About a method of creation of the training selection in tasks of short-term prediction of a power consumption taking into account criteria of informativeness and compactness

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ABSTRACT

The paper considers the method of forming a training sample for intelligent methods of predicting power consumption based on artificial neural networks. The training sample is formed taking into account the criteria of informativeness and compactness. It is shown how much the accuracy of the forecast can be increased with the approach used.

Keywords

training set, forecast short-term electricity loading, electricity market, cognitive methods of analyze data.

1. INTRODUCTION

Process of short-term prediction of a power consumption is one of the mains for power supply company today. It is caused on the one hand by development of mechanisms of interaction of participants Electricity Market in Russian Federation, on the other hand need of execution of the approved rules of the association to trade system developed by the LLC "Trading System Administrator", the regulating relation of subjects and participants Electricity Market in Russian Federation. From the moment of the beginning of operation Electricity Market in 2003 y. power supply companies had no the techniques of creation of prognostic models developed and approved in practice and used only statistical techniques in case of simulation of processes of a power consumption in electrotechnical systems. Now rather large number of methods and approaches to creation of prognostic models of a power consumption, including with use of the intellectual methods based on use of the device of an artificial neural network [1-4] which are put into practice, the enterprises and power supply companies to – subjects Electricity Market is developed.

2. RESEARCH

As a rule, the accuracy of forecasting models in direct ratio depends on quantity and quality of the used external meteoparameters exerting impact on process of a power consumption [5,6] such as ambient air temperature, illuminance, length of luminous day, wind speed [7], etc., or the production parameters influencing process of a power consumption of the industrial enterprise. Experience shows [8] that not only the quantity and quality of the used input parameters, but also a method of formation of learning selection can influence the accuracy of a forecasting model. One of such methods was offered by Russian scientists – N. G. Zagoruyko in the form of function of competitive likeness FRiS-Stolp [9]. The FRiS-Stolp function is intended for increase in compactness of learning selection [10] by means of which distribution of basic data about a power consumption can be received by a set of reference objects - «pillars» and the abnormal data or bursts which are unusual the initial selection are deleted. For this purpose it is necessary to classify the existing retrospective data on a power consumption, to be exact, to distribute them on groups on a sign «the power consumption volume». Values of such signs will correspond to group objects, and all objects entering into one group, we will call images. Objects shall be integrated in groups on the signs which given by expert. In that specific case, as such sign the sign "the power consumption volume" for any discrete interval of time can appear. By operation in the electricity market of the Russian Federation it is accepted to operate with hour intervals of time that approaches in case of application of function of competitive likeness of FRiS-Stolp. Each object of the selected group is checked for two properties – property of competitiveness in relation to objects of the group and property of tolerance in relation to objects of adjacent group. There is a calculated value of competitive likeness of F*, between pillars and objects of an image, the more this value, the better an object of one image protects an object of an adjacent image. Too great value of F* will lead to the fact that a large number of objects will be deleted from learning selection that in our case is inadmissible. Regardless of a type of distribution between pillars and objects the objects located at centers of local bunches and protecting the greatest possible quantity of objects with the given reliability [11] are selected. In case of normal distribution of objects concerning pillars first of all objects, the next two points of mathematical expectation will be selected. Therefore, in case of distribution of objects concerning pillars to the close to normal distribution, the decision of the task of creation of decision functions aims to optimum [12].

For a research of quality of the created selection with use of function of competitive likeness of FRiS-Stolp the hybrid technique of short-term prediction of a power consumption for power supply company [13] was used, based on approximations of a power consumption with use of a sine function which coefficients – amplitude and offset The recognition process which is based on the received pillars consists in an assessment of function of competitive likeness of an object Z. In case of creation of a function model of competitive likeness of FRiS-Stolp the following parameters were set:

- quantity of classes (K);
- total number of objects of a class (N);
- FRiS-function threshold (F*).

