

# **Image Segmentation**

## **Deep Learning Workshop at MBL**

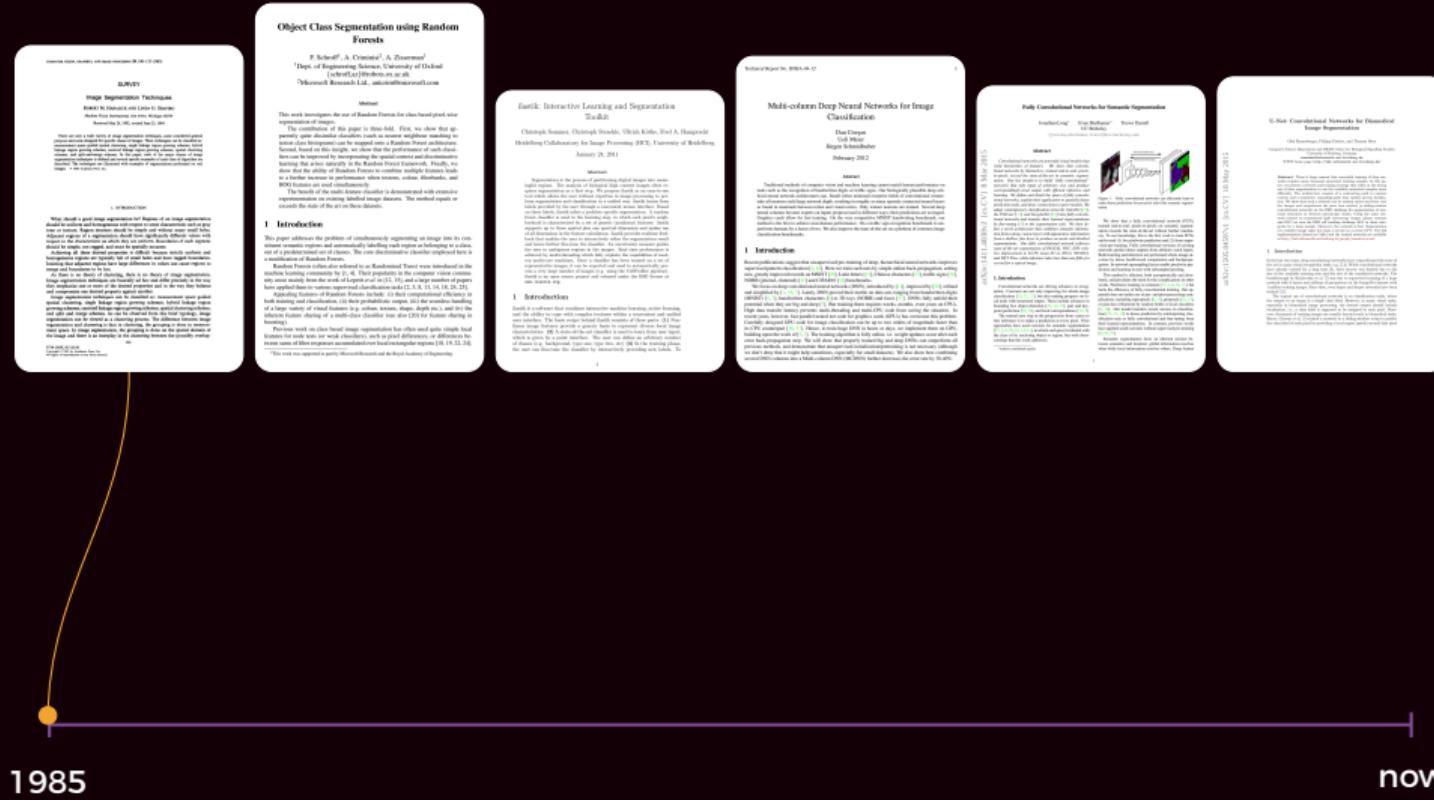
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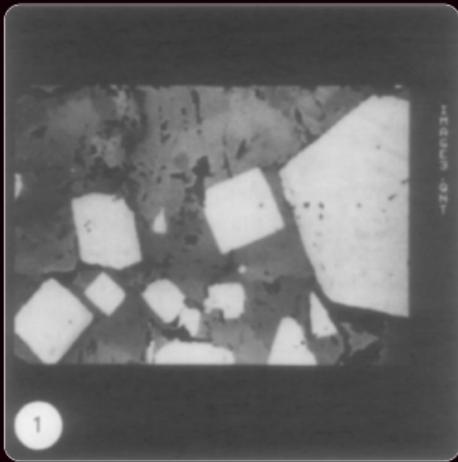
May 12, 2019

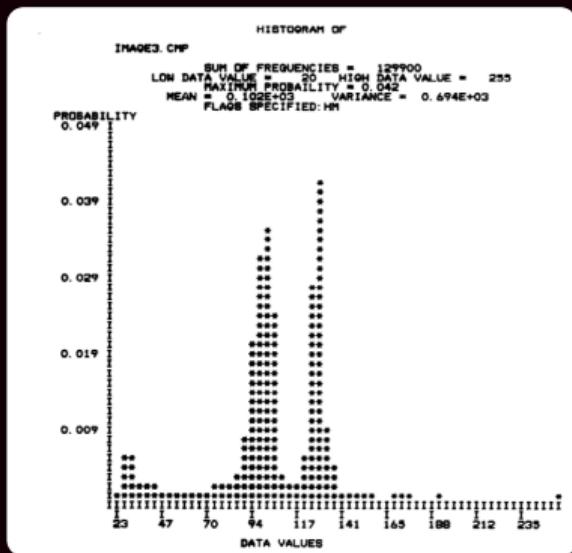
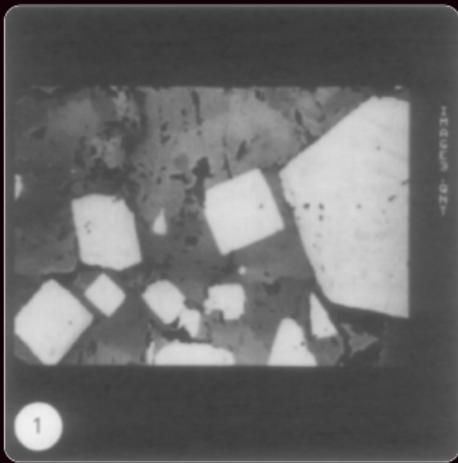


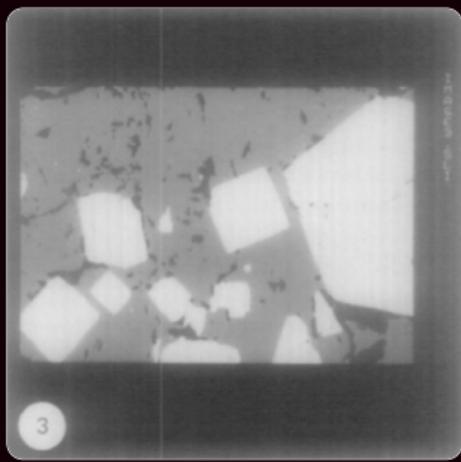
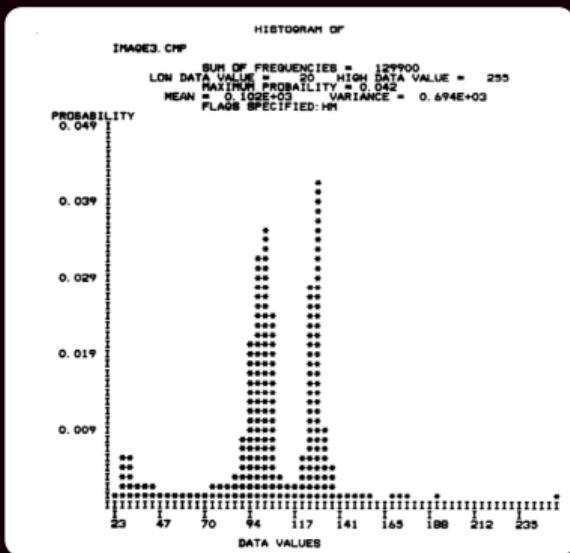
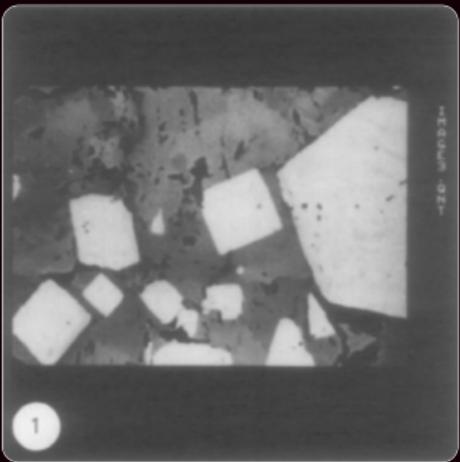
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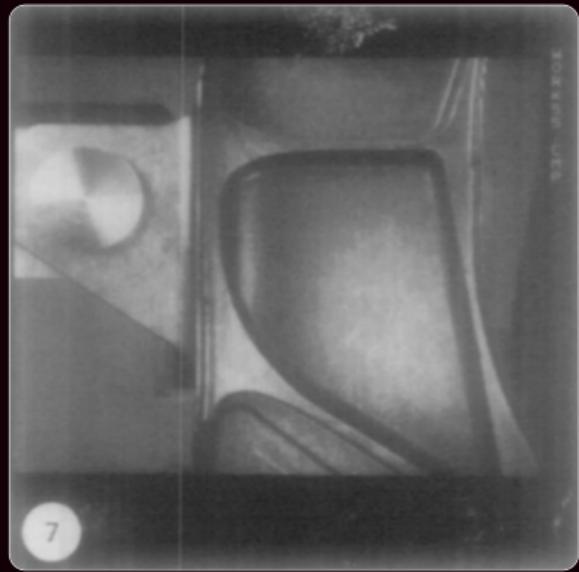
now



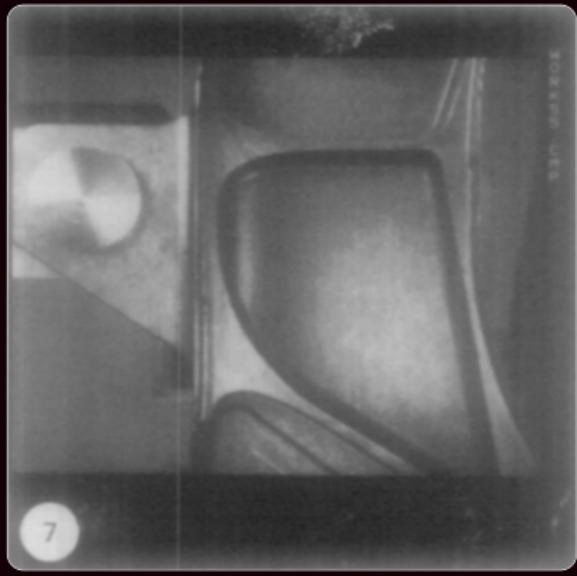




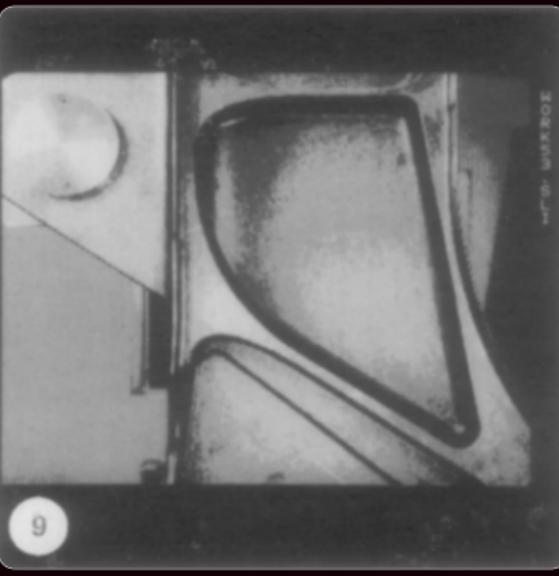




WEST-INDIA CO.



7



9



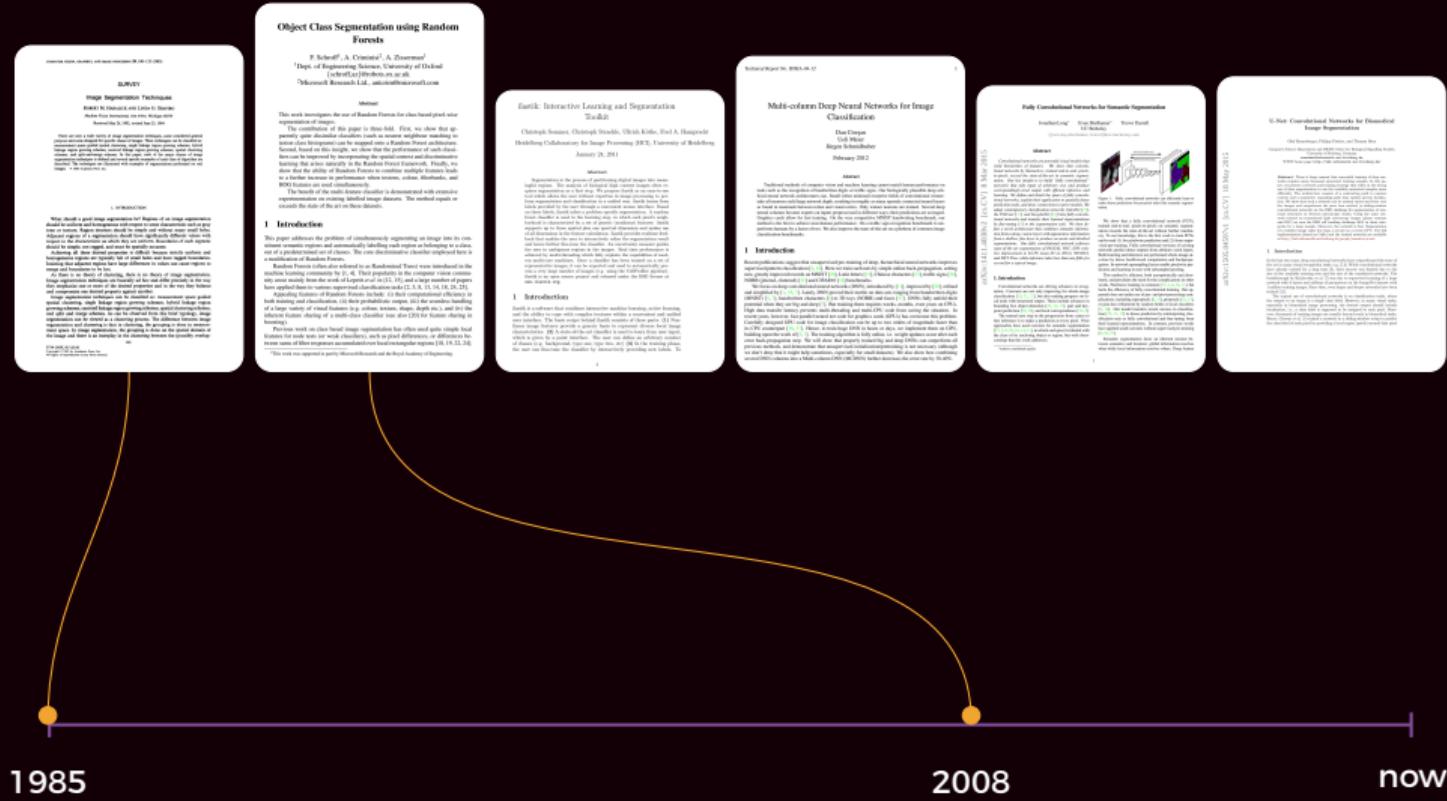
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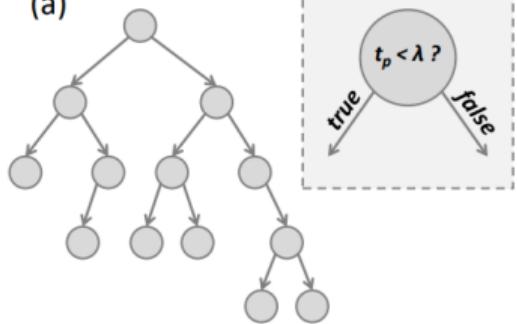
CROSS-CFT

