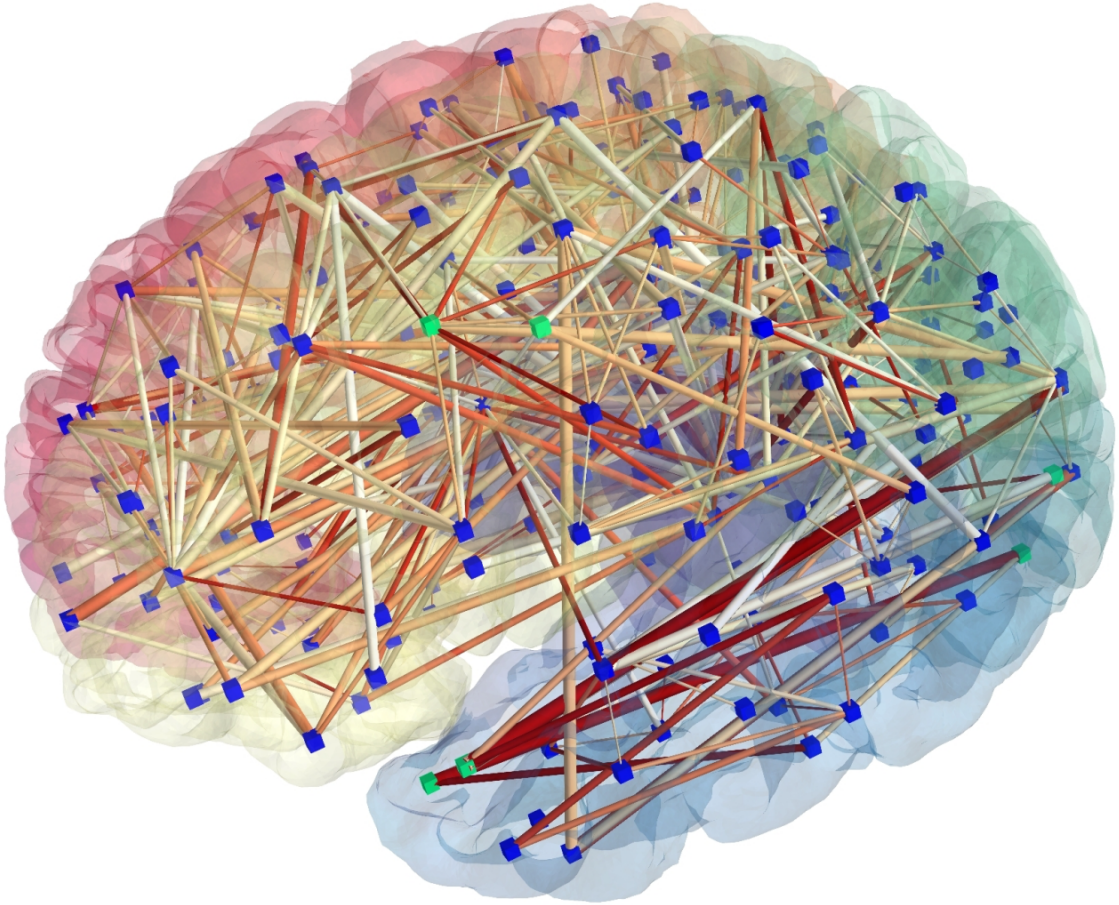
CIRCUIT RECONSTRUCTION FROM EM IMAGES

Shwetha Ram & Mrinal Joshi

Motivation: How is the BRAIN Structured?



Automatic reconstruction of neurons and neuronal connectivity is a central problem in neuroanatomy.

