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Support Vector Machine Neural Network Based Optimal Binary Classifier for Diabetic Retinopathy

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ABSTRACT: This paper explores the neural network as optimal binary classifier for diabetic retinopathy. Diabetic retinopathy is an eye syndrome caused by the impediment of diabetes and it can be detected prior for effective treatment. In this investigation, the sets of parameters describing diabetic retinopathy data are taken. In this multi layer neural network and principal component based performance analysis is explored. Selection of the optimal parameters such as number of hidden layers, learning rules and transfer functions are taken into consideration. The classification results are obtained through rigorous experimentation. The vision of patient may start to deteriorate as diabetes progresses and lead to diabetic retinopathy. In this paper to establish diabetic retinopathy, three models like multi layer perception (MLP), Principal Component Analysis (PCA) and Support vector machine(SVM) are explained and their performances are compared. An automated approach for classification of the disease diabetic retinopathy using images is presented. The designed classification structure has about 97 % sensitivity, 99% specifity and correct classification is calculated to be 95.7%. Testing grades were found to be complaint with the accepted results that are imitative from the physician's direct diagnosis. Result shows that this new neural network SVM model is more accurate than the other NN models. These results suggest that this model is effective for classification of Diabetic Retinopathy.

KEYWORDS: diabetic retinopathy, neural network, support vector machine, specifity,sensitivity

I. INTRODUCTION

Medical error becomes universal matter of international society. Diabetes is a group of metabolic diseases in which a patient has high blood sugar, either because the body does not produces enough insulin, or because the cell does not respond to the produced insulin. One of the common complications in diabetic is diabetic retinopathy. It is widely spread disease. Small blood vessels are damage by it which resulting loss of vision. The risk of disease increases with age. Therefore middle age and older diabetics are prone to diabetic retinopathy. There are two stages of diabetic retinopathy. Early stage of diabetic retinopathy is Non-proliferative diabetic retinopathy (NPDR). Tiny blood vessels within the retina leak blood in this stage. The leaking fluid causes the retina to swell or to form deposits called exudates. Proliferative diabetic retinopathy (PDR) is endeavour by eye to grow or resupply the retina with new blood vessels due to wide spread closure of the retinal blood supply. Many warning signs and circumstances of eye diseases could cause damage and blindness, if not detected and treated at early stage.

In this paper, an automated approach for classification of the disease diabetic retinopathy using the funds images is presented. The evolution of proposed diagnosis system of diabetic retinopathy has been performed by using sets of 140 images which is combination of normal, NPDR and PDR affected images. Pre-processing of images is performed on images. The original image is converted into gray scale image then Adaptive Histogram equalization is applied to improve the contrast of image. To reduce the size of image Discrete Wavelet Transform is applied. Noise is reduced by using Matched Filter Response. After processing of image is completed features are calculated. Then modelling techniques like MLP, PCA and SVM are used and their performance are calculated. Intelligently filtered specific information is provided by decision support system to enhance health care. Reducing medical errors, improving the quality of healthcare and guarantying the safety of patients are the most staid duty of the clinicians. The clinical

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guideline can enhance the security and quality of clinical diagnosis and treatment. Artificial Neural Networks have been employed as a widely used technique for designing decision support system. The decision support system (DSS) is any section of software that takes as input information about a circumstances and that produces as output inferences that can help practitioners in their conclusion and that would be judged by the program user. In medical diagnosis Artificial intelligence has been applied successfully. The measure of medical error is incredible, most of medical errors occurred by human factor could be avoided by computer system. After biological neural systems artificial neural networks are artificial intelligence paradigms, which are loosely modelled machine learning tools. They discover by instruction from past experience data and construct generalization on hidden data.

II. RELATED WORK

Various eye disease detection image processing, neural network algorithms are proposed in past. Many important eye diseases as well as systemic diseases manifest themselves in the retina. While a number of other anatomical structures contribute to the process of vision, this review focuses on retinal imaging and image analysis. Following a brief overview of the most prevalent causes of blindness in the industrialized world that includes age-related macular degeneration, diabetic retinopathy, and glaucoma, the review is devoted to retinal imaging and image analysis methods and their clinical implications.

