Development Of A New Method For Multicolor Image Segmentation of Neuronal Tissue in 20x Expanded Hydrogels

Zachary Steinberg

MIT PRIMES

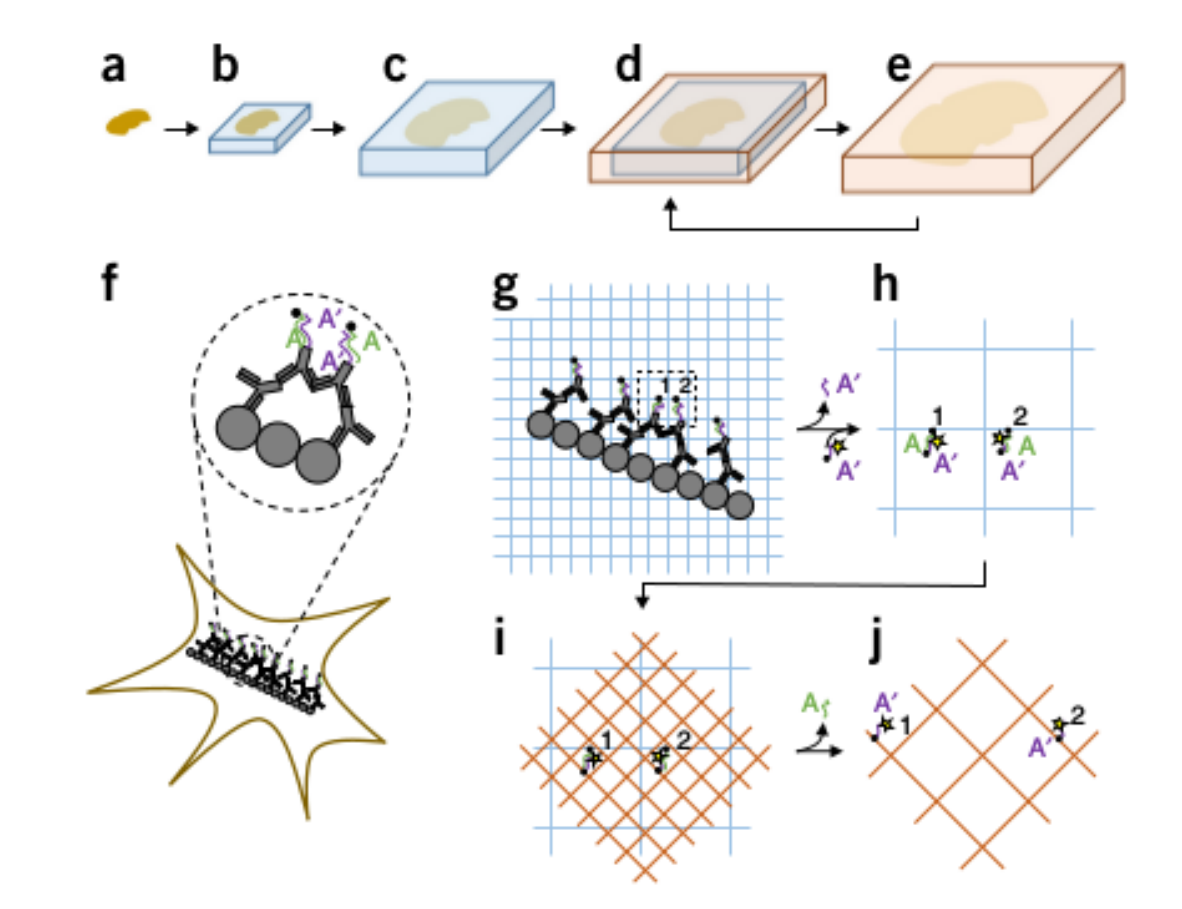
May 21, 2017

Background

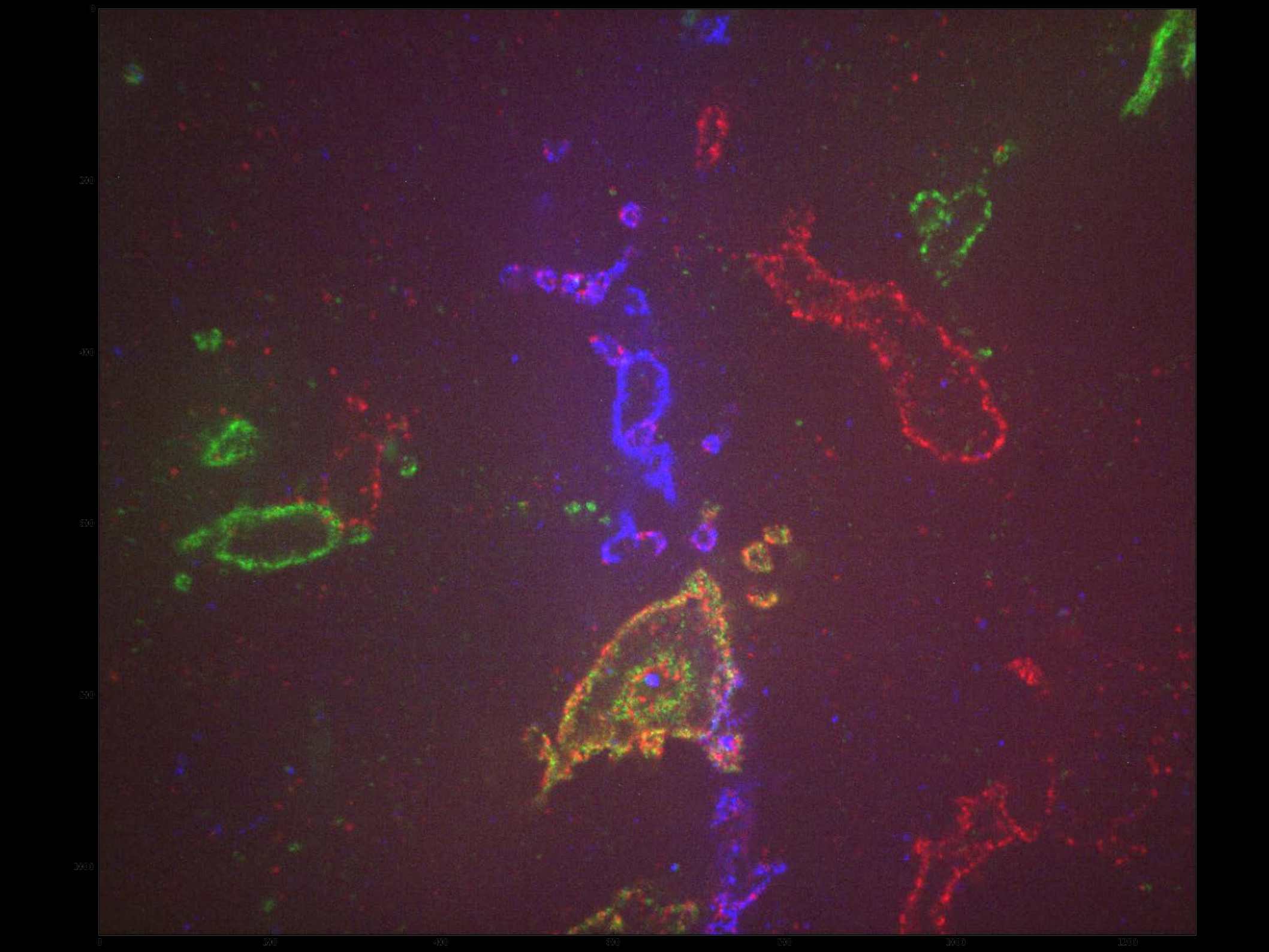
- “Connectomics” is the study of the brain’s circuits
- “Segmentation” is the process of extracting neruon locations from microscope data
- Existing approaches exist for electron microscopy data

Background: ExM

- Small structures with light-based microscopes
- Physically grow a volume in space
- Repetition can obtain up to 20x magnification



