DESIGN HUMAN-COMPUTER INTERACTION SYSTEM TO BUILD ISOSEISMAL.

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ABSTRACT :

Firstly the Earthquake Prevention and Disaster Reduction System is introduced briefly. This GIS-based system can generate an isoseismal automatically from given earthquake by regional experiential attenuation relationship, and assess the damage, economic loss, total of casualty and number of homeless people. Lindian earthquake (2005, Ms=5.1) case is analyzed in detail to show that the problem of assessment by EPDRS. To deal with the problem, new information must be considered to improve the assessment accuracy of isoseismals. The idea to add Human-computer interaction module into the system is described by Wenchuan earthquake case (2008, Ms=8.0). Collect the information from internet to get the intensity of disaster zones. Modeling the Int-variable value by mathematic methodology to calculate isoseismals. The assessment's accuracy can be increased in the new system.

KEYWORDS: GIS, isoseismal, Human-computer interaction, rapid assessment, emergency decision

1. INTRODUCTION

Earthquake is one of the main disasters to humankind. Once a destructive earthquake happens, build isoseismal quickly can be very helpful for the government to quickly make decision of emergence response. In China, there are dozens of cities and large enterprises built their own special systems based on GIS to help prepare initial damage assessment maps. The kernel technology of these systems is based on the experiences of the past earthquake. The methods to build isoseismal mainly rely on the basic earthquake parameters and the intensity attenuation law [1, 2, and 3]. Whether those systems useful or not is worth studying on, especially needs more earthquake cases to validate and develop [4]. Several cases have been presented to show the usability and problems in this kind of system. New information source such as remote sensing and internet are important to consider solving the problem in the old system.

Wenchuan earthquake (M_s=8.0) happened on May 12, 2008. In this paper, the information from internet had been used to amend the isoseismal calculated by the intensity attenuation law.

2. EPDRS

Earthquake Prevention and Disaster Reduction System (EPDRS) is a self-contained software system with good function of earthquake prevention and disaster reduction. It mainly consists of the building damage evaluation system, lifeline damage evaluation system and assistant decision making of earthquake damage system [4]. The basic database of this system includes the regional seismic tectonic environment, the engineering ground situation, the constructions and the lifelines etc. subject coverage.

The damaged areas of buildings, damaged length of highways, bridges or pipelines, damaged number of electric power or communicate facilities in 5 damage states from scenario earthquake can be assessed very fast. Once obtained the basic earthquake parameters from the seismograph, the system can immediately build the isoseismal by using the earthquake intensity attenuation relationship. The influence region of earthquake can be obtained by the spatial operation function of GIS. According to the vulnerability matrix the earthquake damage's categories and distribution of buildings can be assessed, and then the economic loss can be evaluated on based of the loss ratio and the corresponding total worth of the buildings, and the losses of life also be evaluated. The system can create the earthquake damage report; and make emergency response programs including the rescue of the hypo-disasters, the best ways of evacuation and succouring the wounded, the project of rush repairing the lifeline and delivering the succour material etc.

EPDRS is a powerful tool to perform spatial analysis and mapping of losses due to a scenario earthquake. The damaged areas of buildings, damaged length of highways, bridges or pipelines, damaged number of electric power or communicate facilities in 5 damage states from scenario earthquake can be assessed very fast.

3. ANALYZING THE ASSESSMENT FUNCTION of EPDRS

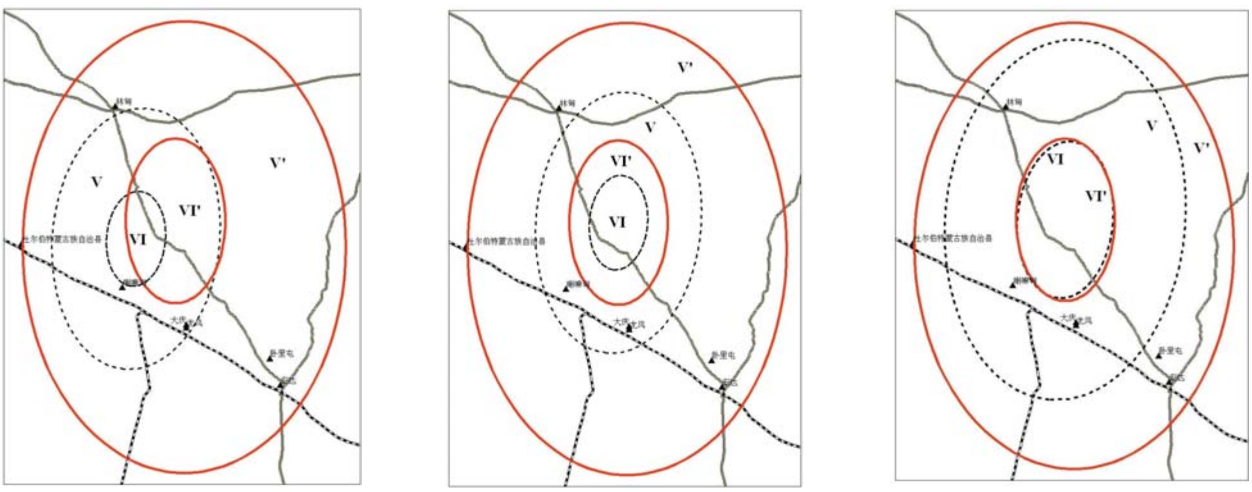
Lindian earthquake (Ms=5.1) occurred on July 25, 2005 in Lindian county, Daqing city, Heilongjiang province, China. Microscopic epicenter is 124.88°E，46.85°N. According to the survey report[1] the epicenter intensity is VI, the direct loss is 6.226 million RMB.

