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Article *in* International Journal of Information Technology · May 2019

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ORIGINAL RESEARCH

An improved method using supervised learning technique for diabetic retinopathy detection

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Received: 4 November 2018 / Accepted: 22 May 2019

Abstract Now a day's intelligent diagnoses approaches are massively accepted for the purpose of advance analysis and detection of several diseases. In this work a supervised learning based approach using artificial neural network (ANN) has been proposed to achieve more accurate diagnoses outcomes for the case of diabetic retinopathy. Features extracted from the retina images are used as input to the ANN based classifier. Customized ANN architecture by estimating several entities of traditional ANN has been used to improve the accuracy of the method. The ANN architecture used in this work is feed forward back propagation neural network. Accuracy obtained for the proposed method is found to be 97.13%. The results suggest that proposed method can be used to detect diabetic retinopathy effectively.

Keywords ANN · Supervised learning · Diabetic retinopathy

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1 Introduction

In vivo eye, equivalent to an intelligent camera, which has an enormously complex organ structure that supports continuously to sends visual information into the brain. So, blindness is the major disability in alive, where as one of the major causes of blindness is diabetic retinopathy (DR) [1, 2]. Diabetic retinopathy generally two types, one is non-proliferative diabetic retinopathy (NPDR) and other is proliferative diabetic retinopathy (PDR) [3]. The initial phase of diabetic retinopathy is non-proliferative diabetic retinopathy. In NPDR stage, blood vessels damaged in the retina. Due to this tiny amount of blood and others organ fluid leak into the eye. In PDR stage, extra damaged blood vessels release special growth chemicals which is responsible for enough grow of blood flow. In this way retina becomes going to be damaged [3]. If these stages are detected early enough by some intelligent diagnoses, actual treatment of diabetic retinopathy is available to recover this disease.

Several extensive researches have been carried out by considering different intelligent computing technique to achieve more accurate diagnoses for the diabetic retinopathy diseases. Some of these are described in short in below. For DR, a novel scheme has been proposed to automatic detection of retinal lesions in [4]. In this novel scheme they considered four major steps: vessel extraction and optic disc removal, pre-processing, candidate lesion detection and post-processing. A comprehensive review on retinopathy detection and monitoring for automatic computer aided diagnosis (CAD) is reported in [5]. Using machine learning techniques, a scheme have been proposed to analysis diabetic retinopathy in [6]. An implementation approach scheme of automated diagnosis of diabetic Retinopathy for the same input data is proposed based on

Published online: 28 May 2019

multiclass SVM in [7]. Performance calculated in term of sensitivity (%), specificity (%), accuracy (%). Receiver operating characteristic (ROC) curves also used to analyze effectiveness of classification and estimated the value of Area under the ROC curve (AUC) is 0.96 which show that classifier performance is excellent. Using digital fundus images, a computer-based detection scheme for diabetes retinopathy stages is described in [8]. In this scheme, the automatic diagnosis of eye is conducted by the used of morphological techniques of image processing and SVM.

Higher order spectra application for diabetes retinopathy stages identification is proposed in [9]. Where 300 subjects are considered having five different eye diseases and SVM classifier is used to classify these into five classes. Author demonstrate the proposed method achieve sensitivity of 82% with specificity of 88% for the classifier. Whereas a screening tool based on artificial neural network is described for the purpose of automatic detection of eye health with the aspect of diabetic retinopathy by the authors mention in [10]. In this method a back propagation neural network is used to detected of diabetic retinopathy. Several filter techniques and network parameter are used to achieve best performance of the network. Authors reported the network achieved sensitivity of 88.4% with a specificity of 83.5% to detect diabetic retinopathy.

In the recent studies, several intelligence methods have been proposed by the researchers to detect DR as well as to get preclusion for progressive damage. Microaneurysms (MAs) Turnover based a novel and noninvasive early detection method for analysis of DR have been described in [11] with a high accuracy, where author considered two different approaches under the proposed methodology to diagnose the progression of DR. In the first approach, MAs turnover obtained using the traditional image analysis whereas in the second approach the author considered seven pathological features which are directly related to MAs turnover. Apart from the traditional image analysis a tree ensemble classifier based microaneurysms detection technique has been described in [12] for retinal images investigation. The performance of the classifier has been evaluated by using several retinal images as an input. However, DR detection is a critical analysis through Microaneurysms (MAs) Turnover. Specifically, retinal analysis using traditional retinal image analysis always required an expert's view to make a decision. In order to overcome this necessity, a framework has been proposed in [13] based on the multiple instance learning (MIL). Particularly in this method instance encoding is a major part to get robust classification result as mentioned by the respective authors. MIL is a kind of a weakly supervised-learning method has given away some benefit over automatic DR detection. The authors in [14] propose a deep MIL method based on convolutional neural network (CNN) for DR detection. The authors have used CNN for the patch-level estimation form the input DR images and then global aggregation for the DR image classification. Also, an end-to-end multi-scale scheme has been considered for DR lesions detection.

