

Watershed Merge Tree Classification for Electron Microscopy Image Segmentation

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Introduction

- Electron microscopy (EM) generates images with sufficient resolution in nanoscale for reconstruction of connectome, i.e. neural circuit map. Terabyte-scale data makes manual analysis infeasible. Automated image analysis is needed.
- Challenging due to intricate intra-cellular structures, large shape variations and high data anisotropy (10 nm in x-y plane, 50 nm in z direction).
- 2D segmentation pipeline: supervised pixel-wise membrane detection + hierarchical segmentation.

Watershed Merge Tree and Boundary Classifier

- Pixel-wise membrane detection: multi-scale context + serial ANNs [Seyedhosseini *et al.*, 2011].
- Watershed transform generates initial over-segmentations and region merging hierarchy.
- Watershed merge tree: representation of region merging order.
- Boundary classifier:
 - Predict about each merge/split.
 - Random forest classifier with 141 features (geometry/intensity/texture/merge saliency).

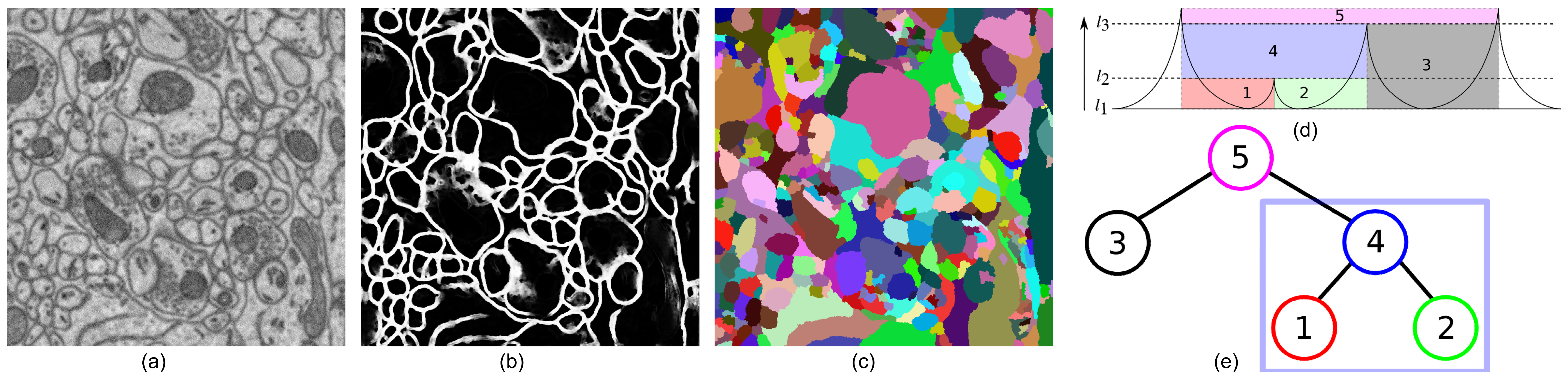


Fig. 1: Example of (a) original EM image, (b) membrane detection, (c) initial watershed over-segmentation, (d) region merging with water level rising and (e) watershed merge tree.

Resolving Merge Tree

- Consistency constraint:
 - Any pixel should be labeled only once.
 - Once a node is selected, its ancestors and descendants must be removed.
- Node potential:
 - Probability that a node does not merge with its sibling and its children merge.
 - In Fig. 2 (b), $P_6 = (1 - P_{6,8})P_{1,2}$.
- Resolving merge tree via greedy optimization:
 - Pick the most potential node;
 - Remove its ancestors and descendants;
 - Repeat until no nodes are left.

