MATHEMATICAL MORPHOLOGY BASED APPROACH FOR BUILDING DAMAGE ESTIMATION FROM VHR AIRBORNE IMAGERY OF ISHINOMAKI AREA IN 2011 PACIFIC COAST OF TOHOKU EARTHQUAKE AND TSUNAMI

Chandana Dinesh
Laboratory of Environmental Informatics
Department of Urban and Environmental Engineering
Kyoto University

BACKGROUND

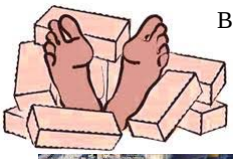
Natural disasters have struck with unprecedented strength in recent years, causing large-scale destruction and immense suffering around the world. As many as 50 million people are estimated to be displaced in any given year due to tsunamis, earthquakes, landslides, flooding and other natural disasters.

- **Tsunami- Great Sumatra Earthquake Tsunami disaster (2004), Tohoku Earthquake and Tsunami(2011)**
- **Earthquake-Earthquakes in Iran ,Haiti, China (Tibet), Chile, New Zealand.**

Injured and Killed thousands of people, Killed thousands of people and damaged billions ($) in coastal region properties, infrastructures, Lifelines.

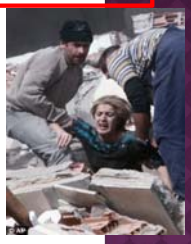
2

Earthquakes Don't Kill People,
But Building Kills People



Report in the journal *Nature* has bad (if somewhat obvious) disaster news for citizens of bad governments: Corrupt countries have been responsible for 83 percent of all deaths caused by building collapse during earthquakes over the last 30 years. Haiti, of course, being responsible for 300,000 of those deaths in the January 2010 quake

Most of people were trapped to the collapsed buildings at the event in the hazard area



3

PURPOSE OF THE STUDY

BUILDINGS DAMAGE ASSESSMENT OF DISASTERS

- Quick response:

  The results could be very useful for the rescue teams deployed immediately after the catastrophe.Less time for recovery.

- Systematic preparedness:

  Receiving rapid, accurate knowledge about the conditions of damaged area after disaster strike is the basis for the reconstruction work.

4

PURPOSE OF THE STUDY

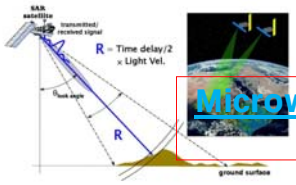
Urban Planning

Environment Problem

Disaster Management

Advance Urban Extraction

Remote sensing Technology



Microwave sensor

Optical sensor

5

METHODOLOGY

FEATURE EXTRACTION USING MORPHOLOGICAL TRANSFORM

Brief Flow chart

Airborne / Space borne Image

Opening / Closing Operator

Extended Differential Morphological Profile

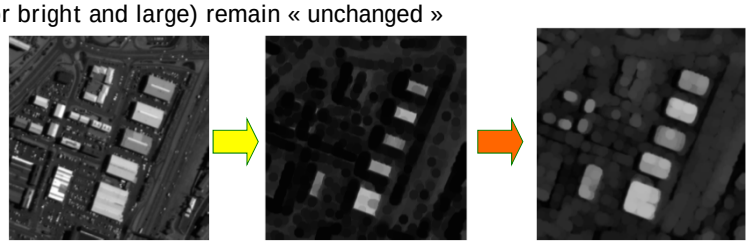
ISODATA / Neural Network Classification

Feature Extraction

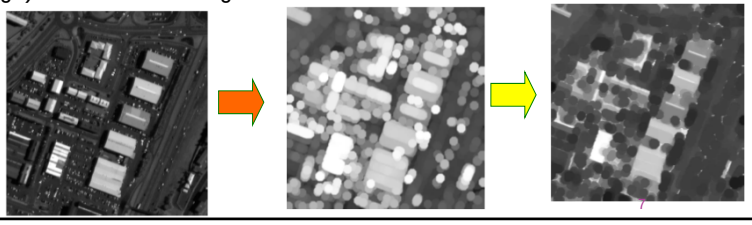
6

METHODOLOGY

· **Opening**: erosion followed by a dilation with the symmetrical SE
Consequence: features that are *brighter* than their immediate surroundings and *smaller* than the SE *disappear*. other features (dark, or bright and large) remain « unchanged »

