Research on Coal Mine Risk Control Technology and Platform Base on Big Data

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Abstract: In order to improve the risk management and control ability, this paper studies coal mine risk management technology and big data platforms. First, BP neural network was optimized through data mining, and correction parameter technology. Based on this, a coal mine risk data prediction model was constructed. Then, combined with the control chart analysis, the coal mine risk early prevention method was proposed. At last, a big data platform to manage coal mine risk was developed. The results of this paper provide implementation methods and tools for coal mine risk management and control, and have reference significance for other enterprises.

1. Introduction

Accident has always been a key factor restricting the development of enterprises. Many domestic and foreign experts and scholars are committed to research on risk assessment and prevention methods for various industries. Johnson studied the important factors and formation mechanism of risks[1,2]. Xie proposed the early prevention mechanism and application of overseas oil and gas exploration risks[3].

Coal mines are high-risk industries. The research on coal mine accident risk management and early prevention is important. In the 21st century, computer and Internet technologies have been fully applied in the management of coal mine enterprises[4,5].

The application of computer technology in coal mine enterprises is relatively mature, but the research of big data is still in starting stage. Therefore, this paper develops the coal mine risk management and control platform based on big data technology.

This paper used historical data and the BP neural network to predict the number of coal mine risks, and used control chart related theories for risk early prevention. Based on this, a coal mine risk management and control system was developed. The application of system can realize the data prediction, risk early prevention and other functions. It enhances the modern and information level of coal mine.

2. Coal mine risk management and control technology

Coal mine risk management and control technology consists of risk prediction, and early prevention. The risk prediction uses the time series neural network to predict the number of risk over time. The risk early prevention uses the control chart to determine whether to warn.
2.1. Risk prediction
The coal mines' risk data have sequential characteristics. BP neural network can predict not only linear data but also nonlinear data in time series prediction, which can effectively reduce prediction errors. Therefore, this article uses BP neural network model to predict coal mine risk data.

Suppose the output sequence of coal mine risk data is \( Y_0, Y_1, \ldots, Y_n \), and the sequence-neural network model can be expressed by Equation (1).

\[
Y_t = TSA(Y_{t-1})
\]

Where \( TSA(.) \) is the system timing characteristic.

According to Eq (1), the time series-neural network model can be constructed. Namely, \( Y_{t-1} \) is used as the input of the BP neural network, \( Y_t \) is the output, and \( n \) samples \( (Y_0, Y_1) \) formed by the time series \( (Y_0, Y_1, \ldots, Y_n) \), \( (Y_1, Y_2), \ldots, (Y_{n-1}, Y_n) \) are provided to the BP neural network for learning, and then \( TSA(.) \) can be gradually approached to grasp the characteristics of coal mine risk changes.

In order to improve the reliability of risk prediction, this article will use data mining related algorithms to analyze the periodic errors of risk data, and use this to correct risk prediction. The algorithm is shown in Equation (2) and (3).

\[
\mu = \frac{1}{m} \sum_{i=n-m}^{n-1} \frac{r_{n-i} - r_{n-i-1}}{r_{n-i}}
\]

In the Equation (2): \( m \) is the amount of reference data; \( n \) is the year of the data to be analyzed; \( r \) is the analyzed risk data; \( \mu \) is the mean value of the risk data; where \( 1 \leq m < n \).

\[
\lambda = \sqrt{\frac{1}{m} \sum_{i=n-m}^{n-1} \frac{(r_{n-i} - r_{n-i-1})^2}{r_{n-i}}}
\]

In the Equation (3): \( \lambda \) is the standard deviation of the data error.

The error and standard deviation of the risk data were calculated by Equation (3) and (4). By observing the discrete situation of the data, the time series-neural network model can be corrected. As shown in Equation (4).

\[
Y_t = \lambda \times TSA(Y_{t-1}) + \beta
\]

In the Equation (4): \( \lambda \) is a constant, \(-5 \leq \lambda \leq 5\), and the paper \( \lambda = -1 \).

