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Room Segmentation in 3D Point Clouds using Anisotropic Potential Fields

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Motivation

Our goal is **automatic segmentation** of indoor **large-scale point clouds** into **rooms**

Challenges:

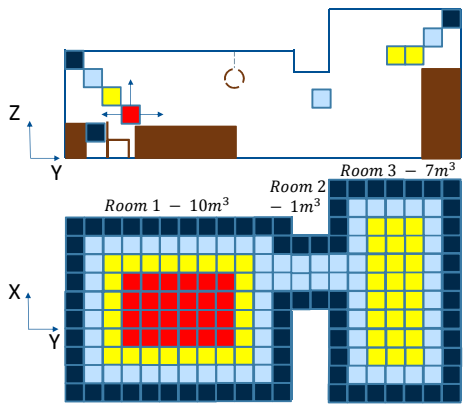
- Non-Manhattan structures
- Sensor noise and occlusion

Main contributions:

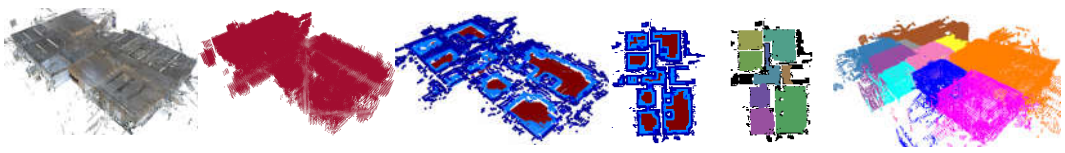
- Method to compute interior free space without assuming knowledge of scanner poses or Manhattan-world structure
- Formulation of 3D anisotropic potential field (PF) that is robust to clutter and occlusion

Key intuition

Rooms are bigger (in volume) parts of free space that are connected to each other through a smaller (in volume) free space (e.g. a door or an arch)



Methodology



Input point cloud | Interior free space | Maxima of 3D PF | 2D PF | Labeled image | Labeled point cloud

Interior free space classification

- Morphological erosion along vertical voxel stack
- Evidence of enclosing $\mathrm{E(v)} = w_1 \cdot \mathrm{I(z-)} + w_2 \cdot \mathrm{I(z+)} + w_3 \cdot \mathrm{I(z)} + w_4 \cdot \mathrm{I}(dom_1) + w_5 \cdot \mathrm{I}(dom_2)$ with MRF

Anisotropic PF field computation

- Along XYZ+ direction to reduce influence of furniture on the PF
- Projection of maxima along each vertical stack of the 3D PF onto 2D image

Labeling

- Hierarchical DBSCAN clustering [1] using distance defined as follows $\mathrm{D} = D_{vis} \cdot w_{vis} + D_{eucl} \cdot w_{eucl} + D_{PF} \cdot w_{PF}$, where $D_{vis}(p,q) = \frac{dist(V(p),V(q))_{hamming}}{\sum_i V_i(p) + \sum_i V_i(q)}$
- Iterative thresholding using connected component labelling and random walker segmentation

Back-labeling to busy space

- 10-nearest neighbor labeling with majority vote onto busy voxels

References

[1] R. Campello et al., “Hierarchical density estimates for data clustering, visualization, and outlier detection”, ACM Transactions on Knowledge Discovery from Data, 2015.

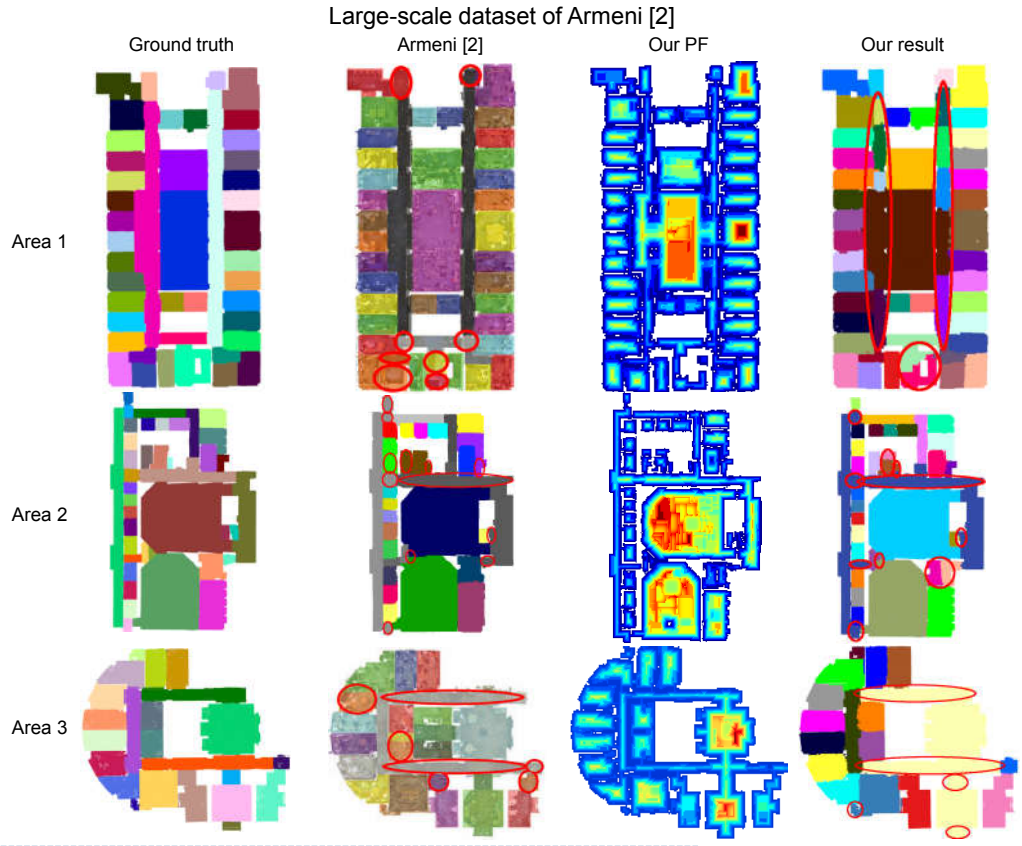
[2] I. Armeni et al., “3D semantic parsing of large-scale indoor spaces”, IEEE Conference on Computer Vision and Pattern Recognition, 2016.

[3] C. Mura et al., “Piecewise-planar reconstruction of multi-room interiors with arbitrary wall arrangements”, Computer Graphics Forum, 2016.

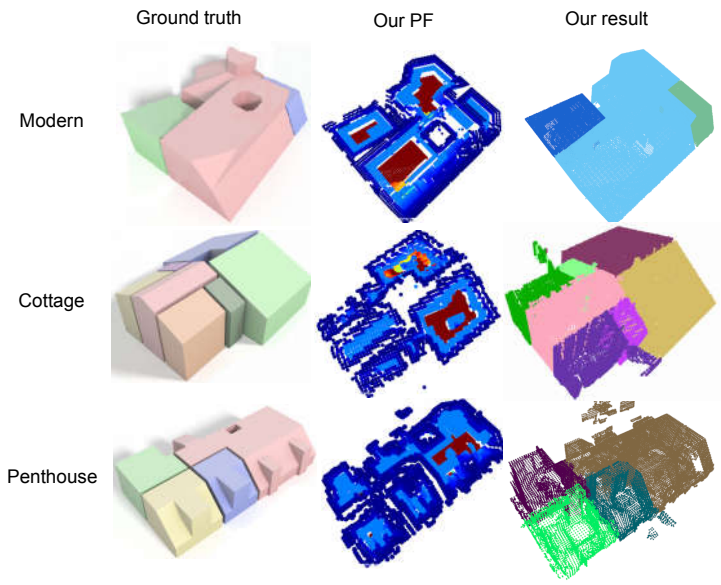
[4] S. Ikehata et al., “Structured indoor modeling”, IEEE International Conference on Computer Vision, 2015.

Results

Large-scale dataset of Armeni [2]



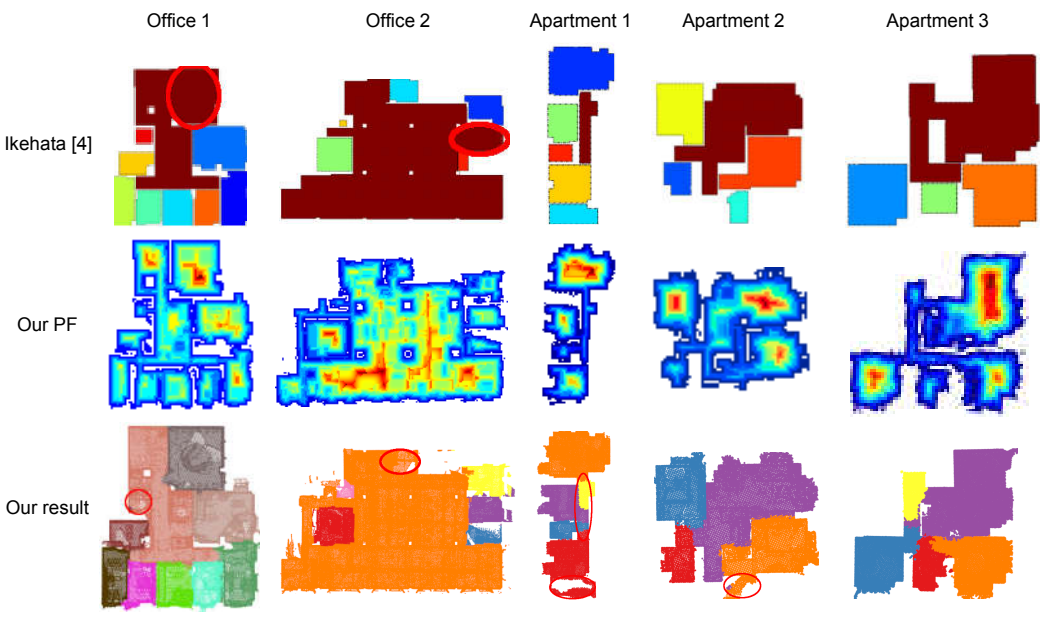
Non-Manhattan dataset of Mura [3]



Quantitative evaluation on the dataset of Armeni [2] using number of incorrectly segmented rooms (smaller is better)

Area	# rooms	Our	[2]
1	44	**3**	8
2	40	**10**	12
3	23	**5**	7
5	68	**7**	13
Total	175	**25**	40

Indoor reconstruction dataset of Ikehata [4]



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