Thyroid Disease Diagnosis Using Hybrid Intelligent Systems

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Abstract: Diagnosis is important issues in patient human treatment because it potency and accuracy in determining whether or not a patient encompasses a specific illness. There has been an outsized increase within the range of thyroid cases over the past few years. Diagnosis of thyroid disease is one among the necessary problems to develop a medical decision support system which is able to facilitate the physicians to require effective decisions. In this paper, we present diagnosis system based on hybrid intelligent systems (Nero-fuzzy network) as classifier tool. In this paper the neural network and fuzzy logic was combined to get the main features of artificial neural networks with those of fuzzy logic and to overcome some of the limitations of these techniques. The experimental results presented for different proportions of training/testing groups show a high classification accuracy and convergence in rates. The overall accuracy is 100% for training and in range between 87 % and 95% for testing. Thyroid disease datasets are taken from UCI machine learning dataset.

Key words: Thyroid disease, Diagnosis techniques, Neural network, Fuzzy logic, Nero-fuzzy classification

I. Introduction

Thyroid hormones produced by the thyroid gland helps control the body’s metabolism. The thyroid gland produces two active thyroid hormones, levothyroxine (abbreviated T4) and triiodothyronine (abbreviated T3). These hormones are important in the production of proteins, in the regulation of body temperature, and in overall energy production and regulation. The seriousness of thyroid disorders should not be underestimated as thyroid storm (an episode of severe hyperthyroidism) and myxedema coma (the end stage of untreated hypothyroidism) may lead to death in a significant number of cases [1-3].

Thyroid performance has a serious effect on many basic organs of the body. If thyroid disorder is not recognized on time, the patient will suffer from thyroid attack or coma which might lead to his death. Therefore, true diagnosis of thyroid disorder (Thyroid low efficiency and high efficiency) based on laboratory and clinical tests (disease symptom) are quite vital. The use of neural networks as a smart tool for classifying thyroid data is more accurate and flexible than other approaches.

Today, the use of smart methods in control systems, signal processing and sample recognition is a powerful tool in various scientific, technical and engineering, medical, and medical engineering researches has been greatly emphasized. An example of the use of such systems in different medical and medical engineering fields could be the following: research on various diseases, simulation of various body organs, and simulation of body metabolisms. In this regard, the research on thyroid disease and its diagnosis by means of smart neural methods has been emphasized by researchers. In neural network approach, it has been tried to pattern human’s brain functions and nervous system. This method is capable of solving complicated issues by relying on learning capacities and parallel processing in natural neural networks. Neural network capabilities and their application in different issues such as signal processing, sample recognition, patterning, identification, prediction, controlling, and optimization have been emphasized in recent decades and these structures are recently used with regard to their learning capability as a common method which is independent of proposed model [4-5].

In general, thyroid disease can be divided into two broad groups of disorders: those, which primarily affect the function of the thyroid gland and those, which involve neoplasms, or tumors, of the thyroid. Both types of disorders are relatively common in the general population. Most thyroid problems can be treated successfully. Abnormalities of thyroid function are usually related to production of too little thyroid hormone (hypothyroidism) or production of too much thyroid hormone (hyperthyroidism)[1-3].

In this study, thyroid disease diagnosis were realized by using hybrid intelligent system which is neuro fuzzy system. In Neuro Fuzzy system the neural network and fuzzy logic was combined to get the main features of artificial neural networks with those of fuzzy logic and to overcome some of the limitations of these techniques where neural network provides learning capability but cannot extract the knowledge from the connection weight and fuzzy logic provide the Interpretability by using if-then rules to describe the problem but cannot automatically
acquire or tune these rules. This paper is organized as follows: In section 2, explanation of thyroid dataset, in Section 3 Hybrid Nero-fuzzy Networks, in section 4 the architecture of used hybrid network. The experimental results are given in section 5 and finally conclusions are reported in section 6.

