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Diagnosis of Breast Cancer Using Neural Network Approach

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Abstract

Background: Breast cancer is one of the fatal disorders causing death in people and second most common reason of mortality (death rate) in women. Early detection of cancer, which usually results in reducing the extent of damage, less extensive treatment and better outcomes. In this paper, we present an artificial neural network inspired from biological neural network which is used for pattern classification of benign and malignant cells

Methods: A feed forward neural network model with back propagation learning algorithm for training the neural network using breast cancer database is simulated with all the variable network constraints to make it efficient, robust and fault tolerated pattern classifier.

Results: The viability of this approach is demonstrated for classification with predictive success of 96.34% with 99.41% sensitivity to malignancy. Hence, it will probably enhance the decision on classifying the malignant cells.

Conclusions: Despite the fact, not all general hospitals have the mammogram facilities the neural network prediction model can increase the rate of diagnosis for breast cancer. This scheme can be used as an auxiliary tool to differentiate between benign and malignant breast cancers.

Keywords: Classification, Neural Network, Back Propagation, Diagnosis, Breast Cancer.

Introduction

A breast cancer is a malignant tumor that starts from cells of the breast. A malignant tumor is a group of cancer cells that may grow into (invade) surrounding tissues or spread (metastasize) to distant areas of the body. It is a variant of cancer originate from breast tissues, commonly from inner lining of milk ducts known as ductal carcinomas or lobules that supply milk to ducts and cancer known as lobular carcinomas [1]. Breast cancer occurs mainly in women, but men can get it, too. Many people do not realize that men have breast tissue and that they can develop breast cancer [2].But breast cancer is less common in men because their breast duct cells are less developed than those of women and because they normally have lower levels of female hormones that affect the growth of breast cells. In women, breast cancer account 22.9% of all cancers (excluding non-melanoma skin cancers) worldwide. During 2008 breast cancer result 13.7% cancer deaths in women and 458,503 deaths all over world [3].

To avoid deadly impact of breast cancer early diagnosis plays important role to reduce the mortality among breast cancer patient. Statistics shows 80% breast cancer of American Society are in early stage and mortality is only 3% in year 2004, assumed reason is early detection of the cancer [4]. Early diagnosis is only possible parameter to reduce the impact of breast cancer before spreading.

Pattern classification is an important field of study in prospect of identifying problem domain in machine learning and has a wide range of application in engineering ,sciences ,medical and other analyzing fields whether a set of attributes aggregately decide the nature and class of the sample being analyzed. Various intelligent techniques are used for classification purpose are decision tree, Neural Network, Genetic Algorithm

With the development of science and technology, Neural Network is one of the techniques to solve pattern classification problem with reliability and intelligent manner with reduced fault as deciding parameters are spread throughout the network, collapse of one of the node have negligible impact on overall network. In this paper a Neural Network is used to classify Benign (non-cancerous) and Malignant (cancerous) cells.

Artificial Neural Network

Artificial Neural Network (ANN) is inspired from the biological neural network of mammalian brain, capable of complex decision making and pattern recognition. Human brain is consisting of billions of cells known as neurons and each neuron have thousands of interconnection to other neural cells. The intellectual capabilities of human are due to this complex interconnection of neural cells. Vast number of neurons aggregately contributes in process of decision making. Artificial Neural Network is simulation of biological neural network with inheritance of various properties such as distributed and connectionist processing to build intelligent systems capable of rigorous and complex decision making

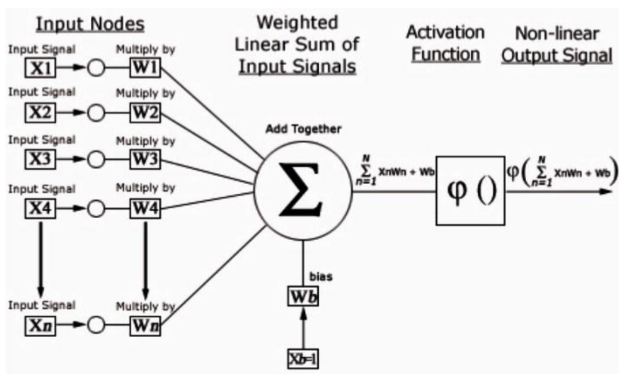

Fig1. Mathematical model of Artificial Neuron

Neurons are fundamental functional unit of Artificial Neural Network. It consist of summation and activation function for connection interaction and triggering purpose to simulate behavior of biological neurons.[7,8]

Artificial Neural Network is a densely interconnected graph architecture consisting of non-linear processing units as nodes and a set of network parameter known as weights are associated to the each edges of the graph .Nodes of the network commutatively perform to generate output. Artificial Neural Network has different classification on basis of number of layers involved in network architecture. Two types are: single layer and multilayer neural network. Neural network adapt to the data set shown to it by adjusting its weight known as learning and makes a representation of the learned data set in the form of weights of the network which are used to make classification of new input samples, Neural Network have distributed network approach and shows recognizable fault tolerance [9, 10]

Back Propagation

In a feed forward network input parameters are passed into the network, network processes these parameter with network weights and a relevant output is generated and have no feedback link, while implementing back propagation algorithm the generated output as actual response of the network are compared to the target response assigned to that particular input parameters class domain and deviation of actual response from target response is evaluated in the form of error. Error is back propagated to the network and weights of the network are adjusted in accordance to the error correction rule [11, 12]. Different methods are possible for weight adjustment.

