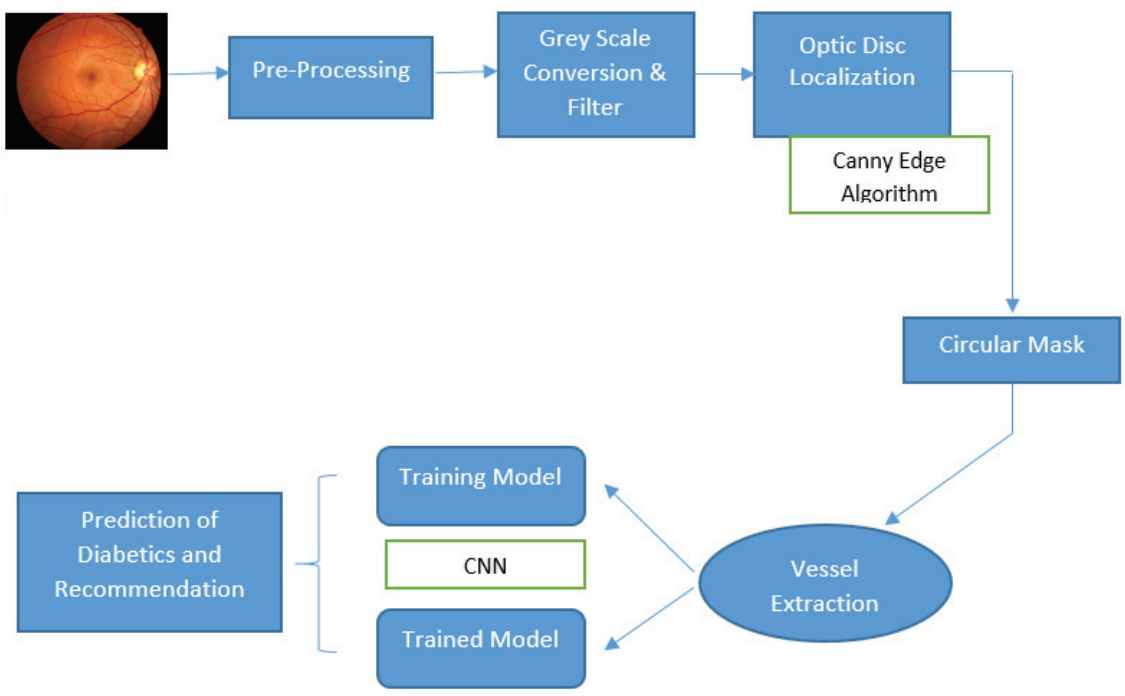

Fig. 1. Proposed Architecture

C. Blood Vessal Extraction

We apply dilation on the intensity images to remove the high levels of different vessels in the blood. The tiny holes present in the images are filled by dilation operation with the help of structuring element. Structure elements (SE) exist in different shapes. The visible disc and blood vessels are removed here using a disc-shaped structure.

D. Classification

The last part of the process is of classification which uses the NN (Neural networks). It is an unregulated method for the diabetes retinopathy detection. Color features of the input image are used to prepare the training set. The system can train itself until error gets minimized in the networks. Maximum trained is the stage at which error is minimum. Input for the diabetes retinopathy detection is the test image.

V. PROPOSED METHODOLOGY

In this proposed methodology, diabetes retinopathy is been detected using computer vision techniques which is invoking image processing and machine learning techniques. Thus the input retinal fundus images are obtained from the public repository. From the input retinal images as shown in Fig. 2 and Fig. 3, image processing steps such as pre-processing, segmentation, blood vessel extraction are been performed. Convolutional Neural Network (CNN), a machine learning approach is applied to predict the normal, abnormalities and recommend the medicinal measures.

In pre-processing, the image acquisition is performed in which the obtained RGB image would be transformed into the gray scale and also the image would be enhanced for further image processing steps.

After pre-processing, optical disk segmentation is been performed. The optical disk is been edged and segmented for analysis. Thus this step is very important for the feature extraction process. Detection of Canny e techniques is been applied to edge and extract the optical disc. The blurred edges are also improved and transmitted for the feature extraction step.

In the feature extraction, blood vessel features are been extracted. Feature extraction is an important step as based on the features only classifier model accuracy is dependent. The objective of the feature extraction algorithm is that it should able to extract meaningful features, objects assisting the normal, and abnormal recognition process. The feature vector consists of the measure values. The convolutional neural network obtains the feature vector as the input and performs the classification phase. The CNN has the training model set which is been trained with the color, feature vector values from the input retinal images. The training model is trained until the error is been minimized to an optimized level. This stage is termed as the maximum trained phase. After this the normal, diabetic retinopathy is been predicted efficiently from the input test images with promising results.

