Diabetic Retinopathy Detection and Classification using Hybrid Multiclass SVM Classifier and Deeplearning Techniques

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Abstract

In the medical field, earlier disease detection is the effective treatment. The diabetic retinopathy causes the lesion on retina this leads to vision loss. Early detection of diabetic retinopathy reduces the vision loss. Detection and classification of diabetic retinopathy can be performed by using AI approaches like machine learning and deep learning techniques. Here the diabetic feature analysis determines the various stages of retinopathy infection caused by unbalanced diabetics. Conventional approaches use the deep learning with convolutional neural network model for retinopathy image classification. Large dataset processing difficulty, complex training and computation time are the major drawbacks of existing work. In this proposed research work, the multi class Support Vector Machine learning technique with lesion and vessel analysis of retinopathy images are performed and the Deep learning technique is used to detect and classify the diabetic retinopathy images. Multi layer performance of deep learning technique is performed to classify the normal and abnormal diabetic retinopathy image data. The objective of this research is to develop a multiclass algorithm by using hybrid machine learning and deep learning techniques for prediction and classification of diabetic retinopathy. The proposed algorithm has been applied on open source diabetic retinopathy image data set. Experimental results are compared with conventional techniques and the proposed work yields better results with Accuracy of 93.33, Sensitivity of 96.71 and Specificity of 99.22. From the results, it was observed that proposed algorithm produced relatively better results than existing conventional algorithms. So, it was decided that the proposed algorithm can be used as diagnosis tool for early detection of diabetic retinopathy.

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I. INTRODUCTION

The diabetic is the increased amount of blood glucose caused by unbalanced insulin. This mainly affects the heart, retinal, nerves and kidney. The diabetic retinopathy presented

the diabetic patients who suffered diabetic with long period like 10 years and above. Diabetic retinopathy analysis performed with various severity analyses for detection, classification and segmentation. The lesion analysis of retina fundus images are appeared as microaneurysms, haemorrhages, soft and hard exudates. Here the lesion analysis classified with various severity level of Diabetic Retinopathy (DR) such as non-lesion, non proliferative and proliferative diabetic retinopathy. Detection of retinopathy image uses various approaches in machine learning techniques [1]. Here the deep learning techniques used widely in DR image analysis. Depends on the feature analysis and classification patter, the abnormal detection, classification and segmentation is performed [2]. Blood vessel blocking in retina leads more severity of diabetic retinopathy [3].A part of eye recognizes light and imparts signals to mind through a nerve in the back of your eye that is optic nerve [4]. To treat the development of new blood vessels at the eye in instances of proliferative diabetic retinopathy called maculopathy. In spite of the fact that retinopathy normally doesn't show up for around five years after a type-1 diabetes determination, it might as of now be available when type-2 diabetes is analyzed. After suffering diabetic of 15 years, 98% of those with type-1 diabetes and 78 percent of those with type 2 have some level of retinal harm. The treatment is about laser photocoagulation it will probably help to prevent vision loss over the long run. Diabetes specialists detect that earlier identification and treatment of retinopathy can prevent or even most, instances of extreme vision loss in individuals who have diabetes [5]. The unusual veins related with diabetic retinopathy refreshing the development of scar tissue, which can pull the retina away from the back of the eye. This may cause spots gliding in your vision, blazes of light or extreme vision loss [6].On the off chance that blood glucose level (glucose) is excessively high for a really long time, it closes off the little veins that keep retina. Eye will attempt to develop fresh blood vessels, yet they will not grow well [7]. The veins begin to debilitate. They can spill blood and liquid into your retina. This can cause another condition called macular edema [8]. It can make your vision blurry.Stages of Diabetic retinopathy are as follows:

1Slight non-proliferative retinopathy: In the sickness' most punctual stage, small veins in your retina change. Little regions swell. Liquid can spill out of them and into your retina.

2Moderate non-proliferative retinopathy: As your infection deteriorates, veins that should keep your retina healthy and change shape. They can't convey blood to your retina. This can change the manner in which your retina looks. These vein changes can trigger diabetic macular edema.

3Serious non-proliferative retinopathy: In the third stage, many veins get obstructed. They can't convey blood to your retina to keep it healthy. Regions of your retina where this happens make exceptional proteins called development factors that advise your retina to develop fresh blood vessels.

