Application of LiDAR-derived high resolution topography to earthquake geology in Japan

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Collaborated with Shinji Toda, Masayuki Yoshimi, Hidetaka Saomoto and Eiji Saito
Wide areal coverage of high-resolution LiDAR data in Japan

http://www.sokugikyo.or.jp/laser/
Association of Precise Survey and Applied Technology
https://gbank.gsj.jp/geonavi/
Contents:

**Earthquake faulting:**
- Detailed mapping earthquake surface rupture
- Detection of surface rupture in densely forested mountainous regions
- 3-D surface displacement field

**Active fault/fold:**
- Mapping faults in urbanized areas
- Identifying long wave-length cryptic deformation
- Recognition of overlooked potential active faults
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Detailed mapping earthquake surface rupture

- Surface rupture associated with the 2011 Fukushima-Iwaki earthquake
Post-Eq. LiDAR (data acquisition and filtering by Aero Asahi Corp.)
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Mapping faults in densely forested mountainous regions

- Surface rupture associated with the 2008 Iwate-Miyagi earthquake
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Maruyama et al. (2011)
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3-dimensional surface deformation

Differentiating pre- and post-earthquake LiDAR data

- Particle image velocimetry (PIV) algorithm: Mukoyama (2011)
- Iterative Closest Point (ICP) algorithm: Nissen et al. (2012)
- Genetic algorithm (GA) for matching functionized topography interpolated by Radial Basis Function (RBF): Saomoto (2013)
• Step 1: Landforms are divided into grids

• Step 2: Functionizing topography in each grid using Radial Basis Function (RBF) interpolation
  \[\text{\rightarrow minimize noise effects}\]

• Step 3: Compute to minimize the distance between functions (each grid) by genetic algorithm
  \[\text{\rightarrow obtain optimal solution (avoid to obtain local solution)}\]
3D displacement field along the central part of the Itozawa fault

Computed by Dr. Hidetaka Saomoto (AFERC, AIST)

preliminary result
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Mapping faults in urbanized areas

Itoigawa-Shizuoka Tectonic Line active fault system in Matsumoto, Nagano Prefecture

Kondo et al. (2008) Geomorphology
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Identifying long wave-length gentle deformation in alluvial plain

- Horinji fault in Hokuriku region

- Destruction of castles and cities on the Tonami Plain by 1586 large earthquake
- Faults responsible for the quake are not found in the plain
• No distinct contour inflections in conventional 1:25,000-scale topographic map
• No active faults were identified in the Tonami Plain

Base topographic map: 1:25,000, C.I.: 10 m (issued by Geospatial Information Authority of Japan)
- The Horinji fault ruptured late Holocene repeatedly with two events in the last 5 ky ago
- The candidate fault responsible for the 1586 earthquake
Virtual enhancing vertical exaggeration of LiDAR DEM delineates subdued gentle anticlinal warping in the plain, proximal to destructed castle and cities and extension of the Horinji fault.
Position and slip sense of fault identified from warping correspond to geological fault as inferred from subsurface geology.

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Detecting active faults with limited geomorphic evidence

- Isurugi fault in Hokuriku region
Base topographic map: 1:25,000, C.I.: 10 m (issued by Geospatial Information Authority of Japan)
Maruyama et al. (unpublished data)
Evidence of recent faulting is only preserved for limited section of the fault (1 km of ca. 20 km) by destroy of faulted landforms due to intense erosion of large river.
Summary:

• High-resolution airborne LiDAR topographic data covers most of major active faults in Japan

• LiDAR topography provides important clues for detecting and characterizing active faults in forested mountain and urban areas

• LiDAR topography is unrivaled data for detecting active structures with long wavelength gentle warping in alluvial plain