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A Study of Neural Network in Diagnosis of Thyroid Disease

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Abstract- Many advances have been made in developing intelligent systems, some inspired by biological neural network. Artificial neural networks are used to solve a variety of problems in pattern recognition, prediction, optimization, associative memory, and control.Nowadays, one of the main issues to create challenges in medicine sciences by developing technology is the disease diagnosis with high accuracy. In the recent decades, Artificial Neural Networks (ANNs) are considered as the best solutions to achieve this goal. Proper interpretation of the functional data about thyroid gland is important for the diagnosis of thyroid disease. The main role of the thyroid gland is to help in regulation of body's metabolism. Production of too little thyroid hormone or production of too much thyroid hormone definites the type of thyroid disease. In this paper we deal with the neural networks, feed forward neural network and how it is used to classify the thyroid disease using back propogation algorithm.

Index Terms— ***Artificial neural network, back propogation learning algorithm, feed forward neural network, thyroid disease***

1 INTRODUCTION

Proper interpretation of the thyroid gland is important for the diagnosis of thyroid disease. It is one of the most important g-land as thyroid hormones are responsible for controlling meta-bolism. Functioning of thyroid has an impact on every organ of the body. This gland makes two active hormones levothyro-xine (abbreviated T4) and triiodothyronine (abbreviated T3). These hormones are important for manufacturing proteins, in regulation of body temperature, and in overall energy production and regulation.

The common thyroid disorder is hypothyroidism in which Thyroid does not produce enough hormone. Less frequently, t-hyroid produces too much hormone which is known as hypert-hyroidism. Groups most commonly affected by the disorder include women and elderly people. The seriousness of the disorders should not be underestimated as the end stage of untreated hyperthyroidism may lead to death in a significant number of cases.

The correct diagnosis of dysfunctions based on clinical and laboratory tests often proves difficult. One of the reason is non specific nature of many thyroid symptoms. This is true for hyperthyroidism where symptoms such as lethargy, confusion, weight gain and poor memory are easily confused with other psychiatric and medical conditions. Laboratory tests have become more accurate and helpful but the results are still not very satisfactory across all situations.

Research activities have shown that artificial neural netwo-rks have powerful pattern classification and pattern recognition ability. They have been used in diagnosis of many different problems like heart diseases, diabetes and thyroid dysfunctioning.The success of neural network may be attributed to its many unique features of pattern recognition and pattern classification.As opposed to traditional approaches, neural networks are data driven methods. They learn from examples with a few prior assumptions about the traditional model[1]. Neural networks have generalization ability. After learning the data presented to them, they can often correctly identify the pattern and then generalize it.

In using neural networks the entire available data set is usu-ally divided into training and test samples. The training sample is used for neural network model building and the test set is used to evaluate the predictive capability of the model. The estimated classification rate can be quite different from the true classification rate particularly when small sized samples are used. To accurately describe the predictive performance of neural networks a resampling technique known as cross validation is used[2].

It uses multiple random training and test subsamples. The ad-vantage of cross validation is that all of the observations or p-atterns in the available sample are used for testing and many of them are also used for training the model.

II Neural Networks

A neural network is a parallel system of interconnected com-puting elements called nodes. Information is processed throu-gh the interaction between a large number of nodes where kn-owledge is not stored in the individual nodes, but rather is it r-epresented by the weights of the connections between the nod-es. Fig 1 consists of a feed forward neural network, it is the simplest type of neural network. In this network information moves only in one direction i.e. forward, from the input nodes to the output nodes through the hidden nodes. There are no cycles or loops in the network. External information enters the network through the input layer while the output layer produces the model situation. The hidden layer provides connections necessary to identify complex patterns in the data. All nodes in the adjacent layers are connected by arcs[4].

