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Application and analysis of geographic information in geological disaster response

Yubin Zhang[1]

[1]National Earthquake Response Support Service, Beijing 100049, P. R. China

617650460@qq.com

Abstract. With the development of remote sensing, satellite positioning and big data integration technologies, the application of geographic information in various stages of disaster response has been promoted. In this paper, the application of geographic information in disaster collection, assessment and trend is introduced according to the characteristics of China's geographic topography, and the geological disaster is then taken as the research object the trend of secondary disaster (i.e.,landslide and barrier lakes) after the occurrence of earthquake by geographic information technology. Specifically, the positioning of public opinion information and extraction technology and the professional information of disaster factors stack technology are integrated into the data layer of the information system to analyze the trend in detail by combining with the mathematical model, which is of great significance for future geological disaster response and rescue.

1. Main feature of geological hazards

1.1 The feature analysis

China has a huge territory and a complicated geological structure. It bears 30% of the global strong earthquakes, and is the country with the largest number of them, even though it covers 1/15 of the world land area. Additionally, the mountainous areas in China account for about 2/3 of total territory. Due to the frequent occurrence of landslides caused by earthquakes, China has become one of the countries with the most serious geological disasters. Generally, the three main characteristics of geological disasters include suddenness, danger and continuity.

(1)The suddenness

The geological disasters such as earthquakes and collapses are difficult to predict accurately with existing technologies, which is a field that has not yet been understood by human beings.

(2)The danger

The geological disasters have caused terrible injury to human beings. For instance, 240,000 people died in Tangshan earthquake in 1976;Wenchuan earthquake in 2008 caused 70,000 people died; Yushu earthquake in 2010 caused about 3,000 people died; In Zhouqu debris Flows in 2010 about 1,500 people died; Ludian earthquake in Yunnan province in 2014 caused 600 people died.

(3)The continuity

The occurrence of geological disasters often leads to the chain reaction of secondary disasters, which makes the single disaster have continuity. Using a case of earthquake, we can observe the following phenomena according to the characteristics of geographical location and geological structure: a. The phenomenon of liquefaction of sand soil will accompany the occurrence of earthquake, resulting in surface collapse. b. If it is close to the coast, there will cause a tsunami. c. If it

is close to the mountains, there will not only cause the collapse and landslides of mountain, but also lead to soil and gravel blocking the river channel, thus forming a barrier lake. This makes the water level to rise rapidly, and then leading to dam failure.

1.2 Analysis of geological disasters

Example 1: Indonesia is located at the junction of three plates (Asia-Europe plate, Indian Ocean plate, and Pacific plate) around the Pacific seismic volcanic belt. In 2004, the tsunami triggered by a 9-magnitude earthquake killed about 230, 000 people. In 2018, a 7.4-magnitude earthquake with the liquefaction of sandy soil gave rise to the ground collapse and finally buried the whole village.

Example 2: Tibet in China is located near the intersection of the Asian plate and the Indian Ocean plate, where the crustal activity is highly active, and low-level earthquakes occur frequently, leading to unstable mountains and soil. The terrain in the east not only is very rugged and relatively steep, but also has adequate rainfall due to the southwest monsoon along Brahmaputra, which is prone to landslides, collapses, debris flows. On October 10, 2018, the landslides occurred in Jiangda country, Tibet autonomous region, and Baiyu country, Sichuan province, resulting in the blockage of the mainstream of Jinsha river and formation of a barrier lake with a length of about 5600 meters, a height of more than 79 meters and a width of about 200 meters. At 17:40 on November 3, 2018, two landslides occurred in the original landslide location in Baige village, Boluo township. The huge financial and material resources were lost, although the flood was drained successfully by the technical intervention.

The two examples above demonstrate fully the characteristics of geological hazards, and show that the existing science and technology have not the function of prediction. The loss caused by disaster can be effectively reduced from three aspects by using geographic information technology after a disaster strikes. Therefore, this paper analyzes the application of geographic information technology in disaster collection, assessment and trend judgement, which will be an important development direction of scientific and standardized geological disaster response.