For a research of opportunities of function of competitive likeness of FRiS – Stolp were used the actual data about a power consumption LLC "Omsk Energy Retail Company". The preset values of the FRiS parameters – functions are provided in table 1. The quantity of classes was determined by quantity of approximable cycles of a power consumption (separately for day and night cycles of a power consumption). Parameter N was determined by quantity of the discrete intervals which described process of a power consumption. Selection of the best parameter value of F* was carried out empirically.

3. EXPERIMENT

In a figure 1 the received distributions of objects concerning pillars are provided. Each of the points given below on a graphics corresponds to value of a power consumption of LLC "Omsk Energy Retail Company" on the given interval of time, according to value of a threshold FRiS-function (F*). Apparently from an illustration with increase in value of a threshold of FRiS-function (F*) the number of objects in each class are decreases i.e. which distance from center considerably differs from average distance in image. For increase in accuracy of recognition it is necessary to delete such objects. In an algorithm FRiS-Stolp for this purpose on first step the objects which function value of competitive likeness is less than the given threshold is deleted. It allows concerning an axis "power consumption" are selected it is adaptive with use of an artificial neural network where process of a power consumption was characterized by the discrete hour interval measurements received from systems of the automated commercial accounting of the electric power. The program with use of the analytical Rapidminer [14] system realizing function of competitive likeness was developed for a research.

to exclude from selection objects which presumably can be the abnormal, or «bursts».

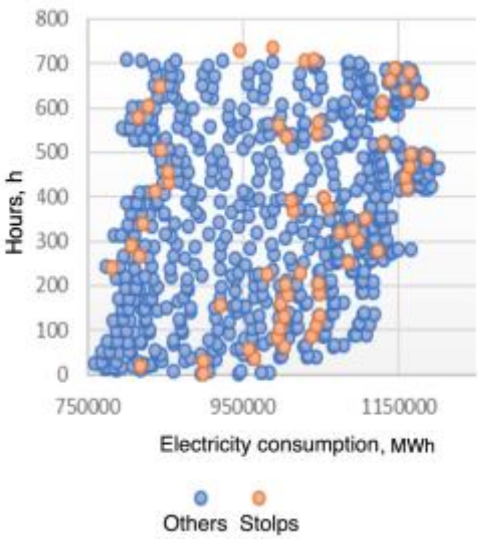
Table 1. The preset values of function parameters of FRiS-Stolp

№	parameter	parameter value
1	K	2
2	N	24
3	F*	0; 0.1; 0.4; 0.8

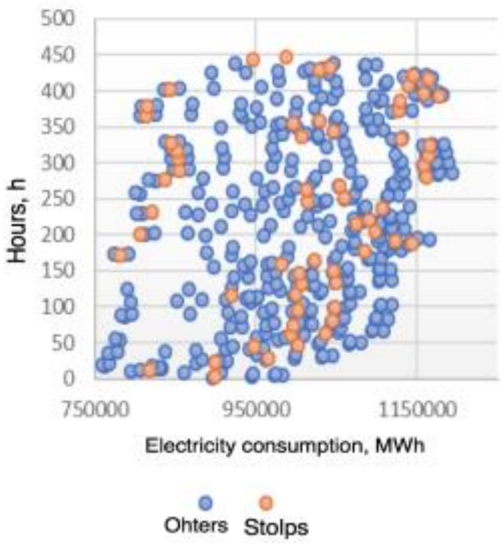
When using FRiS-Stolp the volume of learning selection made 745 objects, the volume of control sample — 300 objectsIn a figure 1 results of application of the FRiS-Stolp function in case of different parameter values (F*) are provided. Follows from the provided results that application of FRiS-function during the reviewing of a special case, namely the decision of the task of short-term prediction with use of the hybrid technique was justified in case of the F*=0.1 parameter. In other cases, the choice of value of this parameter will depend on quality of retrospective data, a profile of consuming of a customer, and use of these or those signs in case of process modeling of prediction of a power consumption.

In case of further increase in value of a threshold of FRiS-function (F*) the average forecast error is increase, it is caused by the fact that from selection significant objects are deleted and quality of training of an artificial neural network worsens.