19a

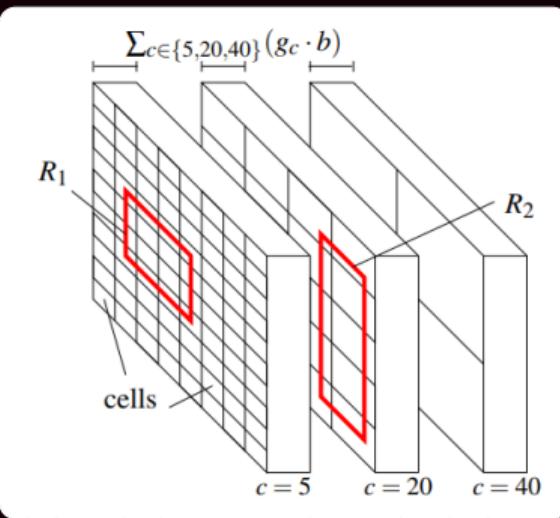
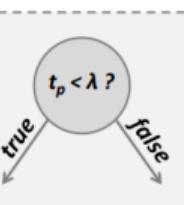
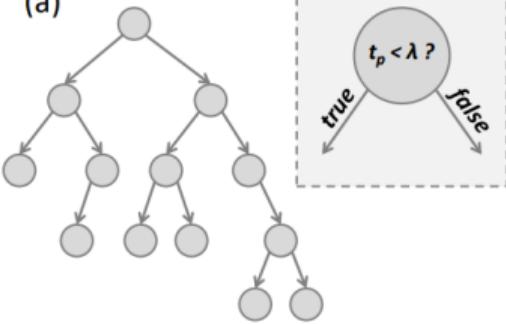
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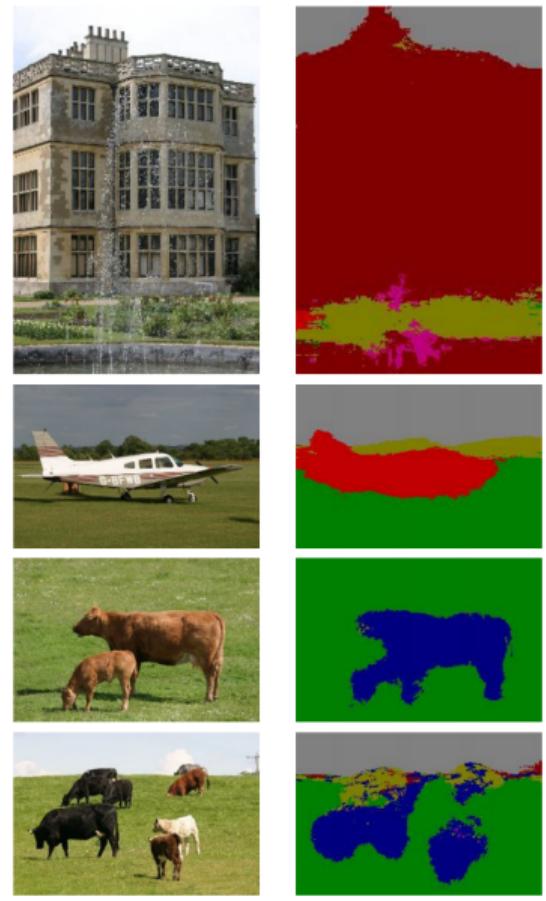
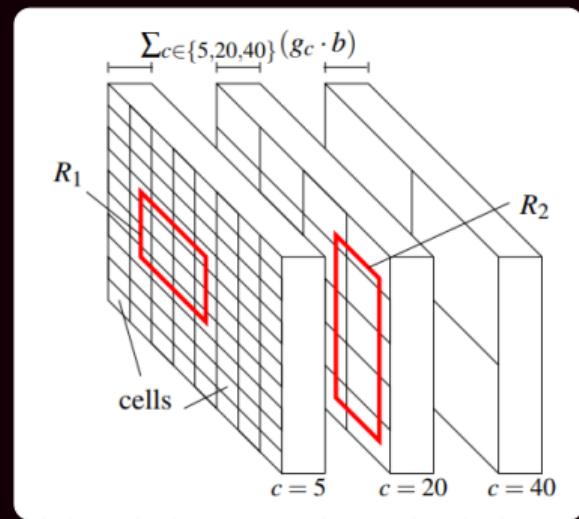
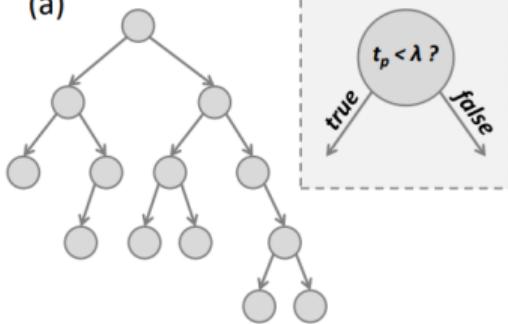
(a)



(a)



(a)

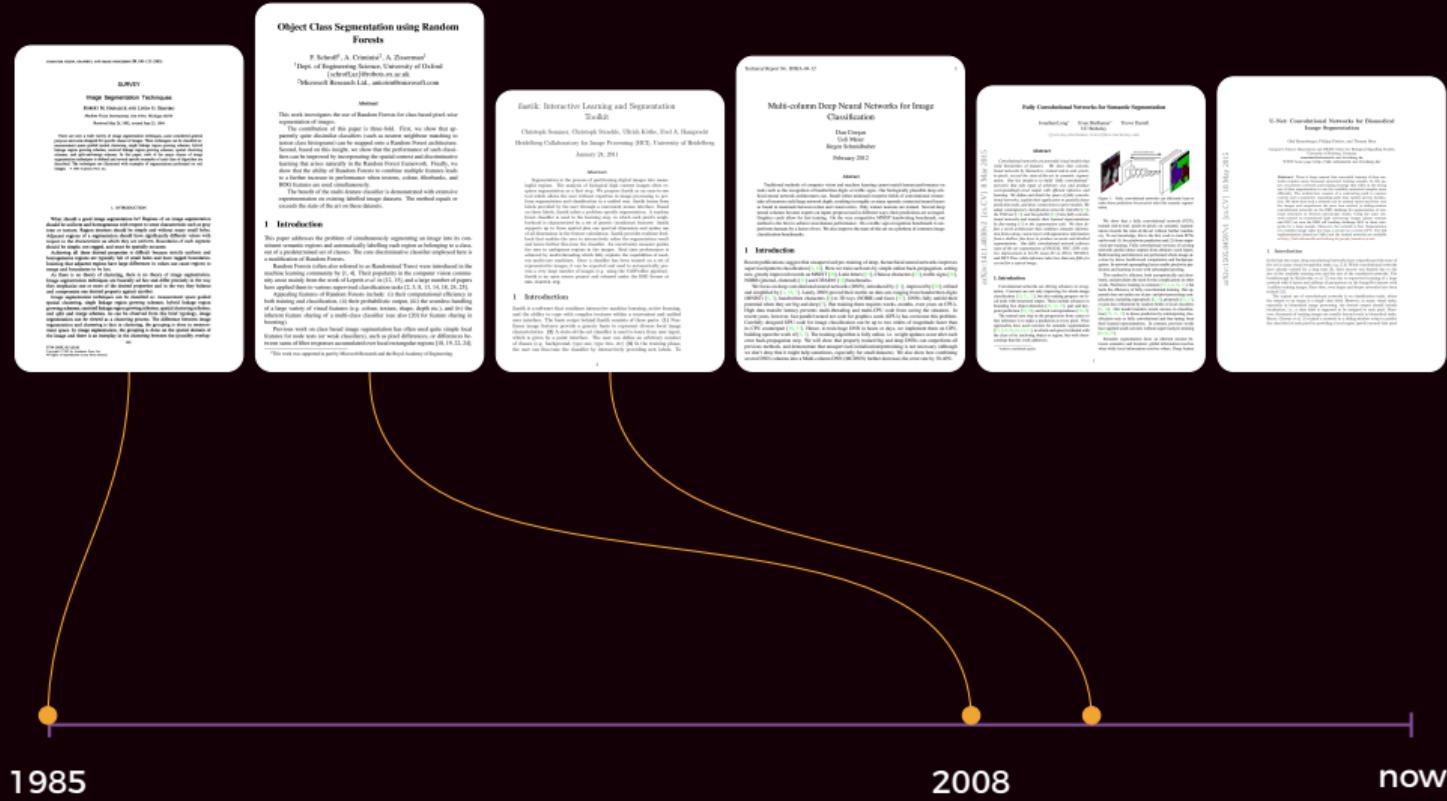


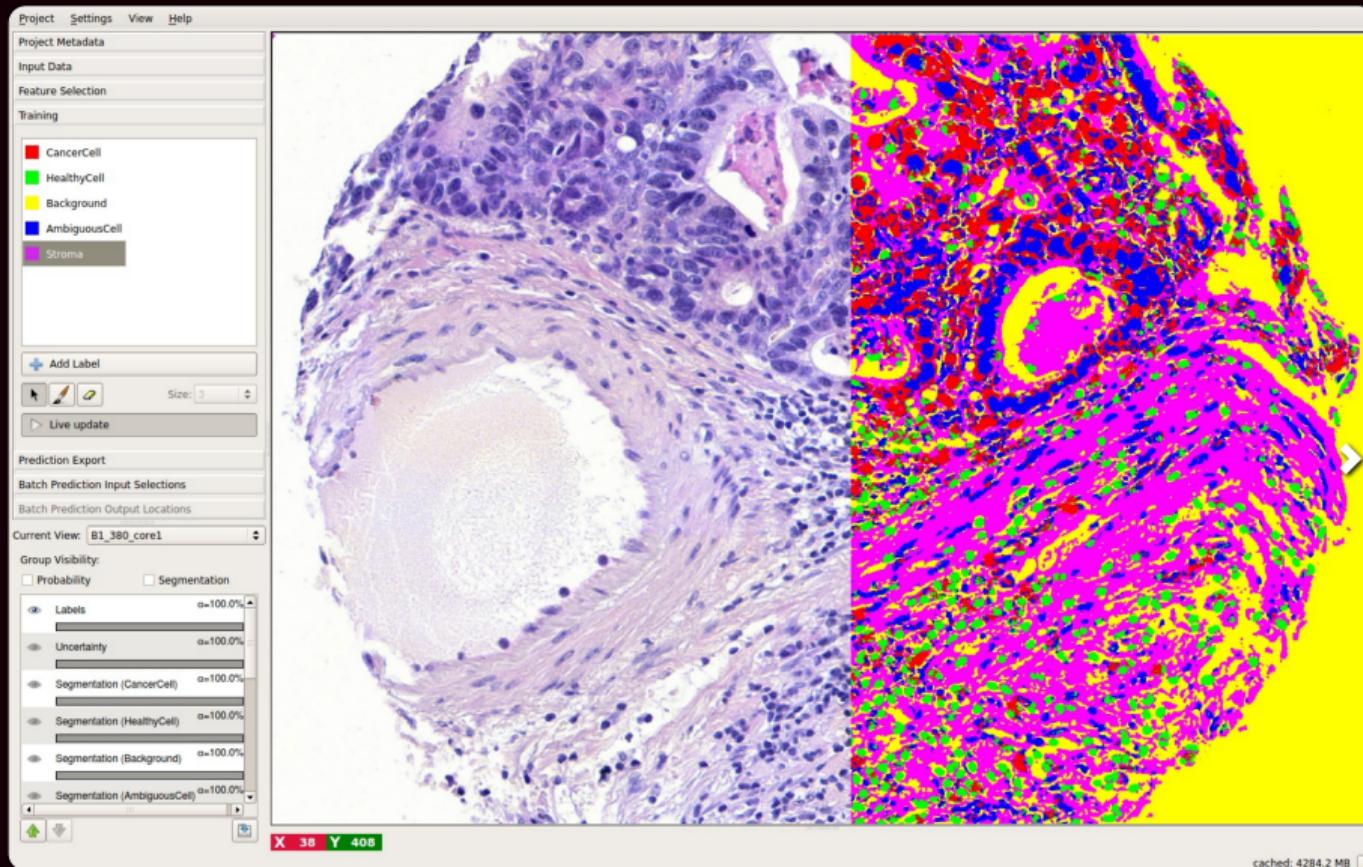
image

MAP posterior

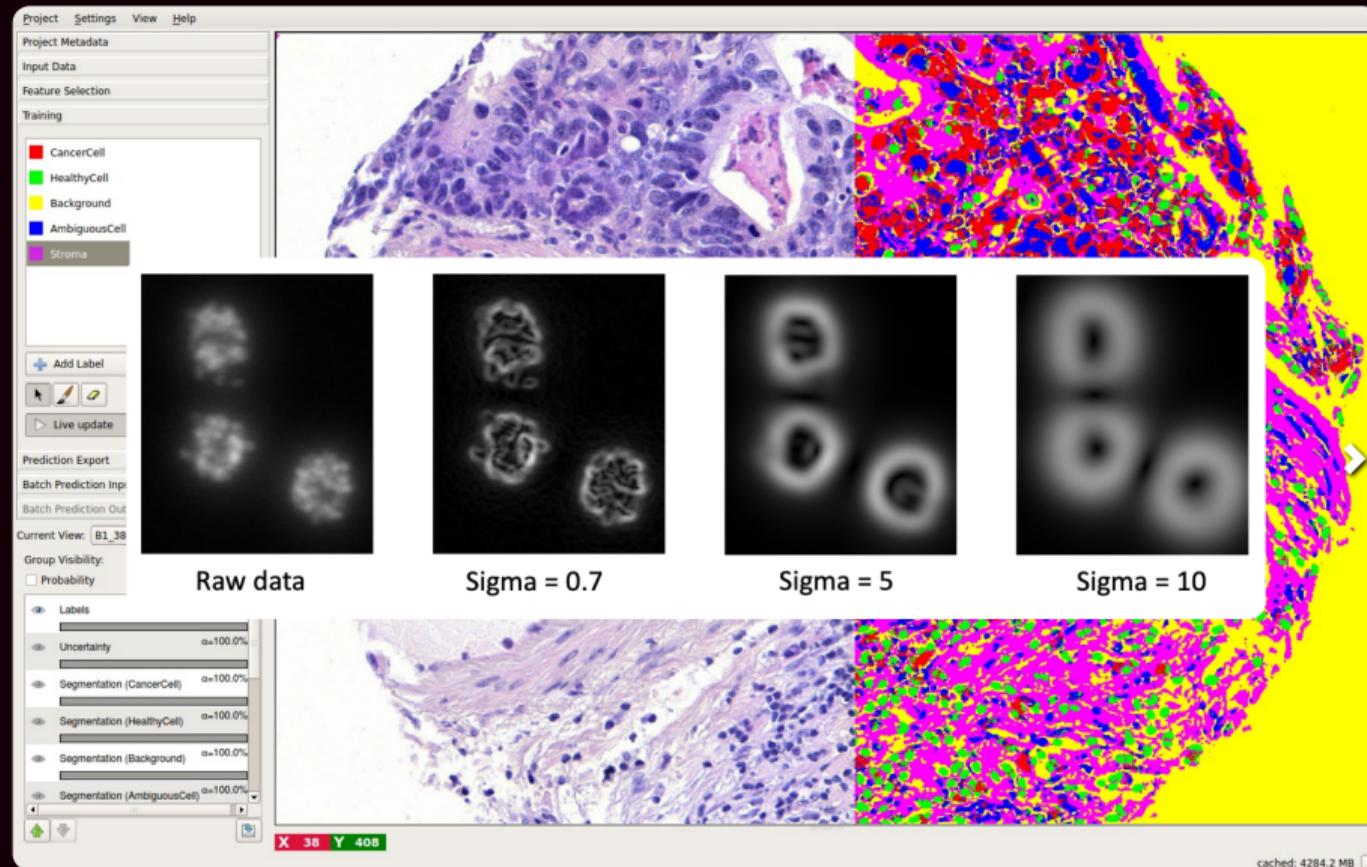
acc. 9-class

84.4%

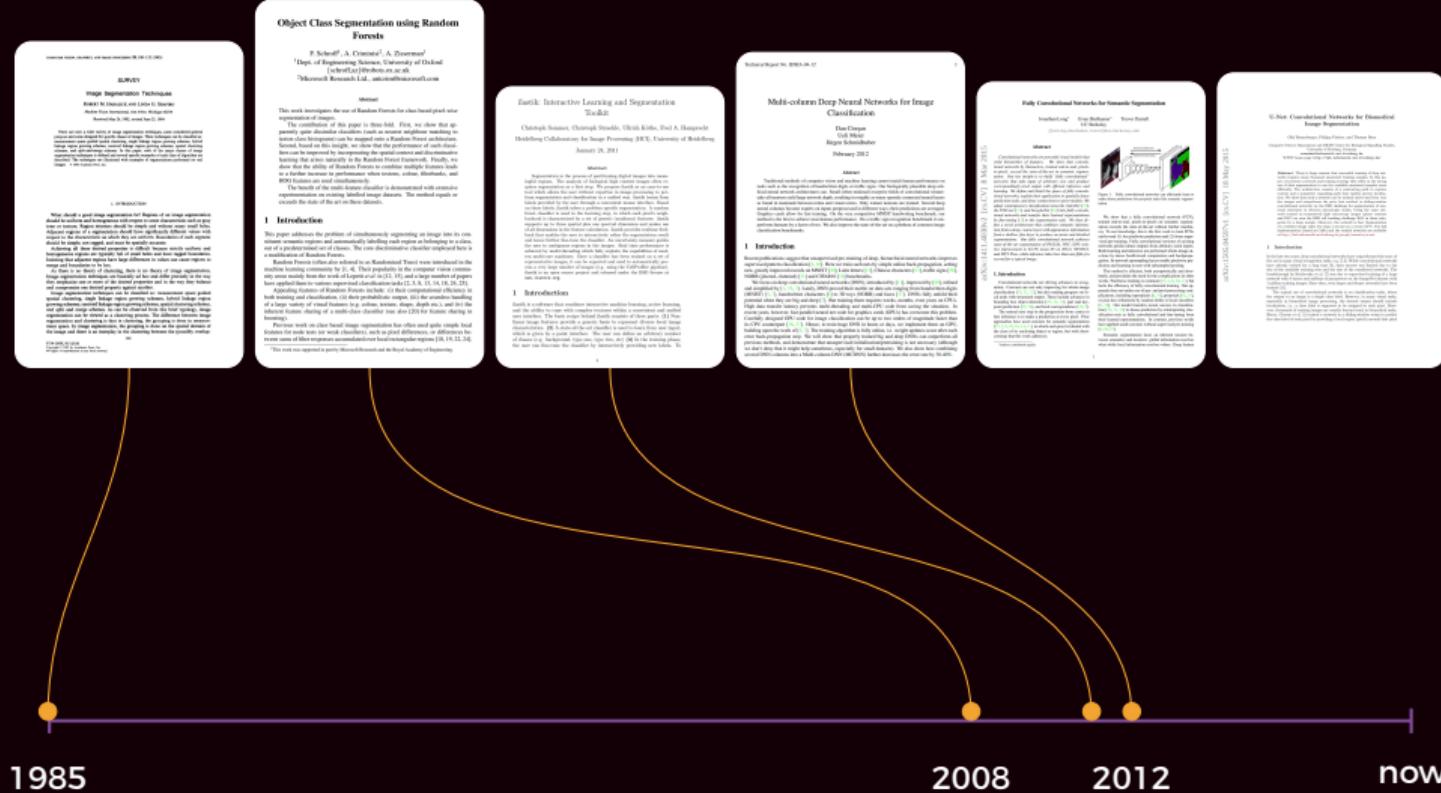


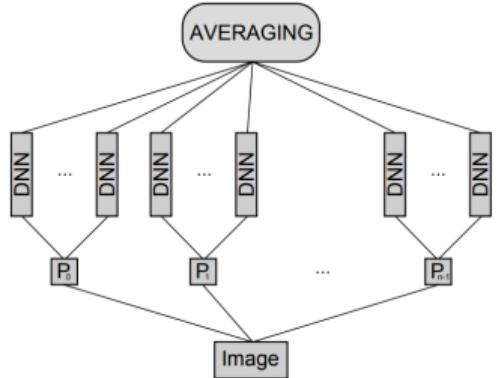
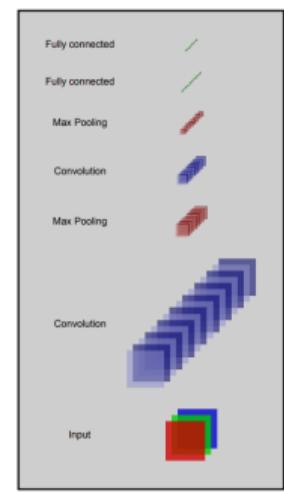


