PHOTOGRAMMETRIC NEWS: Doctoral Dissertation

Ms. Aino Keitaanniemi defended her doctoral dissertation on the 9th of June 2023 at the Aalto University School of Engineering, Finland. PhD Carlos Cabo Gómez, University of Oviedo, Spain, appeared as opponent. The Supervisor was Professor Matti T. Vaaja, Aalto University, School of Engineering, Finland. The title of the thesis was “Improving the measurement strategies and post-processing of Simultaneous Localization and Mapping based handheld laser scanning”.

Abstract of the thesis

Three-dimensional (3D) data technologies such as laser scanning have automated the data collection of 3D mapping. However, built environments include ones without global navigation satellite system access, and where terrestrial laser scanning of the environment would be laborious, time-consuming, and prone to occlusions. In these environments 3D mapping could instead be executed with simultaneous localization and mapping (SLAM) laser scanners (LSs). Regrettably, the effects of these measurement strategies and post-processing of SLAM LS systems have been rarely evaluated.

This dissertation investigated and developed the workflow of SLAM LS systems for 3D mapping in a built environment, with the hypothesis that by evolving measurement paths and practices as data integration and post-processing methods, SLAM LS systems are more suitable to be applied for 3D mapping. The measurement paths and practices were studied in use cases with two commercial SLAM LS systems. The experiments investigated the effect of the measurement paths and existing features in the environment. The integration method utilized a SLAM LS point cloud as supporting data for terrestrial laser scanner (TLS) point cloud registration. In addition, the post-processing was investigated by demonstrating the drift error reduction.

Based on the results, the measurement paths and practices can be evolved with the utilization of a well-planned measurement path. The measurement path should include internal loops based on the environment that it is intended to measure. Stable environments have better point cloud ac- curacy with a minimal number of internal loops. In contrast, unstable environments require more internal loops. The overall path in most built environments should combine these practices. In addition, the internal loops should be located around the landmarks, the diameter of the internal loop should be scaled beside the space, and SLAM LS should be facing the middle of the environment during the internal loop. The environments include dynamic objects, the uneven distribution of the landmarks for the SLAM algorithm or unembellished should be avoided. If avoiding such environment is impossible, the measurement range of SLAM LS should be chosen accordingly, or additional landmarks should be added. These can prevent the drift error from occurring. However, the drift error appeared to be one-dimensional and can be reduced with commercial software from the SLAM LS point cloud.

The results indicate that the integration of SLAM LS and TLS promoted the 3D reconstruction with accuracy optimization in required locations and a reduction of measurement time by 72%.With the evolved measurement paths and practices, the SLAM LS systems could be utilized for 3D mapping

in built environments. The requirements of the 3D reconstructions can be reached by understanding the measurement methods of the SLAM LS.

Keywords: simultaneous localization and mapping, laser scanning, 3D reconstruction, built environment, point cloud, measurement path, 3D, 3D mapping