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Comparison of different feature extraction methods using MLP classifier for DR Detection

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Abstract- This paper focuses on Multi Layer Perception Neural Network (MLPNN) to detect diabetic retinopathy in retinal images. In this paper, the authors present MLPNN based classifier to classify retinal images as normal and abnormal. In order to conduct the experiments for detection of diabetic retinopathy in retinal images, DIARETDB0 database is used. The current database consists of 130 colour fundus images of which 20 are normal and 110 contain signs of the diabetic retinopathy (abnormal). 64-point Discrete Cosine Transform (DCT), 64-point Fast Fourier Transform (FFT), Singular Value Decomposition (SVD) with 09 different statistical parameters are extracted from the retinal images. Three feature vectors formed with the help of DCT, FFT, SVD and 9 statistical parameters. For CV dataset the % classification accuracy of MLPNN classifier is 100%, 100% and 91.47% for DCT, FFT and SVD feature vectors respectively.

Index Terms- Multi Layer Perception Neural Network (MLPNN), Retinal images database DIARETDB0, diabetic retinopathy (DR).

1. INTRODUCTION

In diabetes the blood vessels throughout the body, particularly in the kidneys and eyes get affected. When blood vessels in the eye are affected, it is referred to as diabetic retinopathy (DR). Diabetic retinopathy is a major public health problem and a leading cause of blindness in the World.

Therefore early detection of diabetic retinopathy is very important to avoid vision loss. The occurrence of diabetic retinopathy will result in the disturbance of visual capability and can eventually leads to blindness.

The longer a person has untreated diabetes; there is higher chance of development of diabetic retinopathy. It may leads into vision loss. Diabetic retinopathy becomes symptomatic in its later stage. In the first stage, diabetic patients may not be aware of it [1].

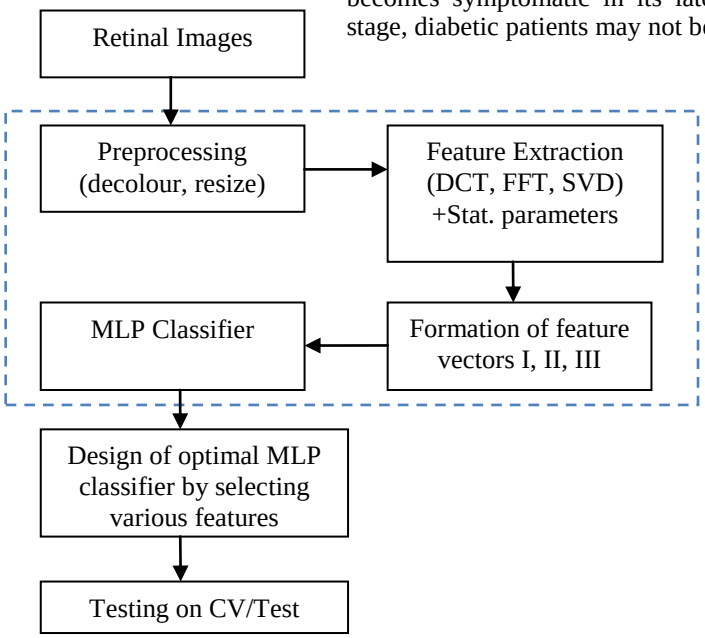

Fig. 1. Overview of the MLP classifier

To ensure that treatment is received in time, the eye fundus of diabetic patients needs to be examined at least once a year. The growing incidence of diabetes, the high cost of examinations and the lack of

specialists increase the work load of physicians and prevent many patients from receiving effective treatment. Automatic detection of clinical signs of DR can help ophthalmologists in the diagnosis of the disease, with the subsequent cost and time saving [2]. In this paper the authors proposed MLPNN based classifier for the detection of diabetic retinopathy. Three feature vectors are formed with the help of DCT, FFT, SVD and 9 statistical parameters. The MLP classifier is trained separately for these three feature vectors and their performance is compared. Fig.1 shows the architecture for proposed MLP based classifier. It consists of different modules: Retinal Fundus Image input, Preprocessing, Feature Extraction, Formation of feature vectors, Multi layer perception (MLP) based Classifier, Designing of optimal MLP classifier and Testing on CV/test dataset.

2. RELATED WORK

A computerized screening system can be used for fully automated mass screening of a large number of retinal images [3]. The identified abnormal retinal images are examined by an ophthalmologist. Definitely it will save the significant amount of workload and time for ophthalmologists. G. G. Gardner et al.[4], proposed a MLPNN to detect the presence of red lesions in image regions of size30 × 30 pixels. They achieved 73.8 % image-based accuracy. In 2001,Hayashi et al [5] presented computer aided diagnosis (CAD) system which assist physician in detecting abnormalities associated with fundus images of the retina. X. Zhang and O. Chutatape [6] used a Support Vector Machine. They reported a true positive rate of 90.6% with 2 false positives per image. The use of cross validation is not mentioned in these works. E. Grisan and A. Rugger [7] presented Image-based results. They obtained Sensitivity 75% and Specificity 99% for a database of 200 images and Sensitivity 83% and Specificity 98% for different database of 60 images laudio A. Perez Daniel A. Schulz, Carlos M Aravena [8] were proposed new cascade classifier based method for online optic disc detection. The method extracts Haar features from rectangular windows that are used to scan the digital image of the eye fundus. María García, María I. López, Jesús Poza [9] proposed lesion based and image-based criteria. The results achieved mean sensitivity of 95.9% for MLP and a mean positive predictive value of 85.7% for RBF. With an image-based criterion, the results achieved a 100% mean sensitivity, 87.5% mean specificity for MLP and RBF respectively.

