Application of artificial neural networks in medicine

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Abstract

The use of neural networks in medicine, normally is linked to disease diagnostics systems. However, neural networks are not only able to recognize examples, but maintain very important information. For this reason, one of the main areas of application of neural networks is the interpretation of medical data. In this article we will discuss the application of neural networks in medicine with a concrete example - a diagnosis of diabetes disease in its early stages.

1. Introduction

Neural networks are nonlinear systems, which make it possible to classify the data better than linear methods.

A distinctive feature of neural networks is that they are not programmed - do not use any rule for diagnosis, but are trained to do so in the examples. Regarding this, neural networks aren't similar to expert systems, the development of which in the 70s was held after a temporary "victory" of artificial intelligence approach against memory modeling, recognition and synthesis models, which was based on the study of neural organization of human brain.

One of the most prominent and developed, the effect of which was based on the knowledge obtained from the experts, was Streptomycin system. This system was developed in Stanford in the early '70s for the diagnosis of septic shock. Half of the patients died, and doctors could reveal sepsis only in 50% of cases. Streptomycin was apparently a real triumph of expert systems technology - because it enabled the detection of sepsis-it in 100% of cases. As a diagnostic program sample served cardiodignostic package, developed by the RES company together with Informatica Cardiology Research Center in Milan. The program enabled non-invasive cardiodiagnostic, based on the spectrum recognition of tahograph. Tahograph histogram represents the intervals between heart beats and its activity spectrum reflects the balance of sympathetic and parasympathetic nervous system, which differs specifically for various diseases. Now we can conclude that neural networks have become an instrument of diagnosis of heart disease - in UK, for example, used in four hospitals for the prevention of myocardial infarct.

Neural networks can also be used to forecast the action of various healing treatments. Successfully applied in chemistry for predicting molecules properties of different interactions.

In this article we will discuss the application of neural networks for diagnosing diabetes disease in its early stages. Nowadays, diabetes is considered one of the most prevalent diseases in the world. According to the World Health Organization, around 30 million people of various ages and breeds suffer from various forms of diabetes[1]. Diabetes is not a consequence of any particular organ pathology, but in general displayed by the metabolic disorder. His symptoms occur in organs or organ systems, which are more vulnerable to this process. Clinical signs of diabetes depend on the type of disease, gender, age, level of insulin, arterial pressure and many other factors.

Neural network technologies are designed to solve many difficult tasks, starting from formulation, among which many medical problems. This is related to the fact that to the researchers are often given a large number of factual materials, for which there is no mathematical model. Artificial neural networks models have shown good results for diagnose nerve disorders [Hul1], Parkinson's disease [Gil2] and Huntington [Sin3] diagnosis. Multilayer perceptron models are used for predicting the risk of occurrence of osteoporosis [Bas4]. For Hepatitis B diagnostic is used generalized

[1] 10 facts about diabetes – *www.who.int/features/factfiles/diabetes/en.*

mathematical regression [Mah5]. One of the most useful tools for solving the tasks above are artificial neural networks - a powerful simulation method of phenomena and processes at the same time very flexible. Modern neural networks are a combination of devices and programs designed for models and specialized equipment for solving a wide range of diagnostics tasks by applying a set of algorithms theory of object recognition. The distinguishing feature of neural networks is the ability to be trained in a specific field. Applied to medical topics, experimental data represent a set of input parameters of the object (in our case health parameters). Training network neural is an interactive process, at the entrance of which net finds secret nonlinear relationships between input parameters and final diagnosis, also the optimal combination of weight coefficients of neurons, joining the neighbour layers for which the error of definig sample class goes to minimum [Yak6]. As one of the advantages of neural networks we should consider their relative simplicity, non-linearity, working with incomplete information, the ability to train on concrete examples. During the training process, as initial input we will give parameters together with the diagnosis, characterizing these parameters. To train a neural network we must have a sufficient number of examples to adapt the system to a certain level of credibility. If the examples are dealing with various diagnostics, then artificial neural network trained in this way allows the diagnosis of each new case, presented by a group of indicators, similar to indicators used to train the others. The apparent advantage of neural model is that the creation is not necessary to present the complex connections to describe the phenomenon that is diagnosed. During the application of neural networks for solving various practical tasks we may face a serie of difficulties. One of the key problems is the application of these technologies and the large degree of difficulty of the network design (not known whether it will be right enough to diagnose disease). This difficulty can complicate network architecture. Simple nets with only one layer (single-layer perceptron) are able to solve only divisible, linear tasks [Gal7]. This limitation can be overcome using multi-layer networks (multilayer perceptron).