All the above mentioned paper has suggested good methods for DR detection but there is still room for improvement such as accuracy obtained in detection, complexity of the method used etc. The main objective of the work is to detect the DR method which can be effectively used in real hospitals. The aim of the proposed method is to suggest an improved method which detects the DR effectively. Considering the drawbacks of all the above mentioned work, an ANN based method for DR detection has been proposed. Performance of the method is enhanced to some extent using proposed method. The rest of the paper is organized as follows. Section 2 of the paper contains the supervised learning techniques, Sect. 3 contains proposed method, Sect. 4 contains the results and Sect. 5 contains the conclusion.

2 Supervised learning techniques

Supervised learning methods are generally applied for pattern recognition and classification. Recently there are many supervised learning algorithm has been used in different fields of engineering. Various types of supervised learning algorithms includes artificial neural network, support vector machine, decision trees etc. In this work artificial neural network (ANN) is chosen as pattern classification tool. From various ANNs, back-propagation network is used in this work [15]. It is a multilayer feed forward neural network. A feed forward neural network is shown in Fig. 1. It is a generalization of least mean square algorithm. The sensitivities are back-propagated through the network backward. The back-propagation neural network is used in this work to determine the epileptic and non-epileptic signals.

3 Proposed method

Proposed ANN based DR detection method consists of various steps which is described in the flowchart shown in Fig. 2. Detail description of the proposed method is shown in subsection below.

3.1 Inputs used

The inputs used in this work are the features extracted from the retinal image. The inputs used for validation of the proposed method has been obtained from UCI machine

