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# Deep Learning for Microscopy Image Analysis

Adam Harmanec

21.10.2022

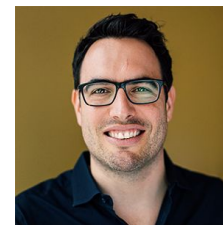
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# Deep Learning @ MBL



Anna Kreshuk  
EMBL Heidelberg



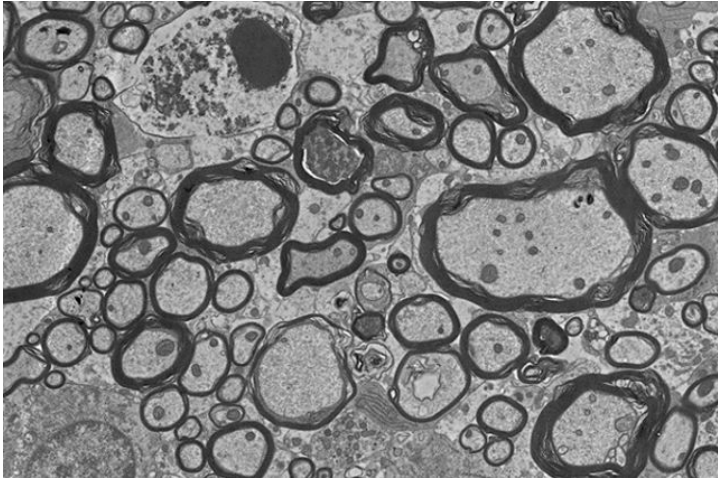
Florian Jug  
Human  
Technopole



Jan Funke  
HHMI Janelia



Microscopy images



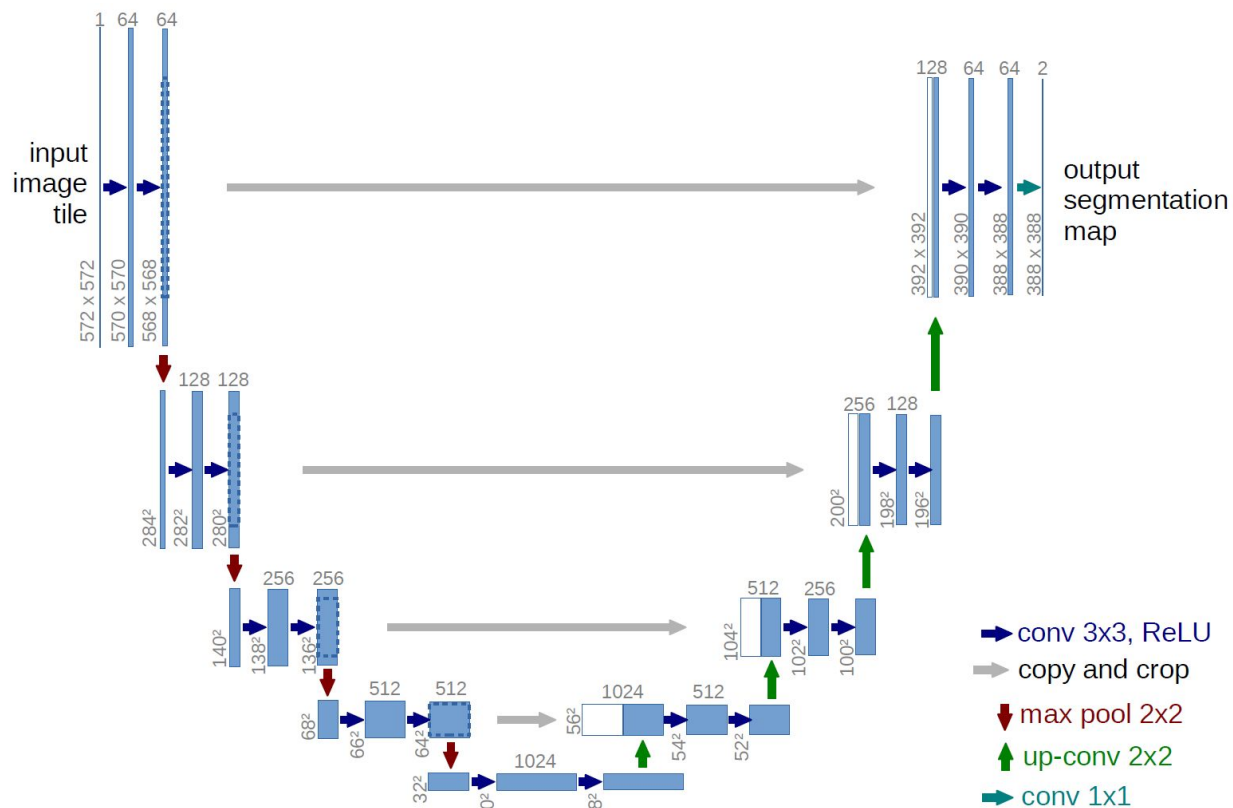
Natural images



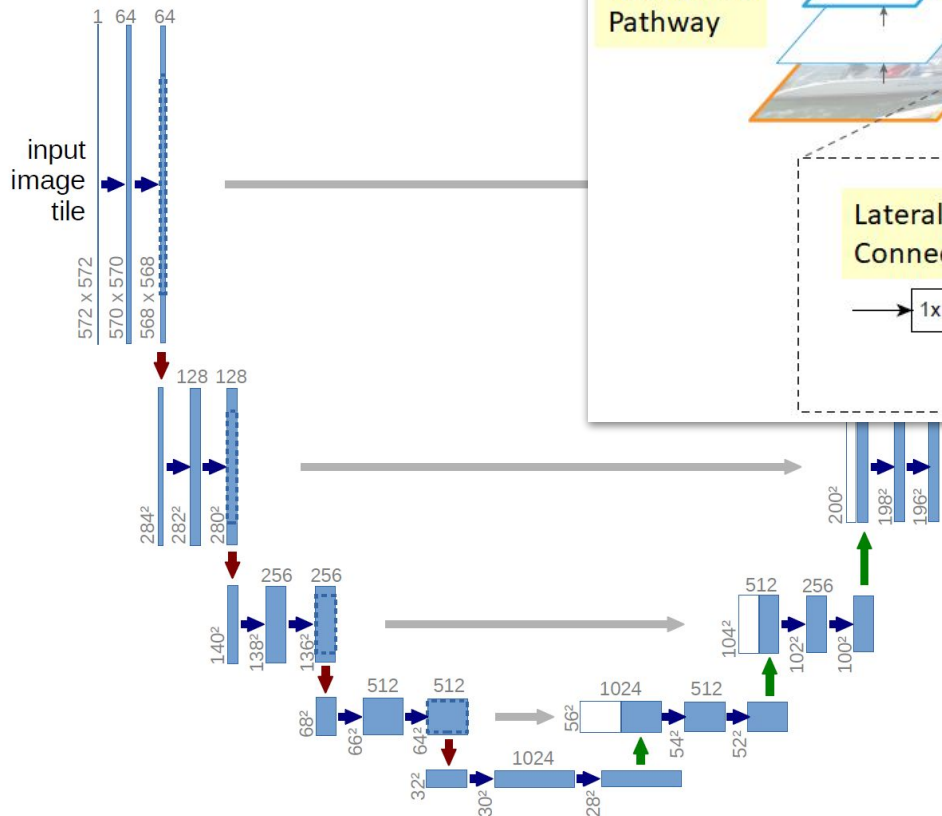
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# Architectures

