A GIS Based Emergency Management System for Daqing

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Abstract: Recently kinds of natural disasters broke out and did wonderful damage to cities. Emergency management becomes an important part of city management. At the same time, the value of GIS in emergency management rose quickly. As an example, a design of a GIS based emergency management system for Daqing is presented in this paper, whose function is to assess the dangerous hazards, forecast the disaster damage, evaluate the losses of the emergency accident and make a quick emergency response. The structure of this system, the structure of database and the function of each module are totally stated in this thesis. However the mathematical models of this system need more researches.

Keywords: emergency management; GIS; major hazards supervision; emergency rescue

1 Introduction

Emergency management is defined as the discipline and profession of applying science, technology, planning, and management to deal with extreme events that can injure or kill large numbers of people, do extensive damage to property, and disrupt community life. In recent years, all kinds of natural disasters frequently broke out, such as tsunami, earthquake, volcanic eruption, flood and extreme weather events. These natural disasters have led to enormous damage to cities and they are especially dangerous for cities with petrochemical enterprises, because that the material and product of petrochemical enterprises are flammable and combustible.

Daqing is located in the northeast part of China with population of two million and territory of 22000 sq km. It is a city that is rich in oil resources, so there are numerous petrochemical enterprises[1]. Under this circumstance, the establishment of emergency management system for Daqing which aims at reducing the losses from natural disasters seems quite essential. Due to previous data, natural disasters threatening Daqing are mainly earthquakes, tornados and freeze disaster, so the natural hazard supervision should be focused on these three aspects.

In recent years, the value of GIS in emergency management arises directly from the benefits of integrating a technology designed to support spatial decision making into a field with a strong need to address numerous critical spatial decisions. Although it has been proved that the use of GIS in emergency management is increasing, it is still a relatively young academic research area with only a few referred journal articles. This emergency management system is a GIS based system. It can be used for major hazards supervision, disaster damage forecast, quick evaluation of losses and decision-making for emergency response as well as post-disaster recovering. The foundation of this system is ArcGIS, and it also integrates many other computer technologies, for example, the multimedia technology.

The overwhelming majority fundamental information of Daqing is stored in database. So, in normal times, the system will contribute to city daily management[2]. However, when a natural disaster happens, it will provide the background information of disaster, calculate the influence coverage of disaster, evaluate the losses through the models established in this system, make a reasonable emergency response and help leaders make a proper rescue scheme.

2 Structure and data basis of the system

2.1 Four-tier structure system

The petrochemical enterprise emergency management system use four-tier structure system[3]. The first tier is called Geographic User Interface tier and its function is accepting request and displaying data information, particularly long-distance entering and browsing. The second tier called GIS Server tier is composed of Web Server and GIS Application Server and it is used in application handling processes. The third tier is GIS Data Storage tier, including normal attribute database and geo-spatial database, and the most important function of this tier is data management. The last tier is On-site supervision monitoring the major hazards. If emergency happens, the system can receive the information as soon as possible and make a quick response. The structure of the emergency management is showed in Figure 1 followed.

2.2 Structure of database

In the database of this system, there are three kinds of data, which are basic information, security information and geographic information. They are mutual independ-

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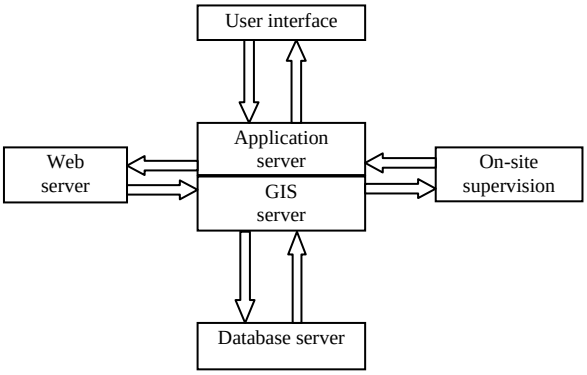

Figure 1. Four-tier structure system

ence and combination. The structure of database is showed in Figure 2.

