Separate Source Predictive Control of Gas Emission based on psobp AdaBoost

Tao Xu and Tong Cheng
Heilongjiang Institute of Technology，Heilongjiang，158100，China
Xutao00@126.com
shepherd_ct@163.com

ABSTRACT
Gas disaster is a great challenge for coal mine enterprises to work safely. Once gas disaster happens, people's life and property safety will face great threat. High precision prediction of gas emission is an important measure to improve gas prevention and gas control, and it is of great practical significance to improve the safety of production and people's life and property safety of mining enterprises. Therefore, this paper discusses a new method of gas emission prediction, and proposes a prediction model of gas emission quantity based on psobp adaboost algorithm, which combines bp neural network, particle swarm optimization algorithm, adaboost iterative lifting algorithm and gas emission source separation prediction method with nonlinear mapping characteristics.
Keywords: *gas emission; particle swarm optimization algorithm; adaboost iterative algorithm*

1 INTRODUCTION

Gas is the general term of all kinds of harmful gases emitted from coal and rock mass under the mine. The types of disaster accidents caused by gas include gas suffocation, gas explosion, coal and gas outburst, etc. the coal and gas outburst and gas explosion accidents cause huge losses to people's living and mine safety production. With the increase of the depth and scope of coal mining, the amount of gas in the mine becomes larger. Many coal mines have evolved into high gas mines, and the amount of gas emission also increases. The frequency of gas explosion and coal and gas outburst caused by gas also increases. The prediction of gas emission is based on the gas content of coal seam, and some reasonable auxiliary parameters are comprehensively selected from the natural factors and mining technology factors, and then the gas emission is counted by using the fixed method, which is an important reference for mine ventilation design, gas prevention and management, If we can effectively predict the amount of gas emission, it has important theoretical and practical significance to reduce the probability of gas accidents and reduce the impact of accidents.

In order to improve the accuracy of gas emission prediction, psobp AdaBoost algorithm is designed to improve the generalization ability of the algorithm. Combined with the theory of gas source prediction, this paper carries out the technical breakthrough of "Research on gas source prediction and control based on psobp AdaBoost". Considering that the gas emission of different gas emission sources is affected by different factors, and some factors are highly correlated, in order to reduce the input dimension of the model, some factors are analyzed by principal component analysis, Then, the psobp AdaBoost gas emission prediction model is constructed for each emission source to effectively predict the gas emission, which has very important economic, social and practical significance for guiding production and preventing gas disasters and accidents.

2 RELATED WORK

Predictive control, namely model predictive control (MPC), is a special kind of control. Its current control action is obtained by solving a finite time domain open-loop optimal control problem at each sampling moment. The current state of the process is the initial state of the optimal control problem, and the optimal control sequence only performs the first control function. This is the biggest difference between it and those algorithms that use pre calculated control laws. In essence, model predictive control solves an open-loop optimal control problem. Its idea has nothing to do with the specific model, but its implementation is related to the model.

Date j proposed a methodology for the enhancement of the energy flexibility and contingency response of a building through predictive control of passive and active storage[1]. Wu x proposed multi-step optimal predictive control for path correction of the agv driven by hub motors[2]. Lutz m proposed optimal trajectory planning and model predictive control of underactuated marine surface vessels using a flatness-based approach[3]. Saloux e proposed model-based predictive control to minimize primary energy use in a solar district heating system with seasonal thermal energy storage[4].seo m proposed low-order model identification and adaptive observer-based predictive control for strip temperature of heating section in annealing furnace[5].h he proposed robust model predictive control for energy management of isolated microgrids based on interval prediction[6]. Hahn s , proposed adaptive operation strategy of a polymer electrolyte membrane fuel cell air system based on model predictive control[7]. Pashinskaya t y proposed predictive control of investment portfolio on the financial market with hidden regime switching and ms var model of returns[8]. Li s proposed finite set model predictive control of a dual-motor torque synchronization system fed by an indirect matrix converter[9]. Liang y proposed multi-model adaptive predictive control for path following of autonomous vehicles[10].
This paper consists of the following parts. The first part introduces the related background and significance of this paper, the second part is the related work of this paper, and the third part is data analysis. The fourth part is example analy-sis. The fifth part is conclusion.