4 Proliferative diabetic retinopathy: This is the most developed stage. New blood vessels develop inside your retina and afterward into the jam inside your eyeballs called glassy humor. Delicate fresh blood vessels are bound to release liquid and drain. Scar tissue begins to frame. This can cause retinal separation, when your retina pulls from the tissue under. This can prompt perpetual visual impairment.

Recently the PC vision with Deep Neural Networks can prepare a model consummately and level of exactness, which is higher than other neural organization models [9]&[10]. The fundus image containing diabetic retinopathy and it has been contemplated. Proposed Model have been prepared with three kinds, back propagation NN, Deep Neural Network (DNN) and Convolutional Neural Network (CNN) in the wake of testing models with CPU prepared Neural model, which gives most minimal exactness in light of one hidden layers while the profound learning models are outperforming NN. The Deep Learning models are fit for measuring the features as veins, liquid trickle, exudates, hemorrhages and miniature aneurysms into various classes. To recognize the objective class edges weighted Fuzzy C-

implies calculation has been utilized. The model will be useful to distinguish the appropriate class of seriousness of diabetic retinopathy image data. Objective of this research work is to improve the performance with multi layering concept using deep learning with parameters of accuracy, sensitivity and specificity. This research contributes to various researchers in the performance of earlier detection and automatic detection states. In this, the proposed multi class SVM and multi layer deep CNN helps to analyze the diabetic retinopathy detection, and classification state. Lesion based analysis detect the abnormality of fundus image. Here the incorporation between morphology and deep learning classification obtains the better analysis than recent literatures.

Rest of this paper summarized as follows, section II presents the literature survey. Section III describes the proposed work with two different classification states. Section IV presented the results discussion. Section V concluded the proposed work and future work also described.

II. LITERATURE SURVEY

Wejdan L Alyoubi, ET al. (2020) have reviewed the diabetic retinopathy analysis with various deep learning techniques. binary, Lesion based, and vessel based classification is studied with CNN performance. Various dataset analysis and approximate accuracy result are the analyzed. Convolutional neural network on diabetic retinopathy image analysis is reviewed and it utilizes the fundus image with five feature analysis. Most of the medical diagnosis system with image processing are uses the deep learning for better analyzed results.

Vijay Kumar G, et al. (2019) has performed the diabetic retinopathy detection using neural network model. Computer vision, machine learning and deep learning techniques are used on the classification of trained dataset. Performance of SVM, Neural network with multi class perceptron and CNN are obtained the result of recognition rate. Feature extraction is used the cross fold validation approach.

Xiaomeng Li, et al. (2020) has presented the CANET for diabetic retinopathy detection. Here the cross disease consideration network to together review DR and diabetic macular edema by investigating the inner connection between the infections with morphological process. This incorporate the normal and abnormal fundus image explicit consideration module to specifically learn valuable features for lesion of retina and the subordinate consideration module to additional feature analysis connection between the two different dataset. This module organizes to create feature extraction and to augment the general exhibition mutually for evaluating DR and DME. This assesses our organization on two public benchmark datasets, i.e., ISBI 2018 IDRiD challenge dataset and Messidor dataset.

Lei Zhang, et al. (2009) has presented the proliferative diabetic retinopathy with matched filter using double sided morphology based thresholding approach.The early finding of proliferative diabetic retinopathy typical confusion of diabetes that harms the retina is essential to protect the vision of diabetes victims. The beginning of PDR is motioned by the presence of neovascular net. Such neovascular nets may be distinguished utilizing retinal vessel extraction strategies. The coordinated channel for retinal vessel extraction applies a neighborhood vessel cross-area examination utilizing twofold sided thresholding to decrease false state to nonline edges. This changed coordinated channels showed higher positive rate and lesser false rate in vessel extraction.

