Introduction to TLS for a geology field course – Instructor overview

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Summary

Geodetic imaging technologies (TLS, ALS, MLS, Structure from Motion, terrestrial radar) have emerged as critical tools for a range of earth science research application from hazard assessment to change detection to stratigraphic sequence analysis. Field experience utilizing geodetic and geophysical tools provides a unique opportunity for upper-level undergraduates to learn research skills applicable to their future graduate research or career path. This unit introduces students to terrestrial laser scanning (TLS), a ground based remote sensing tool that generates 3-dimensional point clouds, with widespread research applications in geodesy, geomorphology, structural geology, and other sub-fields of geology. After an introduction to the basics of TLS, students will design and conduct their own survey of a geologic feature, followed by an optional introductory exploration of TLS data after returning from the field.

Learning Goals

Learning Outcomes

Students are able to:

- Design and conduct a simple TLS survey including:
  - Make necessary calculations to determine the optimal survey parameters and survey design based on site and available time
  - List the individual survey steps (workflow)
  - List the equipment needed for a survey
  - Make supporting field notes such as outcrop sketches, strike/dip measurements, and observations of outcrop conditions

Teaching Objectives

Facilitate student ability to:

- Cognitive: Design and implement a TLS survey design.
- Behavioral: Run a TLS scanner, set up related equipment (ex. targets and GPS) and make supporting field observations.

Context for Use

The content in Unit 1 was designed for upper-level geoscience majors in a field geology course. The material works well for a group of approximately 20 (or fewer) students with an instructor and teaching assistant/s. The ideal number of students for this exercise is 12 students, as they can break into four teams of three, which means each feature will have four scan positions (doable with a group of students in one field day) and gives each student time for hands-on scanner time. This content may also be modified to work in a classroom setting as a lecture (introduction to TLS) and lab (conducting a small survey of a feature) with approximately 20 students, though subsequent units in this module with a focus on processing and interpreting TLS data may be more appropriate for a classroom setting. This may also be adapted to a one-day field trip for a geomorphology, structural geology, geophysics, remote sensing/GIS, or field methods class.

Student experience with field observations, field maps, and trigonometry in addition to other basic calculation skills is expected. In a field course, this unit is ideally situated mid-way through the course, as students will already have some field experience. As this is the introductory unit for the module, it will pair well with any of subsequent units if the module needs to be modified for time.

Description and Teaching Materials

Part 1: Classroom introduction

This unit begins in a classroom setting, with a lecture presentation followed by the distribution of the TLS Manuals and Assignment Packets. The lecture includes background on *why* TLS is used in the earth sciences, and *how* TLS works. Similar material is provided in the manual. This segment should be brief (30 minutes – 1 hour) to allow time for field deployment of the scanner. If possible, have another instructor scan the classroom while giving the first lecture so students can be shown the data. Take a break between the two presentations to show the students the equipment and have them practice setting up targets to break up the lecture time. Inventory the equipment to ensure that all necessary components are present; while this is happening, students may fill out the blank equipment list in their Assignment Packets. Students should bring all typical field equipment with them (writing utensils, straight edge/ruler, field notebook, AND calculator*).

*calculator is essential to complete their work!

Part 2: Field deployment and instrument/survey overview

Introduce the field site, facilitating student discussion to determine the project objectives. Then introduce the instrument and field techniques. This includes how to set up the scanner and the targets as well as identifying the feature/s of interest, planning scanner positions, and planning target positions (in a group discussion). This will likely take the rest of the morning.

Part 3: Conducting the survey

Only a few students can actively work with the instrument at any given time. Students can be broken into teams with 3-5 people to set up the scanner, targets, and GPS. After this, each team can be responsible for conducting one scan from a position previously agreed upon by the group as a whole. Each team should complete the scan resolution worksheet after collecting the panorama scan and prior to collecting their high-resolution detail scan. When their team is not scanning, students should work on recording metadata related to the scan (see TLS Field Methods Manual) as well as typical field observations of the feature of interest and work on their assignments for the day (workflow, equipment list, scan resolution parameter worksheet for all scan positions). After the first two scans, register (tie into the same reference frame) the scans. Repeat this step after each subsequent scan. Plan for a full afternoon for this portion to allow time for students to get individual time using the scanner. Have students measure a feature on the outcrop (large clast, offset between stratigraphic units due to faulting, bed thickness) that is clearly identifiable so they can later compare measurements of the scan within the software to the measurements they took in the field.

