Synapse-Aware Skeleton Generation for Neural Circuits

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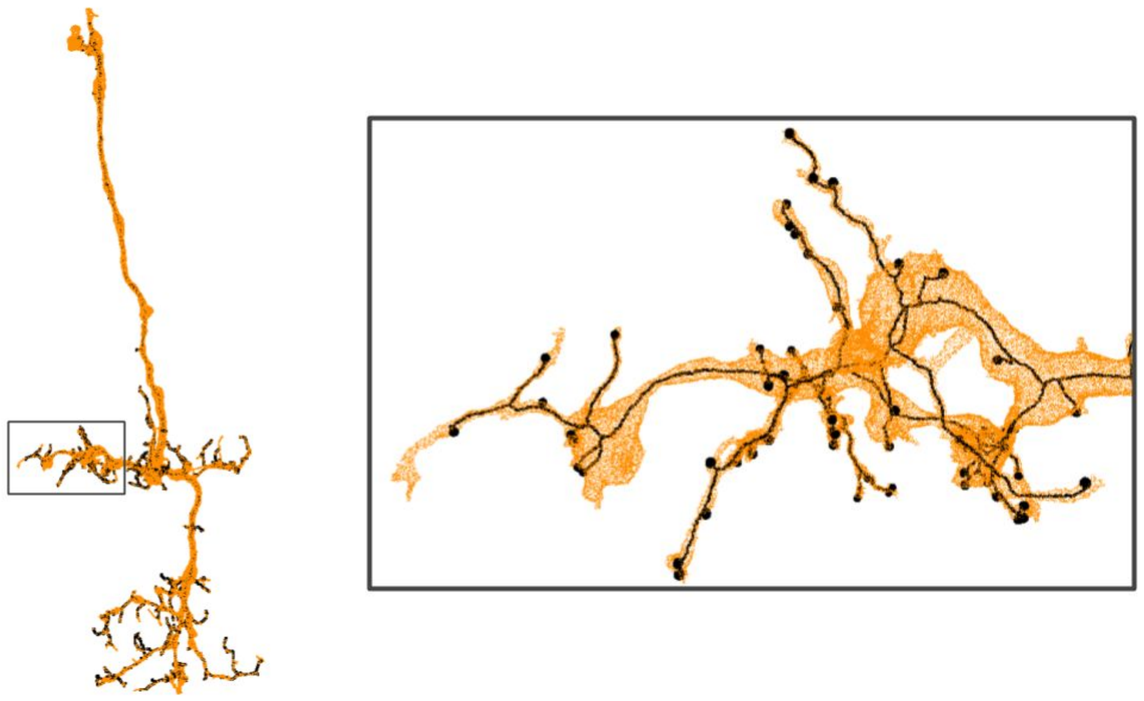
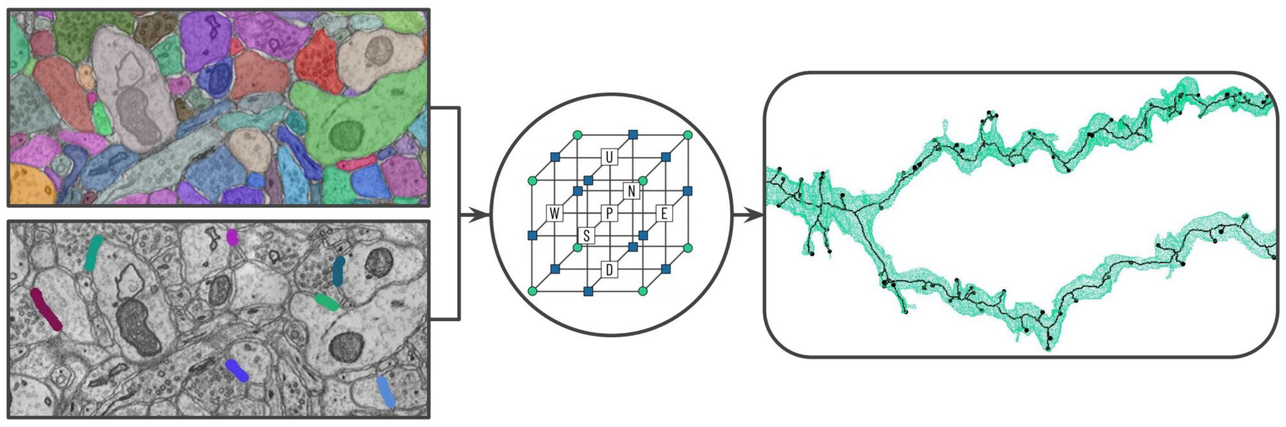
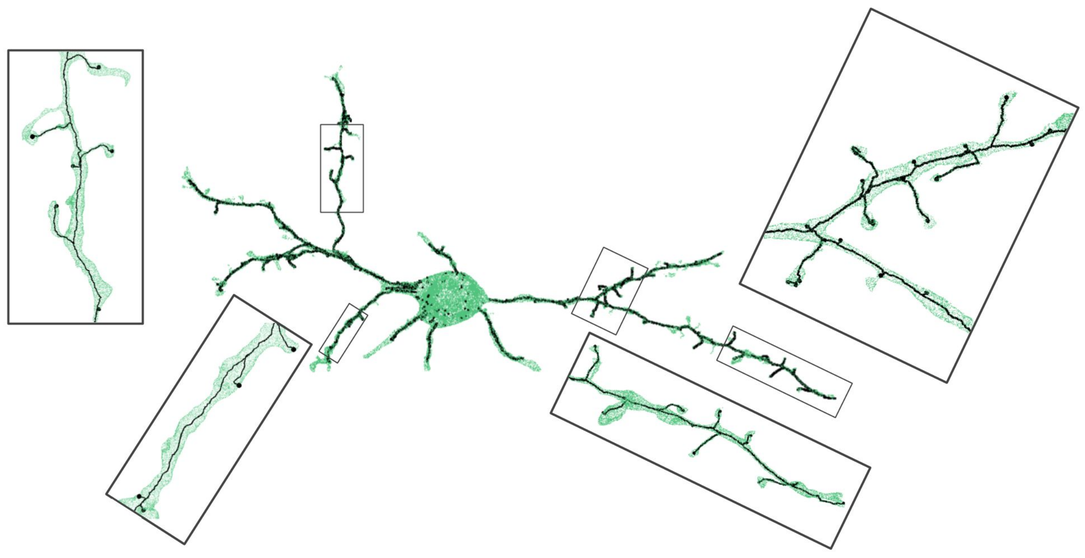
- Reconstructed electron microscopy image volumes contain thousands of interconnected neurons.
- Little research focuses on extracting accurate and expressive wiring diagrams from these datasets.
- Our synapse-aware skeleton generation strategy transforms the volumetric data into an abstract yet expressive format for detailed analysis, accurate simulation, and improved reconstruction.
- Our method produces skeletons with a one-to-one correspondence between synapses and endpoints for complete neurons in a 100 micron cube in minutes.