Sohini R, et al. (2014) has presented the diabetic retinopathy analysis using machine learning approach with AI fundamentals. PC helped screening framework of fundus images with varying brightness and produces a seriousness grade for diabetic retinopathy (DR) utilizing AI. Classifiers, for example, the Gaussian Mixture model, k-nearest neighbor, SVM and AdaBoost are dissected for grouping retinopathy injuries from nonlesions. GMM and kNN classifiers are discovered to be the best classifiers for efficient grouping. A principle

commitment of this paper is the decrease in the quantity of features utilized for lesion characterization by includes positioning utilizing Adaboost where 30 top features are chosen out of 78. An epic two-venture progressive grouping approach is proposed where the nonlesions are dismissed in the initial step. In the subsequent advance, the brilliant sores are delegated hard exudates and cotton fleece spots, and the red sores are named hemorrhages and miniature aneurysms. The DR seriousness reviewing framework is tried on 1200 pictures from the freely accessible MESSIDOR dataset.

Sheikh M Saiful Islam, et al. (2018) has presented the earlier detectionof DR using deep learning technique. Diabetic Retinopathy (DR) is a continually breaking down diseases, being one of the main sources of vision debilitation and visual deficiency. Inconspicuous differentiation among various evaluations and presence of numerous features make the challenging testing task. Also, the current methodology of retinopathy location is an extremely difficult and time-concentrated assignment, which intensely depends on the ability of a doctor. with computer discovery of diabetic retinopathy is crucial for tackle these issues. Beginning phase location of diabetic retinopathy is additionally vital for analysis, which can forestall visual impairment with legitimate treatment. The convolutional neural model performed by distinguishing all microaneurysms (MAs), the main indications of DR, alongside effectively allocating marks to retinal fundus images.

A Sopharak, et al. (2009) has presented the exudates detection of non-dilated diabetic retinopathy image using FLC. Image enhancement preprocessing is applied four features, specifically power, standard deviation on force, tone and various edge pixels, which are separated to supply as info boundaries to coarse division utilizing Fuzzy C Means grouping technique. By adjusting with morphological procedures, the location results are approved by contrasting and master ophthalmologists' hand-drawn ground-facts. Affectability, explicitness, positive prescient worth, positive probability proportion and exactness are utilized to assess in general execution. It is tracked down that this technique recognizes exudates.

III. PROPOSED METHOD

The proposed diabetic retinopathy image analysis utilizes the major performance of detection, segmentation and classification. Here the multi layer SVM with deep learning concept is used for performing better classification. Here the preprocessing of morphological process improves the image rate by performing laplacian concept of Gaussian filter with double factor of filtering approach and the pad array is constructed with the binary state of image. Thresholding of filtered image shows the disk region of segmentation. Background removal uses gray threshold. With the help of vessel extraction, the abnormality is detected. In this, the feature extraction process utilizes the determination factor of energy and homogeneity. This detection state performs the better analyzed result of different classification features.

Major part of the work is classification of different state of severity analysis such as diabetic retinopathy (DR), Age-related Macular Degeneration (AMD) and normal retina. Diabetic retinopathy is characterized hooked on twofold classes, non-proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR). Finding of diabetic retinopathy in fundus nonexistent is performed by deep learning strategies with AI. The initial two consideration modules contain normal pooling layers, max-pooling layers, multiplication layers, connection layer, CONV layer and Fully Connected layers while the these consideration modules contain Fully Connected and multiplication layers.

