Urinary System Diseases Diagnosis Using Artificial Neural Networks

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Summary
The goal of this paper is to evaluate artificial neural network in urinary diseases diagnosis. Artificial neural networks are widely used in medical problems. Artificial neural networks are used to disease diagnosis. Feed-forward back propagation neural network is used as a classifier to distinguish between infected or non-infected with two types of urinary disease. Inflammation of urinary bladder and nephritis of renal pelvis origin are diagnosis by artificial neural network. The results of applying the artificial neural networks methodology to diagnosis based upon selected symptoms show abilities of the network to learn the patterns corresponding to symptoms of the person. In this study, the data were obtained from UCI Machine Learning Repository in order to diagnosed diseases. The data is separated into inputs and targets. The symptoms will act as the inputs to the neural network. The targets for the neural network will be identified with 1's as infected and will be identified with 0's as non-infected. In all cases, the percent correctly classified in the simulation sample by the feed-forward back propagation network is 99 percent. The results show that the proposed diagnosis neural network could be useful for identifying the infected person.

Key words:
Artificial Neural Networks, Urinary System Diseases Diagnosis, and Feed-forward back propagation network.

1. Introduction

The advantage of neural networks over conventional programming lies in their ability to solve problems that do not have an algorithmic solution or the available solution is too complex to be found. Neural networks are well suited to tackle problems that people are good at solving, like prediction, clinical diagnosis, pattern recognition and image analysis and interpretation [1].

Automatic diagnosis of diseases always has been of interest as an interdisciplinary study amongst computer and medical science researchers [5].

Heckerling, Canaris, Flach, Tape, Wigton and Gerber [2] used artificial neural networks (ANN) coupled with genetic algorithms to evolve combinations of clinical variables optimized for predicting urinary tract infection.

Huang and Chen [3] examined a system to diagnose urodynamic stress incontinence (USI) with computer-aided vector-based perineal ultrasound.

Francisco, Juan Manuel, Antonio and Daniel [4] developed a new system from a model based in a multi-agent system in which each neuronal centre corresponds with an agent. This system incorporates a heuristic in order to make it more robust in the presence of possible inconsistencies. The heuristic used is based on a neural network (orthogonal associative memory). Knowledge through training has been added to the system, using correct patterns of behavior of the urinary tract and behavior patterns resulting from dysfunctions in two neuronal centers as a minimum.

Monadjemi and Moallem [5] investigated application of artificial neural networks in typical disease diagnosis. The real procedure of medical diagnosis which usually is employed by physicians was analyzed and converted to a machine implementable format. The results of the experiments and also the advantages of using a fuzzy approach were discussed as well.

Gil, Johnsson, Garicia, Paya and Fernandez [6] evaluated the work out of some artificial neural network models as tools for support in the medical diagnosis of urological dysfunctions. They developed two types of unsupervised and one supervised neural network.

Altunay, Telatar, Erogul and Aydur [7] analyzed the uroflowmetric data and assisted physicians for their diagnosis. They introduced an expert pre-diagnosis system for automatically evaluating possible symptoms from the uroflow signals. The system used artificial neural networks (ANN) and produced a pre-diagnostic result.

Moein, Monadjemi and Moallem [8] analyzed the real procedure of medical diagnosis which usually is employed by physicians and converted to a machine implementable format. Then after selecting some symptoms of eight different diseases, a data set contains the information of a few hundreds cases was configured and applied to a MLP neural network. The results of the experiments and also the advantages of using a fuzzy approach were discussed as well. Outcomes suggest the role of effective symptoms selection and the advantages of data fuzzificaton on a neural networks-based automatic medical diagnosis system.

Brause [9] showed that human diagnostic capabilities are significantly worse than the neural diagnostic systems by successful application examples.

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Lisboa [10] presented a review to assess the evidence of healthcare benefits involving the application of artificial neural networks to the clinical functions of diagnosis, prognosis and survival analysis, in the medical domains of oncology, critical care and cardiovascular medicine.
The role of neural networks is introduced within the context of advances in medical decision support arising from parallel developments in statistics and artificial intelligence.

2. Artificial Neural Networks

An artificial neural network (ANN) is a computational model that attempts to account for the parallel nature of the human brain. An (ANN) is a network of highly interconnecting processing elements (neurons) operating in parallel. These elements are inspired by biological nervous systems. As in nature, the connections between elements largely determine the network function. A subgroup of processing element is called a layer in the network. The first layer is the input layer and the last layer is the output layer. Between the input and output layer, there may be additional layer(s) of units, called hidden layer(s). Fig. 1 represents the typical neural network. You can train a neural network to perform a particular function by adjusting the values of the connections (weights) between elements

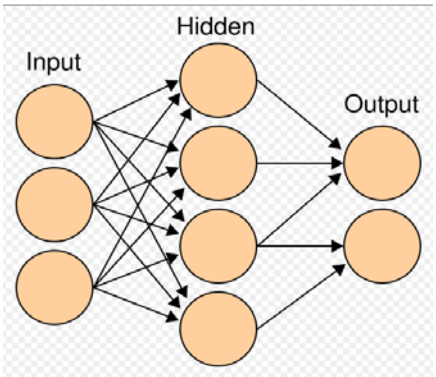

Fig. 1 A typical neural network

Medical Diagnosis using Artificial Neural Networks is currently a very active research area in medicine and it is believed that it will be more widely used in biomedical systems in the next few years. This is primarily because the solution is not restricted to linear form. Neural Networks are ideal in recognizing diseases using scans since there is no need to provide a specific algorithm on how to identify the disease. Neural networks learn by example so the details of how to recognize the disease is not needed [11].

