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Construction of an Algorithm to Support Decision Making in Self-Government Bodies Using a Neural Network

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ABSTRACT: The article deals with the problem of developing a model and algorithm for assessing the state and supporting decision-making in self-government bodies using a neural network of machine learning. A multi-layer direct propagation neural network is constructed as a neural network. The neural network has three inputs, the hidden layer has two neurons and one output. The training sample consists of parametric assessments of educational activities, the social environment and the state of crime in local governments. The dependent parameter in the sample consists of generalized expert assessments of self-government bodies, in numerical form. A model and algorithm of the decision support process using a multilayer neural network of direct propagation perceptron are constructed. Based on the constructed model and the proposed algorithm, the weight coefficients of neurons are calculated and a linear function is constructed to support decision-making. Using this model, a generalized expert assessment is determined for the new self-government body in numerical form, which is interpreted as a proposed solution for improving the condition of the object.

KEY WORDS: model, algorithm, function, training sample, data processing, expert evaluation, parametric evaluation, decision support, machine learning, perceptron, neural network, neuron, function coefficients, self-governing bodies, statistical data, weight coefficients.

I.INTRODUCTION

Neural network technologies are a branch of machine learning dedicated to modeling human intellectual activity. Today, it is an extensive area of research and development of intelligent systems designed for work in difficult-to-formalize areas of human activity. The problems solved by the neural network method are characterized by the presence of a large number of degrees of freedom with the number of options for finding solutions approaching infinity. In contrast to the rigidly deterministic computer programs machine learning systems themselves looking for ways to solve the problem. At the same time, they can change their parameters and structure, improve and develop [1,2].

Using a multi-layer neural network of direct propagation, the classification problem is solved. Classification models-describe rules or a set of rules according to which a description of any new object can be assigned to one of the classes. Such rules are built on the basis of information about existing objects by dividing them into classes [2-4].

II. STATEMENT OF THE PROBLEM

In this article, self-government bodies are considered as the object of research [5], and the subject is decision – making support based on machine learning using neural network technologies. In this case the main task is the following: based on machine learning parametric assessment of educational, social and criminal state authorities and the relevant decisions of the experts expressed by the numbers [6], support decision-making in the new government.

Structure of training dataset. In the classification and regression problem, you need to determine the value of the dependent variable of an object based on the values of other variables that characterize this object. Formally, the problem of classification and regression can be described as follows. There are many objects available:

$$X = \{X_1, X_2, \dots, X_j, \dots, X_n\} \tag{1}$$

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here X_j is— the object under study. In our task, objects are self-government bodies.

Each object is characterized by a set of variables, that is, in the case of the task set, each self-government body is characterized by parametric estimates obtained in three areas of activity (education, social status and crimes):

$$X_j = \{x_{j1}, x_{j2}, \dots, x_{jh}, \dots, x_{jm}, y_j\} \quad (2)$$

Here x_{jh} is — independent variables whose values are known and on the basis of which the value of the dependent variable y is determined. In this example, the independent variables are parametric estimates for the fields of activity. Here, y_j is a dependent indicator and contains numeric values of expert ratings. The training sample has the following matrix representation:

Objects	Parametric estimation of educational activities.	Parametric estimation of the social environment	Parametric estimation of the state of crime	Expert estimation
X_1	x_{11}	x_{12}	x_{13}	y_1
X_2	x_{21}	x_{22}	x_{23}	y_2
X_3	x_{31}	x_{32}	x_{33}	y_3
…	…	…	…	…
X_n	x_{n1}	x_{n2}	x_{n3}	y_n

III. SOLVING THE PROBLEM

The problem can be reduced to a problem solved by a multi-layer neural network with direct signal propagation and reverse error propagation [7,8]. How to build a neural network is solved in two stages:

- Selection of the type (architecture) of the neural network;
- Selection of weights (training) of the neural network.

In the first step, the following is performed: which neurons are used (number of inputs, transfer functions); how to connect the neurons to each other; determines the inputs and outputs of the neural network.

If we take into account that the number of independent variables is three and one dependent variable, then to train this data to a neural network, we will create a neural network perceptron with three inputs and one output. A neural network has a hidden layer with two neurons (Figure 1). The type of selected neural network without feedbacks and the neurons of all layers are fully connected, that is, the output of each neuron of the q – th layer is connected to the input of each neuron (q+1) of the layer [4].