3. DATABASE ACQUISITION

For detection of retinal images as normal or abnormal, DIARETDB0 database is used. The current database consists of 130 colour fundus images of which 20 are normal and 110 contain signs of the diabetic retinopathy (abnormal).

4. MULTI LAYER PERCEPTION NEURAL NETWORK

A multilayer perceptron (MLP) is a feed forward artificial neural network model that maps input data onto appropriate output data [10, 11]. A MLP consists of multiple layers of nodes in a directed graph, with each layer fully connected to the next one. Except for the input nodes, each node is a neuron (or processing element) with a nonlinear activation function. MLP utilizes a supervised learning technique called back propagation for training the network [12,13]. MLP is a modification of the standard linear perceptron and can distinguish data that are not linearly separable [14]. Multilayer perceptron (MLPs) extend the perceptron with hidden layers, i.e. layers of processing elements that are not connected directly to the external world.

5. FEATURE EXTRACTION

For detection of diabetic retinopathy the authors extracted transform domain and statistical features of retinal images. In transform domain features authors used DCT, FFT, SVD and for statistical parameters entropy, mean, standard deviation, average, Euler number, contrast, correlation, energy, homogeneity are used. Such features can contribute to classify images into normal and abnormal images by using Multi layer perception neural network [15,16,17]. Based on above feature extraction techniques three different feature vectors are formed as below:

Feature vector I: DCT with statistical parameters

Feature vector II: FFT with statistical parameters

Feature vector III: SVD with statistical parameters

5.1. *Case 1: DCT and MLP used classifier*

In this case we have used feature vector I as an input to MLPNN. The number of hidden layers (HL), number of processing elements (PEs), learning rule, transfer function and percentage of tagging for optimized MLP classifier is designed and tested on CV/test dataset. It is observed that single hidden layer gives satisfactory results. The minimum Mean Square Error (MSE) is obtained at12 PEs.

The optimal MLP NN is designed with different variations with percentage of CV data tagging, transfer function, learning rules, and step sizes. Then it is tested on training and CV dataset and results are

shown in table 1 to 4. Table 1 & 2 indicate classification accuracy on training data is 100% for normal and abnormal images.

Table1: Confusion matrix on training data using MLP

Output / Desired	o1(Abnormal)	o2(Normal)
o1(Abnormal)	98	0
o2(Normal)	0	19

Table2: Performance parameters for training data using MLP

Performance	o1	o2
MSE	0.012775911	0.005401346
NMSE	0.179927418	0.076068962
MAE	0.080502841	0.057402969
Min Abs Error	0.012287549	0.000687672
Max Abs Error	0.286675841	0.198700197
r	0.90660306	0.976495587
Percent Correct	100	100

The overall accuracy is = 100%

Table 3 & 4 show that on Cross Validation data, the classification accuracy is 100%.

Table3: Confusion matrix for CV data using MLP

Output / Desired	o1(Abnormal)	o2(Normal)
o1(Abnormal)	12	0
o2(Normal)	0	1

Table4: Performance parameters for CV data using MLP

Performance	o1	o2
MSE	0.001511807	0.001550574
NMSE	0.011114458	0.011399464
MAE	0.031651165	0.032038612
Min Abs Error	0.000205108	0.000306975
Max Abs Error	0.142204818	0.152210501
r	0.995418583	0.99527569
Percent Correct	100	100

The overall accuracy is = 100%

The overall accuracy of detection of diabetic retinopathy by using MLPNN based classifier with case I is 100% for normal and abnormal retinal images on train data and cross validation data respectively.

5.2. ***Case II: FFT and MLP used classifier***

In this case we have used feature vector II as an input to MLPNN by varying number of hidden layers (HL), number of processing elements (PEs), learning rule, transfer function and percentage of tagging for optimized MLP classifier design and tested on CV/test dataset. The MSE is obtained on training and CV data sets by using 09 PEs in hidden layer.

Designed MLP NN is tested on training and CV dataset and results are shown in table 5 to 8. Table 5 & 6 indicate that classification accuracy on training data is 99.49% for normal and abnormal images.

Table5: Confusion matrix on training data using MLP

Output / Desired	o1(Abnormal)	o2(Normal)
o1(Abnormal)	97	0
o2(Normal)	1	19

Table6: Performance parameters for training data using MLP

Performance	o1	o2
MSE	0.01075218	0.011414269
NMSE	0.079047577	0.083915105
MAE	0.070459426	0.071302159
Min Abs Error	0.000577614	0.001622906
Max Abs Error	0.498073281	0.558505037
r	0.963038154	0.960272436
Percent Correct	98.97959184	100

The overall accuracy is = 99.49%

Table 7 & 8 show that on Cross Validation data, the classification accuracy is 100%.