3.1 The preliminary assessment

According to the basic parameters (magnitude, epicenter location etc.) obtained by the earthquake observation station of Lindian earthquake, the damage in Daqing Oilfield was assessed by EPDRS: there is no casualty; the highest intensity is VI; the direct loss is 0.43 million RMB.

Figure 1 (a) showed the comparison of the isoseismal distribution maps between the ground survey and the system. The VI and V denoted the isoseismal intensity assessed by system, and VI′, V′ denoted the intensity in ground survey report. The black dot line and the red real line respectively denoted the isoseismals of ground survey and system.

It can be seen that the sizes of the isoseismals from EPDRS is much smaller than that from the survey report. The sizes estimated by EPDRS are about 0.58 times of survey for intensity VI, and 0.52 to 0.58 times for intensity V, that means the area difference of the corresponding intensity zones is much bigger, just almost one third. Apparently, the big difference will induce the damage’s underestimation of EPDRS. It depends on the experiential attenuation relationship adopted by EPDRS. It means the intensity attenuation of Lindian earthquake is quicker than the statistic character of the large scope.



(a) Microscopic epicenter as input (b) Macroscopic epicenter as input (c) The enlarged isoseismal

Figure1 Comparison of isoseismal calculated by EPDRS and the survey report.

3.2 The deep study

3.2.1 Take macroscopic epicenter as input

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[1] Survey Group of Institute of Engineering Mechanics, China Seismological Bureau and Heilongjiang Province Seismological Bureau, *Damage Evaluation Report of Lindian (Ms=5.1) Earthquake Happened on July. 25, 2005*, Institute of Engineering Mechanics, China Earthquake Administration, Harbin, China, 2005

From the isoseismals map of the ground survey report, the macroscopic epicenter can be confirmed as 125.0356°E，46.8797°N. Take it as epicenter parameters and keep magnitude stable, the new isoseismals can be calculated by running EPDRS. The assessment result is: no casualties, the epicenter intensity is VI, the direct loss is 0.68 million RMB. Figure 1 (b) showed the comparison of the isoseismal distribution maps between the ground survey and the system.

3.2.2 Enlarge isoseismals of EPDRS

Enlarge isoseismals of EPDRS at equal-rate and change epicenter from micro-epicenter to macro-epicenter, to be closed with the extreme intensity zone of survey report, showed in figure 1 (c). Calculate the damage again; the loss is 1.271 million RMB.

Apparently, the big difference of isoseismals is the main reason of the damage’s underestimation of EPDRS. Modify isoseismal can improve the assessment precision, so this paper considered new information from internet to modify the isoseismals.

4. DESIGN HUMAN-COMPUTER INTERACTION MODULE TO BUILD ISOSEISMAL

The isosimal is useful to the emergency response, modify the isoseismal by new information is worth studying on. After Wenchuan earthquake happened; the author collected the information of disaster region from internet. Take Wenchuan earthquake as study case to illustrate the human-computer interaction module. The process will be introduced in the following part. The author got different isoseismal map in different days, this paper just showed the result on May 21.

Wenchuan earthquake (M_s=8.0) happened on May 12, 2008 in Sichuan, China. Microscopic epicenter is 103.4°E，31°N[5],. According to the report of the ministry of civil affairs[6], there are 69197 victims, 374176 injured and 18222 missing persons in this earthquake by 12 o’clock on July 21.

4.1 Calculate isoseismals by the intensity attenuation low

In literature [7] the seismic intensity attenuation relations along major axis, minor axis and mean axis are established separately of Sichuan.

$$I_a=7.3568+1.278M-5.0655\lg(R_a+24) \qquad \sigma=0.7 \qquad (4.1)$$
$$I_b=3.9502+1.278M-3.7567\lg(R_b+9) \qquad \sigma=0.7 \qquad (4.2)$$

Where I demotes the intensity, R means epicentral distance (km), a means major axis and b means minor axis, M means magnitude, σ means standard deviation. The isoseismals calculated from them were showed in figure 4, in which the contours with real line and arabic numerals 5~12 denoting the intensities levels. USGS also put forward an isoseismal map [8], showed in figure 2, the contours with dashed line and XII~VI denoting intensity levels.

