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Support Vector Machines and Adaptive-Network-Based Fuzzy Inference Systems in medical diagnosis

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Abstract-In this Study, Support Vector Machines and Adaptive- Network- Based Fuzzy Inference Systems are used in diagnosing acute nephritis disease and heart disease (Data is on cardiac Single Proton Emission Computed Tomography images). Each person is classified into two groups infected and non-infected for both diseases. In medical diagnosing, accuracy plays a key role because a mistake may ultimate death or extremely harmful in long term. In this paper we propose SVM and ANFIS methods and compare them with previous results, and we show that these results are more accurate than prior models. In this research data were obtained from UCI machine learning repository in order to diagnose diseases. SVM has been used in diagnosing acute nephritis disease and it could classify the entire test data's. ANFIS model were used in diagnosing heart attack and it could classify 94.5% of patients.

Keywords: *adaptive network based fuzzy inference system, support vector machine, medical diagnosing, principle component analysis.*

1. Introduction

Computer based medical diagnosing is proposed because of the following reasons: first, a number of studies have shown that physicians do not have enough time to discuss every aspect of the diagnosis and treatment plan with the patients. Secondly, studies also suggest that even if patients are given the time and opportunity to speak with their physicians, they often hesitate to ask certain types of questions. Third, inexperienced physicians do not have enough experiment in diagnosing some certain diseases [1]. ANFIS and SVM are both very powerful ways that can help physicians to diagnose different diseases, most applications of mentioned methods in medicine are classification problems; that is, the task is on the basis of the measured features to assign the patient to one set of few classes.

Qeethara Kadhim Al-Shayea [2] presented medical diagnosing heart and nephritis disease which was realized by using multilayer perceptron artificial neural network with Levenberg-Marquardt back propagation algorithm.

A. Karlas, et al. [3] showed that with using EEG signals Myocardial Ischemia, Ventricular Tachyarrhythmia, Atrial Fibrillation, health state can be classified using artificial neural networks. K. Usha Rani [4] used Multilayer perceptron artificial neural network in heart disease diagnosing. Svetlana Simić, et al. [5] revealed that rule base fuzzy logic can be used in migraine diagnosing with acceptable accuracy, since in medical cases all answers are fuzzy, using this method seems to be useful. Abdulhamit Subasi [6] depicts that adaptive neuro-fuzzy inference system together with wavelet feature extraction can be used in epileptic seizure detection with acceptable accuracy. Zhang,et al. [7] proposed a method in developing a fully automated computer aided diagnosis system to help radiologist in detecting and diagnosing micro-calcifications in digital format mammograms.

2. Classification Methods

2.1. ANFIS

System modeling with conventional methods is not well suited to dealing with uncertainty. In contrast a fuzzy inference system by employing fuzzy if-then rules can model a quantitative aspect of human knowledge and reasoning process without employing quantitative analyses. Figure.1. shows a basic structure of ANFIS system[8].

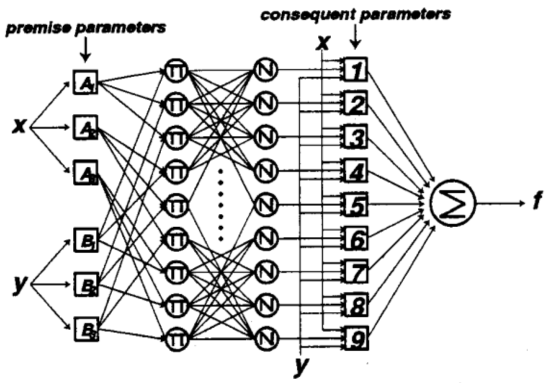

Fig.1. ANFIS structure

There are two types of variables in ANFIS model linear and nonlinear parameters. Linear parameters which are used in the consequent part are updated using LSE but nonlinear parameter which are in the premise part are updated using gradient decent. The following formulas show how gradient decent updates a parameter [8].

$$O_i^k = O_i^k(O_1^{k-1}, \dots O_{\#(k-1)}^{k-1}, a, b, c, \dots) \quad (1)$$

$$E_p = \sum_{m=1}^{\#(L)} (T_{m,p} - O_{m,p}^L)^2 \quad (2)$$

$$E = \sum_{p=1}^{p} E_p \quad (3)$$

$$\frac{\partial E_p}{\partial O_{i,p}^L} = \sum_{m=1}^{\#(k+1)} \frac{\partial E_p}{\partial O_{m,p}^{k+1}} \frac{\partial O_{m,p}^{k+1}}{\partial O_{i,p}^k} \quad (4)$$

$$\frac{\partial E_p}{\partial \alpha} = \sum_{O^* \in S} \frac{\partial E_p}{\partial O^*} \frac{\partial O^*}{\partial \alpha} \quad (5)$$

$$\frac{\partial E}{\partial \alpha} = \sum_{p=1}^{p} \frac{\partial E_p}{\partial \alpha} \quad (6)$$

The mentioned method can be used in medical diagnosis where features are not crisp.

