Modelling of Rock Deformation around Roadway based on Artificial Neural Network (IV) - An IDSS oriented to Control of Rock around Roadway

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Abstract: In this paper, modelling of rock deformation around roadway are described. On the basis of this, a new designed theory for IDSS of six-base integration is advanced, and the thought of constructing mining knowledge base and inference engine by ANN is suggested. An IDSS oriented to control of rock around roadway is developed and the knowledge base, model base, text base, data base and graphics base is posed. At last, the developed system has been put into site use and the fruits are proved to be both active and useful.

Key Words: rock deformation around roadway, artificial neural network, control intelligence decision support system, forecast

Introduction

Roadway is the artery of colliery production, its layout maintenance technique directly has an effect on the safe production and improvement of economic benefit in colliery. And the layout and maintenance of roadway is determined by the accurate forecast for the rock deformation around roadway.

Modelling of Rock Deformation around Roadway

The formula computing the rock deformation around roadway can be described as u=f(T,S), in which u is the rock deformation around roadway, f (*) expresses nonlinear function, T stands for time factor, S consists of (GF, PF). GF stands for set of geological factors, PF stands for set of production technique factors. GF consists of rock quality of roof (Q1), rock quality of two-wall (Q2), rock quality of floor (Q3) and mining depth (H). Pillar width (B), supporting intensity (P) and size of section (S) etc. are included in PF (Zhang Yuxiang, 1994). The problem setting up the forecasting model for rock deformation around roadway is to look for f (*) by mathematical method (Zhang Yuxiang, 1996). Artificial Neural Network is suitable for solving problems such as setting up model and pattern recognition etc. in complicated nonlinear systems. For this reason, this paper tries to setup the forecasting model for rock deformation around roadway by means of Artificial Neural Network.

In the course of looking for f (*), three steps would be divided into. Firstly, defining each index weight and setting up clustering analysis model of rock stability around roadway in the light of GF (Zhang Yuxiang, 1997). Secondly, setting up pattern recognition model of rock stability around roadway according to GF (Zhang Yuxiang, 1997). Thirdly, studying how PF and T affects u by means of information spreading thought and Artificial Neural Network (Zhang Yuxiang, 1997).

An IDSS Oriented to Control of Rock around Roadway

Owing to complexity of geological conditions in colliery, varieties of production process and technology, it is a typical semistructural forecast problem that forecast of rock deformation around roadway. Lots of research has been made and various models have been set up, but they all have their own presume and premise. These causes that each model has its own starting point, each model has its own engineering background, each model has its own scope
of application. In order to avoid limitations of single method, an IDSS objected to control of rock around roadway is developed on the basis of modelling of rock deformation around roadway.

The logic structure of IDSS objected to control of rock around roadway can be described as follows by BNF pattern:

```
<system>:=<knowledge system><problem solving system><language system>
<knowledge System>:=<base file system><base management system>
<base file system>:=<method base><model base><date base>
<knowledge base><text base><graphics base>
<base management system>:=<method base management>
<model base management>
<date base management>
<knowledge base management>
<text base management>
<graphics base management>
<problem solving system>:=<solving key system><knowledge inference system>
=model running system><explanation system>
<language system>:=<man-machine dialogue system><results output system>
```

Base file system is the source of information and knowledge in IDSS. Method base is to store the numerical and nonnumerical method. Method consists of method entity and method description. Method entity is the executable code. Method description gives the major properties of method. The construction of method base can be described as follows by BNF pattern:

```
<method base>:=<method entity><method description>
<method entity>:=clustering analysis method entity>
<pattern recognition method entity>
<weights defining method entity>
<clustering analysis method entity>:=<fuzzy equivalent matrix dynamic entity>
<fuzzy ISODATA entity>
<ART neural networks entity>
<pattern recognition method entity>:=<fuzzy comprehensive judgment>
<fuzzy multiphase statistics entity>
<ART neural networks entity>
<BP neural networks entity>
<fuzzy Pi-Sigma neural networks entity>
<weights defining method entity>:=<BP neural networks entity>
<subjective weights defining entity>
<objective weights defining entity>
<subjective weights defining entity>:=<delphi method><expert investigation>
<contrasting matrix><gradation analysis>
<circle contrasting analysis><fuzzy zone>
<importance arrangement>
<objective weights defining entity>:=<entropy value><major factor analysis>
<grey corresponding analysis>
<pluralistic regression analysis>
<method description>:=<method explanation><variable stipulation>
<method explanation>:=<symbol><name><use><designer><made date>
<variable stipulation>:=<symbol><name><type><value source category>
```

