Design and realization of RS application system for earthquake emergency based on digital earth

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Abstract. The current RS-based earthquake emergency system is mainly based on stand-alone software which cannot meet the requirements of massive remote sensing data and parallel seismic damage information extraction after a devastating earthquake. Taking Shaanxi Province as an example, this paper explored firstly the network-based working mode of seismic damage information extraction and data management strategy for multi-user cooperative operation based on analysing work flow of the RS application to earthquake emergency. Then, using WorldWind java SDK, the RS application system for earthquake emergency based on digital earth platform was brought out in CS architecture. Finally, spatial data tables of classification and grade of seismic damage were designed and the system was developed. This system realized functions including 3D display, management of seismic RS image and GIS data obtained before and after earthquake for different user levels and cooperative extraction and publish of such seismic information as building damage, traffic damage and seismo-geological disasters caused by earthquake in real time. Some application to earthquake cases such as 2014 M_s6.5 Ludian earthquake show that this system can improve the efficiency of seismic damage information interpretation and data sharing, and provide import disaster information for decision making of earthquake emergency rescue and disaster relief.

1. Introduction

As the vigorous development of domestic high satellite and UAV remote sensing technology, the remote sensing data source for earthquake emergency is more and more rich after destructive earthquakes occur. Therefore, how to efficiently use multi-source remote sensing data for earthquake emergency services becomes the one of the problems that need to be solved. There are some scholars began to research and develop earthquake disaster management and recognition system for rapid earthquake remote sensing information extraction. Turkera M and Sumerb E [1] developed the seismic damage evaluation system based on buildings by Matlab and proposed segmentation algorithm based on watershed to detect intact buildings and damaged building. Xiaoqing Wang, etc. [2] developed earthquake disaster emergency and damage assessment system using ENVI/IDL which realized building seismic damage quickly identify and model management based on aerial and satellite images, and completed the development of earthquake emergency remote sensing (EERS) analysis and processing system on the basis of research of key techniques such as earthquake emergency disaster information extraction and damage assessment in 2008. After that, considering the characteristics of urban application, Aixia Dou [3] developed Tianjin Remote Sensing Earthquake Damage Analysis and Processing System (TJ-RSEDAPS), which realized many practical functions including image management, damage degree identification of buildings, key-objects and major facilities, losses assessment of life and economic, damage distribution mapping, and etc.

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With the development of 3D GIS technology, research on earthquake disaster management and recognition technique based on 3D digital earth is becoming a hot spot. Chongjun Yang [4] developed 3D geographic information system on wenchuan earthquake on account of GeoBeans platform, and realized the functions including 3D display of multi-source remote sensing damage images, seismic road interpretation, and etc. Based on discussing the technical methods on application of multi-sensor remote sensing technology for earthquake disaster management, Jixian Zhang, etc. [5] built remote sensing monitoring of the Wenchuan earthquake disaster situation and the information service system which provide functions including disaster information management, visualization and statistical analysis. Jieping Zhou, etc. [6] implemented a 3D visualization management system for UAV remote sensing images based on the VGE-3DGlobeEarth platform, which provided the quad-tree pyramid and LOD model for managing large volume remote sensing images from earthquake zone. There are many advantages on 3D digital earth system such as intuitive and convenient data sharing. However, the currently existing system focuses on the 3D data management and display, and earthquake disaster information extraction and evaluation function is weak. Based on the earthquake emergency prototype system of remote sensing digital earth [7], this paper analyse work flow of remote sensing earthquake emergency using network, and discusses the multi-user collaborative damage extraction mode on the basis of the network and data management strategy, proposed CS architecture of earthquake emergency digital earth platform system of RS applications based on Worldwind.

2. The overall design of the system

Usually EERS work based on single version software, the specific process includes pre-earthquake background remote sensing data preparation, extraction of seismic damage, seismic damage and loss estimation of earthquake damages and earthquake damage products production and display [3].In this situation, collaborative work and how to share the background data and the real-time extracted information of earthquake are questions need to be resolved.

