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Enhance the Performance of Back Propagation Algorithm Using Proportional Conflict Redistribution Rule for the Diagnosis of Hypertension

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***Abstract* -** The objective of this study is to diagnose the patients with hypertension using Artificial Neural Network. Learning rate and momentum coefficient are the parameters used to construct network. The values of parameters are selected randomly and then the values are increased or decreases in every step iteratively. The topologies like Number of hidden layers, number of hidden nodes and the type of activation functions are also used to construct network. In order to improve the accuracy of the network, the result obtained by Back Propagation algorithms has been fused using Proportional Conflict Redistribution (PCR) rule. The output of the Back Propagation networks is considered as the primary diagnosis results and fused this result with Proportional Conflict Redistribution (PCR) rule to get the final results. Fusion method proposed in this paper is to enhance the target performance and reduce the uncertainty level. The experimental result shows that the fusion method produced higher accuracy and lower level of uncertainty.

***Keywords* -** Hypertension, Fusion, Back Propagation, uncertainty, Diagnosis

I. INTRODUCTION

Back Propagation Neural Network and Dempster-Shafer evidence theory are the wide range of applications in the field of information fusion [1]. Initial assessment of the hypertensive patient should include a complete history and physical examination to confirm a diagnosis of hypertension. The diagnosing process include collection of data, analysing the collected data, recognition and classification of data [3]. The expert system has developed, in which the doctors are interacted with the computer to diagnose the diseases. The expert system is a program based on the knowledge, which emulates a human expert in specific field.

The National Heart, Lung and Blood Institute (NHLBI), is identified several factors that increase the risk of hypertension. The high blood pressure is related to the interaction of genetic factors and environmental factors. The value of the genetic factors is an exact amount which can be directly quantified. Environmental factors include lifestyle, reasonable diet, obesity and age [14]. The high blood pressure is caused by the interaction of genetic factors and environmental factors. The attributes used for the diagnosis has been categorized into two namely qualitative and quantitative. The qualitative attributes have been measured by interviewing the patients and the quantitative attributes have been measured using some laboratory tests [18]. When the output of the network is continuous, it performs prediction. When the output of the network is discrete values, it does classification.

The goal of this system is to evaluate artificial neural network for the diagnosis of hypertension on the selected symptoms of the person. Each patient is diagnosed with hypertensive and non-hypertensive. Two different datasets such as a real time hypertension database and Dominican Hypertension (DHTN) are used to investigate the performance of the proposed study [19]. A real time hypertension database is collected with 11 attributes and the common hypertension database of Dr Waldon Garris School of Medicine collected from the Dominican Hypertension (DHTN) with 5 attributes from website.

Datasets used in this research contains patient subjects with male and female, between 25 to 75 years old. Each subject consists of attributes such as age, sex, BMI, family history, smoking habits, alcohol consumption, diabetes, Systolic Blood Pressure, Diastolic Blood Pressure, cholesterol and uric acid. Depending on the value of Lipoprotein (LDL and HDL), Triglyceride and Total cholesterol the value of the variable cholesterol is estimated. From the risk factor of hypertension, all subjects with attribute values are normalized. In order to diagnose the hypertension, the average of three or more DBP and SBP readings have been taken. The value of the attribute Smoking is defined as current or discontinued during the last 6 months. The value of heredity is defined as a mother, father, sister or brother with diagnosed with hypertension. BMI is calculated according to the value of the person's body weight and height. Based on the value of LDL, HDL, Triglyceride and Total cholesterol the attribute lipid profile are estimated.

The sample data are prepared on the basis of symptoms and risk factors. The normalized data are given to the neural network model. The objective of the network is to decide whether an individual have hypertension, based on personal data and the results of medical examinations. The data are trained to identify the hypertension pattern. The results of different experts are combined using Dempster-Shafer Theory to improve the diagnosis result [19]. The diagnosed result is denoted as 0 or 1, which represented that the patient was normal or suffering from hypertension.

Dempster-Shafer approach is reported to produce good results, but has more complex in calculations. Dempster derived the combination rule and Shafer extended Dempster's theory for multiple independent sources of information to define the frame of discernment, degree of belief [20].

This paper is organized as follows: Section II brief about methods and materials, summarizes the Back Propagation algorithms, fundamentals of Dempster-Shafer Theory, and fusion method to combine the BP neural network and Dempster-Shafer theory, Section III describes the experimental results, Section IV concludes the paper.

II. METHODS AND MATERIAL

A. Back Propagation Neural Network

Artificial Neural Network is defined by its architecture, neuron model and the learning algorithm. The network consists of an input layer, hidden layer and output layer. All the inputs are connected to the neurons in the input layer and the bias of each neuron has been connected to all neurons in the network [13]. The neurons in the first layer have been connected to all neurons in the hidden layer and the last layer produces the output of the network.

Figure 1 shows the architecture of Neural Networks with 11 input nodes, 1 hidden layer with 7 nodes and 1 output layer with one node.

