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Combustion Control of Utility Boiler based on GRU Neural Network

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Abstract

Boiler combustion system is a typical dynamic system with many variables, strong coupling, large lag and multi input / multi output. It is very difficult to build a combustion system model in line with the actual working conditions. In this paper, a new modeling method of boiler combustion system based on GRU is proposed At the same time, the gradient lifting decision tree is used to reduce the dimension of the input characteristic matrix. The calculated values are used in the counter balance calculation model of boiler thermal efficiency. The calculation results show that the predicted values of the neural network model can meet the requirements of engineering calculation; the calculated exhaust gas temperature, carbon content in fly ash and coal ash are used for boiler efficiency. The real-time and dynamic calculation of boiler efficiency can be realized; The calculated change of boiler efficiency is basically consistent with the change of actual evaporation.

Keywords

Boiler Combustion, GRU, Efficiency.

1. Introduction

With the development of information technology and the proposal of new infrastructure concept, traditional thermal power plants need to be upgraded in the direction of intelligence [1]. Using artificial intelligence algorithm to build the combustion model of power plant boiler is a research hotspot at present. Boiler efficiency is not only an important index to measure boiler operation state, but also an important goal of boiler combustion optimization. The traditional boiler optimization method mainly adopts cross test or single factor cyclic test to optimize and adjust the combustion conditions through expert experience [2-3]. It is not only time-consuming and laborious, but also the test conditions are limited. Once the coal type or operation state of the boiler changes, the original optimization test results will become invalid. Therefore, in order to better optimize the boiler efficiency, using heuristic algorithm to optimize the boiler parameters is one of the better methods at present. It is required to first build a real-time calculation model between the boiler operating parameters and the boiler efficiency. The existing boiler combustion system modeling is mainly divided into white box model based on combustion mechanism and black box model based on data drive. The white box model is established according to the dynamic physical characteristics of thermodynamic variables [4]. Its model is complex and difficult to be applied to the actual boiler combustion control site. Black box model is based on data modeling, and its computational cost is low. It is generally modeled by data mining, data fitting and other methods. Common black box models are based on neural network [5] and support vector machine [6], which are established on the basis of analyzing the correlation between known operating parameters and experimental data. Compared with the white box model, the black box model is more suitable for complex industrial field control.

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In order to obtain a wide range of real-time boiler efficiency calculation method, this paper uses genetic algorithm to improve neural network algorithm to train the relationship between boiler parameters and boiler exhaust gas temperature, carbon content in fly ash and coal ash, calculate boiler flue gas heat loss and solid incomplete combustion heat loss, reduce the measurement data required by the calculation model and reduce the transformation cost of boiler.

2. Target Boiler and Combustion System

2.1 Data Preprocessing

The original data obtained from the actual power plant can only be applied to the model calculation after preprocessing. In this paper, data processing includes three parts: eliminating outliers, distinguishing steady-state conditions and similarity processing. Due to faults or measuring instruments, there are usually obvious abnormal points in the directly collected data, which are greatly different from the adjacent data points

2.2 Model

Grave et al. Proposed long short term memory (LSTM) neural network to improve RNN model structure, set hidden layer memory units (i.e. input gate, forgetting gate and output gate) to realize time-series memory controllability, and solve the problem of gradient disappearance of RNN model [7]. However, LSTM neural network has complex hidden layer structure and long training sample time [8]. Therefore, CHO et al. Compared with the three gating units of LSTM neural network, GRU neural network has only two gating units, namely reset gate (z) and update gate (r) At the same time, GRU neural network has no separate storage unit [9], which simplifies the number of model parameters, improves the convergence speed of the algorithm, improves the sample training efficiency. Fig. 1 is the structure diagram of GRU neural network.

