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Key Techniques of Expert System for Rock Bolting in Coal Mine Roadways

MA Xin-min[1], YANG Ren-shu[2], LI Qing[3], ZHANG Jing-quan[4]

[1,2,3]School of Mechanics & Civil Engineering , China University of Mining & Technology (Beijing) ,Beijing, China
[4]Xiezhuang Coal Mine of Xinwen Mining Group, Xintai, China
Email: 13811802291@163.com

Abstract: Intelligent designs were achieved through an effective combination of the recent developments of computer intelligence and anchor-supporting technique. They are of great theoretical and practical significance to "digital mine" construction and safe and effective production. By analyzing the present situation of expert system application in the field of mining technique, from the viewpoint of practical application, three aspects were adopted in the design of the expert system, including the target clients, the purpose of design and the structure characteristics. From the view of widespread popularity and practice, this paper put forward architecture of the system. And then several key technical problems were analyzed and discussed. Progressive reasoning and combining decision-making unit by rules and engineering examples constitute make the system to be more efficient and intelligent. A system of intelligent design and automatic drawing was developed based on object-oriented visualizing environment and application of CAD secondary development.

Keywords: Roadway; Bolting; Expert system; Intelligent design

1. Introduction

Roadway design has a close relationship with the safety and benefits of mines. With the rapid development of mining techniques, it has been proved that bolting support is an effective method for the following reasons: saving resource, raising efficiency and reducing production cost (Wang, 2007). In advancement of roadway of coal mine, supporting is the biggest problem of affecting advancement. Because of the geological and environmental conditions are variable, support is the main factor which affects the drifting footage. Development of the Expert System for Rock Bolting in Coal Mine Roadway has the following advantages: as comprehensive as possible to consider various factors, offering a reliable basis for construction decision-making, so it demonstrates theoretical and practical values. An Expert System for rational determination of the openings support form and parameters of coal tunnel was developed by Xiaopu Li and Jianguo Yao(Li,Yao,1993), which built a hierarchical knowledge base, adopt forward and backward chaining and has good effects on the practical application. According to theories of geology, rock mechanics, mining and different geological and mining conditions, Shenhua Jiao(Jiao,2006)developed an intelligent expert system of bolting with wire mesh design. An intelligent design expert system of roadway and room supports was developed by Baogen Yang, building(Yang,2000) the knowledge base used for stability classification of rock mass and roadway bolting design. Artificial neural networks technology was applied in the system; it has good effects on the practical application. By using numerical simulation of FLAC–(3D) Jun Zhang (Zhang, 2009) developed

an expert system of support, which could carry out for theoretical foundation and numerical analysis about engineering analogism. Zuo, X(Zuo,2001) developed the Decision support system of coal mine exploitation disposition, which is composed of the database, model base, method base, knowledge repository, text base and man-machine interface. It has the function of data management, has models such as problems processing, calculation and analysis, simulation, and has the knowledge of some relevant mining experts.

The Expert System for Rock Bolting in Coal Mine Roadway was divided into five parallel subsystems, namely the consultation subsystem, explanation subsystem, knowledge database subsystem, drawing subsystem and help subsystem, as shown in Figure 1.

2. Key techniques of the expert system for rock bolting

2.1. The structure of expert system knowledge base

For a long time, China University of Mining and Technology has been engaged in researches of rock bolting in coal mine roadway both practically and theoretically. The university made a number of advanced resea -rch results, obtained national and provincial awards, cultivated a batch of bracing engineering experts, whose experiences and theoretical monograph are the foundations of expert system of roadway supporting design.

