Point Cloud Registration Refinement in an Urban Environment using 2D Edge-Maps

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Motivation

• High-level detail 3D modeling of large-scale urban environments (i.e., cities).
• How? Registration (3D alignment) between:
  – Terrestrial LiDAR Scanning (TLS).
  – Airborne LiDAR Scanning (ALS).
• In a previous work we developed an efficient method to find a coarse registration between TLS and ALS using a viewpoint dictionary (Avidar et al., ICCV’17).

Local-to-Global Edge-Map Alignment

3D Point Cloud to 2D Edge-Map Conversion

Gravity Direction Estimation

• For each pair of dominant normal vector orientations (\( \vec{R}_{ij} \) and \( \vec{R}_{jk} \)) in the point cloud:
  – Estimate gravity direction \( \vec{g}_{est} = -\vec{R}_{ij} \times \vec{R}_{jk} \)
  – Count inliers: \# normals \( n_i \) where:
    \[ |\langle \vec{g}_{ij}, \vec{g}_{est} \rangle - 90^\circ| < 2\beta \quad (\text{e.g., } \beta = 0.5^\circ) \]
  – Finally, select \( \vec{g}_{est} \) with the most inliers

Edge-Based 2D ICP

• ICP (Iterative Closest Point) is a widely used method for registration of 3D point clouds (Besl and McKay, 1992)
• It is an iterative method that alternates between:
  – Finding nearest neighbor pairs of points between two point clouds
  – Minimizing the distances between these pairs of points
• We use ICP in 2D between the global and local edge-maps by converting them to 2D point clouds

Registration Results

• We tested our method on a challenging dataset with a \(-1\, \text{km}^2\) global cloud (ALS) and 94 local clouds (TLS)

3.7 23 0

Gravity Estimation Results

Conclusions

• The proposed method (using 2D ICP) achieves a reduction in runtime by a factor of 3.7 in comparison to 3D ICP, while maintaining similar registration accuracy.
• The proposed gravity direction estimation method achieves a mean error of \(0.23^\circ\) - an order of magnitude lower than before gravity direction correction is applied

In collaboration with GeoSim

ICSEE, December 2018