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Comparison of four Adaboost algorithm based artificial neural networks in wind speed predictions

Hui Liu [a,b,*], Hong-qi Tian [a], Yan-fei Li [a], Lei Zhang [a]

[a] Key Laboratory of Traffic Safety on Track of Ministry of Education, School of Traffic and Transportation Engineering, Central South University, Changsha 410075, Hunan, China
[b] Institute of Automation, Faculty of Informatics and Electrical Engineering, University of Rostock, Rostock 18119, Mecklenburg-Vorpommern, Germany

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ABSTRACT

The technology of wind speed prediction is important to guarantee the safety of wind power utilization. In this paper, four different hybrid methods are proposed for the high-precision multi-step wind speed predictions based on the Adaboost (*Adaptive Boosting*) algorithm and the MLP (*Multilayer Perceptron*) neural networks. In the hybrid Adaboost–MLP forecasting architecture, four important algorithms are adopted for the training and modeling of the MLP neural networks, including GD-ALR-BP algorithm, GDM-ALR-BP algorithm, CG-BP-FR algorithm and BFGS algorithm. The aim of the study is to investigate the promoted forecasting percentages of the MLP neural networks by the Adaboost algorithm' optimization under various training algorithms. The hybrid models in the performance comparison include Adaboost–GD-ALR-BP–MLP, Adaboost–GDM-ALR-BP–MLP, Adaboost–CG-BP-FR–MLP, Adaboost–BFGS–MLP, GD-ALR-BP–MLP, GDM-ALR-BP–MLP, CG-BP-FR–MLP and BFGS–MLP. Two experimental results show that: (1) the proposed hybrid Adaboost–MLP forecasting architecture is effective for the wind speed predictions; (2) the Adaboost algorithm has promoted the forecasting performance of the MLP neural networks considerably; (3) among the proposed Adaboost–MLP forecasting models, the Adaboost–CG-BP-FR–MLP model has the best performance; and (4) the improved percentages of the MLP neural networks by the Adaboost algorithm decrease step by step with the following sequence of training algorithms as: GD-ALR-BP, GDM-ALR-BP, CG-BP-FR and BFGS.

1. Introduction

As one of the renewable energies, the wind power has been taken much attention by different countries [1–4]. In the wind power, wind speed predicting is important to protect the security of the running systems [5–7].

In recent years, scientists have published their studying progress in the wind speed predictions. Guo et al. [8] developed a new wind speed forecasting strategy based on the chaotic time series modeling technique and the AA (*Apriori Algorithm*). Three steps were put forward to make predictions as: the AA was employed to discover the association rules of the wind speed data in advance; the chaotic time series models were established to forecast the wind speed data; and the forecasted results were finally corrected using the discovered association rules. Petković et al. [9] executed a comparison study of the wind speed distribution prediction by some soft computing methodologies. In their study, the polynomial and RBF (*Radial Basis Functions*) were applied as the kernel function of the SVR (*Support Vector Regression*) to estimate the parameters of the WDF (*Weibull Distribution Function*) to forecast the wind speed

Abbreviations: AA, Apriori Algorithm; RBF, Radial Basis Functions; SVR, Support Vector Regression; WDF, Weibull Distribution Function; MSM, Markov Switching Model; BI, Bayesian Interface; PM, Persistent Model; AR, Auto Regressive; ANN, artificial neural networks; BSBM, Bayesian Structural Break Model; KRRM, Kernel Ridge Regression Method; ALS, Active Learning Strategies; SAA, Seasonal Adjustment Algorithm; ESM, Exponential Smoothing Method; MLP, Multilayer Perceptron; BP, Back Propagation; KSF, Kalman Short-term Filtering; NWP, Numerical Weather Prediction; GA, Genetic Algorithm; PSO, Particle Swarm Optimization; PCA, Principal Component Analysis; FAC, First-order Adaptive Coefficient; SAC, Second-order Adaptive Coefficient; BT, Bayesian Theory; SBM, Structural Break Modeling; UKF, Unscented Kalman Filter; OFM, Organizing Feature Maps; EMD, Empirical Mode Decomposition; WT, Wavelet Transform; SVM, Support Vector Machine; ARIMA, Auto Regressive Integrated Moving Average; MAS, Multiple Architecture System; MLR, Multiple Linear Regression; Adaboost, Adaptive Boosting; GD-ALR-BP, Gradient Descent with Adaptive Learning Rate Back Propagation; GDM-ALR-BP, Gradient Descent with Momentum and Adaptive Learning Rate Back Propagation; CG-BP-FR, Conjugate Gradient Back Propagation with Fletcher-Reeves Updates; BFGS, Broyden–Fletcher–Goldfarb–Shanno.

* Corresponding author at: Key Laboratory of Traffic Safety on Track of Ministry of Education, School of Traffic and Transportation Engineering, Central South University, Changsha 410075, Hunan, China. Tel.: +86 73182655294; fax: +86 73182656374.

