Unified Multi–sensor Advanced Triangulation (UMSAT) for System Calibration and Trajectory Enhancement of Imaging and Ranging Sensors Onboard Mobile Mapping Systems

Tian Zhao and Ayman Habib (USA)

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SUMMARY

Un-crewed aerial Vehicles (UAVs) equipped with integrated global navigation satellite systems/inertial navigation systems (GNSS/INS) as well as imaging (e.g., RGB, multi-spectral, and hyperspectral cameras) and ranging (e.g., LiDAR) sensors are widely used for topographic mapping in a variety of applications such as precision agriculture, coastal monitoring, digital forestry, transportation management, infrastructure monitoring, bulk material estimation, and archaeological documentation. UAV-based remote sensing is becoming a viable alternative for small area mapping due to its ease of deployment, low cost, ability to fill a gap between aerial and proximal mapping platforms, miniaturization/improvement of GNSS/INS georeferencing technologies, and proliferation of imaging/ranging sensors operating in different portions of the electromagnetic spectrum.

Integration of image-based and LiDAR point clouds can provide a comprehensive 3D model of the area of interest. For such integration, ensuring a good alignment between derived data/products at the same or different times from single or several platforms is critical. Although many works have been conducted on this topic, there is still a need for a rigorous integration approach that minimizes the discrepancy between camera and LiDAR data/products caused by inaccurate system calibration parameters and/or trajectory artifacts. This study proposes an automated tightly-coupled camera/LiDAR integration workflow for UAV-based remote sensing systems aided by a GNSS/INS unit. More specifically, the paper presents a unified multi-sensor advanced triangulation (UMSAT), which can handle point, linear, and areal features derived from imaging (e.g., frame cameras and push-broom scanners) and ranging remote sensing systems aided by GNSS/INS position and orientation unit. Through UMSAT, different scenarios for system calibration and/or trajectory refinement will be explored for improving derived data/products from imaging and ranging remote sensing systems while focusing on precision agriculture, digital forestry, and transportation

management. Experimental results from real datasets related to such applications will be presented together with recommendations for future research to improve the performance of UMSAT in GNSS-challenging, and potentially GNSS-denied, environments.