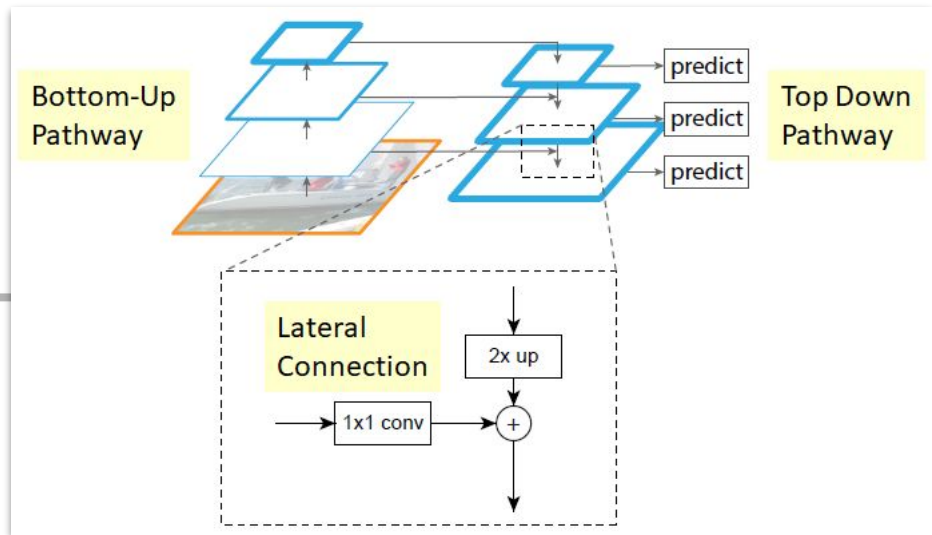
# U-Net



# U-Net

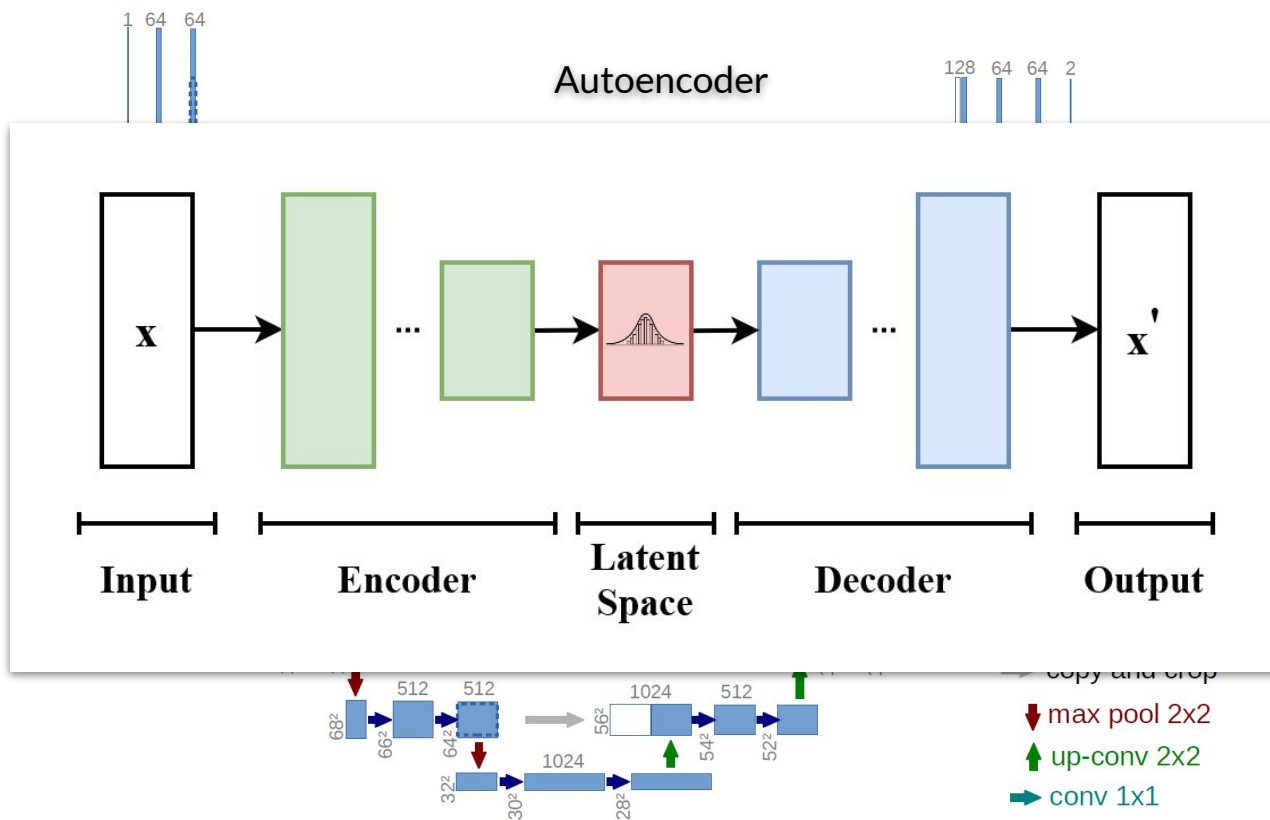


## Feature Pyramid Network (FPN)

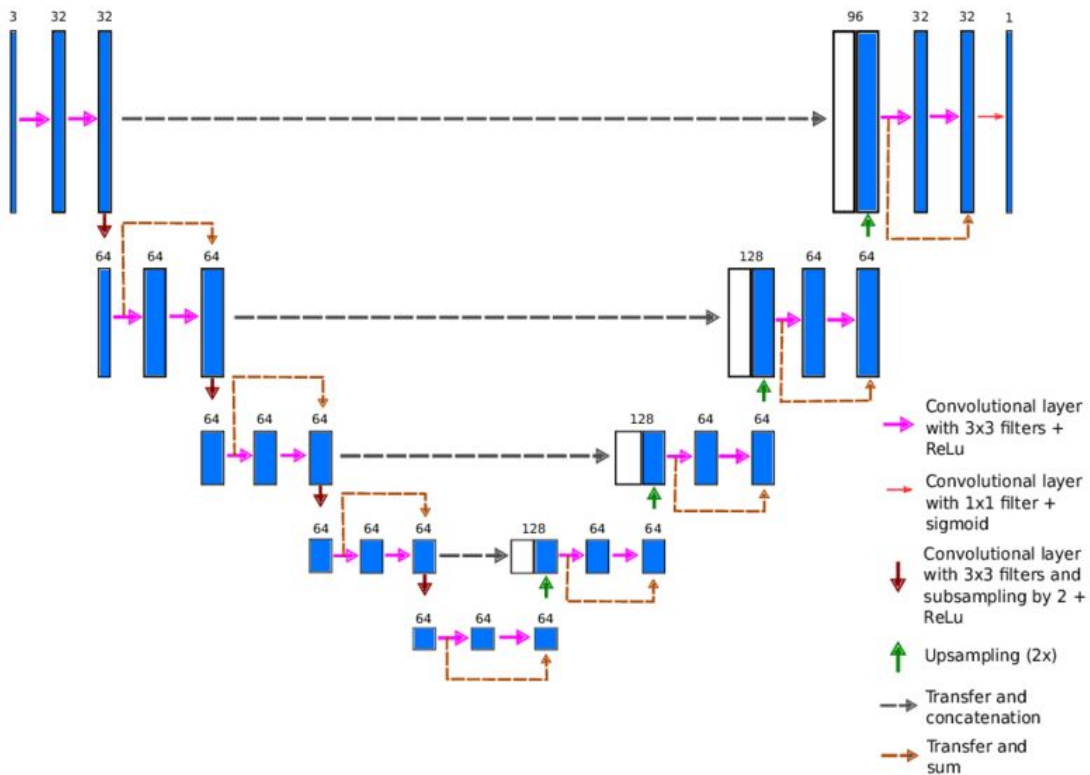


- ➡ conv 3x3, ReLU
- ➡ copy and crop
- ⬇ max pool 2x2
- ⬆ up-conv 2x2
- ➡ conv 1x1