Source:
Chang et al, Nature 2017


0
200
400
600
800
1000
0
200
400
600
800
1000
1200

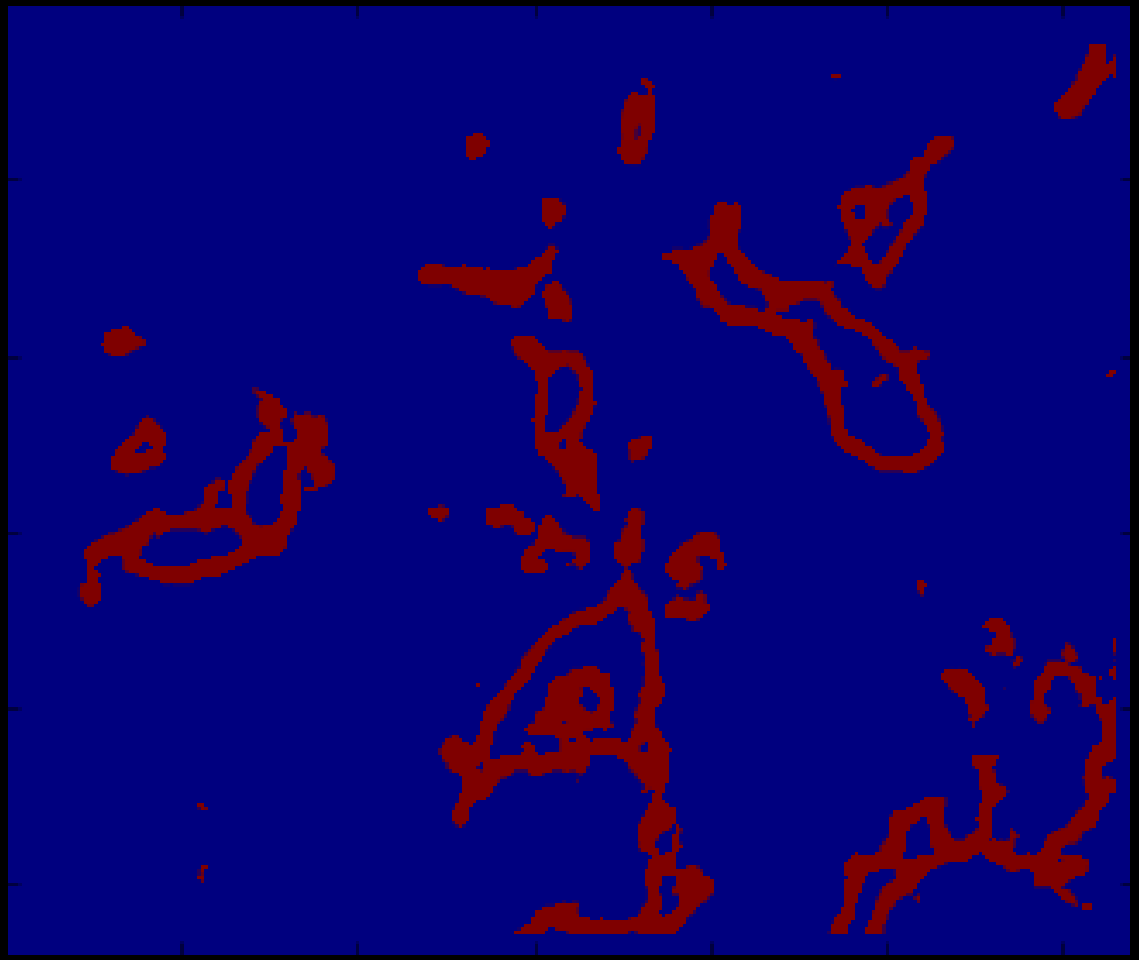
Our approach

Given a microscope image,

1) identify membrane pixels
2) group pixels in clusters
3) merge clusters together