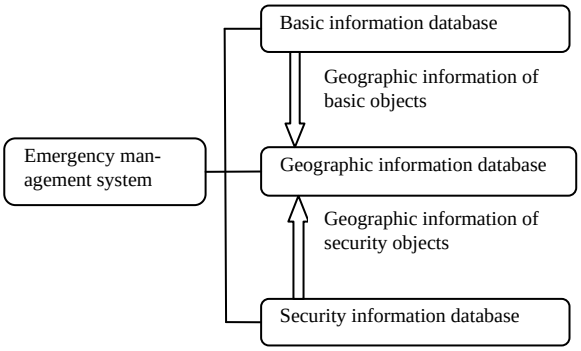

Figure 2. Structure of database

Basic information database is used to organize and store attribute information of objects, usually these objects do not have danger themselves, and these information are collected for giving support to city security management and helping make the correct plan of emergency rescue. Basic information database consists of data of road, population, lows and regulations, dangerous chemical, geography and weather, incident examples, and so on.

Security information database goes to store information of objects with not only attribute information but also geo-spatial information. This database includes hazards database, emergency rescue database, emergency response plans database, accident records database, and so on. In hazards database, basic information of hazards is saved, as well as geographic information like geographic location and distribution of hazards. Emergency rescue database shows requirement and distribution of rescue power. Emergency response plans database and accident records database, just as their names suggest, are about response plans of emergency and records of accidents.

Geographic information is made up for conserving geographic information of objects, such as roads, water supply network, gas supply network, petrochemical enterprises, important buildings, major hazards, fire station, schools, hospitals, and so on. The geographic location distribution information of these objects mentioned above is quite clearly displayed in the electric map built in the system, so as to make these elements always visible and accessible.

3 Function modules of the system

The emergency management system for Daqing is divided into six modules, which are basic information management module, major hazards management module, natural hazards supervising module, emergency rescue module, geographic information management module and system management module. Each part of the system has its particular function that can't be replaced, and each module is made up with several sub-modules.

3.1 Basic information management module

The role basic information management played in this system is Daqing basic information supporter. Using this module, we can input, modify, delete, inquire and export information of geographical meteorological information, safety laws and regulations database, typical accident cases database. Information of population, land and property can also be edited and modified. In addition, information of dangerous chemical, without doubt, is indispensable. Dangerous chemical database includes major hazards' critical value database, dangerous chemical safety technique characteristic database, disposal plans for dangerous chemical and the first aid methods of dangerous chemical poisoning.

3.2 Major hazards management module

The second module called major hazards management module manages urban hazards in visual, quantitative, grading way, making it realistic that hazards can be declared online and identified automatic, and the effect of hazard accidents can be evaluated[4]. To ensure major hazards' information can be updated anytime and improve work efficiency, some hazards' subordinate units owning an account and password can surf the internet and input information of new hazards. If the information entered has been confirmed, it will be formally added to the database[5].

Because of hazards including two kinds: chemical hazards and other hazards, this system should take different methods when automatic identifying major hazards. To chemical hazards, we take the method of estimate their content of dangerous substances, and when its content exceeds the critical value formulated by laws and regulations, it will be identify as a major hazard. However, to other hazards this system uses death radius method to identify. The most important function of this module is analyzing the effect of hazard accident, quantitatively describing casualties and property loss and environmental pollution caused. Because the most possible

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accidents of petrochemical enterprises are dangerous goods leakage, fire or explosion, in this system there will be three different mathematical models established directing at these three kinds of accidents. On the basis of these mathematical models, this system can conduct the accident simulation and analysis. At last, the influence scope and endanger scope will be mapping out in the electronic map. This process is showed in Figure 3 followed. Real-time long-distance monitoring of major hazards is also of great value. Every web cameras settled in different units are linked to the electrical map for convenient click.

