SynEM, automated synapse detection for connectomics

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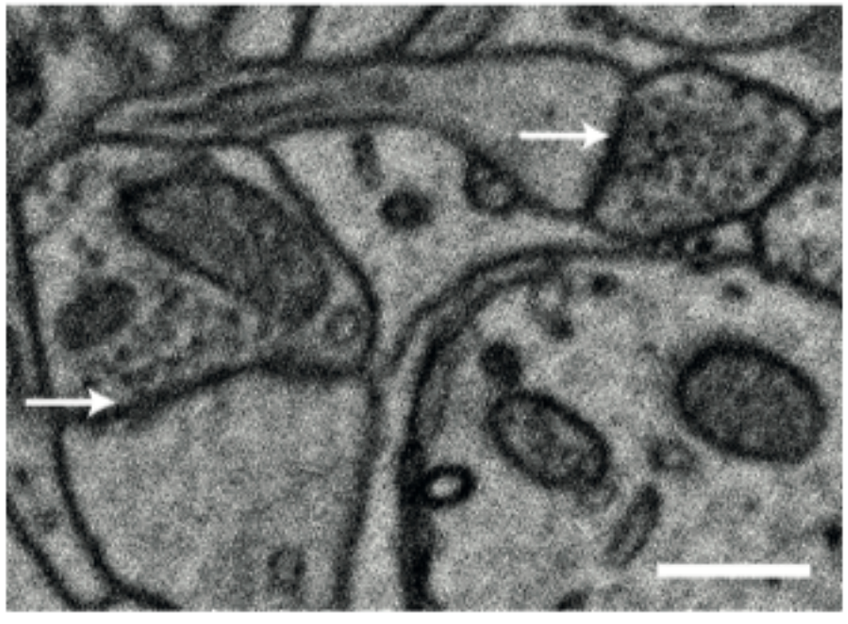
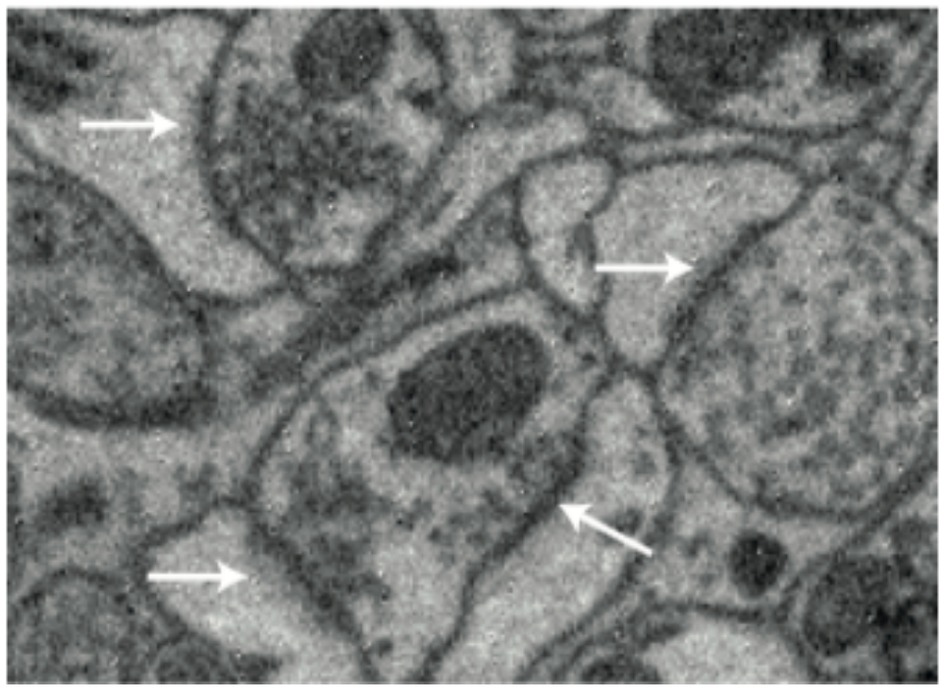
Presented by Gautam Prabhu