The geological condition of XinWen mine lot in Shandong province, China is complicated. The mine has already been exploited for depth of 1 km, where there
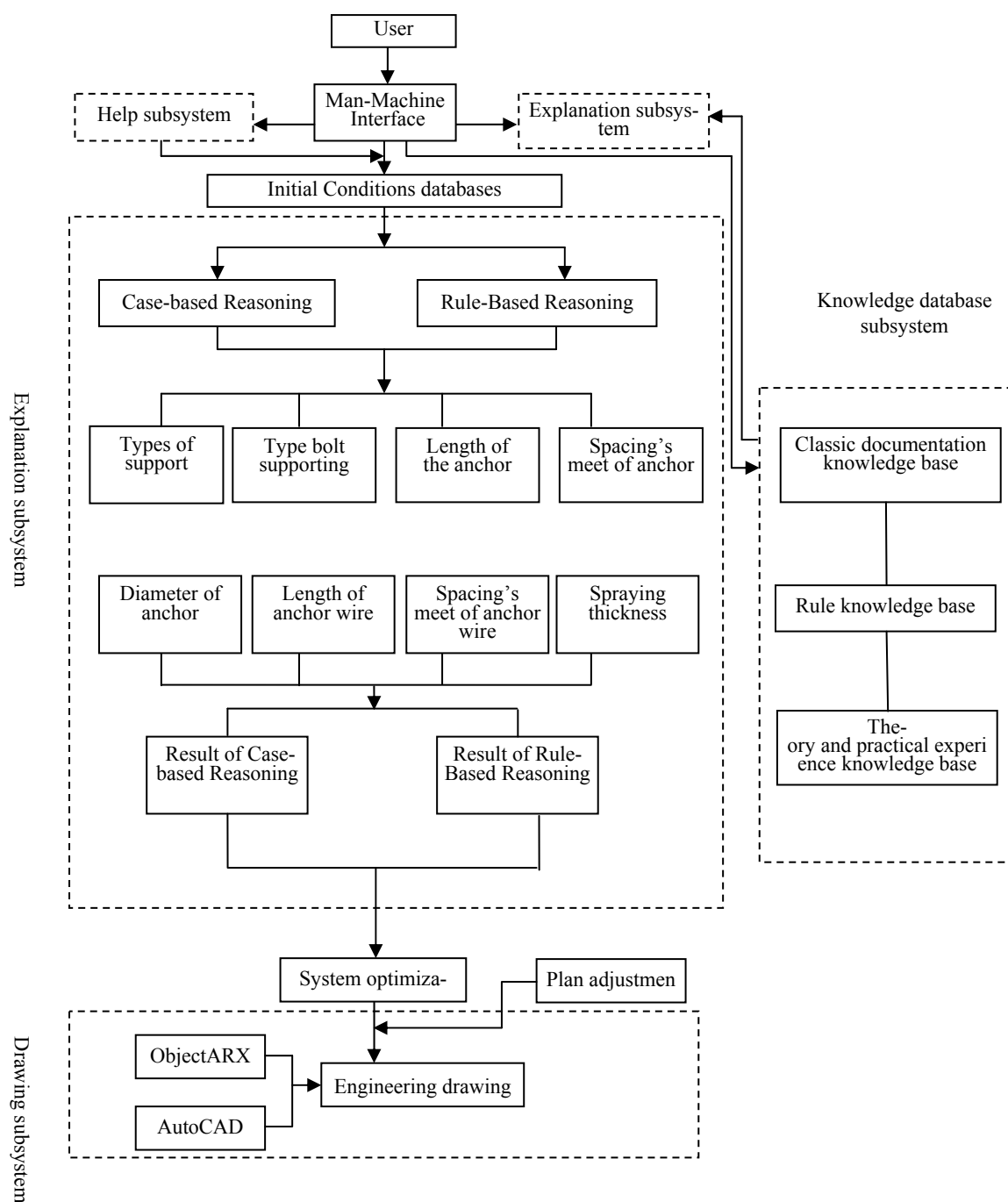
Figure 1. Structure of expert system for rock bolting in coal mine roadways

are kinds of roadways and it is difficult to recover. Hence, there is lots of practical experience of bracing engineering. The typical examples of roadway bolting engineering's related can be the contents of knowledge base.

Standards of roadway bolting: one of relevant standards are the "anchor shotcrete technical specification", the local industry standards "XinWen group anchoring

bolt technical specification" and the mining industry standards " design manual of mining engineering ", etc.

1) Contents

a) A typical case of roadway bolting: Take the typical examples of XinWen roadway bolting in the knowledge base, including trapezoidal roadways, vaulted

roadway tunnels, round arch and different geological structure and rock conditions.Change number of columns: Select the Columns icon from the MS Word Standard toolbar and then select "1 Column" from the selection palette.

b) The determination of theoretical principles of roadway bolting. According to the stability of surrounding rock and conditions of roadway, the rational support form was selected. The choice of the form of support must be safe, and under the premise of considering of reasonable economic and conservation of resources. It must ensure the roadway ventilation, pedestrians and meet the needs.

c) Relevant theoretical calculation formula of roadway surrounding rock and the empirical knowledge. Related theory is suspension theory, the combination of theory, theory of composite arch and experience formula, etc.

d) The key factors of roadway support scheme and key parameters. In this system choose support form and parameters of factors playing an important role can be considered only. These factors can be determined from the following three aspects(Wang,2002): reflect the stability of surrounding rock in different forms, supporting parameters and the decisive role, these factors are independent of each other, simplify analysis, determines the index should facilitate field collection, physical meaning is clear, in the situation of technically allowed, it's easy to get reliable data.

