Fast 3D Scene Segmentation and Partial Object Retrieval Using Local Geometric Surface Features

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What’s on the agenda?

- The pipeline
- Geometric segmentation
- Patch pre-processing
- Descriptor extraction and matching
- Experiments and results
The pipeline

- 3 main parts
  - Segmentation of depth image
  - Pre-processing of each partial object view
  - Retrieval of similar 3D models

Source: https://doi.org/10.1007/978-3-662-61364-1_5
Geometric Segmentation

- Starting of with a depth image
- Estimate surface normals
- Determine edges
- Flood fill

Source: https://doi.org/10.1007/978-3-662-61364-1_5
Patch pre-processing

- Alleviate noise from depth sensor and segmentation step
- Remove outliers
- Normalize patch
  - Centroid at origin
  - Points contained within unit sphere
- Bilateral and multilateral filtering
  - Smooth out surface

Source: https://doi.org/10.1007/978-3-662-61364-1_5
Descriptor Extraction and Matching

- Two similarity measures
  - Local geometric features between points
  - Global similarity between models
  - Weighted average of both

- Downsampling point cloud
  - Voxel grid
  - Weighted average of normals

Source:
differential Fast Point Feature Histogram

- PFH → FPFH → dFPFH
- Captures local geometric transitions
- Descriptors stored in k-d tree
- Similarity
  - Average L2 distances between pairs

\[
dFPFH(q_p, r) = [\text{FPFH}(q_p, r) \Delta \text{FPFH}(q_p, r)] \\
\Delta \text{FPFH}(q_p, r) = \text{FPFH}(q_p, r_{outer}) - \text{FPFH}(r_{inner})
\]

Source: https://ieeexplore.ieee.org/document/5152473

Source: https://www.researchgate.net/publication/275956107_Partial_3D_Object_Retrieval_combining_Local_Shape_Descriptors_with_Global_Fisher_Vectors
Global similarity measure

- Comparing fisher vectors
- Learn a Gaussian Mixture Model
  - Each target model
  - Expectation-maximization algorithm
  - dFPFH signatures
- Generate Fisher Vectors
  - GMM and dFPFH
- Similarity
  - Weighted sum of L2 distances between fisher vectors

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Experiments and results

- Two datasets
  - Object Segmentation Database
  - Virtual Hampson Museum collection

- Segmentation was performed qualitatively

- Retrieval was done quantitatively
  - Partial shape queries from SHREC’16
  - Artificial
  - High quality smartSCAN Breuckmann scanner
  - Low quality Kinect

Source: https://doi.org/10.1007/978-3-662-61364-1_5
Source: https://www.researchgate.net/publication/301484938_SHREC’16_Track_Partial_Shape_Queries_for_3D_Object_Retrieval
Artificial queries
25%
40%

Source: https://doi.org/10.1007/978-3-662-61364-1_5
High quality queries
Three different viewpoint

Source: https://doi.org/10.1007/978-3-662-61364-1_5
Low quality queries
Three different viewpoint

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