In a figure 2 the diagram of the forecast of a power consumption of customers of LLC "Omsk Energy Retail Company", in case of different parameter values of F* is provided. In a figure 3 the diagram of average errors by year interval with different values of F* parameter.



a)



b)

Figure 1. Superimposing of the FRiSStolp function on learning selection; a) in case of value of a threshold Fris-function (F*) = 0; b) in case of value of a threshold Fris-function (F*) = 0.1

Follows from the received results that quality of learning selection can be improved by deleting objects in images which are from pillars on the considerable deleting, it is obvious that when using such learning selection smaller time for training of an artificial neural network will be required, and improving of accuracy of prognostic model is possible.

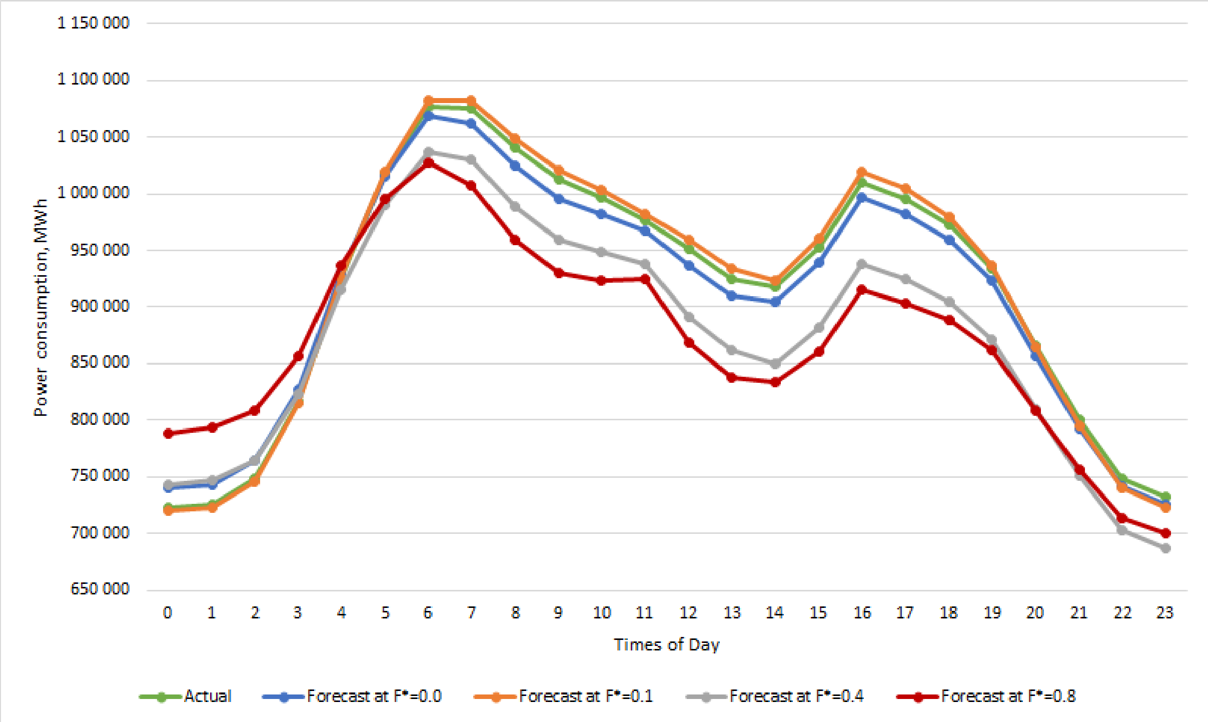


Figure 2. The forecast of a power consumption for February 1, 2016, in case of different parameter values of F*