# U-Net

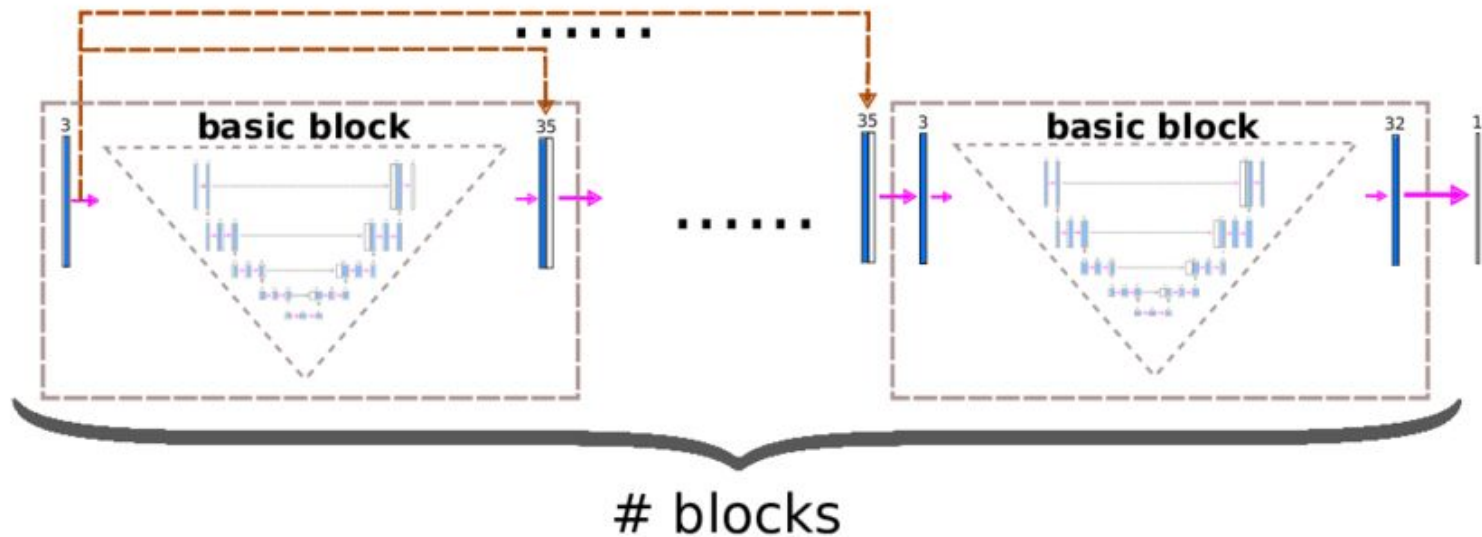


# Res-U-Net

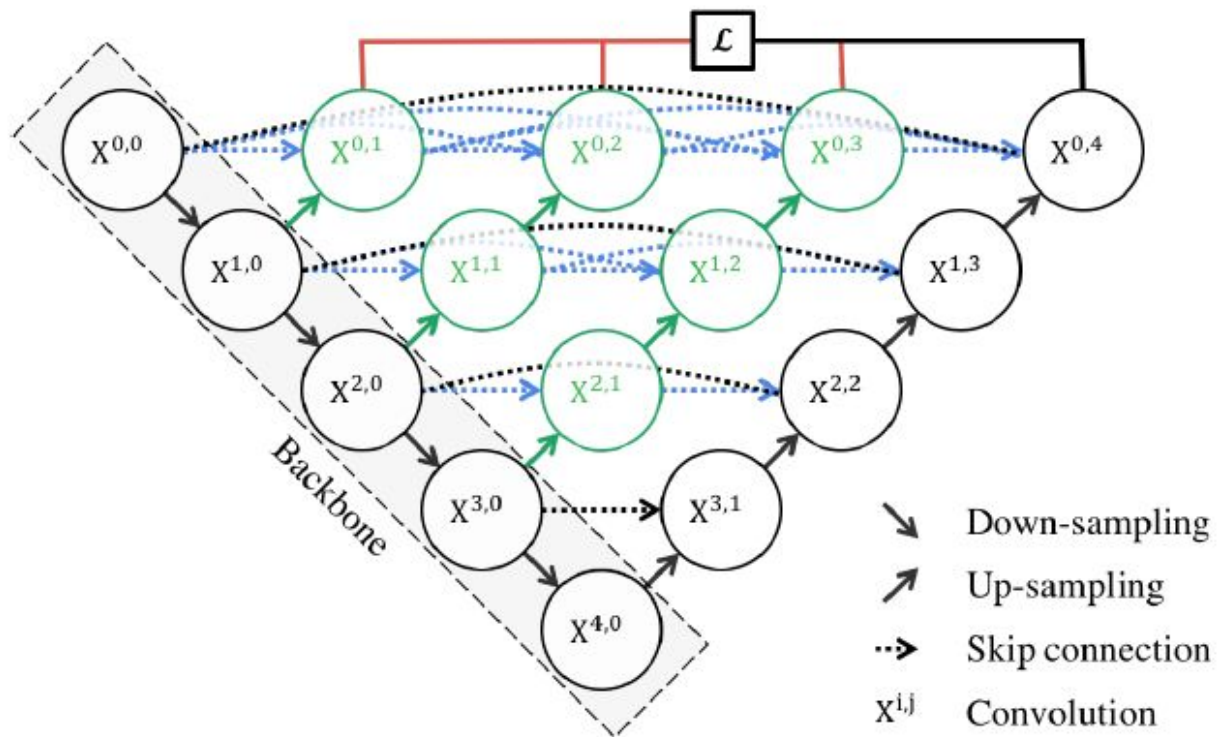




# Stack-U-Net



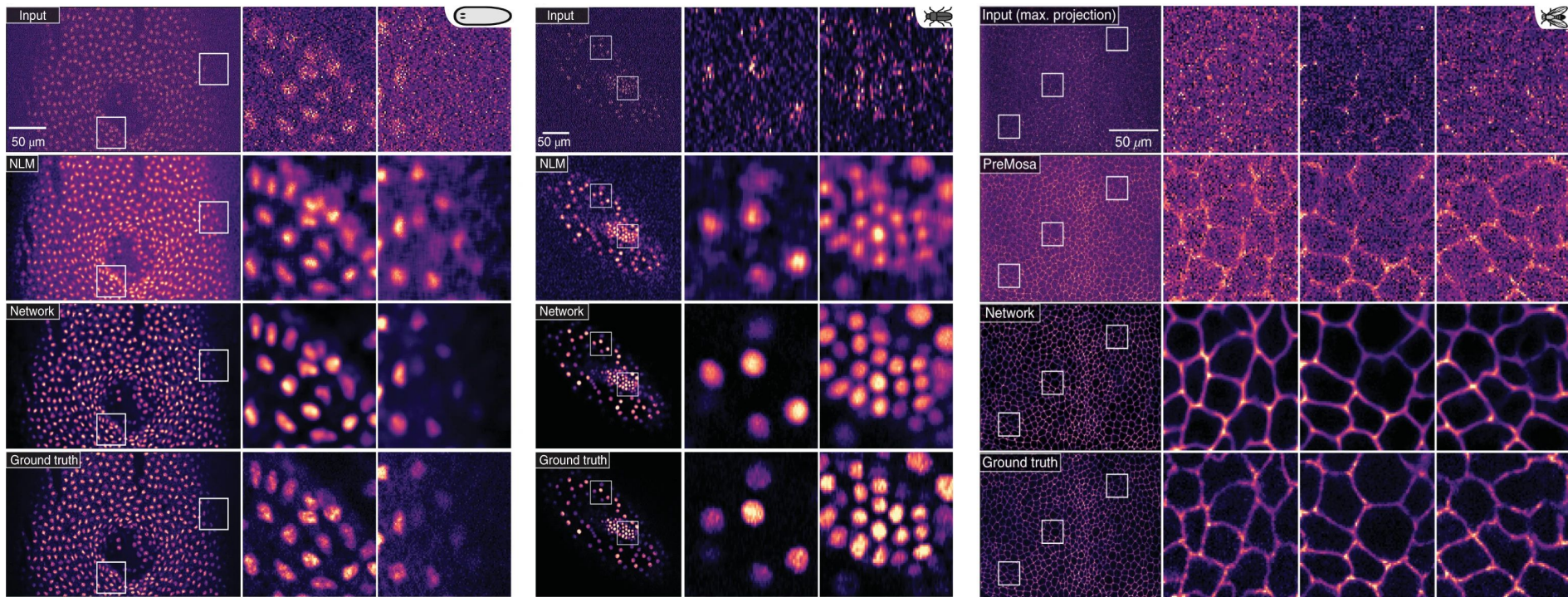
# U-Net++



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# Denoising

# Content-Aware image REstoration (CARE)



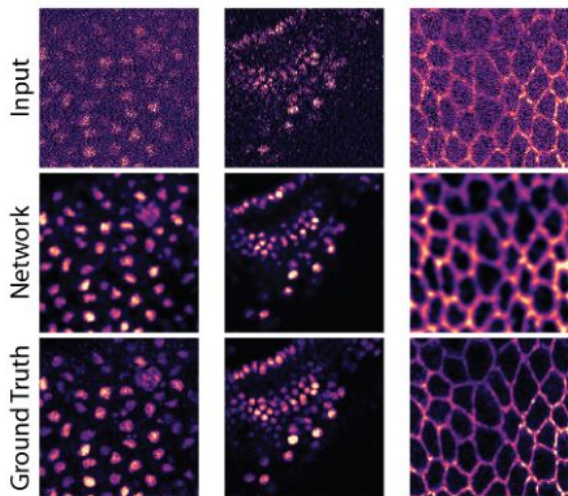
# Denosing failure cases

3D Denosing Network

Trained on **Planaria**

Applied to:

**Planaria** **Tribolium** **Flywing**

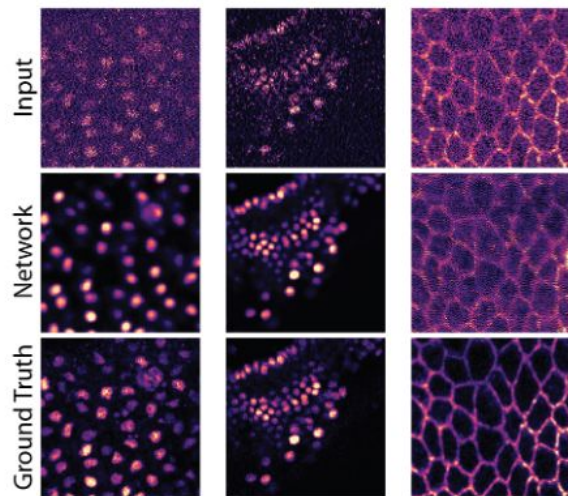


3D Denosing Network