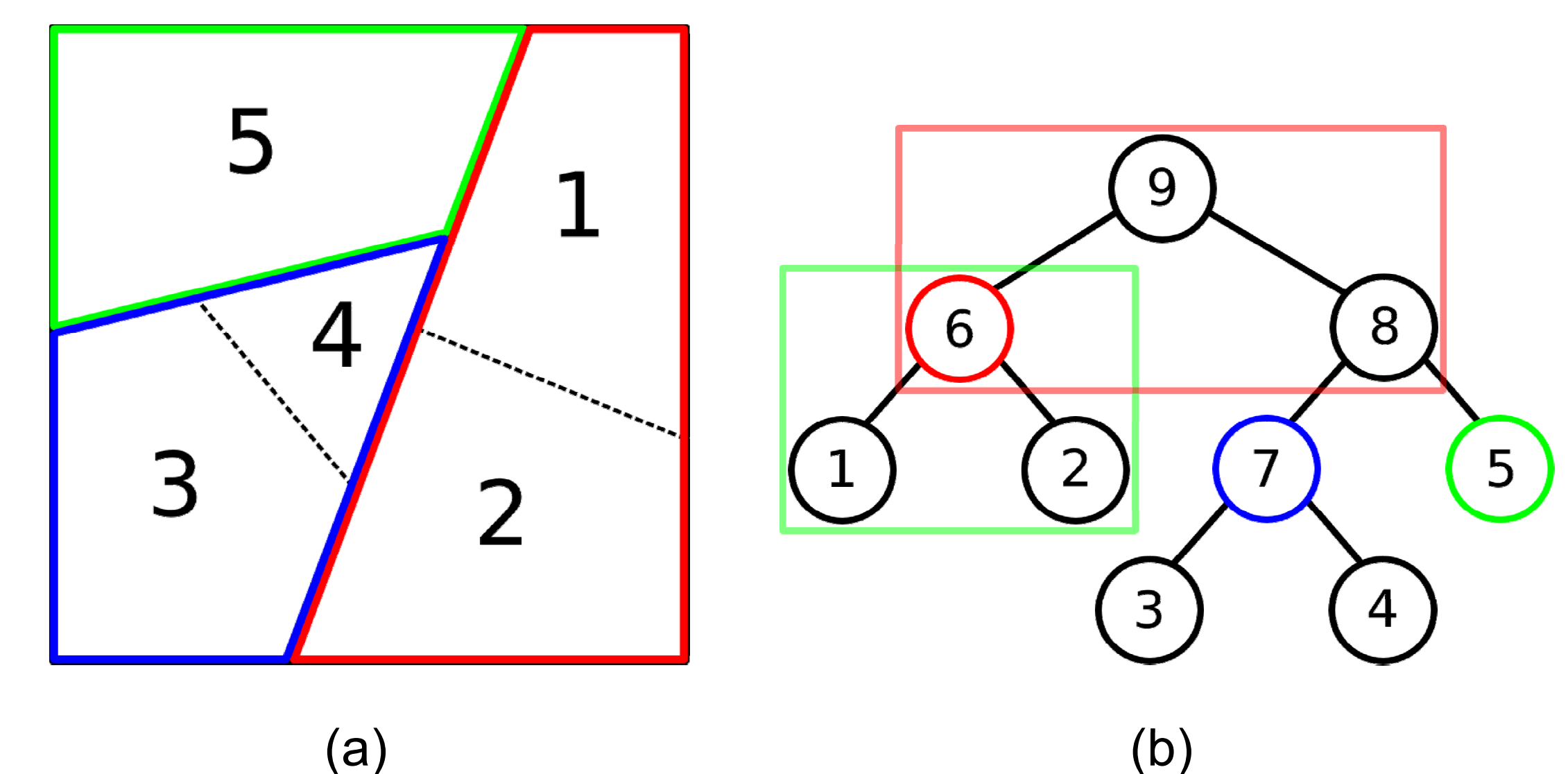


Fig. 2: Illustration of how (a) final segmentation is acquired by (b) resolving a merge tree.

Results

- Data: 700 x 700 x 70 SBFSEM mouse neuropil images (10 x 10 x 50 nm resolution).
- Use Rand error as measurement.
- Cross validation.

