A 3D segments based algorithm for heterogeneous data registration
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Combining image and LiDAR draws increasing interest in surface reconstruction, city and building modeling for constructing 3D virtual reality models because of their complementary nature. However, to gain from this complementarity, these data sources must be precisely registered.

The objective of this study is to propose a new primitive based registration algorithm that takes 3D segments as features in order to register heterogeneous data. The heterogeneity is both in data type (image and LiDAR) and acquisition platform (terrestrial and aerial).

The basic idea of the proposed algorithm consists in defining a global robust distance between two segment sets and proposing a robust approach to minimize this distance based on RANSAC paradigm.

Feature Extraction

3D line segments detection from an indoor scan

Lu, X., Liu, Y., & Li, K. (2019). Fast 3D line segment detection from unorganized point cloud. arXiv preprint arXiv:1901.02532.

3D line cloud reconstruction from image sequence

Manual Hofer, Michael Maurer, and Horst Bischof. Efficient 3D scene abstraction using line segments. Computer Vision and Image Understanding, 157:167–178, 2017.

Global Robust distance between segment sets

We have two segment sets: \( L_1 \) and \( L_2 \)

We define a distance between a segment \( l_1 \) and a segment set \( L_2 \) as:

\[
E^{\text{dist}}(l_1, L_2) = ||l_1||^2_{thr} - \sum_{l_2 \in L_2} ||l_1 \cap l_2|| \max(0, d^2_{thr} - \text{dist}(l_1, l_2)^2)
\]

Finally we can write our final symmetrized robust distance between 3D segments sets as:

\[
\text{dist}(L_1, L_2) = \sum_{l_1 \in L_1} E^{\text{dist}}(l_1, L_2) + \sum_{l_2 \in L_2} E^{\text{dist}}(l_2, L_1)
\]

Evaluation on synthetic data

Comparison of the convergence speed and the robustness of RANSAC and simulated annealing

Performance tests of our algorithm on synthetic data using different initial errors.

Evaluation on Real data

Terrestrial image/Terrestrial LiDAR registration

Aerial image/Terrestrial LiDAR registration

Future Works

- Use planar polygons as primitives .
- Use combinations of more segments to have more characteristic features to match.
- Test the proposed algorithm for solving the aerial image/ Aerial LiDAR registration.