Trained on **Tribolium**

Applied to:

**Planaria** **Tribolium** **Flywing**

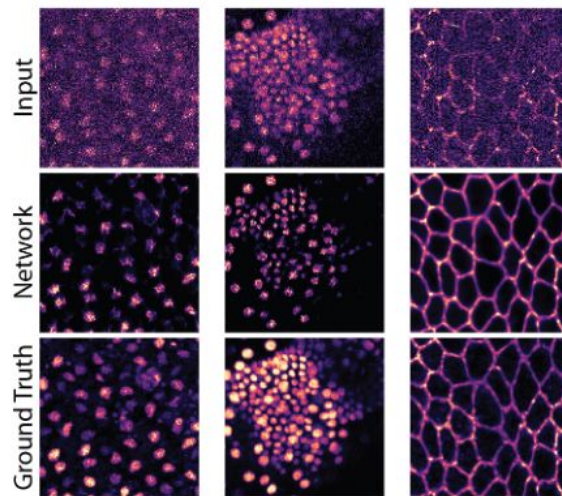


3D Surface Projection Network

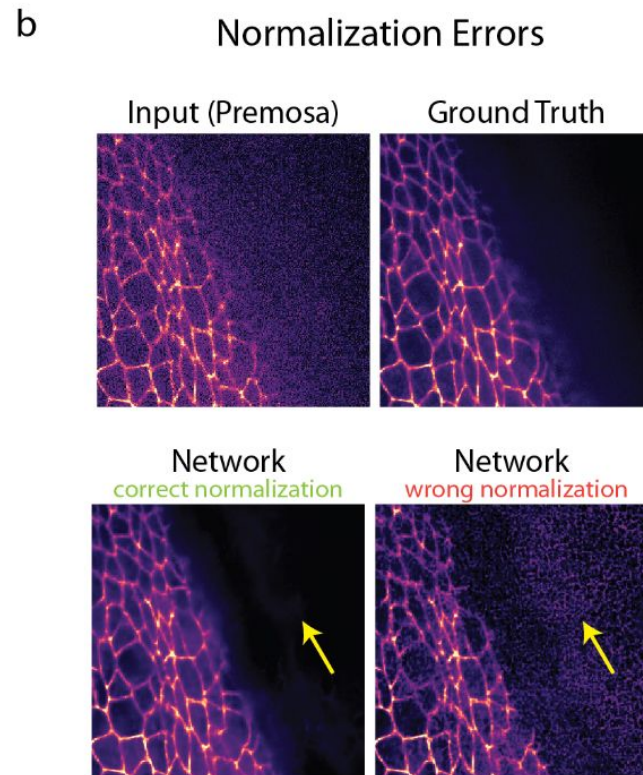
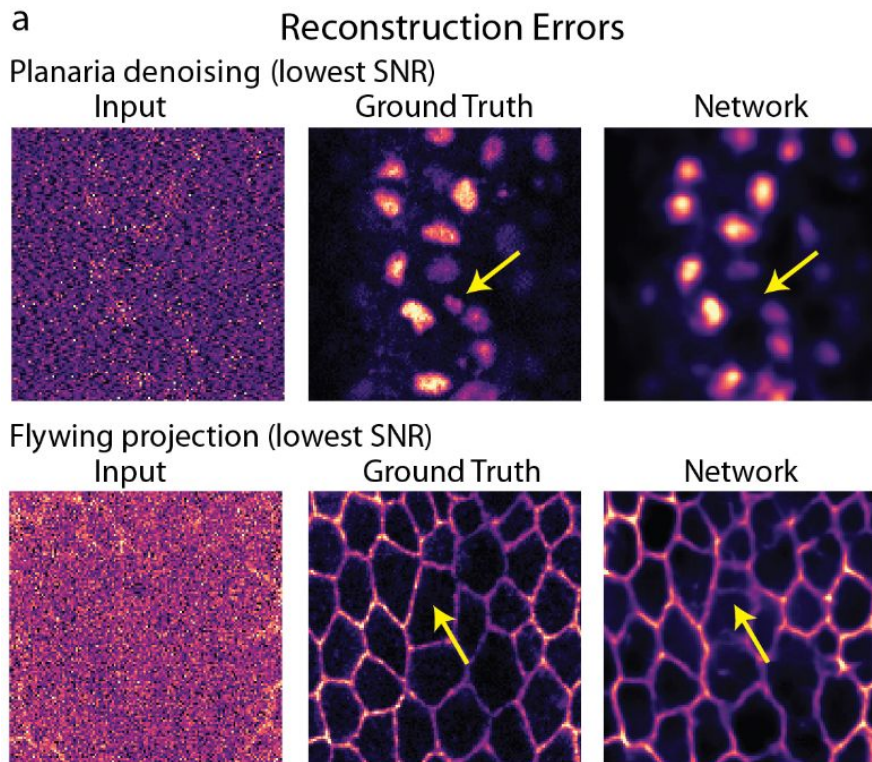
Trained on **Flywing**

