Soft Computing and Energy Time Series

1 Introduction

An improvement of technological process control level can be achieved by time series analysis in order to prediction of their future behavior. The paper deals with the utilization of soft computing to fix best the prediction of energy time series. We can find an application of this prediction by the control in production of energy, heat, etc.

2 Application of Soft Computing

The application of soft computing is spread together with the development of knowledge in the branch of mathematical analyses. The aim is to fix best the prediction of energy time series. The results from regression analysis, dynamic models, fuzzy logic, artificial neural networks, genetic algorithms, chaos analysis, hybrid models, dynamical simulations and other can be applied for these purposes. One of the possible methodologies for time series analyses and prediction is shown in figure 1.

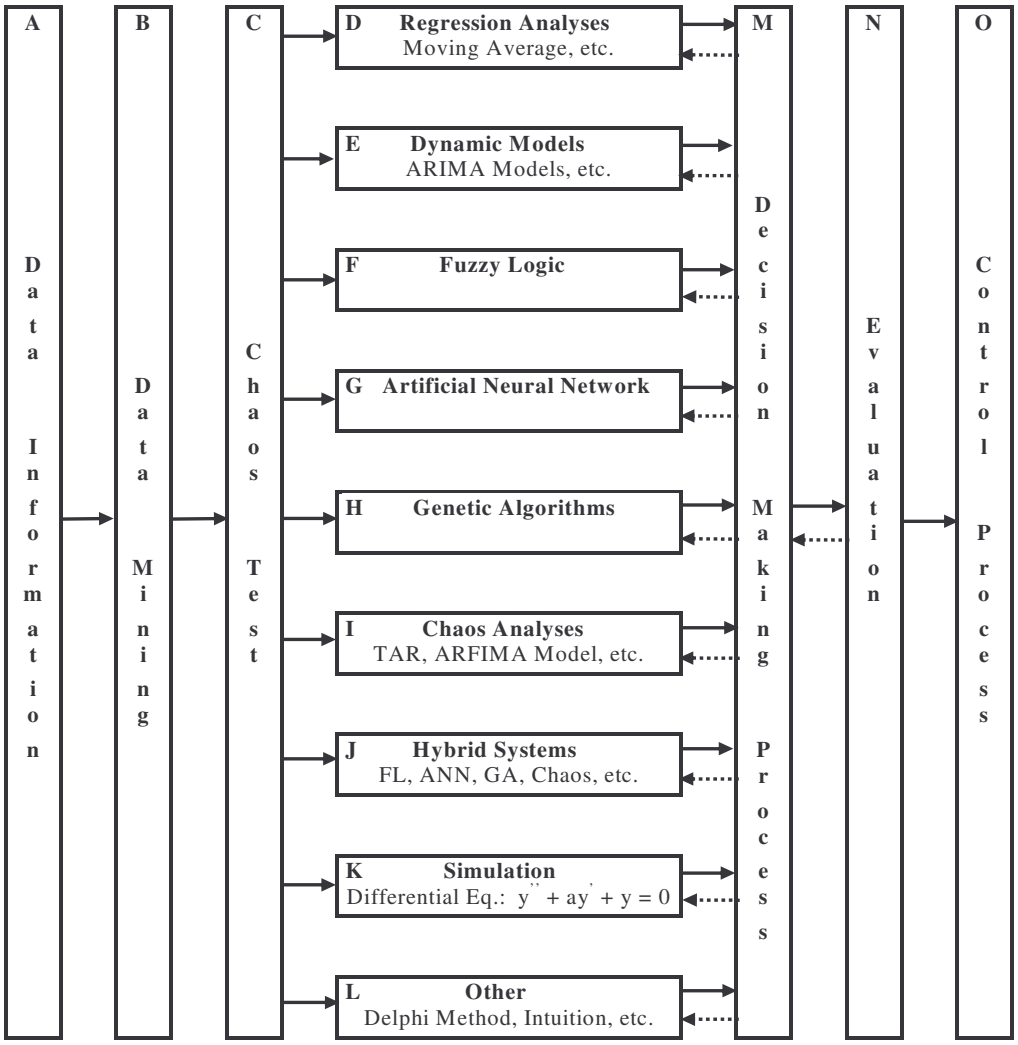

Figure 1: Soft computing and methodology of prediction of time series

The description is as follows:

A Data Information

The values dealing with the history of energy time series might be obtained from measuring devices and databases with various samplings. Some information can be received from news, e.g.: weather forecast, change of structure of systems can be found from the documentation and so on. The time series can be processed by means of mathematics analyses with their advantages.

B Data Mining

Data mining means the classification, sampling, sorting, cleaning, supplement and transformation of data. Data mining can include verification and simple evaluation.