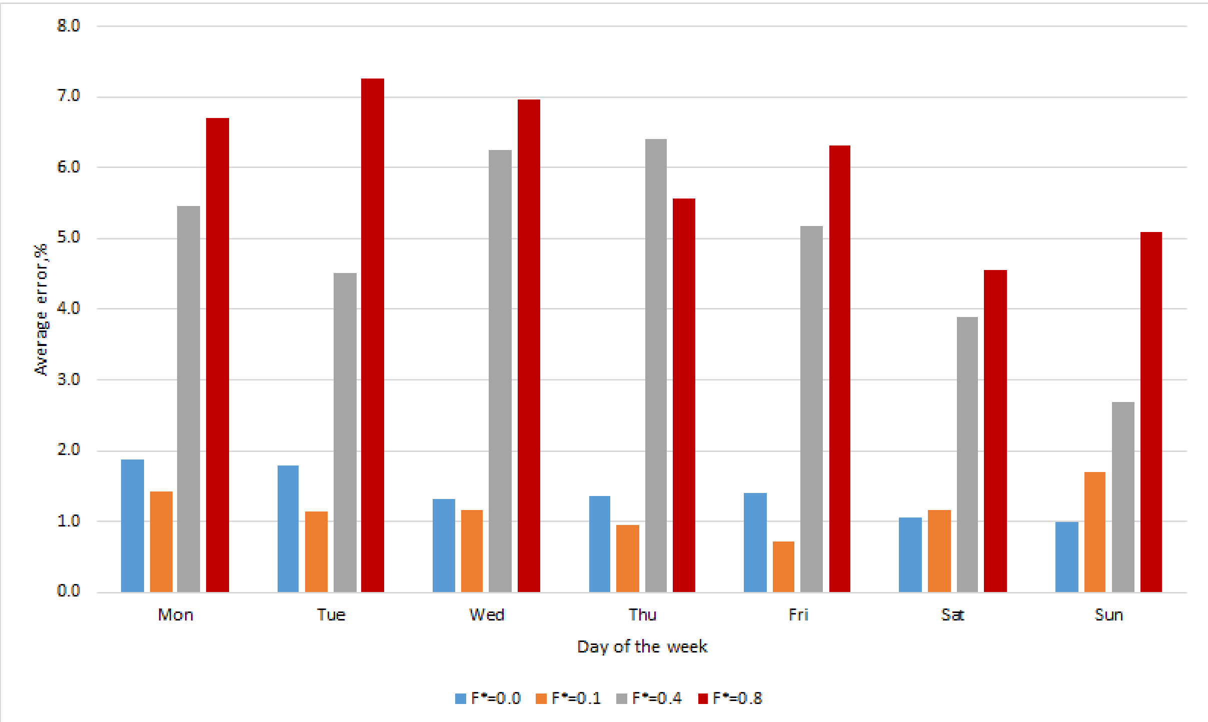


Figure 3. Diagram of distribution of average forecast errors of volumes of a power consumption of LLC "Omsk Energy Retail Company" on days of the week for February, 2016.

The best results were received in case of F*=0.1, namely, the forecast accuracy of the method based on a neural network was improved for 0.2% on an annual interval.

In table 2 the received values of accuracy for the hybrid technique are provided, in case of different values of coefficient F*

Table 2. The received values of accuracy of a forecasting model in case of various values of coefficients of F*

F*	0.0	0.1	0.4	0.8
Error, % on an annual interval, for 2016.	1.7	1.5	4.9	6.1

Follows from the received results that – it is expedient to apply function of competitive likeness of FRiS-Stolpt to the created learning selection in tasks of short-term prediction of a power consumption, to deleting from it «bursts» and the abnormal values. However, it is necessary to understand that to define values of coefficients of function of competitive likeness K, N, F taking into account specifics of the available retrospective data on process of a power consumption and the applied prognostic model. Application of this method allowed to improve a power consumption forecasting accuracy for 0.2% on an annual retrospective interval of the customers LLC "Omsk Energy Retail Company" this about a power consumption.