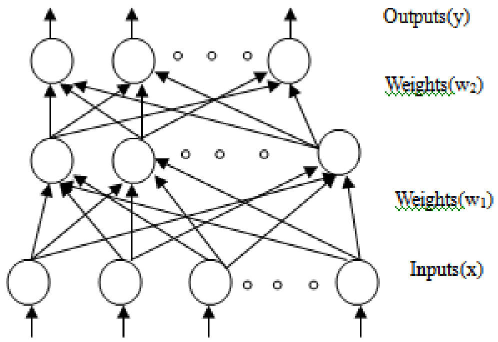

Fig. 1- Feed Forward Neural Network

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Arc weights are parameters in neural network model, these parameters need to be estimated before the network can be adopted for further use. In the process of neural network training the weights are determined, and hence it is the way in which the network learns. For classification problems etwork training is performed via supervised learning in which known outputs and their associated inputs are presented to the network. At each hidden layer node the input node activation values are weighted and summed. The weighted sum is then transmitted by an appropriate transfer function into the hidden node's activation value, which becomes input to the output layer nodes.The very same computation process is repeated at the output nodes. A comparison is performed between network output values and the known actual va-
lues for minimizing the differences between network output values and the known target values for all training patterns.

Let $\mathbf{x} = (x_1, x_2, \ldots x_n)$ be a n-vector of attribute values $\mathbf{y} = (y_1, y_2, \ldots y_m)$ be the m- dimensional output vector from the network, and w_1 and w_2 be the matrices of linking weights from input to hidden layer and from hidden to output layer, respectively. A three layer neural network is a non linear model of the form

$$\mathbf{y} = f_2(\mathbf{w_2} f_1(\mathbf{w_1 x})),$$

where f_1 and f_2 are transfer functions for the hidden and output nodes. The most popular choice for f_1 and f_2 is the logistic function. That is,

$$f_1(x) = f_2(x) = (1+\exp(-x))^{-1}$$

logistic function is used because it has a number of good characteristics, it is bounded and monotonically increasing and bears a better resemblance to real neurons[11].

The purpose of network training is to estimate the weight matrices so that an overall error measure such as sum of squared errors is minimized.

III Classification Method

Thyroid disease can be classified using MLP , RBF , and adap tive CSFNN networks. MLP is the most commonly used neural network model. It consists of successive linear transformations followed by processing with non-linear activation functions.This class of networks consists of multiple layers of computational units, usually interconnected in a feed-forward way. Each neuro-n present in one layer has directed connections to the neurons of the subsequent layers.In many applications the units of these networks apply a sigmoid as an activation function. Multi-layer networks use a variety of learning techniques, the most popular being back-propogation[9]. The output values are compared with the correct answer to compute the value of some predefined error function. By various techniques, the error is subsequently fed back through the network. Using this information, the algorithm adjusts the weights of each connection in order to reduce the value of the error function by some small amount. This process is repeated for a sufficiently large number of training cycles, the network will usually converge to some state where the error of calculations is minimum. In this case, one would say that the network has learned a certain target function.

Due to the rapid training, generality and simplicity of RBF it is attracting a great deal of interest. An RBF network can be considered as a two-layer fully interconnected feedfoward network whose output nodes form a linear combination of the basis functions computed by the hidden layer nodes. It is designed to perform non linear mapping from the input space to hidden space, followed by a linear mapping from the hidden space to the output space.

A hybrid neural network structure called CSFNN combines RBF and MLP in one single network. In this architechture, the nodes behave either as MLP or as RBF. The propogation rule for CSFNN is derived using analytical equations using a one.The network is trained using back propogation algorithm. Furthermore an adaptive learning algorithm and a momentum term are used in back propogation algorithm[5],[6].

IV Methodology

The purpose is to study how robust the neural network performance is in predicting thyroid disease in terms of sampling variability. A cross-validation approach is employed in this study. This section first describes the input data description, then the input data normalization, and cross-validation methodology.

4.1 Data Set Description

Thyroid gland is one of the major glands of human body which resembles a butterfly and is located in front of windpipe. It absorbs the available iodine in food and produces T3 and T4 hormones (Triiodothyronine, tetraiodothyronine and thyroxine). It is the task of controlling and how metabolism, produce protein and body sensitivity to hormones. These hormones regulate metabolism base of the body and affect the growth and function of other systems in the body . The output hormones of thyroid gland are provided by Thyroid Stimulating Hormone (TSH) which pituitary produces. The Thyroid gland itself is regulated by Thyrotropin Releasing Hormone (TRH) which is produced by the hypothalamus[7]. It can be mentioned as the most popular problems of Thyroid gland such as overactive thyroid gland known as hyperthyroidism and under activity gland as hypothyroidism. The type of disease based on its parameters is classified in table.

