Gas Outburst Risk Analysis Based on Pattern Recognition of RS-SVM Model

LIU Jun-e\textsuperscript{a}, ZENG Fan-lei\textsuperscript{b}, GUO Zhang-lin\textsuperscript{c}

\textsuperscript{a}Information school, Beijing Wuzi University, Beijing, China;
\textsuperscript{b}, School of Economics and Management, Hebei Engineering University, Handan Hebei China
\textsuperscript{c}, Department of civil engineering, North China Institute of Science and Technology, East Yanjiao, Beijing, 101601, China

Abstract

Coal and gas outburst disasters are usually accompanied by some of the characteristics of events, through the analysis of gas accident monitoring data, we can draw the pattern characteristics of a gas accident, which can highlight the situation in the future identification of gas according to features of the database, support vector machines in a small sample, high-dimensional pattern recognition has shown great advantages, the combination of VC dimension theory and structural risk minimization principle, the limited sample modal learning experience, can effectively achieve the effect of classification and pattern recognition, In combination with rough set theory, the original sample data reduction, support vector machine so as to post the data to facilitate processing and pattern identification, and finally validated through case study and practical validity of the model.

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Keywords: coal and gas outburst; rough set theory; SVM; risk evaluation; pattern recognition

1. Introduction

Research for gas outburst prediction indexes shows that the coal and gas outburst risk recognition is uncertain, accurate distinction in coal and gas outburst risk is still worldwide problem. In recent years, domestic and foreign researchers had already put forward forecasting methods, for example: neural network prediction method, gray theory method, fuzzy clustering method, etc. Various methods all have their own advantages and limitations. And with rough set-support vector machine (RS-SVM) method using in the coal and gas outburst prediction field does not see commonly, this paper mainly uses rough set theory to extract the core element of the influence of coal and gas outburst, combining with support...
vector machine which have very accurate recognition effect for small sample of gas outburst risk prediction.

2. Pattern Recognition Model

2.1. Rough Sets theory

Rough-set theory, Poland scholars Z.Pawlak put it in 1982, is effective mathematical tools processing imprecise, incomplete or uncertainty data. In the process, it does not need to provide any priori information which is outside of necessary data set, only on the basis of the existing observation data processing, delete the redundant information, thus generating decision rules based on decision rules streamline decision-making index, is a kind of effective redundancy data processing method.

Specific rough set theory is introduced in references [6].

2.2. Support vector machine theory in pattern recognition

SVM method is developed on the basis of statistical theory, and it considered structural risk minimization principle, with finite sample the knowledge offered, it makes model has the right complexity and generalized ability. And the early warning of SVM is on the basis of an inner product function definition $\phi$, which transform nonlinear of the input space $x$ mapped to a high dimensional feature space $F$, and make linear regression in the space, thus lower dimension in the feature space of nonlinear regression problem were transform into the high dimensional feature space of linear regression problem to solve.

Support vector machine (SVM) model choose input node number $m$ and support vector machine (SVM) parameters according to the rule of Optimal criteria only, The network structure number (hidden layer node number) were decided by support vector automatically, and the link weight index were given by the algorithm automatically which is better than Neural Network Model and it has well generalization ability. Specific SVM theory is introduced in reference [8].

2.3. Construction of RS-SVM Forecasting Model

Firstly , with the pre-knowledge which can be got from observation data and the rough set reduction method, redundant index of the evaluation indexes can be reduced to a certain degree, next to using the SVM theory establish a prediction model. With the combination of the two methods, embodies the method complementary advantages characteristics, and got good prediction effect.

Modeling steps:
1) Reasonable analysis of coal and gas outburst influence factors of the gas outburst as evaluation index;
2) According to index data provide prior knowledge, using rough sets algorithm of every evaluation index reduction, remove redundant factors.
3) Use training model to evaluate new data, it is concluded that the current forecast coal and gas outburst risk levels.