2.2. PCA

In this data set as there is high dimensionality in the number of features, we are interested to find a mapping from the inputs in the original 44-dimensional space (number of input features) to a new 6-dimensional space, with minimum loss of information. This can be achieved using PCA algorithm [9].

2.3. SVM

A support vector machine constructs a hyper plane in a high-dimensional space, which can help classification tasks. Though, a good separation is achieved by the hyper plane that has the largest distance to the nearest training data points of any class, since in general as much the margin is large the lower the generalization error of the classifier would take place.

3. The Proposed Diagnosis Model

Adaptive network-based fuzzy inference system is widely used in classification, forecasting and problem solving. In this study ANFIS is used in diagnosing heart disease, as there are 44 features we use PCA with 6 feature outputs to reduce dimensionality, and in the case of ANFIS we choose model with 2 bell shape membership functions in the input.

In diagnosing acute nephritis disease we chose support vector machines with Gaussian Radial Basis Function kernel to get the best result.

4. Experimental Results

4.1. Data

Symptoms, images or signals are the data used in medical diagnosis. The data set is obtained from UCI Machine Learning Repository.

4.2. Heart Disease Data

This data set is consist of 267 SPECT image sets (patients) with 44 continuous feature patterns which were created for each patient. We chose 80 sample used in training the network while 187 samples used in testing the network.

In this part as it is mentioned we used ANFIS and PCA method simultaneously, then we compared the result with artificial neural network which was used in [2]. Finally we show that by using ANFIS better result is reachable.

Fig.2. shows MLP artificial neural networks with Levenberg-Marquardt algorithm prediction Error on 100 different experiments with different initial weights.

It can be seen from Fig.2. That the least percentage error on data is about 8% so having 95% accuracy seems not to be reachable as claimed in [2].

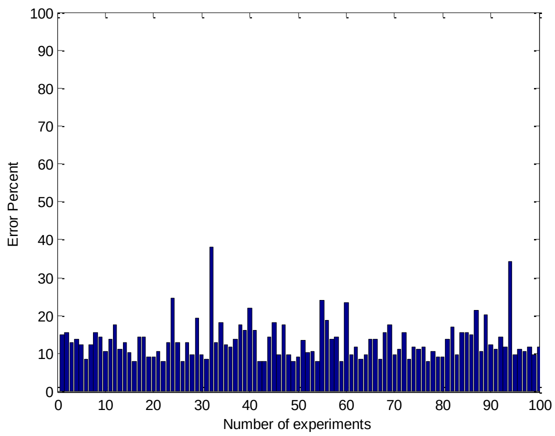

Fig.2. MLP Error on test data

But as mentioned earlier by employing PCA with the output of 6 combined features, and ANFIS with two Gaussian membership functions in the input layer this error can be reduced up to 5.5%.

4.3. Acute Nephritis Diagnosis Data

This dataset contains 120 patients. 90 samples are used for training the network while the rest are used in testing the network. There are 6 features to diagnose this disease: Patient's body temperature {35C-42C}, Occurrence of nausea {yes, no}, Lumbar pain {yes, no}, Urine pushing (Continuous need for urination) {yes, no}, Micturition pains {yes, no} and Burning of urethra, itch, swelling of urethra outlet {yes, no}.

[2] Claimed that by employing Neural network 99% accuracy can be achieved. We have simulated this result on 100 different training and testing data the result shows that neural network can be used as a powerful method, Fig.3. Shows Average percentage error on test data on each experiment.

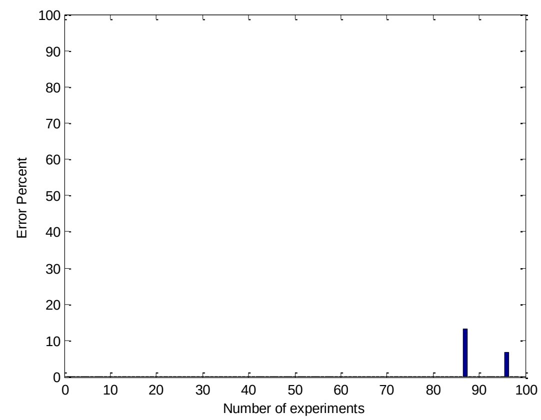

Fig.3. Average percentage error with using MLP

From Fig.3 it can be seen that in 87th experiment and in 96th experiment there exist some errors. In average there is 2% error with standard deviation of 1.4. So we proposed support vector machine that can reduce these errors, even reducing one percent error may cause someone to become healthy. By employing SVM, the accuracy on prediction can be reached to 100%.

5. Conclusion

Through the comparison of ANN, ANFIS in medical diagnosing, it is observed that the structure of detecting heart disease is far more complex and combined with uncertainty to be modeled with ANN. So ANFIS is proposed to cover all uncertainties and showed better results (94.5% accuracy in comparison to 92% accuracy of ANN). Similarly the comparison between SVM and ANN demonstrate that due to the structure of acute nephritis disease better result in detecting infected patients could be achieved through using SVM (100% in comparison to 98%)

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