Detecting Geomorphic Changes - Applying Innovations to Spatial Data Gathering

Using Structure-from-Motion Photogrammetry (SfM)

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Why Measure Geomorphic Changes?
Measurements speak louder than words
Tradition low-cost monitoring method:
Cutting-edge, High-Cost Monitoring Method: Terrestrial LiDAR
Structure-from-Motion Photogrammetry (SfM)

SfM

http://www.tnt.uni-hannover.de/project/motionestimation/
The remaining presentation is a SfM Methods and Applications Walk-through

- Study Area Overview
- Data Gathering
- Data Processing
- Data Density, Accuracy, Precision
- Data Application
- 3D Modeling and Visualization
- Conclusions
Study Area:
Suncook River Valley, Epsom NH
Colored Area = Study Site
Gathering Data
Field Data Gathering: Creating Monuments

- These are created in the same manner as any other monument
- They need to be highly visible
- Seen here: Stake Skirt
- Stake deepness reduces stake abduction
Measurements are needed for scale
Then snap lots of photos...

Very rapid. ~15 to 30 minutes
Data Gathering Review

Gathering Datasets:
15 to 30 min.

Establishing Monuments:
30 minutes to 1 hr.
Data Processing

C:\Python26\ArcGIS10.0>File '"ppt_gui_start.bat" is not recognized as an internal or external command, operable program or batch file.

C:\Python26\ArcGIS10.0>PATH=C:\Program Files\ImageMagick-6.8.6-Q16;C:\Python26\arcGIS10.0\Lib\site-packages\PyQt4;C:\oracle\ora8i\bin;C:\Program Files\Oracle\jre1.1.7\bin;C:\oracle\orant\bin;C:\oracle\ora80\bin;C:\WINDOWS\system32;C:\WINDOWS\system32\Wbem;C:\Program Files\Intel\DMIX;C:\Program Files\ATI Technologies\ATI.ACE\Core-Static;C:\Program Files\Common Files\Roxio Shared\DLLShared\;C:\Program Files\Common Files\Roxio Shared\9.0\DLLShared;\c:\oracle\orant\jkl\bin;C:\Program Files\ZipGenius 6\C:\cygwin\bin;C:\Program Files\MATLAB\MATLAB Compiler Runtime\v714\runtime\win32;C:\Program Files\Microsoft SQL Server\90\Tools\Binn\;C:\Program Files\Microsoft SQL Server\100\Tools\Binn\;C:\Program Files\Microsoft SQL Server\100\DTS\Binn\;C:\Python26;"C:\Python26\ArcGIS10.0"

C:\Python26\ArcGIS10.0>python ppt_gui.py
Working directory created: c:\temp\osm-bundler-jif1zm
BundlerMatching executable path: C:\Python26\ArcGIS10.0\software\bundler\bin\KeMatchFull.exe
Sift executable path: C:\Python26\ArcGIS10.0\software\vlfeat\bin\w32\sift.exe

Processing photo 'P1060065.JPG':
Copy of the photo has been scaled down to 1200x801
Extracting features with the SIFT method from VLFeat library...
Found 10428 features

Processing photo 'P1060066.JPG':
Copy of the photo has been scaled down to 1200x801
Extracting features with the SIFT method from VLFeat library...
Found 13304 features

Processing photo 'P1060067.JPG':
Copy of the photo has been scaled down to 1200x801
Extracting features with the SIFT method from VLFeat library...
There are plenty of SfM software suites out there:
(Most are not free, especially the nicer ones)

- **PIX4D**
  - Freedom to map

- **Microsoft Photosynth**

- **simactive**
  - Cutting-edge photogrammetry software

- **AUTODESK 123D**

- **Leica Geosystems**
What you choose will depend on your needs and budget:

Photosynth: <15min. to create ~60k points

Bundler/PVMS: >10hrs. to create ~100k points
Data Cleaning

expect about an hour of cleaning per 100,000 points
Projecting Point Clouds

- New point clouds are not located in their real-world locations
- They need to be projected into a real scale or coordinate system
- ~1 hour to project a point cloud

Control Points need to be visible
Post-Processing Review

- 1-16 hrs. of processing time (passive)
- 3-5 hrs. of data editing and transformation
Data Density, Accuracy, and Precision
LiDAR (white) vs. SfM (color)

RMSE = 3.0'
I blame the reference LiDAR dataset's poor resolution (3.28084')
Result? Smaller Survey = >Detail
Precision:
Red: ~.35'
Red and Blue: ~.5'
Gully: <.25'
Precision suffers from:

- Distance from camera
- Surface roughness
- Vegetation
- Slope (when converted to raster format)
- Water (Never use SfM on water)
Data Applications
Arc GIS: Converting/Analysis
3D Models and Measurements

Using free software:
- Cloud Compare
- Blender
- Mesh Lab
We can target sections of a survey for 3D modeling
Point Cloud to Mesh Distance:
Mesh Bounding Box Size 15.581893
44.906080 15.974252
Mesh Bounding Box Diag 50.145071
Mesh Volume is 198.428329
Mesh Surface is 1076.514526
General Conclusion

SfM is an excellent tool for building robust spatial models of eroding stream banks on a budget, but requires time to learn.
Conclusions

- Field surveys are much faster than most traditional bank monitoring methods
  - A minimalist survey can be completed with Camera, Stakes, Skirts, Measuring Tape, and Clinometer
- Post-Processing times are highly variable depending on work flow, and generally time-consuming
- Datasets are dense and useful for detecting small changes over a large area
Minimal Field Gear:

First Site Visit:
- Camera
- Stakes
- Colored Stake Skirts
- Hammer

Second Site Visit:
- Above Equipment
- Surveying Gear
Point Cloud Examples:

http://photosynth.net/view.aspx?cid=bcc308a3-06d8-41c3-88f7-340c29b8ce1d

Early spring ^

http://photosynth.net/view.aspx?cid=f56509e1-aedf-4a6d-bc45-89a1a41f9cd6

Summer ^
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