3. Examples and Analysis

The coal and gas system is consisted of attributes set (safety condition attribute sets and safety decision attribute sets). Its decision is based on the level of security to make the plan. Thus first work of the system is to identify the safety categories. In this paper, it investigated the coal and gas outburst influence factors
of coal mine in Fengfeng Coal Mine. With the rough set method to reduce the redundant index to evaluate the risk, and then predict the outburst risk using the SVM model.

Mining depth (r1), geologic structure (r2), firedamp content \( m^{-1} \cdot s^{-1} \) (r3), coal rigidity coefficient (r4), Bringing gas velocity \( \Delta P \) (r5), gas start emission velocity \( q_m \) (r6), gas pressure MPa (r7), slag off (r8), Gas content estimates (r8), Gas change (r9), drill power phe (r10), Risk class (D)

Table 1 Training samples of coal and gas outburst for prediction (decision table)

<table>
<thead>
<tr>
<th>U</th>
<th>A</th>
<th>r1</th>
<th>r2</th>
<th>r3</th>
<th>r4</th>
<th>r5</th>
<th>r6</th>
<th>r7</th>
<th>r8</th>
<th>r9</th>
<th>r10</th>
<th>r11</th>
<th>D</th>
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<td>0</td>
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<td>0.36</td>
<td>9.7</td>
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<td>0.75</td>
<td>0</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td>2</td>
<td>468</td>
<td>1</td>
<td>8.9</td>
<td>0.34</td>
<td>11.4</td>
<td>2.9</td>
<td>1.0</td>
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<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>568</td>
<td>1</td>
<td>8.7</td>
<td>0.36</td>
<td>12.2</td>
<td>3.8</td>
<td>1.1</td>
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<td>1</td>
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<td>0</td>
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<td>2</td>
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<td>533</td>
<td>1</td>
<td>7.3</td>
<td>0.41</td>
<td>9.51</td>
<td>1.7</td>
<td>0.89</td>
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<td>1</td>
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<td>0.26</td>
<td>14.19</td>
<td>3.6</td>
<td>1.47</td>
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<td>0</td>
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<td>3</td>
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<tr>
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<td>0.35</td>
<td>11.12</td>
<td>2.5</td>
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<td>0.34</td>
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<td>0.11</td>
<td>14.23</td>
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<td>1.19</td>
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<td>N</td>
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</table>

Apply the rough set reduction method to reduce the redundant attribute of the decision table 1, then got 8 kernel attribute which were reduced from 11.

The next step is to do the prediction model with the processed data, training with Ls-SVM classifier model can got the experimental model for trained data, then can apply the experimental model to the testing data to forecast its risk degree. There is a trial to validate the efficient of the model and the results come out to be well, shown in table 3.

Table 2 Test results table of prediction training samples of coal and gas outburst

<table>
<thead>
<tr>
<th>indexes</th>
<th>Real state D</th>
<th>Predicted state D</th>
<th>Result comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>1</td>
<td>1</td>
<td>T</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>2</td>
<td>T</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>3</td>
<td>T</td>
</tr>
<tr>
<td>11</td>
<td>3</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>T</td>
<td></td>
</tr>
</tbody>
</table>

According to geological data to analysis the gas outburst prediction, number 11 sample has a smaller outstanding dangerous were predicted to have great outstanding dangerous, it just has little error compared with its real state, and the other 4 test samples have no difference with its real risk state, it means that the model established in this paper has well performance and it can be used to process the risk evaluation.

4. conclusions

With the trial above it gets that there is a well improvement for prediction accuracy rate of RS-SVM model compared with Ls-SVM model only. As the data has been extracted the brief indexes after the
Rough Set method processing, and it is significant for SVM model to make the risk evaluation. Prediction results show that using rough set-support vector machine (SVM) model to predict outburst risk is scientific and feasible. But as a relatively new forecasting method, SVM still has some defects to improve at present. For example: how to select the appropriate kernel function to increase the prediction accuracy, selection of punish coefficient etc. Therefore, to do a more accurate prediction, there is still a need for further discussion and study.

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References:


