Application of RS and GIS in Extraction of Building Damage Caused by Earthquake

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Abstract: The extraction of earthquake damage from remote sensed imagery requires high spatial resolution and temporal effectiveness of acquisition of imagery. The analog photographs and visual interpretation were taken traditionally. Now it is possible to acquire damage information from many commercial high resolution RS satellites. The key techniques are processing velocity and precision. The authors developed the automatic / semiautomatic image process techniques including feature enhancement, and classification, designed the emergency Earthquake Damage and Losses Evaluate System based on Remote Sensing (RSEDLES). The paper introduced the functions of RSEDLES as well as its application to the earthquakes occurred recently.

Keywords: Earthquake Damage, Remote Sensing, Assessment System

1. Introduction

It is well known that China is one of the countries with most serious earthquake disasters. As the main continental earthquake distribution country, the catastrophic earthquakes distributed widely and can not be well forecasted at present. Thus the emergency ability to the outburst damage earthquakes is very important. The effective emergency rescues need the exact earthquake and disasters information. These information acquired usually from local government or from on-site investigation. These methods are not always effective because of the possible damage of electronic powers, communication, or transportation in the disaster region, or a long time interval for investigation.

Because of the high develop of satellite and information techniques, it is possible to acquire the earthquake damage and disasters information from remote sensing imagery. The extraction of damage information from imagery automatically or semiautomatically are researched by many researchers[1-2]. Based on these works, we developed some earthquake damage extraction models and designed the emergency Earthquake Damage and Losses Evaluate System based on Remote Sensing (RSEDLES). The paper is a brief introduction of the work results.

2.Technique Scheme of Extraction of Earthquake Damage Information

The processing of extraction of earthquake damage information from remote sensing are shown in figure 1. The main processes of imageries from various sources are precession, feature enhancement and damage classification; after that, the losses may be assessed. Because of the complexity of damage characteristics on the images, the assistant of GIS may improve to identify the object such as buildings and special feature enhancement models may increase the precision of

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damage recognition. The typical damage image databank of the past damage earthquakes are helpful in the feature understand and arithmetic design.

Considering cases that both images before and after an earthquake occurs can be obtained, precision registration with different resolution and / or from different sensors should be done, then change detection can be used after the feature enhancement and before damage classification.

In order to process fast and effectively, an extractive system design and programming with automatic processing and databank management should be done.

3. Object and Functions of RSEDLES

RSEDLES is designed to extract of earthquake damage information from images with different resolutions and /or different sensors, which based on pilot study results in the precision registration of images, image enhancement arithmetic and damage recognition models et al. The system, based on the ENVI/IDL environment at present, is developed with IDL, VB and VC. The main functions are as followings (Figure 2):

1) integration control environment (ICE)

The Main menu of system is integrated, which includes menus of subsystems, the desktop management and online helps.

2) 2) Databank management subsystem (DBMS)

DBMS realizes the management of data such as images, typical damage image samples, GIS data, feature arithmetic models, case study data and so on. The data management functions are input/output, maintenance, query, report and map/chart views and format transform et al.

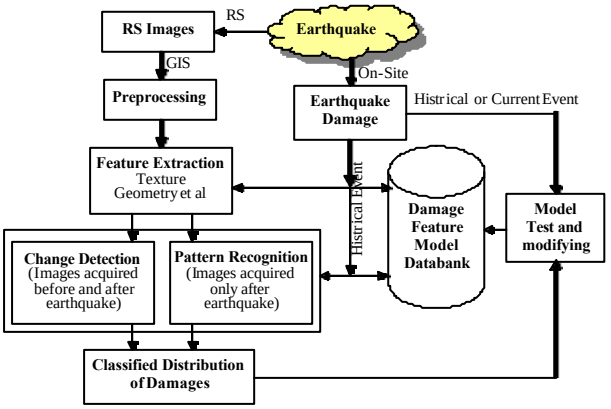

Fig. 1. Technique scheme of extraction of earthquake damage information.