Image processing with matched filter response, Fuzzy logic methods using discrete wavelet transform are proposed for eye disease diagnosis. Decision trees were proposed for diagnosis. Various neural network algorithms were used to develop diagnosis system such as Levenberg-Marquardt learning algorithm, classification tree analysis, Probabilistic Neural network , Bayesian Classification and Support vector machine and Multilayer Perceptron (MLP), Generalized Feed Forward neural network. Povilas and Saltenis had proposed neural network as a eye disease classifier. Sets of glaucomatous and healthy eyes are taken for investigation. A multi-layer neural network and the principal component analysis for feature reduction is explored. The network activation function log sig and the Levenberg-Marquardt learning algorithm have been applied and the results are achieved. The network should be properly evaluated on a larger set of input vectors used for network training and validation [2]. Guven and kara explore a diagnostic system using artificial neural networks (ANN) methods to identify the macular disease from Pattern Electro Retionography (PERG) signals. Implemented the Multilayer feed forward ANN trained with a Levenberg Marquart back propagation algorithm. The end results are classified as Healthy and Diseased. The designed classification structure has about 96% sensitivity, 100% specifity and correct classification is calculated to be 98%. The proposed method could point out the ability of design of a new intelligent assistance diagnosis system [3].

Guven and kara had represented ANN based diagnosis system for subnormal eye through the analysis of Electrooculography (EOG) Signals. Authors implemented the Levenberg Marquart back-propagation algorithm was implemented. The designed classification structure has about 94.1% sensitivity, 93.3 % specipity and positive prediction is calculated to be 94.1%. Results are classified as normal & subnormal eye [4]. Hitzl describes a linear discriminant analysis with forward stepwise variable selection algorithm and classification tree analysis for potential glaucoma suspects with and without visual field defects. In this Humphrey visual field analyzer was used to test the visual fields and Scanning laser tomography measured the optic nerve topography. The generalization error should be reported both in training, test sample and methods should be applied to select a appropriate training sample size for valid generalization [5].

S.Yan represented data mining framework to cluster optic nerve images obtained by Confocal Scanning Laser Tomography (CSLT) in normal subjects and patients with glaucoma. Data driven clustering approach presented with automated characterization. Self organizing maps and expectation maximization methods are used to partition the data into clusters which provided insights into potential sub-classification of glaucoma based on morphological features [6].

Kabari given in this research a hybrid of Neural Network and decision tree to classify eye diseases according to patient complain, symptoms and physical eye examination was given. Macular disease diagnosis assists through Concentrative on ANN auxiliary systems. The aim is to help the ophthalmologist interpret the output of the examination systems easily and diagnose the problem accurately [1]. R.Priya and Aruna had describe three models of Probabilistic Neural network (PNN), Bayesian Classification and Support vector machine (SVM) and their

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performances are compared for diagnose diabetic retinopathy. The features like blood vessels, haemmoraghes of non-proliferative diabetic retinopathy image and exudates of proliferative diabetic retinopathy image are extracted from the raw images using the image processing techniques and fed to the classifier for classification. Experimental result shows that PNN has an accuracy of 89.6 % Bayes Classifier has an accuracy of 94.4% and SV M has an accuracy of 97.6%.This work had give diabetic retinopathy diagnosis method which help to diagnose disease in early state [7]. X Liu, Johnson and Cheng had introduce some of the Intelligent Data Analysis issues and for addressing this issue properly several case studies where introduced .Bayesian networks, evolutionary computations, neural networks and machine learning techniques effectively used for case studies. Case studies are all related with forecasting for visual field deterioration, real world problem solving, screening for eye diseases, consistency checking for chemical structures [8].

Coopmans investigate translational research trajectories to the use of retinal photography for disease screening through the case study pertaining. It gives an inversion of the typical characterisation of research as process that begins at the bench and then moves down stream in linear fashion [9]. Osareh compare two methods for classification of retinal images after segmenting exudates regions. Support Vector machine and neural network classifiers are used to get good class separability between exudates and non-exudates classes. Results from both classifiers are nearly similar [10].

S.Sri Abirami explored the approach to classify normal and glaucoma affected image using fuzzy min-max neural network based on Data core. Two approaches are employed for the classification of close angle glaucoma and open angle glaucoma as arc amount based approach and angle width based approach. Membership function was designed for classifying neurons by considering the characteristics of data and influence of noise in fuzzy min-max neural network [11]. Yenganarayana describe soft computing paradigms that integrate with clinical investigation methods and knowledge. Computational intelligence methods including fuzzy logic, genetic algorithms and neural networks deal in appropriate way with imprecision, partial truth and uncertainty. To develop an intelligent system for diagnosis and prediction of glaucoma knowledge discovery process was used. The acquired knowledge is embedded in a fuzzy logic inference system [12].

