

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

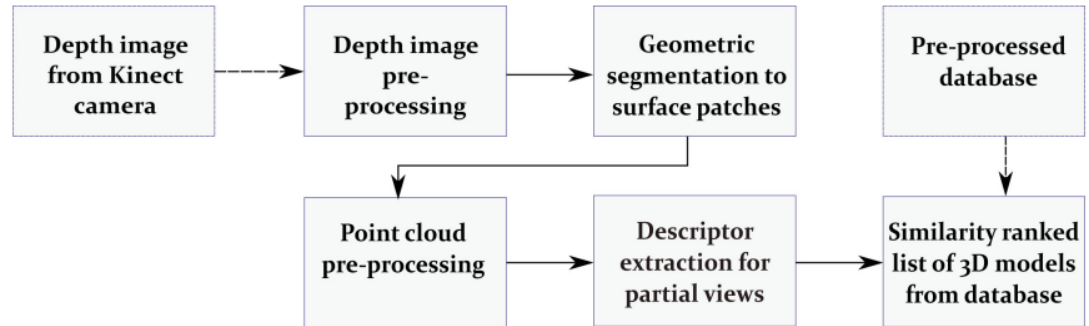
Alexander Szewczyk

What's on the agenda?

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

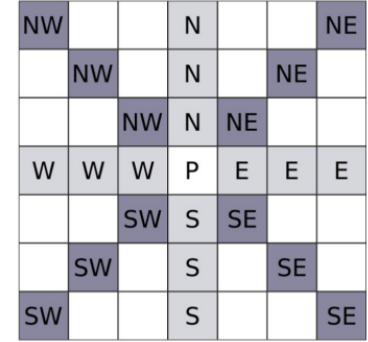
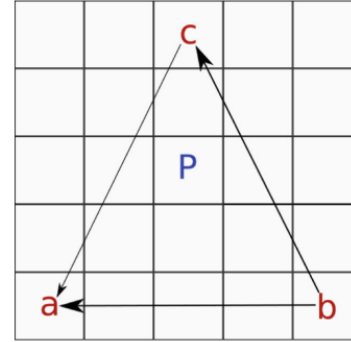
The pipeline