E-mail address: csuliuhui@csu.edu.cn (H. Liu).

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distribution. Song et al. [10] proposed a new wind speed forecasting method using the MSM (*Markov Switching Model*). They adopted the BI (*Bayesian Interface*) to replace the traditional maximum likelihood estimation to evaluate the parameters of the MSM. To validate the performance of the proposed MSM, four other different forecasting models including the PM (*Persistent Model*), the AR (*Auto Regressive*), the ANN (*artificial neural networks*) and the BSBM (*Bayesian Structural Break Model*) were employed in the comparison. Douak et al. [11] proposed a new KRRM (*Kernel Ridge Regression Method*) with the ALS (*Active Learning Strategies*) for the wind speed prediction. The ALS designed in their study were supposed to optimize the collection of the wind speed training samplings to improve the accuracy of the predicting process while minimizing the required numbers of the samplings. Wang et al. [12] proposed a hybrid method for the wind speed forecasting. Three independent modeling algorithms had been adopted in the method, including the SAA (*Seasonal Adjustment Algorithm*), the ESM (*Exponential Smoothing Method*) and the RBF neural networks.

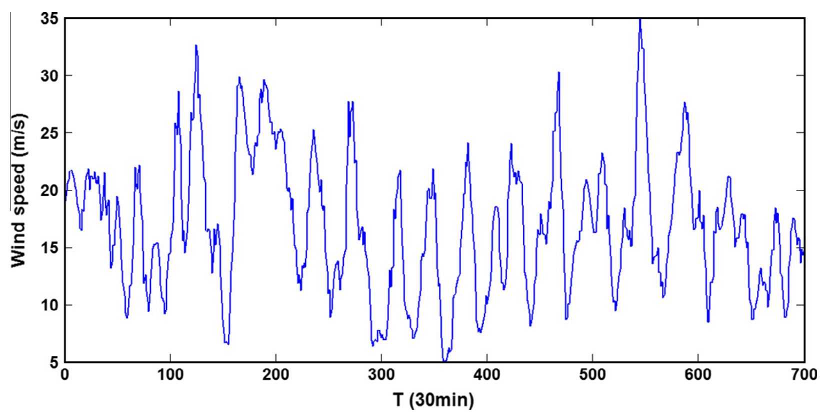

Fig. 1. Original wind speed time series #1.

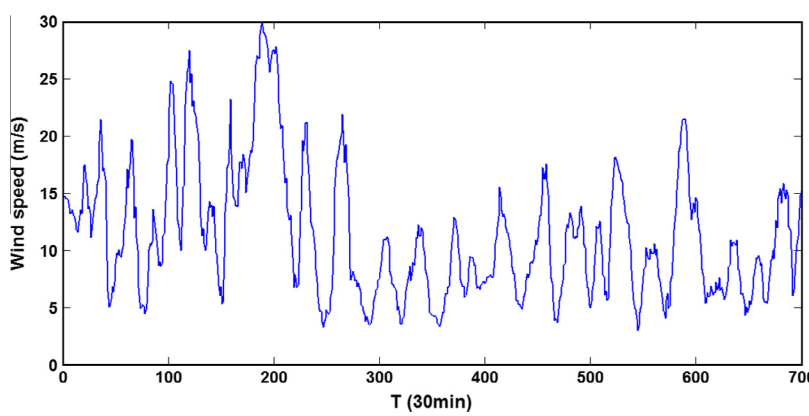

Fig. 2. Original wind speed time series #2.

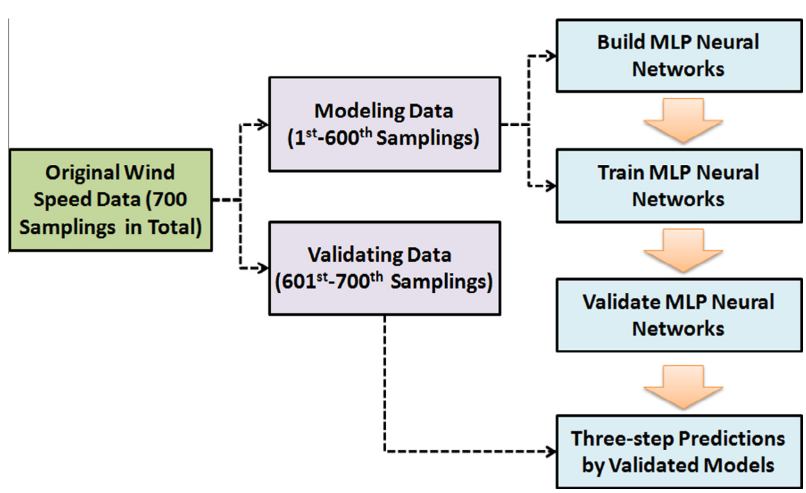

Fig. 3. Data processing format of the original wind speed samplings.