The stability of surrounding rock roadways is to determine the classification of roadway support form and parameters of the foundation. The stability of surrounding rock roadway influence factors of classification are rock strength, rock stress, and the buried depth of roadway, rock roadway width and construction, structure, and the integrity of groundwater, lithology, etc.

2) Knowledge representation

Knowledge representation of roadway surrounding rock is designed expert knowledge into the computer can identify expression forms of language, which will affect the operation of the system efficiency and upgrades. Based on the design of roadway surrounding rock of expert system of investigating and analyzing actual demand, and to determine the rule that knowledge, its advantage is easy to understand and reasoning, facilitate man-machine to exchange information.

Example: the XieZhuang coalmine roadway bolting support scheme expert knowledge with rule says.

Rule clamps X1: If (IF) the kind of stability of surrounding rock roadway is IV, and (AND) the top tray is whole.

Then (THEN) roof supporting form is anchor +M (W) steel nets, two bolting schemes: anchor bolting +steel strip + anchor net or reinforced beam + nets, in high stress area cable-anchors are used.

2.2. System design of the reasoning machine

Expert system of intelligent level and practical depends on the level of expertise and scientific reasoning; the structure of the system is the core of knowledge base and reasoning mechanism (Yang, 2008).

Roadway support design expert system uses a layered reasoning technology. The first step of reasoning and information is to be part of the second step reasoning based on condition of verification. In the case of rules based on support, support knowledge reasoning precision in the precondition of rules with examples of original input data may not identical, therefore, in which case decision rule reasoning, will rule with cases of original data matching is considered, the premise that match their similarity degree. System of layered reasoning technology accelerated the case facts and the rules of "matching speed. Figure 2 says the case-based reasoning process described as follows: reasoning algorithm.

a) Put forward questions. User input system requirements according to the decision of roadway surrounding rock initial conditions, and other relevant information, and to store data in a database. Rock types, such as shape of roadway.

b) Search expert knowledge repository examples. When the original data of some attribute and supporting expert knowledge repository prerequisites similar case, namely the lock the practical condition of the next match. Otherwise, reasoning and the next example end of search and matching.

c) Maximal matching degree. From similar roadway supporting schemes are examples of the similar case or through the combination of multiple instances, the biggest example matching degree form target of the solution, and through the modification of target to meet the current scheme.

Except in the case knowledge reasoning and stratification of regulation, all cases are in accordance with the rules of reasoning tree structure of organization, the rules of the logical relationship between objects on node to embody all nodes were collected from the root node, the case in the logic of the rules of the relationship. With the surrounding rock type of the benchmark for rule reasoning, for example, a tree structure reasoning as Fig. 3 shows.