Applied to:

**Planaria** **Tribolium** **Flywing**



# Denosing failure cases



# Noise2Noise

(a) Gaussian ( $\sigma = 25$ )



(b) Poisson ( $\lambda = 30$ )



Ground truth

Input

Our

Comparison

(c) Bernoulli ( $p = 0.5$ )



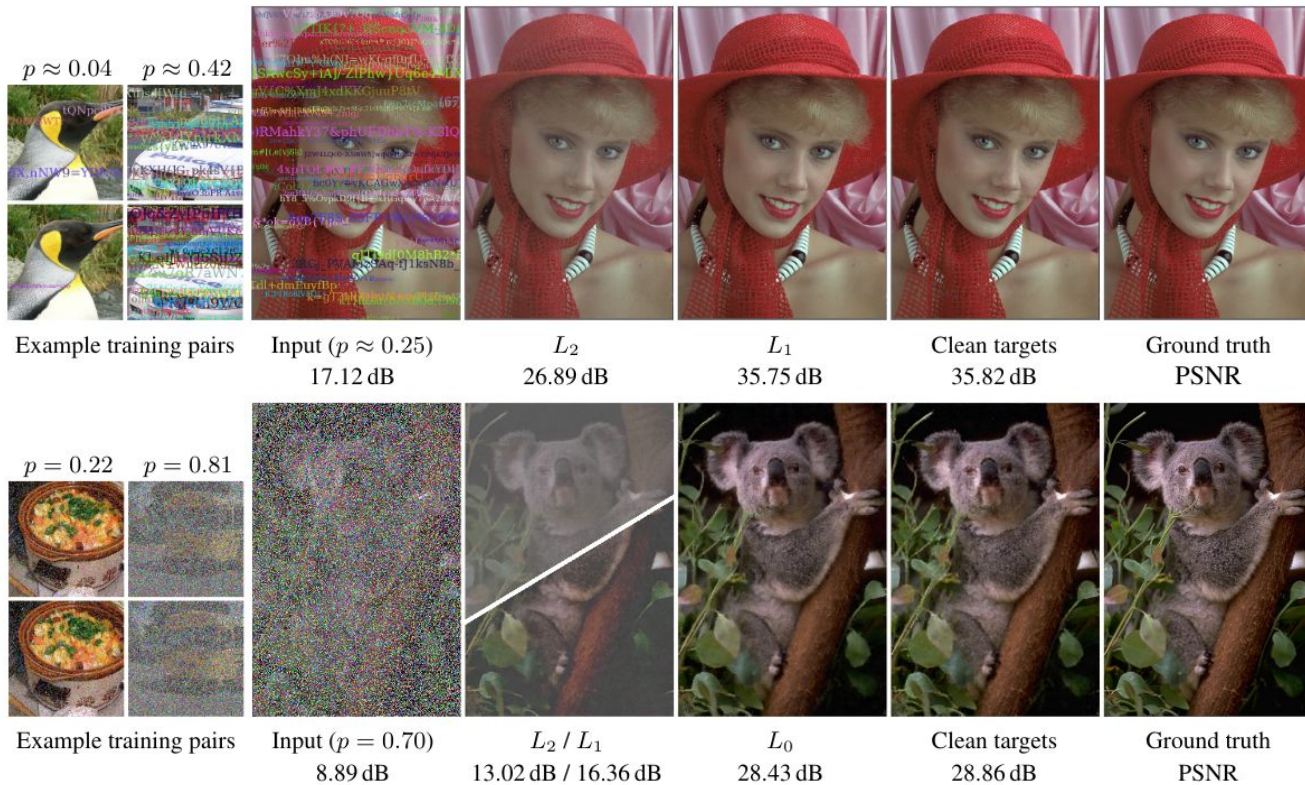
Ground truth

Input

Our

