ABSTRACT

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Title: Alternative Methodologies for Boresight Calibration of GNSS/INS-Assisted Push-Broom Hyperspectral Scanners on UAV Platforms
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Low-cost Unmanned Aerial Vehicles (UAVs) utilizing push-broom hyperspectral scanners are poised to become a popular alternative to conventional remote sensing platforms such as manned aircraft and satellites. In order to employ this emerging technology in fields such as high-throughput phenotyping and precision agriculture, direct georeferencing of hyperspectral data using onboard integrated Global Navigation Satellite Systems (GNSS) and Inertial Navigation Systems (INS) is required. Directly deriving the scanner position and orientation requires the spatial and rotational relationship between the coordinate systems of the GNSS/INS unit and hyperspectral scanner to be measured. The spatial offset (lever arm) between the scanner and GNSS/INS unit can be measured manually. However, the angular relationship (boresight angles) between the scanner and GNSS/INS coordinate systems, which is more critical for accurate generation of georeferenced products, is difficult to establish. This research presents three alternative calibration approaches to estimate the boresight angles relating hyperspectral push-broom scanner and GNSS/INS coordinate systems. For reliable/practical estimation of the boresight angles, the thesis starts with establishing the optimal/minimal flight and control/tie point configuration through a bias impact analysis starting from the point positioning equation. Then, an approximate calibration procedure utilizing tie points in overlapping scenes is presented after making some assumptions about the flight trajectory and topography of covered terrain. Next, two rigorous approaches are introduced – one using Ground Control Points (GCPs) and one using tie

features. The approximate/rigorous approaches are based on enforcing the collinearity and coplanarity of the light rays connecting the perspective centers of the imaging scanner, object point, and the respective image points. To evaluate the accuracy of the proposed approaches, estimated boresight angles are used for ortho-rectification of six hyperspectral UAV datasets acquired over an agricultural field. Qualitative and quantitative evaluations of the results have shown significant improvement in the derived orthophotos to a level equivalent to the Ground Sampling Distance (GSD) of the used scanner (namely, 3-5cm when flying at 60m).