ABSTRACT

The problem of forecasting state variables of electric power system is studied. The paper suggests data-driven adaptive approach based on hybrid-genetic algorithm which combines the advantages of genetic algorithm and simulated annealing algorithm. The proposed method has two stages. At the first stage the input signal is decomposed into orthogonal basis functions based on the Hilbert-Huang transform. The genetic algorithm and simulated annealing algorithm are applied to optimal training of the artificial neural network and support vector machine at the second stage. The results of applying the developed approach for the short-term forecasts of active power flows in the electric networks are presented. The best efficiency of proposed approach is demonstrated on real retrospective data of active power flow forecast using the hybrid-genetic support vector machine algorithm.

Keywords: Artificial Neural Network (ANN), Genetic Algorithm, Hilbert-Huang Transform, Simulated Annealing, State Variable Forecasting, Support Vector Machines (SVM)

INTRODUCTION

Implementation of market principles in planning and control of operating conditions, expansion of the area of coordinating operation control of electric power systems (EPSs) in terms of time (from design of control systems to their realization by dispatching and automatic devices) and situation (coordination of dispatching, continuous automatic and discrete emergency control) all cause fast dynamics of change in EPS operating conditions.

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The key condition for reliable work of EPS is the presence of efficient system forecasting of operation parameters (load flows, power flow, voltage magnitude, etc.) and process characteristics (power and electricity losses, prices, etc) (Voropai, 2010; Kurbatsky, 2008; Kurbatsky, 2009). Quality forecasting of frequency is important for optimization of system-wide management of the Unified National Power Grid of Russia. Such a forecast can prevent an abrupt change in control inputs at random nature of the frequency change caused by various malfunctions or failures of technical means of control systems, inaccuracy of input data, etc. Forecast of active power flows provides an estimation of supply ties, expected operating conditions, capacities to preserve stability of weak connection between internal and external sections of EPS by appropriate control actions.

Most publications note that high accuracy of the state parameters forecasting can be obtained on the basis of artificial neural networks (ANN) models (Tomin, 2009; Gamm, 2011). Neural network learning methods provide a robust approach to approximating real-valued, discrete-valued and vector-valued target functions.

The simulated annealing (SA) (Kirkpatrick, 1983; Wu, 2008) and genetic algorithm (GA) (Goldberg, 1989; Skinner) are two global methods and can be used to determine the optimal solution.

GA can be applied in many areas, it can handle any form of objective function and constraints, whether it is linear or non-linear, continuous or discrete, and theoretically lead to the optimal solution. However, in practical application GA faces serious problems, namely: premature convergence, poor local optimization capability, and slow convergence and no convergence to global optimal solution. In recent years, many authors have worked to improve the GAs, in particular through encoding scheme modifications, selection of fitness function and genetic operator design.

The SA algorithms are able to avoid becoming trapped at local minima. The so-called hybrid genetic algorithm (HGA) (Shi, 2010) presented in this paper combines the advantages of GA and SA algorithms and avoids their shortcomings.

The rest of this paper is organized as follows. The review of the state-of-the-art models for the short-term forecasting is presented in Section II. Application of optimization algorithms for ANN and SVM training is described in Section III. The proposed hybrid genetic algorithm is presented in Section IV. Finally the results of the developed method application to real retrospective and synthetic data are presented.

REVIEW OF THE SHORT-TERM FORECASTING MODELS

Many time series forecasting models have been developed in the last decades. They are based both on the traditional statistical methods (Autoregressive Integrated Moving Average, ARIMA; Generalized Autoregressive Conditional Heteroscedasticity, GARCH; Fourier Spectral Analysis) and on the neural network approaches (Radial Basis Function, RBF; General Regression Neural Networks, GRNN; Multilayer Perception, MLP) (Haykin, 2006). The popularity of the ARIMA model is due to its statistical properties, as well as the well-known Box-Jenkins methodology (Box, 1970) in the mode building process. In addition, various exponential smoothing models can be implemented by ARIMA models (Borovikov, 2006), i.e. linear correlation structure is assumed for the time-series values.

Statistical methods and data mining techniques have been used for developing more accurate bankruptcy prediction models. The statistical methods include regression, discriminant analysis, logistic models, factor analysis etc. The data mining techniques include decision trees, ANNs, fuzzy logic, GA, SVM etc.

ANN Models

The success of ANN is explained by the fact that the neural network structure makes it possible to obtain the models with “good” approxima-
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