2. Experiment

For this article we used a multi-layer model and backpropagation algorithm for training. As activation function - sigmoidal function (Figure 1).

$$F = \frac{1}{1+\exp(-\alpha Y)},$$

where α is a coefficient chosen experimentally.

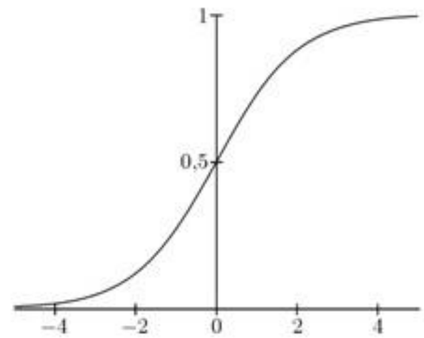

Figure 1: Sigmoidal activation function

Multi-layer perceptron has a high level of connections, which are realized through synapses. The change of level of network connections requires changing of synaptic connections or coefficients of their weights. Combining all the features together with the ability to train their experience, provides the computing power of multi-layer perceptron.

Artificial neural network consists of 3 layers: input, secret and output layer.

Input layer has 12 neurons, while output has only 2. (figure 2).

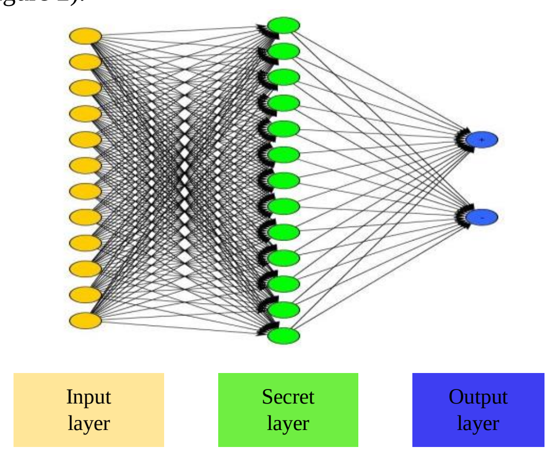

Figure 2: Architecture of neural network

Table 1. Input-layer parameters

Parameter	Type of data, unit
Age	Number (years)
Physical loads	Logic (Yes/No)
Sex	Logic (Female/Male)
Number of pregnancies	Number

Diabetes to relatives	Logic (Yes/No)
Body mass index	Number (kg/m^2)
Skin thickness	Number (mm)
Colesterin level	Number (mg/dl)
Diastolic pressure	Number (mm Hg)
Insulin	Number (µUnit/ml)
Stress	Logic (Yes/No)
Glucose level	Number (mg/dl)

For the design of neural network we used the package of Matlab Neural Network Toolbox R2012a. The package represents a set of functions and data structure, which describes the functions of activation, training algorithms, setting of synaptic connections, etc.

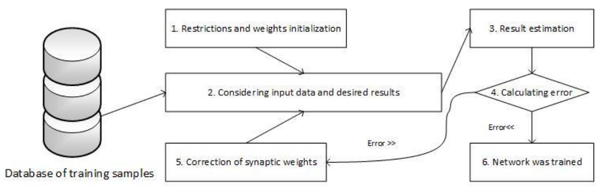

Figure 1: Functional scheme of backpropagation algorithm

The algorithm used (backpropagation) is assumed to estimate the error for output layer, as well as for each of trained network neuron, also neurons correction weights in accordance with current values. At the first step of the algorithm we initialized weights of connections of intermediate neurons with a negligible value (from 0 to 1). After initialization of the weights in the training process of neural network met steps:

- direct signal delivery;
- error calculation for last layer neurons;
- error delivery in the opposite direction (from output to input).

Direct signal delivery is carried by layer, starting from the entry layer, calculating the amount of the input signals for each neuron and with the help of activation function is generated a response of the neuron, which is distributed in the next layer heeding the weight of connection between neurons. The next stage of training - error calculation of neural network as the difference between actual and desired.

Error values obtained are distributed from the last output layer to the first layer of neural network. For this we calculate correction values for neuron weights depending on the current value of the connection between neurons, speed training and error for the corresponding neuron. After fulfilling this stage, the algorithm steps are repeated until we receive the desired error.

3. Conclusions

Trained and tested database consisted of data on 486 patients, among whom 243 were given the diagnosis "diabetes", while the rest were healthy.

Were trained over 240 examples and neural network was tested in 146 samples. The reliability of the model amounted to 89.5%. Theoretical difficulty, workload and time lost for network modeling were compensated by the simplicity of model using. If the task of solving the problem and optimal training are carried out only by specialists, then the practical application of the solution requires only basic knowledge of computer use. The difficulty of interpreting the train system for users deemed unnecessary simple, given that their most important is not the way of functioning of the neural network, but the result information, accuracy and operation speed.

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