A SLAM-BASED PROCEDURE FOR CALIBRATING A MOBILE LASER SCANNING SYSTEM

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EXTENDED ABSTRACT:

Mobile laser scanning (MLS) is an established technology to actively acquire dense 3D point clouds of environments in an efficient way. Mature MLS systems for indoor and outdoor mapping are available which can be assigned mainly to Robotics and Geomatics. In addition to those commercial systems there are countless experimental mobile multi-sensor systems used in research in which laser scanners play a vital role. Mobile mapping systems with laser scanners require very precise knowledge of the vehicle trajectory. For this reason laser scanners are rigidly coupled to an inertial measurement unit (IMU, or GNNS/IMU in outdoor applications) either by mounting the sensors on a suitable platform or by merging them into a sensor head as this is done for the hand held mobile laser scanner Zebedee (Bosse et al, 2012).

Various methods are proposed to determine the offset and the bore sight angle between the coordinate frame of a 2D or 3D laser scanner and the IMU coordinate system. In this paper we review, categorize and point out strength and weakness of those systems. Limitations of the proposed methods are diverse: Some methods require terrestrially scanned test sites, others rely on retro-reflective targets of known shape and size. Another idea stems from calibration experiences of airborne laser scanning. Planar surfaces are identified and located in point clouds which are collected by driving the MLS system in opposite directions preferably in an urban environment. The method we propose avoids such special requirements.

Our calibration procedure is based on a 3D Simultaneous Localization and Mapping (SLAM) formulation. On a high level, the SLAM algorithm estimates the 6 DOF (degrees of freedom) trajectory of the laser scanner frame as a function of time. By taking advantage of the IMU measurements (more precisely the output of the IMU is used as additional observations) this estimation process is significantly stabilized. The 3D translational and rotational state parameters are used to transform the laser scanner recordings (point cloud coordinates given in the local laser scanner coordinate system) into a point cloud that is registered in a 3D world coordinate system. The key algorithm of the SLAM procedure is the correspondence step. Local point clusters with temporally and spatially proximal points are created and local geometric features are extracted from the scans based on the point clusters. The second order moments of the local point clusters are used to detect surface elements of nearly planar patches. The match error of corresponding planar surface patches expressed in the world coordinate frame is formulated as the product of local surface normal multiplied with the vector between the locations of the corresponding planar patches. An optimization step minimizes the surface correspondence error and the IMU measurement deviations by adjusting the current state of the trajectory. Calibration of the bore sight angle and the offset between the laser scanner frame and the IMU frame is taken into account by adding these two parameters into the state parameter of the SLAM algorithm.

Experiments are carried out by using a Faro Focus 3D laser scanner and a GNSS/IMU system of Applanix (POS LV 420). Various urban and non-urban scenes are recorded to investigate a possible scene dependency of the procedure and the quality of the estimated calibration parameters.

REFERENCE

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