Preliminary results in development of an object-based image analysis method for earthquake damage assessment

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Overview

- Commercialization of VHR satellite images.
- Employ remotely sensed images with various spatial resolution in earthquake damage detection.
- Pixel-based, texture-based processing cannot exploit much information contained in a VHR image.
- Visual interpretation has been the most reliable way but time-consuming and requires experienced interpreters.
- Development of an object-based method is current tendency.



Area Morphology

Binary area morphology (Vincent, 1992)

- Area opening γ with parameter **s** removes the component which area is smaller than **s**.
- Area closing ϕ with parameter **s** fills the hole which area is smaller than **s**.

• Grayscale area morphology (Vincent, 1992)

- Thresholding with all possible gray value $h \rightarrow T_h$
- Binary area opening or closing $\rightarrow \gamma(T_h)$ or $\phi(T_h)$
- Supermum or Infimum applied to all

 $\gamma(T_h)$ or $\phi(T_h)$



Area Morphological Scale Space

AOC scale space

- Applying area opening followed by area closing with a parameter s
- ACO scale space
 - Applying area opening followed by area closing with a parameter s



- Theoretically, infinite number of scales.
- Discrete dimension of an image, the number of scales increases one each as a window (area) size increases from one pixel to an image size.
- Practically, a limit number of scales can be used.
- Horizontal and Vertical granulometry can be used to compute the possible object's areas on an image.



- Behavior: from a coarse scale to the finer ones, an object is created and split.
- The linking trees of objects must be formed across the scale space



An object might have

- a father on the next coarser and some children on the next finer scale.
- The scale where an object's tree stops is called "root" scale.

- Extended to multi-spectral images
 - AOC scale space is separately generated for each band
 - But the same set of s is used for all bands.
 - This set can be found by granulometry analysis the first component of PCA.
 - Quantization of intensity can be used to reduce the number of gray value → speed up the computational time.
- Focusing on earthquake damage assessment, scale space is employed to
 - Assist visual interpretation
 - Damaged building detection
 - Building extraction for building inventory database





Assist Visual Interpretation

- Visual interpretation is time-consuming and requires experienced operators.
- Locate an object and then describe its characteristics is normally disturbed by many details inside and around it.



Assist Visual Interpretation (cont.)

- Scale-space images can assist this time-consuming process.
- Scale-space images are represented either in truecolor-composite or false-color-composite.
- Interpretation starts at the coarsest scale and move upward the finer ones to pick up an object at its root scale.



s = 100

s = 1000

s = 50

Original

Damage Detection

Currently developed methods



Our method follows B approach and is object-based approach.

- After pre-processing, scale-space is generated,
- K-mean clustering is applied to assign the spectral index,
- The definition of each spectral index on each scale is giving according to draft land-cover types like soil, vegetation, water, shadow, etc. and stored in a database,
- Object linking tree is formed according to the spectral index. This information is also stored in a database for further extraction.



Testing on QuickBird image of Bam

K-mean clustering on different scales



Original



s = 200

s = 1000



Testing on QuickBird image of Bam

Extracted buildings on scales s = 500, 1000 and 2000 which area assigned on Red, Green and Blue channels.



Original



Extracted buildings





Testing on QuickBird image of Bam



Extracted buildings on all scales are combined

- a) The pre-event images
- b) The post-event images
- c) Areas of damaged buildings



Characterize the damage level of each building block will be developed.

Building extraction for update database

Building is extracted for damage detection

Can be used in updating database

• However, not only the existence of building but also

- More detailed spectral information should be retrieved.
- More context information should be retrieved to combined several parts of a building.
- More classification into residential or commercial buildings, probably by building's size.
- Post-processing the building shape
- Streets, trees, parks should also be detected.
- Algorithm to match extracted results with GIS database needs to be developed.









TEST B: dense distribution of small buildings

Color code according to ID Background



True Color Composite









- The smallest size selected was 10.
 Buildings smaller than 10 pixels (or 3.6 m²) were removed.
- However, the extraction highly depends on the contrast of a feature compared to its surrounding.
- It's difficult to successfully extract all small buildings in such a dense areas.

Selected sample



True Color Composite

Extracted Results

False Color Composite





 Big buildings were successfully extracted in general (either in densely or sparsely distributed areas)

 VHR satellite images provide many details → many different parts of a complex structure can be extracted

 It requires a postprocessing to combine all parts of a building.

Selected sample "Reunification Palace"



3D Visualization "Reunification Palace"

- Using ArcView 3D Analyst interface.
- Extracted building was extruded by its "assigned" height.
- Extracted vegetation polygons were classified into trees and grassland (visual interpretation)
 - Simulation of trees
 (Avenue script by
 Christopher Legg EU
 Forest Inventory and
 Monitoring Project 1998).







- 3D perspective view of ENVI
- Extracted building was assigned some height values.
- A "fake" Digital Surface
 Model was generated and
 draped by QuickBird Image.



3D Visualization "Reunification Palace"



Summary

Object-based method has been proposed and developed to exploit more information possessed in a VHR satellite image.

The key idea is the analysis of spectral information in a morphological scheme.

• It is a promising feature extraction method \rightarrow to detected damaged building and update building inventory database.

Further object-based comparison should be developed for damage detection.

• Due to the complex scenes of the urban areas, it's unable to extract small buildings in a dense residential areas.

 It is possible to extract commercial buildings, big residential buildings in old developed areas and newly constructed buildings in developing area.