Part 4: Exploration of TLS data

The field data collection portion of a TLS research project is only a small portion of the complete workflow, so in the evening students should be introduced to the software used to visualize and

explore the data they produced with their scan earlier in the day. This portion is optional, but strongly encouraged as students will need to be familiar with the software for subsequent units. If possible, the students should work with the data individually to maximize time with the software, but students may also work in pairs or in teams if computers are limited. The TLS Data Exploration and Processing Manual should be distributed to guide student work. Also attach a computer to a projector so students can follow the data exploration process as the instructor walks through the steps on their own machine.

Students should answer two reflective questions in their final write-up. One will cover the societal impetus/importance of using TLS to answer their research question of the day and the other is a metacognition question so students can reflect on what they learned, an important aspect of the learning process. Another question you may have students answer is: what was rewarding and what was challenging about this exercise?

Supporting materials:

- PowerPoint presentation

  Gives background and basic information about TLS

- TLS Field Methods Manual

  Includes TLS functions, considerations for survey design, and scanner specs

- TLS Data Exploration and Processing Manual
  Guided workflow for data exploration (Part 4); this also includes data exploration and processing guides for Units 2, 3, and 4
- Assignment packet
  Includes unit schedule, assignment sheet, blank equipment list, sketch page, notes page, and scan resolution parameters worksheet
- Examples of student work
  Includes example field notes (including metadata and sketch), equipment list, workflow, scan resolution parameter worksheet, and final write-up

Teaching Notes and Tips

Field notes

Although the structure of this unit differs from a usual day in a field geology program, remind students that the skills they learned in their previous weeks of camp (specifically recording observations of the geologic feature of interest) should still be used in addition to the TLS scan. Metadata is an important aspect of TLS, as it is essential to keep good notes on the survey to ensure trouble-free processing and accurate interpretation of the data.

Keeping students occupied

One of the challenges of integrating TLS into a course with more than a few students is making sure that students stay engaged and mentally challenged even while they are waiting for their instrument time. Students will not have experience with laser rangefinders, so teaching them to use the rangefinder and its various functions will take some time. Students should also be encouraged to measure various clear features of the scanned area to ensure they can complete the data exploration portion of their assignment.

Adapting based on available computers

Part 4 of the unit (optional, but strongly encouraged) is designed for students to work on data visualization with the program RiScan Pro on individual machines. This section of the unit can be modified based on resources available. If no student computers are available, we encourage the instructor to project their screen and walk-through the data exploration with students.

Assessments

Formative:

Students will hand in their work from the field, including field notes (atmospheric conditions, metadata about scans), sketch of survey set-up, and scan resolution parameter worksheet for all scans. The work for formative assessment could be graded based on completion (i.e., students completed the work in the field and handed it in to the instructor).

Summative:

Summative assessment for the unit is based on their final write-up, which includes their work flow document, a summary of their metadata collected over the day, details of the data collection, and results of initial data exploration. This assessment has its own rubric. Summative assessment for the module as a whole will be evaluated at the end of the module in Unit 5.

Resources

On the Cutting Edge NAGT-SERC webpages on *Teaching Geodesy*:

http://serc.carleton.edu/NAGTWorkshops/geodesy/index.html

These pages overview existing geodetic curricula materials and include advice on teaching geodesy to undergraduates.

TLS Knowledgebase page on the UNAVCO website:
http://facility.unavco.org/kb/categories/Geodetic+Imaging/Terrestrial+Laser+Scanning+(TLS)/

This page contains all information compiled by UNAVCO on TLS, and includes how-to information, materials from UNAVCO short courses on TLS, and documentation about the TLS systems used by UNAVCO.

OpenTopography resources for educators:

http://www.opentopography.org/index.php/resources/educators

This page includes documentation on using lidar topography and OpenTopography in the classroom. OpenTopography is a resource for the scientific community to access high-resolution topography data collected using lidar and other technologies.

Recently published research using TLS:

Structural geology:

Kirkpatrick, J.D. and E.E. Brodsky (2014), Slickenline orientations as a record of fault rock rheology, Earth & Planet. Sci. Lett, 408, 24-34, doi: 10.1016/j.epsl.2014.09.040

Geomorphology:

Kociuba, W., W. Kubisz, and P. Zagorski (2014), Use of terrestrial laser scanning (TLS) for monitoring and modelling of geomorphic processes and phenomena at a small and medium spatial scale in Polar environment (Scott River — Spitsbergen), Geomorph., 212, 84-96, doi: 10.1016/j.geomorph.2013.02.003

Sedimentology:

Hodge, R., J. Brasington, and K. Richards (2009), Analysing laser-scanned digital terrain models of gravel bed surfaces: linking morphology to sediment transport processes and hydraulics, Sediment. 56, 2024-2043, doi: 10.1111/j.1365-3091.2009.01068.x