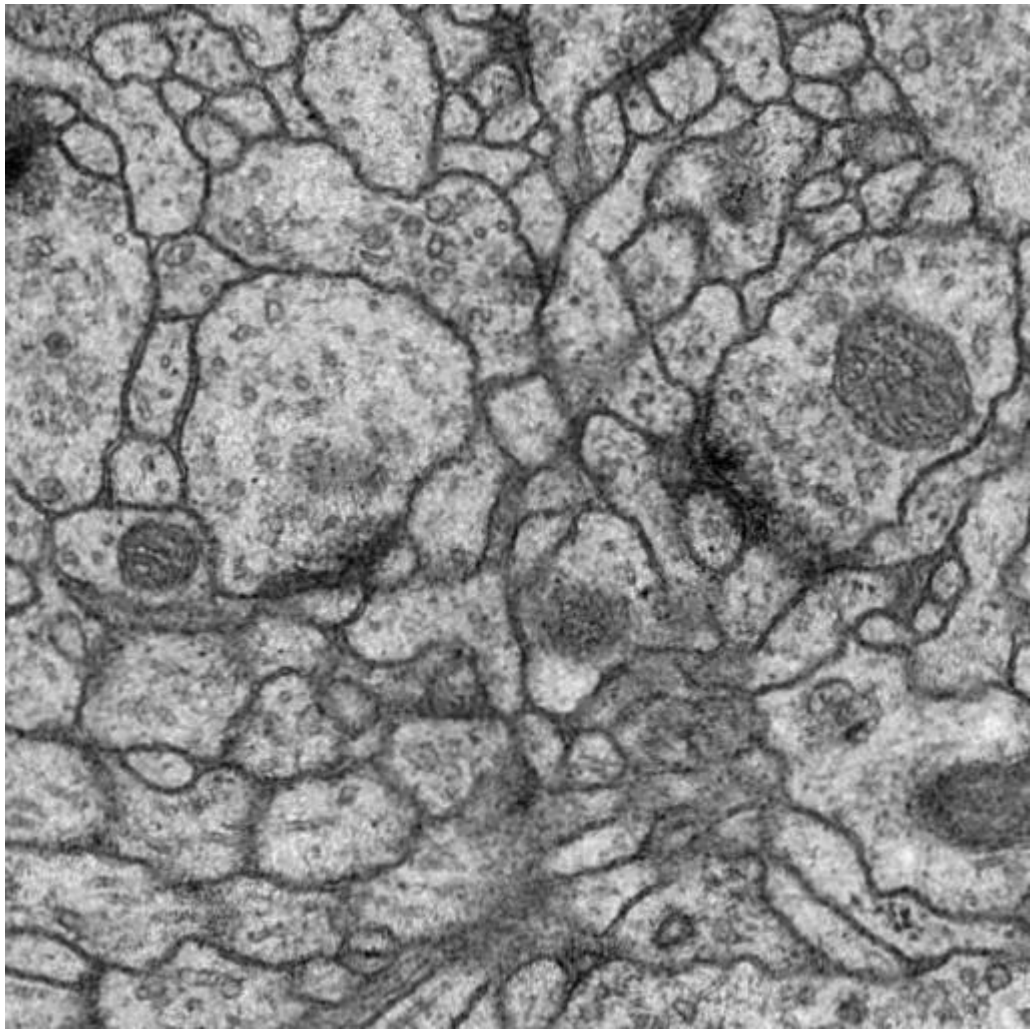
A successful solution would carry great potential to reduce the time spent on manual reconstruction of neural circuits in electron microscopy volumes.

