# RESEARCH AND DEVELOPMENT OF ROADWAY SUPPORTING DATABASE SYSTEM FOR COAL-MINE

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## ABSTRACT

In order to reduce the roof accidents, extend and communicate a great deal of valuable experience and technology in the field of coal mines and roadway supporting, this paper presents the research and development of a information platform, which includes a number of functions, such as information-sharing, data query, decision-making of roadway supporting, and so on. Especially, the part of the decision-making of roadway supporting is discussed emphatically. Other matters are mentioned as well, such as the design of the system fabric, the division of modules and functions and the development mode, etc. After comparing the advantages and the disadvantages of three inference modes, case-based reasoning can be taken as the main decision-making method, according to the feature of the relations between roadway supporting and correlative factors. In fact, these factors cannot be expressed by a theoretical model at all. In the process of implementation, the standard of the degree of similarity (namely knowledge) is formed by the method of weighting fuzzy logic. The inference engine requests database by loading the standard of the degree of similarity (this is the process of inference), and returns final conclusions. The relative decision-making interpretations are shown through the interpreter.

## KEY WORDS

roadway supporting, database application technology, Browser/Server (B/S), Application Service Providers (ASP), expert system

## 1 INTRODUCTION

Comparing with many other countries in the world which mainly produce coal, such as the United States and the Australia, the coal mine in China is mainly exploited underground by the mineworkers. The environment of production and the geological condition become more complex and difficult than usual. In the aspect of roadway supporting and reinforcement, along with the depth of underground mining unceasing increasing, problems of the roadway supporting and reinforcement under the complex geological condition appear more

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prominently. Analysis of the types of the coal mine accidents shows that roof accidents are most serious, the frequency of which is highest. In 2002, roof accidents happened at 2,364 times in China together, death toll comes to 2,766, which are accounted for the number of accidents and death 50.71% and 34.69% respectively.
On the other hand, we have accumulated rich experience and field data during exploiting and construction of coal mines for a long time. But these valuable accumulations have not been able to be reused and shared countrywide so far. The similar roof accidents and problems of construction are still repeating constantly. Main problems are listed as follows:

- The uncertainty is increased with increasing of mining depth,
- The geological conditions of coal mine become more and more complex.
- The communication of information is not enough expedite for available share,
- The abundant valuable experience and the technology have not been popularized widely.

Because of various objective and subjective reasons, roof accidents in coal mine and problems of the roadway supporting puzzle persons continuously and scare the normal safety production of coal mines. Especially under complex geological condition, these problems appear more distinctly. In view of above reasons, we have proposed to develop this system, "research and development of roadway supporting database system for coal mine". Its main function is providing a net platform for information exchange to realize the share of mine and roadway resources and the decision-making for roadway supporting. Expert consultation is provided for user as well.

## 2 SYSTEM FUNCTIONS AND MODULES:

### 2.1 SYSTEM FABRIC

In order to exchange information conveniently and promptly, the system uses the three layer structure of B/S, adopts SQL Server as the background database, runs Microsoft's IIS in the WEB server, and takes ASP(Active Server Pages) as the development tool. The system is composed mainly by three parts: the client side, the application server and the database server. All parts communicate mutually through the standard network protocol or internet technology.

- The client side:

Just need a standard web browser in the client side, like Internet Explorer 5.X, Netscape Navigator 6.X, etc. The user does not need to install the special software for browse.

- The application server:

The application server is WEB server, which can response client's request, form the service flow, and carry out the operation to the database.

- The database server:

The bottom layer of this system is the database server, which is used to store the system information, the data of mine and roadway supporting, the information of users, relative parameters, and such like.

The running mode is shown as Figure 1:


Figure 1 the basic working principle of B/S mode

The working process: The client side accesses the Web server through URL, the Web server requests data from the database server, and returns the results which have been obtained from Web server to the client side browser by the form of HTML.