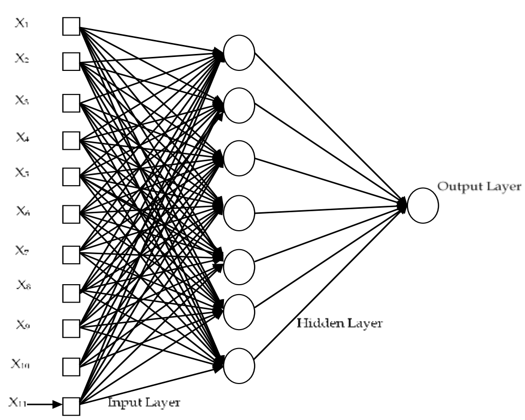

Figure 1. System Architecture for the Diagnosis of Hypertension

The data are separated into inputs and targets. The target values are identified with 1's as hypertension and with 0's as non-hypertension, depending on the severity of the patients. The network is trained by the method of supervised learning and is fed with 11 attributes consisting of symptoms of the patients. The network is tested by considering different amounts of data to get a good degree of accuracy. Combination rules are the special types of aggregation methods in which data are combined from multiple sources. These multiple sources provide different assessments. Dempster-Shafer Theory is based on these independent sources. In order to get the final diagnosis, the evidences are combined using Proportional Conflict Redistribution rule (PCR) [20].

B. Fusion method

The normalized data from the data sample is taken as the input to the Backpropagation algorithms. The outputs of the BP Networks are considered as the new Basic Belief Assignment (BBA) such as m_1, m_2 and m_3, and then these BBAs are fused using Dempster-Shafer Theory to get the final result.

The fusion operators proposed in this research is conjunctive operator. There are two components which involved in the fusion rule such as conjunctive operator and the degree of conflict. It has been defined by:

1) Conjunctive operator:

The combination or join is calculated from the aggregation of two BPA's viz., m_1 and m_2. It can be defined as follows:

$$\boldsymbol{m_\wedge(A) = m_1(A).m_2(A) + m_1(A).m_2(A\cup B) + m_2(A).m_1(A\cup B)} \quad (1)$$

$$\boldsymbol{m_\wedge(B) = m_1(B).m_2(B) + m_1(B).m_2(A\cup B) + m_2(B).m_1(A\cup B)} \quad (2)$$

$$\boldsymbol{m_\wedge(A\cup B) = m_1(A\cup B).m_2(A\cup B)} \quad (3)$$

2) The degree of conflict:

The degree of conflict between the sources is defined as:

$$\boldsymbol{K = m_\wedge(A\cap B) = m_1(A).m_2(B) + m_2(A).m_1(B)} \quad (4)$$

If the degree of conflict k is close to 0 then the BBA of m_1(.) and m_2(.) are not in conflict. When the degree of conflict k is close to 1 then the BBA of m_1(.) and m_2(.) are in total conflict. Any value between 0 and 1 indicates partial conflict. Figure 2: shows fusion methodology.

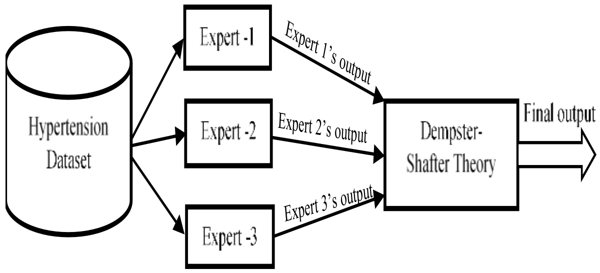

Figure 2. Proposed Fusion System

The diagnosed result of Expert-1, Expert-2 and Expert-3 are the output of three different neural networks are considered as three sources namely m1, m2 and m3. These source are input to Dempster-Shafer Theory. As per pair wise combination, the result of the first two sources (m1, m2) are combined, and again combined with this third source (m3) and can be notated as m123. The conjunctive rule for the combination of these sources can be written as:

$$\boldsymbol{m_{conj}}(\boldsymbol{X}) = \sum_{A\cap B=x} \boldsymbol{m_1}(\boldsymbol{A})\boldsymbol{m_2}(\boldsymbol{B}) \quad (5)$$

And it can be written as:

$$\boldsymbol{m_{12}}(.) = \boldsymbol{m_1} \oplus \boldsymbol{m_2} \quad (6)$$

$$\boldsymbol{m_{123}}(.) = \boldsymbol{m_{12}} \oplus \boldsymbol{m_3} \quad (7)$$

The conjunctive operator is used to reduce the uncertainty but can be used only if one of the experts is reliable. The combination rule proposed in this research is to combine the output of the different experts. If the value of the denominator is non-zero, then the degree of conflict *k* is less than one.

