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## **APPLICATION OF ARTIFICIAL NEURAL NETWORKS FOR PROGNOSIS IN MEDICINE**

*There are two large groups of sources of uncertainty at various stages of construction of neural networks. These groups are discussed in the article and recommendations for their reduction have been proposed.*

**Introduction.** The process of diagnostics and prognostication of the state of cardiovascular system is very complicated, and includes a lot of various rates and big amount of uncertainty factors: raw data, environmental variables, process dynamics of the human body. That is why it is impossible to predict uniquely in medical-biological field. The wide usage of artificial neural networks (ANN) in medicine is required to solve the difficult scientific problems. The possibilities of ANN enable to work on a big data level and to take into consideration the majority of the influence factors and resolve the problem promptly.

**Basic materia.** Microinfarction appearance and the time of it's origin were predicted using artificial neural networks. The sources of uncertainty factors have been detected by the analysis of 128 ANN. This diagram represents the sources of uncertainty.

There are two groups of uncertainty while we are building ANN for it's prognosis. At the top of the chart there are the sources of uncertainty due to input data.

The rates of biological entity are characterized by unstable features which can vary by the influence of external and internal causes (stress influence, social environment, environmental cataclysms, magnetic oscillations etc). That's why the biological object's data are the source of uncertainty.

The research data also include a big amount of uncertainty factors. All these factors are represented in literature [1].

For the body state prognosis we used clinical evidence of cardiovascular system. For the 2 year period the physical examination data of 110 patients of cardiological unit have been analysed. These data included blood examination (Activated Partial thromboplastin time, Prothrombin index, Thrombin time, International normalized ratio, soluble fibrin monomer complex, Antithrombin, Fibrinogen, D-dimer, cholesterol, reactive protein, lipoproteins and others), 1870 characteristics in all. The metrics included the time from the beginning of the examination till the microinfarction formation  $t$  and the presence or absence of the microinfarction  $k$ . The test sample included diagnostic data of ten patients. The recommendations for the quantity of the raw data: after the realization of experiments it has been established, that it is necessary more than 100 raw data for the uncertainty reduction while building ANN.

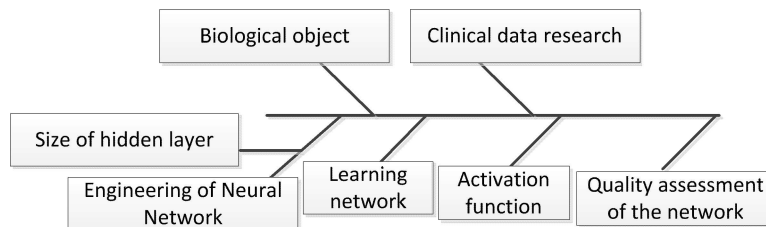


Figure.1 Ishikawa diagram.

The bottom of diagram represents the sources of uncertainty by building and analysis of raw data ANN. These sources can be divided into 4 groups: incorrect neural network planning, quality assessment of ANN, network training process and activation function.

While neural network planning in the first place it is necessary to decide an issue of ball quantity and neuron quantity in each ball.

The recommendations for uncertainty reduction while planning and selection the quantity of hidden balls. For the determination the level of general capacity of the network it is necessary to test the network occasionally by use of independent data set and stop testing if testing error grows up. But the time of training and required data quantity rises. The number of hidden balls of neural network can be corrected and some experiments may be needed to determine the optimal choice.

Estimation criteria of network operation. Estimation criteria should be divided into internal and external. Internal criteria are formed on the basis of data set information whereas external criteria use new information of tested data set, which elements were not used in training. The optimal complication of the network model is formed on the basis of internal and external criteria.

The recommendation for uncertainty reduction using regularity criteria consists in selection of network model which is at most exact in tested data set elements, which were not included intraining data set.

The recommendation for uncertainty reduction using minimal bias criteria require exact coincidence of reference quantity value for two models in which data of various data set of training network were used. Minimal bias criteria enables to choose the model which respond weakly for the changing of training data set and also enables to decide an issue of law restore for the noisy tested data.

The recommendation for uncertainty reduction using bias in the period of time criteria- enables to estimate the correlation level of variable. The certain signs can have various aftereffects, so separate prognostication ensures the best result.

The recommendation for uncertainty reduction using physical reliability criteria requires excluding of models which can provoke unreal results.

The network training

As a rule after neural network training the reference imaging of data is performed. If imaging accuracy is tolerable and errors are in valid limits it is considered that tolerable model is built and good quality of imaging should be expected. [2].

