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Neural network of forecasting electricity consumption by airports

The article analyses the possibilities of forecasting the volumes of electricity consumption by airports using software based on neural networks. A review and comparative analysis of the available software for the task is carried out.

Neural network Forecasting is a very popular topic, given the large impact on business profitability, by minimizing costs. For the energy sector, consumption forecasts are the basic source information for decision making in the process of planning optimal modes of operation and development of the power system. As the main tasks solved on the basis of the received forecasts of consumption of the electric power, it is possible to allocate the following:

1) planning of development of generating capacities and electric networks of electric power system;

2) tariff planning;

3) planning the loading of power plants for the next day, energy and power generation, fuel needs;

4) planning of repair works of the main equipment of power plants and networks.

Traditional statistical models (regression and time series models) and models based on expert systems and neural networks can be used to solve the problem of forecasting electricity consumption [1,8]. The most commonly used models are neural networks. This is due to the fact that it is not necessary to build a model of the object, does not lose performance with incomplete input information. Neural networks are resistant to interference, have high speed.Predicting electricity consumption using artificial neural networks is one of the most actively developed in the energy sector. This is due to the fact that this structure is a universal approximator and is able to build complex nonlinear dependencies, which allows you to successfully predict. he difficulty of creating a neural network is the unavailability of data for its training [2,9-10]

A neural network is a system of simple processors (neurons) connected and interacting with each other. A neuron is the basic element of a neural network, a single simple computational processor capable of perceiving, transforming and propagating signals; in turn, combining a large number of neurons into one network allows solving quite complex problems.

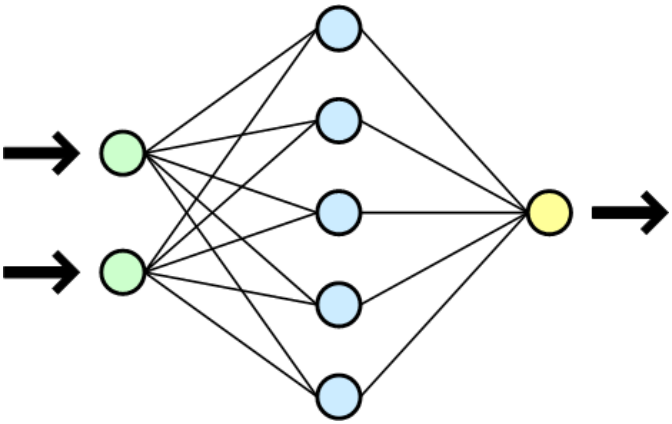

Fig. 1: Structural diagram of a neural network (green colour - input layer of neurons, blue - hidden (intermediate) layer of neurons, yellow - output layer of neurons)

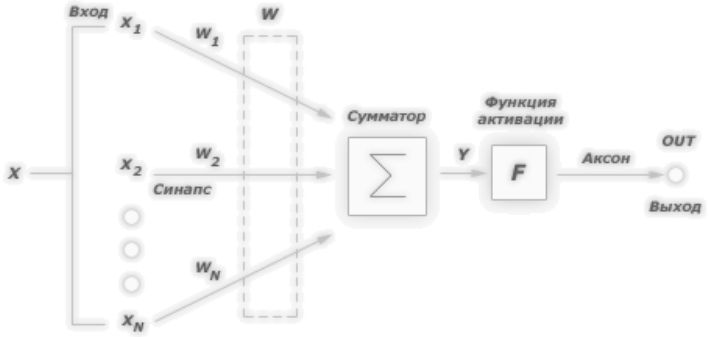

Fig. 2: Schematic of a neuron

The neural network approach is free from model constraints, it is equally suitable for linear and complex nonlinear problems, as well as classification tasks. Training of a neural network primarily consists in changing the 'strength' of connections between neurons. Neural networks are scalable, they are capable of solving problems both within a single piece of equipment and on a plant-wide scale.

Application of neural networks is a rather powerful method of forecasting, which allows to reproduce rather complex dependencies.

Consequently, for high-quality forecasting it is necessary to use qualitatively prepared data, as well as neural packages with greater functionality. There are quite a large number of specialised programs for working with neural networks, some of

which are more universal, others are highly specialised. Let's briefly consider some of the applied programmes:

1. Matlab is a desktop laboratory for mathematical calculations, electrical circuit design and modelling of complex systems. It has a built-in programming language and a very rich toolkit for neural networks - Anfis Editor (training, creation, training and graphical interface), command interface for programme setting of networks, nnTool - for finer network configuration.

2. Statistica - quite powerful software is used for searching and analysing data and identifying statistical patterns. In this package work with neural networks is presented in the module STATISTICA Neural Networks (abbreviated as ST Neural Networks, neural-network package by StatSoft), it is an implementation of the whole set of neural network methods of data analysis [3].Statistica package is designed for statistical analysis, and self-organising maps are presented in it as a separate module).

3. NeuroShell Day Trader is a neural network system that takes into account the specific needs of traders, although it is easy to use, the programme is rather highly specialised [6-7].

4. The program TensorFlow [4,5] is created for working with neural networks by Google and released under the open licence Apache 2.0. The construction of models for working with time series is performed according to the recommendations of the library developers in the Python programming language. Modelling is possible for basic, linear, dense, multistage, recurrent and convolution models.

