The design of coal mine water disasters prevention and control assistance decision system

Jiangtao Xu 1,*, Chengyong Sun 2
1 Henan College of Industry & Information Technology, Jiaozuo, China
2 Bureau of geology and mineral exploration and development of henan province, Zhengzhou, China

*Corresponding author email: gisxjt@qq.com

Abstract. According to actual situation of coal mine water disasters and the expert system research survey, the author has proposed the overall structure of the assistance decision system. The author has established the coal mine water disasters assistance decision platform based on dot NET soft. We has realized the formulation of determination and the preventing and controlling measure of the flood of old hole, roof, floor by using dot Net soft and the CLIPS computer language, combining with database platform established the expert knowledge library and the inference library; has solved the time and the spatial disposition question of the most superior sparse water volume by using the methods of finite element and the linear programming; Moreover aims at these questions of the note thick liquid, searching and draining water, the setup of waterproof rock seam, the forecast of water inflow volume, we has produced the correlation computational methods, result and the operation craft.

1. Basic situation introduction
Because the continuous development of information technology and its widespread application in practical work, the technology ideas and methods of mine flood preventing and controlling are constantly updated and improved. The processing system integrated hydrogeological information, mining information, expert system, forecast information and plan optimization. Development of the processing system has become the research forefront and hotspot at home and abroad. Many academics join in the research of the mine flood prediction theory and methods actively, but most of them value the forecast result, neglect the establishment, optimization and evaluation of preventing and controlling plans [1,2,3]. Therefore, the development and design of coal mine water disasters prevention and control assistance decision system that integrates the role of forecasting, plan optimization, plan evaluation is very necessary. Based on above reasons, we design and develop the coal mine water disasters prevention and control assistance decision system.

2. Purpose of design
The purpose of research and development of coal mine water disasters prevention and control assistance decision system is realized by using database management system, knowledge and inference base of coal mine water disasters prevention and control expert system. On the one hand, through researching and complete analysis of coal mine water disasters prevention and control data, the system improve the
efficiency of hydrogeological information and provide the assistance decision basis for the coal mine managers.

3. Structure of decision system
The system has the following functions: coal mine water disasters forecast, plan optimization, water inflow calculation, and so on.

4. Function of decision system
The function of design system is shown in Figure 1.

4.1. Expert system module

4.1.1. Expert system overall structure. The module of expert system overall structure is shown in Figure 2.

4.1.2. The construction of knowledge. Knowledge base is the core of expert system, it is used for saving up the knowledge and experience of mine hydrogeological expert, after carding, the knowledge and experience could be classified for two types of theory knowledge and experience knowledge.

(1) Knowledge acquisition

At present, we obtained the knowledge by using three ways of convening symposium, case analysis, summarization and induction. According to the actual situation of the project, we adopted the method of convening symposium and summarization and induction. First of all, we sorted the knowledge into three types by using the type of mine flood[4,5]; second, we consulted many books, papers, monographs, standard, and rule reports about the methods of mine flood prediction and prevention, summarized the prediction and prevention methods of mine flood cases and experience in research area, at the same time we standardized above knowledge and offered initially the inference evidence and evaluation standard of each reasoning process, and moreover, we produced a preliminary document by using the knowledge in the base; the third step, the preliminary document was submitted to experts for inspecting, then we may amend and reinforce the inference evidence and evaluation standard by discussing with experts, in the end we confirmed the contents of the knowledge base.
(2) The construction of knowledge base

Knowledge base includes four aspects, diagnostic knowledge, background knowledge, preventing and controlling files, the process knowledge.

The diagnostic knowledge is the core of knowledge base, it was obtained from the long-term practical work of the expert in the field by accumulation, it was an experience knowledge that found and estimated the mine flood reason from a large number of potential rather than causal relationship between the surface characteristics. According to the mine flood causes, the knowledge could be divided into feature, rule and countermeasure knowledge three types. The feature is a qualitative or quantitative description of mine flood features, the important evidence of diagnostic knowledge and the lowest level knowledge; The rule is an expert experience knowledge that has been reorganized and coded, it is a pattern that be used for expressing the causal relation between features and mine flood; The countermeasure knowledge are treatment measure and government plan that be adopted when mine flood happened.