In the figure 1:

- X $\{x_1, x_2, x_3\}$ – vector of network input signals;
- w_1-w_6 – synaptic scales of connections between incoming and hidden layer neurons.
- w_7-w_8 - scales of connections between neurons of the hidden and outgoing layer;
- $\bar{y}$ - The weighted sum of the neural network (net) is the sum of the input vectors and the values of the hidden neurons multiplied by the corresponding weights. Calculated by the formula:

$$net = \sum_{i=0}^{n} x_i w_i \quad (3)$$

In the neurons of the hidden layer, activation functions are used. That is, the weighted sum in the neurons of the hidden layer- *net(h_i)* will send to the output is not correct — the neuron must process and calculate the output signal. For this purpose, an activation function is used, which converts the weighted sum into a number, which will be the output of the neuron. The activation function is denoted as $\phi(net)$ [9]

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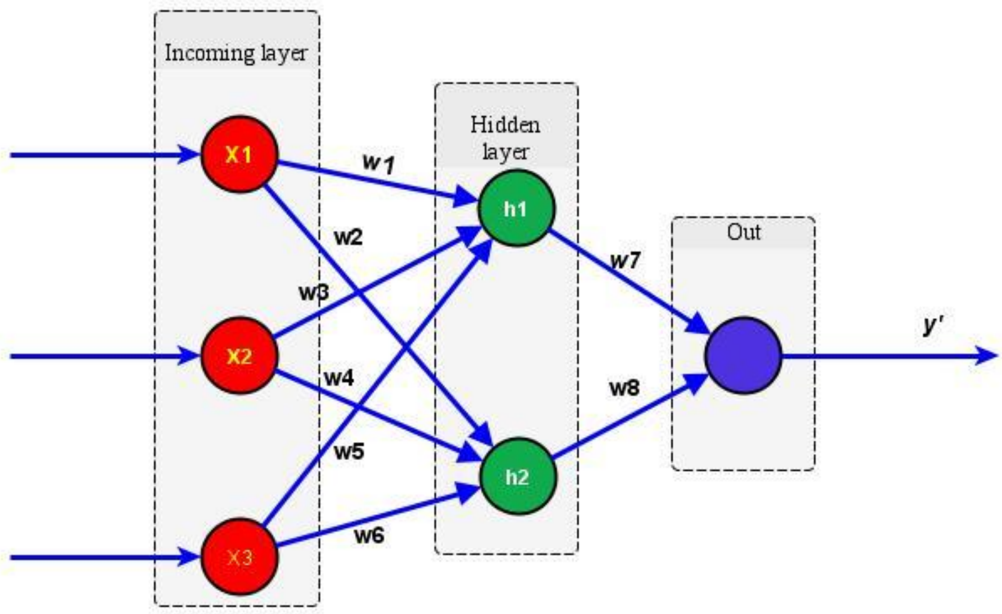

Fig 1. Neural set with three inputs.

Neural network training algorithm. Neural network training is the search for such a set of weight coefficients, in which the input signal after passing through the network provides the result we need. The generalized learning process of a neural network is schematically shown in Figure 2.

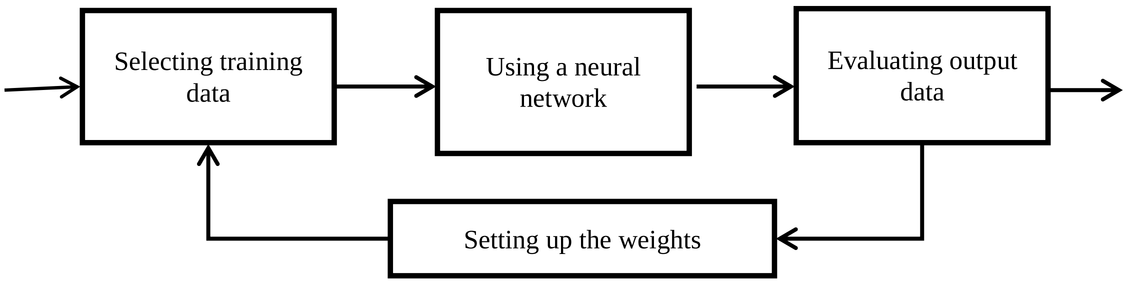

Fig 2. generalized learning process.

The most common method of teaching a multi – layer perceptron is the method of error back propagation and refers to the methods of teaching with a teacher [8].

The learning algorithm looks like this:

Step 0. The training sample is loaded to the vector {x}. The weights of the connections between all neurons are initialized (the weights of all connections are initialized with random small values).

Step-1. As long as the termination condition of the algorithm is incorrect, steps 2 — 9 are performed. The termination condition is determined by the formula:

$$E = \frac{1}{2}(y - y')^2 \qquad (4)$$

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Here, y is the target value, y′ is the actual weighted output value. The process is iterative and uses the principle of "step-by-step" training (on-line training), when the weights of the neurons of the network are adjusted after submitting one training example to its input.

Step 2. For each pair of independent and dependent { data, target value}, steps 3 — 8 are performed. In the following steps, the data is distributed from the inputs to the output throughout the neural network.

Step 3. Each input neuron (x_1, x_2, x_3) sends the resulting xi values to all the neurons in the next hidden layer (h_1, h_2).

Step 4. Hidden neurons h_1, h_2 sums the weighted input values: $net(h_k) = w_{0k} + \sum_{i=1}^{n} x_i * w_{ij}$ applies the activation function:

$$\varphi(net) = 1/(1+exp^{-\alpha * net}) \quad (5)$$

Then sends the result (in the range 0-1) to the output layer neurons. In our case, the only one output neuron.