In the proposed project work, the input dataset images is been obtained from the public repository. The input images are provided to jupyter tool. The pre-processing is done using open cv packages. Psychic tool is been used to split the function of trained and training dataset.

The machine learning algorithm used is convolutional neural network (CNN) for training the model using the training set. Thus CNN renders promising accuracy. Stacked layers models are used in CNN and it makes classifying of the images efficient. The input image pixel based features are extracted and matched with the trained model for predicting diabetic and non- diabetic parameters. We have used inception under CNN.

Inception Modules are more systematic in computation and they also allow deeper Networks by reducing the dimensionality. They were developed to help in solving the problem of high expenses in computation, over fitting along with various other issues [9].

VI. DATASET

Dataset has been obtained from Friedrich-Alexander-Universitat Erlangen-Nurnberg (FAU), a public research university's open image database.

The input retinal images are obtained from the public repository. In this 15 images each of different category have been made available for research analysis. The 3 different categories are - Patients with DR, Patients with Glaucoma and Healthy patients

For specific datasets, binary gold standard vessel segmentation pictures and field of view (FOV) are also made available. Various trained ophthalmologists and specialists have generated the gold standard data.

VII. EXPERIMENTAL RESULTS

In this project study, we have used Google Colab tool for experimental results. In the process, the vessel extraction from retinal input images and training is been performed using convolutional neural network. In the classification phase, the training model is been built and whenever the input image is provided, it's been compared with the trained model and outcome is been predicted.

$$\mathcal{M}(a, b) = \max xc,d \in \mathbb{G}ab\ r2(xc,d) \quad (1)$$

Where in Eq. (1), $\mathbb{G}ab$ is segments group that added the pixel A a, b in the process of segment extraction.

$$\mathbb{P}A = \max(a,)\ \mathcal{M}(a, b) \quad (2)$$

The $\mathbb{P}$ A in Eq. (2), is equivalent to overall segment's diabetic retinopathy probabilities.

Accuracy =

True positive pixels + (True negative pixels / N) * 100%

(3)

The accuracy of various ML algorithms is compared in **Table 1** whereas a graphical representation is shown in **Fig. 4.**

Also, the values of TP (True Positive pixels) and TN (True negative pixels) for different methods is shown in **Table 2**.

The comparison results of classification phase for different methods is shown in a graphical representation in **Fig. 5.**