2.1 Study on predictive control of gas emission

Due to the special storage conditions and poor working environment of coal, the coal industry is facing a very serious problem of safety production. Since entering the 21st century, the state has paid unprecedented attention to the safety production of coal mines. The serious gas accidents in coal mines have decreased, but they still occur from time to time. The safety situation of coal mines is still very severe.
Because of its instability and explosion, gas is one of the important factors endangering coal mine production safety. Gas is a factor that must be considered in mine ventilation design, gas drainage engineering design and gas prevention and control. The level of gas content directly affects the normal operation of coal mine production. From 2005 to 2010, the number of coal mine accidents accounted for 72% - 86% of the total number of accidents in which more than 10 people died at one time in industrial and mining enterprises. Among these major coal mine safety accidents, the percentage of gas accidents was the highest and the harm was the most serious[4]. There are many reasons for coal mine gas accidents in China. Through the investigation and cause analysis of major gas accidents in coal mines in recent years, it is found that one of the main reasons is that we have not fully mastered the law and trend of gas accidents before coal mine gas accidents. This year, China's coal industry has developed rapidly, and the original theory can not adapt to the rapid development of mining technology. Therefore, scientific and reasonable gas emission prediction method is the basis of safety prevention and control work and the necessary premise of coal mine safety work.

2.2 basic idea of AdaBoost algorithm

AdaBoost (adaptive boosting, AdaBoost) is an adaptive iterative enhancement algorithm proposed by Robert schapire and Yoav Freund in 1995. At present, AdaBoost algorithm has been widely used in classification problems, and some scholars are trying to use AdaBoost algorithm to solve prediction problems. The main idea is: for the same training sample set, initialize the sample weight distribution, establish a weak predictor, refer to the prediction results of the weak predictor, update the weight of training samples, increase the weight of less accurate samples, reduce the weight of more accurate samples, through repeated iterations, By adjusting the weight distribution of samples, a group of weak predictor sequences and their weights will be obtained (the more accurate the weak predictor is, the higher the weight it has). Finally, the group of weak predictor sequences obtained will be weighted and combined as a strong predictor for the final decision[5]. AdaBoost algorithm has two advantages: on the one hand, it uses the same training sample set with different weight distribution to replace the mechanism of random training sample selection; On the other hand, the weighted voting mechanism is used to replace the average voting mechanism, which improves the accuracy of the algorithm and is very suitable for solving some practical problems [6].

2.3 overview of particle swarm optimization algorithm

Particle swarm optimization (PSO) is a global optimization algorithm, which was proposed by keneddy and Eberhart of the United States in 1995. Referring to the foraging process of birds, we get enlightenment: suppose that there are a group of birds and a piece of food in an area, birds do not know where the food is, and need to search randomly, but they can communicate

with each other through information, Finally, we found food. Particle swarm optimization (PSO) is gradually used to solve optimization problems because of its advantages of global search[7]. According to the theory of swarm intelligence, the particle in PSO algorithm cooperates and competes to find the optimal solution in complex space. It has the characteristics of evolutionary computation and swarm intelligence. Compared with some traditional evolutionary algorithms, on the one hand, the PSO algorithm retains the global search strategy, on the other hand, it abandons some complex genetic operations. It only uses the velocity displacement model to adjust the particles. The operation is simple, and it can record the global optimal solution and the optimal solution experienced by the individual, and then adjust the particle population [8].

3 DATA ANALYSIS

The standard BP neural network algorithm is generated by random method for initial weight and threshold value, and the connection weight and threshold value between neurons are adjusted by gradient descent method. Therefore, there are some defects such as slow convergence rate and local minimum value, which leads to the excessive prediction error, The prediction results can not meet the actual requirements. Based on this, the author proposes the construction of nonlinear system prediction model by combining PSO optimization algorithm, AdaBoost algorithm and BP neural network. In this prediction model, PSO optimization algorithm is used to optimize the initial weight and off value of BP neural network[9]. AdaBoost obtains a new strong predictor by training multiple psobp based predictors, The structure of the prediction model of the nonlinear system is shown in Figure 1.

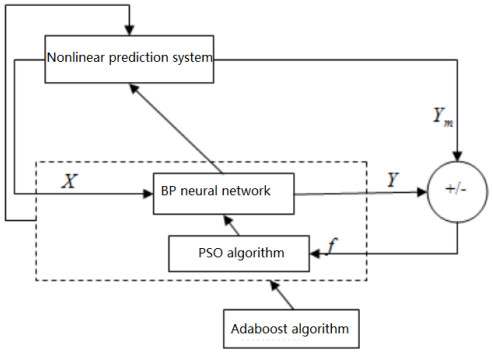

Fig. 1. The structure of PSOBP- Adaboost prediction model

3.1 *basic principle of psobp AdaBoost algorithm*

In view of some defects and shortcomings of BP neural network, PSO optimization algorithm, AdaBoost algorithm and BP neural network are combined to use, and psobp AdaBoost algorithm is proposed. PSO optimization algorithm is used to optimize BP neural network, and some initial weights and thresholds with better fitting effect are selected. The optimized model is used as the base predictor, Then, the AdaBoost algorithm is used to train some psobp based predictors selected for the same sample set, and finally weighted to form a strong predictor to improve the prediction accuracy of the nonlinear system prediction model. The algorithm schematic diagram is shown in Figure 2.

