Neural Network Model for the Prediction of the Evolution of the First Appearance of Stenocardia

OV Melnik

Ryazan State Radioengineering University, Russia

Abstract

The purpose of the work is development of the automatic system, allowing to construct the prognosis of current of the first time appeared stenocardia on base of the set of risk factor and to reveal patients with high risk of the myocardial infarction and sudden cardiac death.

The neural network model was designed. Design, education and testing of network were realized with use software package NeuroPro. After learning given neural network allows to solve the problem of categorizations patient by quality of the prognosis with probability 100% for unfavorable prognosis, 76% for favorable prognosis and 85% for medium prognosis.

Given neural network model with sufficient degree of validity allows to form the prognosis of the evolution of FTAS. Moreover the most certain is a detection of patient with high risk of the myocardial infarction and ventricular fibrillation.

1. Introduction

The first time appeared stenocardia (FTAS) is the first episode of pain registered of patient with myocardial ischemia.

Beside majority of patient with the FTAS approaches or stabilization, or regression of symptoms, but other upshots are possible, such aggravating angina pectoris, myocardium infarction of sudden cardiac death. The first time appeared stenocardia most often moves over to stable form. When patient for the first time addresses on cause of the warmhearted pain, beside he often diagnoses the stable form stenocardia, existing months and even years. At description of the clinic of stenocardia, as a rule, bear in mind most often meeting stable form of exertional angina pectoris with typical paroxysms of pain.

In All-Russian cardiologic scientific centre of Academies of the medical sciences for feature of gravity of stenocardia functional categorization is used, providing referring patient to one of four functional classes.

1-st functional class (FK1) of stenocardia. The angina pectoris is latent since a usual physical load does not cause the paroxysms. The patient without difficulties goes on any distances and rises on stairway. The stenocardia can appear only at load executed quickly and long. As a rule, these loads unaccustomed for sick and present overweening exertion for it. The sick with exertional angina pectoris of the FK1 often do not be aware of heart diseases beside itself.

2-nd functional class (FK2). Sick is noted small restriction to usual activity because of fit of the stenocardia, which appear when walking on even place and in normal rate not less 500 m, at ascent on stairway more, than on one floor.

3-rd functional class (FK3). Sick is sharply limited physical activity because of fit angina pectoris. The paroxysms causes walking on even place and in normal rate on distances 250-500 m, ascent on stairway on one floor. Once in a while alongside with fit of the exertional angina pectoris beside sick appear the fits at rest, but in this case on sick affects some provoking factor.

4-th functional class (FK4). Sick unapt to execute some physical load without arising of paroxysms of pain.

So, the prognosis for a disease for patients with the FTAS greatly differs and depends on big amount of clinic-instrumental parameters (risk factors), such age, heredity, presence of the accompanying diseases etc. It is necessary to reveal and take under intensive supervision patients with the high risk of appearance of serious forms of angina pectoris, the myocardial infarction and ventricular fibrillation.

2. Methods

The aim of the work is development of the neural network (NN) model, allowing to construct the prognosis of the evolution of the first time appeared stenocardia.

It is need to point the following requirements [1]:

- a system must work in real-time mode, because is often obligatory greatly quickly get the information about condition of the patient. So it is required to limit the set input parameter, not having forfeited diagnostic value of output result;

- value of many factors when stating the diagnosis and their intercoupling not always yield to the strict formalization. So better use the neural network selftraining systems.

The construction of the model is required the following stages:

1. The analysis of the raw data, choice and motivation of input parameters. Coding of input information.
2. The choice and modeling of the neural network structure. In most cases for tasks of the categorizations also task of the medical forecast perceptrons are suitable.
3. Preparation of samples of patients and neural network training on their base.
4. Testing of model designed.

Analysis of the source information will conclude in choice of clinic-instrumental factors, on the grounds of which neural network must be formed its prognosis conclusion.

The raw data were presented in the manner of array of information, kept in database about sick with FTAS, created by means of Microsoft Accesses package on base of the medical cards of patients, passable treatment in Ryazan regional cardiological clinic (RRCC).

In process of the analysis were revealled that gross amount of clinic-instrumental parameter, on which there is information on presence was 46. With physicians of RRCC were selected 13 most significant parameters [2]:

1. Age.
2. Smoking.
3. Malignant hypertension.
4. Cholesterol.
5. Systolic blood pressure.
6. Diastolic blood pressure.
7. Heredity (presence of the warmhearted diseases beside close relative).
8. Job type.
9. Condition of the first fit arising.
10. Conservation of the fit.
11. Effect of the nitroglycerine.
12. Consumption of the alcohol.
13. Left ventricular hypertrophy.