Lisoba, Ifeachor and Szczepaniak describe variations in biomedical data which are affected by factors such as medication, environmental conditions, age, weight, mental and physical state. Consequently, clinical expertise is often required for a proper analysis and interpretation of medical data. This has led to the integration of signal processing with intelligent techniques such as artificial neural networks (ANN), expert systems and fuzzy logic to improve performance [13]. Klein describe the method in which eye detection and tracking are applied on testing sets, gathered from different images of face data with complex backgrounds. Experiments point out correct detection rate of 94.9%, which is indicative of the method superiority and high robustness. An eye-tracking and detection system can be divided into four steps as Face detection, eye region detection, pupil detection and eye tracking. This will result in declining the computational complexity and ignoring some factors. The eye region is well detected among these points. Colour entropy in the eye region is used to eliminate the irrelevant candidates [14].

Aliaa presented a method to automatically detect the position of the OD in digital retinal fundus images. The method starts by normalizing luminosity and contrast throughout the image using illumination equalization and adaptive histogram equalization methods respectively [16]. D. Vallabha proposed a method for automated detection and classification of vascular abnormalities in Diabetic Retinopathy using scale and orientation selective Gabor filter banks. A method to classify diabetic retinopathy subjects from changes in visual evoked potential spectral components was present [17]. S. Chaudhury addressed the problem of detecting blood vessels in retinal images. They have used the concept of matched filter for detection of signals to detect piecewise linear segments of blood vessels in retinal images and constructed 12 different templates to search for vessel segments along all possible directions [18]. The performances of three different networks in classification of eye disease data sets are compared in this article. Those include Multilayer Perceptron (MLP), Generalized Feed Forward (GFF) neural networks.

The Artificial Neural Networks (ANN) has been widely used as tools for solving many decision modelling problems. The assorted capabilities and properties of ANN like Input-Output mapping, Adaptively, Non-parametric, Non-linearity

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make it a superior alternative for solving inertly parallel distributive structure and difficult task in comparison of statistical techniques, where rigid assumptions are prepared for the model. Artificial Neural Networks being non-parametric, makes no assumption about the distribution of data and thus capable of letting the data speak for itself. As a result, where large database of relevant medical information are available ANN is solution for modelling complex medical problems [19]. The extracted knowledge from neural networks is transformed as rules which will help experts in understanding which combination of symptom, physical eye examination and patient's complain constituents have a major role in the eye problem. The rules contain information for sorting eye diseases according to their symptoms, physical condition and complain from the patient and knowledge acquired by neural networks from training on previous samples.

III. CLASSIFICATION

MLPs are feed-forward neural networks trained with the standard back-propagation algorithm. It is shown that a network having a single layer of threshold units could classify a set of points perfectly if they were linearly separable. For a set of N points, a two-layer network of threshold units with *N*- 1 unit in the hidden layer could exactly separate an arbitrary dichotomy data. Since it is very likely that one ends up in a "bad" local minimum, the network should be trained a couple of times (typically at least five times), starting from different initial weights [16]. Generalized Feed Forward networks are a generalization of the MLP such that connections can jump over one or more layers. Here you simply specify the number of layers, and the wizard will construct a MLP in which each layer feeds forward to all subsequent layers. In theory, a MLP can solve any problem that a generalized feed forward network can solve. In practice, however, generalized feed forward networks often solve the problem much more efficiently. A classic example of this is the two spiral problem. Without describing the problem, it suffices to say that a standard MLP requires hundreds of times more training epochs than the generalized feed forward network containing the same number of processing elements.

For classification we have used multilayer perceptrons (MLPs) are feed forward neural networks (FF NNs) trained with the standard back propagation algorithm. They are supervised networks so they require a desired response to be trained. Most NN applications involve MLPs. They learn how to transform input data into a desired response, so they are widely used for pattern classification. They are very powerful pattern classifiers. With one or two hidden layers they can approximate virtually any input –output map. They efficiently used the information contained in the input data. A meticulous and careful experimental study has been carried out to determine the optimal configuration of MLP NN model. Table 1 displays the variable parameters of MLP NN Model.

Table 1-Variable parameters of MLP NN model

S.N	Parameter	Typical Range	Optimal value
1	Hidden Layer	1 to 4	1
2	PE	1 to 25	19
3	Learning rule Back propagation algorithm	Momentum, conjugate gradient, Levenberg Maequardt,Step,Delta-bar-delta	Momentum
4	Transfer function of output layer	Linear,Lineartanh, Tanh	Tanh

The architecture of the network used in this study was as follows. A set of 10 hidden layers in the neural network was used with the number of inputs to the neural network (i.e. the number of neurons) is equal to the number of eye states. The neural network used is the feed forward back propagation with the performance function being the Mean Square Error (MSE) and the number of iterations was 1000 and the maximum allowed error was 10-5.