2.1 The Proposed Diagnosis Model

Feed-forward neural networks are widely and successfully used models for classification, forecasting and problem solving. A typical feed-forward back propagation neural network is proposed to diagnosis urinary system diseases. It consists of three layers: the input layer, a hidden layer, and the output layer. A one hidden with 20 hidden layer neurons is created and trained. The input and target samples are automatically divided into training, validation and test sets. The training set is used to teach the network. Training continues as long as the network continues improving on the validation set. The test set provides a completely independent measure of network accuracy. The information moves in only one direction, forward, from the input nodes, through the hidden nodes and to the output nodes as shown in Fig. 2. There are no cycles or loops in the network.

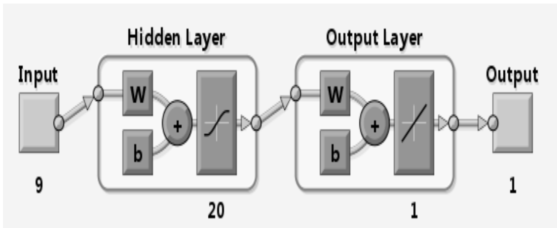

Fig. 2 Feed-Forward back propagation network

In a feed-forward neural network information always moves one direction; it never goes backwards.
It allows signals to travel one-way only; from source to destination; there is no feedback. The hidden neurons are able to learn the pattern in data during the training phase and mapping the relationship between input and output pairs. Each neuron in the hidden layer uses a transfer function to process data it receives from input layer and then transfers the processed information to the output neurons for further processing using a transfer function in each neuron.
The output of the hidden layer can be represented by

$$Y_{Nx1} = f(W_{NxM} X_{M,1} + b_{N,1}) \quad (1)$$

where Y is a vector containing the output from each of the N neurons in a given layer, W is a matrix containing the weights for each of the M inputs for all N neurons, *X* is a vector containing the inputs, b is a vector containing the biases and *f(•)* is the activation function [12].

3. Experimental Results

3.1 Data Analysis

The data was created by a medical expert as a data set to test the expert system, which will perform the presumptive diagnosis of two diseases of the urinary system. The data is obtained from UCI Machine Learning Repository.

The main idea of this data set is to construct the neural network model, which will perform the presumptive diagnosis of two diseases of urinary system. It will be the example of diagnosing of the acute inflammations of urinary bladder and acute nephritises. For better understanding of the problem let us consider definitions of both diseases given by medics. Acute inflammation of urinary bladder is characterized by sudden occurrence of pains in the abdomen region and the urination in form of constant urine pushing, micturition pains and sometimes lack of urine keeping. Temperature of the body is rising, however most often not above 38C. The excreted urine is turbid and sometimes bloody. At proper treatment, symptoms decay usually within several days. However, there is inclination to returns. At persons with acute inflammation of urinary bladder, we should expect that the illness will turn into protracted form. Acute nephritis of renal pelvis origin occurs considerably more often at women than at men. It begins with sudden fever, which reaches, and sometimes exceeds 40C. The fever is accompanied by shivers and one- or both-side lumbar pains, which are sometimes very strong. Symptoms of acute inflammation of urinary bladder appear very often. Quite not infrequently there are nausea and vomiting and spread pains of whole abdomen.

This dataset contains 120 patients. Table 1 presents the patient symptom data which are considered as diagnosis variables. The dataset contains 120 samples. 90 sample used in training the network while 30 samples used in testing the network.

Table 1: Diagnosis variable of datasets used in the study

	Patients symptom data
No.	Diagnosis Variable Name
1	Temperature of patient {35C-42C}
2	Occurrence of nausea {yes, no}
3	Lumbar pain {yes, no}
4	Urine pushing (Continuous need for urination) {yes, no}
5	Micturition pains {yes, no}
6	Burning of urethra, itch, swelling of urethra outlet {yes, no}

3.2 Performance Evaluation

A two-layer feed-forward network with 9 inputs and 20 sigmoid hidden neurons and linear output neurons was created using the neural network toolbox from Matlab 7.9. Inflammation of urinary bladder is the first disease to be diagnosed.

Such net can fit multi-dimensional mapping problems arbitrarily well, given consistent data and enough neurons in its hidden layer as shown in Fig. 2.