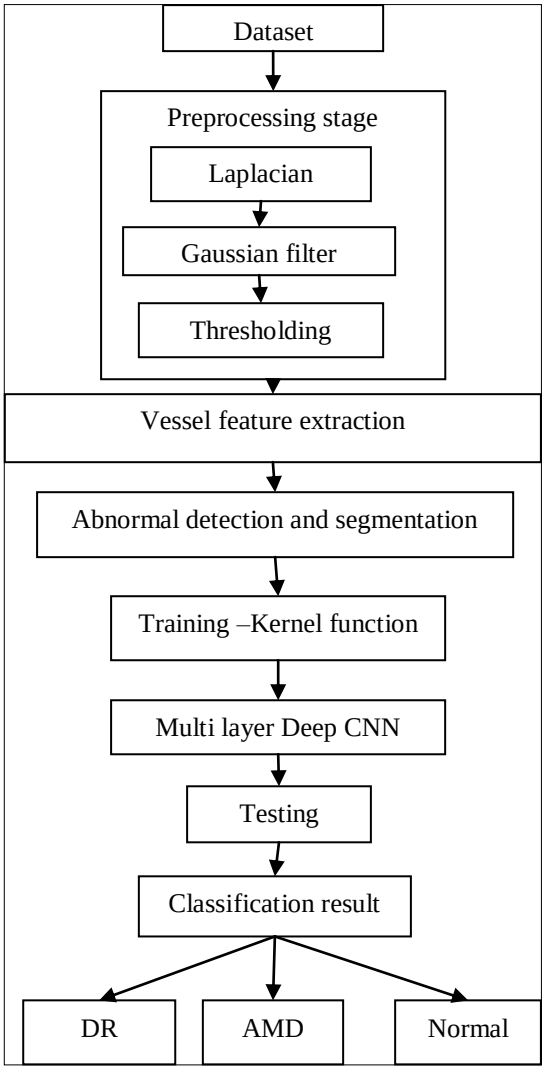

Fig1. Flow diagram of proposed deep learning approach of diabetic retinopathy process

Here the training state utilizes the sigmoid function of classifier and with the help of kernel functioning, the training state performed with the feature selection process. Here the overall process flow of diabetic retinopathy image analysis is shown in figure1. Multi layer performance of SVM with deep learning concept is performed to get the better classification state.

A. Dataset

Diabetic retinopathy dataset with the classification state of DR, AMD and normal retina images are collected. The dataset is collected from https://www.kaggle.com/c/diabetic-retinopathy-detection/data . Entries are scored dependent on the quadratic weighted kappa, which gauges the understanding between two appraisals. This measurement ordinarily differs from 0 to 1. If there is less arrangement between the raters than anticipated by some coincidence, this measurement may go under 0. The quadratic weighted kappa is determined between the scores allocated by the anticipated scores.

B. Preprocessing

Initially, the processing state of morphological performance with top hat filtering is performed to enhance the contrast of image. This helps to adjust the contract of image for better visualization. Information growth, standardization and resizing were performed prior to taking care of the retina image to the deep CNN with preprocessing stage. Top hat transform

is the filtering approach performed with grey level or binary image for adjusting the contrast of retina image.

Laplacian operator on the preprocessing stage performed with estimating neighbor pixel rate and derivative function, which is given by,

$$\nabla_l[P_l] = P_l - P_m \quad (1)$$

Where, P_m presented the channel interference with green colorant factor. After performing filtering process, the thresholding helps to determine the disk for segmentation process. Here the optical disk performed with green channel determination for extractingthe blood vessels. The exact segmentation process needs to rectify the optical disk from the image.

C. Detectionand Segmentation

Diabetic retinopathy happens when veins in the retina changes with lesion defect based on unbalanced blood glucose level. The vessels swell and release liquid off totally. In different cases, abnormal blood vessels develop on the outside of the retina. Thresholding is applied based on the mean value of normal and grey level image, which given below.

$$Th = \frac{1}{2}(M_{normal} + M_{gray}) \quad (2)$$

strel is a disk shaped structuring element with properties:

Neighborhood: [5×5 logical]

Dimensionality: 2

The GLCM for feature analysis with vessel feature and the energy and homogeneity feature trace and histogram based analysis for extraction of features.

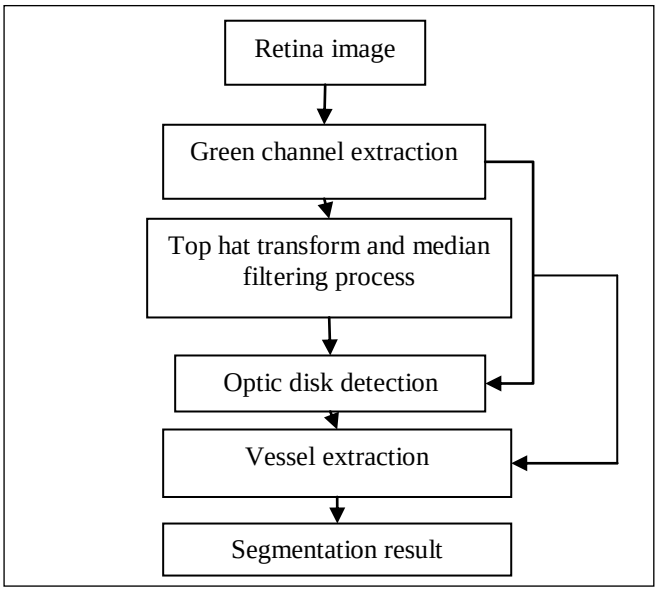

Fig2. Segmentation process based on vessel extraction

The segmentation process of retina image is shown in figure2. This paper presents a enhanced feature analysis for segmentation and detection to discover the lesion region in retinal fundus with high exactness, First, the picture is changed over to HSI model, in the wake of preprocessing potential areas containing exudate, the divided picture without Optic Disk (OD) utilizing calculation Graph cuts, which utilizes the green color extraction After performing the feature extraction vectors are delegated normal and abnormal state then it utilizing a Neural Network Classifier.