A. Principle Components Analysis (PCA)

It is a well known statistical procedure that can be used to derive important features by reducing the dimensionality of a given input vector without losing information. Principle Component Analysis (PCA) is a mathematical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variable into a set of

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values of uncorrelated variable called principle components. The number of principles components is less than or equal to the number of original variables. This transformation is defined in such a way that the first principal component has as high a variance as possible (that is, accounts for as much of the variability in the data as possible), and each succeeding components in turn has the highest variance possible under the constraint that it be orthogonal to (uncorrelated with) the preceding components. Principle components are guaranteed to be independent only if the data set is jointly normally distributed. PCA is sensitive to the relative scaling of the original variables. Depending on the field of application, it is also named the discrete Karhunen-Loeve transform (KLT).

Now, it is mostly used as a tool in exploratory data analysis and for making predictive models. PCA can be done by Eigen value decomposition of a data covariance matrix or singular value decomposition of data matrix. The results of a PCA are usually discussed in terms of component scores (the transformed variable values corresponding to a particular data point) and loading (the weight by which each standardized original variable should be multiplied to get the component score). PCA is the simplest of the true Eigen vector-based multivariate analyses. Often, its operation can thought of as revealing the internal structure of the data in a way which best explains the variance in the data. If a multivariate dataset is visualized as a set of co-ordinate in a high-dimensional data space (1 axis per variable), PCA can supply the user with a lower-dimensional picture, a ''shadow'' of this object when viewed from its (in some sense) most informative viewpoint. This is done by using only the first few principal components so that the dimensionality of the transformed data is reduced.

B. Nearest-Neighbor classifier

In this classification technique, we simply find all the training examples that are relatively similar to the attributes of test example. These examples are known as nearest neighbors and can be used to determine the class label of the test example. A nearest neighbor classifier represents each example as a data point in a d-dimensional space, where d it the number of attributes. The justification for using nearest neighbor is best explained by following saying: ''if it walks like a duck, like a duck, and looks like a duck, them its probably a duck'' [9]. Or we can say, since the neighbor is nearby, it is likely to be the same class as that object.

C. Support Vector Machine (SVM)

This technique has its roots in statistical learning theory and it has shown very promising results in many practical applications, from handwritten digit recognition to text categorization. It also works efficiently with high dimensional data and avoids the problems associated with dimensionality. An SVM training algorithm builds a model that assigns new examples of the separate categories are divided by a clear gap that is as wide as possible as shown in Fig. 1 New examples are then mapped into that same space and their category is predicted, based on which side of the gap they fall on. A support vector machine constructs a hyper-plane or set of hyper planes in a high-dimensional space and a good separation is achieved by the hyper-plane that has the largest distance to the nearest training point of any class, these nearest points are called as support vectors.

IV. RESULTS

The results for NN classification approach for testing samples were obtained using a NN classifier for different eye states of diabetic patients. In scrupulous, model achieved the highest overall classification accuracy, in which it achieved an overall accuracy of 94% compared to the 89.5% accuracy achieved. It can be concluded that model is the best overall model in this classifier in terms of accuracy and in computational time for both training and classification. This ease and solidity in the structure indicates the feasibility of the MLP NN for the online implementation, and the hardware implementation. With chosen optimal parameters of MLP NN, when it is retrained 5 times and tested over cross validation (unseen data sets) five times, the average (and best respectively) classification of 95.7% , 98% overall accuracy, sensitivity 97%, specificity 99% are achieved which shows consistent performance than other NN models and the system runs in a 0.000001 millisecond. It also implies that the MLP NN as a classifier for this work possesses more learning ability than the other NN's. It was found that the MLP neural classifier has the advantage of reducing misclassifications among the neighbourhood classes compared to other NN classifiers as per the confusion matrices. It has provided consistent classification accuracy for both, healthy and diseased instances.

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V. CONCLUSION

This learning confirms that MLP NN artificial neural networks outperforms previous NNs and offer a useful approach for diagnostic algorithms for diabetic patients. Extra studies with larger numbers of real samples are required to better assess the usefulness of artificial neural networks. This study confirms that MLP NN artificial neural networks out performs other NNs and can offer a useful approach for developing diagnostic algorithms for eye diseases. Advance developments in each step of algorithm are required to improve the overall performance of computer aided detection and diagnosis algorithms. Result shows that this new neural network SVM model is more accurate than the other NN models. These results suggest that this model is effective for classification of Diabetic Retinopathy. It is observed that MLPNN is the fastest network, simple in design and synthesis, the lowest average MSE, highest accuracy and ROC analysis is perfect approaching unity.

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