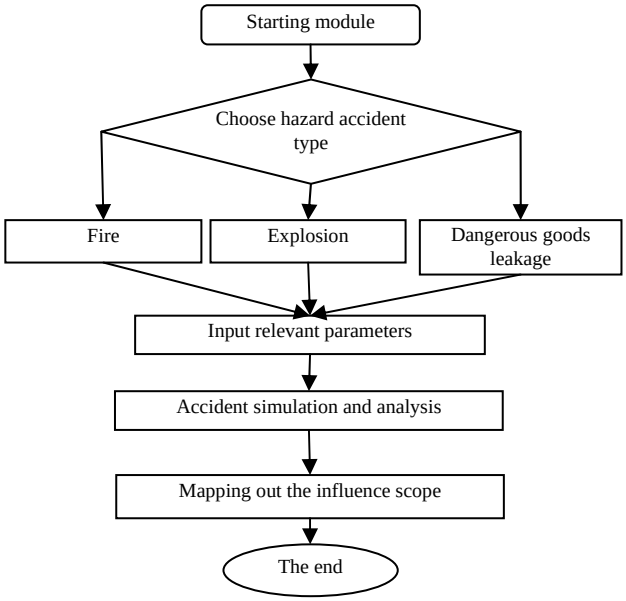

Figure 3. Function process of major hazard module

3.3 Natural hazard supervising module

Considering the fact of Daqing, natural hazard supervising module mainly focuses on earthquakes, tornados and freeze disaster. Three natural hazards bring not only the direct lose but also the secondary lose. The direct lose is caused by natural hazards themselves, such as damage of buildings led by earthquakes and tornados. To evaluate this kind of loss, models of different hazards need to be built. Nevertheless, the secondary lose is caused by major hazards which are brought by the natural hazard accident, for example, the death brought by poisoned-goods-leaking because of freeze breaking its hutch. To evaluate this kind of loss, natural hazard supervising module must be connected to major hazard management module. Finally this module will gain the effect of natural hazards accident, quantitatively describe casualties and property loss and environmental pollution caused and map out the influence scope.

3.4 Emergency rescue module

Emergency rescue module is set up to help leaders of petrochemical enterprises make correct and seasonable decisions[6]. In this module, rescue power and equipment for emergency are efficient and scientific management, providing foundation to compiling the pre-arranged rescue plan. Users can use this module to fix the accident location, inquiry the surrounding environment and know the rescue power distribution and the structure of rescue organization. When an accident happens, the system controllers receive the information and input information to the system. The system starts to calculate the effect of the accident and choose a proper rescue plan from the pre-arranged rescue plan. The analysis consequence will be really important for leaders to make decisions. In this process, information feedback from site of accident must be added to the system at any time[7]. The whole process is showed in Figure 4 followed.

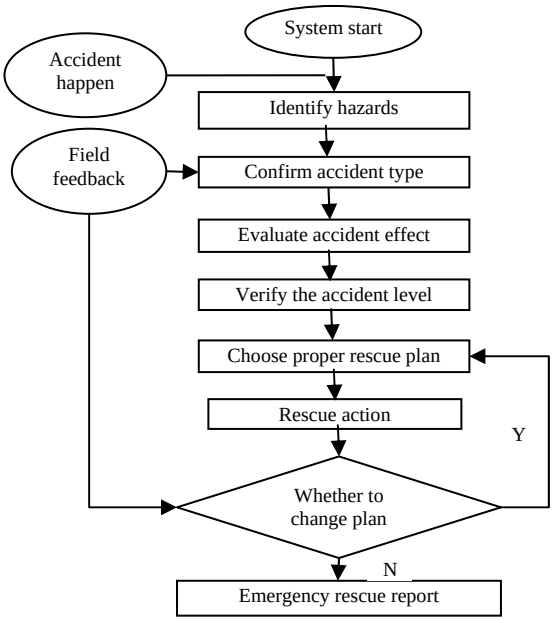

Figure 4. Process of emergency response

3.5 Geographic information module

Geographic information management module provides a series of functions of operating the electronic map, such as zoom in, zoom out, remove, control, preview, print the map, and so on. Users privileged can also add, delete and modify the selected special layers.

3.6 System management module

System management module is only allowed to the system administrator and special users. They can establish, delete and inquire accounts; what's more, they also can tidy, duplicate and recover the data block.

4 Conclusions

The petrochemical enterprise emergency management system for Daqing is a GIS based system, with the func-

tion of hazards assessment, natural disaster damage forecast, quick evaluation of losses and emergency response. It is no doubt that this system will be useful and helpful to Daqing petrochemical enterprises.

However, the focus of this article is just introducing the design of the whole emergency management system, so introduce of mathematical models is lesser. Chosen of different mathematical models will also have big affect on the results. To ensure the system function as well as supposed and achieve an accurate consequence, more research on which model to choose for different hazards is absolutely necessary.

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