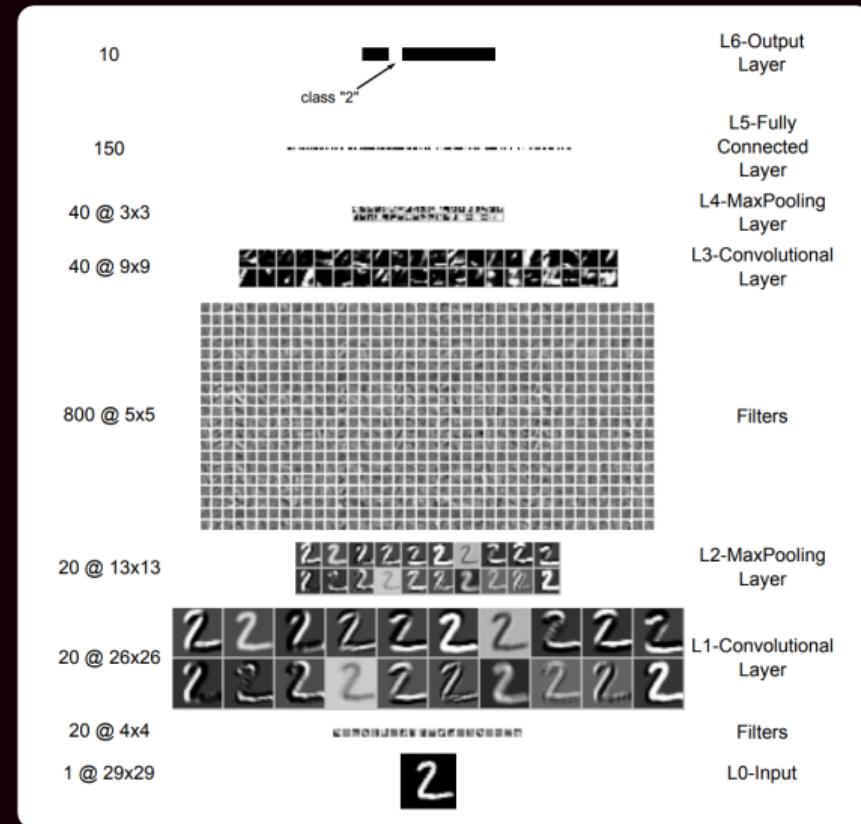
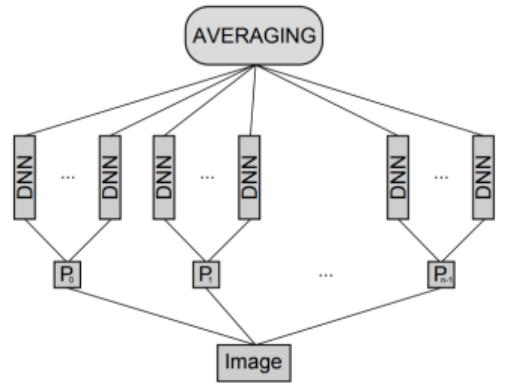
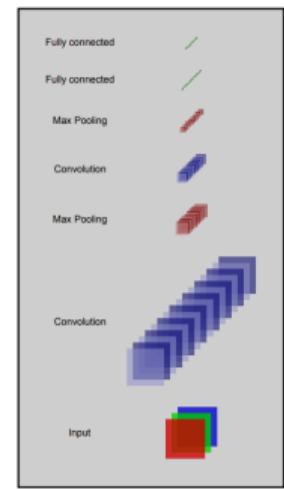
<https://ilastik.org>

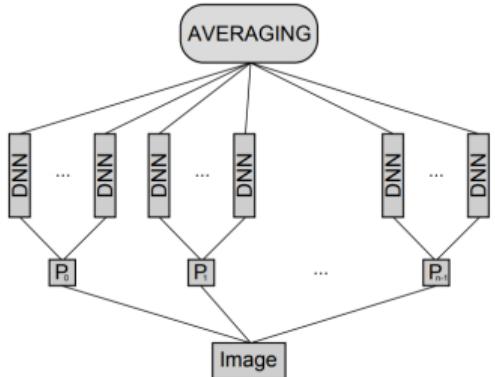
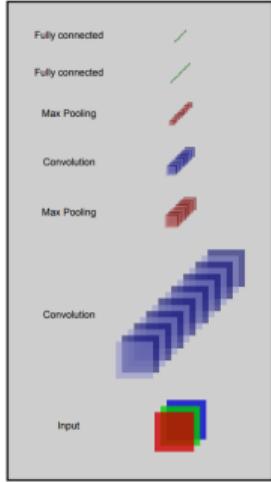


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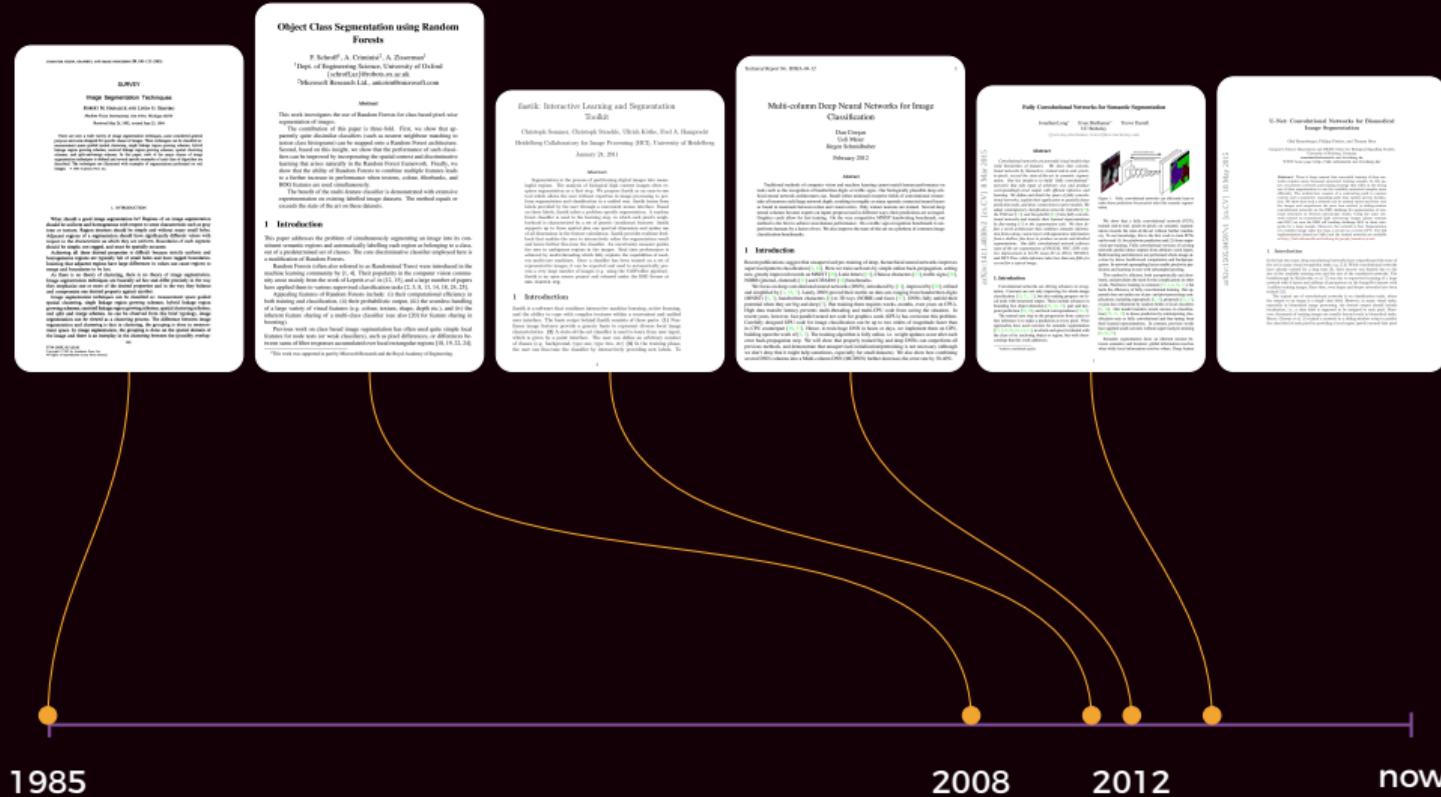


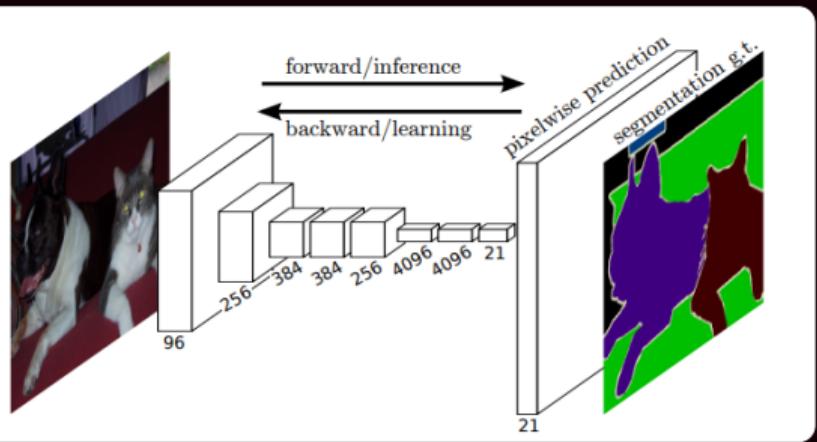


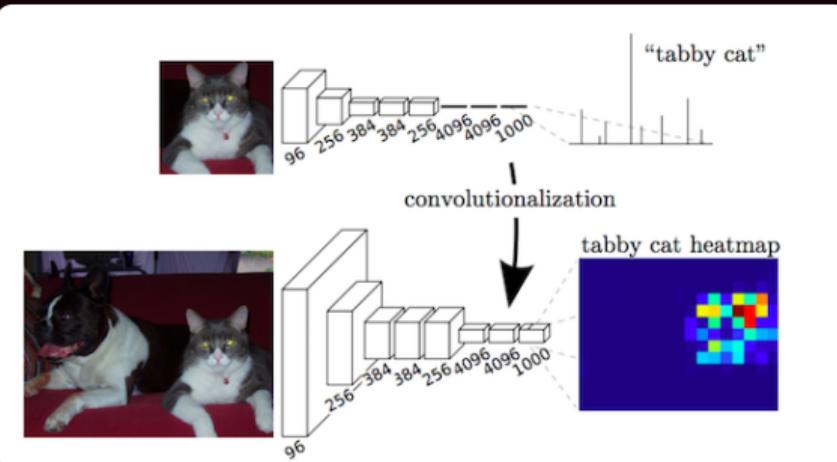
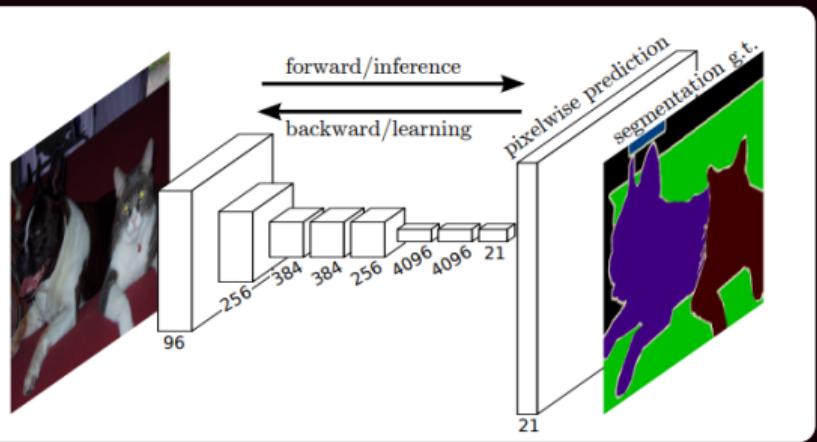


