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Importance of Artificial Neural Network in Medical Diagnosis disease like acute nephritis disease and heart disease

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Abstract— The goal of this paper is to evaluate artificial neural network [ANN] in disease diagnosis. ANN's are often used as a powerful discriminating classifier for tasks in medical diagnosis for early detection of diseases. ANN's are finding many uses in the medical diagnosis application. Two cases are studied. The first one is acute nephritis disease; data is the disease symptoms. The second is the heart disease. Data is on cardiac Single Proton Emission Computed Tomography (SPECT) images. Each patient classified into two categories: infected and non-infected. Classification is an important tool in medical diagnosis decision support. Feed-forward back propagation neural network is used as a classifier to distinguish between infected or non-infected person in both cases. The results of applying the ANNs methodology to acute nephritis diagnosis based upon selected symptoms show abilities of the network to learn the patterns corresponding to symptoms of the person.

Keywords: **ANN, SPECT, acute nephritis disease, heart disease**

I. INTRODUCTION

Artificial neural networks provide a powerful tool to help doctors to analyze, model and make sense of complex clinical data across a broad range of medical applications. Most applications of artificial neural networks to medicine are classification problems; that is, the task is on the basis of the measured features to assign the patient to one of a small set of classes [1]. Medical diagnosis always has been an art: we remember famous doctors as well as famous painters or composers throughout the history. Again, who is called an artist? A person who can carry out something those others cannot, and that is exactly what a good physician does during a medical diagnosis procedure. He (or she) employs his educations, experiences, and talent, to diagnose a disease. A diagnosis procedure usually starts with the patient complaints and the doctor learn more about the patient situation interactively during an interview, as well as by measuring some metrics such as blood pressure or the body temperature. The diagnosis is then determined by taking the whole available patients status into the account. Then depending on that, a suitable treatment is prescribed, and the whole process might be iterated. In each iteration, the diagnosis might be reconfigured, refined, or even rejected [6].

II. SHORT HISTORY OF ANN'S

Artificial intelligence is not a new research field - ANNs have been in the attention of the scientists over the last 60 years. First studies on neural networks were done in 1943 by McCullough and Pitts. After a while, Rosenblatt conceived in 1959 the first learning algorithm, creating a model known as the perceptron, which was then only a solution to simple linear problems. The first non-linear processing capabilities of ANNs were reported in 1974 by Werbos, and afterwards the interest of the scientific community steadily increased, boosted in the last years by the discovery of the back propagation algorithm and by the increase in computational power, due to the exponential advances in computer technology[5].

III. ARTIFICIAL NEURAL NETWORKS

Artificial neural networks (ANN) have emerged as a result of simulation of biological nervous system, such as the brain on a computer. Artificial Neural networks are represented as a set of nodes called neurons and connections between them. The connections have weights associated with them, representing the strength of those connections. Now a day's neural network can be applied to problems that do not have algorithmic solutions or problems for which algorithmic solutions are too complex to be found. In others words the kind of problems in which inputs and outputs variables does not have a clear relationship between them, a neural networks is a efficient approach in such problems. Most neural network architecture has three layers in its structure. First layer is input layer which provides an interface with the environment, second layer is hidden layer where computation is done and last layer is output layer where output is stored. Data is propagated through successive layers, with the final result available at the output layer. Many different types of neural networks are available and multi layer neural networks are the most popular. MLP popularity is due to more than one hidden layer in its structure which helps sometimes in solving complex problems which a single hidden layer neural network cannot solve [13].Figure 1 show multilayer perceptron structure with N number of inputs neurons corresponding to N number of hidden and output neurons.

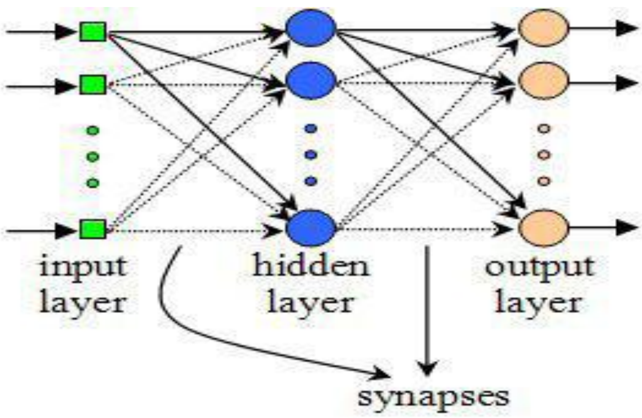

Fig 1: Multilayer Perceptron architecture [13]

Now a day's artificial neural network has become most widely tool used for diagnosis of diseases. Because of the Fault tolerance, Generalization and Learning from environment like capabilities of Artificial neural networks it is becoming more and more popular in medical diagnosis and many more others areas. One of the network structures that have been widely used is the feed forward network where network connections are allowed only between the nodes in one layer and those in the next layer. Feed-forward back propagation neural network is used as a classifier to distinguish between infected or non-infected person [13].