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

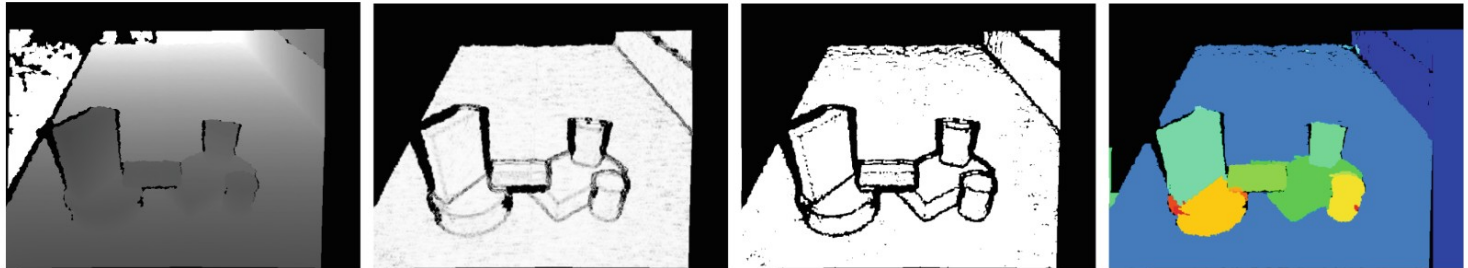


Geometric Segmentation

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



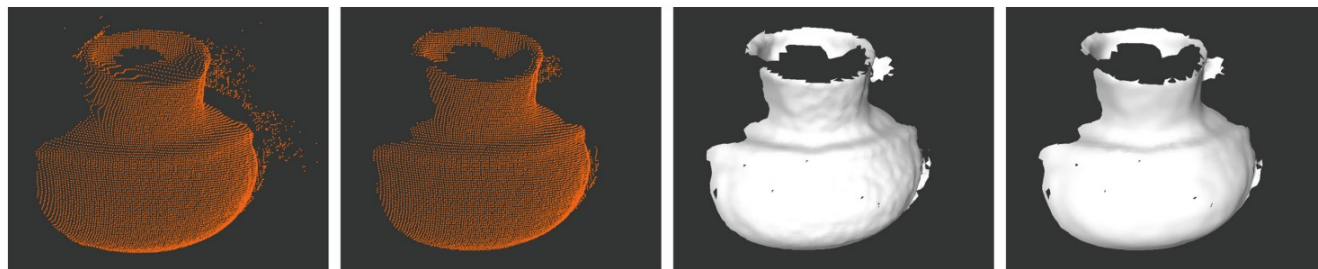
Source: https://doi.org/10.1007/978-3-662-61364-1_5



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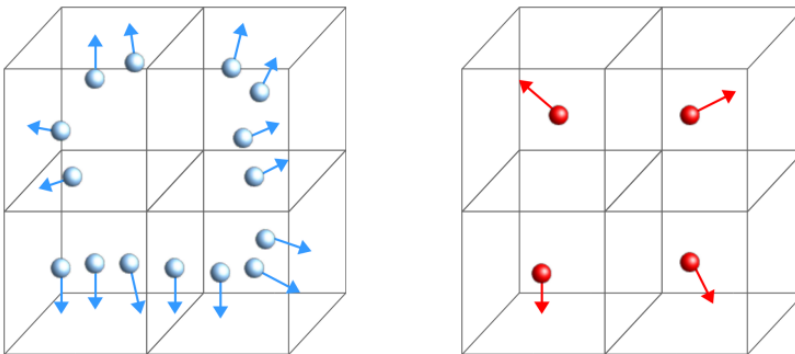
Patch pre-processing

- 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



Descriptor Extraction and Matching

- Two similarity measures
 - Local geometric features between points
 - Global similarity between models
 - Weighted average of both
- Downsample point cloud
 - Voxel grid
 - Weighted average of normals



Source:

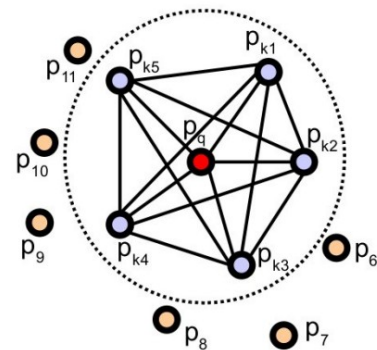
https://www.researchgate.net/publication/327048168_A_Method_for_6D_Pose_Estimation_of_Free-Form_Rigid_Objects_Using_Point_Pair_Features_on_Range_Data

differential Fast Point Feature Histogram

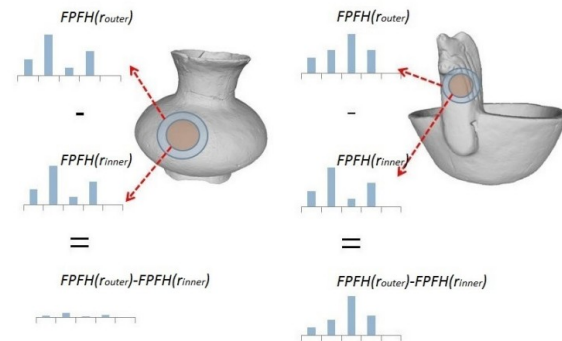
- PFH \rightarrow FPFH \rightarrow dFPFH
- Captures local geometric transitions
- Descriptors stored in k-d tree
- Similarity
 - Average L2 distances between pairs