D. Classification

Deep CNN have been effectively applied in various adjoining subjects, and for analysis of diabetic retinopathy itself. In any case, the significant expense of datasets, just as irregularity between various specialists, blocks the presentation of these techniques. The CNN has eight CONV layers, four max-pooling layers and two Fully Connected layers in general structure; depends on the imaging applications, the layers are selectively used. The SoftMax layer applied at the last layer of Deep CNN for characterization. The feature extraction utilizes the contributions for the initial two consideration modules to choose one infection retina as feature findings.

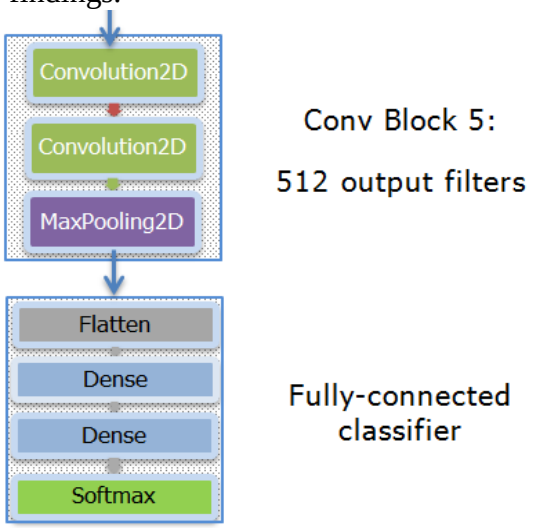

Fig3. Deep learning in DR analysis

The layering arrangements of Deep learning technique are given in figure 3. The diabetic retinopathy datasets are prepared in neural organizations. What's more, founded on the preparation datasets; this can identify whether the individual has (i)normal, (ii) AMD (iii) extreme non-proliferative diabetic retinopathy and (iv) proliferative diabetic retinopathy. The Deep learning layer determinations as follows.

```
layers = [imageInputLayer([346 436 3])
        convolution2dLayer(5,22)
reluLayer
        maxPooling2dLayer(2,'Stride',2)
        convolution2dLayer(5,22)
reluLayer
        maxPooling2dLayer(2,'Stride',2)
fullyConnectedLayer(2)
softmaxLayer
classificationLayer()];
options = trainingoptions('sgdm','MaxEpochs',20, ...
   'InitialLearnRate',0.0001);
 convnet = trainNetwork(traindata,layers,options);
```

Deep learning-based technique for stage identification of diabetic retinopathy by single photography of the human fundus is performed. Here the multistage classification of SVM is to deal with transfer learning, which utilizes comparable datasets with various marking. The introduced technique can be utilized as an evaluating strategy for early discovery of diabetic retinopathy with sensitivity and specificity rate.

E. Performance metrics

The classification performance measures the classification accuracy, sensitivity and specificity. Based on the normal and abnormal image ratio analysis, the performance metrics are calculated. TP and TN represent the True Positive and True Negative. FP and FN represents the False Positive and False Negative. Here the true positive rate determined based on the number of abnormal image, true negative rate is taken by normal image count, false positive depends on the normal image with classified feature and the false negative is the normal image classification.

$$Accuracy = \frac{TN+TP}{TN+TP+FN+FP} \quad (3)$$

$$Sensitivity = \frac{TP}{TP+FN} \quad (4)$$

$$Specificity = \frac{TN}{TN+FP} \quad (5)$$

Various considerations are examined on vessel extraction of fundus image as part of DR identification. DR identified after the vessels have been separated. The down-sampling in CNN module incorporates CONV layer followed by a maximum pooling layer and up sampling module includes CONV and deconvolutional layers to grow the retina image with feature. The approach incorporates three CONV layers and three other normalization layers.Overall performance is done with the MATLAB 2020a tool.