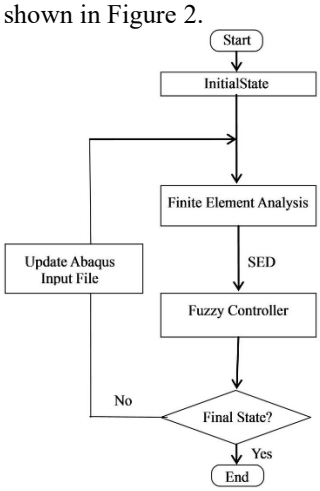

Fig. 2. The comprehensive structure of psobp AdaBoost model

3.2 *flow of psobp AdaBoost algorithm*

Psobp AdaBoost algorithm is used to optimize the initial weight and threshold of BP neural network. The optimized psobp network is used as the weak predictor model, and the optimization process is repeated until some basic predictors with better fitting ability are selected. These weak predictors are trained by AdaBoost, and finally weighted into strong predictors, The flow of the algorithm is shown in Figure 3:

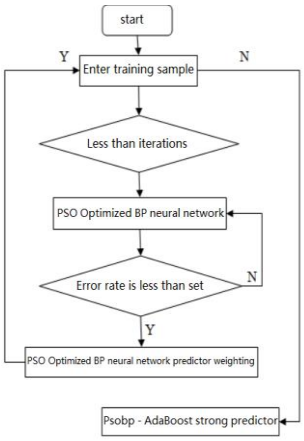

Fig. 3. algorithm flow chart

4 EXAMPLE ANALYSIS

4.1 Analysis of influence factors of gas emission source prediction

The gas in coal seam is the companion of coalification process. The first stage is the initial stage of coal formation, that is, the stage of humic matter carbonization by compressed accumulation mud. When the temperature is lower than 65 ℃, the organic matter is decomposed into CH4, CO2 and H2O; The second stage is the coal metamorphism stage. At this stage, the external environment is continuously isolated, but the temperature and pressure continue to increase. The coal is gradually transformed into lignite. Under the influence of the internal environment, the organic matter is gradually transformed into coal. The gases generated in this stage mainly include CH4 and CO2. The generation of gas is accompanied by the formation of coal and runs through the whole coal forming process. The amount of gas generation is directly affected by the generation of coal and the degree of metamorphism[10]. The analysis of influence factors of gas emission source prediction is shown in Fig 4.

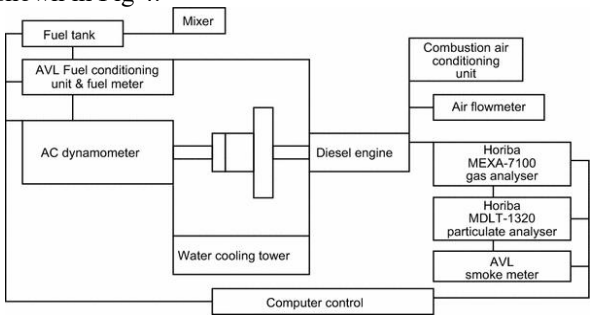

Fig. 4. Analysis of influence factors of gas emission source prediction

The main contents include determining the input variables, output variables, the number of hidden layer neurons, using particle swarm optimization algorithm to select the appropriate initial weights and thresholds of BP neural network, weighted combination psobp network for comprehensive prediction, etc.

Shanxi Province will study and deploy the current key tasks of work safety, strengthen the responsibility of work safety of departments and units at all levels, and pay close attention to the key work in seven industries[11]. The notice defines the key tasks of coal and natural gas this year, takes the investigation of major fire hazards as the starting point, further promotes the three-year action of special rectification of coal mine safety, further improves the gas prevention and control system, promotes gas source treatment, systematic treatment and comprehensive management, and effectively prevents and curbs coal mine gas accidents. Weighted combination psobp network for comprehensive prediction is shown in Fig 5.