Table7: Confusion matrix for CV data using MLP

Output / Desired	o1(Abnormal)	o2(Normal)
o1(Abnormal)	12	0
o2(Normal)	0	1

Table8: Performance parameters for CV data using MLP

Performance	o1	o2
MSE	0.013181031	0.014153721

NMSE	0.185632857	0.199331569
MAE	0.068497543	0.067125926
Min Abs Error	0.009968323	0.001068525
Max Abs Error	0.372323893	0.394062414
r	0.958471605	0.960203605
Percent Correct	100	100

The overall accuracy of detection of diabetic retinopathy by using MLPNN based classifier for case II is 99.49% and 100% for normal and abnormal retinal images on train data and cross validation data respectively.

5.3. *Case III: SVD and MLP used classifier*

In this case we have used feature vector III as an input to MLPNN by varying number of hidden layers (HL), number of processing elements (PEs), learning rule, transfer function and percentage of tagging for optimized MLP classifier design and tested on CV/test dataset. The best MSE results were obtained on training and CV data by using 16 PEs in hidden layer.

Table9: Confusion matrix on training data using MLP

Output / Desired	o1(Abnormal)	o2(Normal)
o1(Abnormal)	97	0
o2(Normal)	1	19

Table10: Performance parameters for training data using MLP

Performance	o1	o2
MSE	0.020375566	0.019930281
NMSE	0.149796519	0.146522889
MAE	0.079444819	0.078617577
Min Abs Error	0.00061553	0.000824319
Max Abs Error	0.865254267	0.862418861
r	0.927384696	0.929190472
Percent Correct	98.97959184	100

The overall accuracy is = 99.48%

Designed MLP NN is tested on training and CV datasets and results are shown in table 9 to 12. Table 9 & 10 indicate that classification accuracy on training data is 99.48% for normal and abnormal images. Table 11 & 12 indicate the classification accuracy on cross validation data is 91.67%.

Table11: Confusion matrix for CV data using MLP

Output / Desired	o1(Abnormal)	o2(Normal)
o1(Abnormal)	10	0
o2(Normal)	2	1

Table12: Performance parameters for CV data using MLP

Performance	o1	o2
MSE	0.114359717	0.115166011
NMSE	1.61056601	1.621921324
MAE	0.215734315	0.212198771
Min Abs Error	0.003682107	0.000908932
Max Abs Error	0.890542608	0.917165149
r	0.358298859	0.381854719
Percent Correct	83.33333333	100

The overall accuracy is = 91.67%

The overall accuracy of detection of diabetic retinopathy by using MLPNN based classifier for case III is 99.48% and 91.67% for normal and abnormal retinal images on train data and cross validation data respectively.

6. RESULTS

The MLPNN based classifier is designed with different three feature vectors (cases I, II and III). The feature vectors are the collection of different features of preprocessed 130 retinal fundus images. Various parameters of MLPNN were changed progressively to set optimal neural network with best results and least complexity with every case. Table 13 provides comparison of selected parameters for MLP NN with three feature extraction methods.

Table13: Comparison of selected parameters for MLP NN with different given cases

Selected parameters	**Case I**	**Case II**	**Case III**
Hidden layer	1	1	1
Optimal PEs	12	09	16
Number of epochs	1000	3000	5000
Exemplars for cross validation	10%	10%	10%
Exemplars	90%	90%	90%

for training			
Step size	0.1	0.1	0.5
Transfer function	Tanh	Tanh	Tanh
Learning rule	Moment um	Momentu m	Momentu m
Time elapsed per epochs per exemplar	0.07ms	0.08ms	0.095ms

The work is carried out on Intel Celeron®2955U - 1.40 GHz computer system with 2GB RAM along with 64 bit operating system.

Table14: Comparison of % of classification accuracy for MLP NN with different given cases

Cases	**Percentage(%) of classification accuracy**	
	On Train Data	**On CV Data**
Case I	100	100
Case II	100	95.45
Case III	99.48	91.67

Table15: Accuracy, sensitivity and specificity percentages using MLP NN

Cases	**Accuracy (%)**	**Sensitivity (%)**	**Specificity (%)**
Case I	100	100	100
Case II	100	100	100
Case III	84.61	83.33	100

Table 14 provides comparison of % of classification accuracy for MLP NN with three feature extraction methods as well as Table 15 presents comparison of accuracy, sensitivity and specificity for MLP NN with three feature extraction methods.

7. DISCUSSION AND CONCLUSION

This paper proposed a MLPNN based classifier system for detection of retinopathy in retinal images. Different features vectors like DCT, FFT, and SVD along with statistical parameters were extracted and used as inputs to the classifier. Percentage of classification accuracy by the MLPNN based classifier is 100%, 100% and 91.47% for DCT, FFT and SVD based feature extraction methods respectively. It is observed from table14 and table15 that with DCT and statistical parameters formed feature vector is best input to design MLPNN based classifier for classification of normal and abnormal retinal images.

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