Science motivations and introductory remarks

GSA 2019

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OpenTopography
High-Resolution Topography Data and Tools
Trying to get at least a few pictures along the Altyn Tagh Fault, western China (1998)
-16 and 32 sq. ft. Flowform kites
-1280x960 pixels from radio triggered Olympus 340 digital camera
-geometry not appropriate for traditional photogrammetry; we needed structure from motion

Washburn, et al., 2003—1 picture
Trying to build a complete model of SP Crater, Northern Arizona with REU students (2013)

- using balloon and auto kite mounted system
- different surveys, weak ground control, under powered processing machines

[Image of people holding a kite]

[Graph showing distance northing and easting in meters]

Trying to align a couple of different model "chunks"

[Image of a crater]

https://www.semana.com/ge/norte/galeria/cine-frankenstein-cumple-200-anos/466860
Science requirements

• Need topography data with sufficient spatial extent and resolution to capture phenomena of interest

• Need topography data with sufficient temporal repeat to capture changes of interest
The Kekerengu Fault is one of several faults that ruptured during the Kaikoura Earthquake.

Kekerengu alone is 30+ km of this intricate ground rupture.
Need ~<meter-scale sampling to cover critical scale breaks and temporal repeat to address log(t) response of some phenomena
Length scales $>10^5$ m and <1 m

M = 5.08 + 1.16*\log(SRL)

Wells and Coppersmith, 1994
“Seeing” at the appropriate scale means measuring at the right scale.

Surface processes act to change elevation through erosion and deposition while tectonic processes depress or elevate the surface directly—their record is best characterized with the right fine scale.

Applies in particular to statistical self similarity.

How long is the coast of Britain?
Statistical self-similarity and fractional dimension
Science: 156, 1967, 636-638

B. B. Mandelbrot

http://en.wikipedia.org/wiki/How_Long_Is_the_Coast_of_Britain%3F_Statistical_Self-Similarity_and_Fractional_Dimension
Major US community studies recognize the scientific value of high resolution topography.

Science communities

- USGS sponsored
- EarthScope
- Seismology
- Geodesy

2017

http://nationalmap.gov/3DEP/
Example scientific motivations

• How do geopatterns on the Earth’s surface arise and what do they tell us about processes?
• How do landscapes influence and record climate and tectonics?
• What are the transport laws that govern the evolution of the Earth’s surface?
• How do faults rupture and slip throughout multiple earthquake cycles and what are the implications for earthquake hazard?
• Landscape and ecosystem dynamics
• Volcano form and process
• Changes in volume of domes, edifice, flows
Advances in and decreasing costs for software (algorithms such as structure from motion), computational hardware (rapid computation of colored point clouds and textured 3D models), and unmanned aerial vehicles (UAVs) as semi-autonomous sensing platforms has absolutely changed the geoscientist’s toolkit.

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The interpretation of structure from motion

By S. Ullman

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(Communicated by S. Brenner, F.R.S. – Received 20 April 1978)

The interpretation of structure from motion is examined from a computational point of view. The question addressed is how the three dimensional structure and motion of objects can be inferred from the two dimensional transformations of their projected images when no three dimensional information is conveyed by the individual projections.

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Object Recognition from Local Scale-Invariant Features

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Abstract

An object recognition system has been developed that uses a new class of local image features. The features are invariant to image scaling, translation, and rotation, and partially invariant to illumination changes and affine or 3D projection.
Detailed geology of Lee Adoyta, Ledi Geraru Research Project Afar Ethiopia:
Rapid acquisition of imagery of deformed fossiliferous and tuff-bearing sedimentary rocks in the Afar region of Ethiopia provide 3D control for paleontological provenance and environmental reconstruction studies.
The emplacement of the active lava flow at Sinabung Volcano, Sumatra, Indonesia, documented by structure-from-motion photogrammetry - Carr, et al., 2018. Pre-eruption 5 m DEM and post eruption SfM registered to unchanged areas.
Ubiquitous point clouds + 3D models: coordinated (mapping and monitoring) and haphazard (autonomous navigation, individual photo collections, etc.)

-Need open access and cyberinfrastructure to support archive, and rapid query, data handling, preprocessing, and differencing

Google car: Gb/sec high accuracy navigation data

Modeling the World from Internet Photo Collections (Snavely, et al., Int J Comput Vis, 2007)