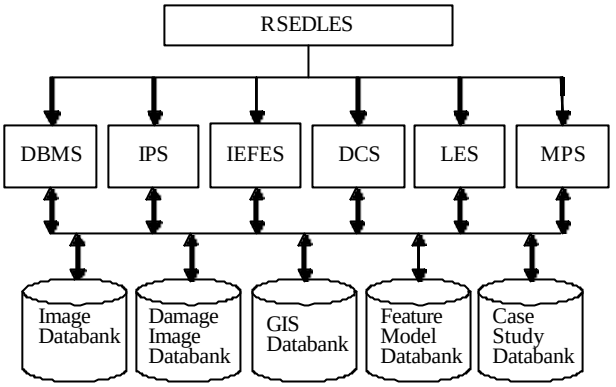

Fig. 2. System structure of RSEDLES.

(Note: The alphabetic acronym is explained in context.)

3) Image preprocessing subsystem (IPS)

The main functions of IPS include basic tools of image processing such as calibration utilities, orthorectification, precision registration, mosaicking, fusion, resampling, image transformation, region of interesting, masking et al.

4) Image enhancement and feature extraction subsystem (IEFES)

IEES is developed to enhance and extract the features of the damage information from images for classing or images of training samples. The main functions are parameters inputs, feature enhancement and extraction, class statistics of training samples, feature model management et al.

5) Damage classification subsystem (DCS)

The feature images are used to earthquake damage classification. If the images before and after an earthquake occurs are used, the change detection can be applied in advance. The classification method can be supervised or unsupervised method. The post classification, such as assign class colors, class statistics, classification to vector et al, can be done.

6) Losses estimation system (LES)

Based on the damage extraction results, empirical building damage matrices to earthquakes and other data, the earthquake losses can be estimated. The main functions are estimate zoning, losses assessment, results mapping and fast report outputting et al. The functions are refers to an actually running system, developed by authors, in the capital areas of China[4].

7) Map processing subsystem (MPS)

The main functions of MPS are input/output of map data, map query, browsing, thematic map creation,

vector and grid overlaying and map layer management et al.

RSEDLES is run under the IBM compatible personal computer and MS windows 2000/XP operation system. The ENVI 3.5/IDL 5.5 or upper versions should be installed in advance. GIS software, such as ArcView 3.x/8.x、MapInfo 5.x or upper versions, can be installed if it is available.

4. Primary Application of RSEDLES

RSEDLES is only an experimental system at present. It has been used to test the validation by cases of earthquakes occurred in Tangshan, Hebei Province in North China in 1976 (Ms=7.8); Zhangbei, Hebei Province in North China in 1998 (Ms=6.2), Taiwan in 1999 (Ms=7.6) and Bhuj in GUJIRAT, west India in 2001 (Ms=7.9). Table 1 lists the classification precision analysis results. The results shows that the computer processing have nearly the same precision level with that of visual interpretation.

Another example is Bachu – Jiashi Earthquake with Ms=6.8 occurred in the west of China's Xinjiang Autonomous Region on Feb 24, 2003. The event caused 268 deaths, which is the largest one in China since Tangshan Earthquake occurred in 1976. Aerial photographs and Spot 5 data were acquired immediately after the event. Through digital image process and extraction of earthquake damage by both visual interpretation and auto-classification, the earthquake damage distribution and isoseismic map were obtained. The results show nearly the same distribution of damage level with that obtained via ground investigation. This is the fist time applying RS in the Earthquake emergency stage in China. It will be helpful in earthquake disaster mitigation effort in China[5].

Table 1. List of earthquake damage classification precision.

Case	Image Type	Methods	Ground Actual Damage			Damage index by Damage classification	Producer Accuracy		Remark
			MMI	Damage index	Damage status		According to pixels (Areas)	According to collapse Rate	
Zhangbei	Radar	Correlations of multi-features			Most part collapsed		72%	58%	
					part collapsed		53%	53%	
					Most part un-collapsed		63%	57%	
Tangshan	Aerial photo-graphs (0.5m)	**Dynamic IsoMix**		0.6		0.6-0.7			Compared with ground truth
		Morphology and region growing			All collapsed		99%		Compared with visual interpretation
					Part collapsed		89%		
India	iKonos (1m)	Morphology and region growing			All collapsed		91%		
					Part collapsed		91%		

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