For processing by network all parameters must be presented in numeric form so question of its coding appears. All parameters used as input for network possible to divide into two classes - quantitative and qualitative. Quantitative parameters are “age”, “cholesterol” and “blood pressure”. Numeric information prepared for the NN processing, advisable scale i.e. justify the ranges of the change the values, for instance, having limited by their interval [0,1] or [-1,1]. Do this possible by means of the most simplest linear transformation:

$$\widetilde{x}_n = \frac{x_n - x_{n\min}}{x_{n\max} - x_{n\min}}(b-a)+a,$$

where x_n and $\widetilde{x}_n$ – magnitudes of source and scaled parameter n; $[x_{nmin}, x_{nmax}]$ – a real range of the change of parameter; $[a, b]$ – an acceptable range of the input signal change.

Table 1. Quantitative clinic-instrumental parameters coding

Smoking	
No	1
Moderate (was smoked but threw; smoking <10 cigarettes per day; <10 years)	2
Chronic (smoking 10-30 years; 10-20 cigarettes per day)	3
Chronic (smoking >30 years)	4
Malignant hypertension	
Absence	1
1 stage	2
2 stage	3
3 stage	4
Job type	
Moderate labour	1
Heavy physical labour	2
Managing job title	3
Large managing job title	4
Heredity	
No	1
Father of mother	2
Father and mother	3
Condition of the first fit arising	
Heavy loads	1
Moderate physical loads	2
Small physical loads	3
Rest	4
Conservation of the fit	
No	1
1-3 days	2
3-5 days	3
>5 days	4
Effect of the nitroglycerine	
Was not used	1
Good effect	2
No effect	3
Consumption of the alcohol	
No or episodic	1
Moderate	2
Chronic drunkenness	3
Left ventricular hypertrophy	
No	1
Yes	2

The network created within the framework of given designing has an internal mechanism of the transformation numeric data to input range [0;1] so no sense for the additional coding.

Qualitative parameters are of the form of ranked data. Their coding is realized by of the change the qualitative description to natural. On the grounds of gradation, presented in table 1, possible to produce the coding of qualitative parameter to quantitative network input values.

Prognostic aim of the NN is in choice of one of probable forecasts of the evolution of the disease. They were chosen the 3 classes of prediction:

CP 1: favorable prognosis for a disease, including regress of the disease and first functional class (FK1) of stenocardia.

CP 2: medium prognosis – FK2 or FK3.

CP 3: unfavorable prognosis – FK4, myocardial infarction or fatal outcome.

For construction of NN model the perceptron structure of network was chosen. It was installed that for decision of the problem is sufficient to use perceptron with one hidden layer.

Structure of output layer depend on type of presentations to output information. For instance in structure of the network can be present the output layer, amount of neuron in which is an equal with amount of considered variant of the forecast (3 output neurons). If NN when processing input data reveals presence of the concrete prognosis, that output corresponding to neuron is 1, but under its absence output equals 0. Since variants of the forecast are incompatible, that values of NN output depending on probable forecast is possible to illustrate in table 2.

Table 2. Neural network output data structure, 3 out

Prognosis	**NN out**		
	Out 1	Out 2	Out 3
CP 1	1	0	0
CP 2	0	1	0
CP 3	0	0	1

The other variant of the presentation of output information is an use of one output (analog or discrete). In this case values of the output parameter are depending on class of the forecast (table 3).

Table 3. Neural network output data structure, 1 out

Prognosis	**NN out**	
	Out 1(discrete)	Out 1 (analog)
CP 1	1	(0,5;1,5)
CP 2	2	(1,5;2,5)
CP 3	3	(2,5;3,5)

The choice of the most optimum structure of output data must be realized experimental.

Is chose following strategy of searching for optimum amount of neuron of the hidden layer. First follows to assign the small quantity a neuron (for instance, 2). At impossibility of the network training finalize amount of neuron is increases. It is initialized and trained new network, repeating parameters previous, but with larger amount of neuron. The process is repeated until one of networks trained completely.

One of the principle of strategies of the NN training – is a creation for each problem several networks with miscellaneous feature. After its training is possible to compare prognostic abilities of different networks at same test example. So, for choosing of optimal NN structure it is necessary to prepare training and test samples.

As source for sheduling training and test sample was taken database of patient with for the first time appeared stenocardia. The full analysis of this database has allowed to reveal 88 patients, beside which were fixed all input parameters, as well as the known evolution of the disease (repeated survey 2-4 year after the first appearance of the pain), which are used for prognostic system learning.

When sheduling training samples it is necessary to check for present of alike example referring to miscellaneous class. Presence of such example reduces reliability of the work to network. When viewing of a priori information patient with alike values of all input parameter, referring to miscellaneous class forecast is not revealed.