IV. RESULTS AND DISCUSSION

Thus the diabetic image analysis in the process state of classification, detection and segmentation is performed well with novel deep learning concept. Here the incorporation of morphology process and machine learning approach helps to determine the better analysis. The input image of normal and abnormal image is given in the figure 4 and 5 respectively.

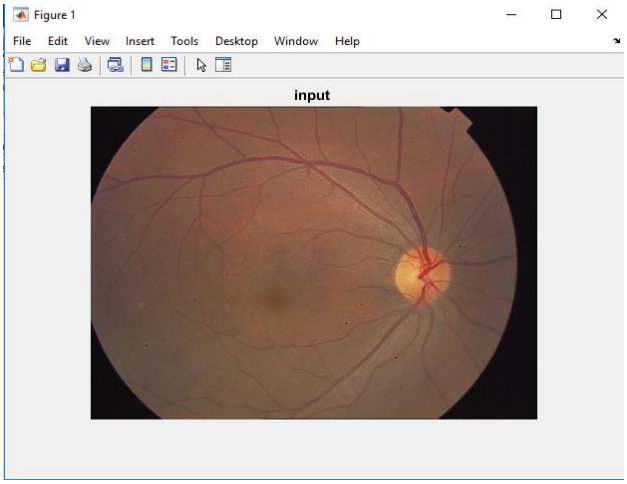

Fig4. Normal retina image as input

Fig5. Abnormal retina image as input

The retinal blood vessel analysis is utilized to conclusion and to assess the advancement of retinal infections, like glaucoma, DR and normal. Numerous considers have been directed to explore vessel division as part of DR discovery.

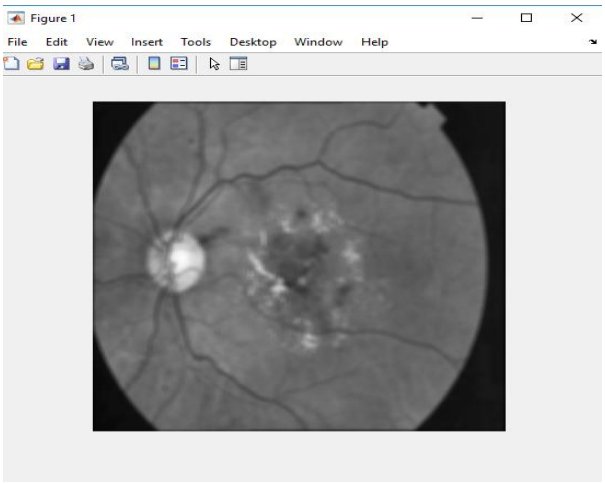

Fig6. Converted gray level image

The DR sores stay in the image after the vessels have been separated. Vessel feature of lesion lead to recognize and characterize DR image data with effective manner. Grey level converter retina image is shown in figure6 and the filtering takes binary threshold, which is shown in the result as figure7.

