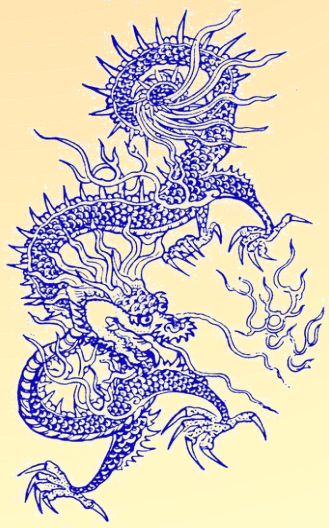
Object Oriented Change Detection of Buildings After a Disaster

Supannee Tanathong
Kurt T. Rudahl
Sally E. Goldin
Department of Computer Engineering
King Mongkut's University of Technology Thonburi
Bangkok, Thailand



ASPRS
Baltimore, USA
8-13 March 2009

After a Disaster – Assessment and Response

What is Unusual about a Disaster?

- 'Incomplete' advance preparation – no good data
- Remote locations with weak local infrastructure
- Infrastructure is incapacitated
- People with good local knowledge are technologically untrained
- Trained people are ignorant of local conditions
- Language translations not available

After a Disaster – Assessment and Response

After a Disaster – Assessment and Response

Geoinformatics Laboratory at KMUTT

- Computer Engineering, not Geography
- Creation of geospatial software with focus on:
  - Developing countries
  - Naive or untrained users
  - Full internationalization (multiple languages)
  - Ability to use low-quality data

After a Disaster – Assessment and Response

Immediate Tasks

- Rescue survivors
- Food and medical aid
- Disease prevention – sanitation and water supplies
- Assess damage
- Rebuild (or relocate)

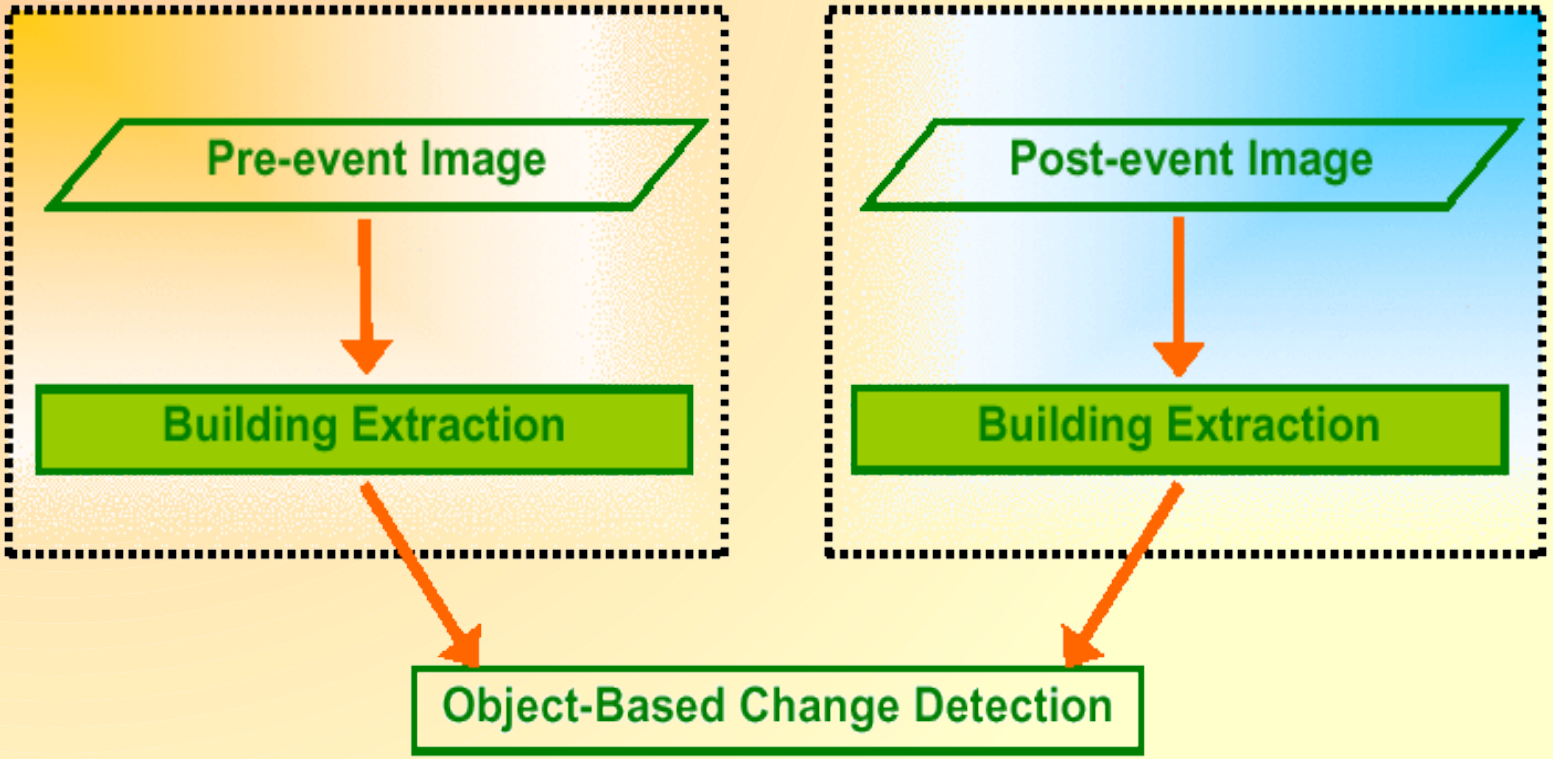
After a Disaster – Assessment and Response

