Hindawi
Mathematical Problems in Engineering
Volume 2023, Article ID 2393411, 13 pages
https://doi.org/10.1155/2023/2393411

Research Article

Development and Application of Visualization System of Gas Geological Dynamic Characteristics under Big Data Framework

Xiao Liu [1,2] **Sen Xu,** [1] **Haixiao Lin** [1] **Xiaoming Ni,** [1] **and Dequan Xuan** [3]

[1] *Henan Polytechnic University, Jiaozuo 454003, China*
[2] *Collaborative Innovation Center of Coal Work Safety and Clean High Efficiency Utilization, Jiaozuo 454003, China*
[3] *School of Safety Science and Emergency Management, Wuhan University of Technology, Wuhan 430070, China*

Correspondence should be addressed to Xiao Liu; liuxiao@hpu.edu.cn

Received 31 July 2022; Accepted 13 September 2022; Published 20 April 2023

Academic Editor: Conghu Liu

In this study, coal and gas outbursts are the "biggest killer" of mine safety production. With the deepening of mining, the mine gas disaster is becoming more and more serious. From the perspective of big data, the establishment of a dynamic visualization system of gas geology integrating gas geology, gas drainage, dynamic outburst prevention, and other information can effectively improving the defects of gas disaster prevention and control in the coal industry, such as insufficient advance, lack of systematic identification methods and backward information collection methods, which is of great significance to improve the ability of gas hazard identification. Based on the precise detection of geology, structure, and gas, this paper proposes to use information technology, the Internet of things, big data analysis, and other technologies to comprehensively analyze the changes in gas occurrence and coal seam occurrence on the basis of the causes of mine gas geological outburst, fully consider the logical relationship between different factors and outburst and adopt the disciplinary advantages of grey theory, fault tree theory, BP neural network, and so on. The tree of coal and gas outburst accidents with general significance is constructed by 24 relatively independent factors. The input vector is determined as the matrix composed of eight main factors affecting and controlling outburst, including gas pressure, coal mechanical strength, comprehensive characteristic coefficient of coal fragmentation, the permeability coefficient of coal, comprehensive characteristic coefficient of coal seam bifurcation and combination, comprehensive characteristic coefficient of coal thickness and coal thickness change, fault complexity coefficients and interlayer sliding comprehensive characteristic coefficient. The geological data affecting coal and gas outbursts are analyzed and calculated scientifically so that the gas geological data can be updated in time, and the change of gas geological laws is presented dynamically, so as to guide the mine to predict the gas disaster more scientifically and reliably.

1. Introduction

Coal and gas outburst (hereinafter referred to as "outburst") is one of the most serious disasters in the coal mine, which is extremely destructive. The shock wave formed when the outburst occurs can destroy the roadway and ventilation facilities; the coal and rock thrown out will bury the mining equipment and operators; and the large amount of gas emitted will cause personnel suffocation or gas explosion accidents. Therefore, the outburst disaster is the key prevention and control object for coal mine safety in our country. Long-term outburst prevention practice shows that outburst is controlled by gas geological conditions. [1–6] In the 21st century, a new round of technological and energy reform is being gestated. The development momentum of industrial informatization, automation, and intelligence is strong, and the technology is becoming more and more mature, which provides new development opportunities and challenges for the transformation of typical and major disaster management in coal mines from traditional qualitative and empirical prevention to modern quantitative and precise prevention and control; and it is also an effective way to curb major accidents in coal mines [7–12].

The outburst risk of mine working face is generally dynamic, which requires that the safety technology and measures should be adjusted in real time [13–15]. The existing outburst disaster prevention and control technology and management methods are mostly static and manual analysis and management in the analysis of coal and rock outburst risks and the construction management of prevention and control technology measures. The automatic monitoring and information detection level of hazard information is not high, and it cannot adapt to the dynamic change of outburst risk of working face. The precision, comprehensiveness, and reliability of mine gas geological analysis, gas extraction analysis, gas emission analysis, and daily outburst prevention and control are not enough, which cannot realize the comprehensive and precise control of gas disaster diversification and automation, and restrict the effectiveness and scientific nature of coal and gas outburst disaster prevention and control technology [16–18]. From the perspective of big data, the establishment of a gas geological dynamic feature system integrating gas geology, gas drainage, dynamic outburst prevention and other information is of great significance to improve the identification ability of hidden dangers of gas disasters and can effectively improve the shortcomings of insufficient advance of gas disaster prevention and control in the coal industry, the lack of systematic identification methods, and backward information collection methods. Many mines have used digitalization and informatization to guide gas prevention and control work, Yangquan mining area has established a two-level coal and gas outburst dynamic prediction method, and the combination of gas geological analysis method and GIS spatial analysis technology to establish a gas geological dynamic analysis system has also been developed. Xinjing Company has made a great breakthrough in gas intelligent technology by using GIS digitalization technology. Thus, a relatively perfect gas geological intelligent dynamic outburst prevention management system is constructed and formed [19–22].

2. Design Ideas of Gas Geological Dynamic Characteristics Visualization System Based on Big Data Framework

The visualization of gas geological dynamic characteristics based on big data framework is based on solving the precise prevention and control of gas disasters, mainly based on the precise detection of geology, structure and gas, using information technology, Internet of things, big data analysis, and other technologies, based on the causes of mine gas geological outburst disasters, giving full play to the role of rich gas geological data in mines, and adopting the disciplinary advantages of grey theory, fault tree theory, BP neural network, and so on, to carry out scientific analysis and calculation on the geological data affecting coal and gas outburst, so that the gas geological data can be updated in time, and dynamically show the changes of gas geological laws, so as to guide the mine to predict gas disasters more scientifically and reliably [23–26].

2.1. Design Purpose

(1) The organic combination of gas geological theory and information technology can be realized in the form of visualization, which provides an advanced research direction for the prediction and prevention of coal mine gas disasters.

(2) Compared with the traditional paper gas geological map, it is convenient to compile, short in cycle, high in accuracy and belongs to the dynamic map, which can update, output and reflect the gas geological information in the dynamic mining process in real time, and is not easy to damage or easy to save.

(3) Try to form a new technology of digital compilation of mine gas geological map, and enrich and improve the research methods of gas geology.

(4) The establishment of visual management of mine gas geology with database support not only makes the entry, query, and update of gas geological information convenient and fast, but also provides data sources for the compilation and update of gas geological maps, making the drawing of gas geological map more standardized and scientific.

