UDC 004.896

S.V. Holub, V.V. Horban
(Cherkasy National University named after Bogdan Khmelnitsky, Ukraine)

Intelligent monitoring of cardiograms

In the modern world, it's important to watch and take care of your health, because the danger is waiting at every step. A large proportion of the diseases are heart disease.

It is very important to detect the disease in a timely manner. In our time, many tasks are performed by work and computer programs. One of these is the task of intelligent monitoring of cardiograms.

Intelligent monitoring is an information technology that is able to make decisions by providing knowledge by organizing observations and processing their results.

The result of the monitoring is:

- identification of the cardiologist;
- detection of a disease.

The task of classification of cardiograms is solving. Before beginning a known list of classes of cardiograms and numerical values of signs. This is done expertly. As in the stage of classification and at the identification stage, it is necessary to construct a decisive rule that can solve each of these tasks of information transformation.

Therefore, it is proposed to use a monitoring intellectual system (MIS). The synthesizer contains more than 20 algorithms for model synthesis. They implement inductive methods of synthesis of models, genetic algorithms, neural networks of their combination in hybrid methods as well as technologies of multilayer and multilevel synthesis of models.

The influence on the results of monitoring of cardiograms has a powerful effect on the synthesis and informativeness of the input data array. This is provided by the skill level of the expert forming the vocabulary of the signs. And the ability of the MIS synthesizer to construct new algorithms for model synthesis adaptively to the properties of an array of input data.

Group method of data handling (GMDH) is a family of inductive algorithms for computer-based mathematical modeling of multi-parametric datasets that features fully automatic structural and parametric optimization of models.

GMDH is used in such fields as data mining, knowledge discovery, prediction, complex systems modeling, optimization and pattern recognition. Li et. al. (2017)'s results showed that GMDH neural network performed better than the

classical forecasting algorithms such as Single Exponential Smooth, Double Exponential Smooth, ARIMA and back-propagation neural network.

GMDH algorithms are characterized by inductive procedure that performs sorting-out of gradually complicated polynomial models and selecting the best solution by means of the so-called external criterion.

A GMDH model with multiple inputs and one output is a subset of components of the base function (1):

$$Y(x_1, \ldots, x_n) = a_0 + \sum_{i=1}^{m} a_i f_i$$

where f are elementary functions dependent on different sets of inputs, a are coefficients and m is the number of the base function components.

In order to find the best solution GMDH algorithms consider various component subsets of the base function (1) called partial models. Coefficients of these models are estimated by the least squares method. GMDH algorithms gradually increase the number of partial model components and find a model structure with optimal complexity indicated by the minimum value of an external criterion. This process is called self-organization of models.

The most popular base function used in GMDH is the gradually complicated Kolmogorov-Gabor polynomial (2):

$$Y(x_1, \ldots, x_n) = a_0 + \sum_{i=1}^{n} a_i x_i + \sum_{i=1}^{n} \sum_{j=i}^{n} a_{ij} x_i x_j + \sum_{i=1}^{n} \sum_{j=i}^{n} \sum_{k=j}^{n} a_{ijk} x_i x_j x_k + \cdots$$

The resulting models are also known as polynomial neural networks. Jürgen Schmidhuber cites GDMH as one of the earliest deep learning methods, remarking that it was used to train eight-layer neural nets as early as 1971.

A simple description of model development using GMDH

For modeling using GMDH, first, the number of inputs for each neuron, polynomial power and input sources of layers after the first layer are decided. Then, the design process begins from the first layer and goes on. All possible combinations of allowable inputs (all possible neurons) are considered. Then polynomial coefficients are determined using one of the available minimizing methods such as singular value decom-position (with training data). Then, neurons that have better external criterion (for testing data) are kept, and others are removed (The input data for development of the model were divided into training and testing groups). If the external criterion for layer's best neuron surpasses the stopping criterion, network

design is completed and the polynomial expression of the best neuron of the last layer is introduced as the math-ematical prediction function; if not, the next layer will be generated, and this process goes on.

GMDH-type neural networks

There are many different ways to choose an order for partial models consideration. The very first consideration order used in GMDH and originally called multilayered inductive procedure is the most popular one. It is a sorting-out of gradually complicated models generated from Kolmogorov-Gabor polynomial. The best model is indicated by the minimum of the external criterion characteristic. Multilayered procedure is equivalent to the Artificial Neural Network with polynomial activation function of neurons. Therefore, the algorithm with such an approach usually referred as GMDH-type Neural Network or Polynomial Neural Network.

Combinatorial GMDH

Another important approach to partial models consideration that becomes more and more popular is a brute force combinatorial search that is either limited or full. This approach has some advantages against Polynomial Neural Networks but requires considerable computational power and thus is not effective for objects with more than 30 inputs in case of full search. An important achievement of Combinatorial GMDH is that it fully outperforms linear regression approach if noise level in the input data is greater than zero.

References

1. Golub S.V. Multi-level simulation in environmental monitoring technologies. Cherkasy: View. from. ChNU named after Bohdan Khmelnytsky, 2007. - 220 p.

2. Group method of data handling - Mode of access: World Wide Web: https://en.wikipedia.org/wiki/Group_method_of_data_handling (viewed on September 27, 2018)