

INTEGRATED AUTOMATED SYSTEM FOR THE IMPLEMENTATION OF FORECAST OF CONSUMPTION ELECTRICAL ENERGY IN LVIV REGION

The IAS "Forecast" is developed for forecasting the electricity consumption in the original production conditions at PJSC "Lvivoblenergo." The statistical and neural network methods are used for the input data verification; is enhanced the space dimensions extending methods for the incoming data to use them with the ANN with non-iterative training.

Keywords: ANN, prediction, forecasting, electricity consumption

Introduction

Effective management in market conditions for most Ukrainian companies was one of the conditions for their successful operation. Effective decision-making is impossible without the ability to foresee the likely future state of the enterprise and the environment in which it exists, in time to prevent possible failures in its work. In the field of power systems operation electric power system possible only under the terms of continuity and indivisibility associated process "production - transmission - use" electrical energy (EE). However, the effective regulation of production of EE and economical use of energy possible on the basis of forecasts of consumption.

In the 2000s, developed a number of software implementations, methods of statistical analysis and forecasting of time series: CaterPillar, MatLab, ForEx Sale, NCSS 97. They are universal and mainstream of a specific subject area, so can not be used as a controller integrated automated advisory system (IAS) in the electricity sector. There are a number of neural network software systems for forecasting (Neuro Office, WinNN, AiNet, HfNet, CasCor, NefTeach), but they also are unspecialized. After binding these programs subject to the electricity sector, in the calculation results are considerably dependent on the chosen model elements of power and set the parameters taken into account. The correctness of the modeling is often compared to the estimated working in manual model, the accuracy of which is generally unknown.

MAED, that belongs to the IAEA developed tools for analyzing energy systems are more specialized for the implementation of medium and long-term forecasts in the electricity sector. It includes analysis model of EE. The application of the model involves setting based on the base year and the development scenario of parameters for the future. The calculation of the projected needs for EE done for each user as a result of changes in parameters that govern certain scenario. There are four groups of parameters: macroeconomic indicators, demographics, indicators of living standards and technological performance. MAED model has the following advantages: forecasting needs in terms of structural transformation of the economy and changes in living standards, the possibility of replacement energy sources, the analysis of the energy consumption of various national programs, compatibility with other models of complex software IAEA. But this model can be adapted to the real production conditions of the electricity industry in Ukraine.

The industry is wide of implementation and effective use for calculations steady state and transient processes became "Interactive automated complex analysis modes" (DAKAR), developed by a group of faculty "Electrical networks and systems" National University "Lviv Polytechnic" under the guidance of Phd. Skrynyk AI [5,1]. The basis of the software module entrusted mathematical model, where the equation of state electricity system formed on the basis of compensating electromotive forces. The model determines the coordinates at which ensured Regime balance, so it can not be used as a working instrument controller.

Description of the algorithm

Consequently, it was necessary to implement integrated automated software system (AIS) for the implementation of EE forecast consumption on the basis of the existing database. For the solution to this problem proposed to develop a complex neural network forecasting consumption to implement EE with the possibility of pre-processing data as statistical and neural network methods with regard to production conditions [6].

In the developed IAS "forecast" [2] an attempt to take advantage of information and analytical tasks. This system is automated, since Decision Manager provides, and the program is only advisory. Therefore, it can be attributed to a separate type - information-analytical tasks of operational management. The main

advantage IAS "Forecast" - the possibility of its functioning in "on-line" or "on-demand" mode, which is essential in solving the problem of operating control modes grid. Tasks of operational forecasting is most relevant in the electricity sector, since most processes are leaking almost immediately (eg short circuit, fall in frequency grid etc.).

The IAS "forecast" has a friendly interface and convenient means of visualization for the dispatcher the necessary information. Based on the initial information that shapes IAS "forecast", Manager, makes conclusions on the admissibility and inadmissibility regime; decides on the optimal path of regime change to achieve maximum economic effect; determines the volume control actions and their place of application; transmits a control action on the object of control.

The Figure 1 shows the tree of objectives to address problems that have been faced with IAS "Forecast".



Fig.1. tree of objectives IAC "Forecast"

calculated parameters that characterize the work of the electricity system, collected from minute increments for each day and kept in the archive file in binary format. So it created a separate software module (see. Figure 1. Branch "Rip incoming information") to convert the binary data from the database format telemetry JSC "Lviv regional electricity of grid" Software predicting the size of the complex IAS "forecast", for further information of the selection test tests. If necessary, file converted of input for IAS"Forecast" can open, save and convert backwards.

