Efficient Global Point Cloud Alignment Using Bayesian Nonparametrics

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Point Cloud Alignment

Problem
find the 3D rotation/translation that aligns two point clouds

Challenge
6D opt with local optima, partial overlap, noise, outliers

Preprocessing
• decouple rotational/translational alignment using surface normals
• use parsimonious BNP mixture representation of normals / points

Rotational Alignment

Novel Refinable Tessellation of S^3
similar to the triangular tessellation of S^2 starting with the projected icosahedron...

...except uses 4D tetrahedra and starts with the 600-cell

Refinement: each tetrahedron refines to 8 tetrahedra, and we select the internal edge that minimizes distortion

Bounds: solve a few small eigenvalue problems for upper, evaluate the objective anywhere in the cell for lower

Theorem: For angular precision ϵ, need N refinements:

\[ N = \max \left\{ 0, \left\lceil \log_2 \left( \frac{\cos \gamma_0}{\cos \left( \frac{\epsilon}{2} \right)} \right) \right\rceil - 1 \right\} \]

\[ \gamma_0 = 36^\circ \]

Evaluation of S^3 Tessellation

Experiments

Happy Buddha: severe partial overlap
Office: partial overlap / noise
Noisy Bunny: severe noise / outliers (60%)
Apartment: rotational symmetry, outliers

Stanford Bunny

BB is 1-2 orders of magnitude faster with state-of-the-art performance