### 2.2 FUNCTIONS AND MODULES :

The system is divided into two major parts: foreground and background. The foreground mainly provide interfaces for clients to use, including several modules such as member registration, data inquiry about coal mine or roadway supporting, decision-making about roadway supporting, expert consultation, and message board. The background is mainly used for administrators to manage the system and set relative items and parameters, which includes several modules such as member management, data management, system management, and so on.

**Data inquiry about coal mine:**

According to the geographical locations, the geological conditions, the type of roadway supporting, the inquiry can be conducted easily to search the information required. If the results retrieved are too many, then the secondary inquiry will be able to be carried out. After getting the returned results, double-clicks any record, clients can see the detailed explanation, including corresponding practical pictures, safety records and other correlative important information.

**Roadway information inquiry:**

The same as stated above, we can also obtain the correlative information of roadways by the same way.

**The decision-making of roadway supporting:**

According to the correlative parameters which is inputted by user, such as the mining modes, the scale of coal mine, the shape and the depth of roadways, the sort and the property of wall rocks in roadways, the intensity and the direction of underground stress, and so on, the inference engine can provide decision support by combining the forward and the backward

inference. Finally, an explication about the process will be given by the interpreter of the system. What is shown in Figure 2:

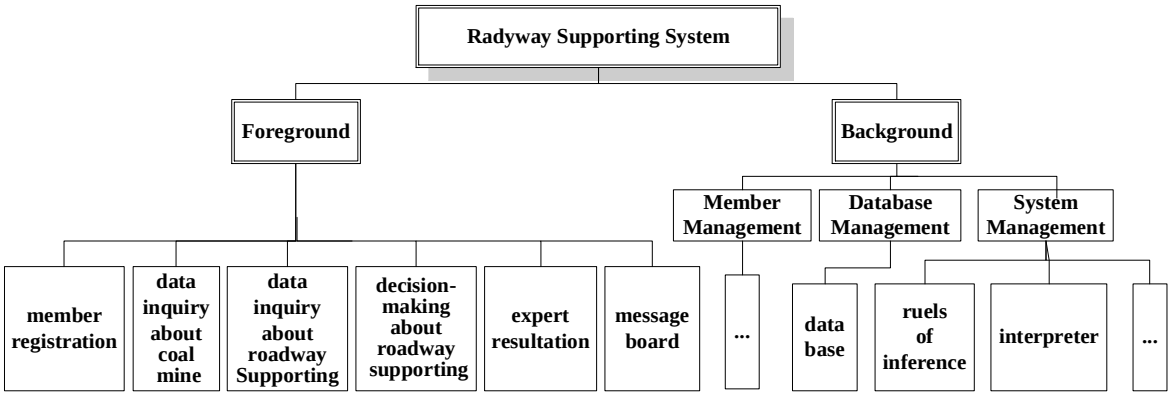


Figure 2 roadway supporting system

**Data management:** Add, delete and modify the data of coal mines or roadways.

**System management:** This part mainly realizes two functions. First, set inference rules to process inference and provide decision-making. Second, set the interpreter interface to provide the interpretations to users.

## 3 DECISION-MAKING SYSTEM

### 3.1 DECISION-MAKING PRINCIPLES:

This system not only is able to inquire the data of mines or roadways, but also can do decision-making according to the information inputted by users, and then provide one or more of reference recommendations.

In the decision-making systems, according to the methods of expressing knowledge, inference can be generally classed as three types, case-based reasoning, model-based reasoning and knowledge-based reasoning.

Case-based Reasoning System (CBRS) is an analogism according human's cognition psychology process which is based on the comparability with past relative cases. Because this kind of inference model obtains the solution of the current problem through accessing the past cases which had been solved, it is extremely valid to resolve the problems which can not be processed ideally through the traditional knowledge-based reasoning. Otherwise, it also has the characteristic of studying from the accumulated cases and self-perfecting. Its shortcoming is incapable of providing a complete proposal, and so still need the further interpretation through forward inference.