C Chaos Test

As the input analysis could be used the methods of determining whether the time series is deterministic, fractal or random. Having proved that the time series is purely random, another search with the aim to determine the future development is irrelevant. We can be disappointed with the results of incorrect analyses. Hurst exponent indicates, whether the time series is normally distributed, has long “memory”, whether the time series trend is an antipersistent (persistent) or reverting (reinforcing) time series. The fractal dimension can be used for these purposes, too. Other possibility is to use the Lyapunov exponent, which determines the range of predictability of time series. If the time series is not random and has a good predictability then it is suitable to continue in other analyses.

D Regression Analyses

It is possible to make a calculation of prediction of time series by means of regression analysis. It is possible to analyze time series in a post-mortal way.

E Dynamic Models

It is possible to make a calculation of prediction of time series by means of the dynamic models represented by means of non seasonal and seasonal ARIMA (Autoregressive Integrated Moving Average) models and by various types of “smooth” models.

F Fuzzy Logic

Another possible calculation is that of trend identification of prediction of time series by means of fuzzy logic. The trend prediction of time series is calculated on the basis of fuzzy rules. The process of fuzzification, fuzzy inference and defuzzification are used.

G Artificial Neural Networks

You can make a calculation of prediction of time series by means of the artificial neural networks. The sigmoid and hyperbolic tangent seems to be the best transfer function for prediction.

H Genetic Algorithms

Another possible calculation is that of the trend identification of prediction of time series by means of genetic algorithms. The trend prediction is calculated on the basis of logical rules when the maximum profit is being searched by means of optimalization.

I Chaos Analyses

The chaos analysis represents the calculation and evaluation of Hurst and Lyapunov exponents as mentioned in section C). The TAR (Threshold Autoregressive) model and ARFIMA (Autoregressive Fractional Integrated Moving Average) model can be mentioned in this section.

J Hybrid Systems

The hybrid systems can be created by the combination of fuzzy logic, artificial neural networks, genetic algorithms and the theory of chaos. There can be various combinations where the neuro – fuzzy- genetic – chaos one is the most complicated.

K Simulation

The simulation is the process that describes the behavior of the analyzed system by means of differential equations. The system can be described as a mechanical – hydraulic – electrical – thermal – production - financial system.

L Other

Other outputs can be based on the intuitive forecasting, Delphi methods and so on. The Delphi method enables us to evaluate the knowledge of analysts and based on the scale of influence leads into the decision making process with there advantages and disadvantages.

M Decision Making Process

Due to possible contradictory outputs from these analyses it is apposite to apply the fuzzy logics for their evaluation. All the inputs are processed in the form of vague description by means of fuzzy rules.

N Evaluation

It is necessary to evaluate and compare the results of prediction with the actual values in a post mortal way. The quality of prediction models can be evaluated, for example by means of MAPE. This way is possible to change the weight of individual analyses. The decision making process is a dynamic one where the continuous and on line evaluation become necessity.

O Control Process

The predicted values can be used for control processes of systems.

3 The Decision Making Process

The decision making process means to choose the best prediction. It can be done in a post mortal way by calculation of Mean Average Prediction Error (MAPE) for N values in the form (1) or by other formula.

$$MAPE = \frac{\sum_{i=1}^{N} \left| \left(P_i - R_i \right) / R_i \right|}{N} \cdot 100 \qquad [\%] \qquad (1)$$

where

P_i – predicted value
R_i – real value
N – number of values

The smallest prediction error indicates the method which has been used for prediction, the other methods can be used for the correction of predicted values.

Beside theses we can evaluate the reliability of prediction process. The estimation of reliability has been made by means of fuzzy logic in a following manner. The figure 2. represents the scheme of fuzzy logic decision making process, where the symbols of individual analyses C,D,E,F,G,H,I,J,K,L are used for inputs and M for output.

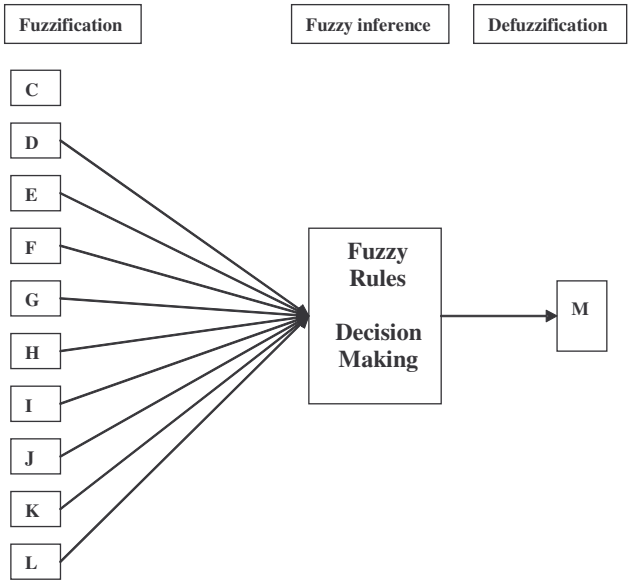

Fig. 2. Scheme of fuzzy logic decision making process

The evaluations of prediction errors from regression analyses, dynamic models, fuzzy logic, artificial neural networks, genetic algorithms, chaos analyses, hybrid systems, simulation and other methods indicate the reliability of the prediction and are the inputs of fuzzy logic in the form:

super high, very high, high, medium, low, very low, super low *reliability.*

All the inputs of fuzzy logic are processed by fuzzy rules. The fuzzy rules are in the form (2):

$$\textit{If } \boldsymbol{A} \textit{ then } \boldsymbol{B}. \qquad (2)$$

The evaluation of prediction errors from various analyses has been used for setting the weights included in fuzzy rules. The analyses with more (less) accurate predictions have higher (lower) weight in the evaluation of reliability of prediction.

The output of fuzzy rules is produced in the form of scale in range from 0% to +100% (from zero to maximum reliability) or via five ranges:

very small, small, medium, high, very high *reliability.*

The figure 3. presents one of the possible simple ways of decision making process. The all inputs mentioned above are set via sliders. The result of decision making process is produced in the form of scale or via five ranges.

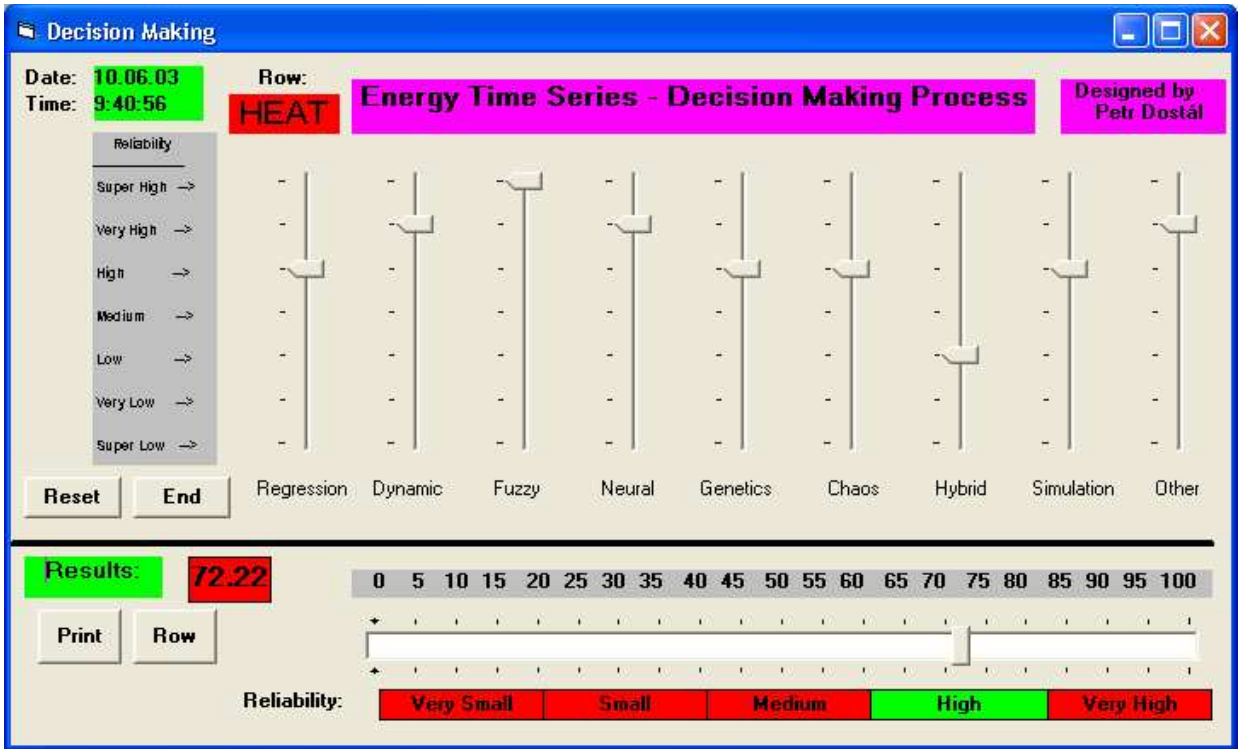

Figure 3: Energy time series – decision making process

The results of evaluation of reliability can be simultaneously used for the choice of the best method which has been used for prediction together with the correction of predicted values from others predictions and analyses. The feedback plays here an important rule.

4 Conclusion

The correct analyses and evaluation gives us the correct answer of prediction of energy time series. The elements of soft computing enable us to improve the quality of control of this process. The prediction process is so complicated that we are forced to use the best methods of analyses. The science turns into art here.