Satellite Data

- Even with current hi-resolution satellites, humans are too small to see
- Can use building destruction as a proxy to locate distressed communities
- Research reported here attempts to apply the GlaK principles to this task

Study Topic – The Andaman Tsunami 2004

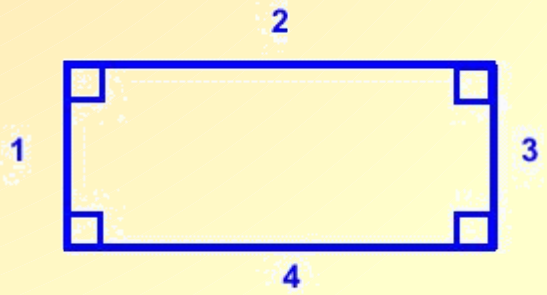
Overall Framework of The System



Note we are not differencing the images then looking for buildings, but the other way around.

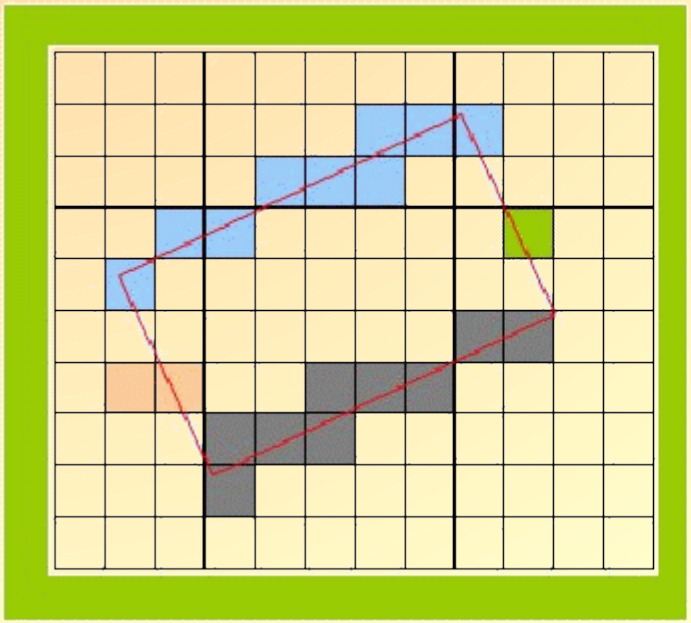
Logic of The System

- Human-made objects are generally distinct from natural landscape in various geometric ways (such as low fractal dimension).
- We want to use *a-priori* knowledge about buildings to separate them from the surroundings.
- Initially, we assume a four-sided building:



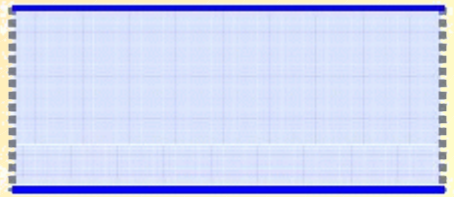
Logic of The System

- However, with 1-meter image resolution, a building may occupy only a few pixels
- The two lines forming the shorter side are frequently undetectable



Logic of The System

- Instead, we will look for pixel regions where:
  - There are two parallel lines (the long sides) of similar extent
  - The region between the lines is homogeneous (all the same)
  - The region between the lines is compact (distinct from surroundings)



Logic of The System

Building extraction outline:

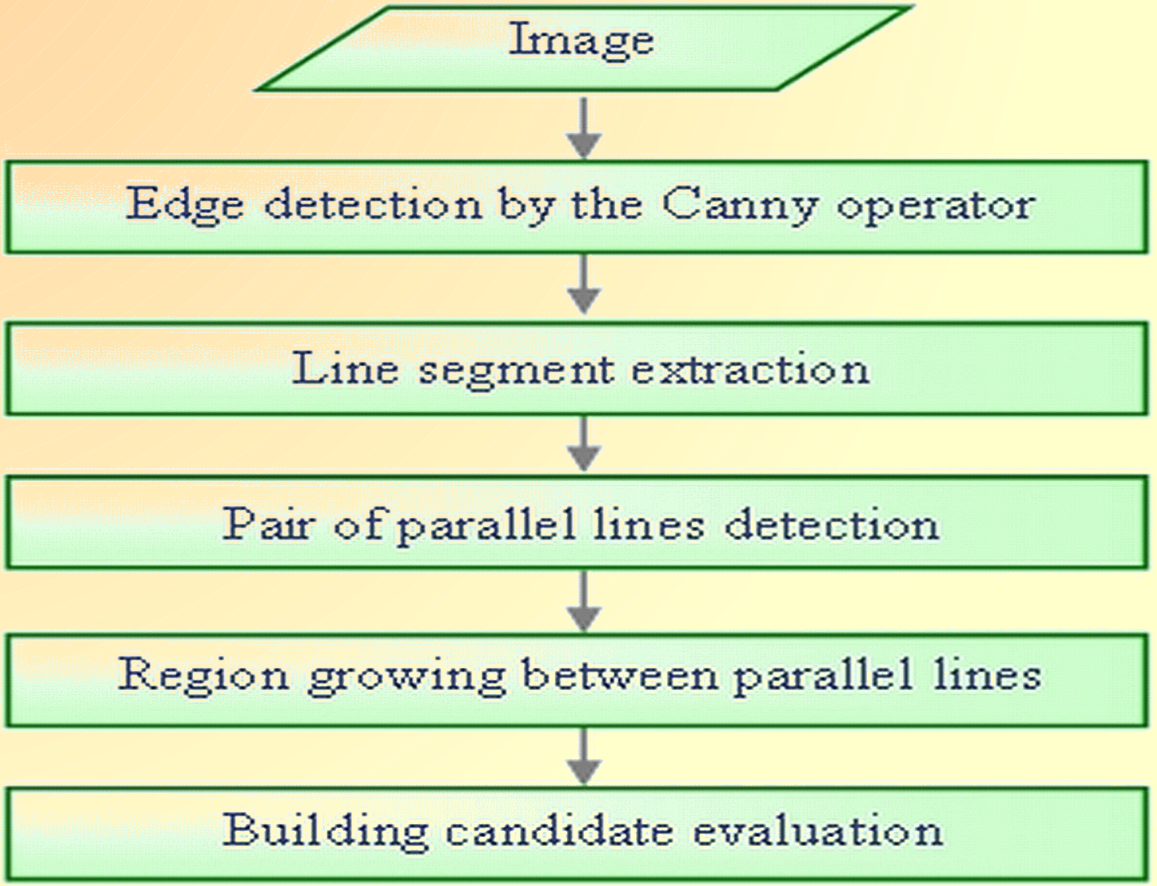


Image Processing Details

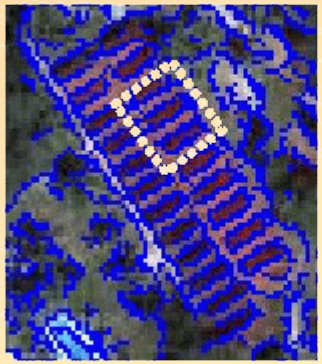
CANNY EDGE DETECTION

Gradient Magnitude

Image Processing Details

LINE SEGMENT EXTRACTION

Gradient Direction



[1° … 360°]