(5) Establish a visualization system of gas geological dynamic characteristics based on big data framework so that gas geological data can be better expressed in the form of visualization, so that field managers can clearly and vividly understand the current mining dynamics and the development and changes of gas parameters, and provide a basis for guiding safe production in time.

2.2. Data Development Structure. The gas geological information applied to the prediction and prevention of coal mine gas outburst mainly has two parts: The first is the data obtained directly through on-site collection, sorting, and testing, such as the layout and characteristics of mining engineering in the mine field or stope (coal seam), the characteristics of coal structure, the distribution of folds and fractures, gas emission and basic parameters, the description of outburst accidents that have occurred, and the data obtained from on-site and indoor tests; the second is the processing information obtained from the comprehensive analysis, processing, and calculation based on the obtained data, for example, through the comprehensive analysis of the coal seam gas occurrence and emission characteristics in the mined area and through the numerical analysis to predict the gas emission status in the nonmined area [27–29].

To realize the gas geological information management of outburst prevention, including the basic links of data acquisition, processing, transmission, storage, and information extraction. Due to the huge number, it is necessary to use computers for auxiliary analysis to improve the speed and quality of information acquisition. In general, it mainly includes the following aspects.

(1) Acquisition and management of original information: a large number of different types of gas geological data, data and maps are constantly exposed in the exploration stage and production process of the coal mine. In order to effectively apply it to safety management, it is necessary to collect and master these information in detail; at the same time, the classified management of information needs to be implemented after the examination and verification of the data and the elimination of the false and the preservation of the true. The purpose of this work is to lay a foundation for later information query, modification, editing and output.

(2) Analysis and refinement of information: the ultimate purpose of acquiring and managing information is to achieve safety management in the production process. Therefore, it is necessary to analyze and calculate based on the mastered original information to obtain deeper secondary information (knowledge). For the safety management of coal and gas outburst, that is to effectively realize the prediction and prediction of accident hidden dangers, and based on this, formulate safe and reliable prevention and control measures in time.

(3) Establishment of database and database management system: because the types of information affecting and controlling gas outburst are complex and diverse, and each type of information contains many factors, in order to facilitate the storage, editing, display and output of information, the above information is usually classified (this paper adopts the layer management method), and the corresponding database (model base) and database (model base) management system are established.

The development structure of this "visualization of dynamic characteristics of gas geology under the condition of big data framework" is shown in Figures 1 and 2. The development is mainly divided into two parts according to the data flow. One is to use MapObjects control to display the electronic map data and query the map data; the second is to use ADO components to access the metadata of electronic map data, which describes the classification information of the map data in detail. Through the query of metadata, the query types can be further subdivided.

3. Analysis and Establishment of Gas Geological Database

3.1. Attributes of Gas Geological Database. In a vector data structure, spatial entities and objects are expressed by basic collection elements such as point, line (line segment, arc segment, line), and surface (polygons). The position of each entity is defined in terms of its relative or absolute coordinates in a spatial coordinate system. As the data expressed by vector data is continuous, it can accurately mark the position, length, and area of spatial entities.

In two-dimensional geographic space, object entities are formed by (X, Y) coordinate pairs in appropriate coordinate systems. In vector data structure, the most basic set elements include point, line, and surface, as shown in Figure 3.

Gas geological phenomena mainly include three aspects: geological phenomena, gas, and geological prospecting engineering related to gas prediction and prevention. The following is to analyze the geological phenomenon of Vass from these three aspects, so as to make clear the composition and main sources of gas geological data, as shown in Figure 4.

Geological phenomena: geological phenomena are extremely complex. The main geological phenomena involved in GIS are strata, faults, ore bodies, and deposits. The stratum is usually an irregular surface, which cannot be expressed by mathematical expressions. In 3D GIS, a method similar to a digital elevation model (DTM) can also be used to represent the stratum interface. The fault is close to the stratum but usually has a certain width. On the other hand, it is often perpendicular or oblique to the topographic surface. In GIS, if the DTM method is adopted, its projection plane and projection angle need to be considered. In the coal seam, the fracture is mainly represented by normal and reverse faults. An ore body is a three-dimensional entity, but it is often extremely irregular, so it is impossible to determine how many faces it is composed of. An approximate expression method is to imitate the DTM method, express its top digital surface model and bottom digital surface model, and then consider its projection plane and projection boundary. In the coal seam, the soft coal stratification and gangue inclusion are similar to the ore body in geometric shape, which can be treated by similar methods. The deposit may include several ore bodies, faults, exploration engineering and other geological phenomena, so the deposit is a composite phenomenon of various geological phenomena, which can be expressed in the form of complex ground features. Here, mineral deposits refer to coal seams.

Gas: for gas, the distribution of gas and its change under the influence of mining are mainly considered. Because the gas is in a continuous distribution state in the coal seam, and the gas distribution changes very little in the vertical direction in the same coal seam, the gas distribution can be displayed by the surface map, and the surface map can be processed by DTM.

Geological exploration engineering: it mainly includes the exploration boreholes in the exploration stage and the borehole data of gas emission and gas content at the working face.

3.2. Structural Design of Gas Geological Attribute Database. The basic parameters of coal mine gas can be divided into drilling data, gas content and related data, gas emission data

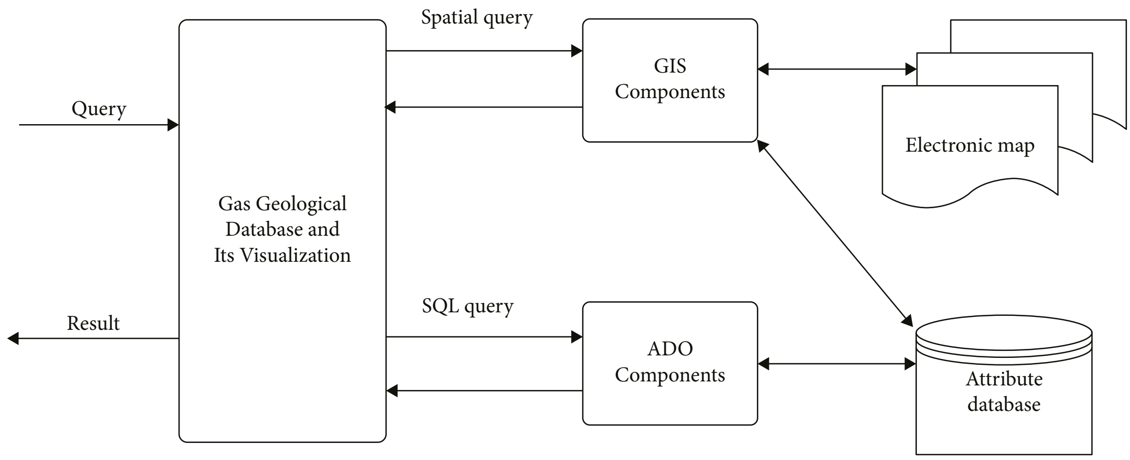


Figure 1: Gas geology database and visualization developing structure.