Model-based reasoning system (MBRS) is to express the interior working process of the subject with a specific set of symbols at first, then carry out simulating, forecasting and interpreting the behavior or process of things according to the model. In MBRS, the most

important thing is that we must find an expression which is able to reflect the essence of the object.

Knowledge-based Reasoning System (KBRS) is a system which includes the knowledge acquisition module and the inference module which aim at specific questions and can be called by the decision-making program. It can acquire knowledge from samples and save it in the knowledge base, and then the inference module utilizes knowledge to resolve specific problems.

As far as we know, the type of roadway supporting is depended on various causes, such as the shape and the depth of roadways, the length of service, the variety of wall-rocks, the possibility of accidents, and so on. However, the relation between each kind of factor and the type of roadway supporting dose not belong to a strong theoretical model, and many factors are affected mutually. The case-based reasoning is more suitable for such decision-making environment, in which the strong theoretical model does not exist or the domain knowledge is incomplete, but the experience is abundant. So this system selects the case-based reasoning as the main inference model, and also absorbs the merits of the other two kinds of inferences in the meantime.

In the CBRS, when the case base is under the control of the database management system, the case base can be organized and managed directly by the functions of the database management system. The CBRS can be divided into two parts: One is the establishment of the case characteristic base and the evaluation standard of the degree of similarity (namely knowledge base), both emphases of this part are the extract of the characteristics (namely the establishment of the case characteristic base) and the determination of the evaluation standard of the degree of similarity; the other is the inference engine whose core is the case base retrieval. The first step of the characteristic retrieval is to find out and compute the set of the similar characteristics. The computation of the set of the similar characteristics is mainly based on the concept of the standard of the degree of similarity. That is to say, assigning a value to the characteristic or the attribute, setting an initial context restraint, and then figuring out the set of the similar characteristics of the attribute value, according the similarly knowledge and the context restraint. The key of the algorithm is the attribute value, the context restraint and the similar knowledge. Second step is transforming it into the standard inquiry statement, and finally founding the related cases in the case characteristic base, which will be taken as the candidate cases.

### 3.2 THE STANDARD OF THE DEGREE OF SIMILARITY DEFINITION:

In general situations, match only refers to exact or complete match, it is the pronoun of “complete same ". But in the actual problems, especially in some situations, in which the object matched is more complex, it is not realistic to take "complete same" as match. It is nearly impossible to find out two complete same physical objects in the protean world, that is to say exact match in the physical world is absurd, and therefore this system mainly adopts " fuzzy match" or "approximately match".

Although some expert systems has mentioned the concept of credibility about the premises and the conclusions of the inference rules, but when data is inquired or compared, they still

uses the principle that all the premises must completely match. That is to say, only all the characteristic values of the rules must be one-to-one mapping completely with those of the actual cases, which have been proved previously(or which have been pre-stored in knowledge base), can the inference rules be applied to infer the conclusions. This kind of processing is a method to treat all the premises with the same standard without considering the impact of each premise to the conclusions. However, the weight of each son-premise of the premises in a inference rule is often different from the one of the others in practical situations. Each son-premise of the inference rules in the knowledge base of this system will be set a weight value in advance, and the weighting fuzzy logic is adopted in the inference engine, which is not just a fuzzy logic. The weighting fuzzy logic is a more perfect and precise reasoning mode.

In the process of inference, the most basic formula is named atomic logic formula. Each atomic logic formula P have a corresponding "true degree "T(P): $-1 \leqslant T(P) \leqslant 1$, namely weighting fuzzy logic formula.