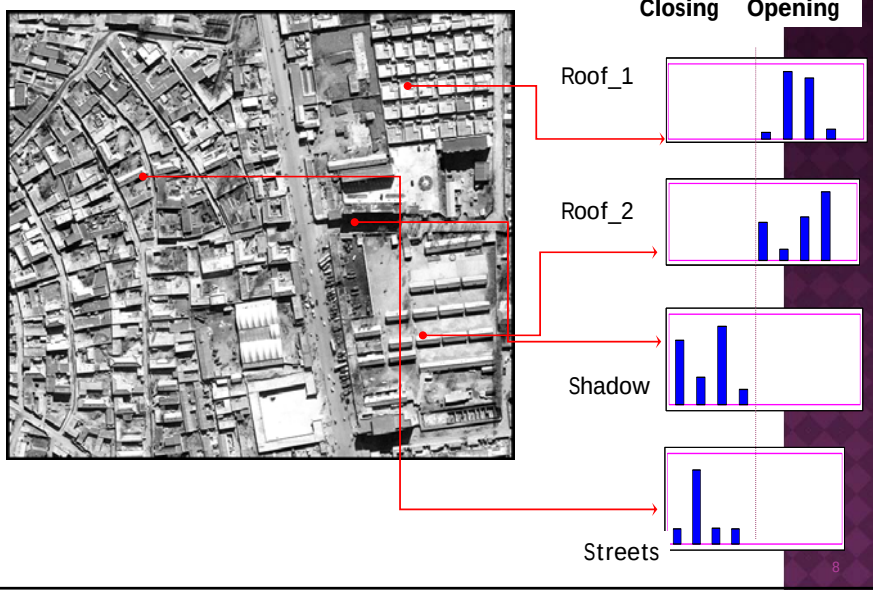


· **Closing**: dilation followed by an erosion with the symmetrical SE
Consequence: features that are *darker* than their immediate surroundings and *smaller* than the SE *disappear*. other features (bright, or dark and large) remain « unchanged »



METHODOLOGY

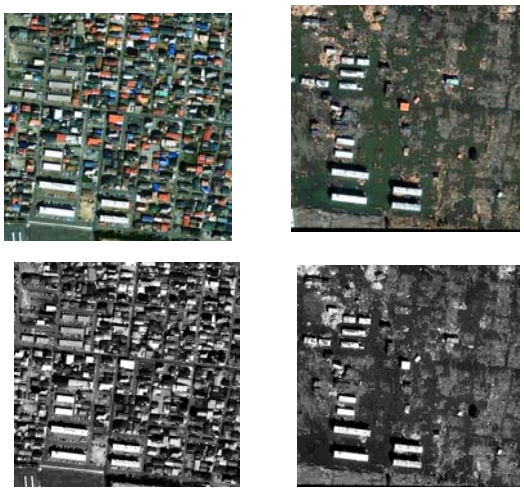
DMP = vector of attributes for each pixel



Case Study-3

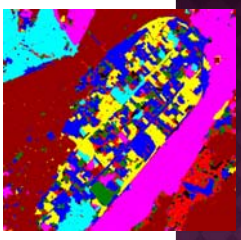
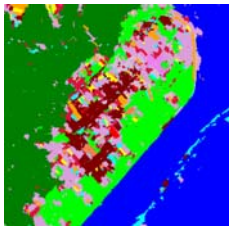
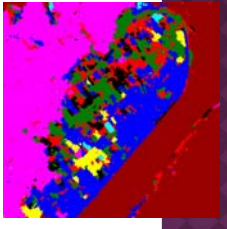
CASE STUDY- 3

Damaged Building Identifying From VHR airborne Imagery , 2011 Pacific Coast of Tohoku Earthquake and Tsunami (Ishinomaki Area- Miyagi Prefecture)



9

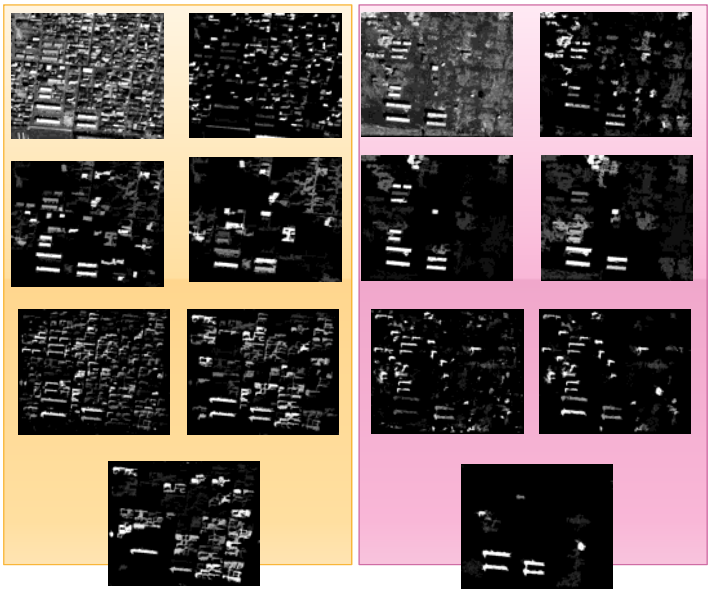
RELATED RESEARCH

	Airborne RGB Image	Sample Class Classification	Fuzzy Tolerant Entropy Based Classification
2008			
2011 April			