After the BP neural network was trained according to the conventional method, this paper took the data of 5 consecutive moments as input to obtain the predicted value of the next moment. This paper took days as the unit. The number of coal mine risks one month before the prediction date was used as the test sample. And the number of coal mine risks two years before the test sample was used as the training sample. For example, to predict the number of coal mine risks in 2020.5.1, the number of coal mine risks in 2020.3.31-2020.4.30 was used as the test sample, and the number of coal mine risks in 2020.3.31-2020.3.30 was used as the training sample. The test sample (the number of coal mine risks from 2020.3.31-2020.4.30) was calculated from the Luxi coal mine enterprise, and the four levels of Major Risks, Serious Risks, General Risks and Low Risks were also calculated. The change trend was shown in the Figure 1.
Figure 1. Predicted results based on time series

It can be seen from Figure 1 that the prediction data is consistent with the actual data of the test sample, and the error is reduced. When the data increases, the predictive and fitting abilities of the BP neural network model improve.

2.2. Risk Early prevention Analysis

Control chart diagram is constructed based on the hypothesis testing. It is often used to detect whether a production process is in control[6]. If the fluctuations in safety production are caused by a major failure in safety management, etc., the production process should be tightly controlled. Using control charts to statistically analyze coal mine risk data, it is possible to effectively determine whether the safety situation is controllable.

The control chart, which contains the middle, upper, and lower control lines, is constructed on the basis of a normal distribution[7]. The normal distribution is determined by two parameters, the mean $\mu$ and the standard deviation $\sigma$. If the random variable $x$ obeys a normal distribution, the probability that $x$ exceeds $(\mu - 3\sigma, \mu + 3\sigma)$ is 0.27%, which is about 3%. Therefore, if the control limit is chosen to be $\mu + 3\sigma$, the probability of making an error judgment for a point, which exceeds the control limit is only 3%. Based on this, the normal distribution plot is rotated 90° anticlockwise, so that the independent variable’s direction of the increase is vertically upward, and $\mu$, $\mu + 3\sigma$, and $\mu - 3\sigma$ are labeled as the center line (CL), the upper control line (UCL), and the lower control line (LCL), respectively.

3. Coal mine risk management techniques

This paper combines coal mine hierarchical control mechanism, data prediction and early prevention model to build a new coal mine risk control method, as shown in Figure 2.
As shown in Figure 2, the most recent three years of data were obtained from the risk information database for analysis, and CL, UCL, and LCL were calculated by Equation (2) and (3), and the historical data is divided into training samples and test samples. The corrected BP neural network was trained after convergence. As shown in the results, if the error is reasonable to carry out prediction analysis, otherwise retrain the BP neural network. If the control chart analysis predicts data points outside the controllable range, an early prevention is performed.

According to the coal mine risk prediction method, a risk control chart was drawn up as shown in Figure 3, using the data from the Luxi coal mine. (Some of the data in the figure are shown in Table 1)

| Date | Actual data | Prediction data (By BP) | UCL  | CL  | LCL  |
|------|-------------|-------------------------|------|-----|------|
| 3.31 | 171         | 170                     |      |     |      |
| 4.01 | 165         | 166                     | 198  | 163 | 128  |
| 4.02 | 162         | 163                     |      |     |      |
| 4.03 | 169         | 168                     |      |     |      |
4. Coal mine risk management and control big data platform design

4.1. Database design
The system platform uses MySQL as the database. MySQL can be accessed interactively using several interfaces for entering queries and viewing the results: a command-line client program, a Web browser, or an X Window System client program. The software platform uses interfaces such as "Select", "Update", "Insert" and "Delete" to access the MySQL database: operation commands to save and retrieve risk data.

In order to better analyze and apply the coal mine risk control platform, this study designed a coal mine risk control big data platform based on a hierarchical model, and built a coal mine risk control database using MySQL. As follow:

```java
Class.forName("com.mysql.jdbc.Driver");
Connection conn=DriverManager.getConnection("jdbc:mysql://127.0.0.1:3306/mine?
useUnicode=true&characterEncoding=utf-8", "root", "root");
```

4.2. Introduction to the system homepage
The system home page shows an overview of the system's functional modules, including data collection, data analysis, integrity management, safety training, and other modules. As shown in Figure 4, the left side of the home page shows the shortcut entrance of all functions, and the middle part shows the results of data analysis in the form of histogram, pie chart and line graph.

![Figure 4. Coal mine risk management platform](image)

5. Conclusions
In this paper, the BP neural network and control charts were combined to predict the number of risks and improve the coal mine risk management and control technology. Based on the coal mine risk management and control technology, the big data analysis method was used to develop a big data platform for coal mine risk management and control. The coal mine risk control technology and big data platform in this paper can carry out coal mine risk control work in a scientific, effective, standardized and convenient manner. And it also can improve the efficiency and quality of coal mine safety production.

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