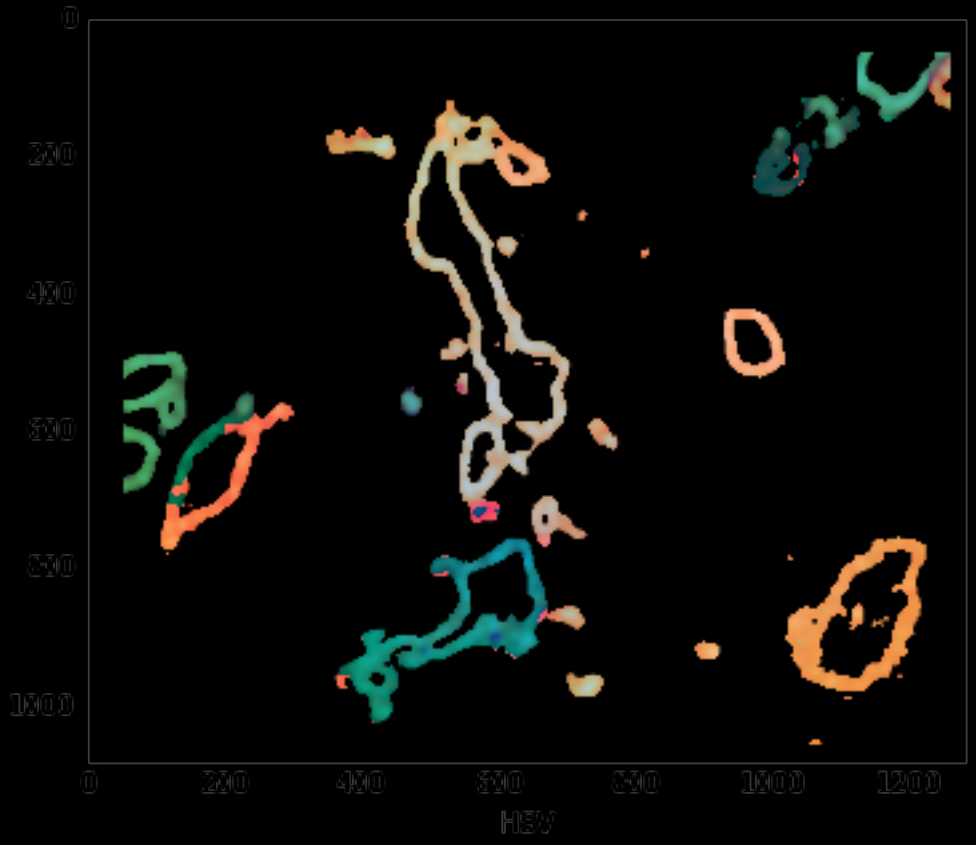
Identify membrane pixels

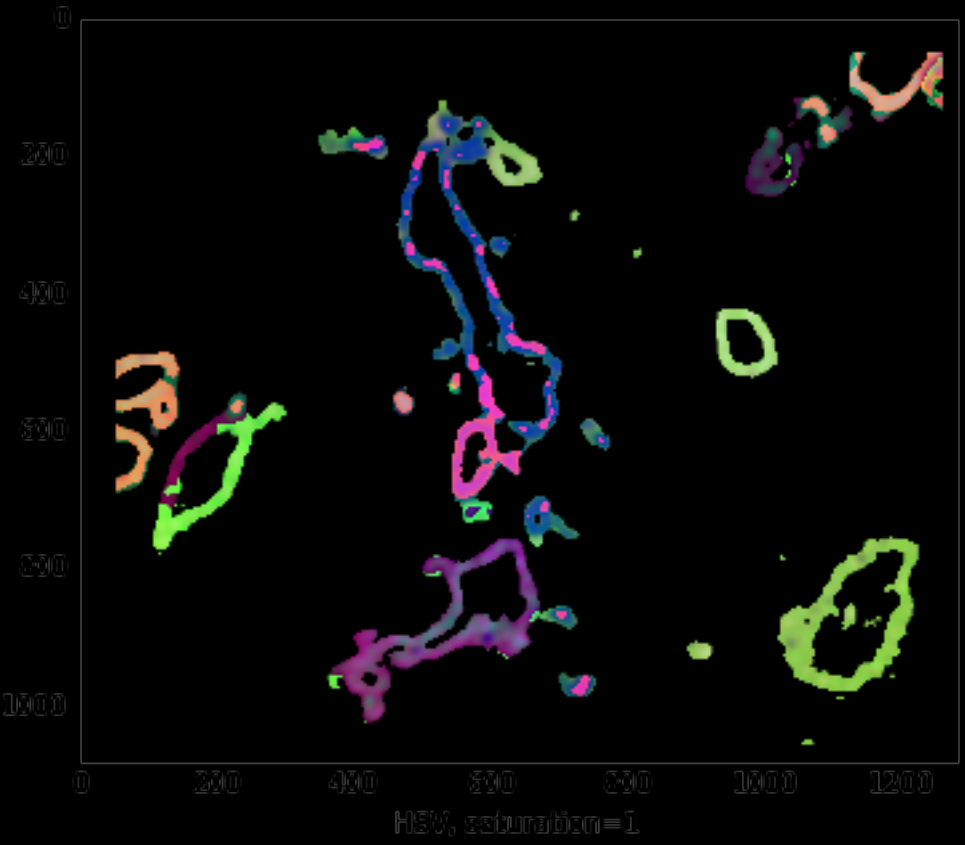
- Convolutional neural net used as an oracle
- Used to remove likely non-membrane pixels