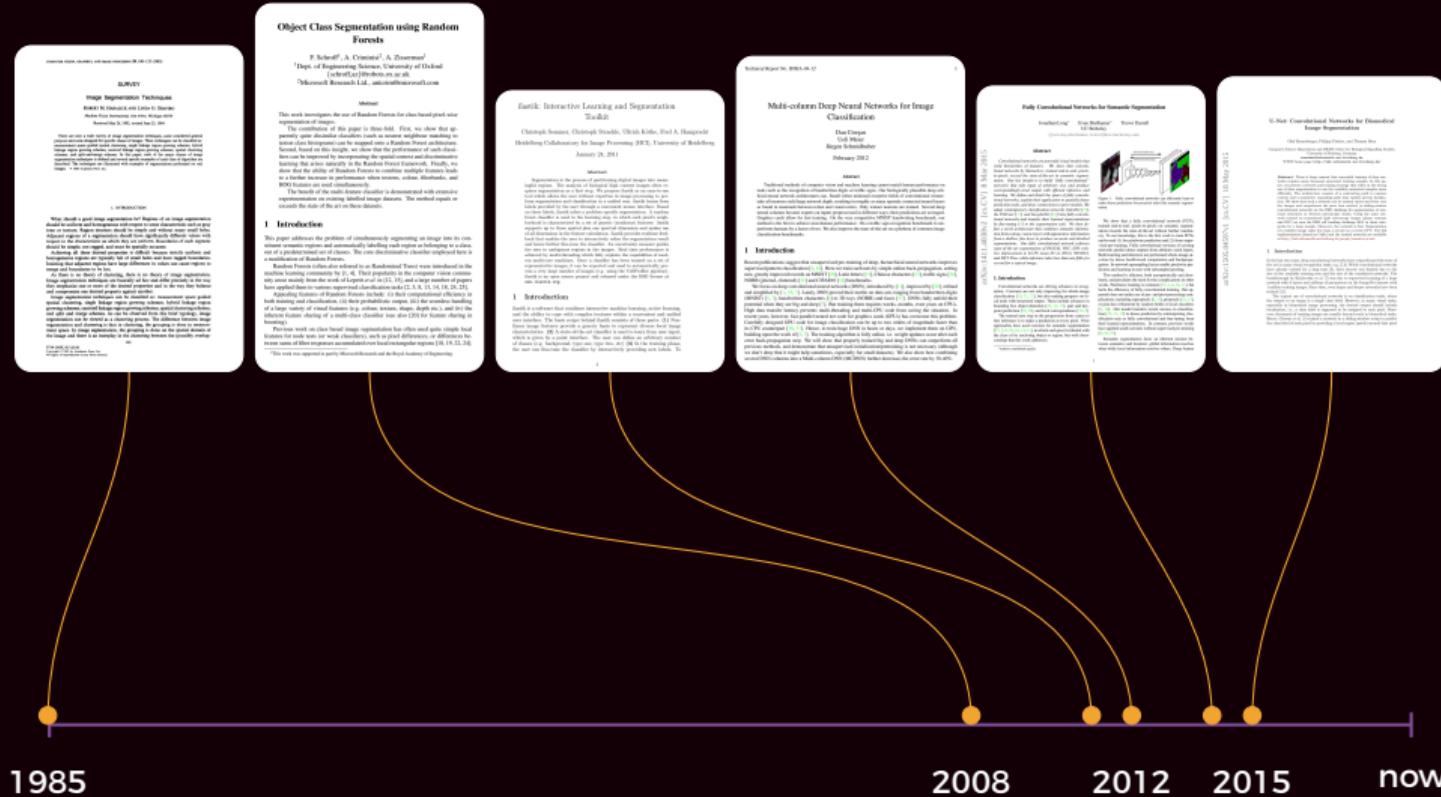


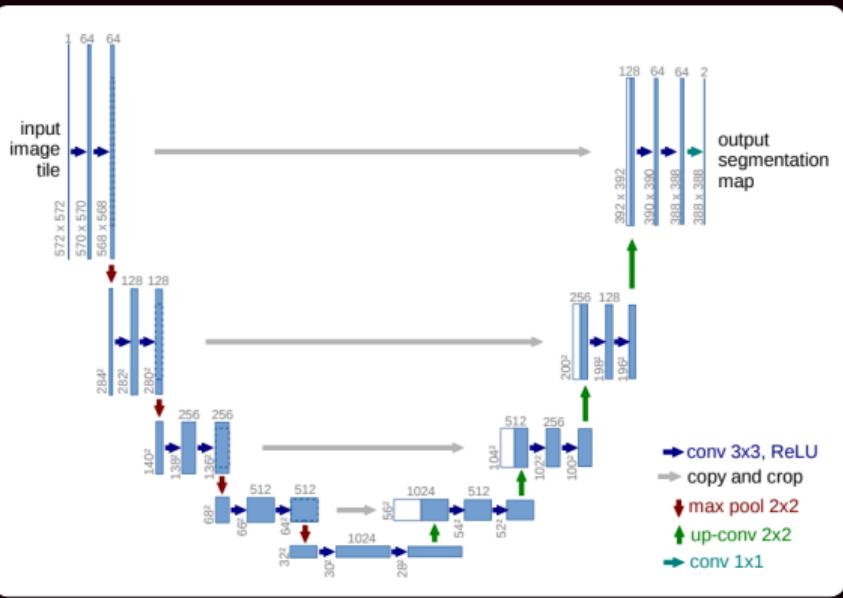
Dataset	Best result of others [%]	MCDNN [%]	Relative improv. [%]
MNIST	0.39	0.23	41
NIST SD 19	see Table 4	see Table 4	30-80
HWDB1.0 on.	7.61	5.61	26
HWDB1.0 off.	10.01	6.5	35
CIFAR10	18.50	11.21	39
traffic signs	1.69	0.54	72
NORB	5.00	2.70	46

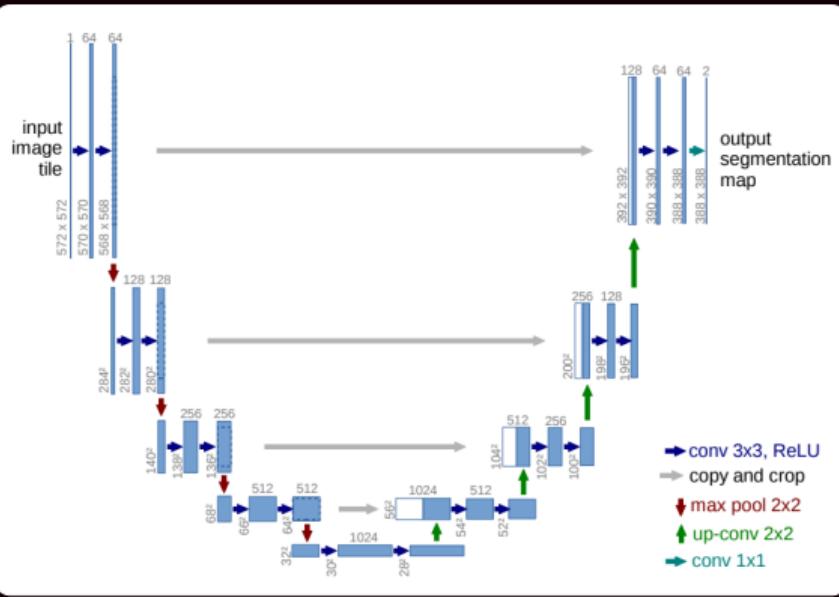


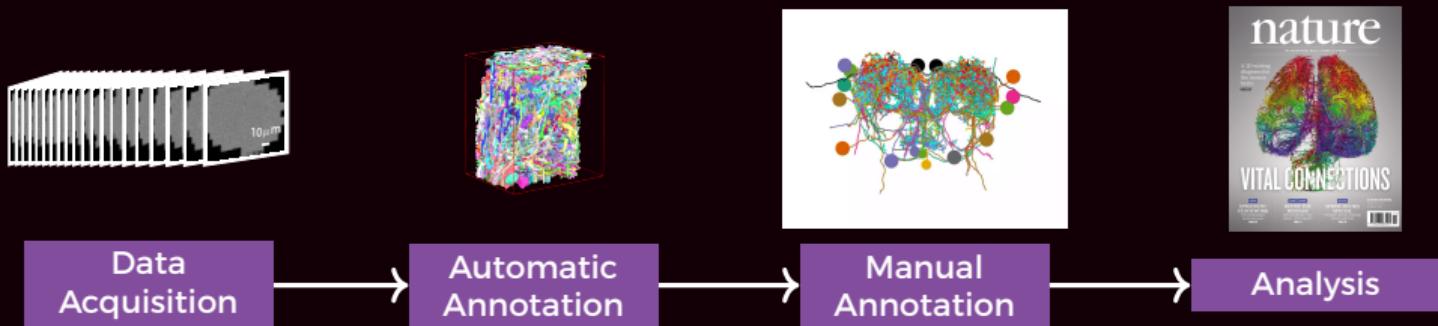














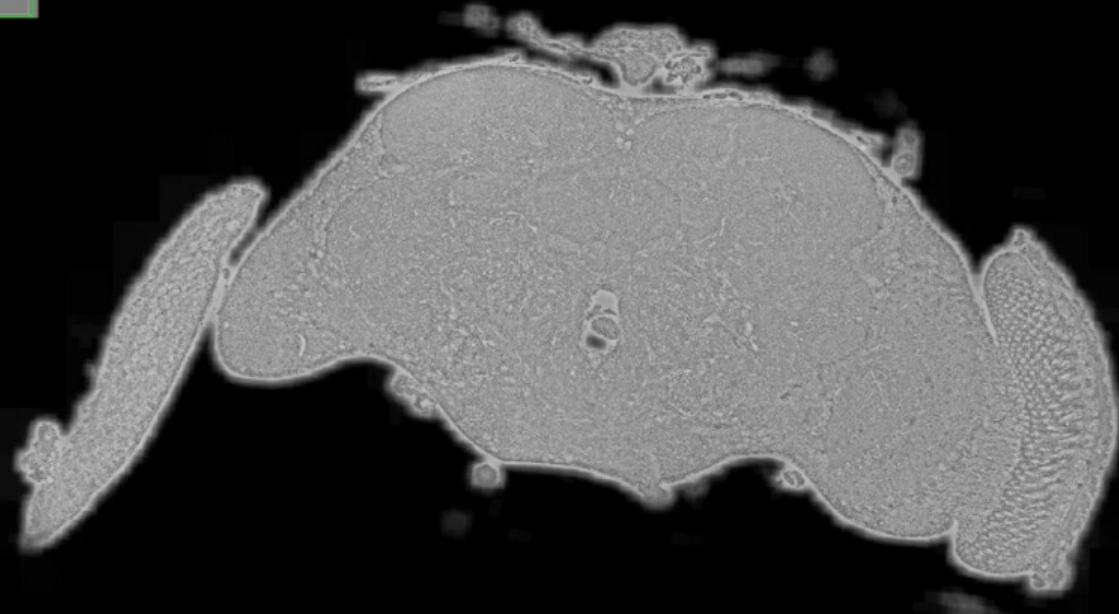
Davi Bock



Stephan Saalfeld

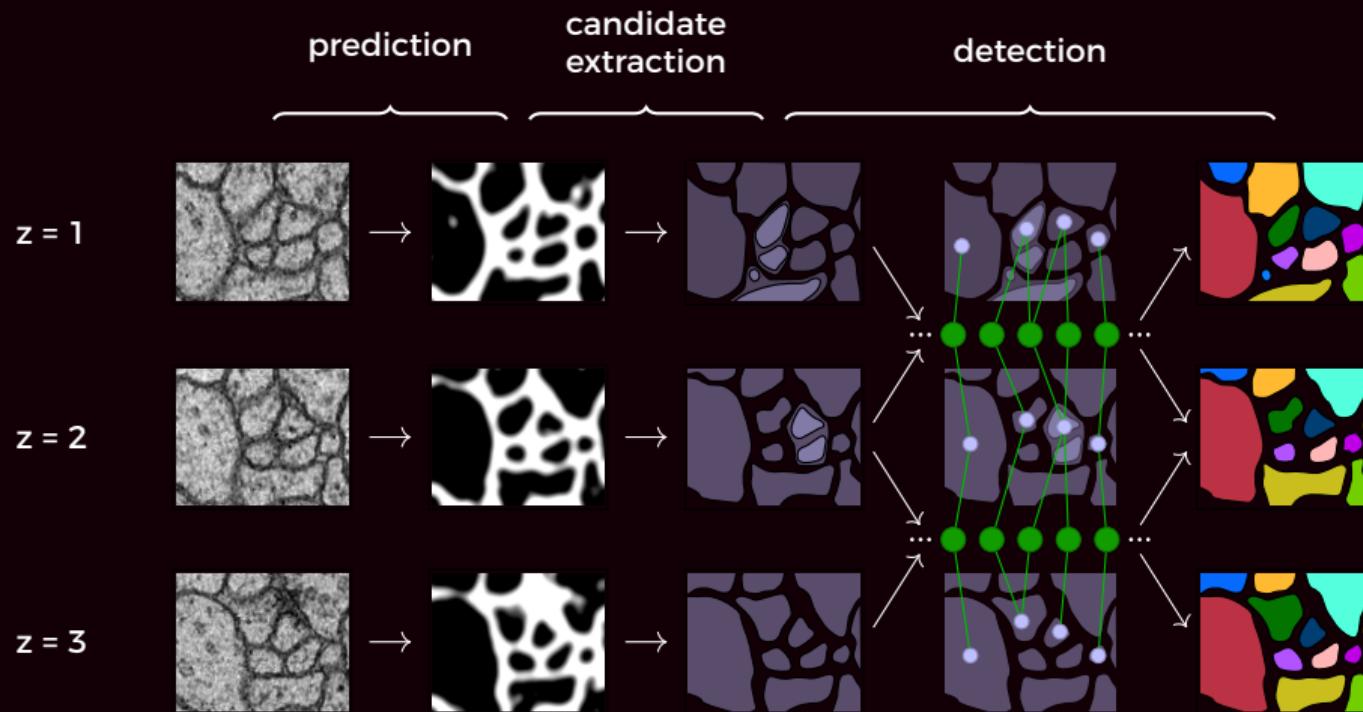


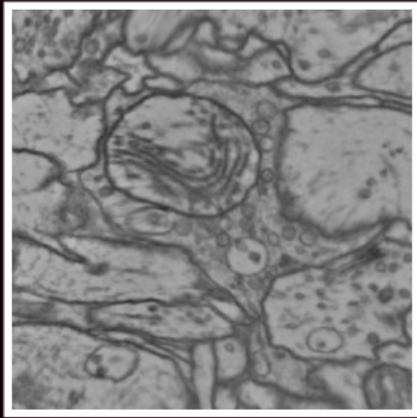
75  $\mu$ m



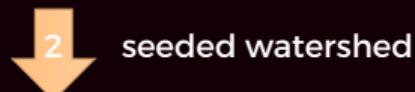
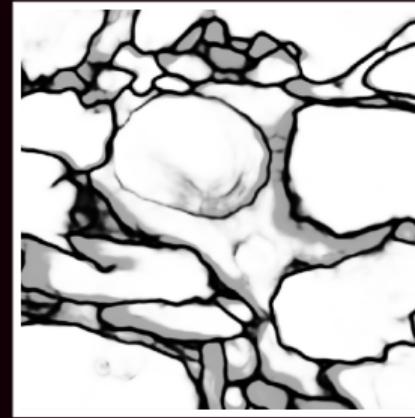
video by Stephan Saalfeld, HHMI Janelia

Zheng et al., A Complete Electron Microscopy Volume of the Brain of Adult *Drosophila melanogaster*, Cell 2018

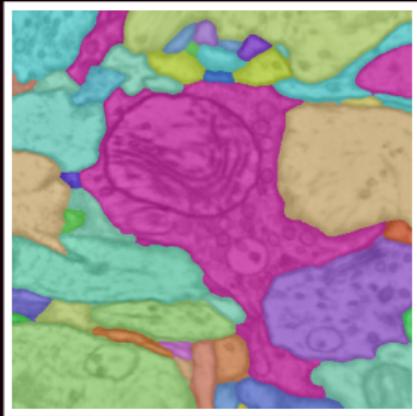




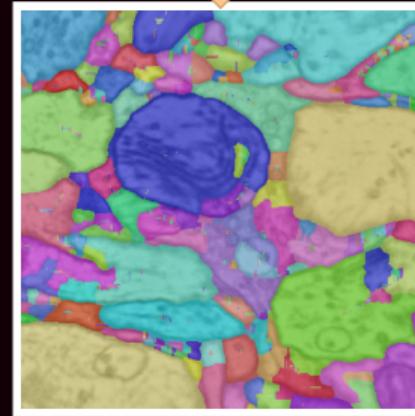
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boundary prediction



