Surface Reconstruction from Fitted Shape Primitives

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Motivation

• Shape detection in point clouds
  – planes, spheres and cylinders

From Shape Detection to Reconstruction

• Limitations of [SWK07]
  – no explicit access to surface
  – no boundaries

• Idea
  – extract primitives via RANSAC
  – extract and reconstruct boundaries on primitives
  – triangulate interior

Reconstruction Pipeline

- Data preprocessing
- RANSAC primitive detection
- Border candidates
- Border loops
- Optimization
- Meshing
Preprocessing I

• Sampling = \( \varepsilon \)-influence required to recognize surface
  – point spacing, anisotropy
  – noise

• Idea
  – iterative growing
  – PCA-analysis
    • \( \lambda_0 \ll \lambda_1, \lambda_2 \)
    • \( e_0^{i+1} \approx e_0^i \)
Preprocessing II

data  sampling spacing  noise std. deviation

data  sampling spacing

smaller  larger
RANSAC Primitive Detection

- **RAN**dom **SA**mple **C**onsensus
  - choose random sample set
  - evaluate score on whole dataset
Boundary Point Candidates

• Extract boundary for each primitive
• Candidates
  – sort neighbors into cones in tangent space
  – boundary candidates: at least two empty cones
  – [GWM01]: angle criterion

[GWM01: S. Gumhold, X. Wang, and R. MacLeod: Feature extraction from point clouds, In Proceedings 10th International Meshing Roundtable, 2001]
Boundary Curves I

• Cleaning
  – pruning
  – Moving Least Squares (MLS, [ABC*03])

• Topology initialization

• Loop extraction

• Prune small loops

Boundary Curves II

• Energy function
  – statistically motivated (Bayesian)
    \[ p(M|D) = \frac{p(D|M)p(M)}{p(D)} \]

• Potentials
  – data fitting
  – Laplacian smoothness
  – consistency
Data Fitting

- Keep original boundary points
- Attraction to boundary points
Laplacian Smoothness

- Attraction to centroid of adjacent nodes
- Uniform sampling for free
- Shrinkage avoided by data fitting
- Not applied to corner points
Consistency Potential

- Consistency with primitive shape
- Consistency between adjacent primitives
- Tagging of boundary points
  - free
  - intersection
  - corner
Optimization

• Discard evidence term
• Transformation into -log-space
• Newton-Raphson line search
Triangulation

• Front growing
• Start within shape
• Stop at boundaries
• Run for each bounded region in each shape
Results - Synthetic
Results – Scanned Datasets
Parallel Publication

- Chen, Chen: Architectural Modeling from Sparsely Scanned Range Data, 2008

Conclusions

• Problem: reconstruction of structurally simple scenes with sharp features

• Idea
  – RANSAC primitive detection
  – Boundary extraction and optimization

Thank you for your attention!