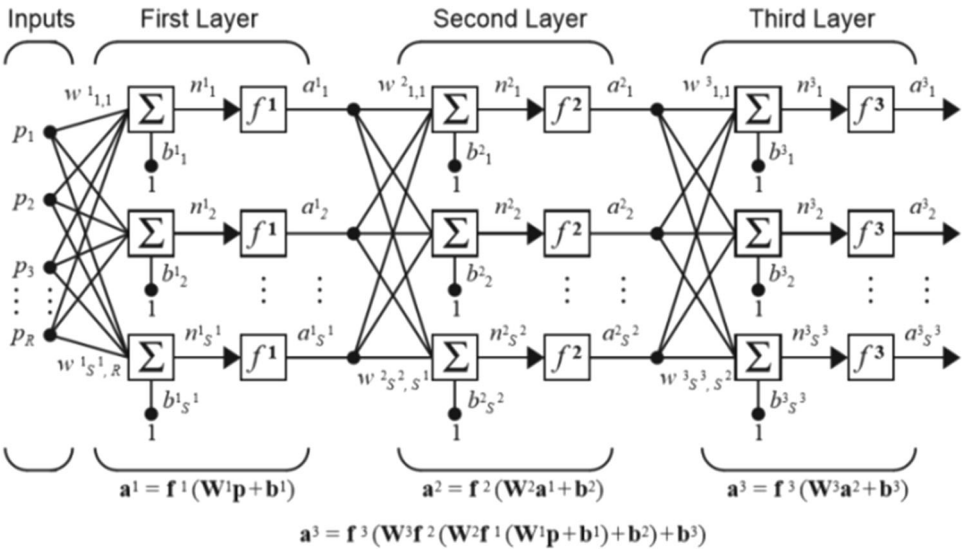

Fig. 1 Three layer feed forward neural network

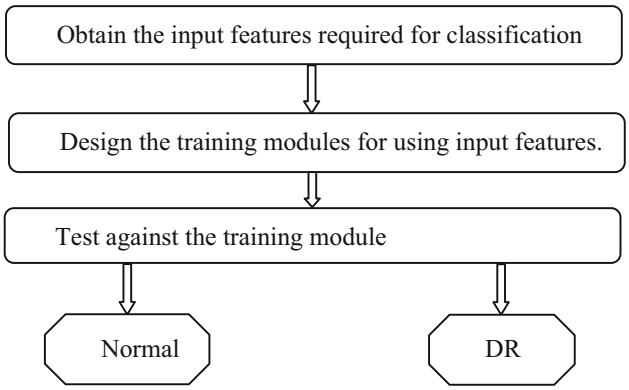

Fig. 2 Flowchart of the proposed method

learning repository [16]. The data has been collected from volunteers. This dataset contains features extracted from the Messidor image set to predict whether an image contains signs of diabetic retinopathy or not [17]. All features represent either a detected lesion, a descriptive feature of an anatomical part or an image-level descriptor. The data set has been divided to two groups, 90% of the data are used in training and remaining 10% are used for testing.

3.2 Design of the proposed method

The features obtained are given to the supervised learning techniques as input to the ANN based method. The neural network used here is a back-propagation neural network. The training algorithm used is a Lavenberg–Marquardt algorithm. After various trial and error methods using different number of neurons, transfer function, hidden layers, the final neural network is selected. Figure 3 shows the optimal neural network obtained. The optimal neural network obtained is a three layer network with 20-10-10 neurons in the hidden layer with tan-sig transfer function. After the network is trained it is tested with various unknown samples. The test results are discussed in the section below.

4 Results and discussion

Proposed ANN based method has been tested with various test samples. Performance of the proposed method has been evaluated in terms of percentage accuracy, specificity, sensitivity and F-scores. The performance of the proposed method is described in the section below.

4.1 Performance varying error goal

To achieve good performance the error goal should be less. Proposed DR detection method has been tested with varying error goal. Results of the ANN based DR detection method are given in Table 1. As the MSE decreases the

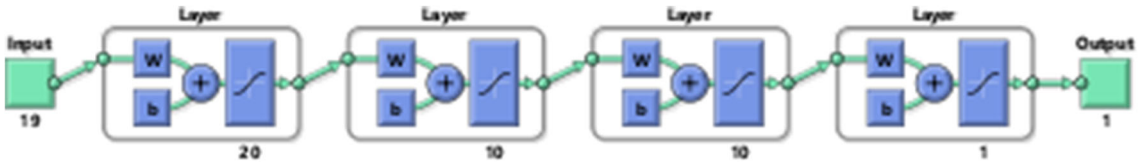

Fig. 3 Optimal neural networks obtained

Table 1 Performance varying error goal

Error goal	Accuracy (%)
0.1	80.50
0.01	83.10
0.001	97.13
0.0001	96.54

accuracy of the method increases. But after certain point the mean accuracy did not increases. The highest accuracy of the method is found to be 97.13% with MSE 0.001. Hence it is chosen as the optimal error goal.

4.2 Performance varying number of neurons

In ANN, estimating the number of neurons required for a task is difficult. The proposed method is tested varying number of neurons. Some of the test results varying number of neurons are given in Table 2. From Table 2 it can be observed that the accuracy of the method is found to be 97.13% with 41 neurons. Hence optimal number of neuron is chosen as 41 for this work.

4.3 Performance varying number of hidden layers

Estimating how many hidden layers should be used is also important. The proposed method is tested with varying number of hidden layers. Table 3 shows the results varying number of hidden layers. The highest accuracy is found with three hidden layers. Hence optimal number of hidden layers is chosen as three for the proposed work.

4.4 Comparison with other methods

Performance of the proposed method is compared with other methods in terms of accuracy and the methods used. Table 4 shows the comparison of proposed method with other methods. From Table 4 it can be observed that proposed method has highest accuracy among all the methods. Hence proposed method can be used effectively for DR detection.

