論 文 の 内 容 の 要 旨

論文題目　3D Geometric Modeling of Urban Structures in World Geodetic Coordinates under Unstable GPS Conditions
（不安定なGPS測位環境下における都市空間の世界座標系での３次元形状モデル化）
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3D models are widely used in many computer vision and computer graphics applications viz. digital preservation of heritage sites, geological survey, autonomous navigation and driving simulators in intelligent transport systems. Several methods are employed for reconstruction of such models which scan 3D structures with 3D scanners and align them into common coordinate system. However, there are some issues which need to be addressed for reconstruction of accurate large-scale 3D models. Among all, issues of high computational cost and error accumulation involved in alignment of huge number of range images are quite common in large-scale modeling. Another issue arises when the application needs the 3D model to be aligned in world coordinate system. Such an issue becomes even worse in urban scenario because the accuracy of GPS is not sufficient for many applications.

The work in this thesis handles the issue of computational cost and error accumulation by aligning range images in local coordinate system using a fast simultaneous alignment method. Several partially overlapping scans of the structure to be modeled are taken with a laser range scanner. A laser range scanner scans the surrounding geometric environment as a point cloud with coordinates of each point wrt. center of scanner. As each scan has its coordinates in individual coordinate system, these scans are brought into common coordinate system which is usually the center of first scan using fast simultaneous alignment method. As a result, a unified point cloud is obtained consisting of point clouds from each scan.

The issue of global alignment into world coordinate system is addressed by measuring world positions of scan centers using GPS and removing outliers based on statistical inferences drawn on confidence of GPS. The confidence of GPS is obtained using information from GPS receiver as well as from range scans. Several measurements are taken at each scan position to have statistically significant data. The measurements having number of visible satellites and their geometric dilution of precision less than empirically chosen thresholds are discarded and k-means clustering followed by inter-quartile range is used on rest of measurements to obtain a set of inliers. As a result, a subset of measurements is obtained as inliers at each scan position. Out of all the scan positions, an optimal set of positions with high confidence of GPS position

estimation is chosen with RANSAC like approach and Hill Climbing optimization. After obtaining the optimum set of positions with high confidence of GPS accuracy, 3D transformation is obtained between locally aligned scan centers and their world positions as non-linear least squares solution using Levenberg-Marquardt algorithm. Global adjustment of 3D model is done into world coordinate system using estimated 3D transformation. Evaluation based on orientation of building facades, positioning on aerial photos, world distance between reference points and overlapping of neighboring regions etc. confirm the accuracy of global alignment.

Towards another independent approach, reflected GPS signals are identified using 3D range scans and are excluded from position estimation calculation because such signals create an additional path difference due to reflections leading to position estimation errors. A transformation between locally aligned scan centers and their world positions obtained from refined GPS positions is used for global adjustment of 3D model. 3D models of huge structures in Hongo campus and Komaba-II campus of The University of Tokyo have been reconstructed using the proposed approach with coordinates of each structure in world geodetic coordinate system. A significant improvement in global alignment of reconstructed 3D model validates the applicability and feasibility of proposed approach to 3D modeling under unstable GPS conditions.