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A 3D SEGMENTS BASED ALGORITHM FOR HETEROGENEOUS DATA REGISTRATION

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Context and Objectives of the Study

- > Combining image and LiDAR draws increasing interest in surface reconstructing 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.



cloud. arXiv preprint arXiv:1901.02532.



3D line cloud reconstruction from image sequence Manuel Hofer, Michael Maurer, and Horst Bischof. Efficient 3d scene abstraction using linesegments.Computer Vision and Image Understanding, 157:167–178, 2017.

Pipeline details

$$d(c) = \frac{\sum_{L_i \in C} sign(v_i, v_1)v_i}{\|\sum_{L_i \in C} v_i\|}$$

3. For each segment L_i :

• If $C = \emptyset$ or $max_{c \in C}d_i$. $d(c) < cos(\varepsilon)$,

create a new cluster and add L_i to it. Else add L_i to the cluster $arg max d_i.d(c)$

Valid cluster associations

We have two segment sets S_1 and S_2 For each cluster associations $As = \{ (c_1^1, c_2^1) \in S_1 \leftrightarrow (c_1^2, c_2^2) \in S_2 \}$ we have several possible forms. As for each cluster C, we have two possible direction **Comparison of the convergence speed and the robustness of RANSAC** and simulated annealing

Transformation			Our result			ICL result		
Translation	Rotation	Scale (s ₀)	Translation Error	Rotation Error	Scale (s)	Translation Error	Rotation Error	Scale (s)
0 m	0°	1	1.77e-15 m	1.06e-15°	$\frac{ s-s_0 }{s_0}=0$	3.6e-16 m	4.7e-15°	$\frac{ s-s_0 }{s_0}=0$
0.39 m	4.66°	0.85	0 m	0.04°	$\frac{ s-s_0 }{s_0}=0$	0.09 m	1.29°	$\frac{ s-s_0 }{s_0}$ =0.005
1.31 m	15.66°	1.5	0 m	0.2°	$\frac{ s-s_0 }{s_0}=0$	0.20 m	15.39°	$\frac{ s-s_0 }{s_0}$ =0.971
4.20 m	32.66°	2	0 m	0.2°	$\frac{ s-s_0 }{s_0}=0$	1.42 m	27.520	$\frac{ s-s_0 }{s_0}$ =0.97

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



vectors:{d(c), -d(c)}: we can define the variables $s_{i}^{j}: i \in [1,2], j \in [1,2], s_{i}^{j} = \pm 1$

If one of the possible forms of As satisfies the condition:

 $| < s_1^1 d(c_1^1), s_2^1 d(c_2^1) > - < s_1^2 d(c_1^2), s_2^2 d(c_2^2) > | < \varepsilon$

we consider that As is valid Else , we reject this association

Optimization

Simulted annealing simulation:

- A new solution is iteratively computed in the vicinity of the current solution.
- □ This new solution is accepted with certain probability depending of its energy(the robust distance in our case).

RANSAC optimization

At each RANSAC iteration, we randomly select a valid cluster association, then randomly select 3D segment in each of the associated clusters. • We compute the rotation based on cluster association.

Evaluation on Real data









Terrestrial image/Terrestrial LiDAR registration





Global Robust distance between segment sets

We have two segments sets: L_1 and L_2 We define a distance between a segment l_1 and a segment set L_2 as:

 $E^{d_{thr}}(l_1, L_2)$ $|l_1|d_{thr}^2 - \sum_{l_2 \in L_2} |l_1^2 \cap l_2^1| max(0, d_{thr}^2 - dist(l_1, l_2)|^2)$

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

> $dist(L_1, L_2)$ $\sum_{1 \in L_1} E^{d_{thr}} (l_1, L_2) + \sum_{l_2 \in L_2} E^{d_{thr}} (l_2, L_1)$ $l_1 \in L_1$

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• we estimate the scale/translation that aligns the associated 3D segments. We keep the sampled transformation that has the minimum robust distance.

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.

Aerial image/Terrestrial image registration