10

CASE STUDY

DMP Images



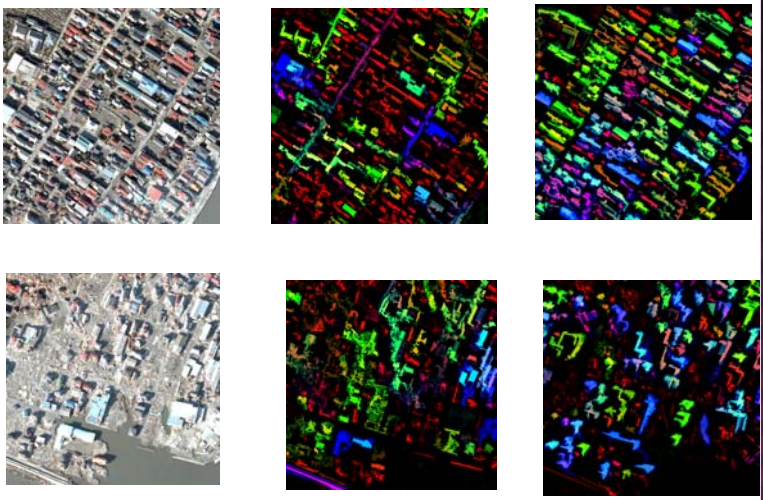
SE with radius from 7-15m. Derivative of the opening profile with r=(b)7, (c)11, (d)15 and closing profile with r=(e)7,(f)11,(g) 15 are shows above respectively.

Pre event

Post eventa

11

Miyagi Prefecture (Suga) Opening Closing



12

ISHINOMAKI AREA, MIYAGI PREFECTURE, EAST PACIFIC COAST, JAPAN

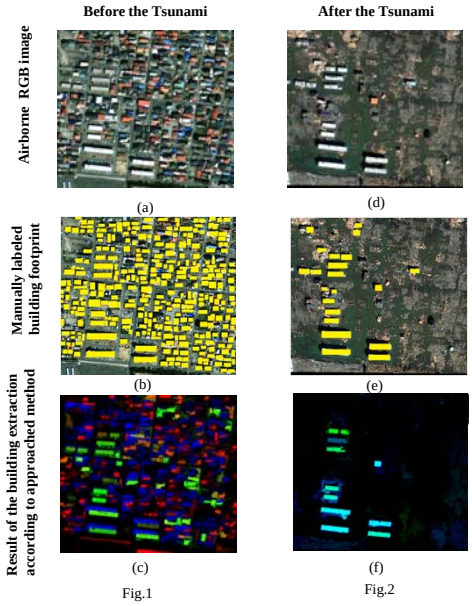


Fig.1 Fig.2

Fig.1. Building extraction results before the earthquake and tsunami hazard. (a) Airborne image of the pre-earthquake area. (b) Manually labeled buildings as ground truth. (c) Result of the building extraction according to approached method.

Fig.2. Building extraction results after the earthquake and tsunami hazard. (d) Airborne image of the post-earthquake in same area. (s) Manually labeled buildings as ground truth. (t) Result of the building extraction according to approached method.

Table 1. Accuracy assessment of pre and post extract building

		Building Extraction Algorithm	Reference Data	Accuracy (%)
Before Tsunami	Object based	1380	1760	78.41
	Pixel based	177613	378368	46,94
After Tsunami	Object based	155	168	92.26
	Pixel based	86592	148600	58.27

13

CONCLUSION

- DMP Building Extraction Method:
  The result shows high accuracy for building extraction using this methodology
- Stucture Element size :-
  The derivative has been calculated relative to a series generated by six iterations of the elementary SE with radius from 7-19m.

Classification methods- SVM, Decision tree, Random forest

- Because of noise:-
  Due to factors such as light intensity, type of camera and lens, motion, temperature, clouds, dust and others.
- *Accuracy*
  Need extra method for improve the accuracy (Rubble detection Use of NDVI, etc.),
  Automatic satellite image registration and so on.

14

end

Your Questions and comments are appreciated

FUTURE WORKS

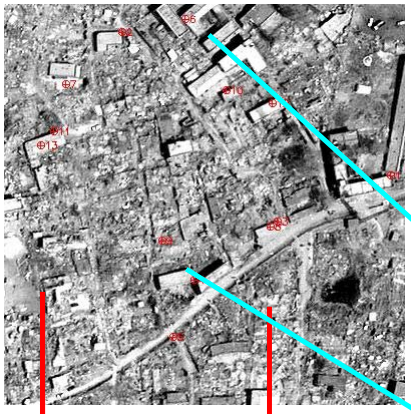
1. Verification the DMP methods results
2. Image Registrations (before and the after the Event)
3. Apply after the event Images
4. Relative methods for improve the accuracy