Results of research

Since the information collection system of these parameters are worked in continuous operation, the analysis files were found the lack of information in regular intervals (sometimes within a few hours). This is due to power cuts, faults and overloading database server telemetry and several other reasons. In this case, the database information was missing or filled with zeros. There were also cases when during data transfer via communication channels and information distortion occurred in the database telemetry JSC "Lviv regional electricity of grid" was present but uninformative because it does not meet the real value of the mains voltage. Therefore there was a need for preprocessing of input data (see. Figure 1. Branch "pre-processing incoming information"). To identify lost data software of implemented method that takes into account regular diurnal variation component time series EE consumption process, which is based on additive model signal. For histogram and estimate the probability density distribution centered signal detect data loss is minimal considering them likely. In the case of short implementations (less than or equal signal period) proposed to use a method that is based on the quasi-stationary additive process model EE consumption.

Following the discovery of lost data was necessary in their elaboration. To eliminate noise signal components used statistical methods. This was built using algorithms Smoothing filters: moving average, filter Hemet Anna with window, sliding median spline interpolation, polynomial Lagrange. Experimental way it was found that the most accurate methods with the least variance in problems of forecasting consumption EE were those methods that use moving average and moving median, although the setting mode of IAS "Forecast" provides switching between all these methods [3].

After pre-processing of data are two methods of verification neural network input data of signal small dimension. The first method of "neighborhood of" based on the principle of "nearest neighbor". To make a forecast of EE by "neighborhood of" must establish a committee iterative artificial neural networks (ANN) with radial basic functions, and their number is the number of projected points. To train the ANN with radial basic functions used not all background process, and only nearest neighborhood of a point from the background by the criterion of minimum Euclidean distance. This we consider aging test data, filter data loss and extend the number of inputs of ANN. The second method of "nearest neighbors" [7], is based on the method of "neighborhood of" architectural and requires modification ANN by entering additional inputs, which allow to increase space input. The feature of the method "k" of nearest neighbors is that the input of

the ANN will serve not only the vector $\hat{\mathbf{x}} \in \hat{\mathbf{X}}$ ($\hat{\mathbf{X}}$ - is some set-carts points), and on the entire cluster \mathbf{X}^* (\mathbf{X}^* - set of input vectors obtained by "k of nearest neighbors"). In training mode for each anchor points: $\hat{\mathbf{x}} \in \hat{\mathbf{X}}^T$ ($\hat{\mathbf{X}}^T$ plural elements by "k of the training sample"), select a subset of k of nearest points, $\bar{\mathbf{X}} = \{\bar{\mathbf{x}}_i, i = \overline{1, K}\}$, $\bar{\mathbf{X}} \subset \hat{\mathbf{X}}^T$. Neural network prediction mode for each anchor points $\hat{\mathbf{x}} \in \bar{\mathbf{X}}^U$ where $\bar{\mathbf{X}}^U$ - a set of projected elements $\bar{\mathbf{X}}^U \in \mathbb{R}^N$, choose a subset of nearest points: $\bar{\bar{\mathbf{X}}} = \{\bar{\bar{\mathbf{x}}}_i, i = \overline{1, K}\}$. The distance between two vectors input parameters, calculated using Euclidean metric.

$$Z = \begin{pmatrix} z_{1,1} z_{1,2} \dots z_{1,col} \\ z_{2,1} z_{2,2} \dots z_{2,col} \\ \dots \\ z_{row,1} z_{row,2} \dots z_{row,col} \end{pmatrix} \quad (1)$$

Also, have been improved architecture ANN predictive of increase in the number of visits from phasing input [8]. Let asked time series $X(t)$ samples process $X(t_1), X(t_2) \dots X(t_i)$ in discrete time points by "time windows". Create the matrix implementations $Z[N, i]$ where $N = \overline{1, \dots, Col}$ implementation or lines; $i = \overline{1, \dots, Row}$ - components or column only input values ANN time window.

The basic idea of phasing method is to convert the $Z[N, i]$ array into an array $X[N, j]$, $j = \overline{1, \dots, J_{max}}$, $J_{max} \geq i_{max}$ and accordingly increase the number of inputs ANN. We introduce CD a variable number of sites on the longest component in $CD = 1, J_{max} = i_{max}$, $X[N, j] \equiv Z[N, i]$. Let entrances ANN is n then k to be submitted entry point signal with numbers

$$\begin{cases} n * (k - 1) + i \text{ mod } n, n \neq k \\ n * k, n = k \end{cases} \quad (2)$$

Where I - creeping point number $i = \overline{1, \dots, M}$

The Feature phasing method of data input time window is that the data are reduced to the range $[0;1]$ Using the model ANN proposed method of forecasting than increasing accuracy, can handle small study sample and in the pace of its receipt.