Type of thyroid disease	T3	T4	TSH
Hypo	Increase	Increase	Reduction
Hyper	Reduction	Reduction	Increase

Table 1- Disease based on parameters

The applied data in this paper is collected by Dr. Pradeep Jain at Ranbaxy pathology labs located in Meerut U.P. In this thyroid disease is classified into 3 groups of hypothyroidism, hyperthyroidism and normal.The total number of laboratory samples are 185. The parameters are as follows.

1. Class attribute (1=normal, 2=hyper, 3=hypo)

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The number of laboratory samples are determined based on the type of disease.

Type disease	No. of samples	Type Class
Normal	140	1
Hyper	20	2
Hypo	25	3
Total	185	

Table 2- Laboratory samples

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4.2 Input Data Normalization

The aim of data pre-processing is to increase network performance. By doing so, it transforms the input to the form which becomes suitable to be used in the network The normalization process of input data to obtain optimal training affects the network which is considered as input pre-processing functions . The researchers indicate that using different normalization methods in back propagation learning algorithm ANNs under training process will increase the training capabilities Without normalization process, network learning will be performed slowly . The various types of normalization methods are as follows:

1.Statistical or Z-Score Normalization
2. Min-Max Normalization
3. Median Normalization
4. Sigmoid Normalization
5. Statistical Normalization

Proper selection of normalization method increases the efficiency of the network performance. Before ANN training we normalize each data base input parameters. Min-Max normalization method is generally used[10]. This method performs rescaling as the features or output are transmitted from a range of values to the new one. Often the range of values are between 0 to 1 or -1 to 1.

4.3 Cross Validation

It is a method that is used for examining robustness of classifiers. One of the simplest method is the single training and testing scheme that is generally employed in medical literature. The original data is split into two groups, first one is used for designing the classifier while the hold out sample for testing purposes.The classification error rate on the test set is reported as the estimate of the classifier's true error rate. There are many problems related to this method. Firstly, most of the times the number of cases in the test sample is relatively small in practice, the estimate of the true classification capability of a classifier is often not satisfactory. Secondly, with the single training and testing method, the training set is much smaller than the whole data set available.Hence the resulting model is unlikely to be the one that would be obtained using all observations. Thirdly, the single training and testing partition may be uncharacteristic of the true underlying population, resulting in large sampling errors.

Resampling techniques such as random subsampling, leaving-One-out, and k-fold cross validation can reduce the error problem by averaging the results over several randomly generated training and testing partitions. For small samples the leaving-one-out technique is preferred, it is computationally difficukt for large data sets. The best method that should be used is four fold cross validation. Two cross validation schemes using mutually exclusive random subsets of data are used[3,8]. Both schemes utilize the same training samples while the test samples vary to measure different perspectives of the classifier performance.

5 Conclusion

It is seen that feed forward neural network can be successfully used for the diagnosis of thyroid disease. Thyroid disease identification is an important yet difficult task from both clinical diagnosis and statistical classification point of view. The poor performance of the traditional model based statistical methods due to large number of interrelated patient attributes as well as extremely unbalanced groups in the thyroid diagnosis problem complicate the relationship between these attributes and the patient true group membership. Artificial neural network is a flexible modeling technique for complex function mapping, show promise in the thyroid disease diagnosis.

The diagnosis of thyroid disease using neural network is robust with respect to sampling variations. A useful model is the one which is robust across different samples or time periods. The cross validation technique provides decision makers with a method for exinaming predictive validity and hence the usefulness of the classification method. For medical diagnosis, employing a classifier with high robustness and reliability in different sampling situations is a very critical issue. Neural networks are both robust and accurate for the task of diagnosing thyroid dysfunction. Not only can they provide excellent overall classification rate, they are also able to identify the more important, harder-to-classify smaller group members.

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