QUANTITATIVE DETECTION OF DAMAGE IN BACHU EARTHQUAKE (2003) FROM LOW RESOLUTION SATELLITE IMAGES

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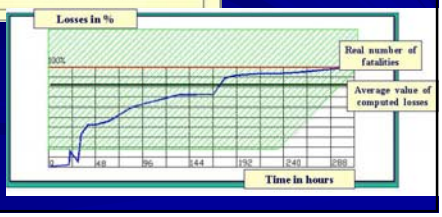
2005.4.19, Cairo

Introduction

- Importance of fast assessment on Earthquake Damage
- Time limitation of rescue
- How to assess hazard quickly

The 1976 Tangshan earthquake in China, killed 242 thousand people.

Statistic result from a Turkey earthquake



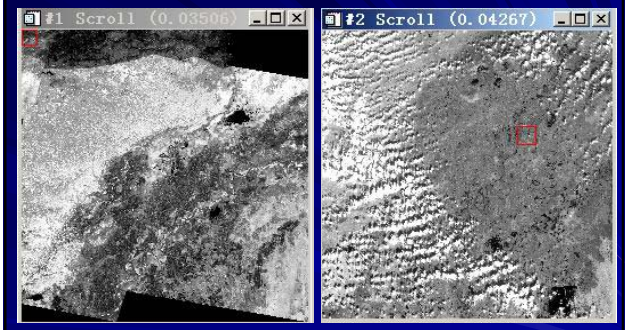
- The rescue team needs to know what kind of damage were caused and where is the most damaged area urgently.
- The earthquake observation network can determine the earthquake magnitude and location.
- A experiential approach is usually adopted to report a very rough death number and total loss is such short a time.
- Remote Sensing Image acquired post earthquake may provide some information.

Remote Sensing Image is helpful for Detecting Earthquake Damage quickly

Earthquake damage detection

- Qualitative, the most damaged area
- Quantitative, isoseismal, the areas with various Intensity

Bachu Earthquake, a case study



Images acquired before and after the earthquake

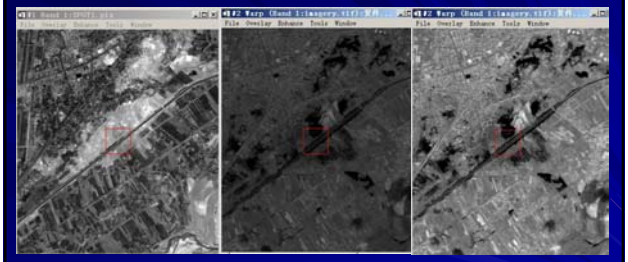
Damage Detection

- Difference between the two images is caused by earthquake damage, and the weather and time of the acquisition, and height of the satellite.
- Just the changes from the former is related with damage, mainly in residential areas.
- A probabilistic model can be established by comparing the changes detected from the images and the ground survey results.
- Intensities of various areas can be identified by the model.

- Spatial Matching is the most important
- By TICs in the region as more as possible.

Histogram Matching

- The residential areas are cut out from the pre- and post-event satellite images firstly by means of referring to a GIS based local map.
- The areas outside of residential areas are taken as the image pair, and then the histogram are matched to get the changing formula to adjust the histogram of the whole post-event image.
- It improves the grey scale matching very much to strengthen the changes by earthquake.



The same area on the pre- and post-event images, the right one is the matched post-event images.

Further image processing

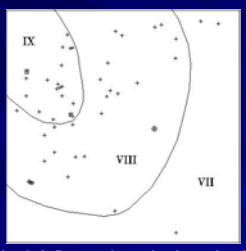
- The subtraction and ratio algorithms were widely used in change detection. The two methods were used to calculate the gray scale of the two corresponding pixels in the same location in the image pair according to formula

$$Z = |X - Y| \quad (1) \qquad Z = \frac{|Y - X|}{X} \quad (2)$$

Where X is the grey scale of a pixel in pre-earthquake image. Y is the grey scale of a pixel in post-earthquake image. Z is the grey scale of a pixel in operated image.