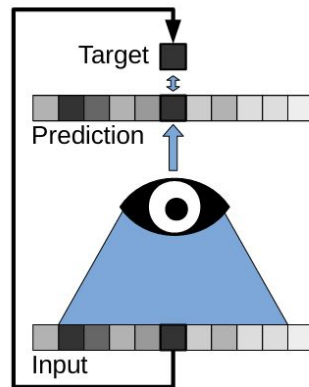
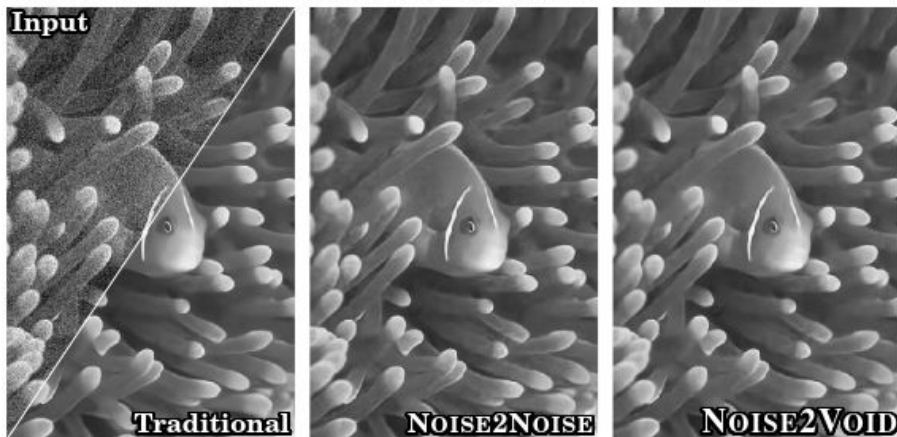
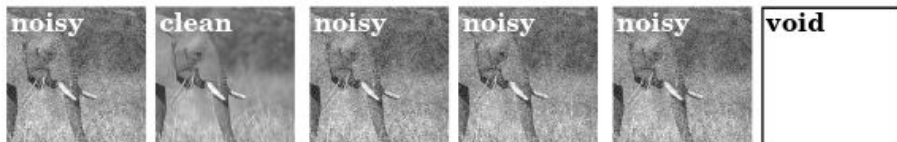
Comparison

# Noise2Noise

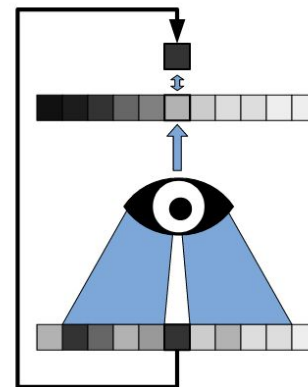




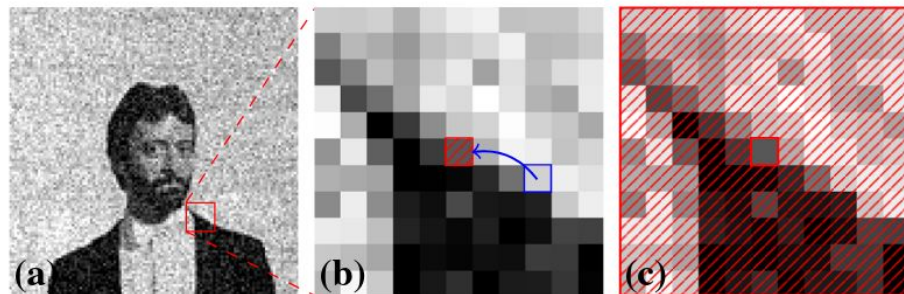
# Noise2Void



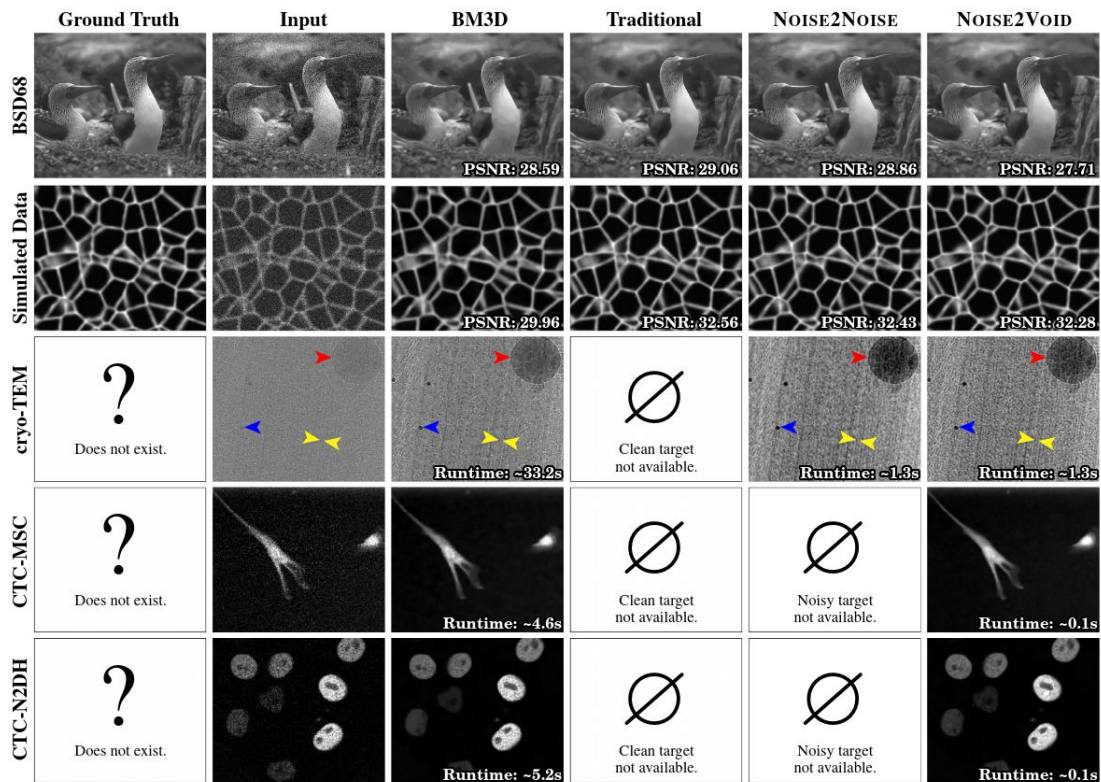
(a)



