Review of modern approaches for power load forecasting

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Abstract

The growth of renewable energy sources' use in the world leads to complication of energy grid control. The challenge is not only in heterogeneous compounds of such system, but also in random nature of power consumption. One of the possibilities to operate power grid with consideration of instant consumption is to provide a load forecasting with greatest possible accuracy. Several approaches offered by scientific community are considered in the article. It includes regression methods as a classical methodology with several developments. The other direction of researches is artificial intelligence's use. Application of classical filtration methods cannot be unconsidered too. Although, only combination of several approaches in one predictive system had shown incredibly high results.

Keywords: Forecasting, Power Consumption, Artificial Intelligence, Regression

1 Introduction

For last twenty years tremendous growth of renewable energy sources' use in centralized power supply can be observed. According to [1] at 2012 all around the world such sources' use increased up to 74 EJ, and in 2050 it will reach incredible 200-300 EJ.

The renewable energy sources unlike the classical technologies of energy generation have global uncertain influences; such are amount of wind, sun light and other natural factors. Although, the power consumption, especially in residential areas, is always a random factor explicitly affecting the despatching task of power grid.

Therefore nowadays matter of load forecasting is becoming more and more important. The increase of short-term forecast accuracy leads to essential lowering of loss in power network and optimization of maintenance works of service provider [2].

The article is devoted to review new researches on short-term predictive systems for power load. Information about classical regression analysis and newly developed methods are included in section "Regression approaches". Section "Artificial intelligence" describes artificial intelligence use for prediction. Section "Additional information" introduces idea of using weather and social factors to improve forecasting. In section "Data pre-processing" data filtration methods are discussed. At last, relevant final remarks are provided in "Conclusion".

2 Regression approaches

First attempts for data structuring and forecasting usually are based on regressive methodology. Classical regressive analysis shows acceptable, although non-competitive with modern models, results. But researchers have developed new regressive methods that are highly comparable with others.

According to [3] one of the steps to improve regression model is to consider in linear regression not only previous power consumption data, but some patterns like daily cycles or seasonality.

As of totally new regression methods Holt-Winter model, Support Vector Machine should be mentioned. In [4] Holt-Winter and Autoregressive Integrated Moving Average models for load forecasting in Pakistan are used. Accordingly, in [5] Support Vector Machine for prediction was researched. Both models can be used either inherently or as a basis for hybrid systems.

3 Artificial intelligence

The parallel direction of the researches considers artificial intelligence as the instrument to data processing and prediction. It includes neural networks, fuzzy logic and genetic algorithms.

The neural networks are known as universal approximation mechanism. Consequently they can be used for a forecasting task. The main challenge with adjusting the neural networks for claimed aim is choosing exact architecture, depth and learning algorithm. This needs good knowledge of artificial neural networks' working principle and big research to find optimal parameters for exact task. Furthermore even with slightest change of the implementation area adjusted network should be totally reset.

In [6] total process of neural networks' choice and training by data sets from New England Pool region is described. The chosen and trained bagged neural networks have shown reduction of power prediction error comparing with traditionally used techniques.

One of the advantages of neural networks use is possibility to work with limited existing data. In such condition neural forecasting models can give better accuracy than any methodology, as was totally reasoned in [7].

Other important characteristic of the neural forecasting systems is possibility of retraining with new incoming data in practical application. To provide such possibility short time of training is required. First way to achieve the goal is to use pattern-based labelling of incoming data. This approach was discussed in [8]. Beside that in [8] several architectures were compared and best results were shown by regression neural network and one-neuron perceptron learned locally.

Though, more logical way to gain short training time is to simplify the structure of neural network. In [9] extreme learning machine as such simple structured model was examined. This newly developed model was used for evaluation of both 1 and 24 hour power prediction and had reached significant accuracy.

The extreme learning machine also can be combined with artificial bee colony algorithms to calculate networks optimal weights as provided in [10]. Such combination of neural approach with genetic algorithms can shorten number of training iterations, hence the system requires less data. It was proved by using New England and North American electric utility data.

Genetic algorithms also can be utilised as a feature selector as it was done in [11]. Offered forecasting strategy has impact on optimizing system reliability and stability.

Similarly neural forecasting model can be improved by adding uncertainty factor representation. It can be achieved by fuzzy representation utility as in classical adaptive neuro fuzzy inference system or in interval type fuzzy logic model. Both possibilities are compared in [12] by power load data from the Victoria region (Australia) and the Ontario Electricity Market (the USA). Interval type fuzzy logic model showed decrease in prediction error against either neural models or adaptive neuro fuzzy inference system.

4 Additional information

Most of the researchers suppose straight correlation between power consumption and weather and social information.

It becomes most noticeable in prediction for residential area as was researched in [13], where a system for one-month-ahead load forecast was designed. Based on Support Vector Machine model was developed by implementing 14 natural and 5 social factors. The researchers suggest that the same approach can lead to more accurate short-term forecasting too.

5 Data pre-processing

As mentioned previously pre-labelled incoming data can extend accuracy possibilities of both modern regression and intellectual models. It can be done manually by the researchers and operator or can be provided by classical telecommunication filtration.

One of the filtration methodologies is Wavelet decomposition. Wavelets convert incoming data signal from time-domain into time-and-frequency representation. That allows receiving several data sets with different frequencies, which in sum represent initial signal. The data sequences then are used to train the networks or form the regression models, whatever is chosen as basic. Summing outcome from the models represent required forecast.

Wavelet use for fractal interpolation in predictive system is described in [14]. As a result it can be concluded that such filtration's use had enabled to achieve high accuracy with less interpolation cycles.

Previously mentioned extreme learning machine and modified artificial bee colony algorithms' combination can be extended by Wavelet transformation too. Such system will be characterized by high speed re-education and decreased performance error as shown in [10].

Usage of Kalman filter allows using extra information about consumption change trend by evaluation not only state vector of incoming data but also its probability density. Such data pre-processing was used in [15] to improve state-space model of load structure to ensure accurate prediction and detailed analysis of power consumption.

7 Conclusions

According to all considered researches present situation in power load forecasting is characterized by several features. First is the fight for the tenth of one percent in accuracy. Second is absents of universality in all presented methods. So that for any particular region optimal approach should be researched again. Regardless, even usage of non-optimal modern system can provide prediction with more than just acceptable result. And it will provide better power grid control than are performed in practice nowadays.

At the end it should be mentioned that best resulting forecasts where achieved by hybrid systems in different combinations. But straight comparison cannot be done because of heterogeneous data sets and time periods used.

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