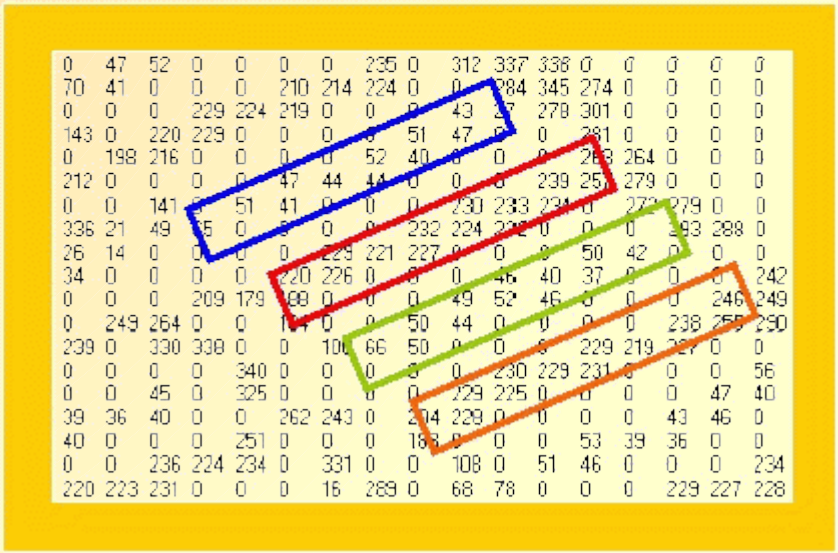
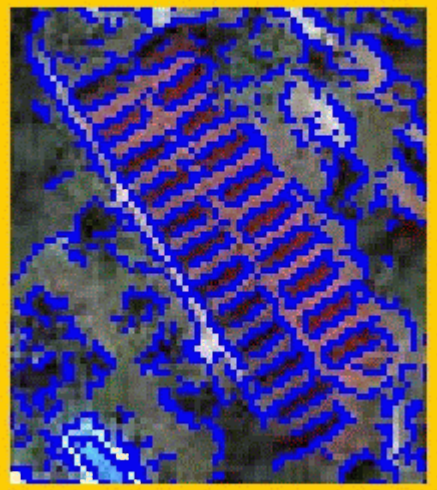
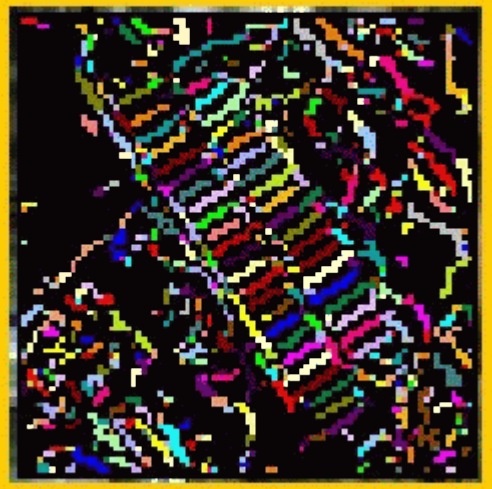


Image Processing Details

LINE SEGMENT EXTRACTION



Edge image



Extracted line segments

Image Processing Details

LINE SEGMENT EXTRACTION

Find properties of a line segment

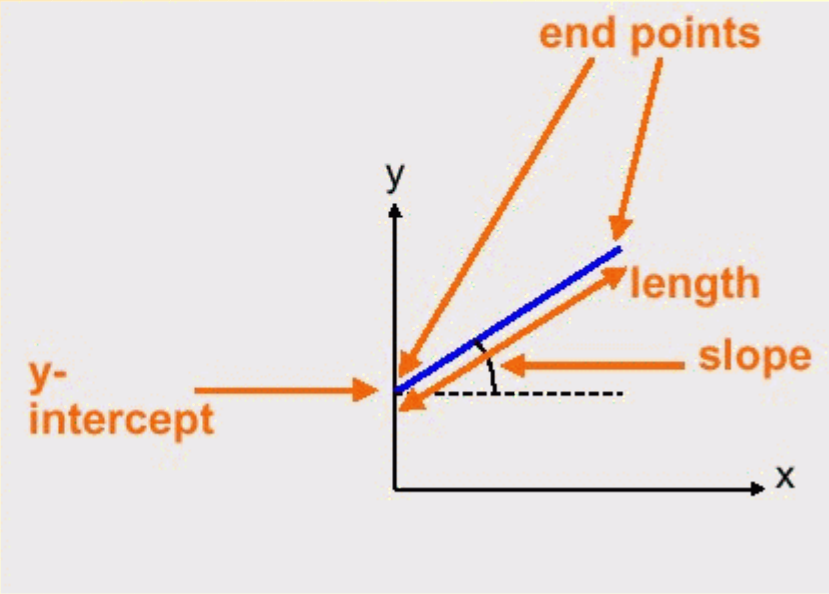
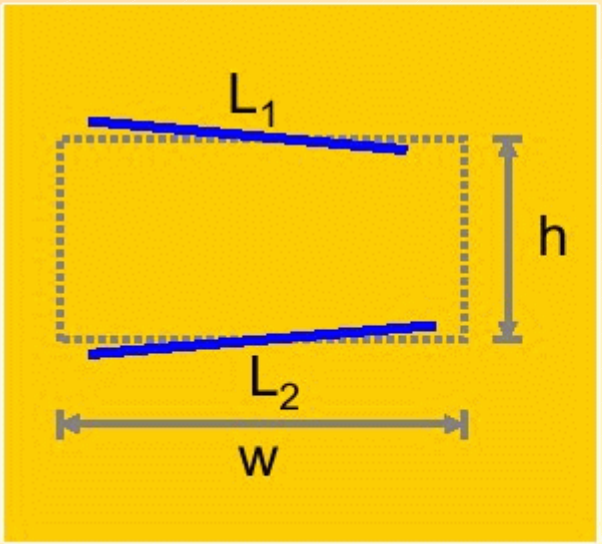