IV. MEDICAL DIAGNOSIS PROBLEMS

The major task of medical science is to prevent and diagnose the diseases. Here our focus is the second task, which as mentioned before, is not a direct and simple task at all. In 2001, Brause highlighted that almost all the physicians are confronted during their formation by the task of learning to diagnose. Here, they have to solve the problem of deducing certain diseases or formulating a treatment based on more or less specified observations and knowledge. Below some certain difficulties of medical diagnosis that have to be taken into account are listed: [6]The basis for a valid diagnosis, a sufficient number of experienced cases, is reached only in the middle of a physician's career and is therefore not yet present at the end of the academic formation.

• This is especially true for rare or new diseases where also experienced physicians are in the same situation as newcomers.

• Principally, humans do not resemble statistic computers but pattern recognition systems. Humans can recognize patterns or objects very easily but fail when probabilities have to be assigned to observations.

• The quality of diagnosis is totally depends on the physician talent as well as his/her experiences.

• Emotional problems and fatigue degrade the doctor's performance.

• The training procedure of doctors, in particular specialists, is a lengthily and expensive one. So even in developed countries we may feel the lack of MDs.

• Medical science is one of the most rapidly growing and changing fields of science. New results disqualify the older treats, new cures and new drugs are introduced day by day. Even unknown diseases turn up every now and then. So a physician should always try hard to keep his/ herself up to date.

Question would be how computers can help in medical diagnosis. Since decades ago, computers have been employed widely in the medical sector. From local and global patient and medicine databases to emergency networks, or as digital archives, computers have served well in the medical sector. Meanwhile, in the case of

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medical diagnosis, regarding the complexity of the task, it has not been realistic yet to expect a fully automatic, computer-based, medical diagnosis system. However, recent advances in the field of intelligent systems are going to materialize a wider usage of computers, armed with AI techniques, in that application. A computer system never gets tired or bored, can be updated easily in a matter of seconds, and is rather cheap and can be easily distributed. Again, a good percentage of visitors of a clinic are not sick or at least their problem is not serious, if an intelligent diagnosis system can refine that percentage, it will set the doctors free to focus on nuclear and more serious cases [6].

V. PROPOSED DIAGNOSIS MODELS

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 [2].

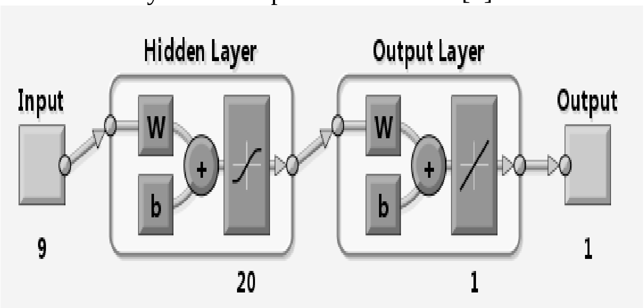

Fig 2: Feed-Forward back propagation network [2]

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 neuronThe output of the hidden layer can be represented by

$YNx1 = f\,(WNxM\ XM,\ 1 + bN,\ 1)$ .... (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 [2].

VI. HOW TO USE ANN IN MEDICINE

Artificial neural networks could be used in every situation in which exists a relationship between some variables that can be considered inputs and other variables that can be predicted (outputs). The most important advantages using artificial neural networks are that this kind of system solves problems that are too complex for conventional technologies, do not have an algorithmic solution or the solution is too complex to be used. These characteristics have often appeared in medicine. Artificial neural networks have been successfully applied on various areas of medicine, such as: diagnostic systems, biomedical analysis, image analysis, drug development. Using artificial neural networks, it can be monitored a lot of health indices (respiration rate, blood pressure, glucose level) or can be predicted the patient response to a therapy. Artificial neural networks have a very important role in image analysis, too, being used together with processing of digital image in recognition and classification. They are used in pattern recognition because of their capacity to learn and to store knowledge. The medical image field is very important because it offers a lot of useful information for diagnosis and therapy. There are also a lot of applications that use neural networks connected with Bayesian statistics (which can estimate the probability density of model parameters given the available data) [3].