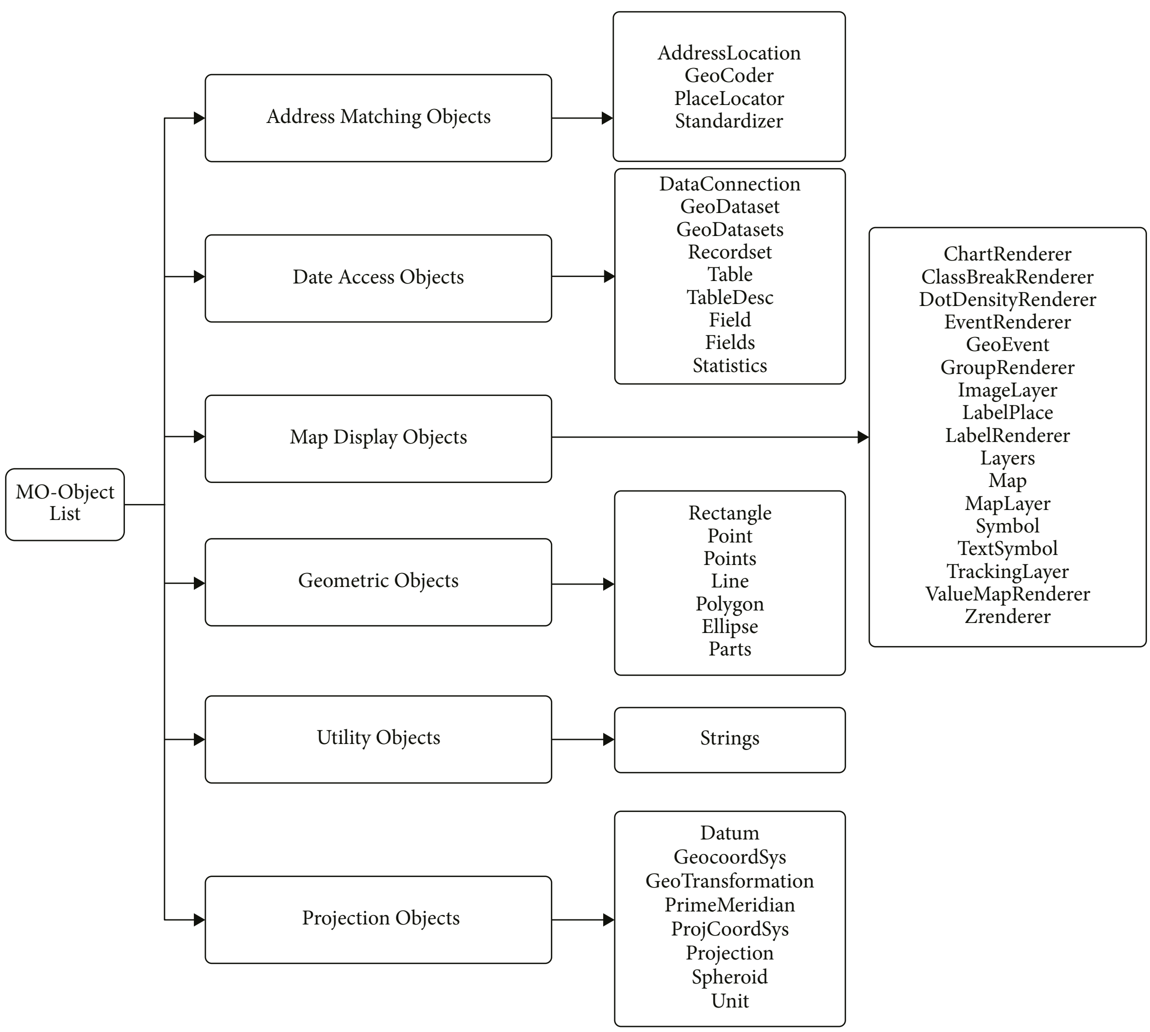
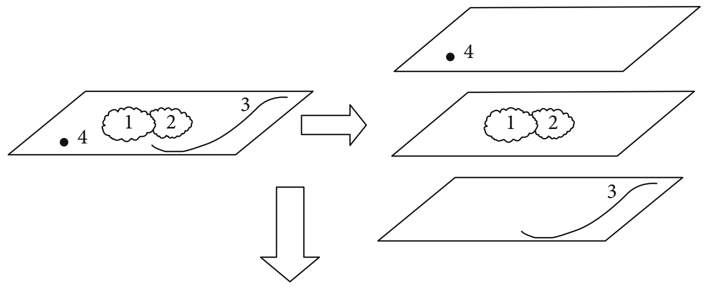


Figure 2: MapObjects structure chart.

of mining face, gas emission data of heading face, and outburst data. 37 table structure designs of gas parameters related databases have been established and some of them are shown in Tables 1 to 5.

3.3. Gas Geological Database Establishment Process. Basic databases are the core of information systems, and poor data organization, data structure, and data quality directly affects the quality of visualization of gas geological



ID	Gas content point	...	Coordinate
4	101 borehole		x, y

Point data structure

ID	Contour line name	...	Coordinate
3	Gas pressure		$x_1, y_1; x_2, y_2; \ldots x_m, y_m$

Linear data structure

ID	Surrounding rock type	...	Coordinate
1	Sandy mudstone		$x_1, y_1; x_2, y_2; \ldots x_m, y_m$
2	Siltstone		$x_1, y_1; x_2, y_2; \ldots x_m, y_m$

Surface data structure

Figure 3: Vector data storage scheme.