In the diagram, I、III、V said the stability of surrounding rock roadway supporting decision scheme for category, the main delay-independent conditions.
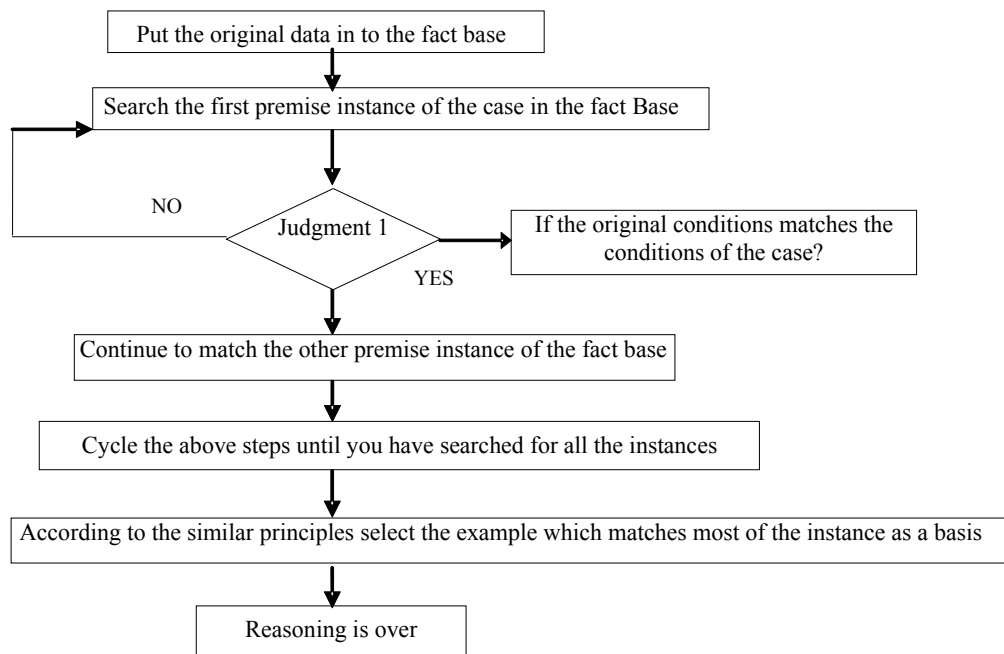
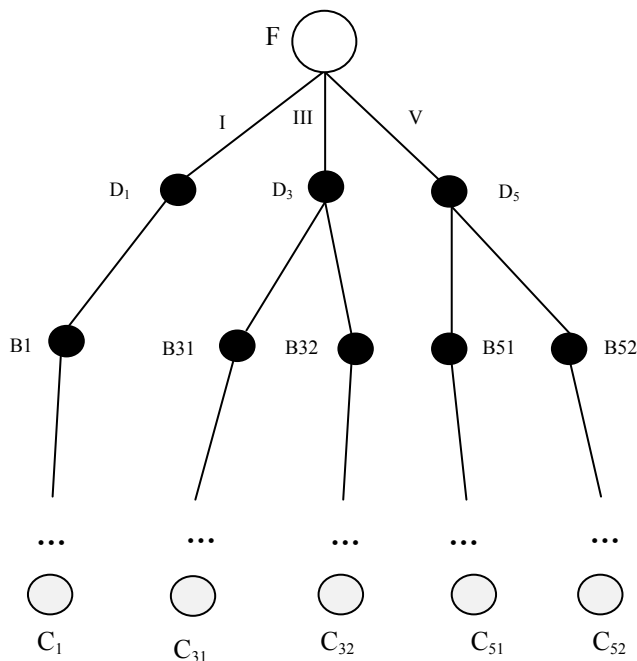**Figure 2. The flowchart of case hierarchical reasoning**

Figure 3. Decision tree of system

D1, D3, D5, roof supporting conditions, expressed as delay-independent conditions. B1, B31, B32, B51, B52 two sides roadway bolting said, as part of the content of supporting schemes decision-making,

C1, C31, C32, C51, C52 finally said supporting parameters.

User input data according to the prompt, such as the stability of surrounding rock type and roof rock breaking degrees, and the system would be stored in a database, the original system based on the rules of the repository of primitive conditions quantitative rules of judgment and matching, input if matching is formed the basic structure of reasoning tree trunk parts, based on the trunk of similarity degree of matching condition continued to lock down the matching, this rule will along the trunk of the tree structure to the branches and outspread, until the reasoning completed part needed to support scheme, all the conclusion.

3. Examples of engineering application

Name: - 850 roadway in return; the second Service life of 10 years, Buried deep 850 m, direct roof for fine-grained sandstone, hard, density, thickness 6.8 m, direct bottom for silty sandstone, density and brittle fracture is flat, thickness 1.42 m. For fine-grained sandstone, see hard density, thickness 2.1 m, tunnels through the scope, hydrogeological condition relatively simple, there was no local fissure water, but the effect of flood, Sloping roof, the surrounding rock types of IV class.

a) *Support type inference*

The surrounding rock types: the fourth type, of steel strip + anchor for concrete. Heading for the trapezoidal profile.

b) *Supporting parameters reasoning*

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Roadway excavation for steel strip + anchor bolting net. The roadway supporting parameters for: 22 mm diameter and length of 2,200 mm of high-strength rock-bolting roof, roof bolt and two row spacing, for 640mm 1000 mm for two, for spacing, row spacing for 800 mm 1000 mm.

c) Practical support scheme

Practical support scheme and reasoning, part of the conservative design parameters. To verify the reliability of the system.

4. Conclusions

Based on the development of the system XinWen colliery in the actual production of universality and fully considering the extensive of using, the theory and experience, it was showed that the system has a high practicability and reliability by actual application.

The system included knowledge of roadway surrounding rock engineering and typical case of roadway surrounding rock engineering, normative rules of roadway surrounding rock engineering experts theory, empirical knowledge base, etc, which could assure the knowledge content, comprehensively and practically. For the system of intelligent reasoning provided a powerful support.

Reasoning machine design based on rule reasoning and case knowledge reasoning, effectively solved the problem of one-sidedness of single reasoning result. At the same time, it is assured speed and accuracy of the

reasoning by using a one-sided reasoning and decision tree structure.

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