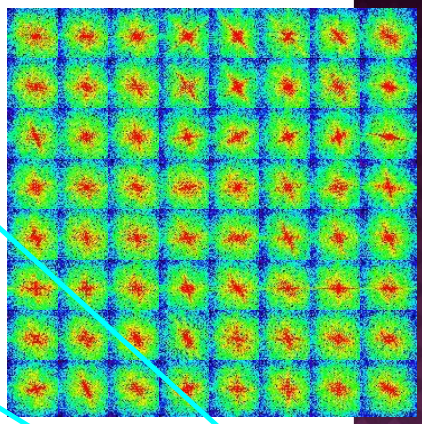
Result:

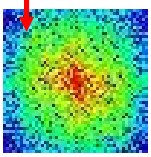
Damage area Image

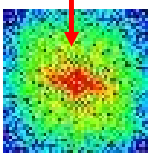
FAST FOURIER TRANSFORM

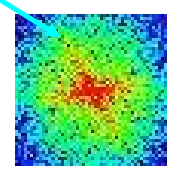
Log of FFT 50mX50mX64

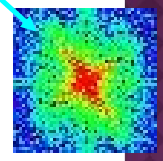








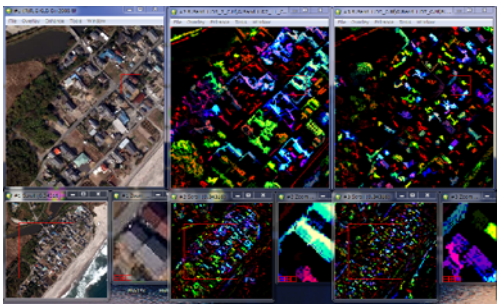


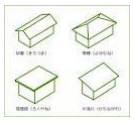


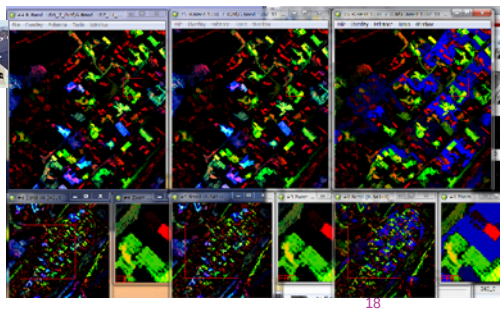
Enlarge Log of FFT images (damage area)

Enlarge Log of FFT images (Undamaged Struct)

PROBLUMS







18

CONFERENCE AND JOURNALS

Conferences

1. “Identify Damaged Buildings from High-Resolution Satellite Imagery in Hazard Area Using Differential Morphology”, Chandana Dinesh Kumara, Masayuki Tamura, ICSBE -International Conference on Sustainable Built Environment, Kandy, Sri Lanka 2010.12.12-14

2. “Identify Damaged Buildings from High-Resolution Satellite Imagery in Hazard Area Using Differential Morphology”, Chandana Dinesh Kumara, Masayuki Tamura, ICIAfS 10 - 5th International Conference on Information and Automation for Sustainability, Colombo, Sri Lanka 2010.12.17-19,

3. 第 20 回生研フォーラム「広域の環境・災害リスク情報の収集と利用フォーラム」 “Extraction and Assessment of Buildings Damages from High-Resolution Satellite Imagery (Orel Presentation)”,International Center for Urban Safety Engineering (ICUS), 17-18/03/2011
4. Sydney Australia-34th International Symposium on Remote Sensing of Environment Sydney Convention and Exhibition Centre, Australia- Sydney, 2011 April 9-18, http://www.isprs.org/proceedings/2011/ISRSE-34/211104015Final00886.pdf
5. ISPRS Hannover Workshop 2011: High Resolution Earth Imaging for Geospatial Information, June 14-17, Hannover, Germany.

6. International Conference on Building Resilience: TSUNAMI DAMAGED BUILDINGS ASSESSMENT USING HIGH-RESOLUTION SATELLITE IMAGERY, GIS & GPS DATA, U.Abdul Bari,P. Chandana Dinesh, Mazayuki Tamura, P.G. Ranjith Dissanayake, Interdisciplinary approaches to disaster risk reduction and the development of sustainable communities", Kandalama, Sri Lanka from 20th - 22nd July 2011.

7. IGARSS-2011 , Vancouver, Canada, 2011 July 22- August 3 http://igarss11.org/Papers/viewpapers.asp?papernum=3488

Journals

1. "Identifying Damaged Buildings from High-Resolution Satellite Imagery in Hazardous Areas Using Morphological Operators", International Journal of Natural Hazard. (reviewed)
2. "Detecting and assessment of tsunami building damage using high-resolution satellite images with GIS data", International Journal of Disaster Resilience in the Built Environment. (reviewed)

19