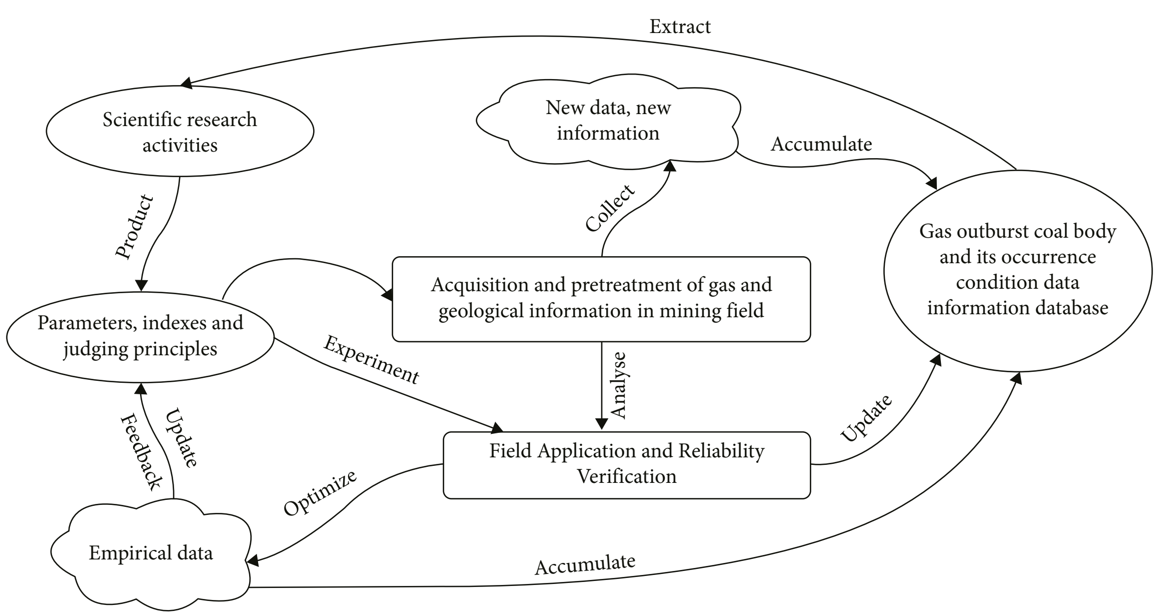


Figure 4: Data composition and sources.

dynamic characteristics. Therefore, we must strictly grasp every technical link in the process of database construction. Specifically, the database building operation is to adopt various inspection methods and necessary means to ensure that all data can enter the database system correctly. The workflows of the established gas geological dynamic data framework are shown in Figures 5 and 6.

Table 1: Surface drilling datasheet structure.

Field number	Field name	Field type	Field length	Decimal places	Field name meaning
1	ID	Long	4	0	Serial number
2	CQ	Char	16	—	Mining area
3	ZK_num	Long	8	0	Drilling number
4	ZK_X	Long	12	2	Hole X coordinates
5	ZK_Y	Long	12	2	Hole Y coordinate
6	ZK_depth	Single	8	2	Hole termination depth
7	ZK_level	Single	8	2	Elevation of bore hole
8	ZK_coal	Logical	2	—	Whether see coal
9	MC_ply	Single	4	2	Coal seam thickness
10	ZK_obliquity	Single	2	2	Drilling angle

Table 2: The volume of gas discharge on coal face datasheet structure.

Field number	Field name	Field type	Field length	Decimal places	Field name meaning
1	ID	Long	4	0	Serial number
2	CQ	Char	16	—	Mining area
3	GZM_name	Char	16	—	Working face name
4	KC_depth	Single	8	2	Mining depth
5	JL_date	Data	8	—	Record time
6	MC_thick	Single	6	2	Average coal seam thickness
7	KC_thick	Single	6	2	Height mining
8	HC_ways	Char	16	—	Extraction method
9	TF_volume	Single	8	2	Air volume
10	WS_con	Single	8	2	Gas concentration
11	RCL	Single	8	2	Average daily production
12	WS_X	Single	8	2	Gas emission point X coordinate
13	WS_Y	Single	8	2	Gas emission point Y coordinate

Table 3: Gas pressure datasheet structure.

Field number	Field name	Field type	Field length	Decimal places	Field name meaning
1	ID	Long	4	0	Serial number
2	CQ	Char	16	—	Mining area
3	CS_site	Char	16	—	Test site
4	CS_data	Date	8	—	Test time
5	JM_ level	Single	8	2	See coal elevation
6	WS_press	Single	8	2	Gas pressure
7	CS_X	Single	8	2	Test point X coordinate
8	CS_Y	Single	8	2	Test point Y coordinate
9	BZ	Char	64	—	Remark

Table 4: Gas content datasheet structure.

Field number	Field name	Field type	Field length	Decimal places	Field name meaning
1	ID	Long	4	0	Serial number
2	CS_site	Char	16	—	Test site
3	CQ	Char	16	—	Mining area
4	CS_depth	Single	8	2	Test depth
5	M_density	Single	8	2	The density of coal sample
6	MC_temper	Single	8	2	Temperature of coal seam
7	WS_content	Single	8	2	Gas content
8	Porosity	Single	8	4	Porosity
9	XF_a	Single	8	4	Adsorption constant a
10	XF_b	Single	8	4	Adsorption constant b
11	M_wet	Single	8	2	Moisture
12	M_Mash	Single	8	2	Ash
13	Volatilization	Single	8	2	Volatile
14	M_vol weight	Single	8	2	Bulk density of coal
15	CS_X	Single	8	2	Test point X coordinate
16	CS_Y	Single	8	2	Test point Y coordinate

Table 5: The dot of gas outburst datasheet structure.

