COMPLEX SYSTEMS, INFRASTRUCTURE & SENSORS FRONTIERS

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Dr. Hartzell conducts research in geospatial remote sensing with an emphasis on Light Detection And Ranging (LIDAR) systems. His work focuses on sensor and data calibration to improve measurement quality and point cloud data registration. A significant contribution of his work is the advancement of rigorous measurement uncertainty estimation through exposure of new applications and development of open source methods applicable to broad lidar sensor categories and popular data formats such as digital surface models.

GEOSPATIAL SENSOR CALIBRATION & DATA UNCERTAINTY

All measurements contain error, and knowledge of that error enables geospatial analysists to improve the spatial quality of their data, determine appropriate data use, and estimate confidence in derived products such as measurements of ground surface deformation due to earthquakes, landslides, or glacier motion. Sensor calibration is primarily concerned with reducing biases due to imperfect understanding of sensor geometry, while data uncertainty refers to estimation of random error in the reported 3D spatial data and downstream computed quantities. Current methods for spatial uncertainty estimation are often sensor-specific and rarely used in the measurements and products derived from the lidar data.

Rather than relying on laborious and sparse manual or in-situ measurements for quality estimation, Dr. Hartzell has adapted uncertainty estimation methods from the computer vision field to geospatial data workflows to automate uncertainty estimation for horizontal ground motion measurements derived from airborne lidar data. Combined with his work to make lidar uncertainty estimation available to large classes of airborne lidar sensors, an end-to-end workflow for quantifying lidar remote sensing measurement uncertainty is being developed to empower geospatial analysts to make more informed decisions from their data.

(a)

(b)

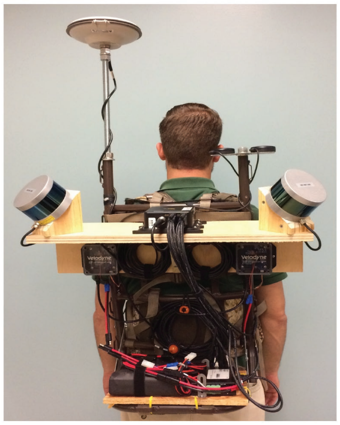


Figure (a) *The Autonomous Terrestrial LidAr Scanner (ATLAS) operating at Helheim Glacier in south Greenland. Sensor bias was modeled and removed from the raw sensor measurements to improve the temporal spatial registration of the final data product.* ***Figure (b)*** *Dual lidar backpack mapping system assembled in the Geosensing Systems Engineering laboratory at the Cullen College of Engineering. In addition to hardware integration, software for system calibration was developed to generate high fidelity point clouds.*

Publications

1. Hartzell, P. and Glennie, C., "Propagated Uncertainty for Horizontal Ground Motion Derived from Multi-Temporal Digital Elevation Models," 2020 IEEE Geoscience and Remote Sensing Symposium, Waikoloa Village, HI, USA, 2020.

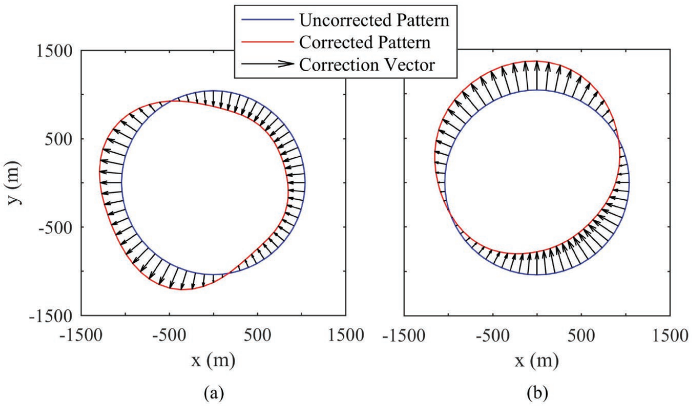
2. Glennie, C. L. and Hartzell, P. J., "Accuracy Assessment and Calibration of Low-Cost Autonomous LIDAR Sensors," International Archives of the Photogrammetry Remote Sensing and Spatial Information Sciences, XLIII-B1-2020, 2020, 371–376.

3. Brown, R., P. Hartzell, C. Glennie, "Evaluation of SPL100 Single Photon Lidar Data," Remote Sensing, 2020, 12(4), 722.

4. Pan, Z., P. Hartzell, C. Glennie, "Calibration of an Airborne Single-Photon Lidar System With a Wedge Scanner," IEEE Geoscience and Remote Sensing Letters, 2017, 14(8), 1418-1422.

5. Hartzell, P., P. Gadomski, C. Glennie, D. Finnegan, J. Deems, "Rigorous Error Propagation for Terrestrial Laser Scanning with Application to Snow Volume Uncertainty," Journal of Glaciology, 2015, 66(230), 1147-1158.

(c)



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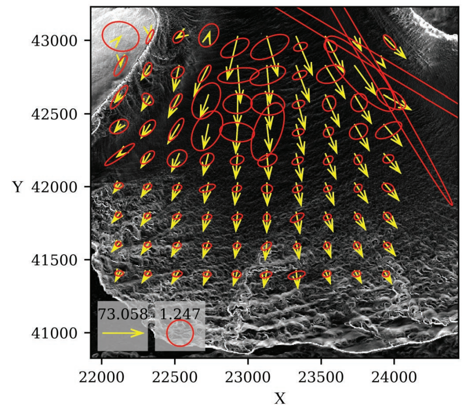

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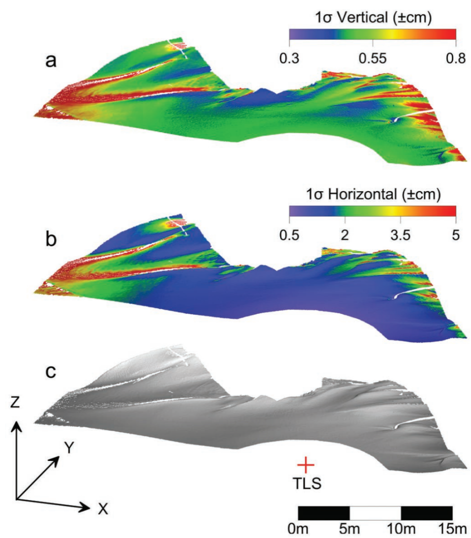

Figure (c) *Two examples of uncalibrated (blue) and calibrated (red) ground scan patterns for a Leica SPL100 airborne single photon lidar system. The correction is scaled by a factor of 300 for visibility.* ***Figure (d)*** *Automated measurement and rigorous uncertainty estimation of horizontal deformation experienced by the Canada Glacier in Taylor Valley, Antarctica. The yellow arrows indicate measured displacement and the red ellipses indicate one-sigma uncertainty bounds.* ***Figure (e)****Typical one-sigma (a) vertical and (b) horizontal uncertainties of lidar data collected on the snow surface by the continuously operating lidar at Mammoth Mountain, California. The snow topography is illustrated in (c), with the red cross indicating the location of the lidar system.*

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