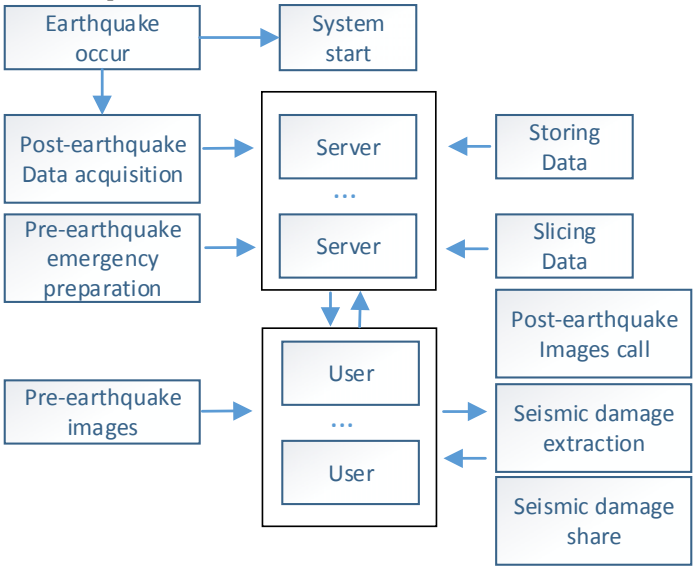


Figure 1. Network-based workflow of remote sensing application to earthquake emergency.

In this paper, we based on the WorldWind digital earth platform to make sure full use of the network environment (the specific work process is shown in figure1), including network-based data preparation for the earthquake emergency response and the post-earthquake emergency work. Network-based data preparation before earthquake mainly contains slicing and storing of fundamental geographic information, elevation data, background of remote sensing images, population, and economic data through distributed server providing data support for earthquake emergency. After the earthquake, on the one hand, the server slice and import multi-source data from different stages. On the other hand, different users from different computers can use the earthquake emergency client calls for post-earthquake and pre-earthquake disaster images to be displayed in 3D mode, then they can analyse and extract the seismic disaster information such as the building damage, road damage, geological disaster,

at the same time the system will share the extracted information shows to different users in real-time (figure 1 shows the overall workflow).

According to the business workflow above, the system is divided into the presentation tier, business logic tier and data service tier. The first tier is the presentation tier, whose mainly function is the system access for the three kinds of earthquake emergency users such as administrators, professional users, and emergency decision makers by the client. The second tier's function is logic control by the client-side, including web through the network environment, invoking geography information. The third tier is composed of spatial database and remote sensing database, storage the data produced in the process of earthquake emergency, and basic data provide requirements for server and client calls, as shown in figure 2.