Preprocessing

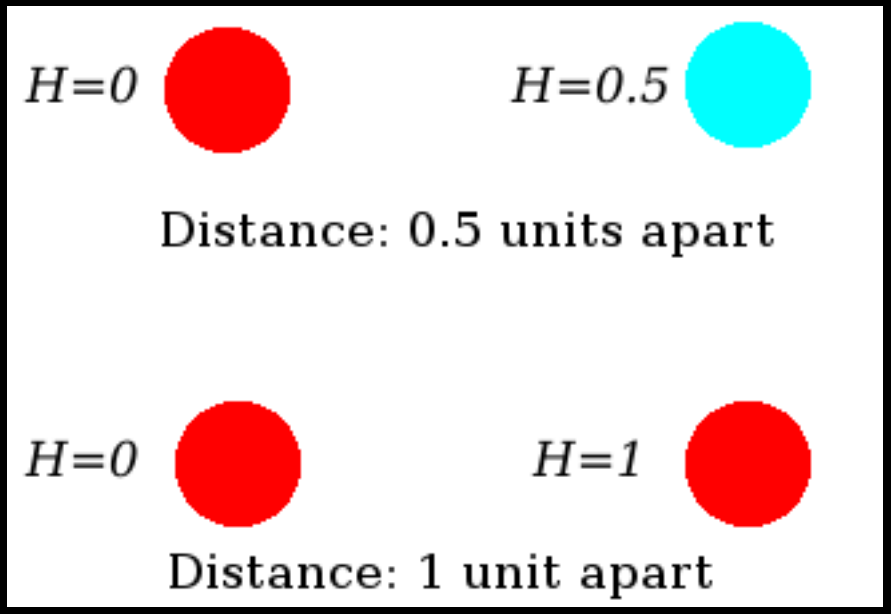
- Blur
- Convert to HSV
- To better differentiate neuron from background, set saturation = 1