II. Thyroid Dataset
The thyroid dataset includes 215 instances. Each instance has five attributes plus the class attribute. All samples have five features. These are: T3, Total Serum thyroxin, Total serum triiodothyronine, Basal thyroid-stimulating hormone (TSH), and Maximal absolute difference of TSH value after injection of 200 micro grams of thyrotropin-releasing hormone as compared to the basal value. All attributes are continuous. Each of the instances has to be categorized into one of the three classes as shown in table 1:

<table>
<thead>
<tr>
<th>Class</th>
<th>Thyroid state</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>Normal (150 instances)</td>
</tr>
<tr>
<td>Class 2</td>
<td>Hyperthyroidism (35 instances)</td>
</tr>
<tr>
<td>Class 3</td>
<td>Hypothyroidism (30 instances)</td>
</tr>
</tbody>
</table>

Data-set is a thyroid gland database taken from the UCI machine learning repository was used as one of the benchmark datasets for testing classifiers [6].

III. Nero-Fuzzy System
The approach of Artificial Intelligence brings Human Intelligence in machines. There are many application areas (Scientific, Industrial and Commercial etc) in which analysis of uncertain, imprecise and incomplete information is required. Fuzzy Inference Systems and Neural Networks technologies look promising towards the design of Intelligent Systems. Fuzzy Inference System builds up of fuzzy IFTHEN rules. In FIS, inference is viewed as a process of propagation of elastic constraints. Fuzzy sets were introduced by Zadeh in 1965 as a means of representing and manipulating data that was not precise, but rather fuzzy [7].

In Fuzzy Logic, everything is a matter of degree. A Fuzzy Set is a set with un-sharp boundaries. There are two types of FIS namely, Takagi-Sugeno and Mamdani. Takagi –Sugeno Neuro Fuzzy model makes use of the integration of Back-Propagation to learn membership function and Least Mean Square Estimation to determine the co-efficient of linear combination in the rule’s conclusion whereas Mamdani Neuro Fuzzy model uses a supervised learning technique (such as Back-Propagation) to learn the membership function. The generation of Fuzzy Rule includes the following steps:

a) Fuzzification of Inputs.
b) Combination/Aggregation.
c) Rule generation.
d) Defuzzification.

An artificial neural network is a system based on the operation of biological neural networks. Another aspect of it is that there are different architectures, which consequently requires different types of algorithms, but despite of this, it is relatively simple. It is an adaptive, most often nonlinear system that learns to perform an input/output from data. Adaptive means that the system parameters (inputs and weights) are changed during operation, normally called the training phase. After the training phase, parameters are fixed and the system is tested to solve the problem. It is built with a systematic step-by-step procedure to optimize a performance criterion which is called learning rule. The input/output training data are basics of neural network technology, because they convey the necessary information to find the optimal solution. Flexibility is achieved in input/output map due to nonlinear nature of Neural Network processing elements. An input is presented to the neural network and a corresponding desired or target response set at the output [8].

There are three types of learning in Neural Network:

a) Supervised learning.
b) Un-Supervised learning.
c) Reinforcement learning.

An error is composed from the difference between the desired response and the system output. This error information is fed back to the system and adjusts the system parameters in the learning rule. The process is repeated until the performance is acceptable. Two types of network are there:

a) Feed-Forward.
b) Feed-Backward.

ANN-based solutions are extremely efficient in terms of development time and resources, and in many difficult problems artificial neural networks provide performance that is difficult to match with other technologies. For ANN, user has to specify a structure and learning algorithm. The combined approach of ANN and FIS overcomes from the drawbacks of each individual approach. FIS has learning ability whereas ANN has a strong Rule Base provides added advantage. The combined approach of FIS and ANN can be classified into three types of Neuro Fuzzy System [9]:

a) Cooperative
Nauck defines a hybrid Neuro-fuzzy system as a fuzzy system that uses a learning algorithm based on gradients or inspired by the neural networks theory (heuristic learning strategies) to determine its parameters (fuzzy sets and fuzzy rules) through the patterns processing (input and output. These systems share data structure and knowledge representation [10]. There are several different ways to develop hybrid Neuro-fuzzy systems; therefore, being a recent research subject, each researcher has defined its own particular models. These models are similar in their essence, but they present basic differences. The use of intelligent hybrid systems is growing rapidly with successful applications in many areas including process control, engineering design, financial trading, credit evaluation, medical diagnosis, and cognitive simulation. The computational process envisioned for fuzzy neural systems is as follows. It starts with the development of a “fuzzy neuron” based on the understanding of biological neuronal morphologies, followed by learning mechanisms. This leads to the following three steps in a fuzzy neural computational process [11]:

- Development of fuzzy neural models motivated by biological neurons.
- Models of synaptic connections which incorporates fuzziness into neural network.
- Development of learning algorithms (that is the method of adjusting the synaptic weights).