Field number	Field name	Field type	Field length	Decimal places	Field name meaning
1	ID	Long	4	0	Serial number
2	CQ	Char	16	—	Mining area
3	TC_site	Char	16	—	Coal and gas outburst location
4	TC_depth	Single	8	2	Coal and gas outburst depth
5	TC_data	Date	8	0	Coal and gas outburst time
6	TC_coal vol	Single	8	2	Coal and gas outburst coal quantity
7	TC_gas vol	Single	8	2	Coal and gas outburst gas amount
8	TC_type	Char	8	—	Types of coal and gas outburst
9	TC_*X*	Single	8	2	Outburst point *X* coordinates
10	TC_*Y*	Single	8	2	Outburst point *Y* coordinates

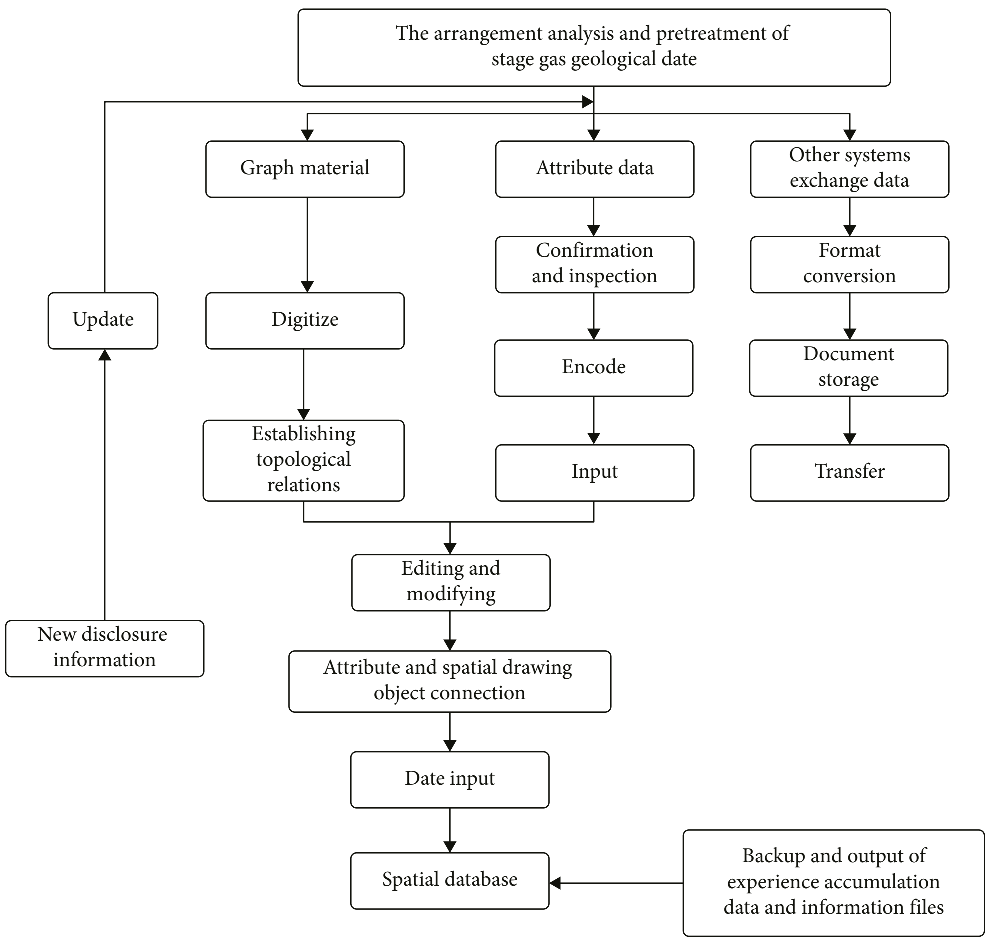


Figure 5: Working flow of building gas geology database.

4. Gas Geological Database Modeling

The diversified and accurate prevention and control technology of gas disasters is mainly based on the accurate detection of geology, structure, and gas; based on the current information technology, Internet of things, big data analysis, and other technologies, guided by the scientific concept of accurate coal mining, based on the causes and occurrence rules of mine gas outburst disasters, and supported by multisource information acquisition and sensing equipment, computers, and multinetwork fusion transmission equipment, Taking the diversified and accurate prevention and control models and software of gas disasters as tools, the accurate analysis and zoning of gas geology are carried out from the perspective of accurate control of mine gas geology; the intelligent evaluation of gas drainage reaching the standard and the optimal design of drainage boreholes are carried out from the perspective of accurate and reliable gas drainage, and the continuous monitoring and early warning of outburst anomalies are carried out from the perspective of intelligent early warning of gas emission. From the perspective of daily outburst prevention management norms, they carry out the standardized management and integrated analysis of the "four in one" comprehensive outburst

Attribute Table of Gas Outburst Occurrence Point

	Features	Gas outbu	Vertical de	Elevation	Roadway	Location	Thickness	Geological
1	Pulverized	150	583	−560	Coal road	II816CM	8	
2	Pulverized	200	583	−560	Coal road	II816CM	8	Small fold
3		0	615	615	Rock lane	II816CM	8~12	Thicken
4	Pulverized	1230000	613	−590	Stone gate	II818CM	8~13	Thicken
5		2200	613	−590	Rock lane	II818	8~13	Thicken
6	f=0.2~0.4	0	552	−529	Stone gate	II814CM	8~13	Thicken
7	f=0.4	5000	552	−529	Semi coal	II814CM	2. 0	Coal seam
8	f=0.3	0	552	−529	Stone gate	II814CM	8~15	Thicken
9		521	378	−355	Stone gate	3#MY	7. 2	Not mined
10	Gas pressu	1600	321	−298	Stone gate	4#MY	10. 0	8. 9 thicke
11	Gas pressu	513	321	−298	Stone gate	4#MY	9. 1	Small flod
12	Gas pressu	300	425	−400	Drift	Pit bottom	9	
13		1890	460	−437	Stone gate	II821CM	8	
14		6528	396	−373	Stone gate	1#MY	10. 5	8. 9 thicke
15	f=0.2	2000	483	−460	Coal road	II823CM	10~13	Coal seam
16	f=0.3	13000	454	−431	Coal road	II822CM	10	Coal seam
17	f=0.3	100	435	−412	Coal road	II822CM	12	Top plate
18	f=0.3	2000	454	−431	Coal road	II822CM	11	Flod
19		0	379	−356	Stone gate	4#MY	12. 7	Fault
20		1930	413	−390	Stone gate	2#MY	8	Fault
21		234	365	−342	Stone gate	4-84MY	12. 2	Flod
22		600	347	−324	Drift	8#ZC	8. 5	
23	Gas pressu	938	347	−324	Stone gate	6#MY	8. 5	
24		1584	386	−363			8. 5	

Figure 6: Attributes list scanning.

prevention measures information, realize the dynamic acquisition and comprehensive analysis of data in various links of the mine, such as "gas geology ⟶ gas drainage ⟶ gas monitoring ⟶ daily outburst prevention", and carry out the accurate prevention and control of diversified gas disasters.