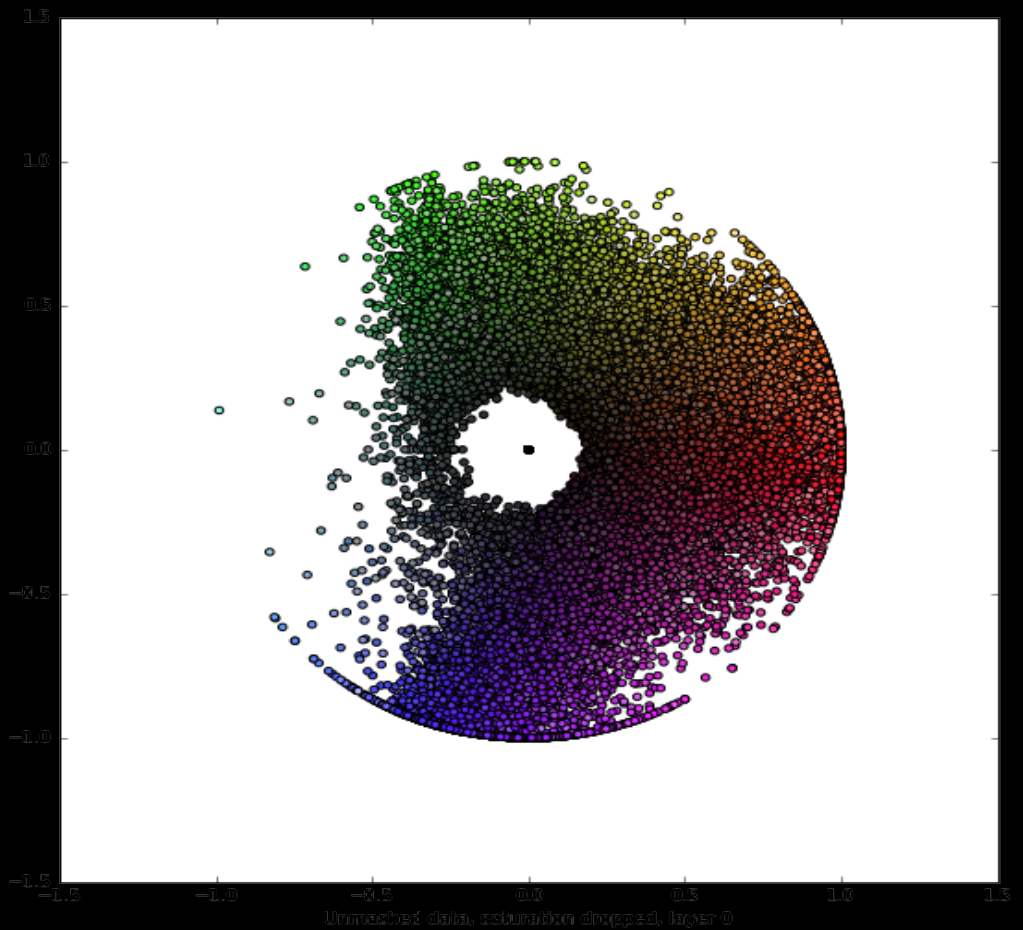




Preprocessing

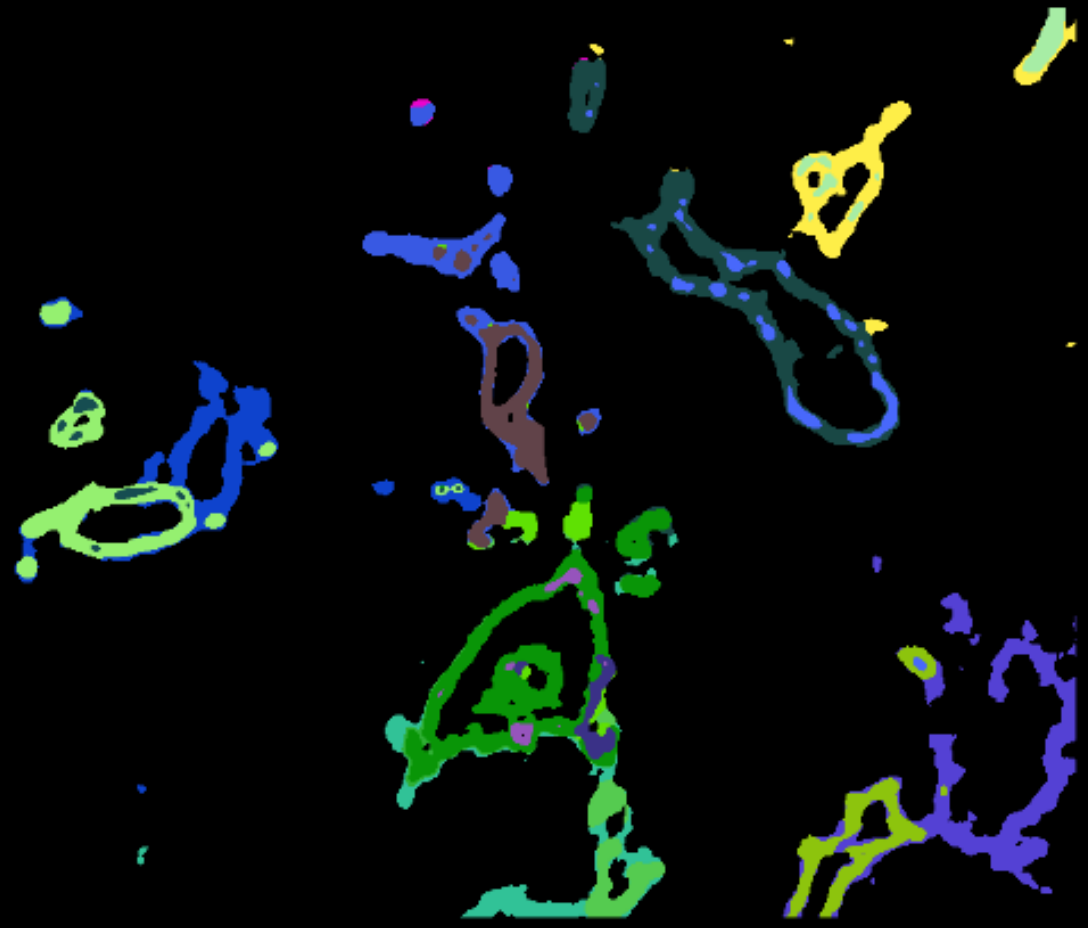
- Distances in HSV are problematic due to the hue discontinuity
- Transform to a polar “color wheel” plot