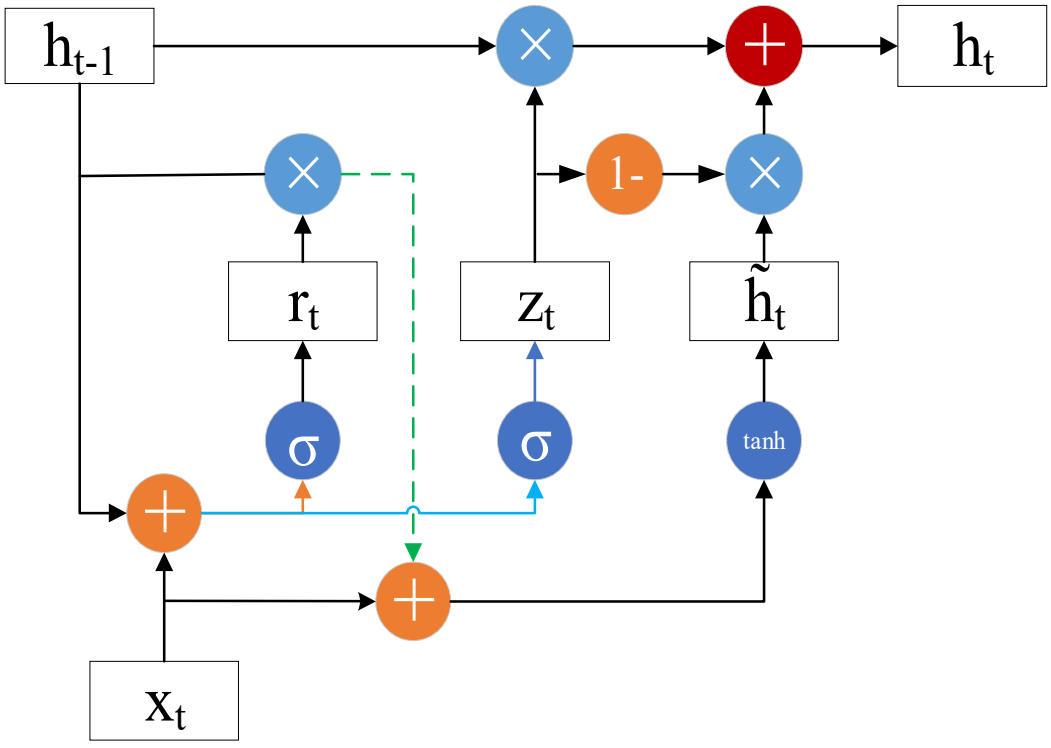

Figure 1. GRU gating mechanism

2.3 Results and Analysis

In the actual production process of the power plant, the carbon content and coal quality data of fly ash on the same day can only be sampled discretely. Therefore, the samples around the sampling

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point are selected to train the carbon content and coal ash of fly ash. When training the neural network model, the sample data is randomly divided into training set and test set, and the division ratio of training set and test set is 7 : 3., The prediction results can meet the prediction needs of most samples. For the carbon content of fly ash and coal ash, some results are quite different from expectations. This is because in actual production, the test times of fly ash carbon content and coal quality data are less. In order to make full use of the operation data of the power plant, the test data at one time is extended to other times, resulting in large deviation of some sample data. Based on the actual test data., The change of boiler efficiency is approximately consistent with the actual evaporation. When the actual evaporation capacity of the boiler decreases, the boiler efficiency decreases, which may be related to the boiler heat storage. The reduction of load leads to the increase of flue gas per unit coal quantity of the boiler, but the flue gas temperature does not decrease, resulting in the increase of flue gas heat loss and the sudden decrease of boiler efficiency. In addition, when the actual evaporation capacity of the boiler is more than 60% of the rated evaporation capacity, the boiler efficiency is easy to maintain a high level.

3. Conclusion

The neural network algorithm is used to calculate the exhaust gas temperature, carbon content in fly ash and coal ash, and then the exhaust gas heat loss and solid incomplete combustion heat loss of the boiler are calculated, which are substituted into the counter balance calculation model of boiler efficiency to obtain the boiler efficiency. The calculated change of boiler efficiency is approximately consistent with the change of actual evaporation. When the actual evaporation of the boiler decreases, the boiler efficiency decreases. The actual evaporation capacity of the boiler is more than 60% of the rated evaporation capacity.

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