The gas geological database is the basis of developing the gas geological law. In the face of much gas geological data, scientific and effective analysis is the key to developing gas geological law research. In order to meet the needs of gas geological data with different attributes to carry out gas geological law research, different gas geological data models need to be used. In this paper, the fault tree model, the BP neural network, and grey theory are used to study the geological characteristics of gas. First, digital fusion is carried out, and the multiple information of mine gas parameters, coal seam parameters, geological exploration, geological structure, working face, and roadway are classified, fitted, and analyzed by the fault tree method to determine the main controlling factors of gas storage. Then, the BP neural gas network is used to establish a multiple regression analysis model of gas parameters and various factors. On the basis of the above research, the grey theory is used for quantitative fitting, and the contour of gas parameters is automatically drawn, and finally the geological law integrating gas, structure, coal seam, geology, and other factors is generated. [30, 31].

4.1. Accident Tree Modeling. Coal and gas outbursts are the result of the comprehensive action of gas, coal structure, in-situ stress, and other factors. Geological structures control the distribution of outburst risk by controlling gas occurrence, coal seam occurrence, and structural stress. More than 80% of the accidents occurred near faults and other geological structures. [32] Therefore, gas geological analysis and control takes geological structure as the monitoring focus, analyzes gas occurrence and coal seam occurrence changes in parallel, [33, 34] fully considers the logical relationship between different factors and outburst, simplifies and merges some repeated basic events, and finally, determines the general model of coal and gas outburst fault tree with general significance constructed by 24 relatively independent factors (Figure 7).

4.2. BP Neural Network Modeling. The key to the establishment of the BP network model is to determine the number of nodes in the input layer, output layer, and hidden layer of the network, that is, to determine the input vector, output vector, and intermediate vector. Considering the organic combination with the general fault tree model of coal and gas outburst, this paper takes all 24 basic events ($X1 \sim X24$) of the fault tree model as the input vector of the BP network model. In the BP network model of gas outburst area prediction, the input vector is determined to be the matrix composed of 8 main factors affecting and controlling the outburst of the mine, which are: $C1$-gas pressure P, $C2$-coal mechanical strength, $C3$-coal body crushing comprehensive characteristic coefficient, $C4$-coal permeability coefficient, $C5$-coal seam bifurcation and combination comprehensive characteristic coefficient, $C6$-coal thickness and coal thickness change comprehensive characteristic coefficient, $C7$-fault complexity coefficient $C8$-comprehensive characteristic coefficient of interlayer sliding.

The output vector is the risk characteristics of a gas outburst. According to the outburst intensity, it is divided into four types: no outburst (type I); outburst threat (with dynamic phenomenon or abnormal gas emission, type II); general outburst (coal $0 \sim 100t$, accompanied by a large amount of gas, type III); and serious outburst (coal more than $100t$, accompanied by a large amount of gas, type IV). The output matrix is $O1$ (1, 0, 0, 0), $O2$ (0, 1, 0, 0), $O3$ (0, 0, 1, 0), and $O4$ (0, 0, 0, 1).

In general, the general relationship between the value of the hidden layer (middle layer) and the number of input vectors (m) and the number of output vectors (n) is $(2m + n)$.

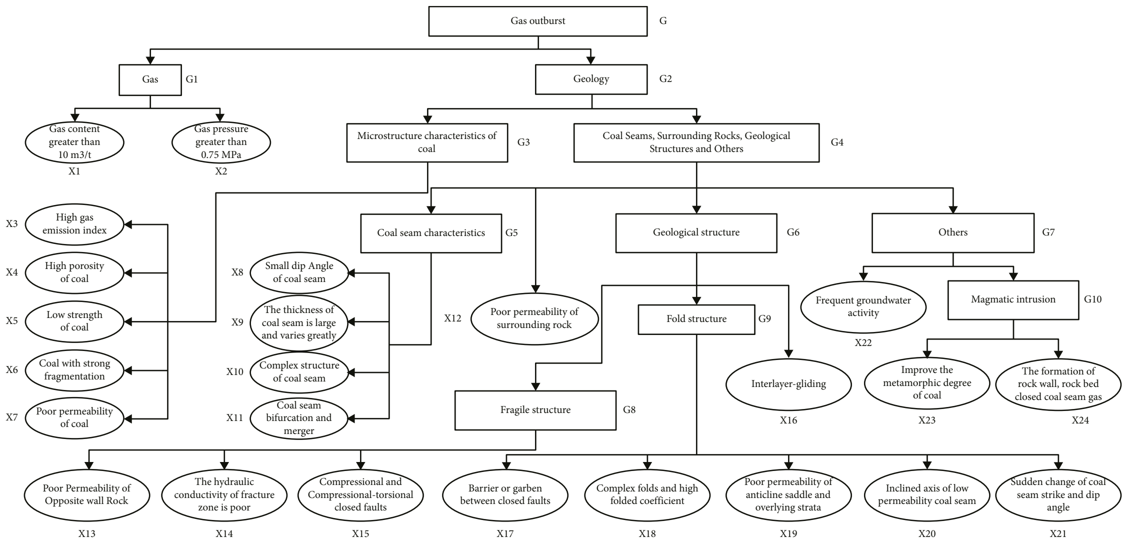


Figure 7: Accident tree model diagram.

According to this principle and experience, the initial value of the number of hidden layer (middle layer) vector elements here is 20.

4.3. Grey Theory Modeling. The sequence composed of gas emissions (2.72, 3.03, 4.86, and 6.98) is relatively small compared with the observed values of the whole period, but it has a great disturbance to the whole sequence. It can be said that these values are not the real behavior sequence of the grey system, and modeling and prediction with these distorted values of the whole grey system is bound to reduce the prediction accuracy. Therefore, we should weaken the sequential growth trend. The second-order weakening operator is introduced to obtain: $XD2 = (5.57, 5.96, 6.45, \text{and } 6.98)$. Replace $XD2$ at the corresponding position of the original sequence to get a new sequence:

$X = (5.57, 5.96, 6.45, 6.98, 6.87, 7.46, 7.32, 7.69, 7.66, 7.92, 8.18, 8.11, \text{and } 8.63)$; GM (1, 1) model is established by using the 1st ~ 8th data in the sequence X to predict the gas emission of II914 working face. The modeling process is as follows:

$$\begin{aligned} X^{(0)} &= (5.57, 5.96, 6.45, 6.98, 6.87, 7.46, 7.32), \\ X^{(1)} &= 1 - AGOX^{(0)} \\ &= (5.57, 11.53, 17.98, 24.96, 31.83, 39.29, 46.61). \end{aligned} \tag{1}$$