Step 5. The output neuron, using formula (3), sums the weighted input values, and applies the activation function to calculate the output value.Then the error is propagated backwards.

Step 6. The output neuron receives the target value — the output value that is correct for this input signal, and calculates the error, as well as calculates the amount by which the weight of the connection will change. In addition, it calculates the value of the offset adjustment: and sends it to the neurons in the previous layer.

Step 7. Each hidden neuron sums up the incoming errors (from the neurons in the subsequent layer) and calculates the error value by multiplying the resulting value by the derivative of the activation function, as well as calculates the amount by which the link weight will change: In addition, it calculates the amount of offset correction.

Step 8. Each output neuron changes the weights of its connections to the bias element and the hidden neurons. Each hidden neuron changes the weights of its connections to the offset element and the output neuron

Step 9. Checking the termination condition of the algorithm.

The result of training the neural network and the graph of the above algorithm is shown in Figure 3-4.

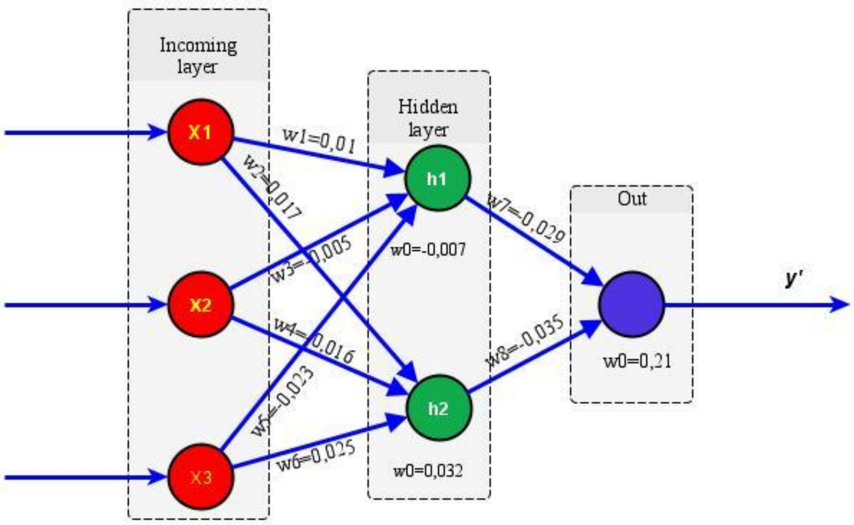

Fig 3. The values of the weight coefficients of the neural network

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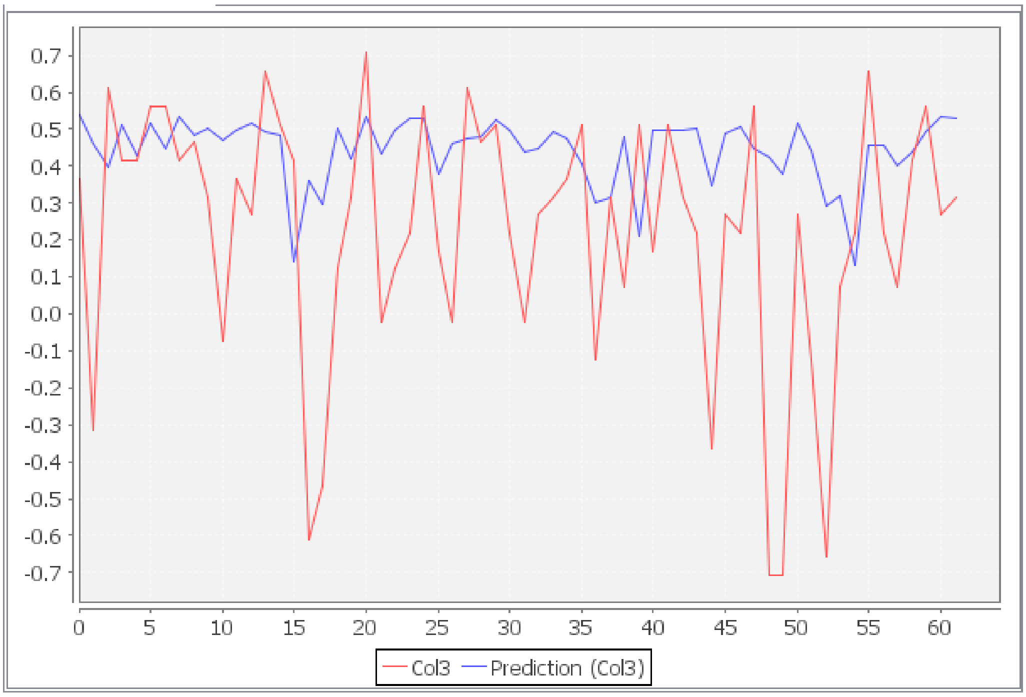

Fig 4. Graph of weighted and target values of expert assessments.

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