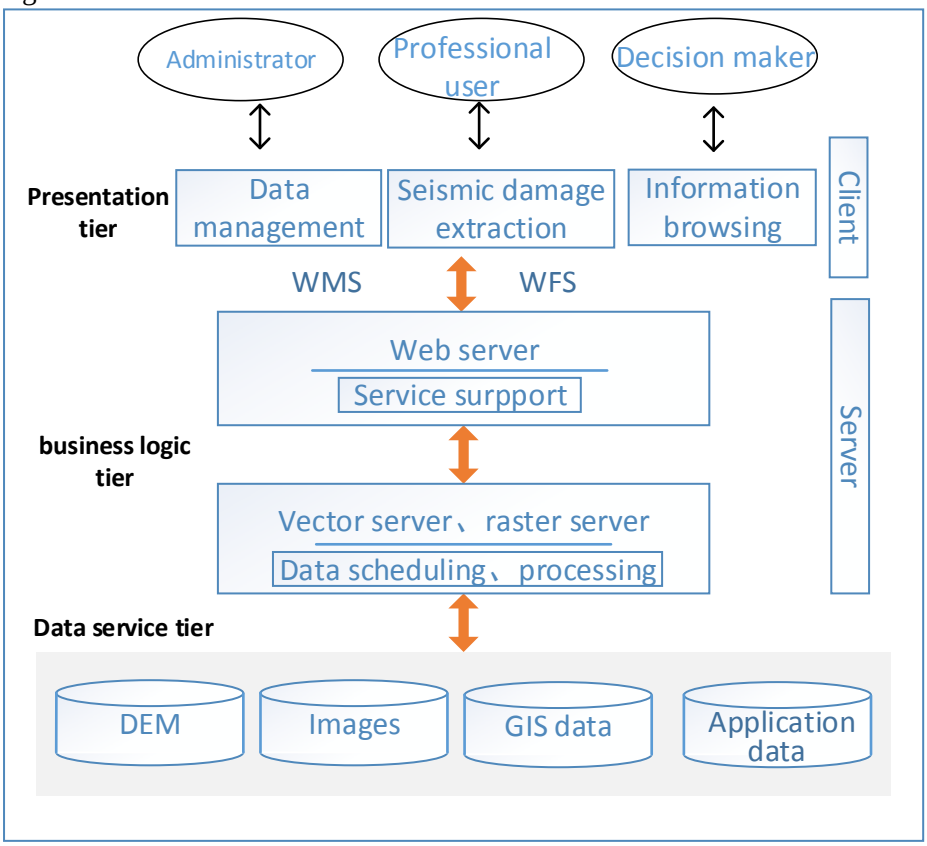


Figure 2. Overview of an RS application system for collaborative seismic damage information extraction and visualization based on 3D digital earth.

3. The design of remote sensing earthquake emergency database

In order to make the management of EERS data standard, efficient, easy to use, database design (figure 3) can be classified into spatial database, remote sensing image database, earthquake professional database and system management database. According to the specific function, different database stores corresponding earthquake-related information. Details of the design are as follows.

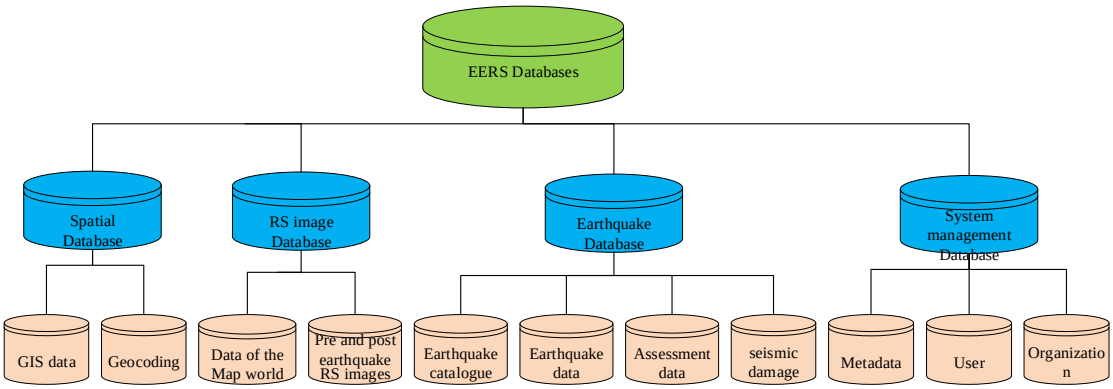


Figure 3. Overview of database structure of RS application system.

(1) Spatial database. It stores the emergency basic spatial data of the residential area, the key objects, administrative divisions and related provinces, cities, counties, townships and attributes of the standard geographic coding data in demonstration zone.

(2) Remote sensing image database. It stores the pre-earthquake background RS data of the Map world and the medium and high resolution in demonstration area, pre-earthquake high resolution data of key area and multi-source RS images acquired after earthquake such as UAV images and airborne high resolution images.

(3) Earthquake professional database. It stores the historical earthquake, basic information of current earthquake, rapid assessment of earthquake, seismic intensity map, classification of buildings and seismic geological hazard information. Table 1 shows the design of earthquake damage levels of different objects from RS images, which is a classification standard for different users sharing and updating the visual interpretation results to the server.

(4) System management database. It stores the data of system operation related to the user, the organization and related metadata, etc.

Table 1. The designation of earthquake damage levels of different objects from RS images.