OPPORTUNITY

- In the middle of a connectomics revolution (2017 paper)
- Great developments have been made in microscopy, making cubic millimeter brain datasets plausible
- Neurite reconstruction annotation strategies growing much faster than synaptic annotation; neurite reconstruction increased by 50-fold but with no corresponding increase in synaptic recognition



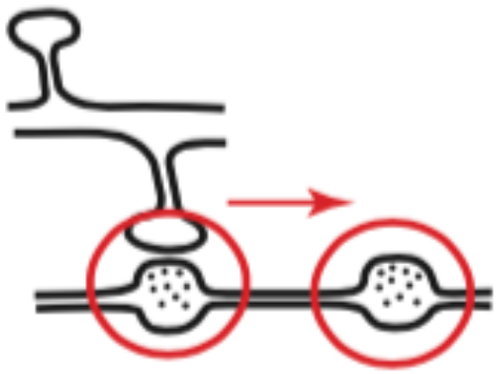


CHALLENGE

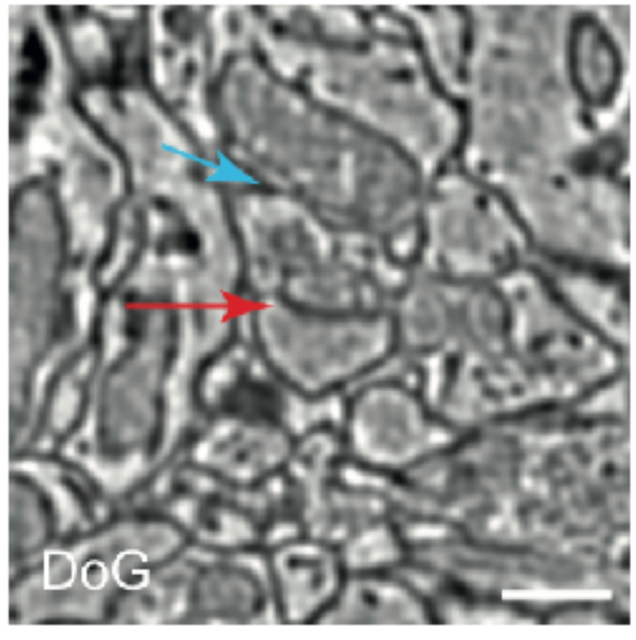
- Data analysis lags far behind imaging; one cubic millimeter of gray matter contains ~1 billion synapses

- Synaptic annotation has become the limiting step in dense large-scale connectomics