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VII. ADVANTAGES

We can say that neural network approaches differ from traditional statistical techniques in many ways and the differences can be exploited by the application developer. They are powerful alternative tools and a complement to statistical techniques when data are multivariate with a high degree of interdependence between factors, when the data are noisy or incomplete, or when many hypotheses are to be pursued and high computational rates are required. With their unique features, both methods together can lead to a powerful decision-making tool. Studies and investigations are being made to enhance the applications of ANNs and to achieve the benefits of this new technology. Most frequently quoted advantages of the application of neural networks are:

- Neural network models can provide highly accurate results in comparison with regression models.
- Neural network models are able to learn any complex non-linear mapping / approximate any continuous function and can handle non linearity's implicitly.
- The significance and accuracy of neural network models can be assessed using the traditional statistical measures of mean squared error and R2.
- Neural network models automatically handle variable interactions if they exist.
- Neural networks as non-parametric methods do not make a prior assumptions about the distribution of the data/input-output mapping function.
- Neural networks are very flexible with respect to incomplete, missing and noisy data/ NNs are fault tolerant.
- Neural networks models can be easily updated. It means they are suitable for dynamic environment.
- Artificial neural networks overcome some limitations of other statistical methods, while generalizing them.
- ANNs have associative ability. That is, once developed, an ANN is generally robust to missing or inaccurate data's. The multi-co-linearity does not impact on the ANN's performance as it does on the performance of least-squares regression's ANN is a reliable tool for predicting the determinants of relationship quality [4].

VIII. APPLICATIONS OF ANN'S IN MEDICINE

Evaluations of the key prognostic factors in different forms of cancer have shown that we must have more precise therapy guidelines and a more accurate prediction of the patients' outcome. Statistical analysis should be very useful for the clinician, as a tool providing more clarity to the complicated classification systems, risk group categories or therapeutic options. The TNM system is a key tool in oncology, describing the anatomic extent of the different forms of cancer, being helpful to the clinician in the process of therapeutic choice. However, the system has its own limitations: although it has specifications for every organ location, it does not comprise many newer markers or pathological findings, which are necessary for specific diagnosis and therapy. This is the main reason why new prediction instruments are needed, which could adjust to every specific clinical parameter, giving results of great accuracy. ANNs are a possible solution, permitting to discover nonlinear relationships between all the parameters (depending on each other or independent), being superior to the logistic regression, which need supplementary modeling in order to have a comparable flexibility. With the power and speed of the actual computer hardware and dedicated software, ANNs can easily correlate different prediction factors, find hidden interactions among variables, predict an outcome for a group of patients, stratify patients in risk groups, or approximate a function and complete a known pattern. Other possible (and already verified) applications of the ANNs in medicine include, but are not limited to the diagnosis, imaging, pathology and prognosis evaluation of appendicitis, back pain, dementia, myocardial infarction, arrhythmias, psychiatric disorders, acute pulmonary embolism or sexually transmitted diseases [5].

IX.EXPERIMENTAL RESULT

A) Data Analysis

Symptoms, images or signals are the data used in medical diagnosis. The data set is obtained from UCI Machine Learning Repository [1].

B) Acute Nephritis Diagnosis Data

The data was created by a medical expert as a data set to test the expert system, which will perform the presumptive diagnosis of one of the urinary system diseases. The main idea of this data set is to construct the neural network

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model, which will perform the presumptive diagnosis of acute nephritis. 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. 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 [1].

Table 1.Diagnosis variable of datasets used in the study [1]

Patient symptoms 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)

C) Heart Disease Diagnosis Data

The dataset describes diagnosing of cardiac Single Proton Emission Computed Tomography (SPECT) images. Each of the patients is classified into two categories: normal and abnormal. The database of 267 SPECT image sets (patients) was processed to extract features that summarize the original SPECT images. As a result, 44 continuous feature patterns were created for each patient. The pattern was further processed to obtain 22 binary feature patterns. SPECT data has 267 instances that are described by 23 binary attributes. The dataset contains 267 samples. 80 sample used in training the network while 187 samples used in testing the network [1].

D) Performance Evaluation

Neural network toolbox from Matlab 7.9 is used to evaluate the performance of the proposed networks. Acute nephritis of renal pelvis origin is the first disease to be diagnosed. A two-layer feed-forward network with 6 inputs and 20 sigmoid hidden neurons and linear output neurons was created. 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. Fig.3 shows the training state values. Best validation performance is 2.8548e-007 at epoch 7 as shown in Fig.4. The mean squared error (MSE) is the average squared difference between outputs and targets. Lower values are better while zero means no error [1].

