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FORECASTING OF ELECTRIC POWER LOSSES IN ELECTRIC NETWORKS OF POWER SYSTEMS WITH APPLICATION OF ARTIFICIAL NEURAL NETWORKS

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The urgency of perfection of management of electro power objects at the present stage of development of power grows because of change of conditions of their functioning. For maintenance of an appropriate level of reliability of functioning of electro power objects it is required perfection of systems of dispatching management by development of new approaches, including based on methods of an artificial intellect.

Efficiency of the decision of problems of operative management of electric networks (EN) demands maintenance of speed in rate of real process. These features influence on methodical, the software and the used computing base, procedures of use of an artificial intellect being components in control systems. Now it is possible to provide increase of speed of computing systems due to training a neural network outside of real time at maintenance of the account of a difficult surface of function of quality and adaptation to changes of topology of an electric network and to change of a mode.

Electrical energy (EE) losses in electric networks are the major parameter of profitability of their work. Calculation of losses in an electric network is necessary at drawing up and the analysis of power and energy balances on each power supply system with an estimation of efficiency of actions on input of compensating devices, means of regulation of a voltage and jet capacity, etc. In this connection carrying out of researches on perfection of design procedures of actual technical losses EE in networks and a substantiation of normative characteristics of losses EE are actual.

In the Azerbaijan Research and Design and survey institute of Power (ARDSIP) various techniques, algorithms and the corresponding software for calculation of losses EE in EN for calculation of actual technical losses EE [1, 2] are developed.

One of widely used approaches to construction of systems of AI - **i**mitating. The given approach is classical for cybernetics with one of its base concepts - "a black box" - the device, the information on internal structure and which contents is absent completely, but specifications of entrance and target signals are known. The object, which behaviour is simulated represents such "a black box". It is not important for us, that at it and at model inside and as it functions, the main thing that our model in similar situations behaved precisely as. Thus, here, after training and self-organizing, one more property of the person - ability to copy that others make is simulated, not pressing in a detail, what for it is necessary. The basic lack of the imitating approach also is low information ability of the majority of the models constructed with its help.

Many real processes in PS cannot be adequately described with the help of traditional models as a matter of fact are essentially nonlinear.

Special artificial neural networks (ANN) can serve in the given situation the adequate device for the decision of problems of diagnostics and forecasting [3, 4], realizing ideas of a prediction and classification at presence of the training sequences, distinguished as high speed of training and universal approximating opportunities.

The purpose of the present work is the opportunity of forecasting of losses of the electric power in electric networks of power supply systems with application of artificial neural networks. The greatest distribution to power was received with three kinds ANN: multilayered networks of direct distribution, Kohonen network, recurrent Hopfield networks. Set of researches that is reflected in [5] is devoted to neural-network simulation of various problems of operative management EPS.

The important stage in creation ANN is its training which consists in adjustment of parameters ANN. Kind ANN defines features of training.

As the basic stages of realization NN approach for the decision of set of various problems it is possible to allocate: preparation of the data for training a network; creating a network; training a network; testing a network; simulation a network.

The big role for a learning efficiency of a network is played with architecture of NN. It is known, that by means of three-layer NN it is possible to approximate any function with as is wished set accuracy [3, 4]. Accuracy is defined by neurons number in the latent layer, but at too big dimension of the latent layer there can come the phenomenon named over train of a network. For elimination of this lack it is necessary, that the number of neuron in an intermediate layer was much less, than number of training images. On the other hand, at too small dimension of the latent layer it is possible to get in an undesirable local minimum.

The greatest interest represents algorithm of return distribution of a mistake as is effective means for training multilayered neural networks of direct distribution. The algorithm minimizes a root-mean-square mistake of a neural network.

It is possible to draw the following conclusions on advantages of use of artificial neural networks (ANN): an opportunity of construction of models of difficult processes; high reliability of reception of result by virtue of formation of obvious dependence of required parameters from set.

On the basis of the lead comparison it is obvious, that artificial neural models will be more effective under following conditions: the simulated object is very much combined; simulated object essentially nonlinear.

If to state a comparative estimation to the determined methods of calculation of losses of capacity (design of experiments) and calculation of losses of capacity with the help of the device of neural networks it is necessary to allocate advantage of the last which consist in economy of time of calculation.

Intellectual information systems can use "libraries" of the most various methods and the algorithms realizing different approaches to processes of training, self-organizing and evolution at synthesis of systems of AI. As by present time is not present neither the generalizing theory of an artificial intellect, nor a working sample of full-function AI-model it is impossible to tell what from these approaches is correct and what erroneous: most likely they are capable to supplement harmoniously each other.

The artificial intellect is realized with use of four approaches: logic, evolutionary, imitating and structural. All these four directions develop in parallel, frequently mutually being bound.

Multiple layers of neurons training. Mathematically the problem consists in a finding of such values of weight factors that the mistake of a mismatch between reaction of a network and the required response for all examples of training sample was minimized. Summation is conducted on all neuron a target layer and on all images process able by a network:

$$\min E(w) = \sum_{i=1}^{p} E_p = \sum_{i=1}^{p} \sum_{j=1}^{m} (y_{ij} - d_{ij})^2, \quad (1)$$

where y_{ij}, d_{ij} are accordingly actual and desirable reaction *j-th* neuron a target layer on *i-th* an entrance vector, p is number of examples in training sample, m is number of neurons in a target layer.

All existing methods of training can be classified on deterministic and stochastic. In the deterministic methods formulas of return distribution of a mistake are used. Now are developed, as various updating of algorithm of return distribution of a mistake, and more powerful procedures of training ANN realizing such methods of search, as a method of the connected gradients, quasiNewton methods, etc. [3-4].