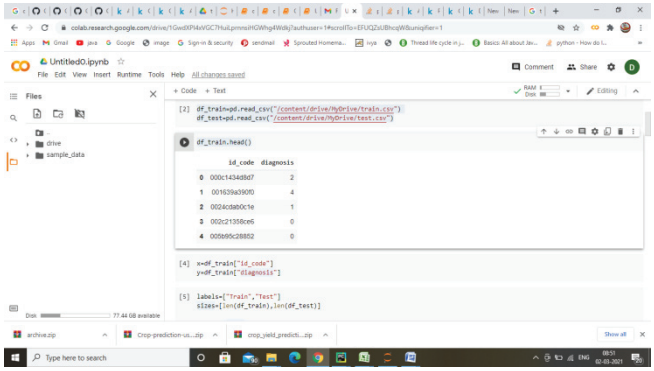

Fig. 2. Input image in google colab tool

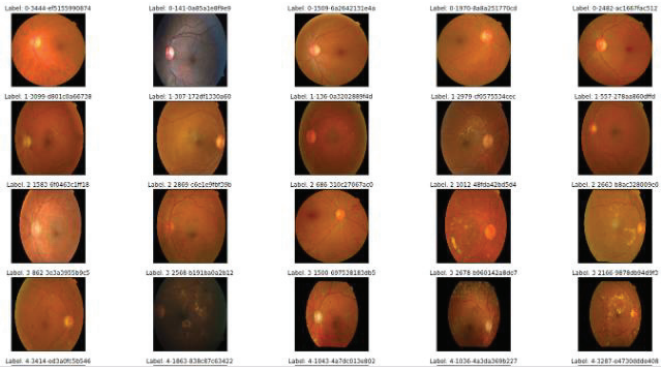

Fig. 3. Labeling of images

TABLE I. TABLE 1. ACCURACY OF VARIOUS ML ALGORITHMS

Method	Accuracy
SVM	87.40%
CNN	98.50%

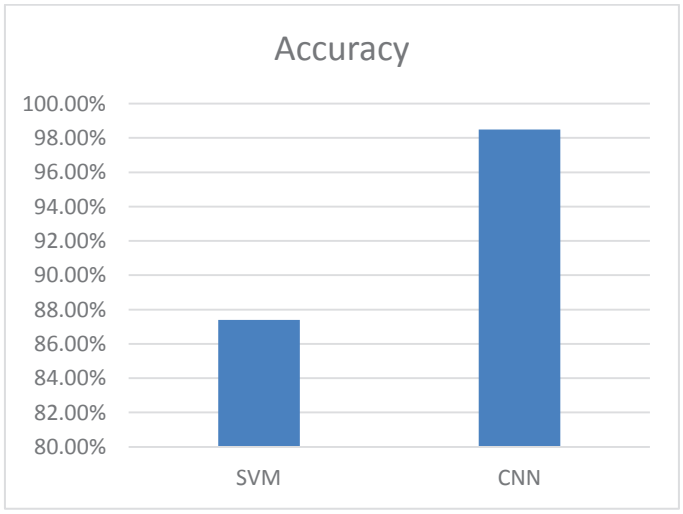

Fig. 4. Depicting accuracy

TABLE II. VARIOUS VALUES OF TP AND TN FOR DIFFERENT METHODS

Method	TP	TN
SVM	176	44
CNN	179	46

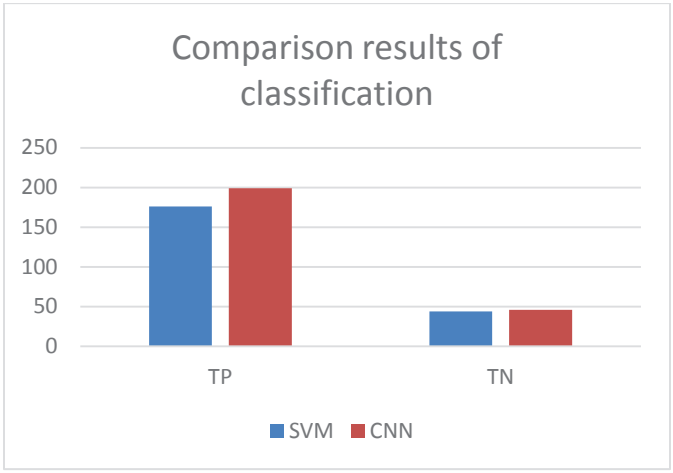

Fig. 5. Depicting comparison results of classification

VIII. CONCLUSION

This project study accepts the retinal fundus image as the input to detect diabetic retinopathy. This project experimental result is carried in Google Colab. The computer vision and machine learning techniques are applied on the input image to predict normal, diabetic stage and recommend accurate medicinal measures. The framework developed was evaluated on open access public repository datasets, achieving an accuracy of 98.50% using CNN as compared to the accuracy of 87.40% achieved by SVM. These results perform better than several advanced unsupervised ML techniques. It results in decrease of procedural complexity and improved assessment metrics, hence making it suitable to be used in the diagnosis of DR using retinal image analysis.

REFERENCES

[1] Sharad Kumar Yadav, Shailesh Kumar, Basant Kumar, Rajiv Gupta," Comparative Analysis of Fundus Image Enhancement in Detection of Diabetic Retinopathy", In: Humanitarian Technology Conference (R10-HTC) Volume: 2016 IEEE Region 10 (pp. 1-5). IEEE [2016]

[2] Jyoti Dnyaneshwar Labhade, L. K. Chouthmol, Suraj Deshmukh, "Diabetic Retinopathy Detection Using Soft Computing Techniques", In: 2016 International Conference on Automatic Control and Dynamic Optimization Techniques (ICACDOT) [2016]

[3] Wei Zhou, Chengdong Wu, Dali Chen, Zhen zhu Wang, Yugen Yi, Wenyou Du," A Novel Approach for Red Lesions Detection Using Superpixel Multi-Feature Classification in Color Fundus Images",In: 2017 29th Chinese Control And Decision Conference (CCDC) [2017]

[4] Ravitej Singh Rekhi, Ashish Issac, Malay Kishore Dutta Carlos M. Travieso, "Automated classification of exudates from digital fundus images",In: 2017 International Conference and Workshop on Bioinspired Intelligence (IWOBI) [2017]

[5] Vijay M. Mane, Prof. (Dr.) D.V.Jadhav, Akshay Bansod, "An automatic approach to Hemorrhages detection", In: 2015 International Conference on Information Processing (ICIP) [2015]

[6] Shuang Yu, Di Xiao and Yogesan Kanagasingam,“Machine Learning Based Automatic Neovascularization Detection on Optic Disc Region”, In: IEEE Journal of Biomedical and Health Informatics (Volume 22, Issue 3, May 2018) [2018]

[7] Enrique V. Carrera, Andr´es Gonz´alez, Ricardo Carrera,, “Automated detection of diabetic retinopathy using SVM”,In: IEEE XXIV International Conference on Electronics, Electrical Engineering and Computing (INTERCON) [2017].

[8] Harini R, Sheela N,“FeatureExtraction and Classification of Retinal Images for Automated Detection of Diabetic Retinopathy”, In: 2016 Second International Conference on Cognitive Computing and Information Processing (CCIP) [2016].

[9] Bharath Raj,”A Simple Guide to the Versions of the Inception Network”,[2018].