$$dFPFH(q_p, r) = [FPFH(q_p, r) \Delta FPFH(q_p, r)]$$

$$\Delta FPFH(q_p, r) = FPFH(q_p, r_{outer}) - FPFH(r_{inner})$$



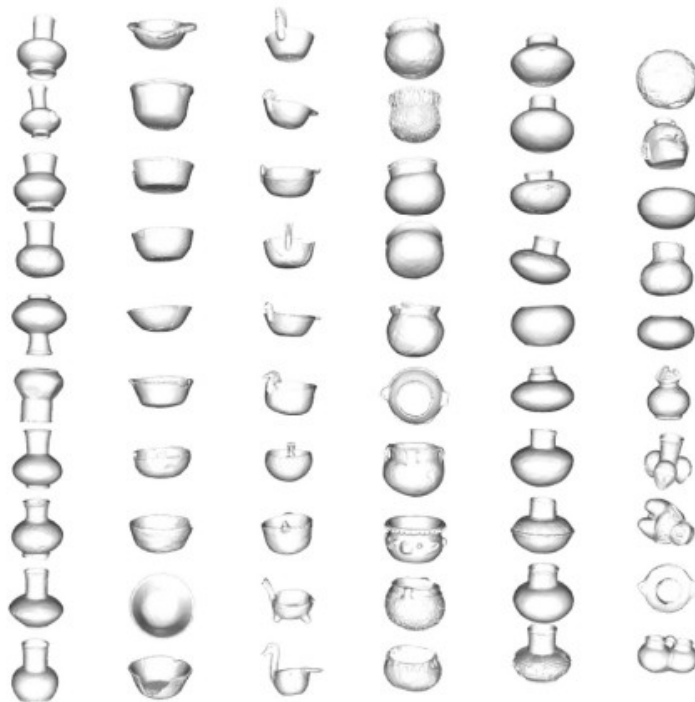
Source: <https://ieeexplore.ieee.org/document/5152473>



Source:
https://www.researchgate.net/publication/275956107_Partial_3D_Object_Retrieval_combining_Local_Shape_Descriptors_with_Global_Fisher_Vectors

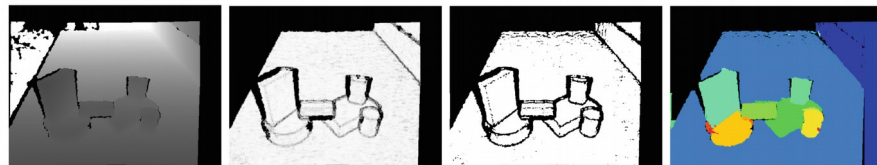
Global similarity measure

- 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



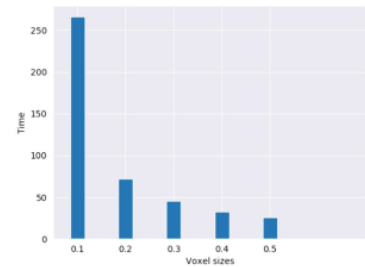
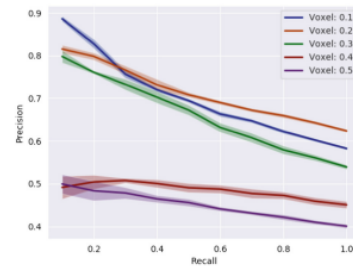
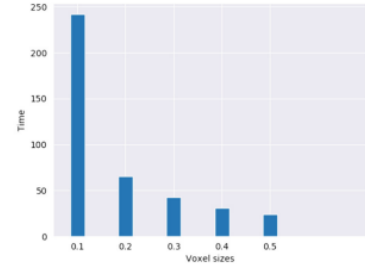
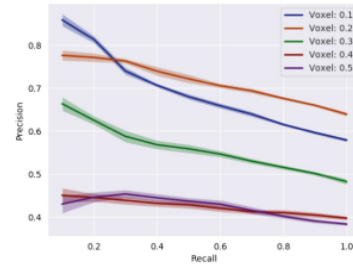
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- Two datasets
 - Object Segmentation Database
 - Virtual Hampson Museum collection
- Segmentation was performed qualitatively
- Retrieval was done quantitatively
 - Partial shape queries from SHREC'16
 - Artificial
 - High quality smartSCAN Breuckmann scanner
 - Low quality Kinect