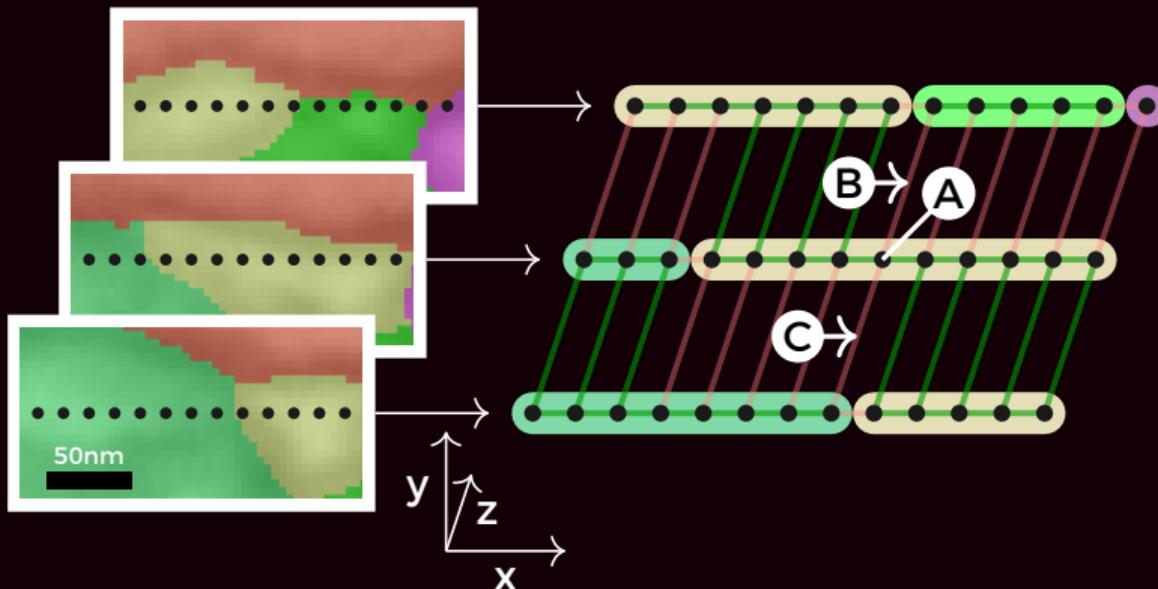
2  
seeded watershed



3  
agglomeration

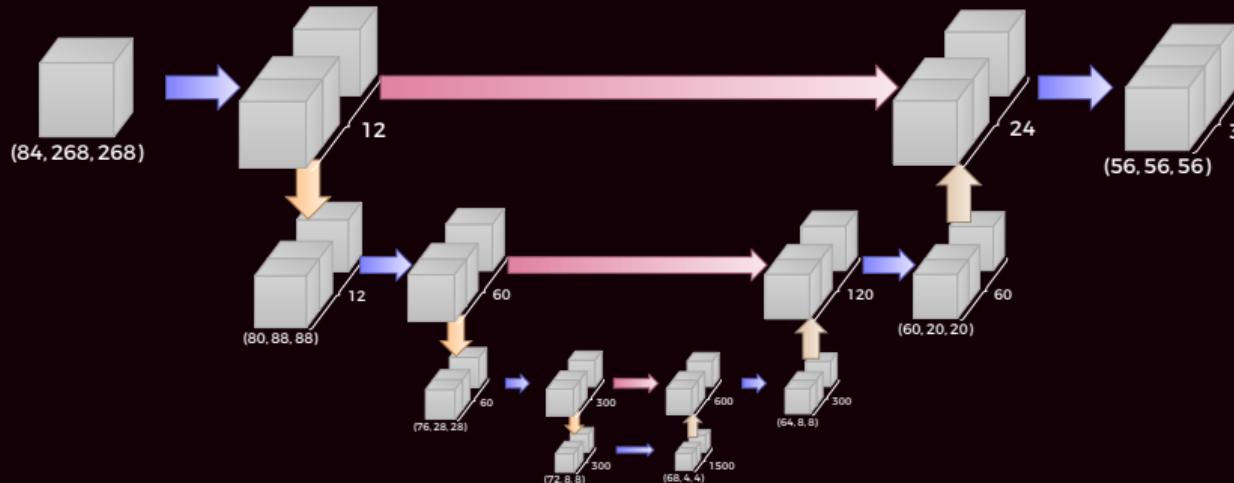


# Affinity Prediction Instead of Boundary Labeling

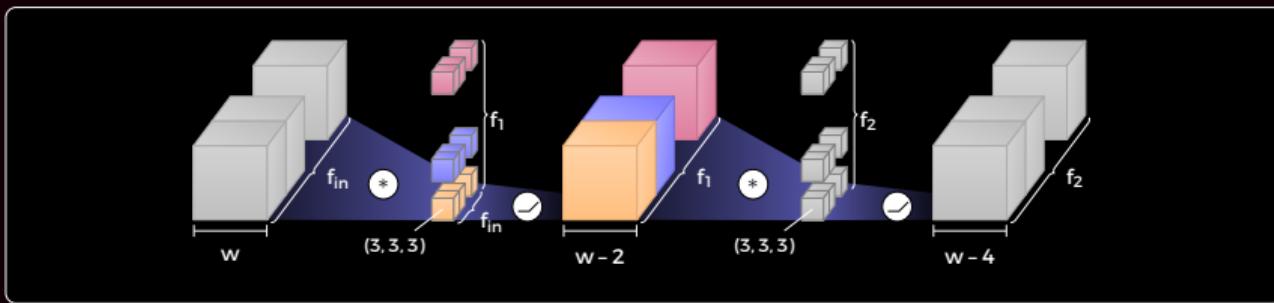
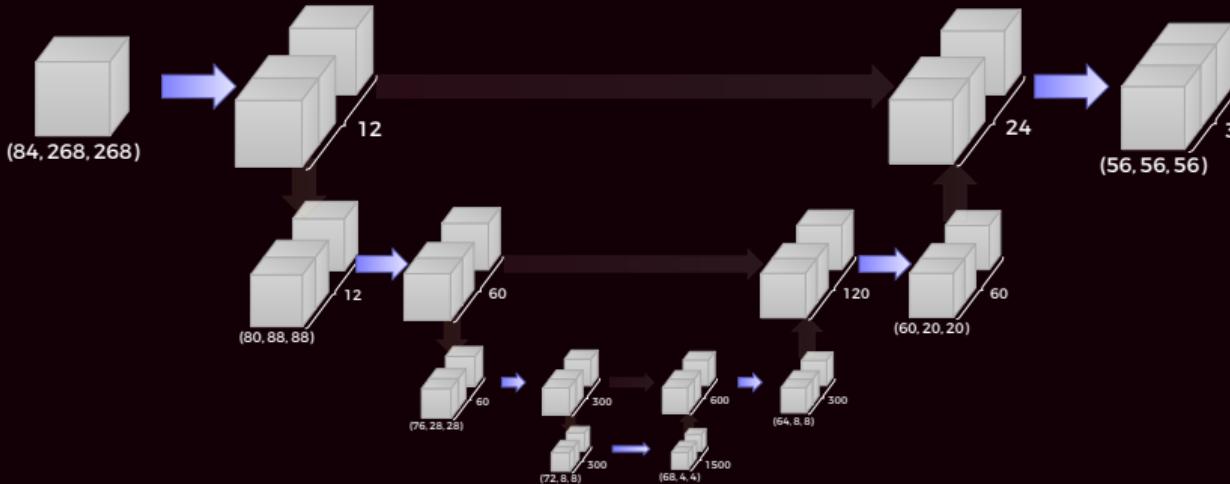


MALIS: Maximin affinity learning of image segmentation, Turaga et al., NIPS 2009

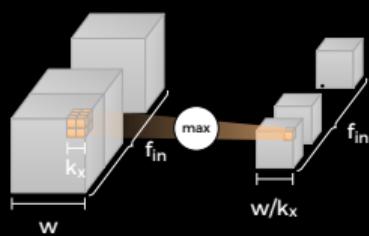
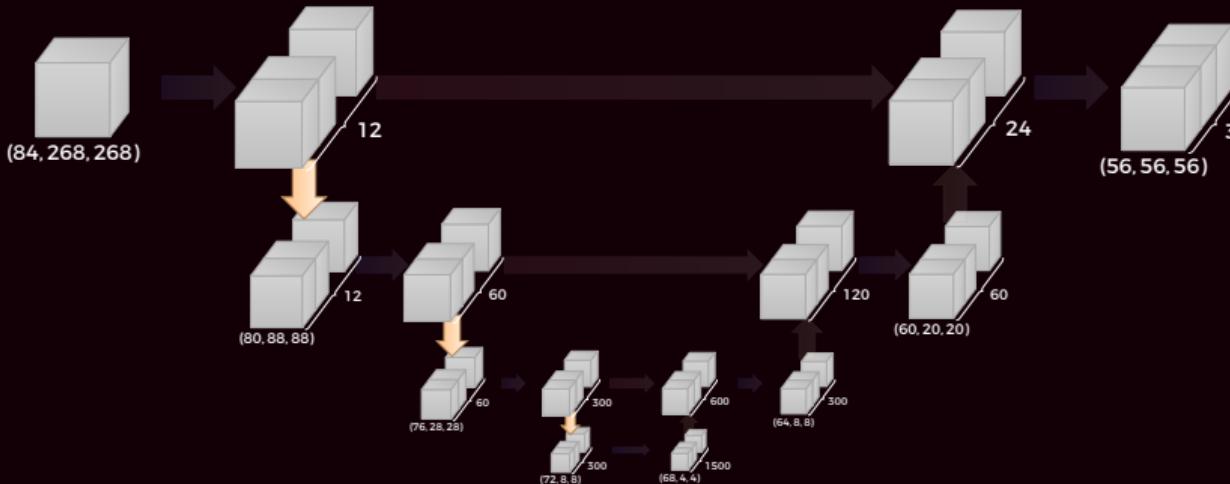
# 3D U-Net Architecture



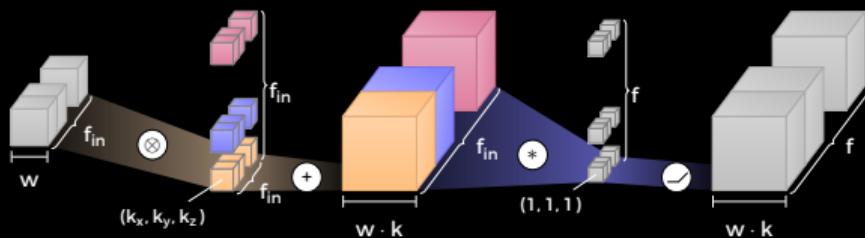
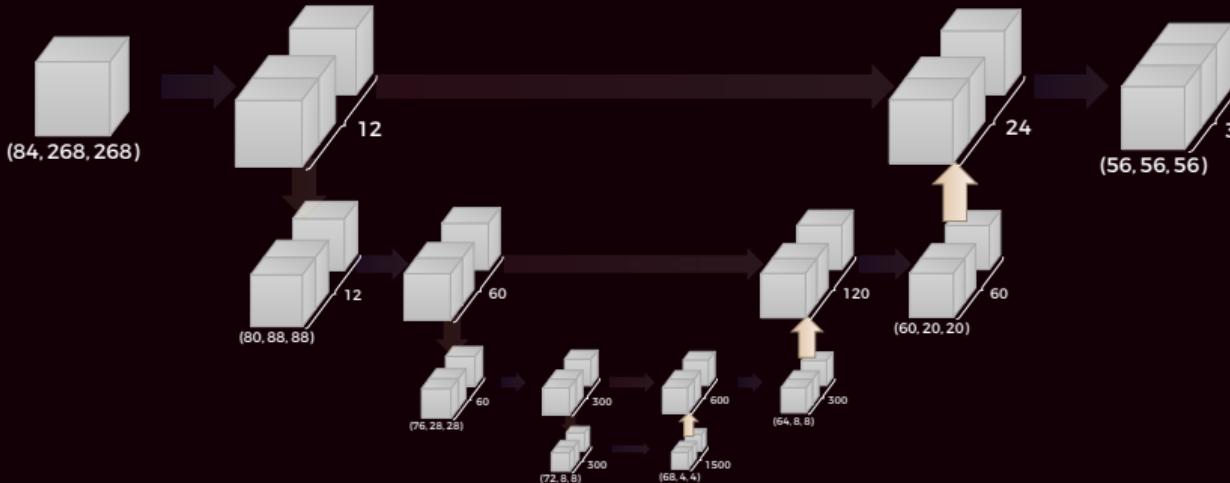
# 3D U-Net Architecture



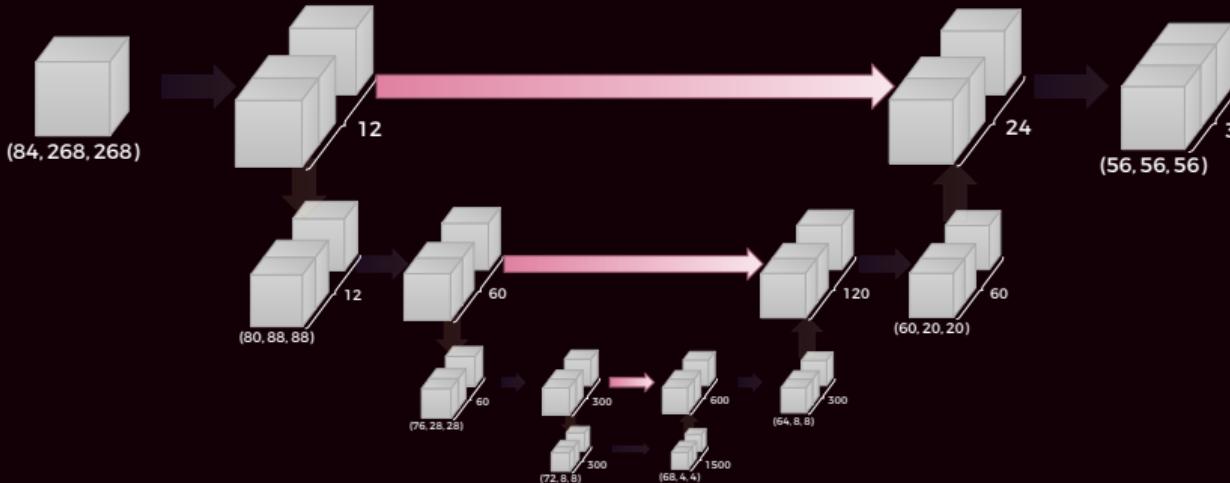
# 3D U-Net Architecture

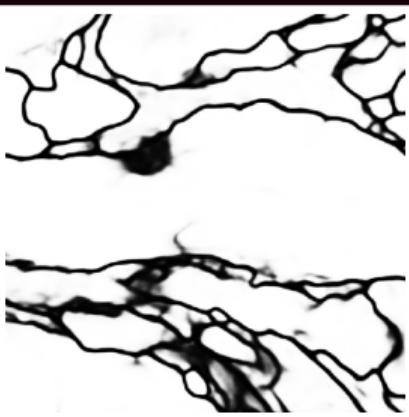


# 3D U-Net Architecture



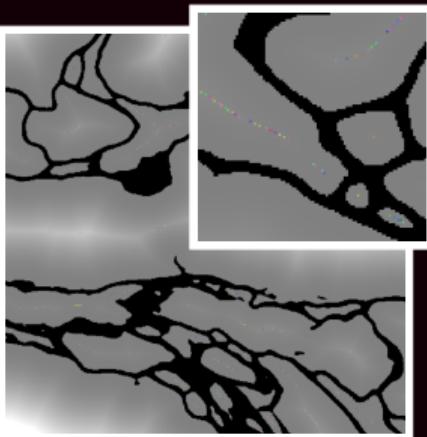
# 3D U-Net Architecture



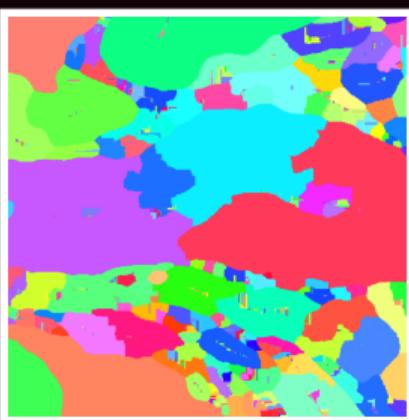


averaged affinities

threshold at 0.5

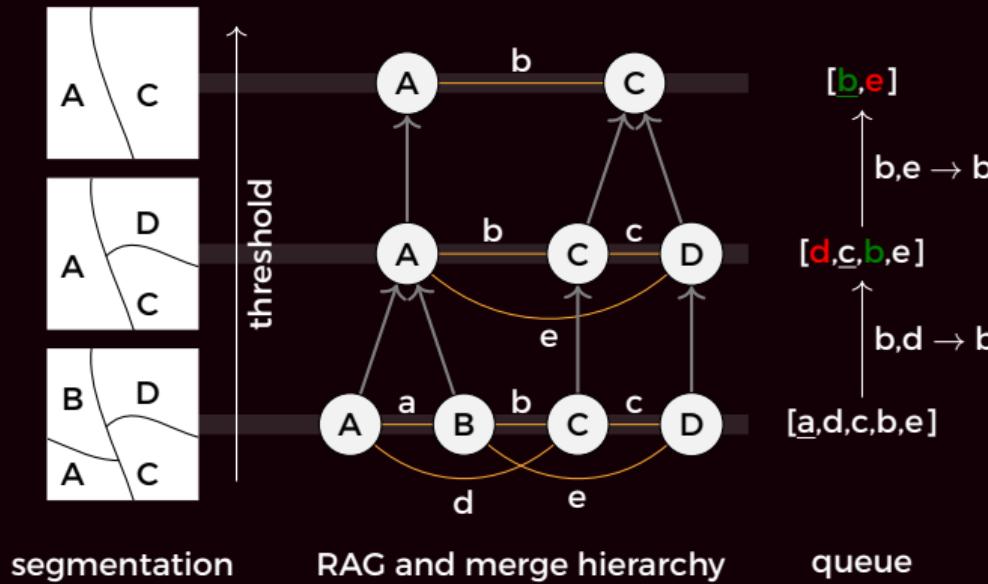


distance transform



seeded watershed

# Agglomeration



# Neuron Segmentation in Drosophila, FIB-SEM

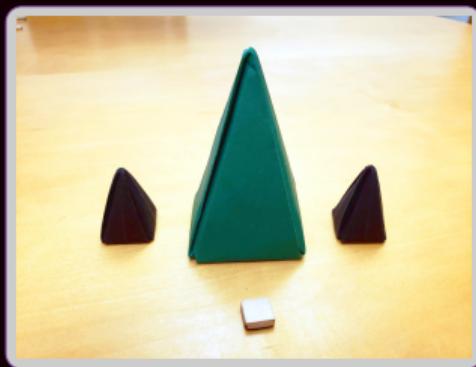
# Zendo



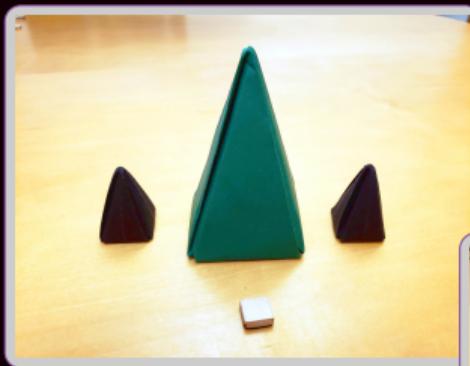
# Zendo



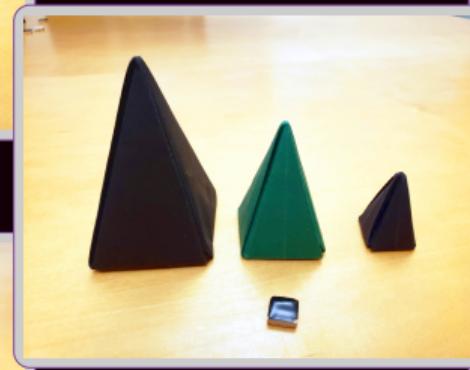
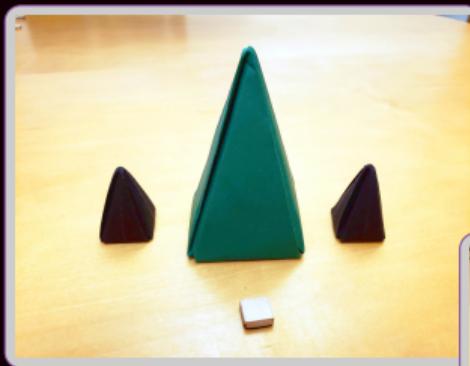
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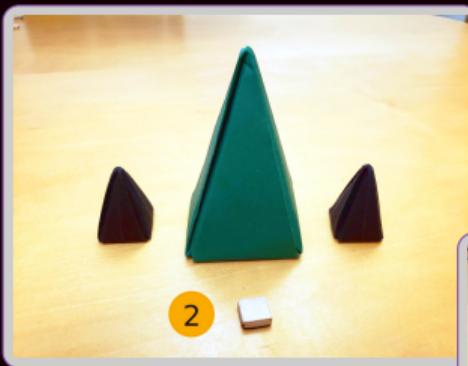
# Zendo