Disaster type	Feature type	Classification	Level
Building damage	Single(point), Group(polygon)	High-rise building, Multi-storey building, Ordinary house, Industrial plant, Large open house, Other house	Collapse, Partial collapse, not collapsed with obvious damage, not collapsed without obvious damage
Road damage	Point, Line	Motorway, First class road, Second class road, Third class road and others	Completely damaged, Severely damaged, Moderately damaged, Slightly damaged, Intact
Seismic geological damage	Point, Line, Polygon	Earthquake fault, Ground fissure, Water and sand erupt, Landslide, Rockfall, Debris flow, Other	Severe, Moderate, Slightly
Other Secondary disaster	Point, Line, Polygon		Severe, Moderate, Slightly

4. The main functions and applications of the system

The system is CS architecture containing clients and servers. The Client developed by WoldWind SDK, whose integrated environment menus is shown in figure4. The server integrate Geoserver and Arcgis Server, as is shown in figure 5. After destructive earthquake occur, the client of the system (as is shown in figure 6) automatically load seismic RS images of arranged region from distributed servers,

which provide 3D display of disasters for professional users. The extracted result can be stored automatically to servers for other users' reference. The main functions are introduced as below.

(1) Data management function. On the server side, it mainly contains users' data management of adding, deleting, modifying users of different roles, earthquake-related metadata management, slicing and updating of background RS images, DEM. On the client side, the user can upload and update specific earthquake-related seismic disaster images, vector data, GDP and population data for key areas.

(2) 3D browsing thematic information function. According to different requirements, the system carries out corresponding 3D rendering to the background information of the earthquake, damage images and thematic information, and elevation exaggeration rendering for special interpretation needs. For the key object in database, it can be displayed by serial number or name.

(3) Real-time damage interpretation and publishing function. For professional users, according to the needs of multi-source remote sensing data such as the domestic satellites and UAV, the client load the corresponding data for extraction of building damage, road damage and geological disasters caused by earthquake in real time. After extracting the damage vector information is automatically stored in the database through the server, another user on demand, automatic access to available earthquake damage information as a basis for collaborative task and working. In the case of M_s6.5 Ludian earthquake occurred at August 5 2014, figure 7-9 show the different disaster extraction interface.

Damage project	Management	3D Browse	Damage extraction	Damage search	Map world publish	System configuration	Help
Open project Close project manage	Database update Raster upload Vector upload Service manage Publish manage	Backgroud Post-earthquake image Post-thematic Key object	Share in real time Building damage Road damage Geological damage Key object damage Other	Selection Mearsure	Map world search Damage transfer Damage service publish	Server config Log out User manage Geocode search	System Help About system

Figure 4. The integrate environment menus of client.

User manage	Data manage	System config	help
Add user Delete user Modify user Connect config	Metadata DEM update Background update Thematic	Database config Network confg	Help system About system

Figure 5. The integrated environment menus of server.



Figure 6. Main interface of client.



Figure 7. Single building damage extraction.

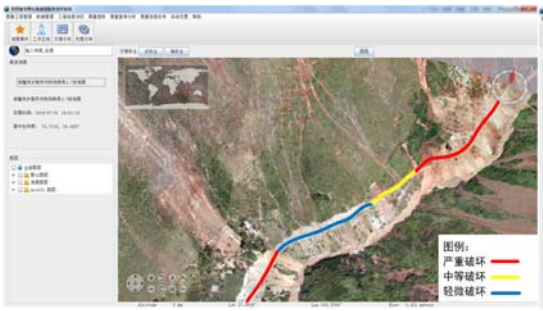


Figure 8. Road damage extraction.



Figure 9. Seismic geological disaster extraction.

5. Discussion and Conclusion

3D GIS is intuitive and realistic, which provides a good environment for the damage extraction users. With the rapid development of remote sensing technology and network technology, multi-user collaborative disaster information extraction based on digital earth is an important direction of development of remote sensing.

Analysing workflow of EERS using network, this paper realized CS architecture of RS application system based on WorldWind SDK. This system realized 3D display and management of remote sensing image and geographic information obtained before and after earthquake for different user levels. The system also implemented the functions of the cooperative extraction and seismic information publishing such as building damage, road damage and geological disasters caused by earthquake in real-time. Some applications to earthquake cases such as 2014 M_S6.5 Ludian earthquake show that this system can improve the efficiency of seismic damage information interpretation and data sharing, and provide import disaster information for decision making of earthquake emergency rescue and disaster relief.

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Acknowledgments

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