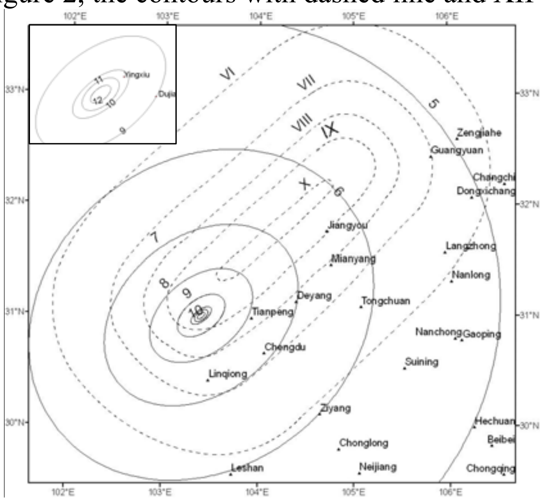

Figure 2 Isoseismals calculated by USGS and the intensity attenuation low

Figure 2 showed the big difference between the isoseismals calculated by USGS and the intensity attenuation low, which one is more closer to the reality needs more information to validate.

The information of 44 cities or towns has been collected. Get the intensity values of that 44 samples by referencing GB/T 17742－1999, Seismic Intensity Scale of China[9]; and take those as Int-variable of the sample points. Build isoseismals by the value of these samples.

4.2 Build Isoseismal by Human-Computer Interaction Module

Sample points had been stored in GIS environment with the attitudes (XY-coordinates and Int-variables). Symbolized the sample points in different Int-variables by different colors, overlaid with the isoseismal calculated by the intensity attenuation low, showed in figure 5. By comparison, that can be seen the latter underestimate the intensity.

Take mathematic method to model Int-variables, the contours can be calculated, which means isoseismals.

4.2.1 Step 1：Trend Surface models

Global method, an inexact interpolation, trend surfaces analysis approximate points with known values with a polynomial equation. A cubic polynomial surface as equation 4.3 had been taken to model the trend of Int-variables' spatial distribution. After global polynomial interpolation had been processed, the contours, the preliminary isoseismals can be got.

$$Z(x,y)=b_0+b_1x+b_2y+b_3x^2+b_4xy+b_5y^2+b_6x^3+b_7x^2y+b_8xy^2+b_9y^3 \tag{4.3}$$

Where Z(x,y) is surface equation[20], (b_0, b_1, b_2…) is coefficients which can be calculate by the XY-coordinates of sample points.

4.2.1 Step 2: modify the isoseismals of the meizoseismal area

From figure 3 it can be seen the distribution of the sample points with different Int-variables: 4 sample points with XI, 8 sample points with X. Take the boundary points as the vertices to generate the polylines of different intensity zones respectively, then use BEZIER_INTERPOLATION algorithm to smooth them, the isoseismal X and XI can be got. The final isoseismals showed in figure 4.

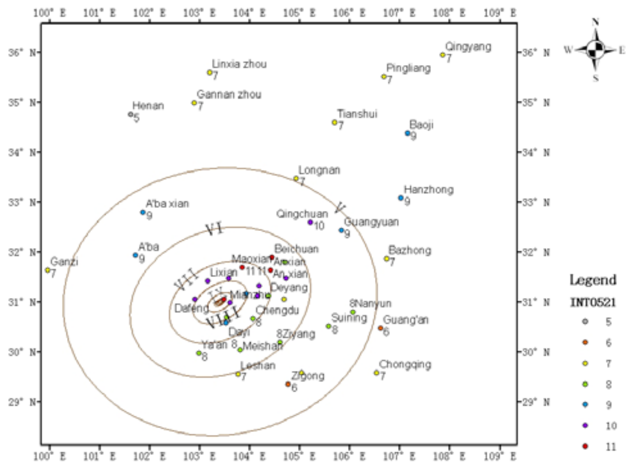

Figure 3 Sample intensity on May 21

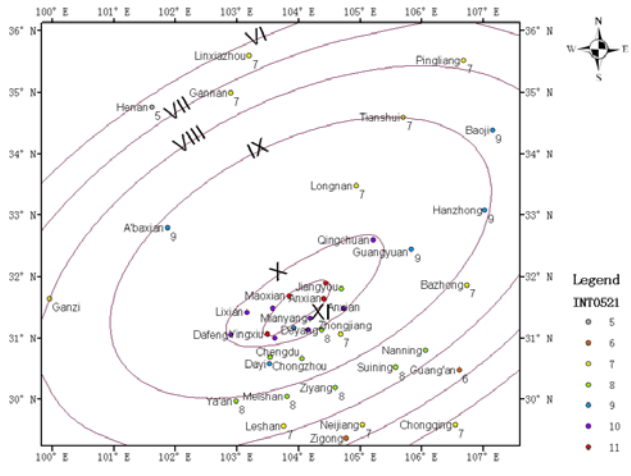

Figure 4 The modified isoseismals

5.CONCLUSION

This paper first introduced the Earthquake Prevention and Disaster Reduction System briefly. Analyzed Lindian earthquake (2005, Ms=5.1) in detail to show that the problem of assessment by EPDRS. Add Human-computer interaction module into the system to deal with the problem. The paper takes Wenchuan earthquake as study case, considering the new information to improve the assessment accuracy of isoseismals. Collect the information from internet to get the intensity of disaster zones. Modeling the Int-variable value by mathematic methodology to calculate isoseismals. The assessment's accuracy can be increased in the new system by Human-computer interaction module.

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