For CP 1 are presence 27 examples, for CP 2 - 46 examples, for CP 3 - 15 examples. The most typical records of each class of the prognosis were selected for training of networks. It was formed reference group of training sample, consisting of 22 patient records with the known prognosis.

Design, education and testing of network were realized with use software package NeuroPro. The NeuroPro program is freeware alpha-version product working by Windows for studies in accordance with artificial neural networks and extractions of the knowledges from tables given by means of neural networks.

3. Results

The experimental NN study with formed structure input and output data has shown that network is trained completely under minimum amount neuron in hidden layer, equal 4, however best prognostic abilities reveal when increase amount neuron of to 13-20.

The analysis of prognostic quality of network was conducted coming from maximum mistake of the generalization on each of output. The dependencies of the said criterion from amount of neuron of hidden layer were built. At fig.1 dependency for network with 3 outputs is presented.

The nature of the dependencies possible to explain as follows. Error of the generalization is identified the difference between desired and real NN output within test sample. While like difference on output beside training samples is identified error of the training. Their dependency from number of hidden layers is different. Error of the training on measure of the increase the number neuron decreases, but error of the generalization has a more complex nature of the change. First she decreases, but then, reaching minimum, begins to increase. The number of the degrees of freedom of neural network - a total number of synaptic weight, which is defined by number of neuron in hidden and output layers. The characteristic of NN lose the ability to generalization under overweening increase the number of its degrees of freedom name the conversion training. For each of variant of the presentation to output information was evaluated value each of entry (the clinic-instrumental factor) and efficiency of the work depending on numbers neuron.

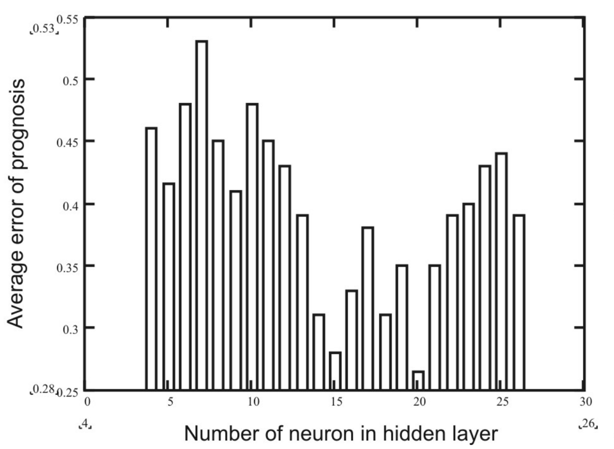

Figure 1. Maximum mistake of the generalization depend on number of neuron in hidden layer. Network with 3 outs (Out 2).

The most efficient has shown be structures with 13 neurons in hidden layer, one analog out (80% correct prediction at all classes) and with 20 neurons in hidden layer, 3 binary out. After learning given neural network allows to solve the problem of categorizations patient by quality of the prognosis with probability 100% for unfavorable prognosis, 76% for favorable prognosis and 85% for medium prognosis.

4. Discussion and conclusions

The neural network model for the prediction of evolution of the first time appeared stenocardia was designed.

Most significant clinic-instrumental parameters (factors of risk) were selected. All parameters were coding to numeric form. In study are included 88 patients with FTAS diagnosis. As input data, on the base of which prognosis is formed, the 13 most significant risk factor, got under primary examination, were selected. Based on result of the repeated survey (2-4 year after the first appearance of the pain) patients were divided into 3 classes: favorable prognosis for a disease, including regress of the disease and 1-st functional class (FK) of stenocardia, medium prognosis - 2-nd or 3-rd FK, and unfavorable prognosis - 4-th FK, myocardial infarction or fatal outcome.

It was formed training sample, consisting of 22 patient records with the known prognosis and testing sample consist of remained records. The neural network model (two-layer perceptron) was selected, designed, trained and tested.

Given neural network model with sufficient degree of validity allows to form the prognosis of the evolution of FTAS. Moreover the most certain is a detection of patient with high risk of the myocardial infarction and ventricular fibrillation.

References

[1] Melnik O.V., Vikhrov S.P., Miheev A.A., Yakushin K.S. Foundations of the construction of the automatic system for integrated diagnostics of cardiovascular diseases. Biomedical technology and radioengineering: 2007:5:33-5.

[2] Melnik O.V., Yakushin K.S Possibilities of the forecasting of the first time appeared stenocardia with use the mathematical model of neural networks. Medical bulletin: 2008:273-3.

O.V. Melnik
Biomedical and Semiconductor Electronics Department
Ryazan State Radioengineering University
Gagarina, 59/1
Ryazan, Russia
390005

omela111@yandex.ru