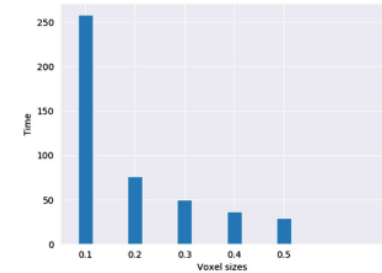
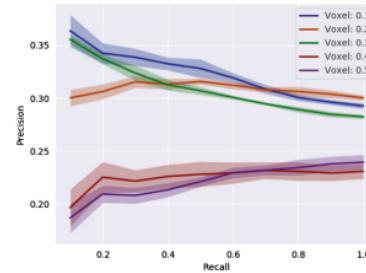
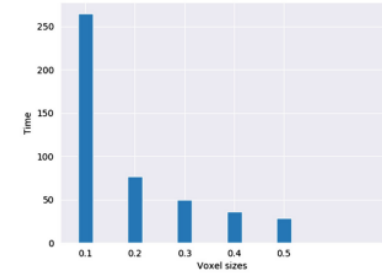
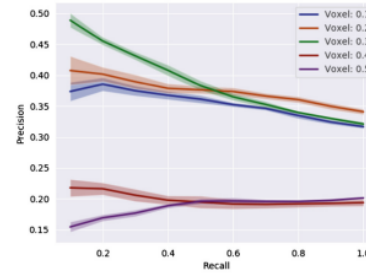
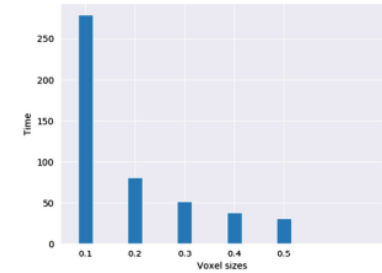
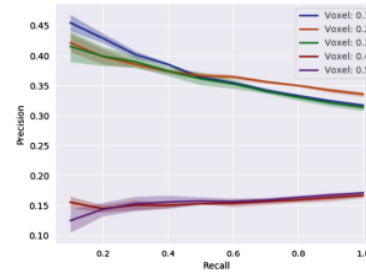
Source:
https://www.researchgate.net/publication/301484938_SHREC'16_Track_Partial_Shape_Queries_for_3D_Object_Retrieval

Artificial queries
25%
40%

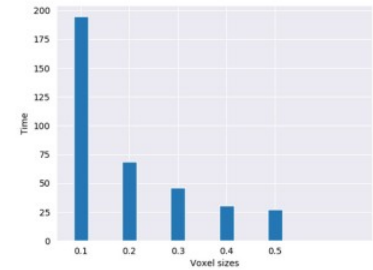
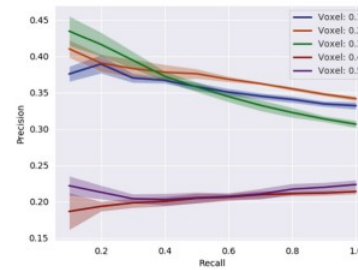
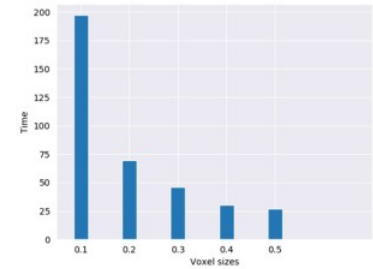
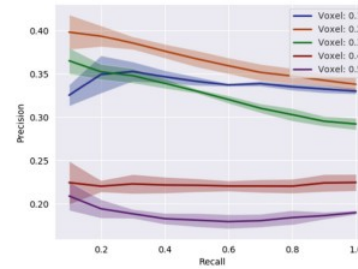
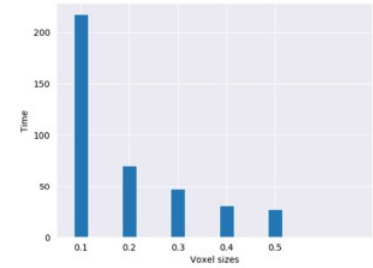
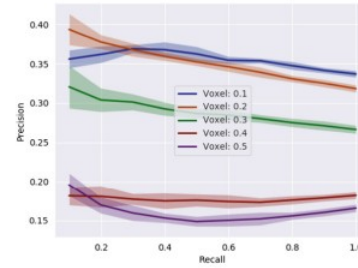


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High quality queries Three different viewpoint



Low quality queries Three different viewpoint



Sources

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- <https://www.sciencedirect.com/science/article/pii/S0031320316000595?via%3Dihub>
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