The specific formulas are shown as follows:

$$T(x) = \sum_{i=1}^{n} w_i T(x_i) \qquad (1)$$

$$T(x_i) = 1 - \left| f_i(x_{i1}) - f_i(x_{i0}) \right| \qquad (2),$$

$$\left| f_i(x_{i1}) - f_i(x_{i0}) \right| \qquad (3)$$

The formula 3 indicates the semantic distance from $x_{i1}$ to $x_{i0}$. To the serial variables, the distance takes the absolute value of the difference of both which have been fuzzified before ; to the non-correlation discrete variables, like the modes of roadway construction works, the precise logic is adopted, for example, if both variables are completely identity, the result is 1, or else the result is 0; to the correlation discrete variables, translate the characteristics into numeral at first, then compute according to the formula 2, take the absolute value finally. For example, the roadway property has the following several kinds of characteristics: Coal lane/Rock lane/Half coal rock lane. The variable takes 1 for coal lane, 0 for rock lane and 0.5 for half coal rock lane. $w_i$ is the corresponding weight (namely context restraint). From the formula 1, the true degree of the conjunct of the weighting fuzzy logic is the sum of the weighted son true degree. Therefore the weighting fuzzy logic is different from the traditional fuzzy logic; according which if a son-item is false, the result is false ultimately. In this system, when the true degree of a son-item is unknown (that is to say the knowledge is incomplete), may set the true degree of the sub-condition whose value is null to zero. Because the true degree of the entire condition can be figured out really according to the true degree of the sub-conditions with the corresponding weight, the method of the treatment is equivalent to neglect the item of the corresponding sub-condition which can not be sure of false or true (namely unknown). The degree of the influence of neglecting some sub-conditions is mainly decided by the corresponding weight. The true degree of the entire formula will increase with the true degree of the sub-condition increasing. The true degree of

sub-conditions are more, the true degree of the entire goes higher, as is conform to the human being's actual intuition.

### 3.3 THE INFERENCE MECHANISM OF THIS SYSTEM:

In the inference process, according to different situations, the system adopts an adjoint means of both inference processes. One is the depth inference, another is the extent inference. The depth inference is namely taking true degree as the only standard, returning to the inference results, and sorting the order by the size of the true degree. The extend inference is namely sorting the order by the probability that each kind of solution appears.

Because the generally operating of dispatching SQL statements to database can not achieve some advanced functions, the system adopts a new method to pack a suite of integrative storage processes at first, and then invokes these storage processes. One example of invoking a storage process shows as follows:

```
set comm=server.createobject("adodb.command")   'connect database
comm.commantype=4                                'set some parameters for query
                                                 'put parameters into storage process
comm.Parameters.append comm.CreateParameter("@f1", adChar, adParamInput,18,cauchy)
comm.Parameters.append comm.CreateParameter("@f2",adChar,adParamInput,18,null)
……..
comm.Parameters.appendcomm.CreateParameter("@w1",adInteger,adParamInput,,1)
comm.Parameters.appendcomm.CreateParameter("@w2",adInteger,adParamInput,,1)
……..
set comm.activeconnection=conn  'c
comm.commandtext="dbo.inquiry_precision"
set rs=server.createobject("adodb.recordset")    'create record object
rs.CursorType=3                                  ' set cursor parameter
rs.open comm,1,1                                 'execute storage process
```

What above codes carries out is the precise inference. The system transmits the fuzzy function and the weight value to the storage process, inquiry_precision(), which is chosen by the experts, and returns the results performed in the codes. The results returned are sorted in the order of the true degree. Much is rowed at front, then little is rowed at behind. The system recommends several decision-making plans to user by the order of the priority. When the user clicks on some plans, the system can provide the related decision-making supports through the forward inference by the interpreter to the users, which include the related explanations, the inference rules, the true degree of the recommendations, the frequency of occurrences, etc.

## 4 CONCLUSIONS

This article introduces a kind of information exchange platform with B/S structure of the three layers. This platform synthesizes many of various techniques such as the expert system, the weighting fuzzy logic, the database development, ASP, etc. It is not only may provide the inquiry function about the coal-mines and the roadways for the users, but also can able to carry out the case inference according to the information inputted by the users and provide the decision-making supports for roadway supporting speedily.

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