2. Disaster collection

When disaster strikes, the state emergency response agency will immediately start the emergency response. Given that the information must be real-time and accurate for decision making, the disaster information includes basic information and real-time information.

2.1. Basic information

The basic information consists of relatively stable information such as geographical location, geological structure, administrative division, population density and transportation networks. As the original database, it should be invoked at any time. The spatial information technology proposed firstly in the 1960s has been developing rapidly in China since the mid-1970s, which takes the Remote sensing (RS), Geographical Information system (GIS) and Global positioning system (GPS) as the core, and is based on the computer and communication technology. The Spatial Information technology is a comprehensive and integrated information science and technology for the collection, measurement, analysis, storage, management, display, dissemination and application of information relating to the distribution of the geospace [1]. In the past decade, due to the wide application and development of space information technology in China, a complete land geographic information system has been established, and widely used in local production and life with a high degree of integration. The comprehensive application of these technologies provides a guarantee for us in quickly extracting the basic information of the disaster area.

2.2. Real-time information

The real-time information includes whether communication, water supply, power supply and traffic lifeline are normal, the number of victims and the distribution of victims, and is divided into professional information and public opinion information.

2.2.1 Collection of professional information

After the disaster, the professional information serving the decision-making system must meet two requirements, i.e., timeliness and accuracy. Presently, the Remote Sensing (RS) technology has become an important means of disaster collection and assessment, which can quickly provide remote sensing images with a resolution of one meter, and has the characteristics of wide, fast and intuitive observation range.

The realization carrier of remote sensing has different types and characteristics. China's meteorological satellites and MODIS satellites with medium resolution have become important means of large-scale disaster dynamic monitoring due to its high time resolution and wide imaging range. The radar remote sensing, which have the function of all-weather data acquisition and certain penetrability, can penetrate clouds to obtain information about the situation of ground disasters when the weather conditions are bad. The disaster situation is accurately judged by comparing the images before and after disasters. Additionally, a clearer display can be got by adopting the France's SPOT, U.S. QuickBird and some image data. Media data has gradually become an important means of obtaining disaster information in disaster areas.

2.2.2 Collection of public opinion information. The mining of information data has become a frontier subject nowadays. With the gradual improvement of big data retrieval and analysis functions, the targeted extraction of disaster information from social media data has gradually become a crucial means in acquiring the disaster information in disaster areas. The popularity of smart phones is the basis for achieving the above goals, as well as the nodes for providing sufficient information sources and locating. According to the 42nd statistical report on Internet development in China released by CNNIC, as of June 2018, the number of internet users has reached 800 million, including 750 million smart phone users.

The LBS (Location Based Services) technology refers to the positioning of geographical location through mobile terminals (smart phones) on the basis of geographic information technology, and the cooperation with the base station network of mobile operators, thus determining the actual location information of mobile users and providing value-added services related to location information. In short, this technology allows us to obtain three key points through a single social information, namely, time, content and location. When a disaster occurs, the important disaster information can be extracted by using LBS to analyze the big data in disaster areas.

In short, this technology allows us to obtain three essential points namely, time, content and location.

For example, in Jiuzhaigou earthquake in Sichuan province on August 8, 2017, the number of micro-blogs published by mobile terminals after the earthquake is far greater than that before the earthquake, as shown in Figure 1. This provides a large number of data sources for the information extraction after the disaster, and determines the distribution location and number of victims, thus assisting the expert system to making decision.
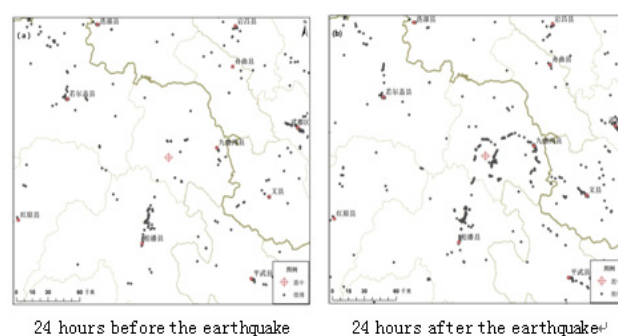

24 hours before the earthquake   24 hours after the earthquake

Figure 1. Micro-blog heat map.