In the first case procedure of correction of weights uses the information on a gradient of function of mistake E and demands differentiability of function of activation.

Minimization of function of quality is carried out on the basis of algorithm gradient descent in space of the weight factors, carried out consistently for all images of training sample

The algorithm of training ANN with the help of procedure of return distribution is below resulted:

1. To submit on inputs of a network one of possible images and in a mode of usual functioning ANN when signals are distributed from inputs to outputs to calculate values of the last.
2. To calculate $\delta^{(N)}$ for a target layer. To calculate changes of weights $\Delta w^{(N)}$ layer N.
3. To calculate accordingly $\delta^{(n)}$ and $d\Delta w\kappa^{(n)}$ for all other layers, n=1.., N.
4. To correct all weights in ANN

NN expansions to popular packages of applied programs considerably facilitate process of designing of intellectual systems on computer. For example, Excel Neural Package supplements MS Excel with algorithms of the data processing, neural networks using technology.

At creation NN it is necessary to take into account that the general number of connections of a network (weights) should be in some times or even on the order of less volume of training sample. It will provide smooth enough approximation of the data. Otherwise NN "will simply be retrained", i.e. will remember the data, having lost an opportunity to do statistically significant a prediction on the new data.

Further results of forecasting of losses of active capacity in having electric networks PS joint-stock company "Azerenerji" from active capacities of power plants on base ANN are resulted. The block the circuit of algorithm of application ANN for calculation of losses EE is resulted on fig.

In table 1 and 2 factors of the equation of regress for forecasting losses of capacity as full square-law model received on full factorial experiment are resulted.

Table 1. Factors of square-law model of regress (B_0 = 49.543)

№	Node name	Factor type	Lower limit	Upper limit	Linear coefficients	Nonlinear coefficients
1	STPS-1	P	100.00	400.00	1.3173	1.3291
2	GRESSEV	P	144.00	576.00	4.2234	6.7666
3	BAKTPS-1	P	26.80	107.20	-0.4704	0.3601
4	SHIR220	P	120.00	480.00	1.6042	1.3821
5	TotalTPS	P	1369.20	3423.00	12.2802	19.8756
6	TotalTPS	Q	1053.12	1755.20	1.6797	0.6623

Table 2. The mixed factors of regress

	2	3	4	5	6
1	0.9180	0.0867	0.7697	-4.7666	-0.0069
2		0.7682	1.2135	-13.0612	-0.0355
3			0.1319	-1.9674	-0.0204
4				-6.0603	-0.0107
5					0.6021

MSE has made 0.78 %, the maximal mistake has made less than 2.12 %.

Forecasting losses of capacity by training ANN has been made and the verbal description is received. The maximal mistake of calculation of losses with use ANN has made less than 0.2 %, MSE has made 0.1 %.

The comparative estimation of the determined methods for EE losses calculation and ANN based algorithm for EE losses calculation, shows advantage of the last which consist in accuracy of calculation.

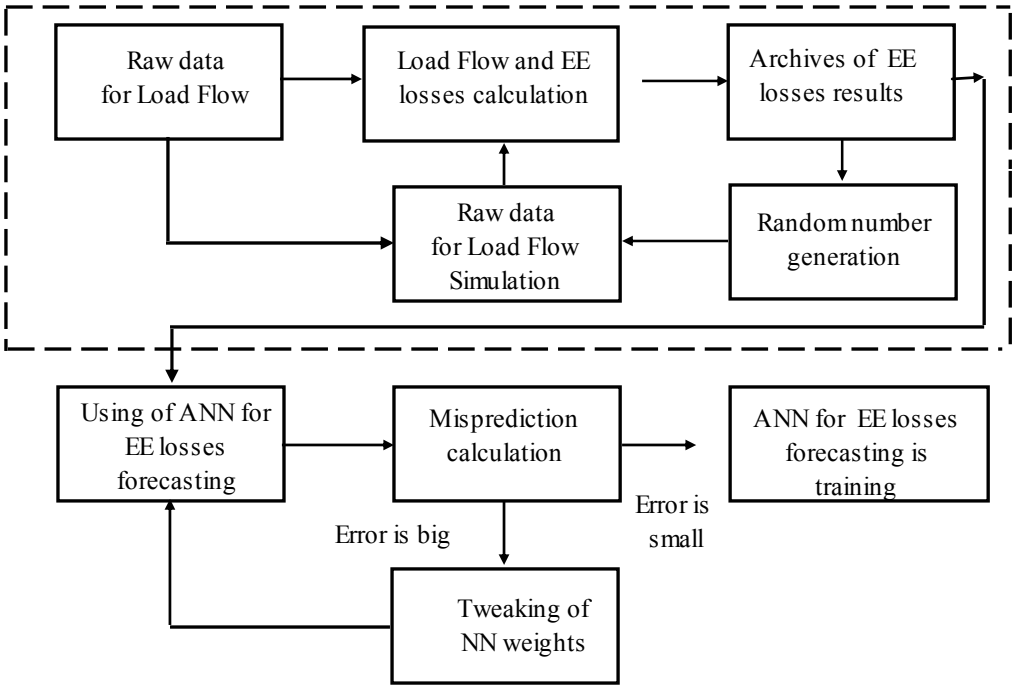

Fig. Flowchart for ANN based algorithm for EE losses calculation.

THE CONCLUSION

1. The algorithm for forecasting losses of the electric power in electric networks of power supply systems with application of artificial neural networks is developed.
2. It is established, that forecasting of losses of the electric power in electric networks of power supply systems with application of artificial neural networks has higher accuracy in comparison with traditional methods and can be successfully applied in problems of operative management by power systems.

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