Image Processing Details

PAIR OF PARALLEL LINES DETECTION

Conditions to form a major line pair:



(a) Length(L_1) > T_w

(b) Length(L_2) > T_w

(c) Dist(L1, L2) > T_H

(d) |Orient(L1) – Orient (L2)| ~ 0

Image Processing Details

PAIR OF PARALLEL LINES DETECTION

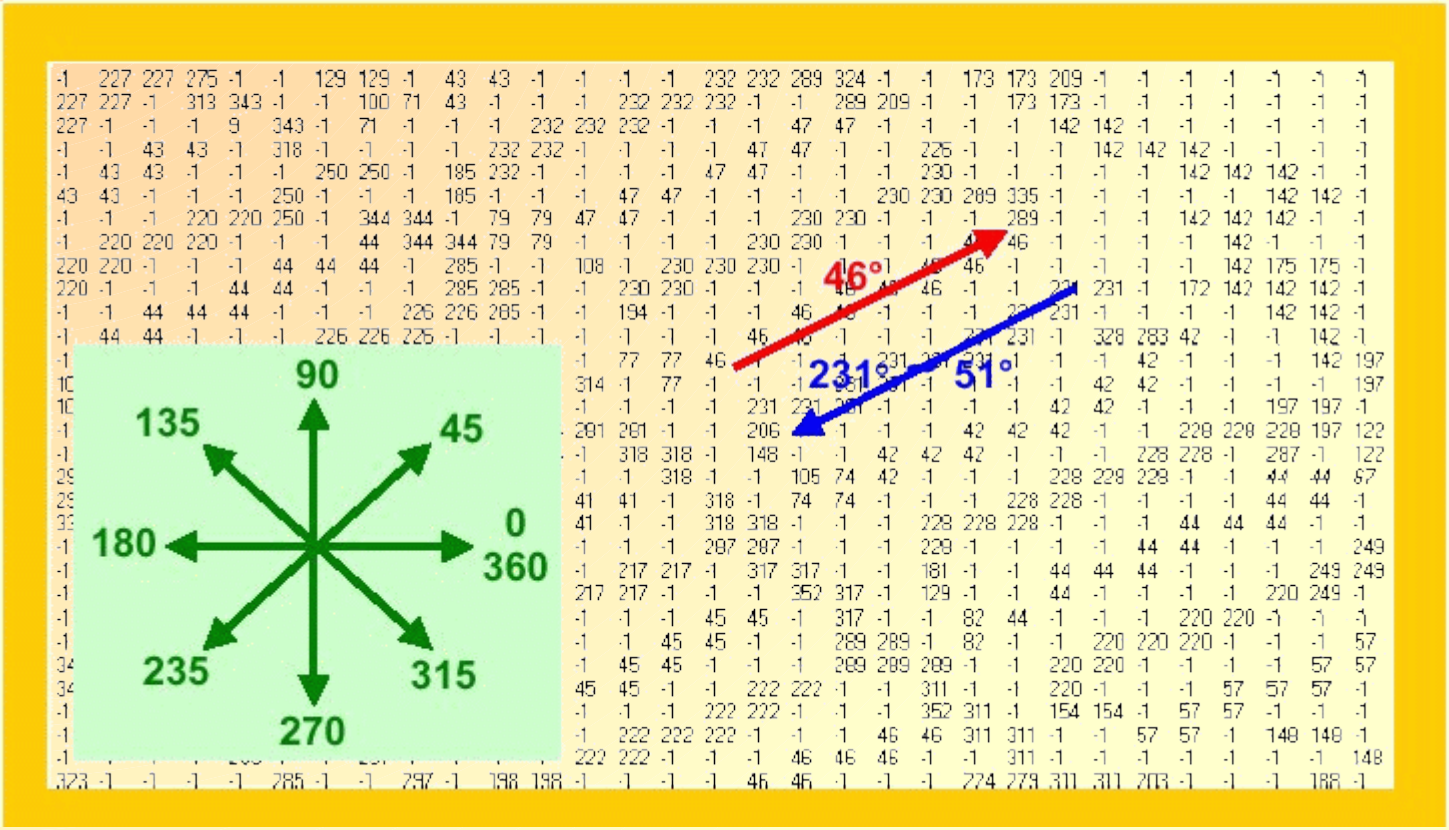
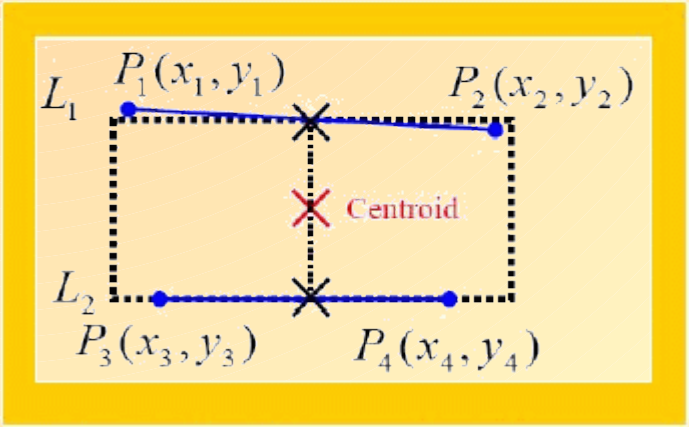


