Research on mine emergency rescue command system based on chambers

ZHAN Zina, JIN Longzhe, CAO Zhaoni, JIAO Shanshan, BAI Nan*

Civil and Environmental Engineering Institute, University of Science and Technology Beijing, Beijing 100083, China

Abstract

With the all-around advance of the “six systems” construction in mine, including the emergency chamber system playing an important role in mine production safety and refuge. Through the research of the disaster emergency decision in mine and geographic information System (GIS), the paper brings forward that the GIS makes significant in emergency aid-decision. Based on the emergency chamber system, it shows the basic method and module function of the system construction, not only which contains the rich and powerful data and knowledge base of emergency aid-decision, but also has the dynamic display of disaster control simulation and optimal escape route selection based on emergency chambers. The system can provide technical support to the Emergency rescue Command in mine production.

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Keywords: emergency systems; GIS; rescue command; disaster analysis; optimum escape route

1. Introduction

Over the past decade, the death toll in coal mine accidents in China is up to more than 80,000, according to the analysis of accidental death, only 10% of the death immediately died of the moment injury of gas outburst, fires, explosions, and other accidents [1], over 80% of the others were killed due to the exhausted oxygen in around areas, the toxic gases of high concentrations and unclear or blocked evacuation routes, which were leading refugees not to escape from the dangerous site and not receive treatment timely [2]. Thus, the painful lessons require that an effective security system is constructed as soon as possible, emergency rescue command system in mine is established for emergency training and exercises in normal times and for risk avoiding and rescue in emergency to do accident prevention and rescue work and to avoid more and more miners injured.

With the all-around advance of the “six systems” construction in mine, emergency refuse system was newly proposed [3-4]. Because the research is still in the primary stage in China, the important issues to be solved urgently regarding safety and rescue in mine are how to maximize the role and function of the emergency refuge system, how to guide mines to enter the chambers within the less time in the disaster, how to determine the optimum escape route in the complex environment of disaster. Therefore, the paper describes the construction of emergency rescue command system in mine based on chambers.
2. Mine emergency rescue command system and WebGIS

2.1. Mine emergency rescue command system

Once the occurrence of disasters underground, such as gas outburst, gas explosion, fire, water inrush and roof accident, because of more restrictive factors and complex and changeable situation of mine emergency rescue, the rescue in mine has more technical, timeliness and greater risk compared with other industries, carried out with close co-ordination of the rescue teams and centralized control [5]. The emergency chambers provide the living space for underground mines and a longer prime-time for rescue. But due to relatively closed underground space and limited escape and rescue space, the distress mines often escape blindly and confusedly, causing crowded, even through the fire district or water district, which will be resulting in greater danger. So if the underground distress mines could not be commanded to escape from the dangerous sites, it could not only cause the emergency chamber system not playing a maximum function and role, but also major property damage and more serious casualties.

The purpose of establishing Mine Emergency Rescue Command System is [6]: (1) In the event of disaster occurring, to control the risk source, to avoid the expansion of disaster affect, to eliminate the risk as far as possible; (2) to quickly organize rescue, to schedule personnel and material, to master the disaster development, to command the miners in distress to evacuate; (3) to reduce disaster damage, casualties and property losses as much as possible. So the system not only include the information of the physical space of the spatial layout of the risk source underground, mine environmental monitoring situation, the layout of emergency chamber facilities and emergency rescue force and so on, but also has the function of the real-time display of mine disaster development and affect, such as fire, gas outburst, gas explosion, water inrush and roof accident, as well as the display of the optimum route based on the emergency refuse facilities.

2.2. Application of WebGIS

Geographic Information System (GIS) is a computer system for storage and processing of spatial information through the effective management of spatial information and other types of information, so that a large number of abstract and boring data becomes vivid, intuitive and easy to understand, to improve work efficiency and management of scientific and accurate[7].

WebGIS is a geographic information system based on browser / server mode, clients can operate the system simply only through a common browser, by which any users can get the information needed and the services that server provides. Meanwhile, WebGIS has good scalability and openness [8]. Graphical information processing functions of WebGIS could achieve dynamic simulation of the various elements taking advantage of the three-dimensional dynamic simulation technology, not only including the spatial distribution data of various elements, but also including its attribute data, avoiding the phenomenon of separation of graphics and its attribute data; WebGIS has a uniform database management system to facilitate system integration and information sharing; and WebGIS has a unique spatial analysis function that it can take advantage of its spatial and attribute database combine with efficient algorithms for spatial analysis.

WebGIS is introduced to the mine disaster control and simulation and emergency rescue command system, combining perfectly with disaster information and emergency rescue information, it is significant to construct the powerful mine emergency command system based on WebGIS.

3. Structure and function of mine emergency rescue command system

3.1. Overall structure of the system

According to the analysis of system requirement and development objective, mine emergency rescue command system based on chambers includes: the module of mine decision-making system, the module of emergency rescue force, the module of rescue total control, emergency training and exercises module, system maintenance module, disaster handling support module, etc. The structural framing is shown in Fig 1.

(1) The module of mine decision-making system

The module has the essential function of maintenance and management of the basic mine information, mainly constituted by the mine-related distribution of electronic maps and the related database, including the mine situation database, major hidden disaster information database and mine safety monitoring information database, as well as the distribution of the working force, the layout of underground emergency facilities, underground telephone arrangement. And Safety monitoring information database includes coal dust monitoring database, database of gas monitoring of the working force, the
information database of underground self-rescuers and the information database of environment monitoring of emergency chambers.

