Research of coal gas warning model based on fuzzy clustering

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Received 1 March 2014. www.cmnt.lv

Abstract

Prevention of coal safety is the major problem that has been a concern around the world, coal mine gas disaster forecast predicted in advance is essential. In this paper, coal environmental parameters and device parameters monitoring data are acquired, coal gas fault symptom information are extracted, the gas concentration level of warning model is established using fuzzy clustering method. Simulation results show that the proposed fault classification model is accurate, reliable, practical value, and that can obtain the integration of coal mine gas fault level decision results.

Keywords: coal, gas failure warning, fuzzy clustering, model

1 Introduction

Coal production environment has a complex operating procedure, gas and coal dust, coal and gas outburst and so on always are be the threat of disasters. Furthermore, mine production is a multi-step, multi-link integrated industry, it has a complicated process, often mobile workplace and harsh environment characteristics, so that it exists the risk factors that are be hidden in the system, all of these is not conducive to safe production [1]. For a long time it is generally believed that coal is the not high technical level, but requiring relatively low labor-intensive industries in China, therefore, investment in technology is inadequate, equipment level is poor, industrial technology talent shortage, low labor productivity. Thus, once gas explosion accident occurs, it easily lead to losses or even the destruction of the whole mine phenomenon [2].

In recent years the accident-prone coal industry in China is caused by many factors, including, the occurrence of spontaneous, combustion of coal complicated conditions, coal quality of employees is not high, it is difficult to meet the working environment for staff quality requirements, as well as coal mine safety technology equipment is not in place Some research scholars and research institutions active efforts to improve coal mine production automation and disaster early warning and forecasting etc. [3-7]. Fu Hua et al., identified the gas monitoring structural model of multi-sensor data fusion, state-space methods were described in this structural model, a state space gas monitoring system model using multi-sensor data fusion was established. By artificial intelligence methods, a fuzzy neural network algorithm was applied to multi-sensor information fusion modelling. Wang Yufen et al, proposed coal mine gas monitoring system than can be designed based on ZigBee. The multi-sensor signal based on fuzzy logic anxious fusion technology were be used in coal gas monitoring system by Zhang Qian et al, reducing the uncertainty of a single sensor, improving the utilization of multi-sensor data, and enhance reliable gas monitoring and accuracy of coal mine production safety has provided a guarantee. Xu Yaosong et al, proposed and implemented a set of computer software and hardware, special test equipment and communication lines were combined with the integrated coal mining rig performance detection system. Using the system to detect mines rig performance parameters in the same conditions, and coal generates comprehensive test rig performance reports, historical data can be post-analysis with data fusion theory. The use of Bayesian estimation method and the adaptive weighted information processing and data fusion, Shao Liang Shan et al., solved the gas prediction process uncertainty and imprecision problem, and considering new ways of coal mine gas concentration, other related parameters, in order to achieve the integration of the gas-line status information, optimize the predictive parameters and improve the accuracy of prediction of mine gas.

In this paper, firstly, we will draw an assumption of a variety of mathematical models of gas sensor fault conditions, and thus generate training and testing samples. The use of fuzzy clustering algorithm, when looking for a sample from a sample of the central data centre, differential evolution algorithms ensure that the selected accuracy and experiments proved the feasibility of the method described above.

2 GAS CONCENTRATION REQUIREMENTS AND STANDARDS UNDER A MINE

Mine production is the multi-process, multi-link integrated industry, it has complicated process, moving place of work, harsh environment characteristics, so many risk factors exist in the system, it is not conducive to safe production.

According to 2014 China coal mine safety operating procedures, Mine Gas Emission rating should be based on a relative of mine gas, mine gas emission in absolute amount and form of gas emission into [8]:

1) Low gas mine: Mine Gas Emission relatively less than or equal to $10m^3$ / t and mine gas emission in the absolute amount is less than or equal to $40m^3$ / min.

2) High Gas Mine: Mine Gas Emission five relatively greater than $10m^3$ / t or greater than mine gas emission in absolute $40m^3$ / min.

3) Coal (rock) and gas (carbon dioxide) outburst.