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Table 1: Segmentation Rand errors.

	bin 2	bin 3	bin4	bin 5	avg.
Thresholding	0.2749	0.2419	0.2115	0.2717	0.2500
Merge tree	0.1529	0.1113	0.1029	0.1595	0.1316

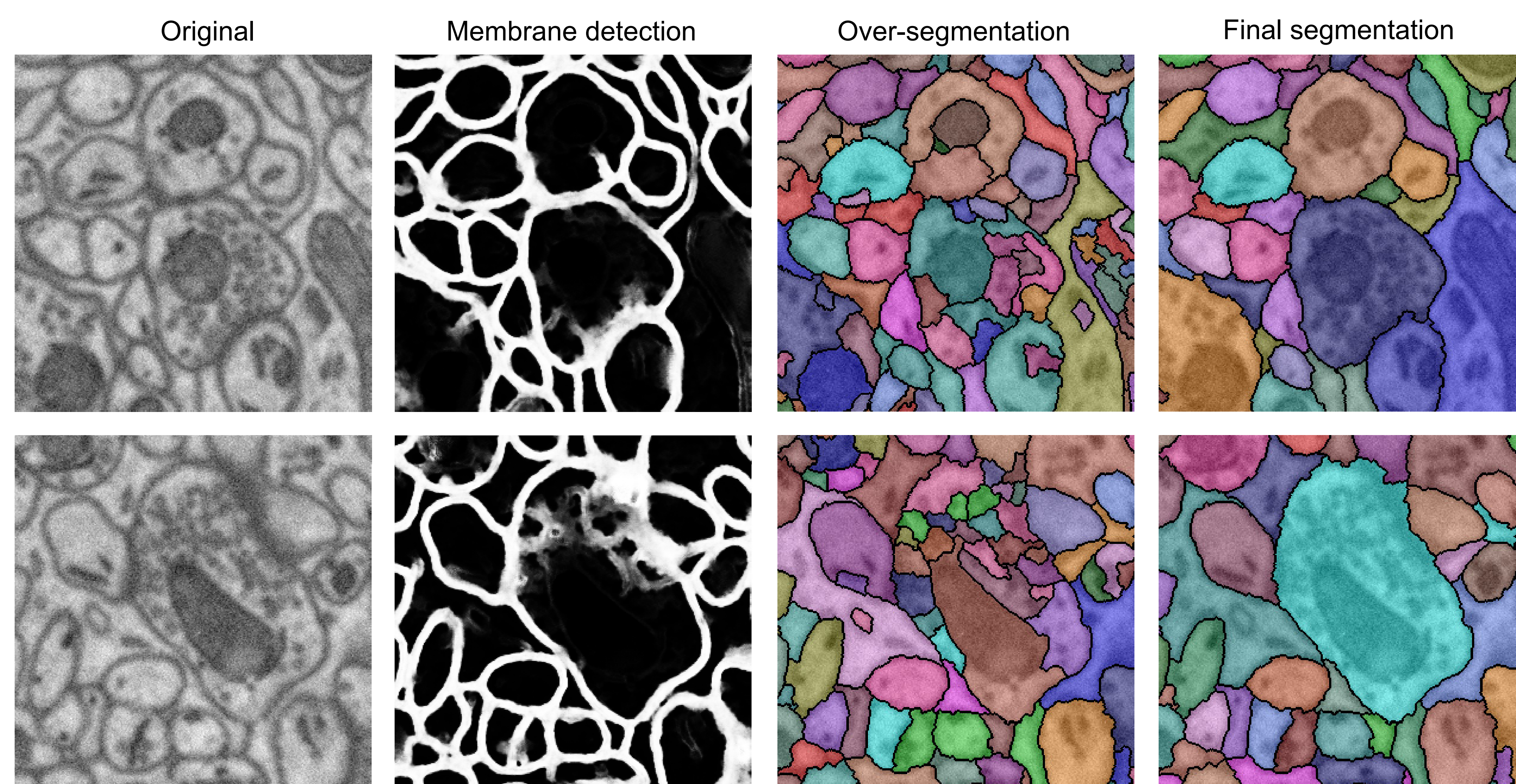


Fig. 3: Segmentation results of two image regions (zoomed in).

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