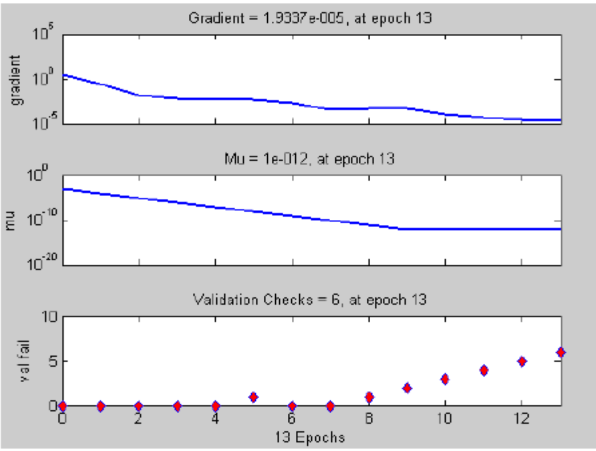

Fig.3 training state values[1]

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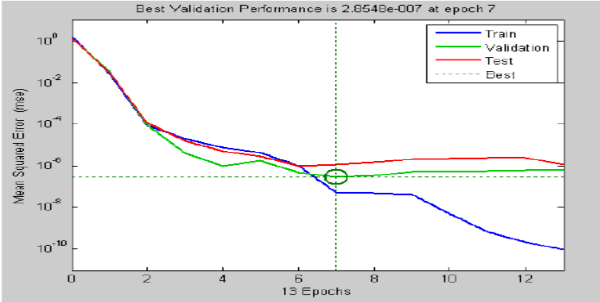

Fig.4 Epoch 7 [1]

Table 2. The Mean Square Error (MSE) and Regression values for the training validation and testing [1]

	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. The MSE is equal to 3.96199e-5 and the regression is equal to 9.99936e-1. Heart disease is the second disease to be diagnosed. A two-layer feed-forward network with 22 inputs and 20 sigmoid hidden neurons and linear output neurons was created. Such net can fit multi-dimensional mapping problems arbitrarily well, given consistent data and enough neurons in its hidden layer as shown in Fig.3. Levenberg-Marquardt back propagation algorithm was used with train the network. The results of applying the artificial neural networks methodology to distinguish between normal and abnormal person based upon binary feature patterns extracted from SPECT images showed very good abilities of the network to learn the patterns. The network was simulated in the testing set. The results were very good; the network was able to classify 95% of the cases in the testing set. Fig.5 shows the training state values. Best validation performance is 0.088329 at epoch 3 as shown in Fig.6 [1].

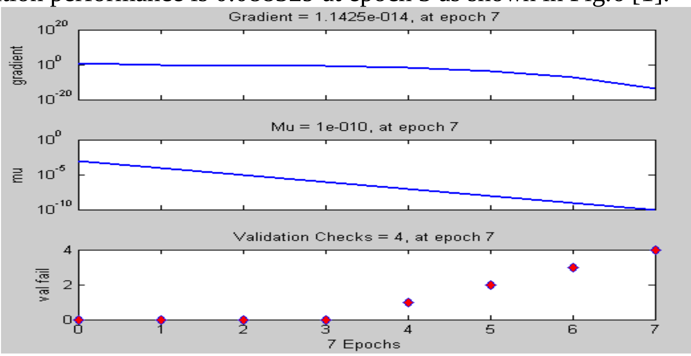

Fig.5 training state values [1]

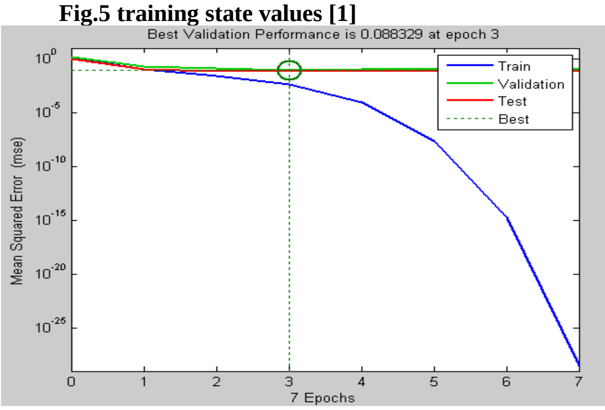

Fig.6 Epoch 3 [1]

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Table 3 The Mean Square Error (MSE) and regression values for the training validation and testing [1]

	MSE	R
Training	4.86802e-3	9.92593e-1
Validation	8.83292e-2	8.50794e-1
Testing	7.47611e-1	8.72846e-1

The percent correctly classified in the simulation sample by the feed-forward back propagation network is 95 percent. The MSE is equal to 2.78711e-2 and the regression is equal to 9.50148e-1 [1].

X.CONCLUSION

In this paper we have tried to survey most reported works in the area of artificial neural network in medical diagnosis. This study aimed to evaluate artificial neural network in disease diagnosis. The feed-forward back propagation neural network with supervised learning is proposed to diagnose the disease. Artificial neural network provide a powerful tool to help doctor to analyze, model and make sense of complex clinical data across a broad range of medical application. Artificial neural networks showed significant results in dealing with data represented in symptoms and images. Results showed that the proposed diagnosis neural network could be useful for identifying the infected person The artificial neural networks with the ability of learning by example are a very flexible and powerful tool in medical diagnosis and have a lot to offer to modern medicine.

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