Trajectory Evaluation Using Repeated Rail-Bound Measurements

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Key words: Engineering survey; GNSS/GPS; Positioning; quality assessment; trajectory estimation

SUMMARY

In kinematic laser scanning, trajectory estimation has a significant impact on the quality of the resulting point cloud. By referring to trajectory estimation, we consider position and orientation of the platform over time. Due to its large influence on the quality of the point cloud, a separate evaluation of the trajectory is desirable, though challenging caused by its kinematic nature. In order to analyze the precision of the trajectory estimation, kinematic measurements have to be reproduced reliably. This requirement was met at the University of Bonn by constructing a rail track of circa 140 m in length. Combined with a rail-bound wagon mounting the system under test, the track can be used to repeat kinematic measurements, enabling trajectory evaluation.

In this paper, we propose a method to analyze and evaluate the result of repeated, rail-bound measurements regarding their precision and accuracy. Starting with the chronologically ordered raw data, the methodology first spatially sorts the measurements and then approximates them to a mean trajectory. The deviations between the single position observations and the approximation indicate the cross-track precision of the measurements in horizontal and vertical direction. Similarly, the orientation measurements can be analyzed. For both, the entire measurement and the individual laps, RMS values for position and orientation are computed. Furthermore, the spatial distribution of the deviations can be analyzed.

With the addition of a higher-order reference, our methodology also determines the accuracy of the system under test. This requires the simultaneous tracking of the rail-bound wagon using a measurement system of superior accuracy such as a total station. After calibration, both trajectories can be compared using techniques similar to those used for precision analysis.

Finally, the methodology was used to evaluate the estimated trajectory from a low-cost GNSS/IMU

unit, which was attached to the rail-bound wagon. This allowed an in-depth analysis, for example, regarding effects due to filtering or current GNSS conditions. Using the proposed methodology, we were able to show, that the trajectory estimation meets the expectations in terms of precision and accuracy. In further studies, the developed method can be applied to test other systems or filtering algorithms.