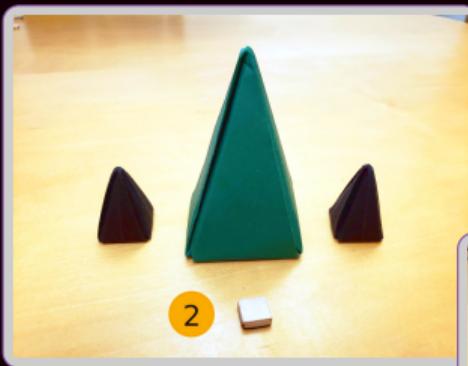
# Zendo



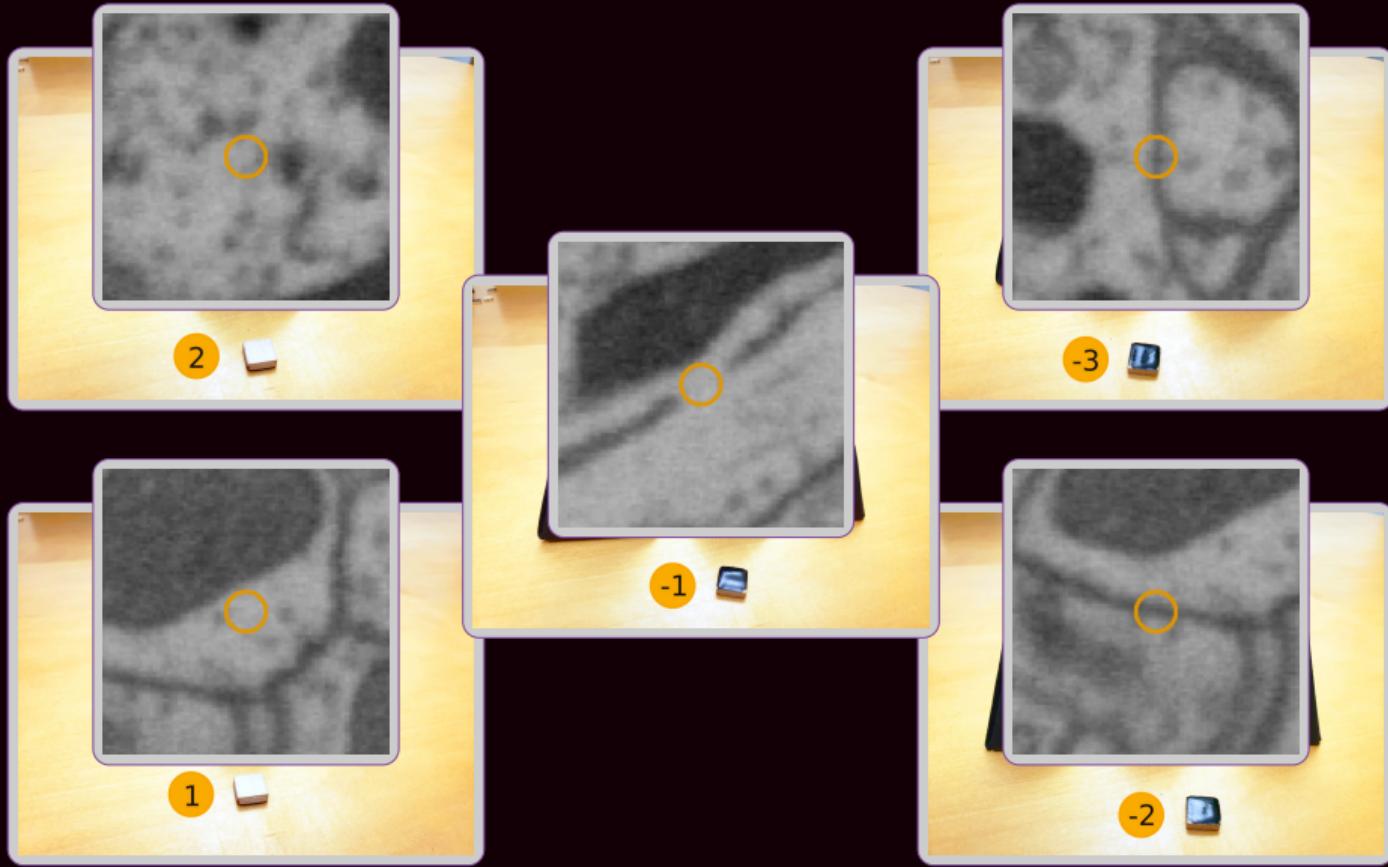
# Zendo



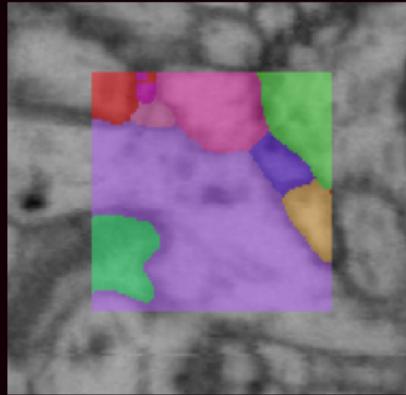
# Zendo



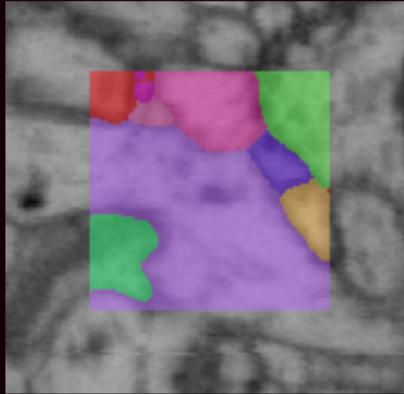
# Zendo



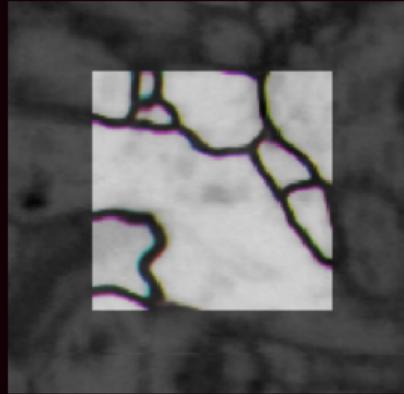
**labels**



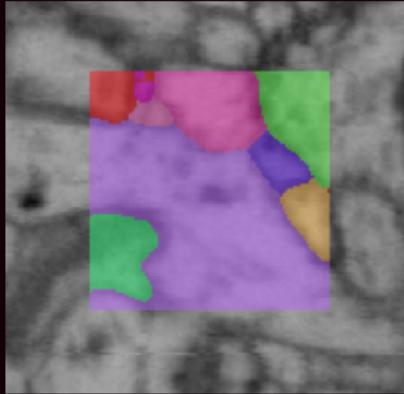
labels



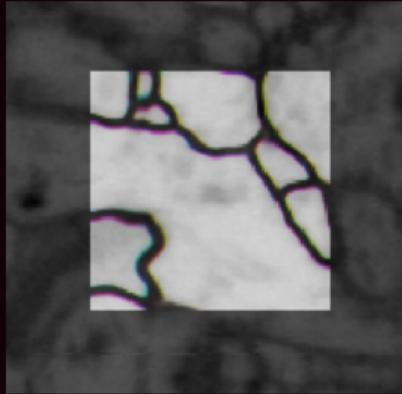
boundaries



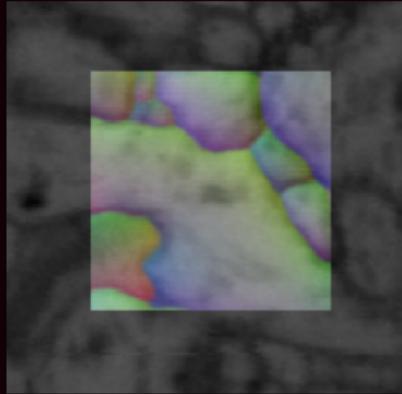
labels



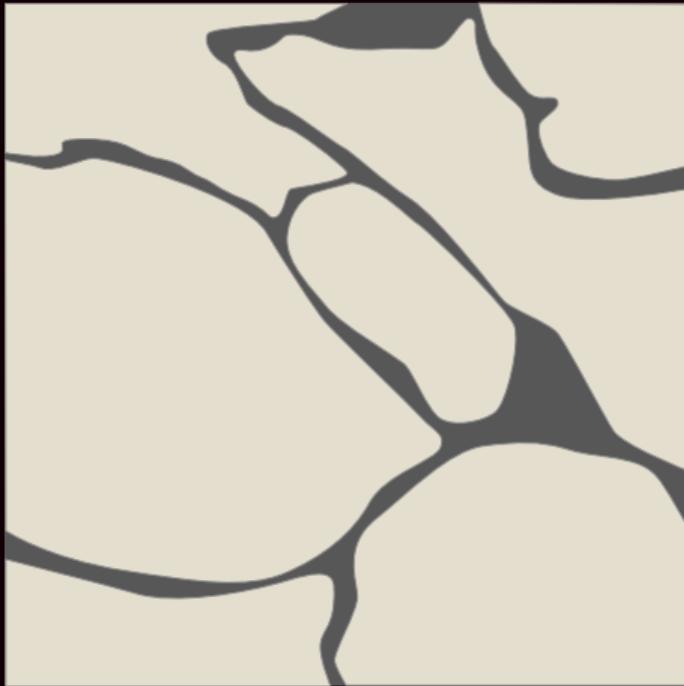
boundaries



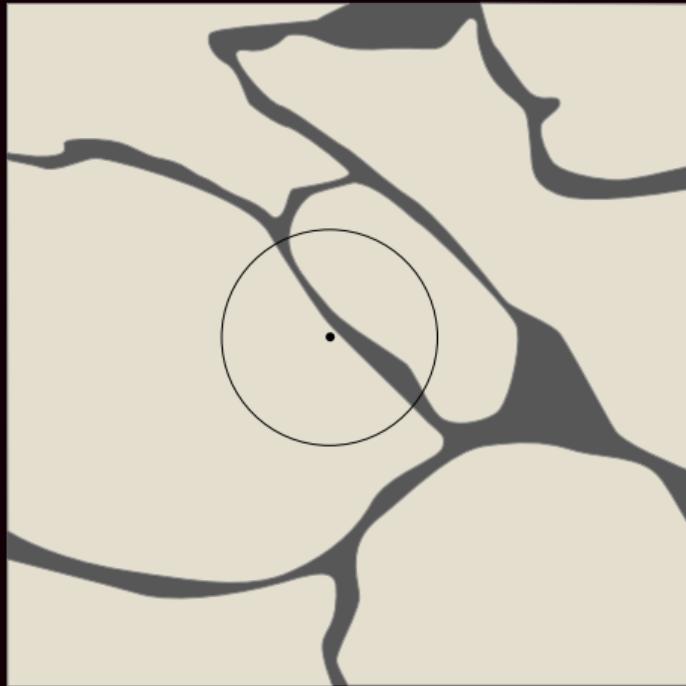
local shape descriptors



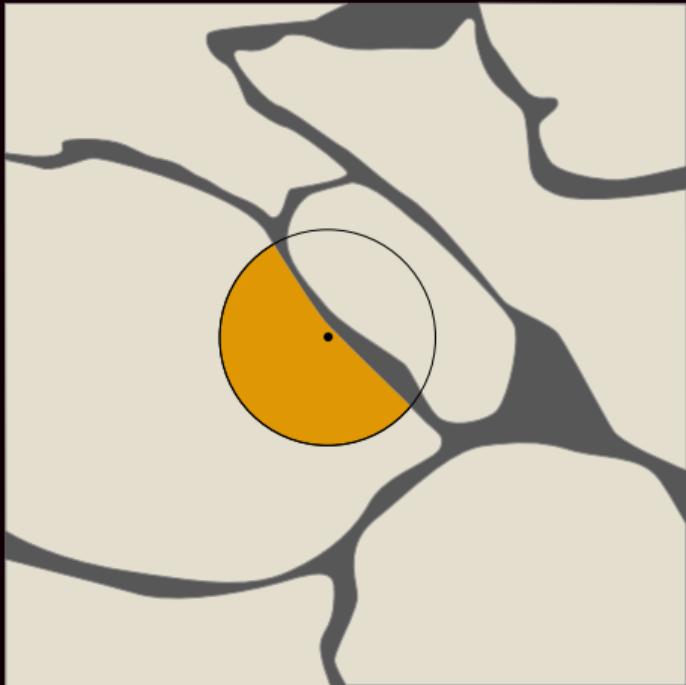
## Local Shape Descriptors



## Local Shape Descriptors

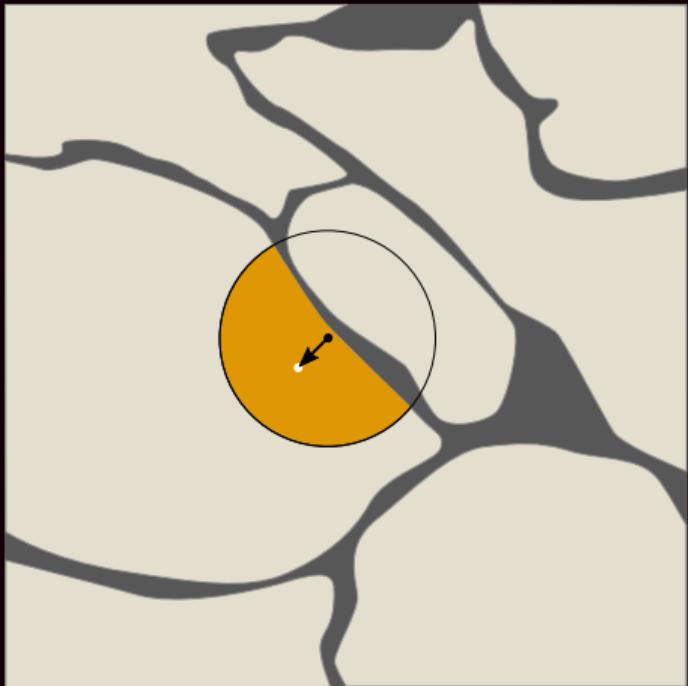


# Local Shape Descriptors



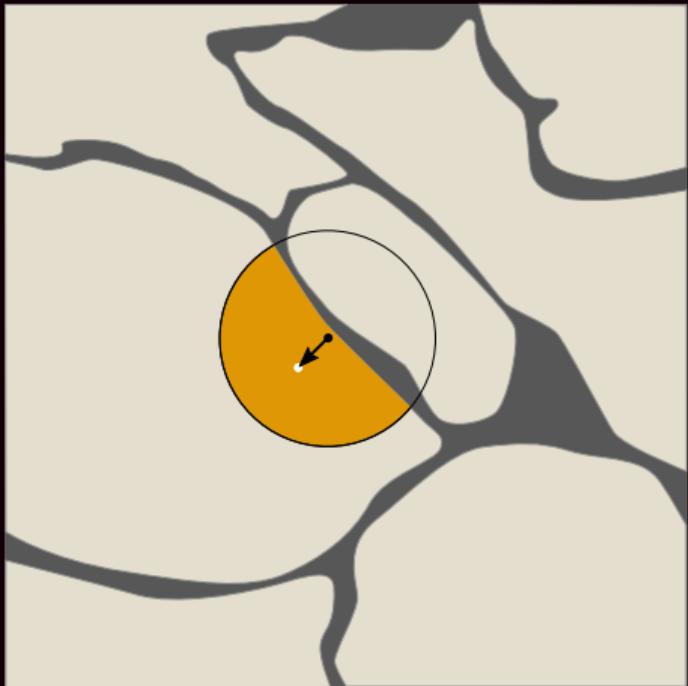
LSD =  
(s,  
size,

# Local Shape Descriptors



LSD =  
( $s$ , size,  
 $m_x, m_y, m_z$ , offset to center,

# Local Shape Descriptors



LSD =

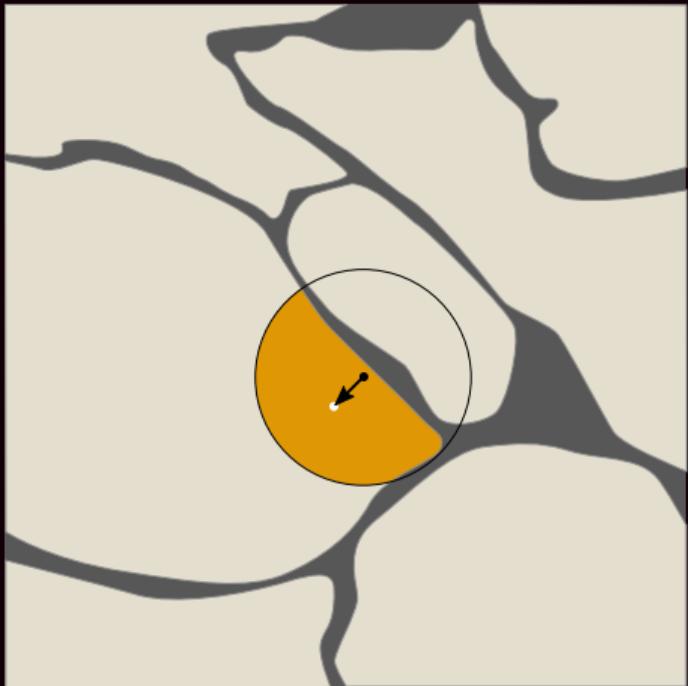
( $s$ , size,

$m_x, m_y, m_z$ , offset to center,

$C_{xx}, C_{yy}, C_{zz}$ , correlation of

$C_{xy}, C_{xz}, C_{yz}$ ) coordinates

# Local Shape Descriptors



LSD =

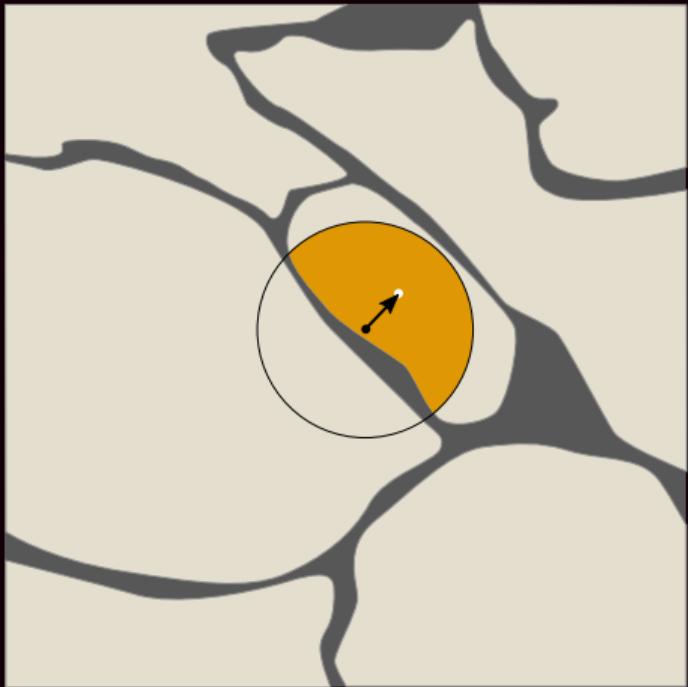
( $s$ , size,

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$C_{xy}, C_{xz}, C_{yz}$ ) coordinates