There are extreme situations, i.e., the information in disaster areas acquired by searching the signal. This means that there are power and communication outages, which can judge that the disaster is very serious.

3. Disaster analysis

The disaster analysis is an important basis for correctly understanding disasters and formulating disaster rescue plans. Its assessment has different contents due to different types of disaster and different changes of regions. According to the factors involved in the disaster, the disaster analysis method can be divided into the causing disaster factors, the disaster environment and bearing body, where the disaster is determined by the first two methods. In the disaster assessment, the influence of the former on the latter is analyzed through the relationship between the disaster and its bearing body [2].

The basic principles based on GIS and RS to assess the disaster loss are as follows: a. The spatial distribution information and loss degree of disasters are obtained by using the RS technology to monitor and extract the natural characteristic index of disasters. b. The spatial distribution of disasters and spatial distribution of its bearing body are superimposed to calculate the disaster loss and spatial distribution information by the social-economics data before disaster provided by GIS database and the spatial analysis function of GIS.

We can intuitively understand the scene of the disaster area (as data layer) through the geographic information system, and explore the disaster mechanism (as task layer) through the mathematical model. The combination between them can be used as a means of disaster analysis.

In the case of different content, processes and means of seismic risk assessment, the assessment methods are different. The common methods are used in the seismic risk assessment by combining with GIS include logistic regression method, analytic hierarchy process (AHP), artificial neural network (ANN), deterministic coefficient (CF) method, etc. [3]. Additionally, there are other research models, such as simplified Newmark displacement model. In the actual seismic risk assessment, the mutual verification mode of multiple evaluation methods can make up the shortages of one method according to the difficulty level of data acquisition and the accuracy of basic data [4].

4. Disaster trend

The disaster response includes rescue and prediction, which are guided by the results of the disaster analysis. Meanwhile, the rescue operation is also guided by using the predetermined results, thus ensuring the efficiency and safety of rescue.

4.1 Importance of post-disaster prediction

When disaster strikes, it is necessary to accurately determine the disaster-causing mechanism and prediction whether a secondary disaster occurs. If there is a possibility of secondary disasters, it needs to determine the type and location of disasters and quickly organize preventive measures, since the geological hazards have the risk of continuous disaster. For example, an earthquake can cause a mountain to crack and loose rock, and eventually collapse or slide. When the collapse or landslide occurs, the downstream river channel will be affected, thus forming a barrier lake. However, its dam can withstand how much load and how fast the water level rises, which needs to organize the response plan by using the analysis results of the previous step to simulate and deduce the trend of disaster occurrence and give a relatively objective risk probability. The landslide is taken as an example to explore in the following.

4.2 Application of GIS in landslide prediction

Traditional prediction for the seismic landslide is mainly based on qualitative evaluation, relying on the data obtained by field survey and measurement, and the drawing and calculation are completed manually based on these data. However, manual operation can result in low efficiency and accuracy [5]. The geological disaster evaluation, division, risk assessment and digital simulation in the process

of disaster occurrence can be realized by combining GIS with mathematical model and expert system. Presently, the method with the combination of GIS technology and geohazard spatial prediction model has become a new trend of geohazard risk assessment and early warning research [6]. The existing factors causing landslides can be extended to predict the spatial location of future landslides [7], which requires a comprehensive analysis of geological factors related to the spatial distribution of landslides. Generally, the statistical analysis models are adopted for this kind of analysis, since they are mainly used for the environmental analysis of the existing geological structure of landslide. On this basis, the danger level is obtained and the risk probability is divided by using the mathematical methods [8]. In a word, GIS has become an ideal tool for analyzing the disaster-causing factors in the prediction and evaluation of geological hazards.

5. Conclusion

In this paper, the application of technology in obtaining, analyzing and applying disaster information is introduced firstly, and the method of seismic public opinion analysis is then proposed by combining with the developing geographic information technology. This is conducive to promoting the standardization and efficiency of disaster response of relief agencies and reducing the harm of geological disasters to the country. The research in this paper is still at the initial stage. In order to improve the accuracy of prediction analysis, we will increase more coupling studies of different evaluation models in the future.

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