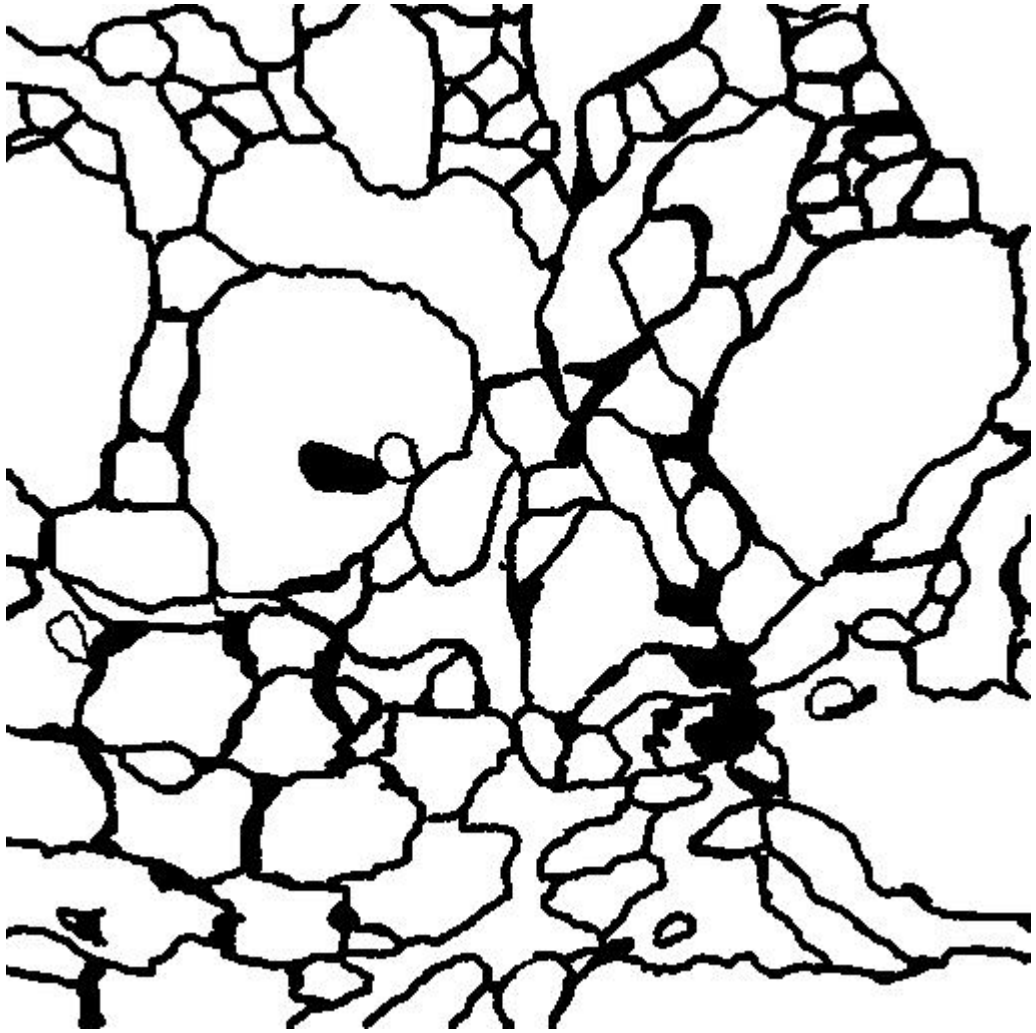
MOTIVATION

- There are three major challenges in this problem:
  - Segmentation: Assessment of neuron labelings in terms of pixel-based measures
  - Synapse detection: Detection of synapses
  - Connectivity: Identification of synaptic partners

- These three are ongoing challenges at the upcoming MICCAI 2016

We focus on SEGMENTATION





DATASET

- Open source datasets available as part of challenges hosted by ISBI 2012 and MICCAI 2016.

- These are from adult Drosophila melanogaster brain tissue, comprising neuron segmentation ground truth and annotations for synaptic connections.

- The images are representative of actual images in the real-world, containing some noise and small image alignment errors.