Image Processing Details

REGION GROWING BETWEEN PARALLEL LINES

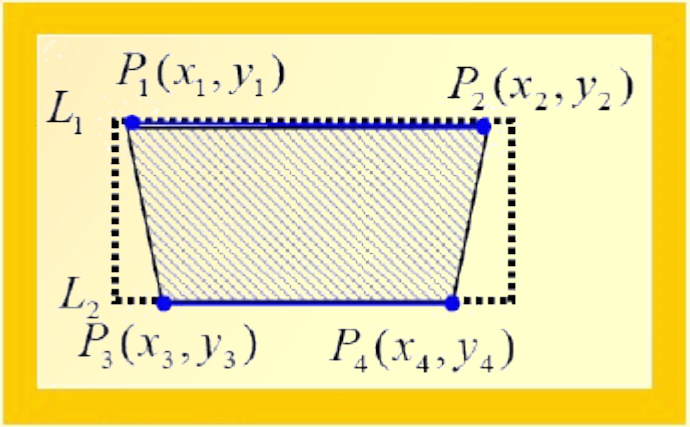
Calculate two parameters for the region growing:

(a) Seed point



- **Centroid of the major line pair**

(b) Threshold

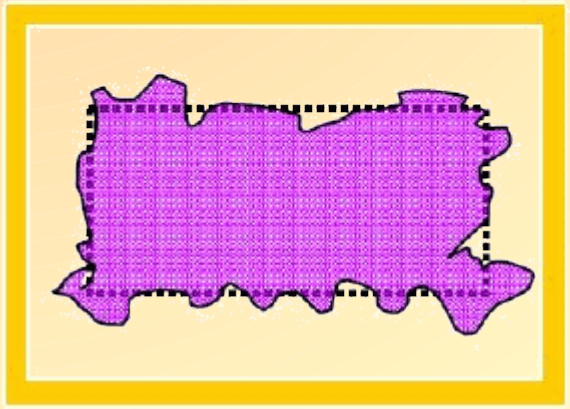


- **Median filter**
- **Difference between min and max color of pixels.**

Image Processing Details

BUILDING CANDIDATE EVALUATION

The region can be a building candidate if it has a compact shape.