1. The simplicity of the linear model allows to ‘increase the weight’ for each parameter.

2.The difference between the dense model and the linear model is that there are additional layers between the input and output. The model has the following form:

```
dense = tf.keras.Sequential([
  tf.keras.layers.Dense(units=32, activation='relu'),
  tf.keras.layers.Dense(units=32, activation='relu'),
  tf.keras.layers.Dense(units=1)
```

3.Multistage dense model, for multistage model use training data for a period in time, three time data-current, previous, pre-previous. The code of the model is in the form of:

```
multi_step_dense = tf.keras.Sequential([
  tf.keras.layers.Flatten(),
  tf.keras.layers.Dense(units=32, activation='relu'),
  tf.keras.layers.Dense(units=32, activation='relu'),
  tf.keras.layers.Dense(units=1),
  tf.keras.layers.Reshape([1, -1]),
```

4.The convolutional model was proposed by Jan Likun in 1988 and is one of the more efficient modern models, based on a simulation of the biological eye. The essence of convolutional model is the use of convolutional layers that utilise the

convolution operation of data transfer to subsequent spheres. This model is widely used in medicine, retail, automotive, marketing and computer vision.
The code of the model is as follows,

```
conv_model = tf.keras.Sequential([
  tf.keras.layers.Conv1D(filters=32,
])
2.6
        kernel_size=(3,),
        activation='relu'),
tf.keras.layers.Dense(units=32, activation='relu'),
tf.keras.layers.Dense(units=1),
```

5.The recurrent model (LTSM) builds parallel links (approximate graph) and uses long and short term memory. This model is used particularly in speech recognition. Model code:

```
lstm_model = tf.keras.models.Sequential([
  tf.keras.layers.LSTM(16, return_sequences=True),
  tf.keras.layers.Dense(units=1)
```

Building a satisfactory forecast of the airport's electricity consumption remains an urgent task that requires continuous attention. One of the explanations is the accounting and calculation of planned costs for the purchase and consumption of electricity. The airport, being a large electricity consumer, is naturally a participant of the wholesale electricity market, and its purchase is associated with a preliminary analysis of the required volume. Deviations of its real consumption from the purchased volume to a lesser extent generate risks of penalties for suppliers, and to a greater extent - risks of additional purchase of electricity at a much higher (naturally) non-optimal price. In addition, an overestimated forecast of electricity consumption may contribute to the growth of costs for inefficient and useless use of already purchased electricity. Therefore, the satisfactory reliability of the forecast of electricity consumption by the airport, the quality of its planning and the cost-effective discipline of electricity supply operation contributes to the effective management of electricity consumption.

Conclusions

Therefore, we can conclude that the use of neural networks can provide profit on financial markets beyond its normal value. However, the effective solution of forecasting problems is achieved only when the neural network is trained on a large amount of data and a high-quality training sample is used. In this case, the algorithm will give a satisfactory result, but without a full set of data, the neural network is fundamentally unable to learn. Thus, the further direction of research on the application of neural networks for forecasting the volume of electricity consumption

by the airport will be the creation of formalised approaches to the formation of the information base for the application of these software products.

References

1. Haikin S. Neural networks: a full course. 2nd ed. M .: Williams, 2006. P. 89-102.
2. Derya Aydın, Hüseyin Toros: Prediction of Short-Term Electricity Consumption by Artificial Neural Networks Using Temperature Variables // European Journal of Science and Technology No. 14, p. 393-398, December 2018, URL: https://dergipark.org.tr/en/download/article-file/616792.
3. Prasanna Kumar, Dr. Mervin Herbert, Dr. Srikanth Rao: Demand forecasting Using Artificial Neural Network Based on Different Learning Methods: Comparative Analysis // International journal for research in applied science and engineering technology, URL: https://www.ijraset.com/fileserve.php?FID=381.
4. www.tensorflow.org
5. Amita Kapoor, Antonio Gulli, Sujit Pal (2022) Deep Learning with TensorFlow and Keras (Third Edition). Packt Publishing
6. Andrienko V.M., Tulyakova A.S. (2011), "Analysis and modeling of the dynamics of the Ukrainian stock markettion", *Scientific Journal "Aspect",* vol. 2, pp. 34.
7. Wasserman F. (1992), *"Neurocomputing: Theoriya and practice"*, USA.
8. Garyachevska I.V., Movenko S.Y. Development of artificial neural networks for forecasting electricity consumption // KhNTU Bulletin №3(66), Vol. 1.2-18. C. 250- 259
9. T. Dzheria, V. Shenchuk Forecasting electricity consumption using neural networks// Control, Navigation and Communication Systems. 2023. No. 2. P.42-44 doi: 10.26906/SUNZ.2023.2.042
10. Claudio Guarnaccia, Joseph Quartieri, Carmine Tepedino , Svetoslav Iliev, Silviya Popova. Neural Network and Time Series Analysis Approaches in Predicting Electricity Consumption of Public Transportation Vehicles// WSEAS transactions on environment and development, Vol.11, 2015. P. 312-324