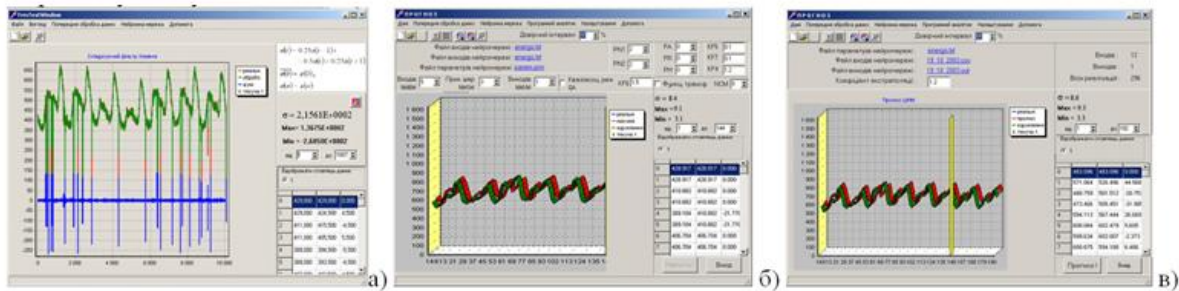


Fig.2. Three main windows of dialogs IAS "Forecast"
(a - provisional data; b - training ANN; v - forecast of ANN)

The Program IAS "Forecast" can run on a PC with a processor not below Pentium II or compatible operating environment in Windows. For normal operation of the program requires at least 128 MB of RAM and at least 100 MB of free disk space. To install the program you need 1.5 MB of free hard disk space. Figure 2. presents three main windows IAC "Forecast".

Access to windows a and b represented in Figure 2 is only possible mode settings. In this mode, you can recycle all parameters and write them in the configuration file IAS "Forecast". Controllers are only available using the program mode, ie the implementation of neural prediction (see. Figure 2 shows a window).

In IAS "Weather" laid five types of calendar example (see. Figure 3). The file support the work IAS "forecast" for each prediction parameters settings is provided of neural network. Changing these parameters is possible only mode configuration and is available to the dispatcher. Manager can only select the top menu

EE consumption of forecast for any area of the city is equipped with telephone and Lviv region, pointing out how much to predict this option. It starts with a neural network parameters are in a file official support of IAS "Forecast".



Fig.3 Generalized classification of consumption forecasts

Once made forecast of EE which gave query manager and the screen displays the result. Forecast consumption EE represented as a graph and output plates and reduced to the mean value range error calculations, and minimum and maximum deviation of signal.

An objective of limit the length of time series with ANN training, to implement short-, medium-, long- and naddovhoterminovyh example, the possibility of averaging the input data for a certain period of time. Here is an example of short-term load forecasting EE removed by means of preliminary telemetry data

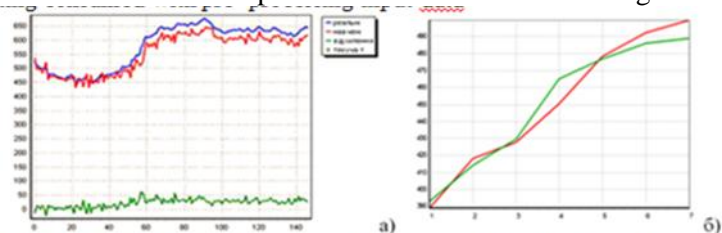


Fig.4. Neural network forecasting EE consumed with pre- processing input data (a- short-term, b – operative)

processing, using neiterative ANN ordered with additional connections between neurons of hidden layer. ANN consisting of 7,6,5 neurons in the input, hidden, output layers respectively. Its studied 140 values, predicted the next 7 points mean square error of 3.97% and maximum 7.35%. These forecast results can already be used in a production environment. Forecast results shown in Fig. 4 a.

Examples of the use of IAS "forecast" for operational forecasting consumption EE. The study sample formed using the method of "nearest neighbors". The number of neurons in the input, hidden and output layers ANN is: 47, 19, 1, respectively. In this case the training of sample matched optimally, it contains a small amount of conflicting data, and its length is sufficient for quality training. Mean square error of prediction was 1.52% and maximum 2.97%. Forecast results shown in Fig. 4 b. Neural network forecasting consumed with pre- processing input data

Conclusion

Adapted of methodology of system analysis and construction tasks to EE forecast consumption on the basis of neural network modeling and forecasting tools, thus improving the accuracy of short-term neural prediction of 30-50%, 20-30% mid-term, and effectively use it in tasks "real time. "

A program of IAS "forecast" and applied it to the power supply company JSC "Lvivoblenergo", which provided efficiency of administrative decisions by allowing the controller processing and presentation of example EE consumption in real time.

The software of module verification input information found practical application and implemented in JSP " Lviv regional electricity of grid " as separate functional blocks of operational research version of operational and information complex control subsystem operational and supervisory control modes of consumption of electric energy.

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