REFERENCES

[1] Y.T. Chae, R. Horesh, Y. Hwang, Y.M. Lee, "Artificial neural network model for forecasting sub-hourly electricity usage in commercial buildings", *Energy and Buildings*, pp. 184-194, 2016. DOI: 10.1016/j.enbuild.2015.11.045

[2] E.V. Birukov, V.Z. Manusov, "Daily electrical load forecasting in power supply systems on the basis of fuzzy neural networks", *Proc. 8th Korea-Russia International Symposium on Science and Technology (KORUS 2004)*, vol. 1, pp. 197-201, 2004. DOI: 10.1109/KORUS.2004.1555318

[3] I.E. Shepelev, I.I. Nadtoka, S.A. Vyalkova, S.O. Gubsky, "Determination of optimal metaparameters for neural network short-term forecasting of power consumption of a large city", *Proc. All-Russian Science and Technology Conf. "Neuroinformatics-2015"*, Moscow, vol. 2, pp. 148–154, 2015. [in Russian]

[4] V.I. Potapov, A.S. Gritsay, D.A. Tyunkov, G.E. Sinitsin, "Using neural network for building short-term forecast of electricity load of LLC "Omsk Energy Retail Company"", *Bulletin of the Tomsk Polytechnic University. Geo Assets Engineering*, vol. 327, no. 8, pp. 44-51, 2016.

[5] I.I Nadtoka, M.A. Balasim, "Mathematical Modelling and Short-term Forecasting of Electricity Consumption of the Power System, with Due Account of Air Temperature and Natural Illumination, Based on Support Vector Machine and Particle Swarm", *Procedia Engineering*, vol. 129, pp. 657-663, 2015. DOI: 10.1016/j.proeng.2015.12.087

[6] B.I. Makoklyuev, A.S. Polizharov, A.V. Antonov, "Methods and instruments for power consumption forecasting in electric power companies", *Proc. IEEE 5th International Conference on Power Engineering, Energy and Electrical Drives*, pp. 268-271, 2015. DOI: 10.1109/PowerEng.2015.7266331

[7] D.D. Dugin, A.S. Gritsay, "The use of the temperature-wind index in the problems of short-term forecasting of power consumption", *Proc. All-Russian Science Conf. students, undergraduates, graduate students "Actual issues of energy"*, Omsk, pp. 51-56, 2016. [in Russia]

[8] E. Almeshaiei, H. Soltan, "A methodology for Electric Power Load Forecasting", *Alexandria Engineering Journal*, vol. 50, no. 2, pp. 137-144, 2011. DOI: 10.1016/j.aej.2011.01.015

[9] I.A. Borisova, V.V. Dyubanov, O.A. Kutnenko, N.G. Zagoruiko, "Use of the FRiS-Function for Taxonomy, Attribute Selection and Decision Rule Construction", *Knowledge Processing and Data Analysis. Lecture Notes in Computer Science*, pp. 256-270, 2011. DOI: 10.1007/978-3-642-22140-8_17

[10] N.G. Zagoruiko, I.A. Borisova, O.A. Kutnenko, V.V. Dyubanov, "A construction of a compressed description of data using a function of rival similarity", *Journal of Applied and Industrial Mathematics*, vol. 7, no. 2, pp. 275-286, 2013. DOI: 10.1134/S199047891302018X

[11] K.V. Chau, "The reliability of an artificial neural network", *Advances in Engineering Software*, vol. 38, no. 3, pp. 145-149, 2007. DOI: 10.1016/j.advengsoft.2006.09.008

[12] N.G. Zagoruiko, I.A. Borisova, V.V. Dyubanov, O.A. Kutnenko, "A quantitative measure of compactness and similarity in a competitive space", *Journal of Applied and Industrial Mathematics*, vol. 5, no. 1, pp. 144-154, 2011. DOI: 10.1134/S1990478911010157

[13] R.N. Khamitov, A.S. Gritsay, D.A. Tyunkov, G.E. Sinitsin, "Day-ahead short-term forecasting electricity load via approximation", *IOP Conf. Series: Materials Science and Engineering*, vol. 189, 2017. DOI: 10.1088/1757-899X/189/1/012005

[14] A.S. Gritsay, N.S. Kostin, "Expansion of analytical platform Rapidminer for construction of forecast models of WECM", *Proc. Interuniversity Science and Technology Conf. "Informatics, computers, complexes, systems and networks"*, Omsk, pp. 125-129, 2014. [in Russia]