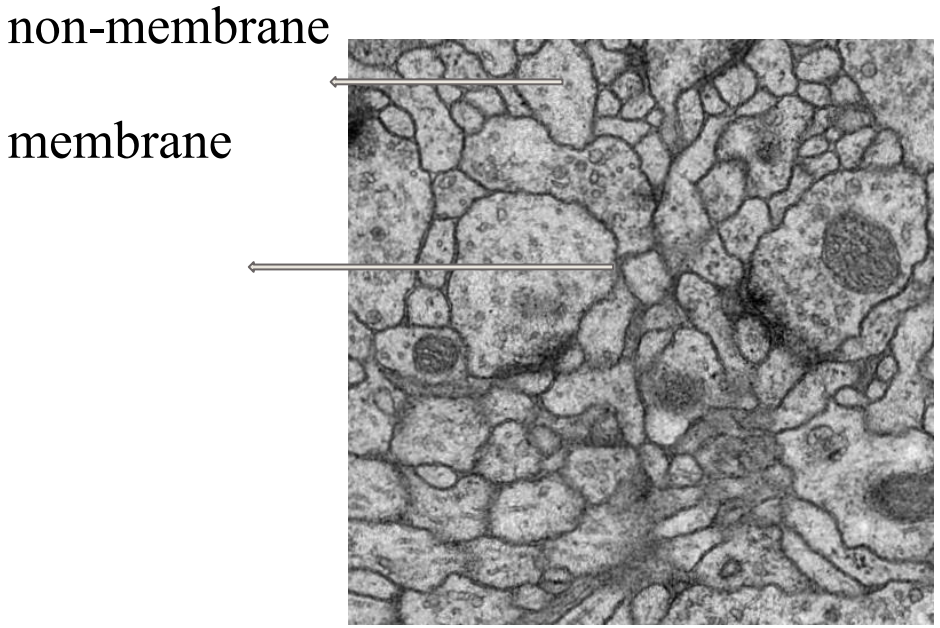
DATASET- ISBI 2012

- Sections from a serial section Transmission Electron Microscopy (ssTEM) data set of the Drosophila first instar larva ventral nerve cord (VNC)
- The microcube measures 2 x 2 x 1.5 microns approx., with a resolution of 4x4x50 nm/pixel.
- 30 train images
- 30 test images

APPROACH

- To segment biological neuron membranes, we use artificial neural network as a pixel classifier

- Pixel classified as **membrane** or **non-membrane**



APPROACH

- Pixel based approach
- Windowing on every pixel (65x65) to provide context. Reflecting around borders
- Output is a softmax classification – probabilistic estimate of each class as the output

ConvNet ARCHITECTURE

Layer	Type	Maps and neurons	Kernel size
0	Input	65 x 65 x 1	
Layer 1	Convolutional	62 x 62 x 48	4 x 4
Layer 2	Max Pooling	31 x 31 x 48	2 x 2
Layer 3	Convolutional	28 x 28 x 48	4 x 4
Layer 4	Max Pooling	14 x 14 x 48	2 x 2
Layer 5	Convolutional	10 x 10 x 48	5 x 5
Layer 6	Max Pooling	5 x 5 x 48	2 x 2
Layer 7	Fully Connected	200	1 x 1
Layer 8	Fully Connected - Softmax	2	

