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Research on prediction of gas emission based on self-organizing data mining in coal mines

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Abstract

In order to accurately predicting gas emission in coal mines, the complicated nonlinear characteristics of gas emission was analysis, the prediction method was put forward for gas emission based on self-organizing data mining. It was used the ternary quadratic polynomial for the local function and the original variable was used in each generation, and the minimum deviation principle was used for criteria of model selected. And then, the high-order equation of prediction was established for gas emission by self-organizing data mining method. The fitness relative error of this prediction model was $\pm 0.03\%$ and predictive relative error was $\pm 1.45\%$ to gas emission in coal mine. The results show that: self-organizing data mining method can automatically analyze non-linear relation between the gas emission and the factors, and can be establish the explicit high order equation to descript the gas emission laws, and the prediction model has enough prediction accuracy for application of actual engineering in coal mines.

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Nomenclature

y absolute of gas emission (m^3/min)

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X	the factors of gas emission
a	undetermined coefficients of local function
r	the numbers of iterations

1. Introduction

It is a fundamental safety work to calculating the gas content in coal seam and forecasting the gas emission from coal and rock in coal mine. In the 1950s, it has been established some measurement methods and processes of gas content in coal bed, and has been put forward and applied the mine statistical method to calculate and predict mine gas content and emission in coal mines in China. In the 1980s, the method of different-source prediction for gas emission also has been proposed and applied. Since then, the method of analogy method, the gas geology mathematical model, velocity method and other prediction methods for gas emission have been put forward and applied. After decades of exploration and study by researcher and scholar, it has been formed the maturity and traditional prediction method and technology for gas emission in coal mines that was suitable the coal seam occurrence conditions in China. All the methods and technologies was offer a scientific basis to design and retrofit for the new and old coal mine. With the expansion of coal mining intensity and production scale, people has deepening understood and grasped the essential feature of mine gas emission system by the development and its application of computer technology and mathematics method and the nonlinear theory. So, many new prediction methods has been to research and application for coal seam gas emission, For example, based on multivariate linear regression to prediction gas emission [1], based on the grey system theory [2], neural network [3], support vector machine (SVM) [4–5], evidence theory [6], chaos theory [7], fractal theory [8], rough set theory [9], and so on methods to prediction gas emission in coal mines. The research and application of these new methods have been to promoting the improvement of the level of research on mine gas emission rule, and improved and raised the level of the coal mine safety production.

Self-Organizing Data Mining Method (SODM) is a series of algorithms to solving complicated and nonlinear systems based on Group Method of Data Handling (GMDH) which proposed by Ivakhnenko academician in Ukraine academy of sciences in 1967. This method can overcome the problems of neural network such as can't explain the results of practical significance, over-fitting, and also have the advantages of using a priori knowledge of system, inductive learning algorithm process. So, it have widely useful[10–13]. In 1980s, the self-organizing data mining method was introduced into China. Then, some scholars has studied and applied the method, such as economic early warning based on self-organizing data mining method [14]; Power demand predict [15]; E-commerce customer prediction [16], etc., but its application range are mainly concentrated in the economic, financial, business, and so on, it was rarely found in study of safety and disaster prevention and control in coal mine.

There have a lots of factors to influence the mine gas emission in coal mines such as gas content, coal and rock mining scale, production process, ventilation mode and others. The subsystem of gas emission has typical characteristics of complex nonlinear system, we still can't know exactly how much variables affecting this subsystem state, and also cannot establish a deterministic system dynamics equation to describe the gas emission [17]. The self-organizing data mining method is a heuristic self-organization method to study complex multivariable system. When in the case of unknown nonlinear systems structure, this method can be established its mathematical model according to a small amount of input and output data. Therefore, this paper attempts to introduce self-organizing data mining method to analysis the coupling relationship between coal mine gas emission factors for the coal mine gas emission prediction research, and to establish the prediction model. It would be to provide new methods for the prevention and control of gas disaster and to improve the level of coal mine disaster control in coal mine.

2. The basic principle of self-organizing data mining

The basic idea of the SODM is using the general iterative algorithm to establish a simple initial model then to gradually build a model of optimal complex according to internal criteria and external criteria by the samples of complex system. The new model structure is more complicated than the original model in each step and still retain certain evolution characteristics of the original system structure. This entire modelling process is completely self-

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