When knowledge is represented by a weight vector in a multidimensional space of the connectionist framework, the knowledge vector can often be moved in a range while preserving its truth. The limit of this range is called the validity bound of knowledge.

An instance used to train a neural network consists of an input pattern and a class label. In this experiment calculated error directly involves in adjustment of weights of last layer, while in inner layers preceding layer adjust its weights parameter in terms of summated effect of weights and adjustments of nodes of succeeding layer to reduce intensity of weight adjustment from output layer to inner layers.

Whole process is known as learning, the purpose of learning is to bring the knowledge vector to within the validity bound. A bound on weight modification is imposed so that previous network knowledge is preserved while there is room for refining the knowledge. Another important independent parameter of neural network is learning rate meant to control the speed of the learning process. Once the Artificial Neural Network has finished the learning process it can process new input samples for classification.

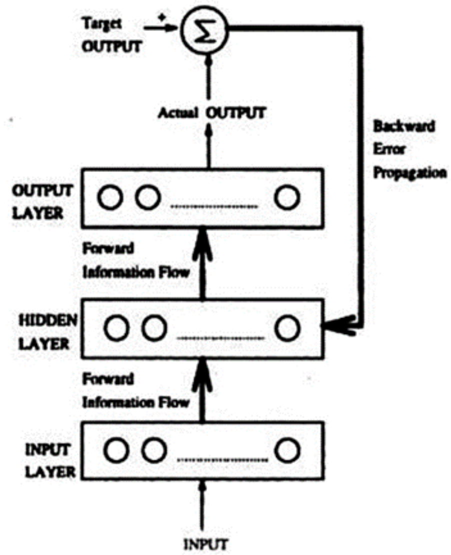

Fig.2 Back propagation Network

Materials

The data adopted in this paper was obtained from "Wisconsin Diagnostic Breast Cancer data base" (WDBC), Wisconsin university which is publically available on the internet. It contains 699 instances with an ID and class domain. Two classes are Benign and Malignant. Class distribution has composition of Benign: 458 (65.5%) and Malignant: 241 (34.5%).[13] 16 (16/699) instances were excluded because of the missing values from the database and the new dataset contains 683 samples. Database is partitioned into three parts for training, validation and testing purpose.

Description of database

- Number of instances taken 683

- Number of instance attributes: 9 (excluding class attribute)

Number of classes: 2 (Benign or Malignant)

Attribute Information

Attribute	**Domain**
1. Sample code number	ID number
2. Clump thickness	1-10
3. Uniformity of cell size	1-10
4. Uniformity of cell shape	1-10
5. Marginal adhesion	1-10
6. Single epithelial cell size	1-10
7. Bare nuclei	1-10
8. Bland chromatin	1-10
9. Normal nucleoli	1-10
10. Mitosis	1-10
11. Class	(2 for Benign, 4 for Malignant)

We have processed (removing id number and commas) the database to use it in program and replaced the class values as {0, 1} for Benign and Malignant respectively.

Method

A set of instance attributes which are extracted earlier from the database, are used as input data to establish the custom neural network prediction model it should adhere to the following standards :

- Each trial shall use a different set of randomly selected instances for testing.
- Neural network will use the University of Wisconsin Original Breast Cancer Database.
- The number of iterations for simulator is user defined at runtime of the application

The 9 morphological instances features (clump thickness, uniformity of cell size, uniformity of cell shape, marginal adhesion, single epithelial cell size, bare nuclei, bland chromatin, normal nucleoli, and marginal adhesion) are analyzed to comprehend their significance over the prediction results. Architect and optimize a neural network model, each network should adhere to the following control variable standards:

1. Reserve some instances for testing i.e. those instances should not be used for training.
2. Each trial shall use a different set of randomly selected instances for testing.
3. The network should be optimized to yield best results.
4. Analyze results to determine success and failures of implementations.
5. Determine if neural networks were successful at predicting malignant versus benign.
6. Identify areas for improvement

Implementation of Algorithm

A neural network prediction model is created which comprises of the following algorithmic components:

1. **Logical Input Layer:** It receives inputs to simulate the on/off firing of neurons.

2. **Sigmoid Function.** The activation levels of nodes can be discrete (e.g. 0 and 1) or continuous across range (e.g. [0, 1]) or unrestricted. This depends on the activation (transfer) function chosen If it is a hard limiting function, then the activation levels are 0 (or -1). A sigmoid function have activation levels limited to a continuous range of reals [0, 1].