(1) Height (H)

(2) Width (W)

(3) Centroid (xc,yc)

(4) Slope of major axis

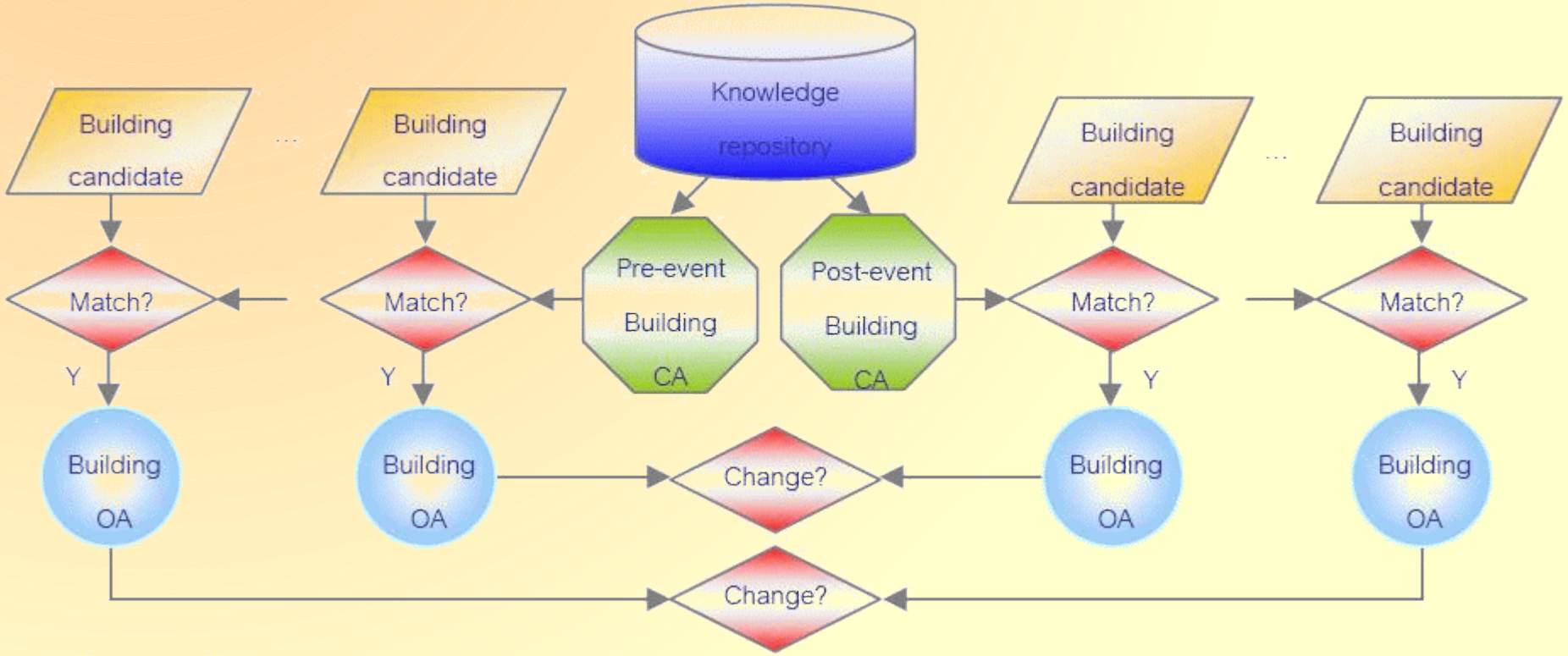
(5) Slope of minor axis

Image Processing Details

- We collect all the objects defined by pairs of parallel lines, and assign a probability based on
  - Plausible dimensions (size and aspect ratio)
  - Uniform internal region
- Various other measures were tried and found not useful
- Clearly, 'plausible' dimensions, and even building shape, depend heavily on the particular locale.

Object Processing

We want to match up pre- and post-event objects:



Object Processing

- Each candidate building in the before- and after-event images is converted into an 'agent'.
- Each agent has knowledge about itself (location, time, etc).
- Each agent has limited abilities to evaluate its relationship to other agents.
- Agents from the before and after images try to find their counterparts.

Object Processing

- For any given agent, three results are possible:
  - A match is found with essentially the same location and properties.
    Conclusion: no or minimal damage
  - A match is found, but with changed location or size
    Conclusion: significant damage occurred
  - No match is found
    Conclusion: extensive damage making the building unrecognizable
- Important to remember that we are not really trying to evaluate individual buildings, but rather to estimate the severity of damage within a community.

Experiments

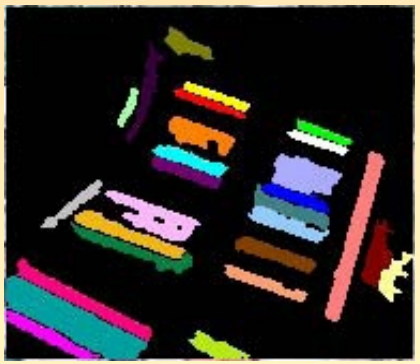
- Reported experiments involving two building types: industrial buildings (warehouses) and residential.
- Two IKONOS images with 1-meter resolution captured on 24 January 2004 (pre-event) and 29 December 2004 (immediately post-event)
- Phuket Island in the Andaman Sea coastal region of Thailand.
- All of the software was written by Ms. Supannee Tanathong as part of her Master's thesis.

