A Tale of Two Targets: Scanning rockmasses with and building facades with static and mobile LiDAR

Matt Lato[1], Robin Harrap[1], Mark Diederichs[1], & Jean Hutchinson[1]

1. Geological Science and Geological Engineering, Queen's University 2ml@queensu.ca

Abstract

Light detection and ranging (LiDAR) uses the reflection of light from objects to produce referenced locations. LiDAR sensors can be employed in static or mobile environments, depending on the instrument configuration and project needs. Static systems are comprised of a sensor, tripod, and (often) a GPS. Mobile systems are comprised of a vehicle (truck, helicopter, or airplane), a sensor, a differential GPS, and an inertial measurement unit (IMU or INS). LiDAR sensors themselves are of two types; time-of-flight (ToF) and phase-based. The characteristics of the different acquisition systems and an example of the resulting data from each system will be discussed and demonstrated. Our research objective is to conduct experiments that will test the validity of the capacity of lidar to be used to assess both geotechnical and urban infrastructure targets using both static and mobile LiDAR. The critical concerns being orientation based sampling bias and occlusion.

Background and Reference

The predominant issues between the two classes are dynamic range and acquisition speed, the two classes being time-of-flight (ToF) and phase-based sensors. ToF sensors can collect data out to as much as 1,200m from the sensor location. However, the sensor is limited to a collection rate of typically between 2,000 - 10,000 3d points per second. The limited acquisition rate results from the time required for each pulse to travel the full range (1,200m) and return to the sensor. Upon completion of the 'trip', the sensor must re-power for the next pulse and the returned information must be written to memory. For static and low range (truck or helicopter mounted) systems, increasing the strength of the pulse to limit the recharge time, would change the safety classification of the laser; thus precluding use in public areas. Phase-based sensors on the other hand can collect data within a range of 0.5m to 70m. In contrast to the ToF sensors, the collection rate for a phase-based scanner is upward of 500,000 points per second. The accuracy of a phase-based sensor is typically in the range of 0.1-3mm while a ToF sensor is in the range of 1-10cm per data-point. The prices for systems using the two approaches are comparable.

Methods and Data

The decision to use a ToF sensor versus a phase-based system is typically based on the location of the object or scene being scanned in relation to the sensor, although availability of an instrument is often a consideration as well. If the scene is in the range window of a phase-based scanner there are no disadvantages in comparison to a ToF sensor. The data generated by both systems are comparable and generally given as a 3d location plus a returned signal intensity value. For projects that involve precision engineering, such as structural design, a phase-based system has significant advantages: acquisition time and accuracy are both superior for these systems.

Results

Current research at Queen's University is focused on data collection guidelines and processing workflows, and in particular on infrastructure targets and on geotechnical applications of LiDAR data. Exploring the different data collection methods, processing options, and deliverables have led to the development of guidelines for effective scanning practices (Lato et al., 2007). For example, for a geomechanical evaluation of a rockmass, high resolution and high accuracy data is required. Conversely, for models of stationary urban objects, such as telephone poles, the required spatial resolution is lowered but the overall target area is much larger. One key result from our work is a characterization of the effects of static scanner placement and resolution of feature extraction (Lato et al, 2007).

Significant research has been completed on evaluating mobile LiDAR collection, where time of flight LiDAR units are mounted on a truck and driven (at standard traffic speeds) through an area. The preliminary results demonstrate, from mobile acquisition, point clouds of acceptable density to perform both urban analysis and geotechnical evaluations. The considerable advantage of the mobile system is the ability to collect vast amounts of data, over large areas, in a minimal amount of time. This allows the acquisition of LIDAR data along transportation corridors such as rail lines and highways without significant disruption of traffic or safety concerns for operators.

Conclusion

Significant research has also been directed toward the development of workflows for processing point clouds. Individual target scans are in the gigabyte range and cause significant computational issues. Being able to reduce file size, while effectively processing the points into object representation is a vital component to any LiDAR solution. This research has been conducted using Leica Cyclone and InnovMetric PolyWorks software.

To date our work has focused on efficient scanning of complex rockcuts and buildings; both cases show highly complex surface morphologies. We are also investigating aspects of the output workflow including integration with 3d modelling and with Google Earth.

Our scanning experiments to date have demonstrated that geotechnical and urban infrastructure targets can be effectively scanned with static and mobile LiDAR. With static LiDAR, placement is critically important to avoid an orientation based sampling bias or occlusion. With both static and mobile systems, data volumes are a daunting challenge. We are now working on enhancing aspects of LiDAR workflow using object recognition methods from computer vision research.

References

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