0.1h / μm^3

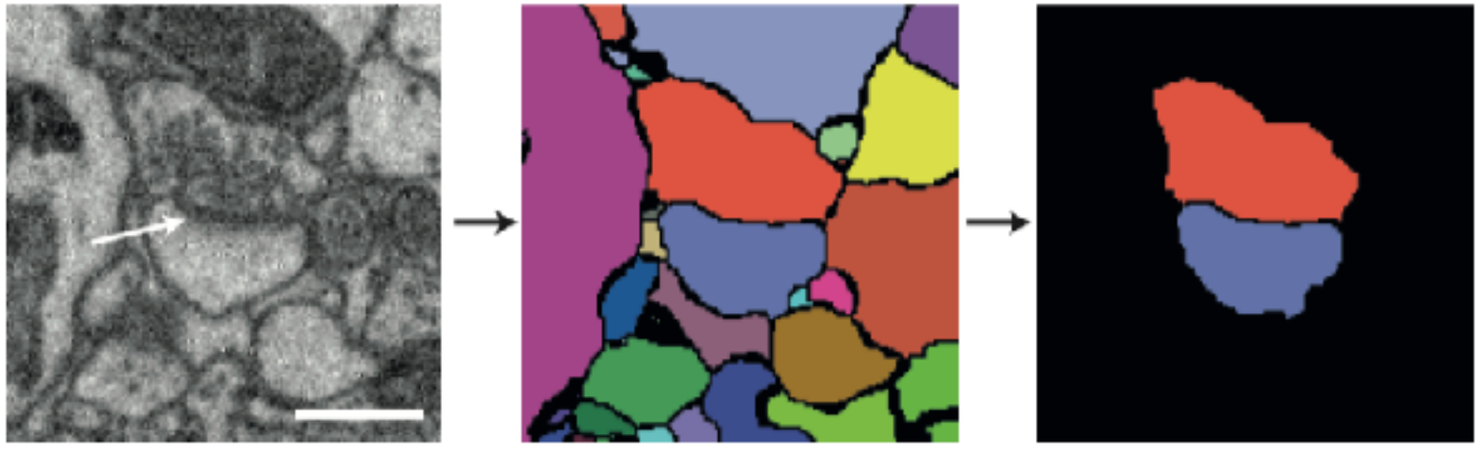


1min / bouton



ACTION

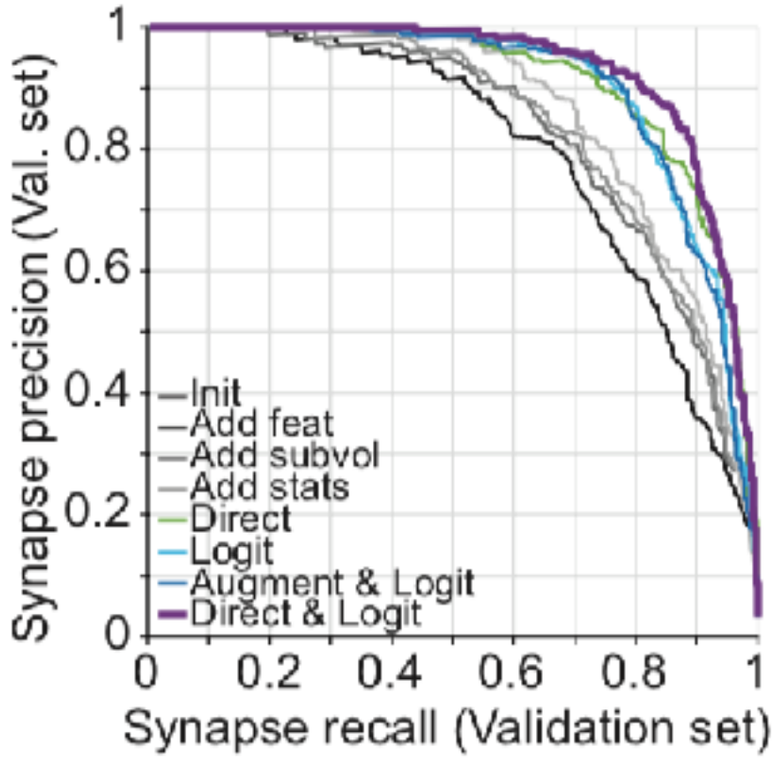
- Developed SynEM, an automated synapse detection method
- Method uses machine learning - 11 texture features, 5 shape features; uses “boosted decision stumps” trained by LogitBoost



Texture:
Raw data
3 EVs of Structure Tensor
3 EVs of Hessian
Gaussian Smoothing
Difference of Gaussians
Laplacian of Gaussian
Gauss Gradient Magn.
Local standard deviation
Int./var.
Local entropy
Sphere average
Shape:
Number of voxels
Diameter (vx based)
Lengths of principal axes
Principal axis product
Convex hull (vx based)

RESOLUTION

- SynEM has 87% precision and 88% recall for classification synapses and non-synaptic interfaces
- It also had 94% precision of classification and 89% recall for classification of spine synapses
- It also outperforms many other attempts to classify
- SynEM Is sufficiently computationally efficient to apply to large connectomics datasets - to run for a 1 mm ^ 3 dataset, it would take 279.9 days on a mid-size computational cluster



precision is the % of classified synapses that are actually synapses

recall is the % of actual synapses that are classified as such

$$\text{Precision} = \frac{tp}{tp + fp}$$

$$\text{Recall} = \frac{tp}{tp + fn}$$

FEEDBACK & FUTURE WORK

- I found it a really interesting and well-written article
- Lots of technical jargon and a math-heavy methods section

- Still could be better at synapse detection; also could improve for classifying inhibitory vs excitatory synapses (precision/recall is lower for for inhibitory synapses)