Least square estimation of parameter columns $\hat{a} = (a, b)^T$,

$$\begin{aligned} \hat{a} &= (a, b)^T \\ &= \left(B^T B\right)^{-1} B^T Y_N \\ &= \begin{bmatrix} -0.03748 \\ 5.87891 \end{bmatrix}. \end{aligned} \tag{2}$$

Determine the model: $\mathrm{d}x^{(1)}/\mathrm{d}t - 0.03748\mathrm{X}^{(1)} = 5.87891$

Determine the time response sequence: $\hat{x}(k+1) = 162.3934e^{0.03748k} - 156.8234$

Comparison between sequence $\hat{x}^{(0)}(k)$ and sequence $\hat{x}^{(1)}(k)$ Table 6.

As can be seen from the calculated results in Table 6, the residuals of the resulting prediction models are −0.07, +0.26, −0.16, −0.07, and −0.39, and the relative error prediction values are 1.01%, 3.48%, 2.18%, 0.91%, and 5.01%, all of which meet the accuracy requirements.

5. Visualization of Gas Geological Dynamic Characteristics under Big Data Framework

The design of coal and gas outburst prediction information systems is the core content of the whole system. Its main work is to transform the system logical model proposed in the system analysis stage into a realizable physical model; that is, the problem of "what to do" proposed in the system analysis stage is further concretized and refined into the problem of "how to do". In this paper, the design of coal and gas outburst regional prediction information system adopts modular and open design ideas, follows the principles of systematization, practicality, versatility, and scalability, and strives to make the system a practical information system with advanced technology, reliable operation, and high efficiency. The whole system function development adopts a rapid prototyping method and submodule implementation. The visualization function module of gas geological dynamics under the condition of a big data framework is shown in Figure 8.

Thematic mapping is a method with powerful analysis functions and data visualization. By using thematic graphics to represent and display data and using certain thematic rendering means, the information status and change trend that can hardly be displayed in the data list can be displayed intuitively and clearly. Usually, thematic maps use color rendering, hatch patterns, symbols, rectangles, pie charts, and other ways to express data. Different thematic maps can

Table 6: The verifying conclusions using predicting model.

Time	k	Measure value $x^{(0)}(k)$	Predicted value $\hat{x}^{(0)}(k)$	Residual error $\varepsilon^{(0)}(k) = x^{(0)}(k) - \hat{x}^{(0)}(k)$	Relative error $\Delta k = \lvert\varepsilon^{(0)}(k)\rvert / x^{(0)}(k)$ (%)
2005.4	5	6.87	6.94	−0.07	1.01
2005.5	6	7.46	7.20	+0.26	3.48
2005.6	7	7.32	7.48	−0.16	2.18
2005.7	8	7.69	7.76	−0.07	0.91
2005.8	9	7.66	8.05	−0.39	5.01

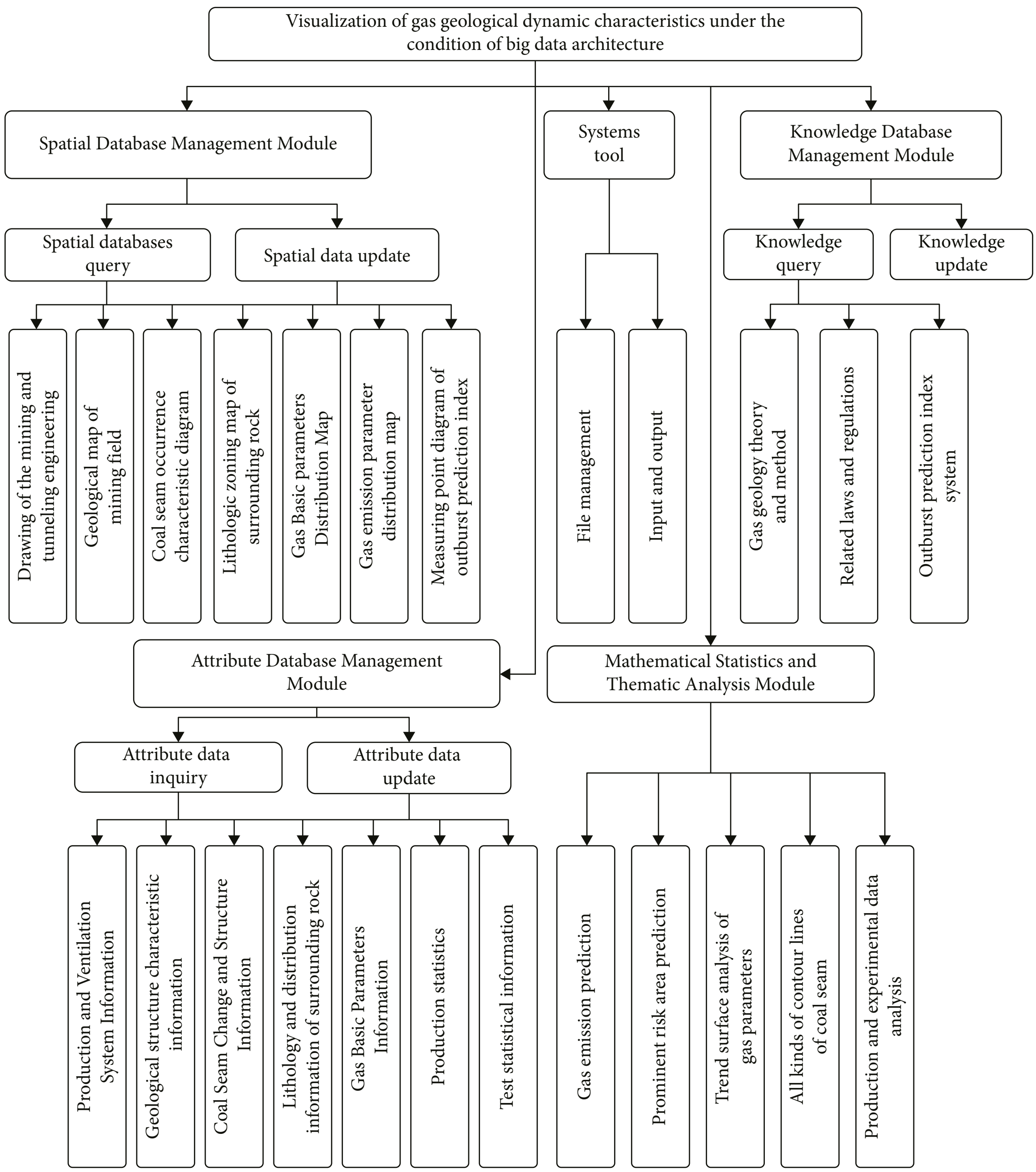


Figure 8: Vass geological dynamic visualization framework under big data framework.