- After the image pair for change detection is prepared, the grey scale difference and ratio are calculated for every pixel.

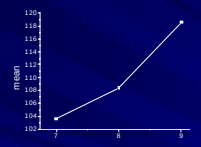
Ground survey report

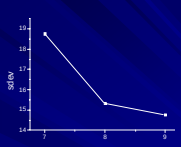


The left figure show the isoseismls, the areas with various intensities covered by satellite images.

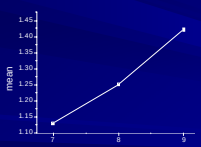
The right pictures show the collapsed houses and dead sheep.

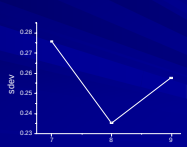
- The statistic analysis for the residential areas with post-earthquake ground survey data is carried out, the values of mean and standard deviation of regions with intensities IX, VIII and VII are obtained, they changing obviously along with intensities.
- A preliminary probabilistic model for earthquake damage evaluation is built by these statistic variables.





The mean and standard deviation of difference image in areas with VII,VIII and IX.

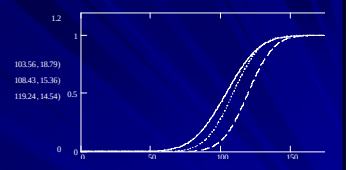


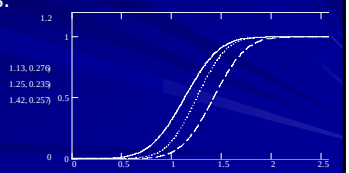


The mean and standard deviation of ratio image in areas with VII,VIII and IX.

A normal distribution function is adopted to describe the grey scale probability distribution with the mean and standard deviation in various intensity areas.

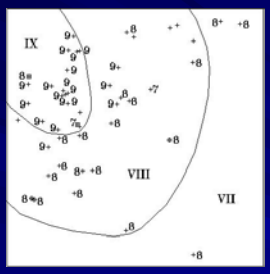
Right graphs show the grey scale probability distribution in areas with intensity VII,VIII and IX in difference (upper) and ratio images.



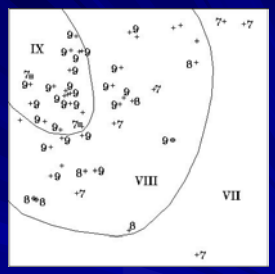


Quantitative identification of damaged areas

- As internal checking, the probabilities of three intensities in every residential area are calculated from the model and the grey scale in difference and ratio images.
- The intensity with the maximum probability is compared with intensity in the area from post earthquake ground survey to show the reliability of the method developed in this paper.



Identification of isoseismals from difference image.



Identification of isoseismals from ratio image.

The intensities in the residential areas with reported intensity IX with maximum possibilities are consistent with the ground survey result both in difference and ratio images. The intensity identification in the residential areas with intensity VIII take on good prospect, but the result for intensity in VII si not good enough. The intensity in the residential areas with intensity VII can be identified from ratio images.

Conclusions

- This study examined the potential use of low-resolution satellite images to identify the intensity of the damaged area. The pre- and post-earthquake images covered Bachu region, which was damaged during the Feb.24, 2003 earthquake, was adopted as a case stydy of earthquake damage detection by means of change detection.
- A approach to strengthen the grey scale change caused by earthquake, and lighten the differences caused by other factors is presented with a good effect in change detection between the pre- and post-earthquake satellite images.

- The ratio and subtraction algorithms were used to calculate the grey scale difference of the pixels.
- Normal distribution function is suggested for the probability model from the statistic analysis of both in difference image and ratio image, in residential areas with intensities VII,VIII and IX .

- The results of comparison with ground report show that the intensity in the residential areas with intensity IX can be identified with maximum probability, and the identification of areas with intensity VII and VIII were difficult. The situation can be improved by combining the results coming from difference and ratio images.

- From the validation of this earthquake case, a preliminary probability model for earthquake damage detection is built in the paper, based on the remote sensing images change detection.
- It needs to be checked and improved in more earthquake cases.

THE END

THANK YOU