IV. The Architecture Hybrid Network

The architecture of the NF network based on Takaj fuzzy inference system consists of three layers; they represent an input layer, hidden layer represent fuzzification and rule layer, and output layer respectively. Figure 1 shows the structure of NF network.

Figure (1) Structure of Neuro Fuzzy Network

In order to derive a learning algorithm for a NF network with a gradient descent technique, the inference rule must use differentiable membership function type; in this work the Gaussian membership function will be used. The adjusted parameters in the NF network can be divided into two categories based on if (antecedent) part and then (consequent) part of the fuzzy rules. For example in the antecedent part, the mean and variance are fine-tuned, whereas in the consequent part, the adjusted parameters are the consequence weights. The gradient descent based on BP algorithm is employed to adjust the parameters in NF network by using training patterns.

To initialize network’s weights we use the following strategy:

- Weights from n input layer to n in hidden layer which represent center and variance for membership function shows in the following pseudo code.

```plaintext
z=1
For i = 1: FuzzySet_No
    For j = 1: InputVariable_No
        Wij = -IPattern_ijk
    End
    z=z+1
End
```

- Weights from hidden layer to neuron in output layer which represent the parameters of consequent for fuzzy rule base shows in the following pseudo code.

```plaintext
For z = 1: OutputVariable_No
    For j = 1: Hider_No
        Vz = OPattern_ik
    End
End
```
Where \( IPattern \) is a matrix for input of training data set and \( OPattern \) is a vector for output of the first training data set.

V. Experimental Results

Data set is dividing randomly into groups of training and testing set. Then each group will be normalized using Min-Max Normalization as the following equation:

\[
y = \frac{(x_{\text{max}} - x_{\text{min}}) \cdot (x - x_{\text{min}})}{(x_{\text{max}} - x_{\text{min}})} + x_{\text{min}}
\]

Where:
- \( x_{\text{max}} \): maximum number in input pattern.
- \( x_{\text{min}} \): minimum number in input pattern.
- \( x \): current value want to normalize.

This method performs rescaling for input where it is transmitted from a range of values to the new one. Often the ranges of values are mostly between 0 to 1 or -1 to 1 [12]. From practice we find the best value for training the network when the number of fuzzy set is 5 for each input and this is used for all groups, while there are three nodes in output layer. Table 2 shows the rate of training and testing set for each group and accuracies that result from neuro fuzzy system for each group.

<table>
<thead>
<tr>
<th>Group no.</th>
<th>Training set (%)</th>
<th>Testing set (%)</th>
<th>Training accuracy (%)</th>
<th>Testing accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10%</td>
<td>90%</td>
<td>100%</td>
<td>87%</td>
</tr>
<tr>
<td>2</td>
<td>30%</td>
<td>70%</td>
<td>100%</td>
<td>93%</td>
</tr>
<tr>
<td>3</td>
<td>60%</td>
<td>40%</td>
<td>100%</td>
<td>95%</td>
</tr>
</tbody>
</table>

Table 3 shows mean square error (MSE) of used neuro fuzzy network of each three group in this study:

<table>
<thead>
<tr>
<th>Group no.</th>
<th>Train samples</th>
<th>Testing samples</th>
<th>Network error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22</td>
<td>193</td>
<td>0.000162</td>
</tr>
<tr>
<td>2</td>
<td>64</td>
<td>151</td>
<td>0.0063</td>
</tr>
<tr>
<td>3</td>
<td>129</td>
<td>86</td>
<td>0.043</td>
</tr>
</tbody>
</table>

VI. Conclusions

Diagnosis of thyroid disease is one among the necessary problems to develop a medical decision support system. In this work hybrid intelligent system which is neuro fuzzy system are used. In Neuro Fuzzy system the neural network and fuzzy logic was combined to get the main features of artificial neural networks with those of fuzzy logic. Three groups of training and testing are used. From the table2 we show that Neuro Fuzzy system gave good result where the accuracy is 100% for training and in range between 87 % and 95% for testing which mean that Neuro Fuzzy system could be used to help diagnosis of thyroid disease.

References