SfM point cloud generation, scaling, and georeferencing approaches in an undergraduate field course

Les Hasbargen, Earth & Atmospheric Sciences, SUNY Oneonta
Leslie.Hasbargen@oneonta.edu

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Abstract

Making a point cloud is not hard to do, even with smartphones or very low end cameras. More challenging is the alignment and scaling of the point cloud. This presentation documents the challenges and successes of using low cost and open source software to teach point cloud generation in field settings. Students worked on the project in a phased approach, where they learned how to use surveying tools to locate objects in the field, then build point cloud models back in the computer lab. Two significant hurdles challenged the students. Even with background lectures on the use of ground control points to facilitate model scaling and rotation, most students had problems properly surveying GCPs, and then using GCPs to align and scale their point clouds. Perhaps one issue is the condensed nature of the exercise, which took place over two weeks (two 75 minute lectures and two 225 minute lab sessions). Some ideas for future implementation include practice labs indoors in easily controlled and manageable settings before conducting field surveys, conducting two or more such field surveys from start to finish, and extending the lab over a three week period.

The Vision for SfM in a Field Course

- Bring the field home with you
- Measure streams, hillslopes, landslides, folds, faults, rock orientation, sedimentary layer characteristics
- Build STEM competency
- Engage students with real world 3D data, which they collect and interact with

Fall 2018 SfM Teaching Approach: More is Better!

- 5 week module provides several formative experiences
- Week 1: Learn SfM in class (Agisoft PhotoScan Standard + Cloud Compare to scale and align point cloud)
- Week 2: SfM of geomorphic hillslope features, such as tree throw mounds, hillslope creep, rock capped pedestals; group activity
- Week 3: Landslide SfM, single sheet GCP; group activity
- Week 4: Hydraulic geometry in bedrock and alluvial channels, multiple GCPs shot with total station, or tape-compass; group activity
- Week 5: Summative experience; each student documents geomorphic features in a post-glacial gorge

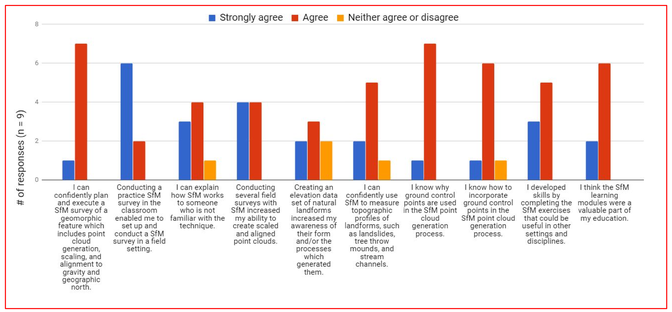
Ground Control Points (GCPs)

- Small rigid objects with measurable points
- High visibility in point clouds
- Align to gravity
- Align to north
- Locate in a georeferenced world

The Reality of Teaching SfM, or what I learned after 2016 season

- This is not a 1 hour exercise! Lots of moving parts: cameras, softwares, and scientific goals for using the data
- Video **tutorials** are very helpful
- **Multiple survey experiences**, starting in the classroom, can build confidence and familiarity with workflows
- **Beware of lighting** and texture in the feature to be captured
- **Things that stymie learning**: Poor alignment of cameras or too many cameras (lousy 3D model, or waiting too long…)
- Provide **purpose** for the survey: learn from multiple perspective views, develop skill sets, answer process-related questions

Students value the SfM learning experience; survey after 4 weeks



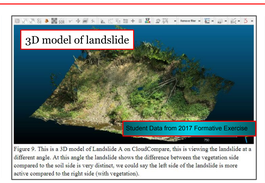


Figure 9. This is a 3D model of Landslide A on CloudCompare, this is viewing the landslide at a different angle. At this angle the landslide shows the difference between the vegetation side compared to the soil side is very distinct, we could say the left side of the landslide is more native compared to the right side (with vegetation).

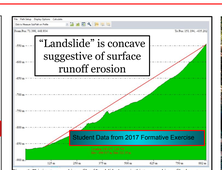
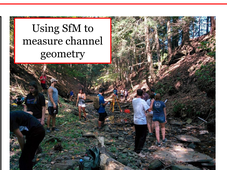
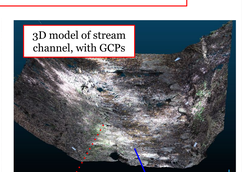
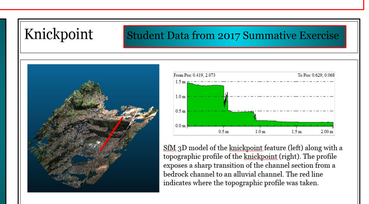


Figure 6. This is a topographic profile of Landslide A, again this topographic profile shows a





Can they learn SfM well enough to collect high quality data sets?
I think the answer is YES.
SfM data sets have far greater detail than any other readily available data…



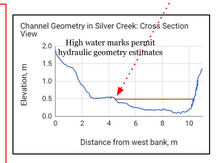
SfM 3D model of the knickpoint feature (left) along with a topographic profile of the knickpoint (right). The profile exposes a sharp transition of the channel section from a bedrock channel to an alluvial channel. The red line indicates where the topographic profile was taken.

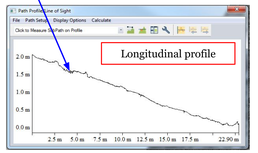
Methods to Scale and Align Point Clouds from SfM

- Single card ground control points
  - Easy to align to north and gravity
  - Good for 1-5 m surveys
- Distributed GCPs (5 to 100s m separation)
  - Laser rangefinder with inclinometer and compass can be used to find local coordinates: cheap, lightweight, fast, and decimeter accuracy
  - Total station combined with GPS receivers: heavy, expensive, and precise to mm

What's the End Game? Why spend time on 3D data with undergraduates?

- Point clouds define shape, and shape is linked to process
- Introduce students to forces in real world settings (stream hydraulics, for instance)
  - Channel geometry, friction, and hydraulic radius can be investigated
  - Concave profiles on landslide surfaces highlight runoff erosion
  - Convexity on landslide surfaces reveal recent incision
  - Change detection is possible over an entire area
- Are the complications of the 3D world hindrances to learning?





What's the next step?

- Drones: more views can reveal and resolve more
- Focus exploration of 3D data--what can we learn from documenting form at the process scale?
- Are undergrads ready for this?

Acknowledgements: Thanks to SUNY Oneonta students in Geological Data & Analysis, and Geomorphology 2016-2017 for wrestling with poorly designed workflows and recalcitrant software.