Levenberg-Marquardt back propagation algorithm was used with train the network. Training automatically stops when generalization stops improving, as indicated by an increase in the mean square error (MSE) of the validation samples.

The results of applying the artificial neural networks methodology to distinguish between healthy and unhealthy person based upon selected symptoms showed very good abilities of the network to learn the patterns corresponding to symptoms of the person. The network was simulated in the testing set (i.e. cases the network has not seen before). The results were very good; the network was able to classify 99% of the cases in the testing set.

Best validation performance is 2.8548e-007 at epoch 7 as shown in Fig. 3. The mean squared error (MSE) is the average squared difference between outputs and targets. Lower values are better while zero means no error.

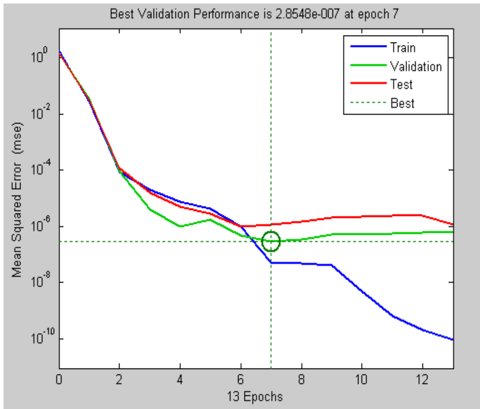

Fig. 3

Table 2 presents the result for training, validation and testing samples. Mean squared error (MSE) and regression (R) is illustrated in table 2.

Table 2: The Mean Square Error (MSE) and Regression values for the training, validation and testing.

	MSE	R
Training	5.11986e-8	9.99999e-1
Validation	2.85475e-7	9.99999e-1
Testing	1.13132e-6	9.99997e-1

The percent correctly classified in the simulation sample by the feed-forward back propagation network is 99 percent as shown in Fig. 4. The MSE is equal to 3.96199e-5 and the regression is equal to 9.99936e-1.

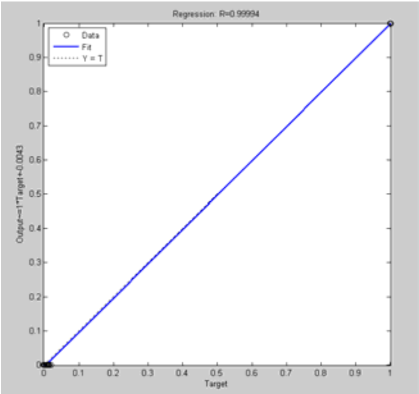

Fig. 4

Nephritis of renal pelvis origin is the second disease to be diagnosed using feed-forward network. The same data set is used in both of the diseases to diagnose. The network was simulated in the testing set (i.e. cases the network has not seen before). The results were very good; the network was able to classify 99% of the cases in the testing set.
Best validation performance is 1.3052e-008 at epoch 8 as shown in Fig. 5. The mean squared error (MSE) is the average squared difference between outputs and targets. Lower values are better while zero means no error.

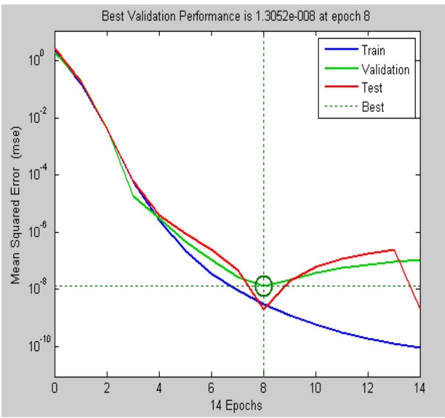

Fig. 5

Table 3 presents the result for training, validation and testing samples. Mean squared error (MSE) and regression (R) is illustrated in table 3.

Table 3: The Mean Square Error (MSE) and Regression values for the training, validation and testing.

	MSE	R
Training	3.00485e-9	9.99999e-1
Validation	1.30523e-8	9.99999e-1
Testing	2.06624e-9	9.99999e-1

The percent correctly classified in the simulation sample by the feed-forward back propagation network is 99 percent as shown in Fig. 6.

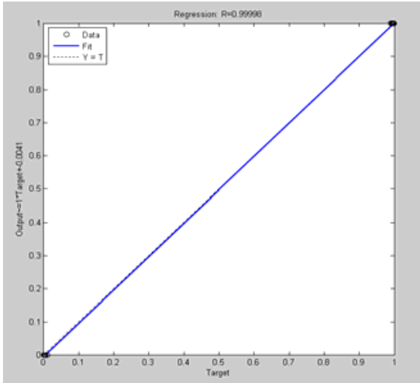

Fig. 6

4. Conclusions

This study aimed to test neural network model with learning algorithm: the feed-forward back propagation neural network with supervised learning in terms of their ability of disease diagnosis. The results of applying the supervised neural networks in diagnosis of the disease based upon the selected symptoms showed that artificial neural networks are able to learn the patterns corresponding to symptoms of the person. Artificial neural networks showed significant results in urinary system diseases diagnosis.

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