Oversegmentation

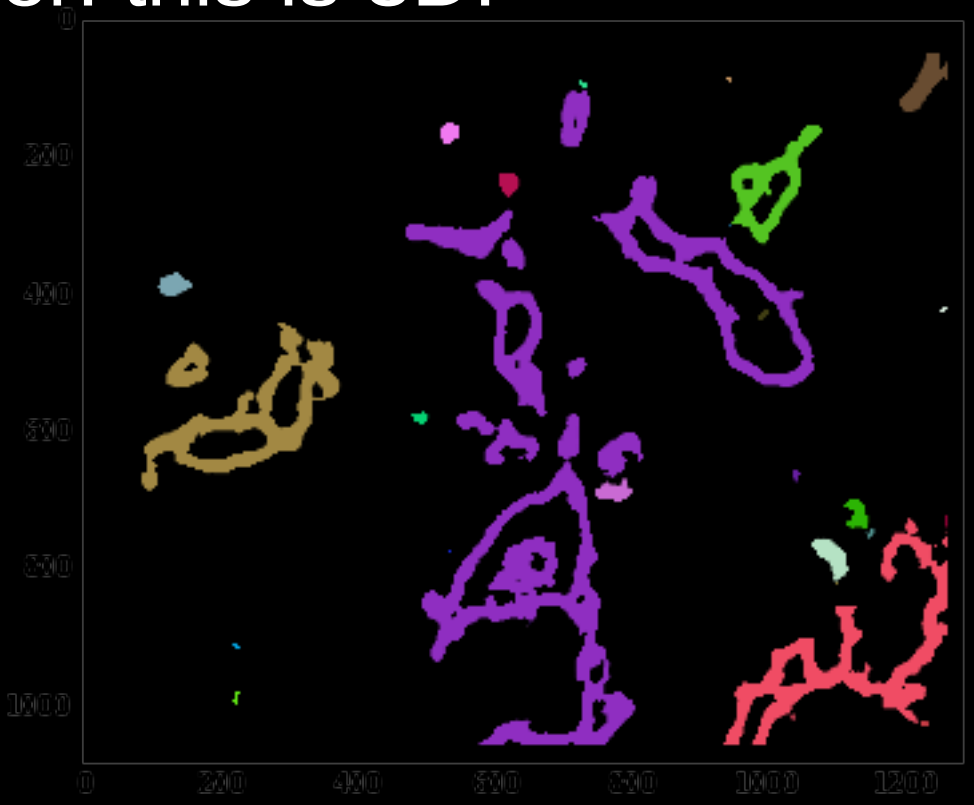
- Classify neurons by color using k-means



(One color per supervoxel)

Merging – Connected components

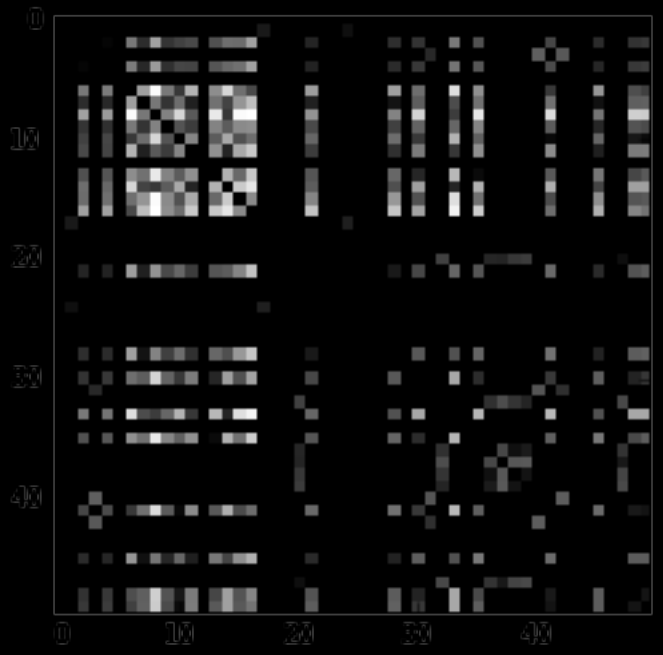
- Find all supervoxels in a region that are connected
- Remember: this is 3D!



(One color per connected region)

Merging

- Merge together connected supervoxels that share a color
- Construct a color adjacency matrix and only merge two supervoxels if their colors are close enough in color space.



Results – one slice

3D Results

More 3D Results

Even More 3D Results

Future work

- Differentiate background from membrane
- Use smarter heuristics for merging based on hue
- Gradients currently can connect neurons of different colors
- Extend to even denser labeling

Thank you!