5 Conclusion

In this work, a back-propagation neural network based method has been proposed for DR detection. Features are extracted from the retina image of DR and normal persons. Input features given to the classifier are features collected from various DR and non DR patients. After various trial and error methods final neural network is designed using back-propagation neural network architecture. Accuracy of the proposed method has been found to be 97.13% in recognizing DR. The proposed method can be used

Table 2 Performance varying number of neurons

Number of neurons	Accuracy (%)	Specificity	Sensitivity	F-scores
30-30-1	96.17	0.962	0.960	0.963
40-40-1	95.04	0.946	0.954	0.953
50-50-1	95.48	0.953	0.955	0.957
20-10-10-1	97.13	0.970	0.972	0.972
30-30-30-1	96.43	0.959	0.968	0.966
40-30-20-1	96.43	0.964	0.963	0.966
50-40-40-1	95.91	0.953	0.963	0.961

Table 3 Performance varying number of hidden layers

Number of hidden layers	Accuracy (%)	Specificity	Sensitivity	F-scores
2	96.17	0.962	0.960	0.963
3	97.13	0.970	0.972	0.972
4	96.43	0.959	0.968	0.966

Table 4 Comparison

Authors	Methods used	Overall accuracy (%)
Adarsh et al. [7]	SVM	95
Acharya et al. [8]	Digital methods	82
Acharya et al. [9]	Higher order spectra	82
Gardner et al. [10]	ANN	88.4
Proposed method	Back-propagation neural network	97.13

effectively in hospitals for monitoring patients with DR. The limitation of the proposed method is that if the images are not correctly obtained with accurate features, the effectiveness of the method may decrease. The future scope of the study is to take the images of the DR patients, use a suitable method for feature extraction and check the accuracy of the method with the patients.

References

1. Kocur I, Resnikoff S (2002) Visual impairment and blindness in Europe and their prevention. Br J Ophthalmol 86:716–722
2. Evans J, Rooney C, Ashwood F, Dattani N, Wormald R (1996) Blindness and partial sight in England and Wales: April 1990–March 1991. Health Trends 28:5–12
3. Kanth S, Jaiswal A, Kakkar M (2013) Identification of different stages of diabetic retinopathy using artificial neural network. In: Sixth international conference on contemporary computing
4. Sil Kar S, Maity S (2018) Automatic detection of retinal lesions for screening of diabetic retinopathy. IEEE Trans Biomed Eng 65:608–618
5. Agarwal S, Acharjya K, Sharma S, Pandita S (2016) Automatic computer aided diagnosis for early diabetic retinopathy detection and monitoring: a comprehensive review. In: Online international conference on green engineering and technologies, pp 1–7
6. Roychowdhury S, Koozekanani D, Parhi K (2014) DREAM: diabetic retinopathy analysis using machine learning. IEEE J Biomed Health Inf 18:1717–1728
7. Adarsh P, Jeyakumari D (2013) Multiclass SVM-based automated diagnosis of diabetic retinopathy. In: International conference on communications and signal processing, pp 206–210
8. Acharya U, Lim C, Ng E, Chee C, Tamura T (2009) Computer-based detection of diabetes retinopathy stages using digital fundus images. P I Mech Eng H 223:545–553
9. Acharya R, Chua C, Ng E, Yu W, Chee C (2008) Application of higher order spectra for the identification of diabetes retinopathy stages. J Med Syst 32:481–488
10. Gardner G, Keating D, Williamson T, Elliott A (1996) Automatic detection of diabetic retinopathy using an artificial neural network: a screening tool. Brit J Ophthalmol 80:940–944
11. Xu J, Zhang X, Chen H, Li J, Zhang J, Shao L, Wang G (2018) Automatic analysis of microaneurysms turnover to diagnose the progression of diabetic retinopathy. IEEE Access 6:9632–9642
12. Habib M, Welikala R, Hoppe A, Owen C, Rudnicka A, Barman S (2017) Detection of microaneurysms in retinal images using an ensemble classifier. Inf Med Unlocked 9:44–57
13. Costa P, Galdran A, Smailagic A, Campilho A (2018) A weakly-supervised framework for interpretable diabetic retinopathy detection on retinal images. IEEE Access 6:18747–18758
14. Zhou L, Zhao Y, Yang J, Yu Q, Xu X (2018) Deep multiple instance learning for automatic detection of diabetic retinopathy in retinal images. IET Image Proc 12:563–571
15. Yadav A, Swetapadma A (2015) A single ended directional fault section identifier and fault locator for double circuit transmission lines using combined wavelet and ANN approach. Int J Electr Power Energy Syst 69:27–33
16. UCI machine learning repository. https://archive.ics.uci.edu/ml/datasets/Diabetic+Retinopathy+Debrecen+Data+Set
17. Balint A, Andras H (2014) An ensemble-based system for automatic screening of diabetic retinopathy. Knowl Based Syst 60:20–27