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SUPPORT SYSTEMS FOR DECISION AND NEGOTIATION PROCESSES

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AN INTELLIGENT AND DISTRIBUTED DECISION SUPPORT SYSTEM FOR RESCUE IN COAL MINES

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Abstract: This paper introduces a computerized support system for use in mine rescue. The system consisting of seven functional subsystems adopts artificial intelligence(AI) and communication network(CN) techniques. After a general description of system's structure, the paper discusses two issues in particular: a) What intelligent support will users need and how much can the system provide. b) How could network facilities be utilized in mine rescue decision making. Finally, an experiment result and some issues to be studied are given.
Keywords: Artificial Intelligence, Distributed DSS, Mine Rescue, Emergency Decision Making, Multi-Node Cooperation.

1. Introduction

To guarantee the safety of miners, security is a very important point in coal production. As underground conditions are extremely complicated, it is difficult to avoid mine disasters absolutely though a variety of advanced protective measures could be taken. Once a certain disaster occurs, prompt rescue will be necessary and critical. However men are limited in their unaided ability to respond to such an eventuality as mine fire or water gush immediately and properly, Sage(1987). To cope with such a problem, we have developed a computerized support system, intelligent and distributed decision support system for rescue in coal mines(IDDSS-RCM), the main feature of which is to employ the techniques of both AI and computer communication network(CCN).

The remainder of this paper is organized as follows. Section 2 describes briefly the features of mine rescue and the role of computerized support system in mine rescue. Section 3 presents the structure of IDDSS-RCM. Section 4 discusses the issue of AI in IDDSS-RCM, what needed and what available. Section 5 discusses the issue of distributed support of CCN, and finally Section 6 gives a summary and some issues to be studied.

2. The Role Of Computerized Support System In Mine Rescue

From the viewpoint of decision science, the mine rescue is a kind of emergency decision problems. The so-called emergency decision typically has following characteristics.

a) The occurence of decision objects is unpredictable or uncontrollable.

b) The decision situation changes rapidly.

c) The consequences will be disastrous and of heavy losses.

d) Decision makers have to make decisions in a passive way.

A knowledge-based and networked computer system will provide facilities to cope with emergency decision problems.

a) To transmit information quickly and precisely.

b) To supply necessary data, models and expertise.

c) To supply visual graphs and tables.

d) To supply a reasoning capability with an expert level.

e) To gain the aids from experts in remote sites.

In coal mines, since the geological structure is varied and underground space is narrow, disasters are easy to spread but difficult to rescue. This implys that what is very important is the early steps of rescuing process, in which the key points are precise information, prompt response, appropriate rescue scenario and coordinative activities.

Obviously a well designed knowledge-based and networked system will play a significant role in mine rescue. IDDSS-RCM is one of such applied systems.

3. Structure Of IDDSS-RCM

In IDDSS-RCM there are five functions, disaster warning, disaster situation report, emergency information inquiry, rescue decision support, and materials and manpower arrangement. To fulfill these functions, a modular system struture as shown in

Fig.1 is presented.

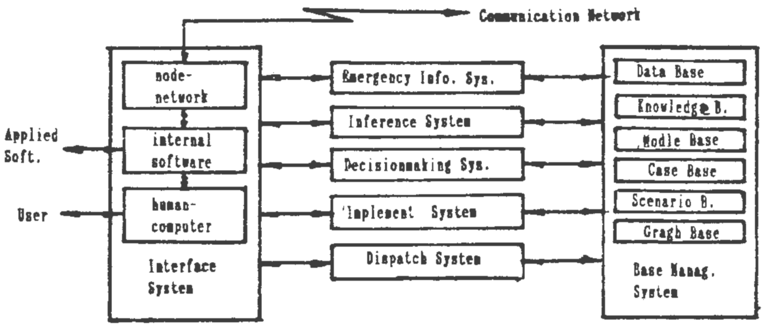

Fig.1 Modular system structure of IDDSS-RCM

The interface system supplys users a user-friendly interface. It includes three branches: Human-computer interface has several forms to input user's information such as multi-item selection, question filling, yes/no answer and time-limited default. Node-network interface links user's programm and network communication programm dynamically and automatically. Internal software interface links the system to other applied systems in the local node, such as a mine safety detection system.

The emergency information system is a quick response module, used at the early stage of disaster rescue. Just a simple key press, stored emergency information will be quickly displayed on the screen. Available information includes the distribution of miners in the disaster area and the optimal route of withdrawal from disaster site etc.

