Analysis and Prediction of Meteorological Data Based on Edge Computing and Neural Network

Jianxin Wang, Anyang National Climatological Observatory, China*
Geng Li, Henan Polytechnic University, China

ABSTRACT

In this work, aiming at the problem of missing element values in real-time meteorological data, the authors propose a radial basis function (RBF) neural network model based on rough set to optimize the analysis and prediction of meteorological data. In this model, the relative humidity of a single station is taken as an example, and the meteorological influencing factors are reduced by rough set theory. The key factors are used as the input of RBF neural network to interpolate the missing data. The experimental results show that the interpolation effect of the model is significantly higher than that of the linear interpolation method, which provides an effective processing method for the lack of real-time meteorological data and improves the analysis and prediction effect of meteorological data.

KEYWORDS

Cloud Center, Deep Learning, Edge Computing, Meteorological Data, Neural Network, Prediction Analysis, Radial Basis Function, Rough Set

INTRODUCTION

The meteorological environment is the foundation for the survival and development of human society. However, due to the excessive usage of resources for economic development, the meteorological environment is severely damaged and becomes extremely fragile (Li et al., 2012). Therefore, the analysis and prediction of meteorological data is great significance to environmental governance and improvement. Meteorological observation data are mainly collected through automatic weather stations. Modern automatic weather stations have basic functions, such as data collection, data processing, data storage, data transmission, data quality control, and operation monitoring (Tang & Gao, 2008). The realization of these functions depends on the accurate acquisition of real-time data. Due to the existence of electromagnetic waves and man-made interference sources, and the unpredictability of the environment where the automatic weather station collector is located, the data received during the operation of the automatic weather station is inaccurate (Pepin & Duane, 2010). In addition, predicting and verifying the collected real-time data can improve the stability of the automatic weather station operation and the convenience of manual operation, which make the weather data more predictable, and effectively increase the functions of the control system for managers. This provides a reliable basis for decision-making (Liu et al., 2006).

At present, the analysis and prediction methods and theories of meteorological data have developed rapidly, which provides strong support conditions for the analysis and prediction of large, complex and information-rich data sets (Wang, Zhang, Wang et al, 2020). Recently, many researchers have carried out extensive works on the specific problems of meteorological data analysis and prediction,

DOI: 10.4018/IJDST.291081 *Corresponding Author

and proposed a variety of approaches, such as methods based on statistics, methods based on machine learning, and methods based on deep learning (DL) method. Among them, deep learning technology is one of the most popular methods, which deals with complex problems by simulating the learning and training functions of biological neural networks (Rasheed et al., 2020; Wang, Han, Leung et al, 2020). It has strong parallel processing, redundancy and fault tolerance, association, memory, self-organization, and self-adaptation functions. However, a network model of deep learning usually contains a large number of neuron parameters, which causes its computational efficiency to be greatly reduced and restricts its development in the field of meteorological data processing. In order to optimize the data processing capabilities of neural networks, many methods have proposed in decades, and edge computing is a fastest growing one approach (Molina-Masegosa & Gozalvez, 2017). The combination of this technology and deep learning mainly reflects two advantages: firstly, DL can be integrated into the framework of edge computing, which enables adaptive management of the network edge. In addition, edge computing also pushes a large number of model calculations from the cloud down to the edge, and achieves low-latency, high-reliability intelligent services (Liu et al., 2020).

In the application of edge computing, because the computing resources of mobile terminals are relatively limited, and DL has the characteristics of complex models and large amounts of calculations, the end-cloud architecture is proposed to achieve model training and inference, i.e., end (edge devices) provides model input, and the cloud (remote data center) executes the calculation process. In the processing of meteorological data, edge devices usually involve multiple data collection, such as temperature data, visibility data, wind speed data, and precipitation data. Different meteorological data have different characteristics, and thus their edge prediction models are also different. In the temperature data prediction model, the BP neural network model is widely used, and its basic idea is to achieve an information processing system with the smallest mean square error between the input signal and the expected signal through local search (Bhm, 2000). During the working period, the signal is usually transmitted to the output layer by the transfer function after nonlinear processing in the hidden layer. In addition, the GM (1,1) prediction model is suitable for the temperature prediction model (Xiao & Deng, 2001). The model is designed to show the dynamic input changes of the data, and its basic idea is to highlight the characteristics of recent input data. Thus, it can better highlight all the data in the time series. The result of the dynamic change of the measured variable is an ideal short-term prediction model. After setting the starting time sequence point, a self-contained differential equation is established for the independent variables, and then the value of each parameter is determined by the least square method to derive the prediction model. The genetic neural network model is a classic model in the visibility prediction problem (Palmes et al., 2005). That genetic neural network is a BP neural network that improves the ability of random search. Its basic idea is to randomly generate a set of initial solutions for different entry points of the problem situation, and then establish the fitness function that evaluates the fitness of different individuals. The higher the fitness means the greater the probability of being selected. Then the selected individual will cross and mutate, and mutagen rating individuals will have higher fitness. It should be note that the initial solution is generated to the process of generating an adaptive solution to the problem, and this process is called an iteration. After sufficient iterations, there will be one individual remaining in the convergence area, and the optimal solution can be obtained by finally disassembling the selected individual. In the wind speed prediction model, discrete Hopfield pattern recognition and General Regression Neural Network (GRNN) nonlinear combination prediction method are very popular (Zhang, 2015). Discrete Hopfield network is a kind of neural network that simulates the associative function of biological memory. It achieves stable equilibrium point through its own dynamic evolution to understand new patterns and achieve the purpose of association. Based on the theory of nonlinear regression analysis, GRNN has strong ability in approximation, learning and classification, as well as strong nonlinear mapping ability and high fault tolerance. For precipitation prediction model, EEMD-GRNN model can usually have excellent performance (Amanollahi & Ausati, 2020). The model consists of two parts, i.e., EEMD decomposition method and GRNN nonlinear combination forecasting method. Nonlinear and

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