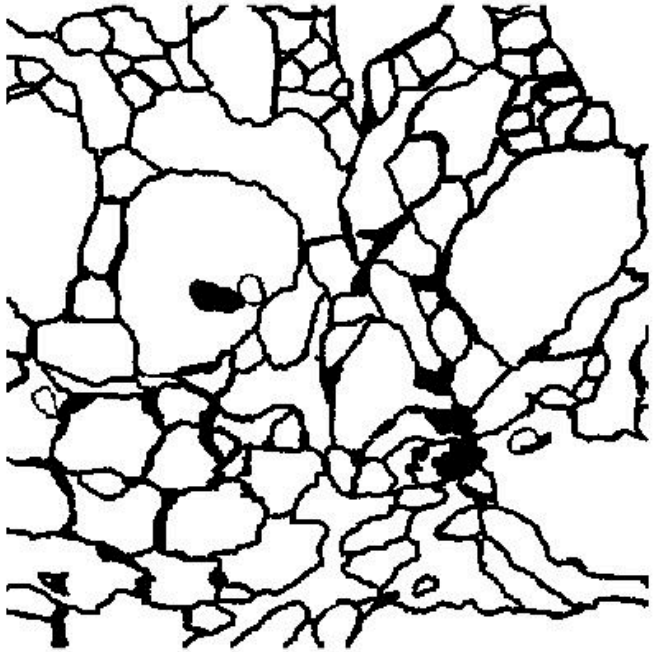
DETAILS

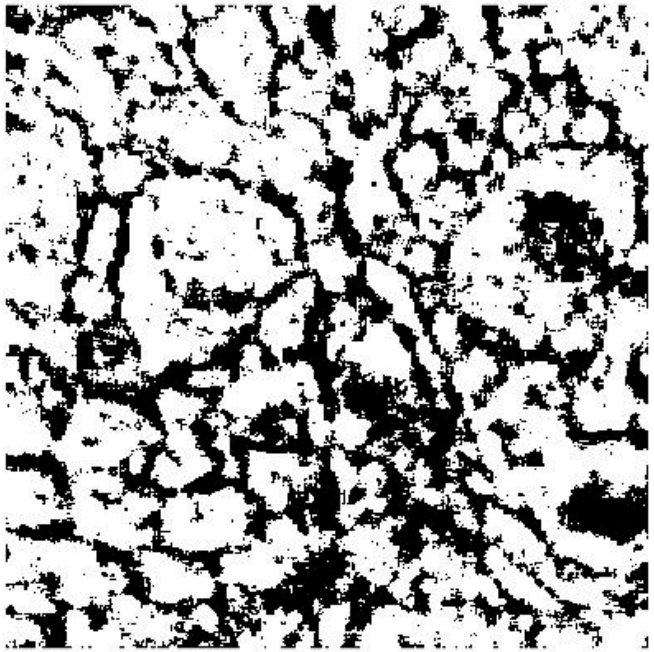
- The Training dataset in the challenge was partitioned into:
  - Training dataset: 20 images each of 512 x 512 pixels
  - Validation dataset: 5 images each of 512 x 512 pixels
  - Test dataset: 5 images each of 512 x 512 pixels

- Test dataset in the challenge: 30 images each of 512 x 512 pixels

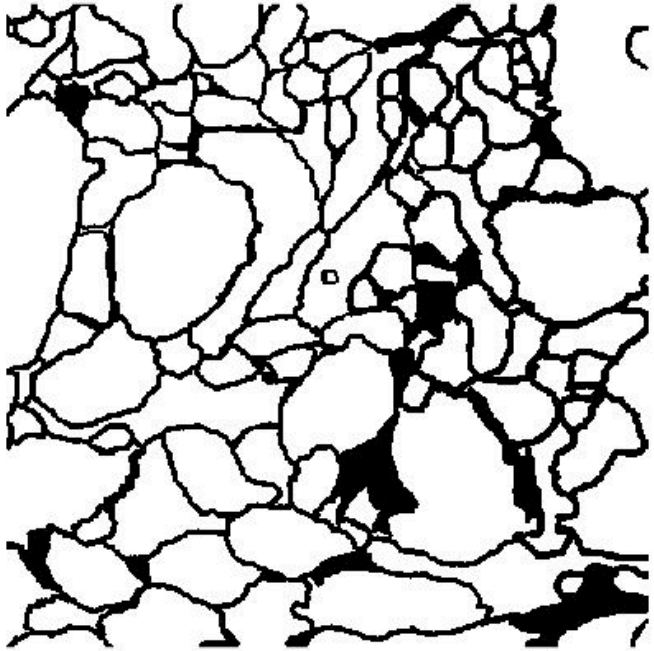
- Implementation done on Caffe using SGD, Momentum upgrade and exponential decay of learning rate