Experiment 1 - Industrial

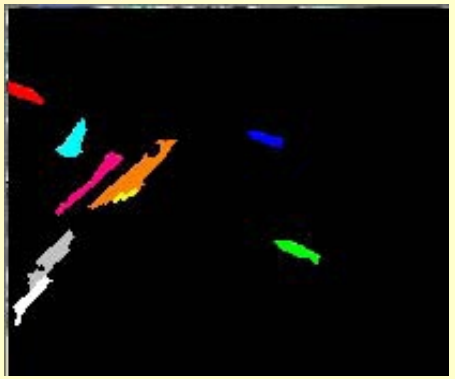
Pre-event image

Post-event Image

Candidate objects



Candidate objects

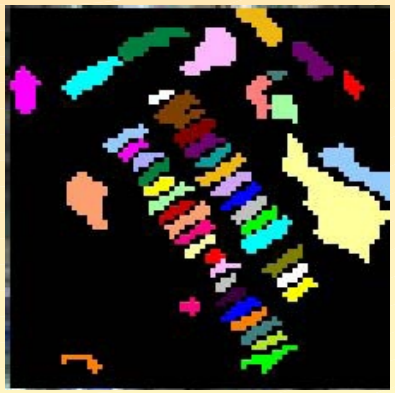


Experiment 2 - Residential

Pre-event image

Post-event Image

Candidate objects

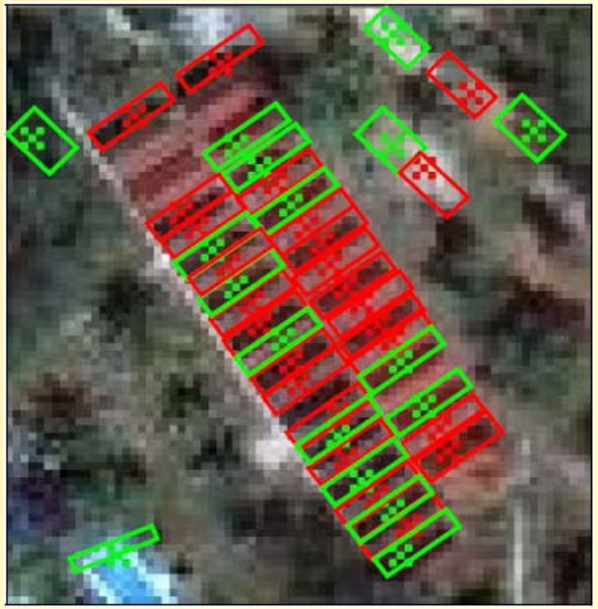


Candidate objects

Experiment Results

Industrial Area Changes

Residential Area Changes



Red indicates buildings apparently damaged
Green indicates building which disappeared

Experimental Results - Summary

Industrial Area:

- Two buildings were changed after the disaster while the remaining had disappeared or were no longer recognized as buildings. This matched visual interpretation.

Residential Area:

- 23 buildings were changed in the post-disaster image in either area or structure, which matched visual interpretation
- Due to the failed detection of some buildings in the post-disaster image, our change detection falsely reported that 12 buildings had disappeared in the post-disaster image. Thus, destruction was significantly over estimated.

Conclusions

We have presented

- A method for extracting buildings as objects from remote sensing images
  - We employ edge detection and region growing approaches to supplement each other in order to locate building
  - We can detect both large-size buildings in industrial areas and small-size buildings in residential areas with 75 percent accuracy
- An object-oriented approach to assessing building damage following a disaster
  - An agent-based approach permits us to fine-tune the object detection for different types of objects by having different rule sets and parameters

ACKNOWLEDGMENT

We would like to thank the Thai Geo-Informatics and Space Technology Development Agency (GISTDA) for providing remotely sensed imagery, and the International Water Management Institute for permission to use their remotely sensed images during software testing.

Contacts

Supannee Tanathong - *littlebearproject@yahoo.co.uk*
Kurt T. Rudahl - *rudahl@rsgis.net*
Sally E. Goldin - *seg@goldin-rudahl.com*
Dragon software is at
http:///www.dragon-ips.com
Geoinformatics Laboratory at King Mongkut's University
http://www.cpe.kmutt.ac.th/glak