Causes of uncertainty increasing of data set can be provoked:

- imperfect data with high randomness. In this case requirements for the observation accuracy should be raised; in cases of time series the pitch of discretization can be required;

- negligible factors which determine the regularity. This problem can be solved by broadening of factors set;

After gaining the expected value absolute and relational errors can be received for the each pitch of prognostication. After receiving tolerable results of prognostication it can be considered that network has optimal complexity and is ready for data imaging.

The general scheme of uncertainty reduction while training the network:

1. The present example (first) and its input parameters are taken from the training selection. Then they are directed to the input synapses of the network. As a rule each input parameter is directed to one input synapse.

2. The neural network performs required number of operation cycles and input parameters vector transmittes to the neural association.

3. The signals of output neurons are measured.

4. Interpretation of received signals is performed and value has been estimated. It defines the difference between the network answer and required answer. The value is calculated with use of estimator. The less the value the better the recognized example and the nearer network answer. The value zero means that required goal is achieved. It should be noted that untrained neural network can produce correct answer only accidentally.

5. If value is zero nothing happens. On the basis of value correcting coefficients for the each matrix weight are calculated and than synaptic weight is adjusted (reverse functioning). The training means correction of synaptic weight.

6. Trancision to next example is occured, and the operations recur. Passing all examples is the cycle of training.

Each example has its own value during passing the cycle. Composite score of example set is calculated. If after passing some cycles the composite score is zero the training is finished [2].

The recomendations for uncertainty reduction using number of hidden elements. During the selection of hidden elements number the number of hidden elements  $h$  shouldn't be more than doubled number of input elements:  $h \leq 2i + 1$ , in addition it is necessary to select the lesser number of hidden elements. In addition the number of training data should be in  $\frac{1}{e}$  times more than the number of network weight quantity. [3].

If data dimension can be reduced the lesser number of hidden units should be used.

When training using structureless input it is required that number of hidden units was larger than the entries. The number of hidden elements which are needed for the classification problem solving, should rise with rising the number of classes in which the space of entries is divided[4].

The activation functions of the element(neuron) summarize the balanced entries from all adjunct elements. This range is selected (0; - 1), or (-1; +1). Large values

always shrink to add the reduced contribution. That is why the activation functions should be nonlinear [5].

The recommendations for uncertainty reduction: for the gaining qualitative results, the training, the control and the tested data set should be representative, in addition this data set should be representative separately. If trained data are not representative this model will be not so good or unsuitable [6].

The error which is found at the expense of error, causes uncertainty while neural network planning uses for prognostication accuracy evaluation  $E_{bp}$  and uncertainty reduction:

$$E_{bp} = \frac{\sum |e_i|}{n_{bp}}, \quad (1)$$

the lower the value  $E_{bp}$  - the better prognosis. On the ground of experiment series the network GRNN 17:17-6-3-2:2 (figure.2). is optimal. This neural network shows the best result among 186 built neural networks. While it's building we used the rule of training with a teacher, sigma activation function, two hidden balls and 9 neurons.

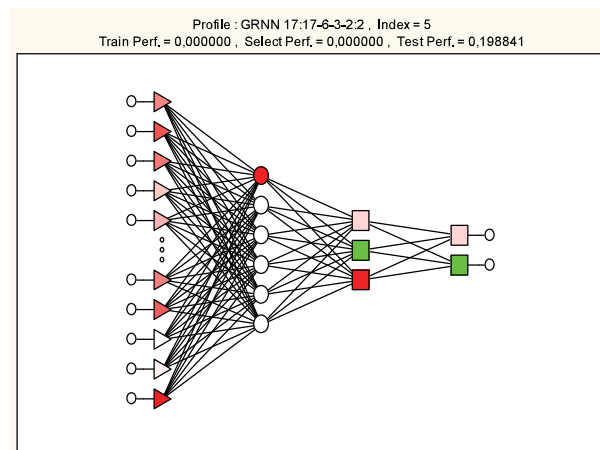


Figure.2 Neural network GRNN 17:17-6-3-2:2

The following architecture of neural networks is used:

1. Radially-basic network
2. Linear network
3. Multilayer perceptron
4. Neural network of general regression

Minimal error was showed in network, witch belongs to neural networks of general regression and has 17 input neurons, 6 and 3 neuronsin hidden balls. This network while training on tested set data has error 0,043, while check on tested data set - 0,001.

**Conclusion** At the article the results of ANN building have been analysed. The sources of uncertainty factors occurrence have been discovered. Approaches to the reduction of uncertainty with the recommendations have been proposed. The formula for forecast precision have been proposed. As an example the effective architectures of ANN have been built and estimated. These architectures are: multilayer perceptron, probability neural network, BPE network and its modifications. The network which could build prognostication with the minimal error of tested set belong to networks of general regression, the network which uses nuclear approximation for the regression building. This neural network can be used in cardiology for cardiac microinfarction prognostication.

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