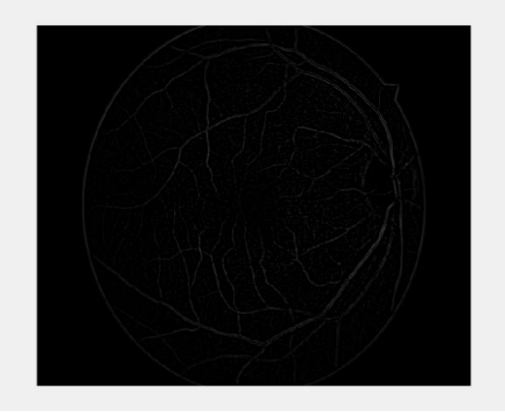

Fig7. Vessel extraction feature with thresholding analysis

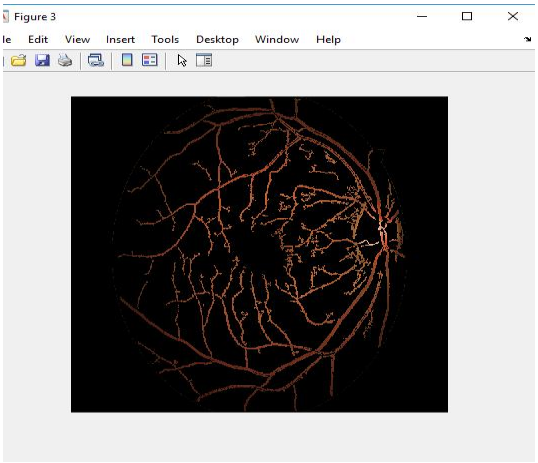

Fig8. Vessel extraction on segmentation

In the segmentation process, the vessel feature is analyzed and obtains the extraction phase of retina by rectifying the optical disk for abnormal detection. The vessel extraction result is given in the figure 8. Overall performance on DR image segmentation with accuracy of detection rate is given in the figure 9. Depends on the kaggle dataset, the result comparison is carried out and the proposed work achieves the better performance than existing work. Classification accuracy of multi layer SVM with proposed logic achives the result than traditional SVM. The classification result is shown in fig10.

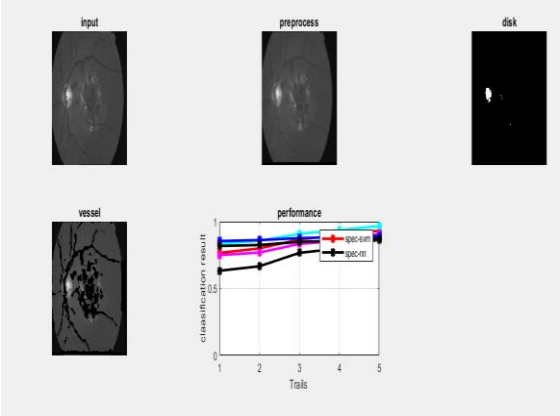

Fig9. Performance result of different stages of detection state

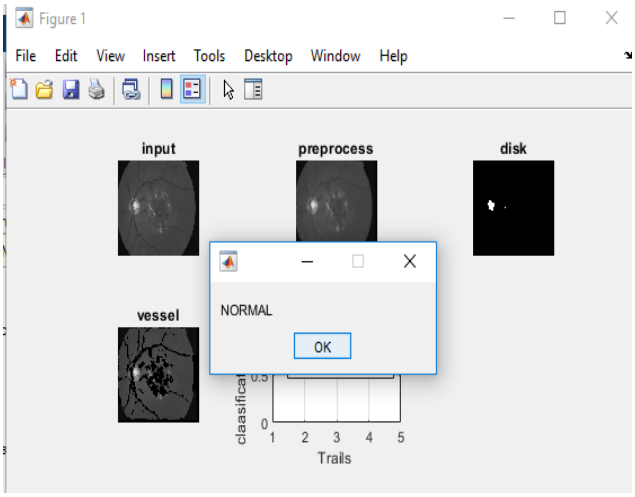

Fig10. Classification Accuracy with detection state retina image

By performing effective computation of deep learning in diabetic retinopathy detection, classification and segmentation process are performed well with obtaining the result of accuracy, sensitivity and specificity. The result comparison is given in the table 1.

Table 1: Comparison result of classification

Parameter	Existing work	Proposed work
Accuracy	92.3	93.33
Sensitivity	92	96.71
Specificity	72	99.22

Proposed performance of DR image analysis obtains the better result by accuracy of 93.33% , sensitivity of 96.71% and specificity of 99.22 %. These results are taken based on the kaggel DR image analysis dataset, which classifies the image based on the severity level of diabetic retinopathy. Therefore, the proposed performance of multi layer SVM with deep learning multi class procedure obtained the better classification result.

V. CONCLUSION AND FUTURE SCOPE

Thus the performance state of Diabetic Retinopathy image analysis on the normal, DR and AMD state obtained the better classification result. Here the detection, segmentation and classification process are performed well with occupying the computerized analysis. Here the preprocessing state of enhancement and classification layer performance improves the result of overall process. The disk removal, use of top hat filter and vessel extraction feature with energy and homogeneity feature analysis improves the result. In Deep learning, the CNN layering process is applied for classification state such as input layer, convolution2d layer, Relu layer, max pooling layer, convolutional layer, softmax layer and fully connected layer. All these performances are determined with the deep learning technique for DR image classification. The experimental result obtains the better performance than most recent literature surveys. In future, the work may extended with large image database utility system for increasing many application in the field of medical image processing and diagnosis process based feature analysis is performed to get the better system.

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