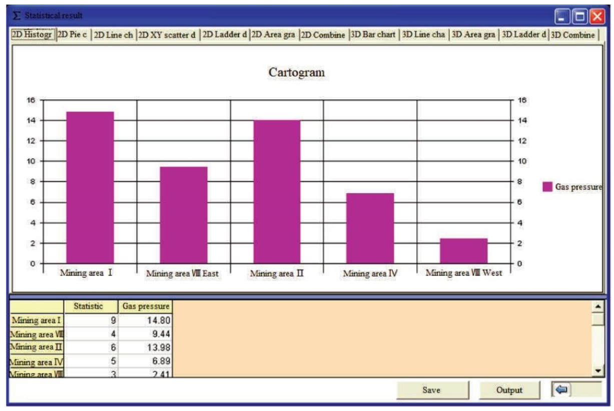


Figure 9: The block diagram of gas content in eighth coal of Luling mining.

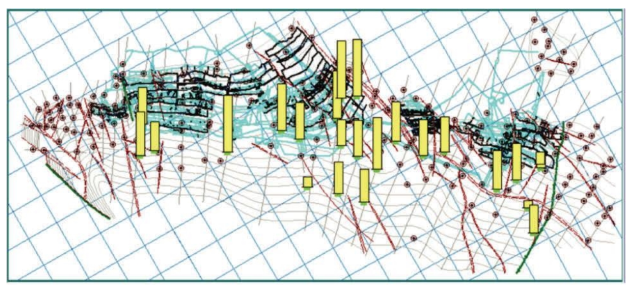


Figure 10: The point diagram of the gas press in the eighth coal of Luling mining.

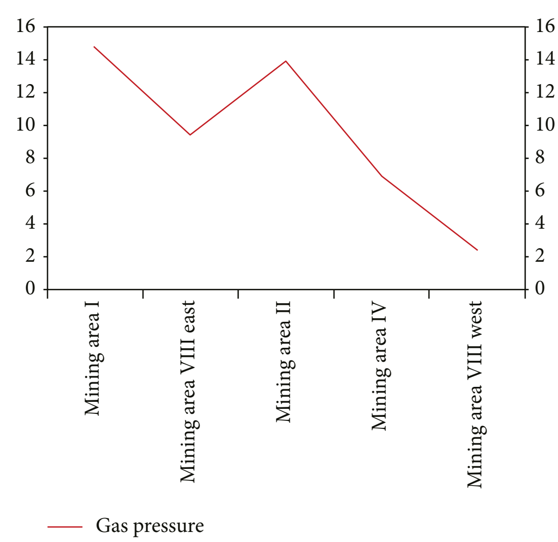


Figure 11: The gas press by mine section in the eighth coal of Luling mining.

be created by assigning these colors, patterns, or symbols according to specific values in the data. In the gas geological database and its visualization system, MapObjects can be used to analyze various thematic maps such as the following level symbol maps, range maps, independent value maps, pie charts, and histograms, as shown in Figures 9–12.

Only parts of the thematic maps are listed above. The thematic maps of gas emission and coal thickness points of 8

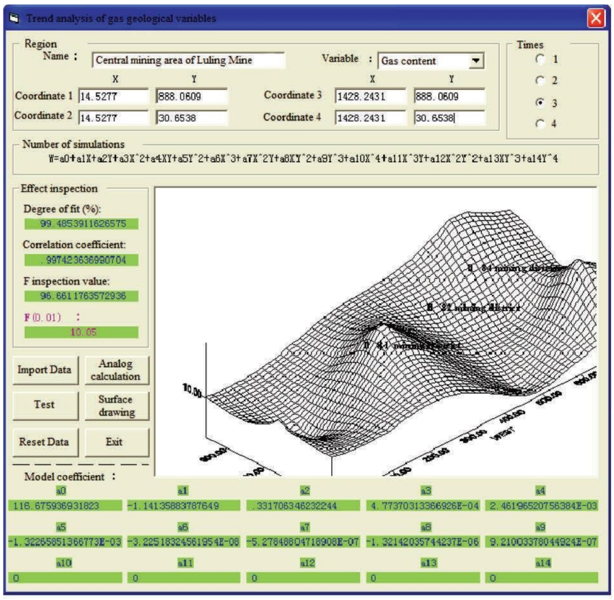


Figure 12: Trend analysis of gas geological variables.

coal seams in Luling Mine are similar to this, and they are not listed here one by one.

6. Conclusions

The irresistible development momentum of industrial informatization, automation, and intelligence has provided new development opportunities and challenges for the transformation of typical and major disaster management in coal mines from traditional qualitative and empirical prevention to modern quantitative and precise prevention. Based on the causes of coal mine gas outburst disasters, this paper adopts information technology, the Internet, big data analysis, and other technologies and gives full play to the role of abundant coal mine gas geological data, and combines relevant disciplines to scientifically analyze and calculate the geological data that affect coal and gas outburst, so that the gas geological data can be updated in time and the changes of gas geological laws can be dynamically displayed. The main conclusions are as follows:

(1) A gas geological attribute database is established based on borehole data, gas content and related data, gas emission data, and outburst data of mining faces on the basis of accurate gas detection.

(2) A coal and gas outburst fault tree constructed by 24 relatively independent factors is established through grey theory, fault tree theory, BP neural network, and other disciplines.

(3) Taking the matrix composed of 8 main factors affecting and controlling outburst in Luling coal mine as the input vector, then the geological data of coal and gas outburst are scientifically analyzed and calculated. As a result, the possibility of visualization and real-time gas geological data is verified.

Data Availability

All data generated or analyzed during this study are included in this published article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

This study was supported by the National Natural Science Foundation of China Youth Science Foundation Project (No.51804100) and National Natural Science Foundation of China Joint Fund Project (No.U1904126).

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