3. **Summation Function:** Each input to the neuron is multiplied by its corresponding weighting. This

allows neurons to eliminate the impact of certain inputs by having weighting approach zero and allows others input to have larger weighting Step Function. Incorporate malignancy weightings.

4. **Step Function:** Applied to determine an ultimate diagnosis per network. Due to the desire to be more successful at predicting malignancy, the accuracy is biased to identify borderline cases as malignant

Inputs are received and neural network is initialized by passing neurons to the hidden layers of the back propagation network they process each inputs, to achieve good generalization, the number of training instances should be related to that of adaptable connection weights in such a way that the weights are not over constrained or underdetermined.

Since the size of the neural-network structure is determined by the numbers of nodes and connections, it follows that weight adaptation cannot lead to good generalization without an appropriately large structure to accommodate observed instances. Given a fixed structure and an initial weight setting, poor weight adaptation suggests the structure or the initial weights or both be changed and summation function activates the activation function to figure out the actual output corresponding to the desired output (i.e. Benign =0 or Malignant = 1 class which is set to some variable in the program) and step function shows the output whether the input variables belongs to Benign or malignant class.

Results

Neural Network Performance Analysis

Neural Network is bound to various constraints such as number of hidden layers, number of nodes in hidden layer, learning rate these constraints are dealt simultaneously to obtain an efficient topology with small root mean square (RMS) error. Training is done to obtain a low RMS error with maximum upper bound iteration to avoid endless looping. It is observed that more complex the network higher the over fitting. Number of layer increased increases the over fitting. It is found that more complex network requires more training for better performance but if over trained then network start memorizing and performance is good for training data but degrades for validation data number of nodes in hidden layer is also varied to found effects on performance and shows negligible changes and it is hard to reach at any conclusion. After playing these network architectural constraints a most accurate architecture is obtained with 1 hidden layer (HL) and 25 hidden layer nodes (HLN).The most important parameter is learning rate. Learning rate has higher influence in comparison to network topology. Lower learning rate result well over fitting effect but higher learning rate result faster convergence.

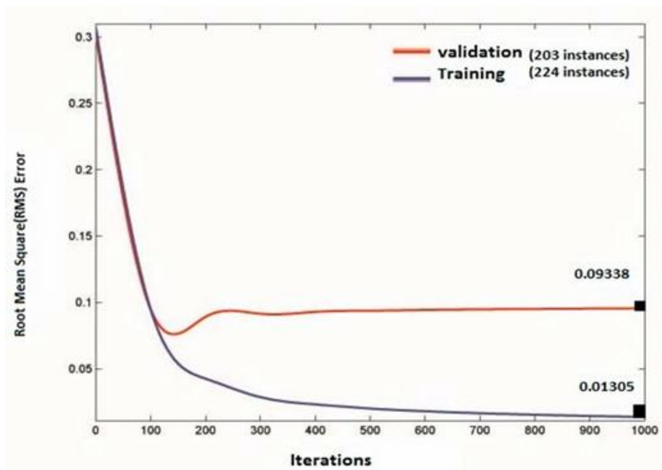

Fig.3 observed overfitting effect

Overfitting Effect

(HL=1, HLN=25, LR=0.1)

On completing the training the performance is recoded on training, validation and testing instances

Experimental Evaluation

Table 1. Performance Statistics

	Instances Taken	Wrong classifications	Accuracy
Training	224	0	100%
Validation	203	5	97.54%
Testing	256	20	92.19%
Total	683	25	96.34%

Table 2. RMS Error Statistics

	Training	Validation
RMS Error	0.01305	0.09338

Discussion

- Since the knowledge of a neural network is determined by how its neurons are connected and how those connections are weighted. The backpropagation rule indicates how to adapt weights but not how to change the structure.

- The backpropagation algorithm is not incremental in nature. Suppose it was trained on instance set A and then retrained on set B, its knowledge about set A may be lost. To learn a new instance while keeping old memory, the backpropagation network has to be trained on the new instance along with old instances

Further improvement can be done with some incremental learning algorithm equipped with back propagation will probably enhance the diagnosis more effectively

Based on clinical practice, a high proportion of patients with suspicious benign conditions who could not exclude a possible malignancy would require further investigations or surgery, which would increase the burden on patients. Hence neural network technology will become more prevalent in assisting radiologists with making diagnoses while it can reduce economic and mental burden on patients and prolong time of breast cancer patients.

Conclusion

Nowadays Artificial Neural Network (ANN) are used in biomedical field such as cardiology, neurology, oncology, gastroenterology.[14, 15] Advantage of neural network is that they perform from the training sample show to them instead of rules as expert system does, so they are more automated with intelligent decision making and are not affected from human error factors like emotion, lack of attention or experience. Neural network shows good reliability once training is finished.[16] In this paper an artificial neural network is used with back propagation algorithm to diagnose breast cancer with good accuracy.

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