4.1.3. Inference engine. Inferring new conclusion from the existed rules and facts is one of the main purposes of developing the expert system, the process from the rules and facts to conclusions is accomplished by the inference engine. Today many reasoning theory methods are applied in expert system, but the choice of reasoning theory methods are generally decided by the problem property[6,7]. Coal mine water disasters prevention and control is a complex work, which consisted of three parts, the judgement of mine flood types and the confirmation of mine flood reasons are obtained by using the positive inferential method; the confirmation and optimization evaluation of preventing and controlling plans are obtained by using the negative inferential method; but we adopted the MYCINO imprecise inferential method in the entire expert system.

4.1.4. The construction of the rule. The rule base is mainly used for saving the logical and inferential rules, it is the main component of inference engine. There many are inferential rules in the rule base, and each rule is a sentence, for example "If the condition is content, then this operation will be carried out". Sentences expression:

IF <triggering fact is true > THEN <conclusion fact occur> CONFIDENCE <*>.

If is the condition, THEN is the operation or conclusion, CONFIDENCE is the possibility of operation or conclusion.

For a section of the knowledge or a fact, we always divide them into two parts, IF and THEN. For example, the sentence: "If the acidity of mine flood is too heavy, then flood will be the old hole flood." The sentence can be transformed to the following productive rules:

IF < the acidity of mine flood is too heavy > THEN < flood will be the old hole flood > CONFIDENCE1 <*>;

IF < the acidity of mine flood is too heavy > THEN < flood will be the roof flood> CONFIDENCE2 <*>;

IF < the acidity of mine flood is too heavy > THEN < flood will be the floor flood> CONFIDENCE3 <*>;

Sometimes, the knowledge narrative of the actual problems is not the corresponding relation of IF-THEN, before using, we should convert them into the appropriate form. The expert system is based on the CLIPS--a artificial intelligence language. First, we gather and summarize the expert knowledge, then we establish the rule base of coal mine water disasters prevention and control expert system.

The rule base principle of the expert system: if the confidence or CONFIDENCE of the mine flood feature is a value lower than fifteen in a column, then the value of confidence or CONFIDENCE is zero in the column, else the value of confidence or CONFIDENCE is the minimum in the column. For multi-condition, we adopt devolution analogy by using the same principle.
4.2. The waterproof module of coal mine
According to the rules and regulations of "mine hydrogeological regulations", the module has achieved the calculation of waterproof rock seam.

4.3. The calculation and optimization module of mine dropping pressure by drainage
The module adopts the analytical forecast method of mine flood volume, the method considered problems from many aspects. The calculation schematic diagram is shown in Figure 3. The flow chart of optimization drainage model is shown in Figure 4.

![Figure 3. Calculation structure diagram](image)

![Figure 4. The flow chart of optimization drainage model](image)

4.4. The forecast module of coal mine water inflow
We forecast the coal mine water inflow in unit time by using the hydrogeological analogy method, QS curve method, and so on.

5. Systems development and application
Our data management platform is SQL database, the platform of design and development are Dot NET and CLIPS artificial intelligence language. The purpose of research and developing the system includes three parts: serve the practice, enhance forecast precision, provide technology and measures guidance for the mine hydrogeological workers. The assistance decision system has been applied in Pingdingshan Coal Co.Ltd, Inspection results is good.

6. Conclusion
The system integrates prediction, scheme formulation, parameter calculation, scheme optimization and design, which not only minimizes the disadvantages caused by their single use, but also provides a comprehensive reference for coal mine water disaster prevention and control. However, in order to develop a fully functional and systematic decision support system for mine water hazard prevention and control, it is necessary to improve it in practical application and gradually mature.
Acknowledgments
This paper was supported by scientific research projects of college in henan province (15A170007).

References
[1] Pan Shuren, Establishment of imprecise reasoning model for coal mine water hazard control, Energy Technology and Management, 2006.2.
[2] Liu Guangqing, Yu Xulei, Li Fenghai etc., Expert system for mine roof water hazard prediction and control, The Journal of Hazard and Control, 2001.3.
[3] Liu Weitao, Expert system method for predicting and evaluating floor water inrush, The Journal of Hazard and Control, 2001.6.
[4] Chen Xuexing, Liu Weitao, Zhang Wenquan, Expert system for predicting floor water inrush, Industry and Mine Automation, 2001.1.
[5] Joseph Giarratano, Expert system principles and programming, Mechanical industry press, 2000.
[6] Hua Shanshan, Li Longshu, Research and implementation of CLIPS and high-level language interaction, Development of microcomputer, 2005.10: 65-67.
[7] Wen Guangchao, Zhang Hanrui, Hydrogeological unit division of pingdingshan coalfield[J]. Safety in Coal Mines, 2013, 44(04):38-42.