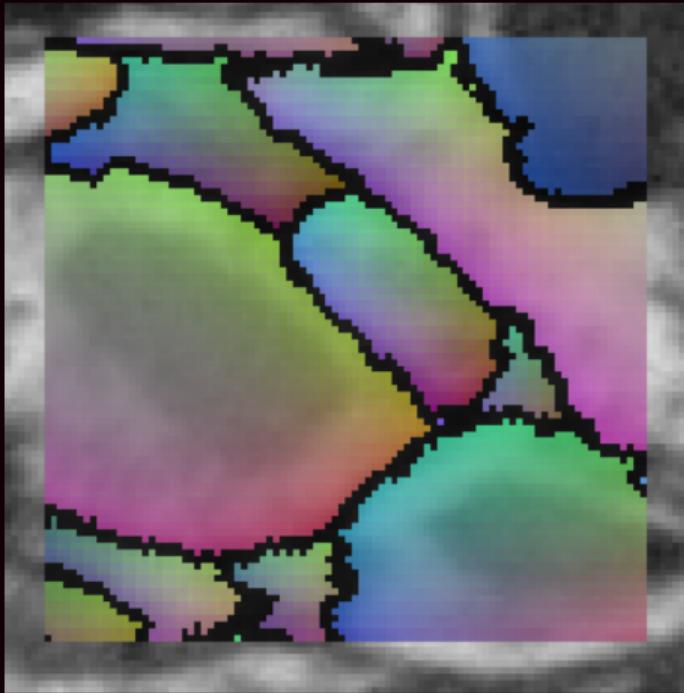
# Local Shape Descriptors



LSD =

( $s$ , size,  
 $m_x, m_y, m_z$ , offset to center,  
 $C_{xx}, C_{yy}, C_{zz}$ , correlation of  
 $C_{xy}, C_{xz}, C_{yz}$ ) coordinates

# Local Shape Descriptors



LSDs from ground-truth segmentation

LSD =

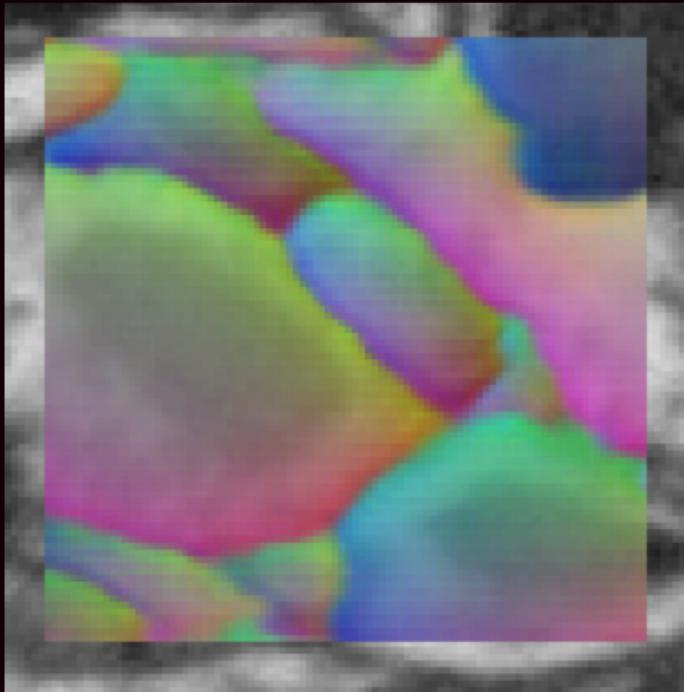
( $s$ , size,

$m_x, m_y, m_z$ , offset to center,

$C_{xx}, C_{yy}, C_{zz}$ , correlation of

$C_{xy}, C_{xz}, C_{yz}$ ) coordinates

# Local Shape Descriptors



predicted LSDs

LSD =

( $s$ , size,

$m_x, m_y, m_z$ , offset to center,

$C_{xx}, C_{yy}, C_{zz}$ , correlation of

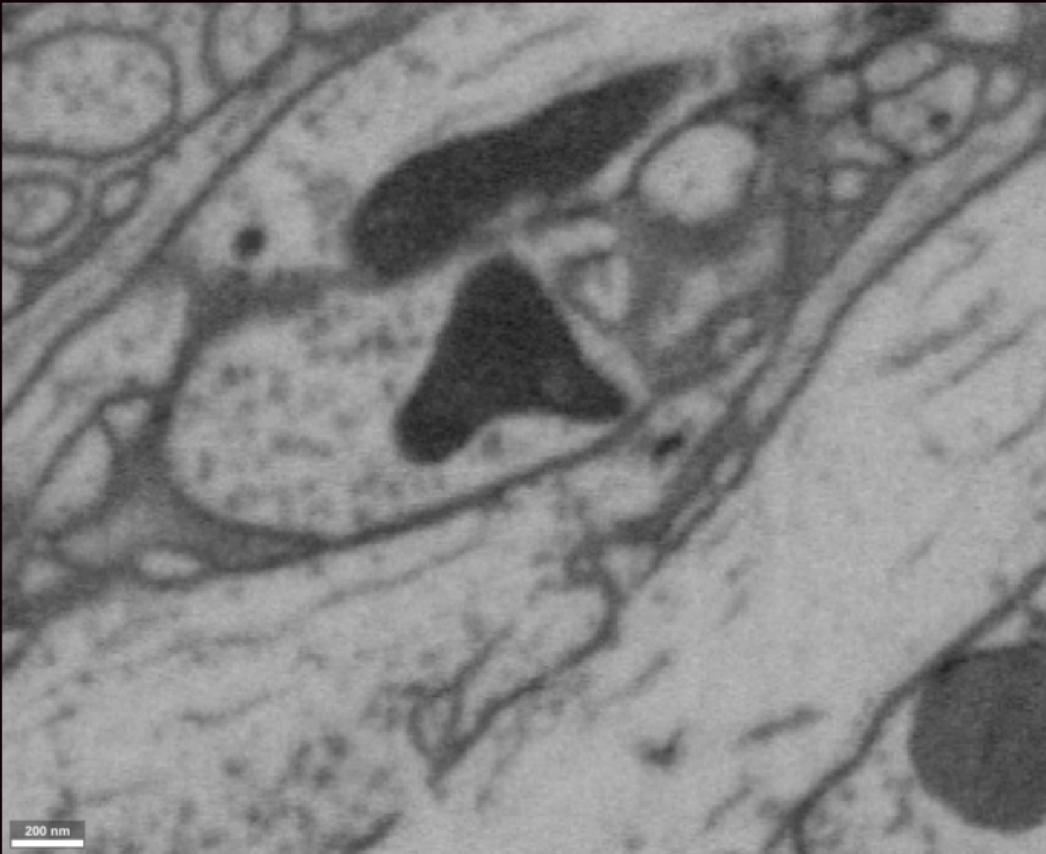
$C_{xy}, C_{xz}, C_{yz}$ ) coordinates

Trained with

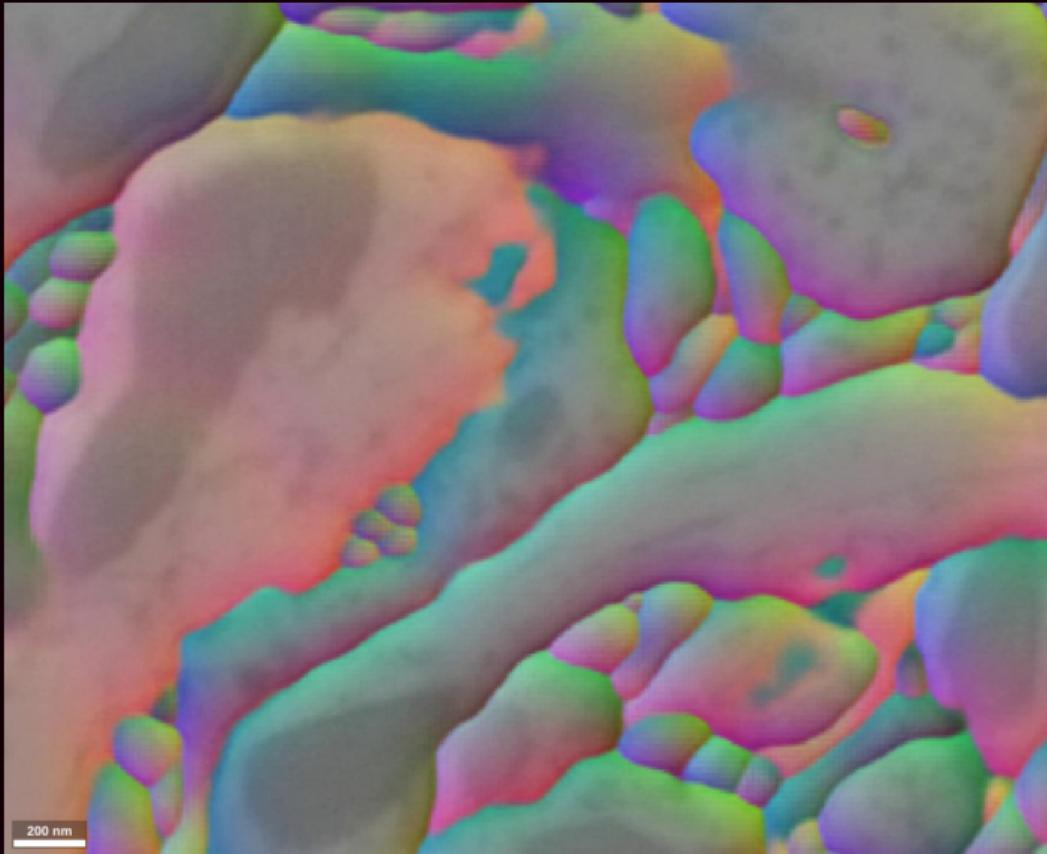


Gunpowder

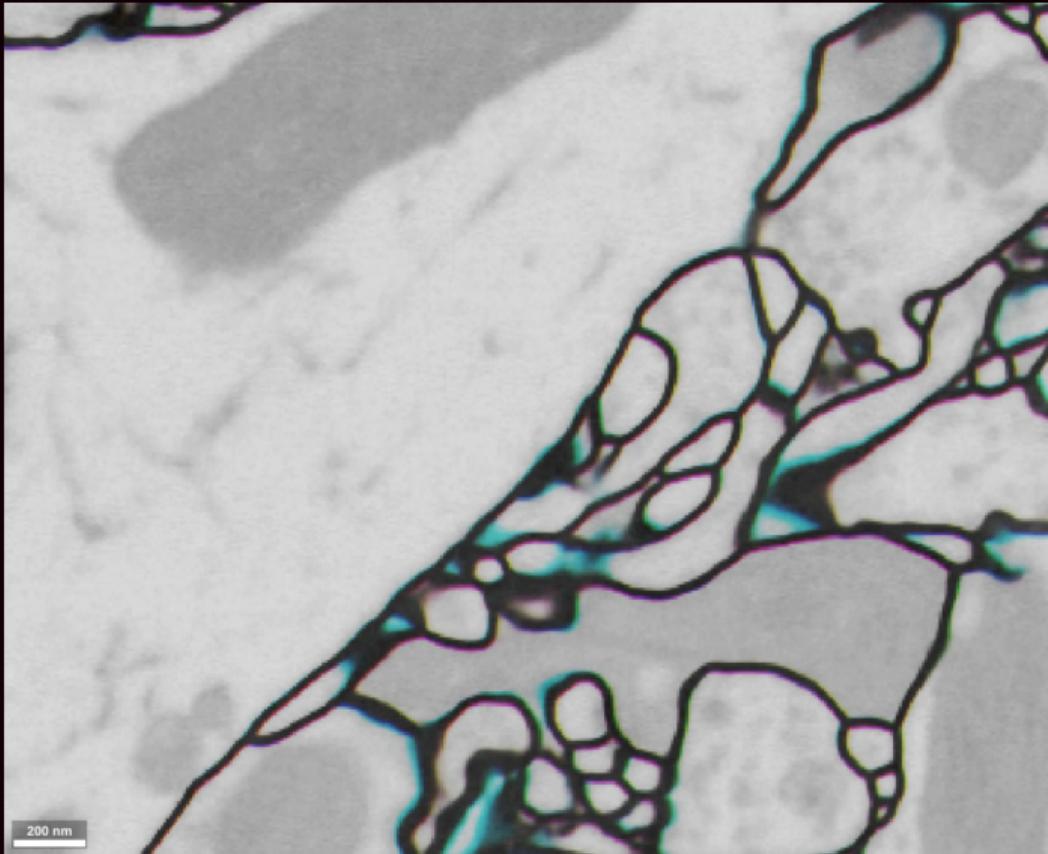
<https://funkey.science/gunpowder>



FIB19 (FIB-SEM at 8nm resolution, fly optic lobe, imaged by Hess lab for FlyEM)



FIB19 (FIB-SEM at 8nm resolution, fly optic lobe, imaged by Hess lab for FlyEM)



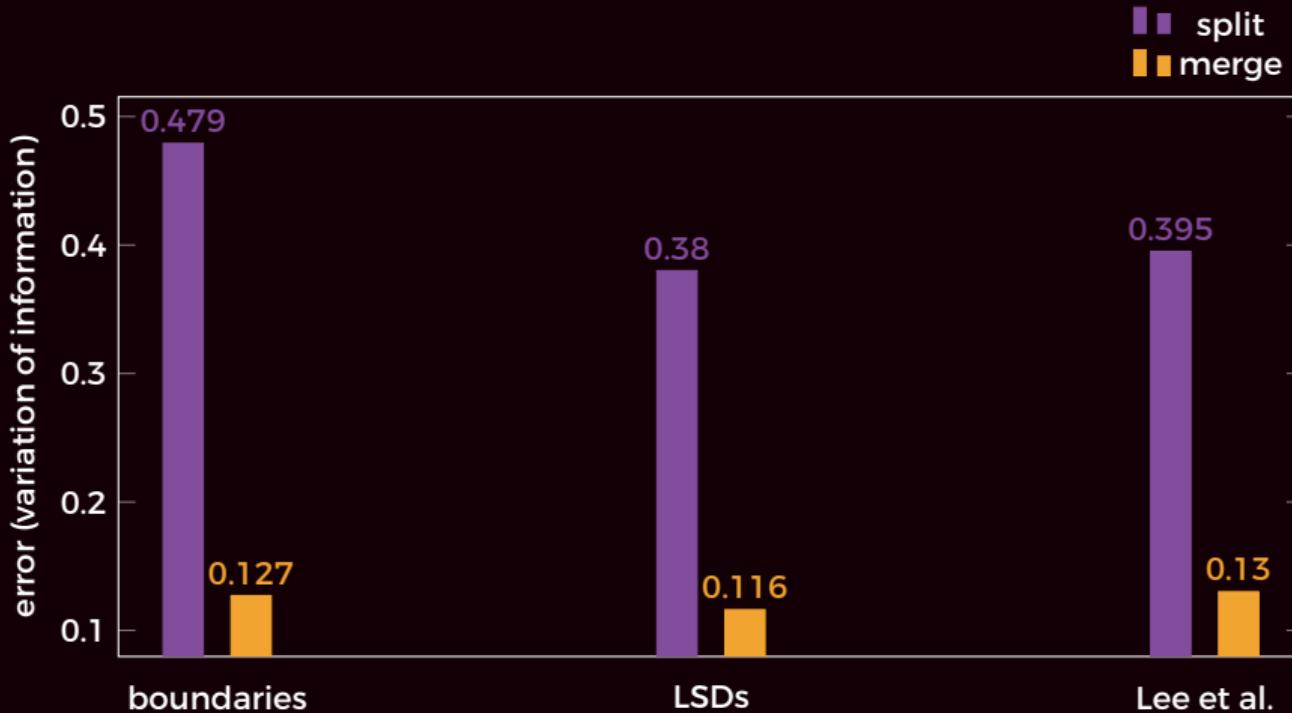
FIB19 (FIB-SEM at 8nm resolution, fly optic lobe, imaged by Hess lab for FlyEM)