(2) The module of emergency rescue force

The module is the core of the mine emergency rescue personnel and materials, which has the basic functions of maintenance and management of mine emergency rescue, including emergency plans, the database of emergency rescue teams, the database of emergency experts, the database of scheduling contact ways, the database of relief equipments, medical care information and the information of internal mine rescue bases distribution, Emergency plans of the actual situation developed for the mine and universal plans of mine safety are queried in the database of emergency plans.

(3) The module of rescue total control

It is the core of the mine emergency rescue command system, which has the basic functions of maintaining and managing organization, command and scheduling of mine emergency rescue, and provides a complete solution for mine emergencies and disasters. The module can achieve information query, graphics editing, attribute update of the basic situation of the mine, the main disaster hidden information and rescue force and resources, forecasting the disaster development and choosing and showing the optimum escape route. The module mainly include the sub-module of disaster analysis, emergency response procedures and responsibilities of departments and leaders, escape route information underground, the sub-module of the rescue power dispatch and external emergency resources scheduling. And the sub-module of disaster analysis could achieve the dynamic display of analysis and forecasting and sphere of influence about gas outburst, coal and gas explosion, fire, water inrush and roof accident, and draw the dynamic routes based on chambers underground. Thus it is to facilitate the leaders to activate contingency plans and schedule rescue forces in a timely manner in the event of disaster occurring, and trend forecasting of disaster evolution can effectively help decision makers control the disaster situation and command escaping and rescue so as to minimize damage and casualties disaster causes.

Fig. 1. Structural framing of the modules in the system

(4) Emergency training and exercises module

The module implements paperless office and information sharing of online training and drills learning for the particularity of the operation of the mine production safety and the emergency facilities, possessing the basic function of
(5) Disaster handling support module

It provides the files and contents in the form of knowledge base and video database about disasters handling ways, the operation procedures of the emergency facilities and safety laws, regulations and procedures and so on, to improve the speed and level of coordination of the mine emergency response and rescue, helping decision makers take appropriate measure timely to cope with mutations of disaster. In accordance with the five major disaster types underground, The module can integrate information about emergency response measures, the specialists and equipments according to disaster characteristics. Furthermore, the emergency operating procedures and videos could help decision-makers command refugees operate, use and regulate equipments and systems of chambers in emergency.

(6) System maintenance module

Based on database and knowledge base, system environment is built, combined with a good user interface and user-computer dialogue process, the three managers of the system are defined, according to the different departments and responsibilities, implementing every level administrator operate the system database and knowledge base in different permission, and effectively achieving query, editing and analysis of the mining and excavation map and ventilation system map, to ensure stability and security of database and knowledge base, as well as mine electronic map.

3.2. Organizational design and function of the system

(1) Design ideas

The system is designed with the instruction of object-oriented thought, combined theory and practice, adopting multi-level browser and the server (Browser / Server) structure of the system and making full use of Geographical Information System technology. Thus it is programmed with Visual C #, which possess the powerful SQL Server 2008 database to facilitate future database expansion and ensure the safety and feasibility of the database, considering the data sharing with the combination application of existing internal office network in mining enterprise because of more data tables. The system of mine emergency rescue command is developed to achieve the efficient, rapid and orderly mine rescue and minimize and reduce casualties and property result from disasters underground.

(2) Data Display and Functionality of the system

All data for being queried and displayed is stored in the database of the system. When some feature information needs to be queried, firstly WebGIS maps the surface object information in the spatial database of the feature map layer, then the system retrieves the associated attribute data in accordance with the relevant fields in the spatial database, finally, the object information is integrated and displayed in the form of the chart.

The flow of the system function is shown in Fig 2, through the transmission data in the basic information module of safety monitoring and the historical data in the mine basic information module is imported and analyzed , the system could shows the real-time changes on mine laneway electronic map, and carry out the acquisition and analysis the dangerous source underground, once monitoring equipments in laneway develop abnormal situations or sound the alarm, the system is able to analyze and determine the type and the location of underground disaster occurring with the monitoring and control system and mine communication system. The system can achieve the analysis and display the influence degree and scope of the disaster according to the analysis of underground monitoring data or historical data. And the optimal escape routes could be chosen and shown on the map based on the location of miners and the distribution of the chambers underground, and the system could automatically determinate the appropriate disaster contingency plans, and automatically integrate and show the information about measures, appropriate experts and relief equipments in order to schedule and command the emergency work, and achieve the high efficiency dispatch of emergency rescue force. When the external resources are needed, the 26 rescue bases on the whole country are shown on china map, the specific equipment information of every base are listed in form of the figure. And the optimal dispatch program could not only be achieved in the external resource dispatch sub-module, but also the optimal dispatch route is shown on the china map.

3.3. Application

The system has applied in Changchun mine attached to LU’AN group in Shanxi province, achieving the dynamic display of analysis and forecasting and sphere of influence about gas outburst, gas explosion, fire, water inrush and roof accident, and drawing the dynamic routes based on chambers underground. It brings in multiple functions taking into account following extensibility, and the system is effectively combined with existing “six systems” developed in Changchun mine.
The results proves that the system contributes to the day-to-day management and mine emergency rescue capability and efficiency, and supplies a new, informationalized and intelligence platform.

4. Constructions

Mine emergency rescue command system was developed based on chambers, including the 7 modules (the module of mine decision-making system, the module of emergency rescue force, the module of rescue total control, emergency training and exercises module, system maintenance module, disaster handling support module).

The system combines the physical property with data attribute of the underground map based on WebGIS platform, integrating the information of underground laneways, mining faces, a variety of relief equipments and others for centralization of information management and resource sharing. Meanwhile, it was developed and achieved to forecast the areas disaster affects, select the optimal escape route based on the chambers underground, supply the disaster management program and counter-plans in order to carry out the scientific, normative management, as well as timeliness, accurate response.

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