When gas or carbon dioxide concentration exceeds 0.75%

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in mine total return airway or a wing in the return airway, the reasons must be identified and processed immediately. When gas concentration exceeds 1.0% and the carbon dioxide concentration exceeds 1.5% in mining area return airway or mining face in the return airway, the working must be stopped, the withdrawal of personnel, take measures for processing. If mine safety monitoring system equipped with mechanized, coal face, water, mining and coal seam thickness is less than 0.8m, then in coal face of the protective layer, when gas drainage (drainage rate of more than 25%) and increased air volume has reached the maximum allowable wind speed, its return airway gas concentrations in air flow can not be reduced to 1.0% or less, in the return airway gas Merry maximum allowable concentration of 1.5 %. Dedicated lane shall discharge gas production operations and set up electrical equipment. When roadway maintenance working, the gas concentration must be less than 1.5%. Specifically as shown in Table 1.

TABLE 1 Gas concentration fault classification model

Measurement Points	Gas concentration	Carbon Dioxide Concentration (%)	Treatment Measures
The total return airway	0.75	0.75	Immediately identify the reasons
A wing of the return airway	0.75	0.75	Immediately identify the reasons
Return airway	1.0	1.5	Stop working, the withdrawal of staff
Roadway maintenance	1.5	1.5	Stop Repair

3 Sensor fault diagnosis based on fuzzy clustering

3.1 FUZZY CLUSTERING ALGORITHM

1) Data standardization.

Assume domain $U=\{x_1,x_2,\cdots,x_n\}$ is classified object, each object has m indicators that expressed their traits, namely [10, 11]

$$x_i=\{x_{i1},x_{i2},\cdots,x_{im}\}\ \text{(i=1,2,…,n).} \tag{1}$$

Thus, to obtain the original data matrix

$$\begin{pmatrix} x_{11} & x_{12} & \dots & x_{1m} \\ x_{21} & x_{22} & \dots & x_{2m} \\ \vdots & \vdots & \dots & \vdots \\ x_{n1} & x_{n2} & \dots & x_{nm} \end{pmatrix}, \tag{2}$$

where, x_{nm} represents raw data of *m* indicators and *n* categories objects.

There are various dimensions in the coal mine sensors, such as: temperature, CO, gas, dust concentration. If you intend to get the raw data fault classification information from these sensors, it is required for the sensor to detect the value of different dimensions for data conversion, that is, the normalization process. There are several different methods of data changes algorithms, fuzzy matrices according to the requirements of this article, the change data to [0,1].

2) Fuzzy c-partition space for:

$$M=\left\{u\in R^{c\times N}\,\middle|\,u_{ik}\in[0,1],\forall i,k;\sum_{i=1}^{c}u_{ik}=1,\forall k\right\}. \tag{3}$$

That there is a class *c*, *N* data samples, for any data sample of its 1, for a certain class of membership values is 1, for one class, all classes values of membership are less than *N*.

3) Establish a fuzzy similar matrix.

Determine the similarity coefficient and fuzzy similar matrix, according to the traditional clustering methods [12, 13], the degree of similarity between x_i and x_j is $r_{ij}=R(x_i,x_j)$ that is calculated by Euclidean distance method:

$$d(x_i,x_j)=\sqrt{\sum_{k=1}^{m}(x_{ik}-x_{jk})^2}. \tag{4}$$

Elements of Fuzzy Partition Matrix

$$u_{ik}=\frac{1}{\sum_{j=1}^{c}\left(\frac{d_{ik}}{d_{jk}}\right)^{\frac{2}{m-1}}}, \tag{5}$$

4) Cluster centers are:

$$v_i=\frac{\sum_{k=1}^{N}(u_{ik})^m x_k}{\sum_{k=1}^{N}(u_{ik})^m}. \tag{6}$$

The specific implementation is shown in Figure 1:

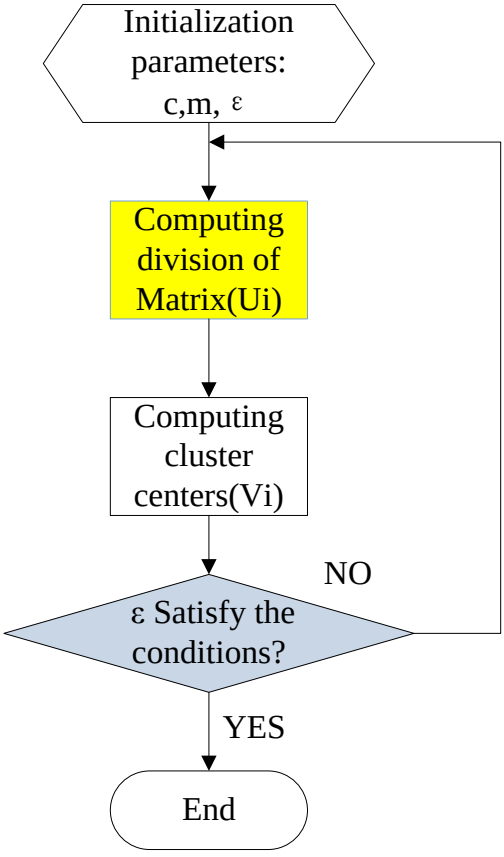

FIGURE 1 Fuzzy clustering algorithm flowchart

3.2 GAS FAILURE PREDICTION MODELING

According gas failure prediction model established in Table 1, using the rand () function, it generated the gas concentration detected values near four states, namely, 0.1 ± 0.1%, 0.75 ± 0.2%, 1.0 ± 0.2%, 1.5 ± 0.2%. There are 20 four models the data samples. The data distribution shown in Figure 2. The four models corresponding to the respective forecast classified as: normal concentration, timely processing status, stops working, waiting for repair, stop maintenance, rapid evacuation, emergency warning. Numerical simulation using Matalb7.6, as shown in Figure 1 algorithm flow, m=2, c=4, the membership value accuracy 1e-6, the final classification results shown in Figure 3. As can be seen classification points A, B, C, D more accurately represents the gas concentration predicted value.

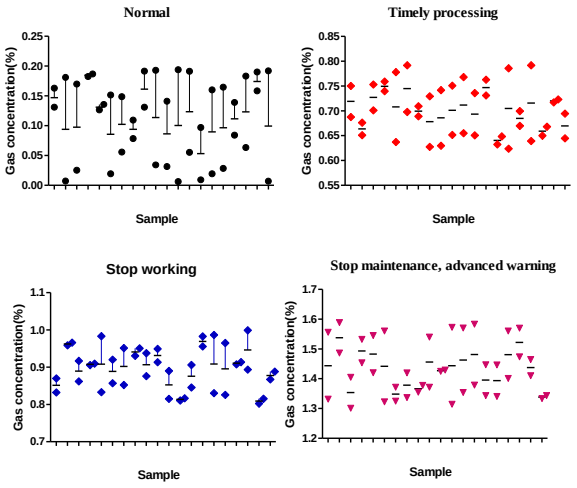

FIGURE 2 Gas concentration data sample

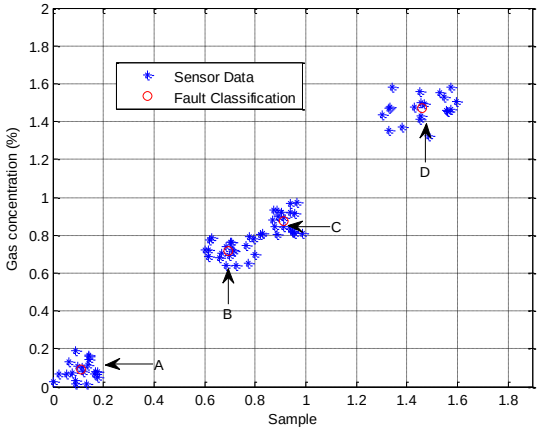

FIGURE 3 Fuzzy Clustering failure prediction

4 Conclusions

Fuzzy clustering method is based on the type of signal samples to establish the difference between the ambiguities. It can more objectively reflect the changing nature of the gas concentration. In this paper Based on in-depth analysis of the interaction mechanism of insecurity on the mine, numerical simulation of gas concentration prediction model is achieved, determining the weighting coefficients of the model parameters established. Forecasting and early warning model improves the clustering of credibility and real-time.

Acknowledgments

This research is supported by "Reserve Talents of University Overseas Research Program of Heilongjiang" and "key project of Jiamusi University Research" (No: Lz2011-018).

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