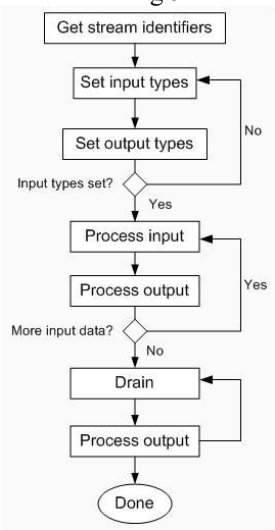

Fig. 5. Weighted combination psobp network for comprehensive prediction

At the same time, special gas consultation shall be organized and carried out in combination with the dual prevention mechanism of classified control of safety risks and troubleshooting and treatment of hidden dangers, so as to investigate potential hazards. Further promote the treatment of major gas disasters in combination with the three-year action plan for special rectification of work safety. Highlight the key points of gas prevention and control, and strengthen the management of key links of on-site control. Highlight the implementation of two "four in one" comprehensive outburst prevention measures; For the comprehensive effectiveness of various mine fire prevention and extinguishing measures for

mining spontaneous combustion and easy coal seams and the natural fire monitoring system, especially during the repurchase of high-altitude mines, it is necessary to formulate careful safety measures to effectively prevent the superposition of gas and fire accidents. Effectively strengthen the gas prevention and control of mines to be closed.

Shanxi provincial emergency management department requires all coal mining enterprises to pay close attention to key links such as mining deployment, gas spot check, ventilation system, monitoring and monitoring, dust prevention and control and natural fire. The Provincial Emergency Management Bureau requires the coal mine safety supervision departments at all levels to regularly organize and carry out safety production inspection, close and exit the mine[12]. Gas prevention and control is not only the top priority of coal mine safety production, but also an important measure to prevent and curb major coal accidents. First, further improve the gas prevention and control responsibility system. After the reform and reorganization of state-owned enterprises in our province, the provincial coal group company must further improve the gas governance responsibility system at all levels, improve the organization and scientific distribution of personnel, and ensure that gas management is not empty and unimpeded.

It must combine the dual prevention mechanism of safety risk hierarchical control and hidden danger investigation and treatment, take the investigation of major gas disasters as a means to explore the problems of mining deployment, ventilation system, gas treatment and other systems, and form a consultation report. The main person in charge of coal shall hold a special meeting to study and solve the key problems of major problems.

According to the requirements of gas prevention and control, "fine drainage for one year, fine drainage for three years and five years as planned", the meeting of high gas and coal and outburst coal mines shall formulate a revised and perfect gas mining standard scheme, formulate an annual gas sampling standard implementation plan, and implement "one mine and one policy".

4.2 model establishment

In the three models, the structure of BP neural network is different, and the setting of parameters such as training function, learning rate, maximum iteration times and target error are the same, but also different, The author will be determined by experiments and referring to the results of relevant scholars. The construction steps of gas emission prediction model based on psobp AdaBoost are as follows:

(1) Select m groups as training data and N groups as test data from the original data, use premnmx function to normalize the original training data and test data, after normalizing, the sample data will be limited in [- 1,1] interval.

(2) Using training samples, PSO optimization algorithm is used to optimize the constructed BP neural network to obtain appropriate initial weights and thresholds, and the optimization process is repeated until *T* psobp models with good fitting and generalization ability are selected as weak predictors, and their initial weights and thresholds are saved.

(3) The initial weight distribution of training samples is carried out, and the weights are distributed $D_t(i) = \frac{1}{m}$.

(4) When training the first weak predictor, the psobp neural network with the training parameters and the initial weights and thresholds of the network are used to train the training samples. The regression model $g_t(x) \rightarrow y$ is established, and the error sum of $g_t(x)$ is calculated according to formula (1) ξ_t。

$$\xi_t = \sum D_t(i) \tag{1}$$

(5) According to the sum of sequence errors, the weight distribution of the next round of training samples is adjusted according to formula (2);

$$D_{t+1}(i)\ \frac{D_t(i)}{B_t} \begin{cases} \beta_t, \dfrac{g_t(x_i) - y_i}{y_i} \le \phi \\ 1, \dfrac{g_t(x_i) - y_i}{y_i} \ge \phi \end{cases} \tag{2}$$

(6) After t iteration, the weak prediction function f (g, a) of group t psobp can be obtained, and the final gas emission intensity predictor can be obtained according to formula (3).

$$g_{out}(x) = \frac{\sum_{t=1}^{T}\left((\log\frac{1}{\beta_t}) \bullet g_t(x)\right)}{\sum_{t=1}^{T}\left(\log\frac{1}{\beta_t}\right)} \tag{3}$$

5 CONCLUSION

The amount of gas emission is affected by many factors. There is a complex nonlinear relationship between the influencing factors and the amount of gas emission. In order to further improve the prediction accuracy of gas emission, the idea of gas source prediction is intro-

duced. Aiming at the identification of the dynamic complex nonlinear system of gas emission prediction, this paper uses psobp AdaBoost algorithm with highly nonlinear mapping ability to establish a prediction model, which solves the prediction problem of gas emission, which is affected by many factors and has highly nonlinear characteristics. The prediction of gas emission is to predict the amount of gas emission in future mine working face, which is of great significance to mine ventilation design, gas drainage engineering design, gas prevention and control.

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