The inference system is a disaster rescue expert system. Since disaster situation is often incomplete and/or imprecise, fuzzy linguistic variables, Negoita(1985), and default logic, Reither (1980), are adopted. That is, if A not true then $\bar{A}$ true. Where A is a proposition and $\bar{A}$ is the negative proposition of A.

By this way the inference system can function normally even if knowledge or information is incomplete and imprecise.

The decision making system is designed to assist decision maker in making rescue scenario by doing two tasks.

a)To simulate the operation of rescue scenarios by using a set of mathematical models and estimate the risk of each scenario.

b) To compare all alternatives according to given criterions, then aid decision maker to select a prefered one.

The implementation system is an intelligent calculating module, used to calculate the amount of manpower and quantities of materials necessary for implementing the rescue scenario.

The central dispatch system is installed in the headquarters of the coal mine only. When a disaster node is unable to accomplish disaster rescue independently, the subsystem will collect and arrange all forces within the whole network to rescue the disaster site. Generally this process will go in three steps. First through communication network the subsystem gets the data about materials available at each node, then runs allocation model with the data as input, finally according to calculated results informs each node to transfer shared materials to the disaster site.

The bases management system executes common operations on the bases and keeps the consistency of each other. The resources of model base, graph base, case base, knowledge base and part of data base can be shared within the network, but rescue scenarios and most data are particular to the local node.

4. Intelligence In IDDSS-RCM

Since most people lack the chance of undergoing eventualities, especially serious disasters, one is apt to lose his nerve when encountering an eventuality. In addition. the individual ability of processing information is unequal to process great amount of information within a short time to cope with such emergency situation as a coal mine disaster. Therefore man's intelligent ability needs to be reinforced.

IDDSS-RCM can partly but effectualy meet the needs by utilizing three categories of expertize.

a) Emergency measures related to various mine disasters.

b) Commonly used rules of rescue.

c) The standards of mine rescue measures.

Several fuzzy linguistic variables are introduced, such as big, fast, far and near etc. Reasoning rules are expressed by fuzzy production rule as well. For example,

Rule1:

if big(fire) with F11 and near(fire site, downcast) with F12

then draught fan reverse with F1.

Where F11 and F12 are degrees of membership of facts big(fire), near(fire site, downcast), respectively. F1 is degree of membership of the conclusion, draught fan reverse, and

$$F1 = C1*MIN(F11,F12)$$

where $0<C1<=1$ is belief factor of Rule1. Only when $F1>T(R1)$, T(R1) is the threshold of Rule1, the conclusion of Rule1 is acceptable and can be regarded as a new fact of other rules.

Upon these knowledge and rules, an expert system is developed to analyses disaster situation and propose rescue measures.

5. Distributed Support Of IDDSS-RCM

Distributed processing and networking have several advantages over a centralized approach. However typically the proposals for networking have focused on one aspect or another without looking at the complete picture, Jacob and Pirkul(1990). A distributed decision support system enables users not only to share models, data and knowledge, but also share the experts who are distributed at different nodes within the network. Whenever a user is confronted with some difficult problems beyond the capability of the computer system, he may ask for help from those who are familiar with his problems but at other nodes with facilities of the network . This advantage is not a simple electric mail but a way of cooperation between distributed nodes, Dai(1992). In IDDSS-RCM, it is performed by network interface module.

For example, suppose the decision maker of a disaster node is perplexed by a certain situation which he has never encountered before, then he can consult an experienced expert at another node. The consulted expert will analyse the information received from the disaster node, and offer a rescue proposal, then transmit it to the decision maker for his reference. Since this exchange process is automatically finished by network interface module, it seems as if the decision maker possesses the same intelligence as that consulted expert. In this way the user's intelligence is reinforced.

6. Conclusions

In this paper a practical system and its main features are introduced. We view a computerized support system as a human-computer-human interaction environment, and human experts can be shared as well as other resources. We have examined the system under simulated situations on a network consistintg of a SUN SPRAC 1+ and several IBM PC/AT's. The performance test shows that the system will be usefull as a decision support tool for mine rescue.

Certainly there are still lots of issues to be studied for further improving the system, such as automatic knowledge acquisition by learning from paradiams, and reduction of possible decision conflicts between distributed decision makers. We intend to explore these issues in order to make computerized support systems more effective.

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