Arlo Sheridan

## Results on CREMI Challenge

<https://cremi.org>





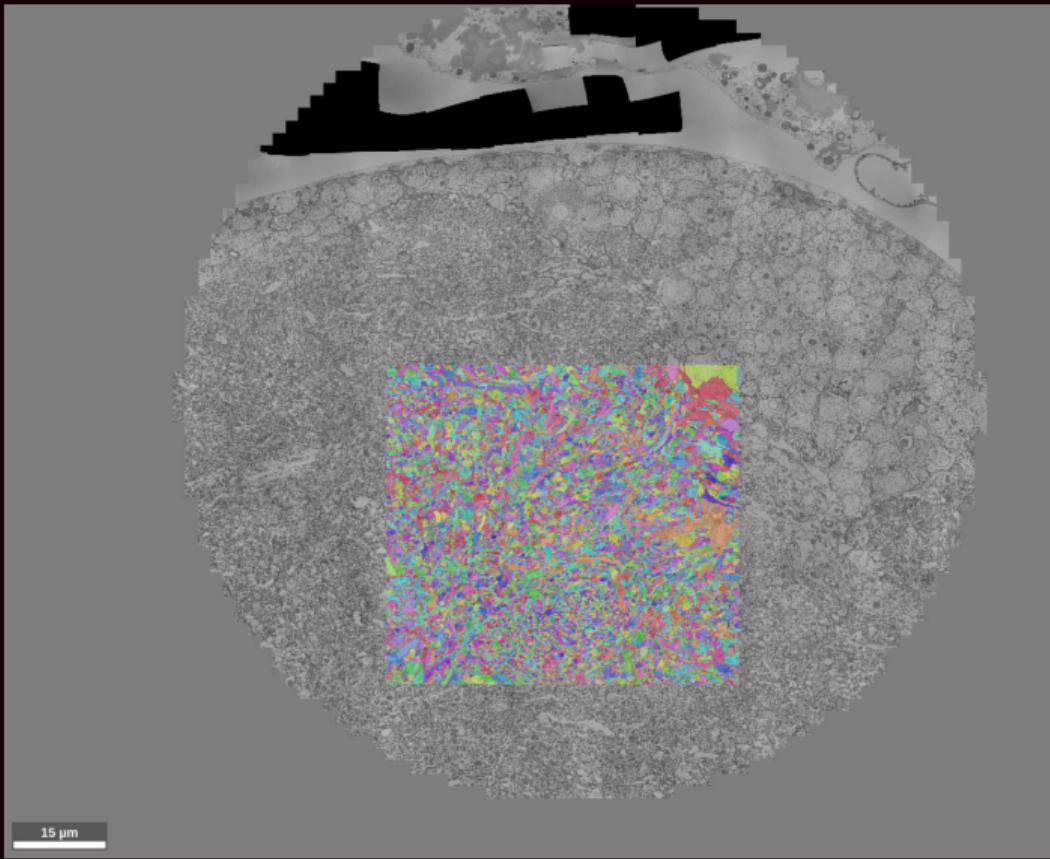
Arlo Sheridan

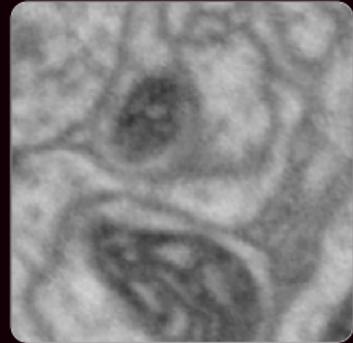


Constantin Pape

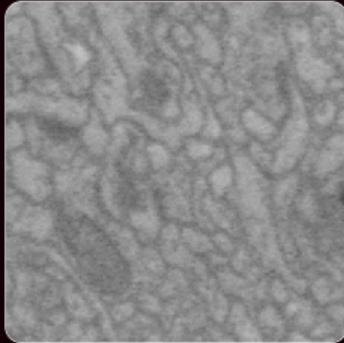


Tri Nguyen

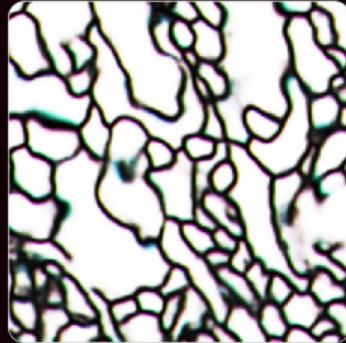




train (fly, 8nm)



test (zebrafish, 12nm)

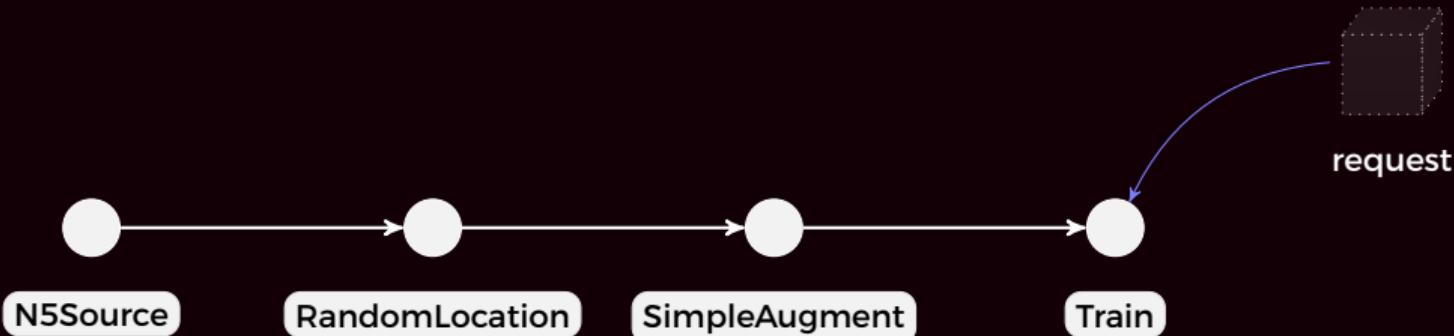


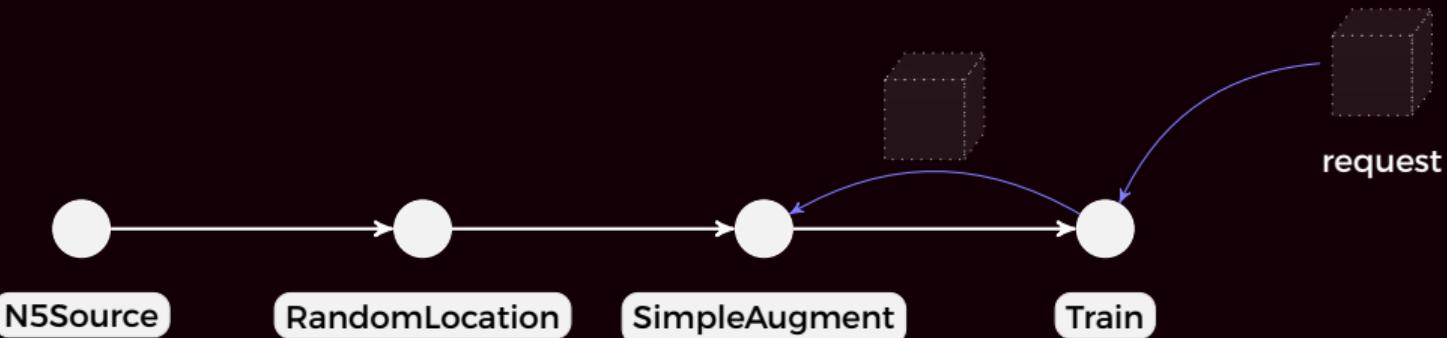
boundaries only

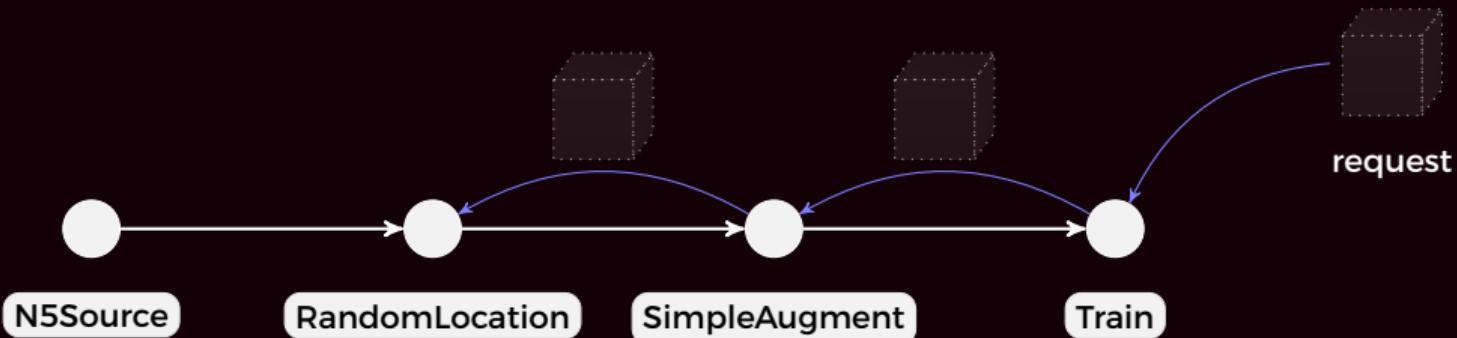


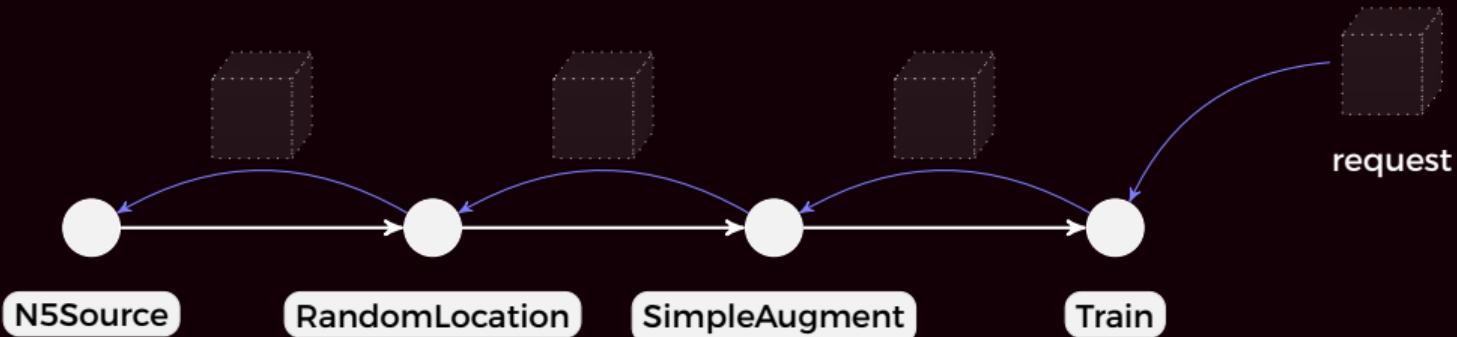
boundaries + LSDs

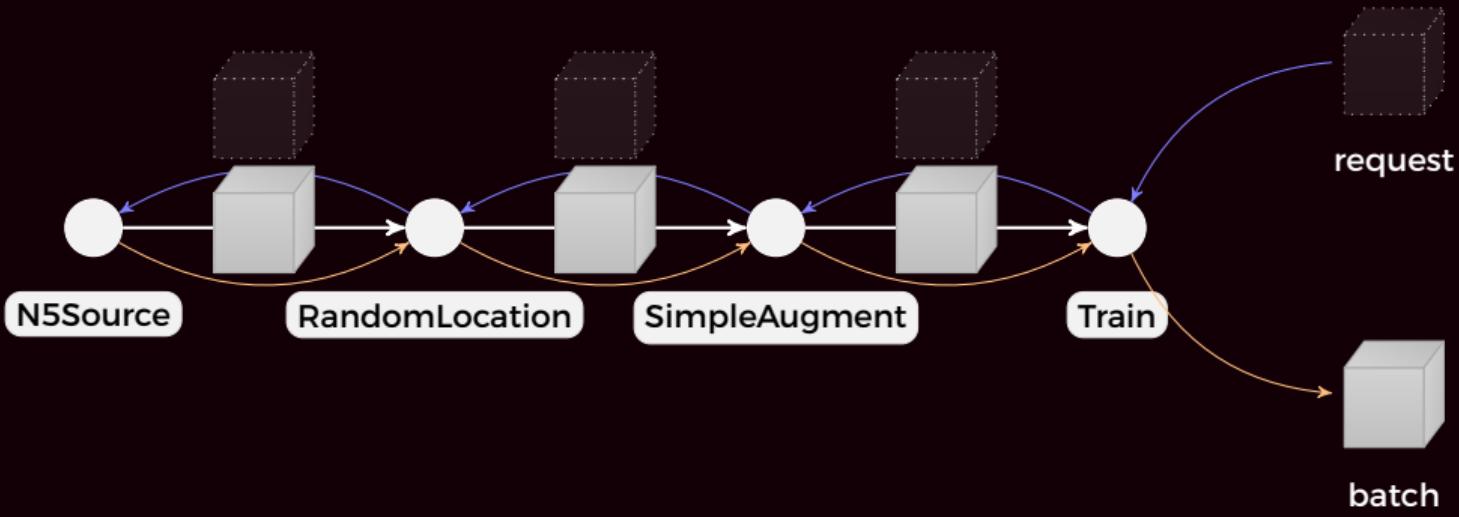


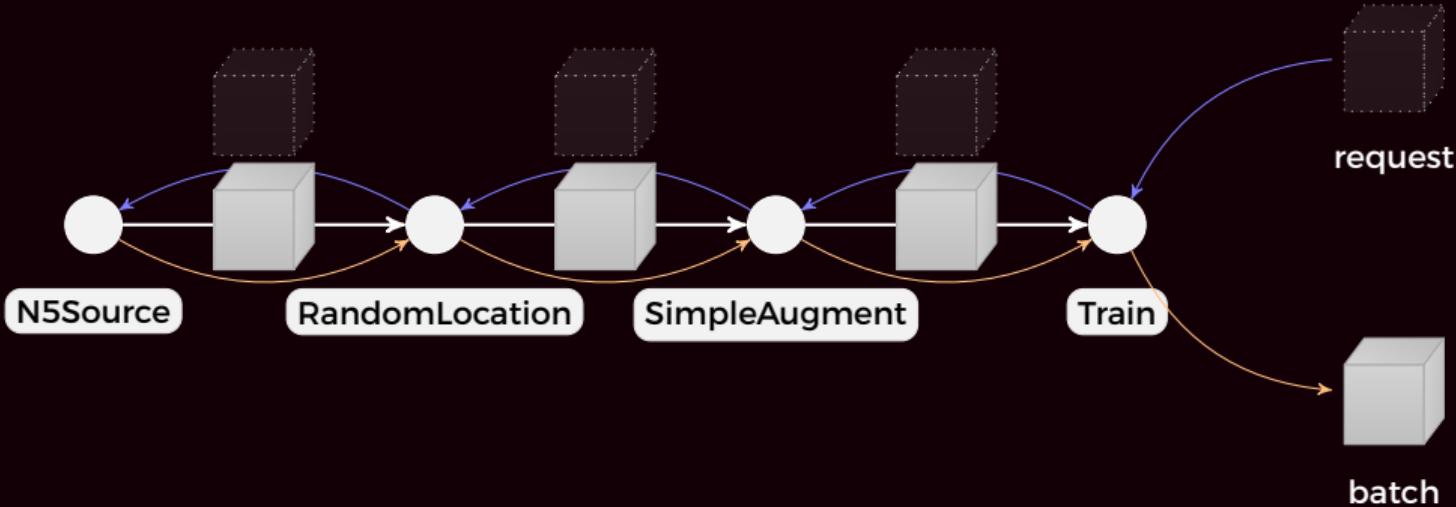












## Code

```
from gunpowder import *

dag = N5Source(...) + RandomLocation() + SimpleAugment() + Train(...)

with build(dag):
    batch = dag.request_batch(BatchRequest((84,268,268)))
```

## Features

- data sources for various formats
- elastic augmentation
- pre-caching of batches
- on-the-fly training/prediction
- batch inspection and profiling
- nD, multi-channel
- arrays and point sets



Gunpowder

<https://funkey.science/gunpowder>

# Thank You!

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- Anna Kreshuk
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