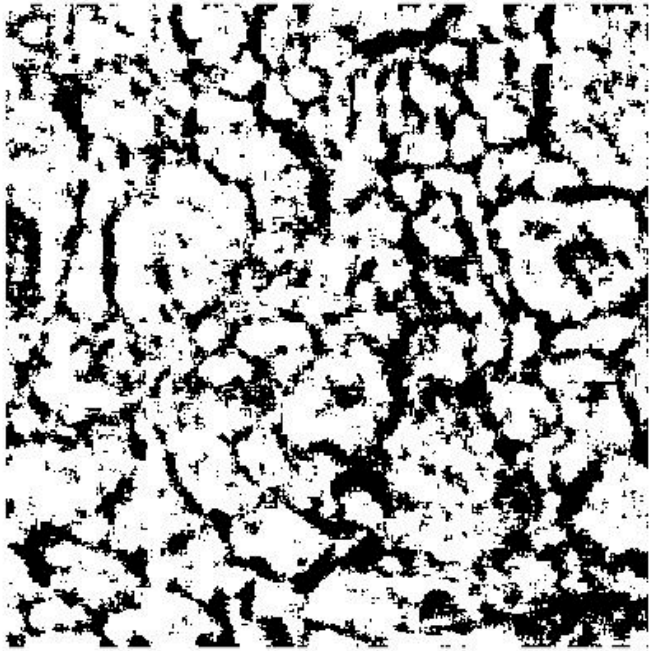
RESULTS – Training images



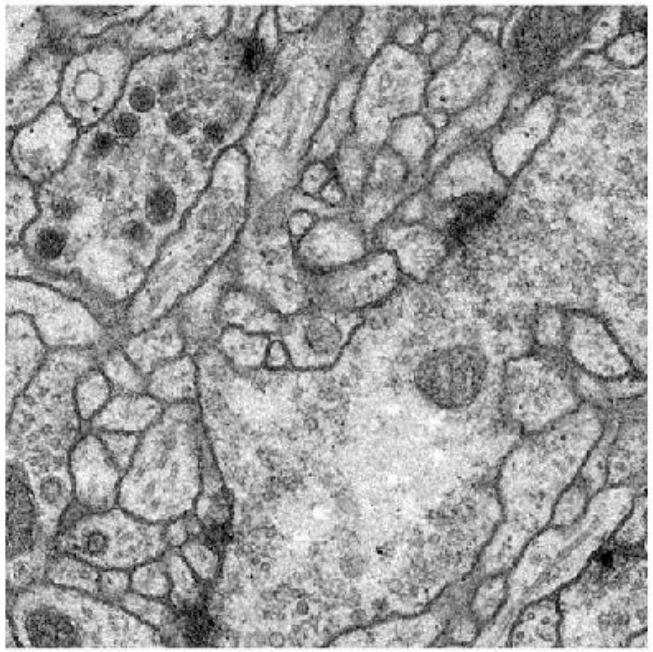


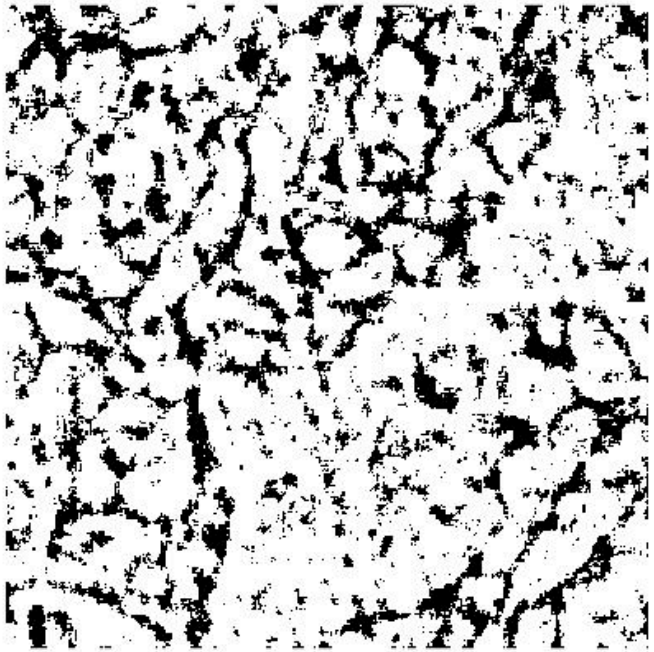
RESULTS – Validation images





RESULTS – Test images





RESULTS

- Training Accuracy: 77.45%
- Validation Accuracy: 72.78%
- Test Accuracy: 69.32%

FUTURE WORK

- Further post-process the image to get a good segmentation map.
- We can try augmenting the dataset.
- Attempt 3D Segmentation and other challenges in connectomics like synapse detection and connectivity.

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