C. The Proportional Conflict Redistribution (PCR) rule

The Proportional Conflict Redistribution (PCR) rule is used to transfer total or partial conflicting masses. The common principle of PCR rule is to redistribute the conflicting mass, after the conjunctive rule has been applied. Dezert and Smarandache proposed a list of Proportional Conflict Redistribution (PCR) rules such as PCR_1 to PCR_6 according to distributing proportion [13]. The PCR_1 to PCR_5 is used to combine only two sources and PCR_6 is given for more than two sources, since it processed backwards on the track of conjunctive rule and it redistributes conflicting belief. The following are the steps to evaluate PCR_6 rule:

Step 1. Load the data from hypertension dataset
Step 2. Divided the data set into training and testing
Step 3. Diagnose the hypertension using BackPropagation Neural Network training algorithms
Step 4. Calculate the Basic Belief Assignment and uncertainty for the primary sources
Step 5. Calculate the conjunctive rule
Step 6. Calculate the Degree of conflict
Step 7. Repeat the steps for the current pattern of n-1 sources
Step 8. The conflicting quantitative mass k is redistributed only to the elements involved in conflict A and B but not to AUB. Therefore $m_1(A).m_2(B)$ is redistributed to A and B proportionally to their quantitative masses assigned by the sources or experts $m_1(A)$ and $m_2(B)$.
Step 9. Adding all the corresponding mass to get m_{pcr6}

III. RESULTS AND DISCUSSION

The performance measures such as True Positive, False Positive, False Negative and True Negative are calculated. The experimental results of the test sets are presented as a confusion matrix. The accuracy can be calculated as the trace of the matrix divided by the total sum of the entries. The confusion matrix provides where the misclassification had occurred. Generally, a confusion matrix contains information about the actual and the predicted classes. In the confusion matrix, the columns represent the test data, while the rows represent the labels assigned by the classifier. The following table shows the confusion matrix which is used to calculate diagnostic performance.

Table 1. Confusion Matrix

Original Classes	Predicted classes by the classifier	
	Disease Present	Disease Present
Positive	**TP**	**FN**
Negative	**FP**	**TN**

It summarizes the number of instances predicted correctly or incorrectly by a classification model. In a two-class classification problem with two predefined classes namely positive diagnosis and negative diagnosis are the classified test cases and are divided into four categories:

1. True Positives (TP) - correctly classified positive cases
2. True Negatives(TN)-correctly classified negative cases
3. False Positives(FP)-incorrectly classified negative cases
4. False Negatives(FN)-incorrectly classified positive cases

Based on these categories the procedure accuracy showed that the proportion of the diseases in the test dataset was correctly recognized by the expert. Accuracy is that the algorithm predict the probability correctly predicted positive and negative samples. Objective is to compare different neural networks with fusion method. The experimental results are evaluated on the complete data set. In order to identify the best Back Propagation method, the accuracy of the network is evaluated.

The accuracy of each of network provides beliefs. The beliefs and uncertainty values are calculated from the result of three networks. The results of combination of three sources are evaluated by conjunctive rule as beliefs. Then these beliefs are combined to receive final diagnosis result using Proportional Conflict Redistribution rule.

The diagnosed result of BP Algorithms are considered as three sources such as m_1, m_2 and m_3. As per pair wise combination, the result of the first two sources (m_1, m_2) are combined and the result again be combined with the third sources (m_3) and can be notated as m_{123}. The confusion matrix shows that the class 1 points to percentage of positive to hypertension and class 0 points to percentage of negative to hypertension. The value for A, B and AUB are calculated from the confusion matrix as follows:

$$\boldsymbol{A = True\ Positive + True\ Negative}) * \boldsymbol{100(Correct\ Diagnosis)} \quad \textbf{(8)}$$

$$\boldsymbol{B = False\ Negative * 100(Wrong\ Diagnosis)} \quad \textbf{(9)}$$

$$\boldsymbol{AUB = 1 - (A + B)(False\ Positive)} \quad \textbf{(10)}$$

Table 2. Comparison between BP algorithms and PCR_6 rule on data set

Methods	Correct Diagnosis Accuracy (%)	
	Real Data set	DHTN Data set
BP algorithm 1	92.800	92.400
BP algorithm 2	96.400	94.900
BP algorithm 3	93.300	93.100
PCR_6 Rule	99.494	99.430

The final result produced by PCR Rule is 99.49 % on real data set as shown in table 2. Artificial Neural Network algorithms are used to diagnose correctly and wrongly diagnosed cases. Therefore, result produced by fusion method is the best method. The algorithm was implemented in MATLAB since it increases the flexibility when computing large number of records

IV. CONCLUSION

In this paper, Proportional Conflict Redistribution rule has been presented to apply the fusion methodology on the results of different feed-forward back propagation neural network algorithms. The proposed algorithm makes the decision level fusion, which is to reduce the uncertainty of the information and increase the performance of the diagnosis system. The feed-forward back propagation neural network with supervised learning is proposed to diagnose the disease. For this process, first the primary classifier such as Feed Forward Back Propagation Neural Network algorithms are applied to dataset and these results are combined using Dempster-Shafer Theory. The experimental results produced by back propagation algorithms are compared with fusion method. The result shows that the fusion method using Proportion Conflict Redistribution rule from Dempster-Shafer Theory produces the highest accuracy.

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