ABSTRACT

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LiDAR units onboard airborne and terrestrial platforms have been established as a proven technology for the acquisition of dense point clouds for a wide range of applications, such as digital building model generation, transportation corridor monitoring, precision agriculture, and infrastructure monitoring. Furthermore, integrating such systems with one or more cameras would allow forward and backward projection between imagery and LiDAR data, thus facilitating several high-level data processing activities, such as reliable feature extraction and colorization of point clouds. However, the attainment of the full 3D point positioning potential of such systems is contingent on an accurate calibration of the mobile mapping unit as a whole.

First, this research aims at proposing a calibration procedure for terrestrial multi-unit LiDAR systems to directly estimate the mounting parameters relating multiple spinning multi-beam laser scanners to the onboard GNSS/INS unit in order to derive point clouds with high positional accuracy. To ensure the accuracy of the estimated mounting parameters, an optimal configuration of target primitives and drive-runs is determined by analyzing the potential impact of bias in mounting parameters of a LiDAR unit on the resultant point cloud for different orientations of target primitives and different drive-run scenarios. This impact is also verified experimentally by simulating a bias in each mounting parameter separately. Finally, the optimal configuration is used within an experimental setup to evaluate the performance of the proposed calibration procedure. Then, this proposed multi-unit LiDAR system calibration strategy is extended for multi-LiDAR multi-camera systems in order to

allow a simultaneous estimation of the mounting parameters relating the different laser scanners as well as cameras to the onboard GNSS/INS unit. Such a calibration would enhance the registration accuracy of point clouds derived from LiDAR data and imagery, along with their accuracy with respect to the ground truth. Finally, in order to qualitatively evaluate the calibration results for a generic mobile mapping system and allow the visualization of point clouds, imagery data, and their registration quality, an interface denoted as I-LIVE (Image-LiDAR Interactive Visualization Environment) is developed. Apart from its visualization functions, I-LIVE mainly serves as a tool for the qualitative quality control of GNSS/INS-derived trajectory and LiDAR-camera system calibration.

The proposed multi-sensor system calibration procedures are experimentally evaluated by calibrating several mobile mapping platforms with varying number of LiDAR units and cameras. For all cases, the system calibration is seen to attain accuracies better than the ones expected based on the specifications of the involved hardware components, i.e., the LiDAR units, cameras, and GNSS/INS units.