Model base is to store the constructive model. Model consists of model entity and model description. Model entity is the executable code. Model description gives the major properties of model. The construction of model base can be described as follows by BNF pattern:

```
<model base>:=<model entity><model description>
```
Data base is the set of numerical and nonnumerical data, it can provide the information for numerical and nonnumerical computation. It consists of data base file, transmission interface and other system files. Text base consists of text information. It can provide the text information for solving problem. The construction of knowledge base can be described by BNF pattern:

<knowledge base>::=<example knowledge base>::=<neural network knowledge base>::=<network model>:<structure>:<parameter>

In order to eliminate onecssidedness dealing with knowledge by classical method, knowledge is treated by neural networks. There existed some problem in classical mining knowledge system: Firstly, bottleneck problem during obtaining knowledge. The knowledge is obtained by the dialogue between knowledge engineer and mining expert in traditional knowledge processing system. Obtaining knowledge is indirect. It not only costs lots of time and power, but also has a lower efficiency. In addition, some knowledge can only be sensed, not explained. It is difficult to describe knowledge with certain regulation. But it is useful for mining expert to solve some mining engineering problem. Therefore, the difficulty during obtaining knowledge cause some problem such as short of knowledge and lower intelligence level inevitably. Secondly, traditional knowledge system did not have the self-perfected function in practice. The intelligence level of system is determined by initial knowledge level. It is short of learning ability. This restricted system property greatly. Thirdly, there existed some problem such as matching conflict, combination explosion and infinite recursion in traditional knowledge system. Fourthly, because that traditional knowledge system is based on regulation express, it is difficult for user to know the essence for solving problem. Fifthly, because the solving tactics is hidden in the order of regulation, it is difficult to maintain the knowledge system. Therefore, knowledge is treated by neural networks in this paper. Neural networks is not only to store and manage the knowledge base, but also to realise the inference engine. Graphics base is to provide the graphics support for solving problem.

Base management system has three major functions, that is object definition, object search and object operation. The object definition is to set up the corresponding object base, examine the object integrity, transmit messages within system and coordinate and manage each base. The object search is to search object base according to computation results of relations provided by user. The object operation is to operate object such as additions, deletions and renewal.

User dialogue management is the link between user and problem solving system. Its main function is to receive and recognize the problem to be solved and display the description information for user, receive and recognize the dialogue demand such as screen and running speed etc.

Problem solving system consists of solving key system, model running system, knowledge inference system and explanation system.

Application of IDSS Oriented to Control of Rock around Roadway

The developed system has been put into site use. In particular, by means of forecasting model of rock deformation around roadway based on artificial neural networks, 45 roadways in China have been passed inspection and the results are proved to be both active and useful. The average error forecasted is under 5% (Zhang Yuxiang, 1996). This proved the model is effective and satisfactory for solving engineering problem.
In this paper, we take the roadway in a certain colliery for example, to indicate the forecasting procedure.

The roof of roadway is sandstone and sand-shale, two-wall of which is coal seam, the floor of roadway is protected by pillar, the pillar width is 5m. There are two kinds of support in the roadway, that is, one is the 29U steel arched yielding support (AYS, supporting intensity is 0.031Mpa), another is circular closed support (CCS, supporting intensity is 0.076Mpa). From the measurement on the spot, we can know that according to the evaluation method of rock quality promoted by China National Criterion, the rock quality of roof Qr = 346, the rock quality of two-wall Qw = 211, the rock quality of floor Qf = 211, mining depth H = 530m.

In the light of above data, the forecasting value of rock deformation around roadway can be calculated. The contrasting value between forecasting value and practical value shown as follows.

Table 1. Contrasting table between forecasting value and practical value

<table>
<thead>
<tr>
<th>VALUE</th>
<th>AYS</th>
<th>CCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>u₀ (mm)</td>
<td>705.33</td>
<td>357.11</td>
</tr>
<tr>
<td>v₀ (mm/d)</td>
<td>3.3596</td>
<td>1.7043</td>
</tr>
<tr>
<td>u₁ (mm)</td>
<td>1262.28</td>
<td>641.64</td>
</tr>
</tbody>
</table>

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References