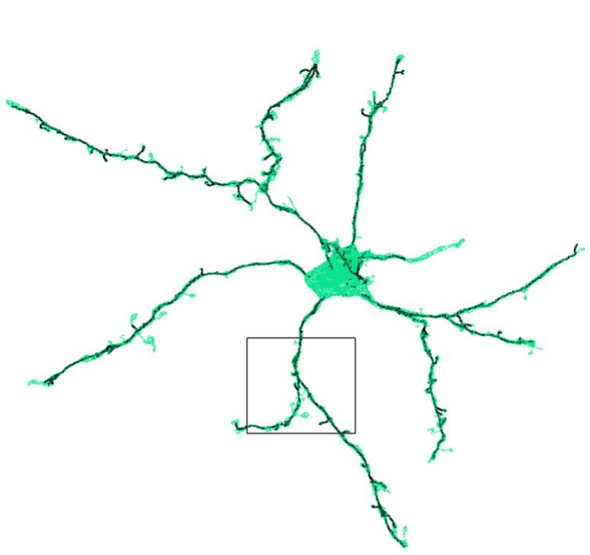


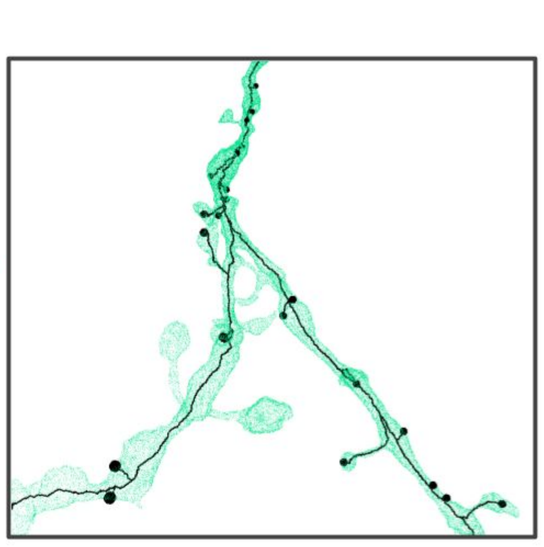


- We refine the skeletons and guarantee cycle-free graphs by finding the shortest path from the soma to all synapses.
- We prune points along the skeleton that is not on a shortest path from a synapse to the soma.

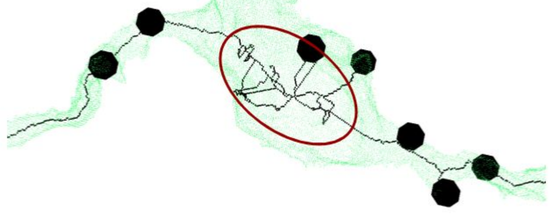


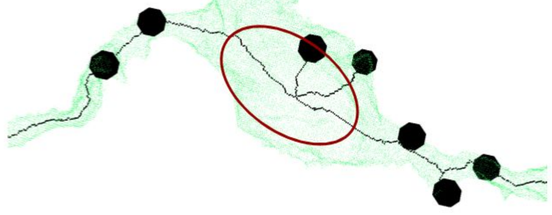
- On average, we outperform two baseline methods, TEASER and isthmus thinning, on three evaluation metrics: neural reconstruction integrity, width estimation, and skeleton size.
- Neither baseline guarantees a one-to-one correspondence between synapses and endpoints.
- The geodesic distance along our skeletons from each synapse to the soma over all neurons is 47% farther (12μm) than the Euclidean distance.





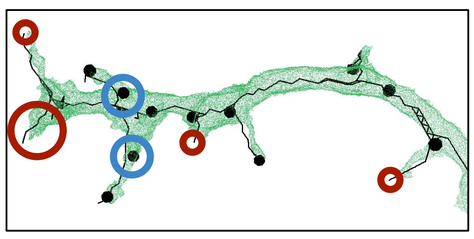
- We build on existing topological thinning strategies that erode surfaces to produce centerlines.
- Our method takes as input a neuron segmentation and corresponding list of synapses.
- The skeleton generation process connects all synapses and concurrently produces accurate width estimates for all neurites at every point along the skeleton.



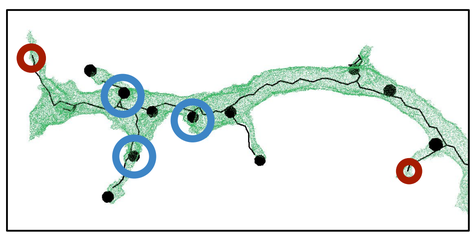


- We evaluate our method on 868 neurons and neuron fragments from three different species: rat, fruit fly, and zebra finch.
- We achieve a perfect one-to-one correspondence between synapses and endpoints with an average absolute mean width error of 19 nanometers.

TEASER



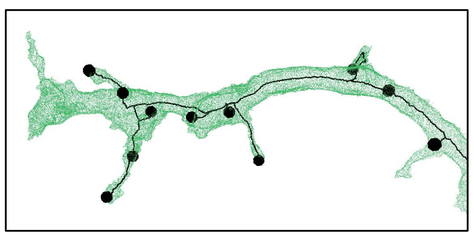
Isthmus Thinning



Endpoints without Synapses

Synapses without Endpoints

Ours



Source code is available at
https://www.rhoana.org/synapseaware.

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