Towards a rapid, multi-scale assessment of earthquake vulnerability

based on satellite remote sensing and omnidirectional imaging

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Earthquake Model Central Asia (EMCA)  Inventory Data Capture Tools (IDCT)
Motivation

- **Seismic vulnerability of buildings** is a key component in risk assessment.

- Best results come from a thoroughly (outside and inside) assessment of a building by experts, **but:**

  - **Inventory data** is often out-of-date, spatially fragmented or highly aggregated.

  - **Need for new approaches** to estimate building inventory and thus vulnerability in a rapid, standardized, comparable and scalable way.
Vision

- A rapid visual survey can lead to a reasonable first assessment over broad areas.
- By coupling remote sensing (topview) with omnidirectional imaging (streetview), this could be done in an optimal way (in terms of time and resources).

- Open-source tools, low-cost data sources.
- Globally applicable on regional and local scale.
Overview of the approach

Probabilistic Framework

Inventory Database

Hazard Assessment + Vulnerability Assessment = Risk Assessment
Analysis of medium-resolution satellite images

Stage of Stratification

Pixels

Workflow / Results

Homogenous areas in terms of building type and age

Intersection

Building types

Age of built-up areas

object-oriented LULCC

Change-detection

Homogenous areas (unlabeled)

Unsupervised Segmentation

Landsat Image t1

Landsat Image t2

Landsat Image t3

Pixels → Segments → Thematic classes → Urban Structure Types
Analysis of medium-resolution satellite images

Stage of Stratification

Urban Structure Types

Urban Structure Type: 8
Type: 1-2 storey masonry, brick
Age: built between 1994 and 2009

Urban Structure Type: 10
Type: 3-6 storey brick, concrete, panel
Age: built before 1977

Urban Structure Type: 16
Type: industrial, commercial
Age: built before 1977

Bishkek
Stratified sampling and analysis of high-resolution satellite images

Sample areas

Extraction of building footprint and location

Building shape, area, roof-type, roof-color/-material, etc.
Acquisition and analysis of high-resolution omnidirectional images

Omnidirectional image stream (Bishkek 2010)
Acquisition and analysis of high-resolution omnidirectional images

Automated height measurement from 3d-points

Vertical shape, soft-storey detection, no. of windows, etc.
+ manual image interpretation by local (+global) experts from civil-engineering
Data integration

- **Priors from medium-resolution satellite images:**
  - Estimated Age
  - Land-Use / Land-Cover

- **Information from high-resolution satellite images:**
  - Building footprints
  - ...

- **Information from omnidirectional images:**
  - Estimated Height of Structures
  - ...

- **Priors from manual data entry:**
  - Expert knowledge
  - Ancillary data
Vulnerability estimation (EMS-98): Bayesian Network

Age: 1994-2009
No. of storeys: 9
Type: 5-9 storey, concrete, panel, frame
Vuln: E
Conclusion

- Stratified sampling using remote sensing helps to focus local analysis.
- Omnidirectional imaging: fast deployed, easily operated.
- Feature extraction from multiple image sources proved successful.
- Bayesian approach to data integration seems promising.

- Approach is scalable, flexible and transferable.
- Acquisition time and costs could be significantly reduced.

- Need to further strengthen the use of open source GIS and RS software.
- Need to improve geo-data access already in the pre-disaster phase.
- Global initiatives need interaction with local experts.
Thank you for your attention!