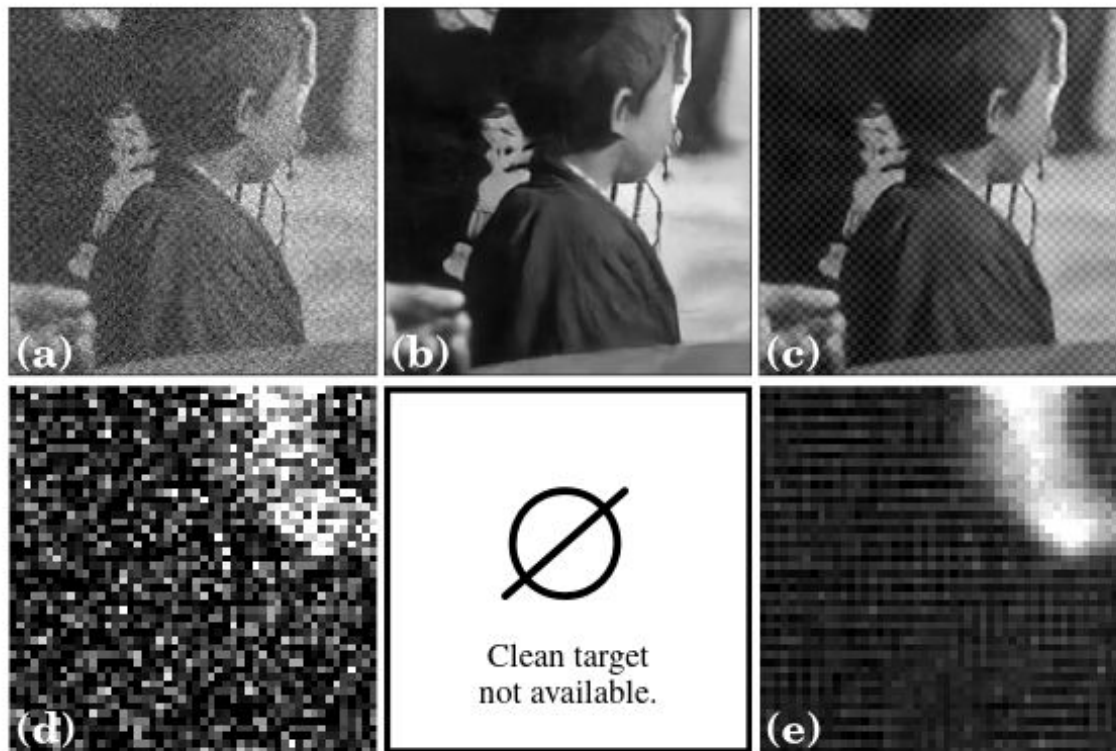
(b)



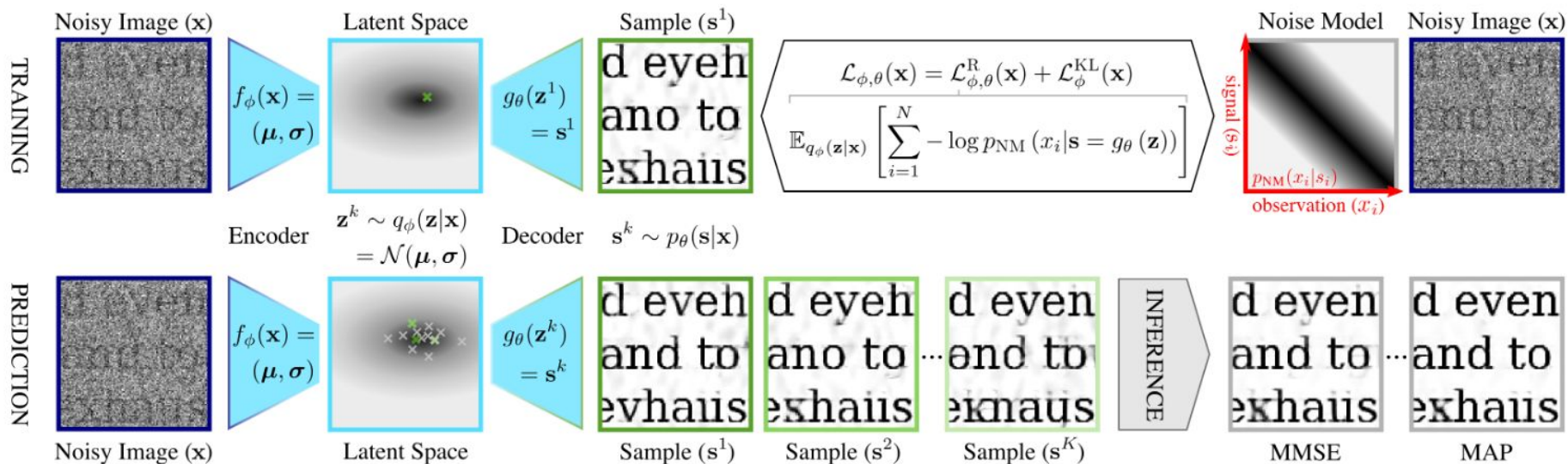
# Noise2Void



# Noise2Void failure cases



# Diversity Denoising

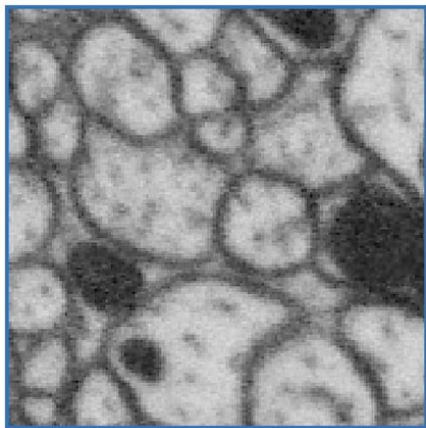


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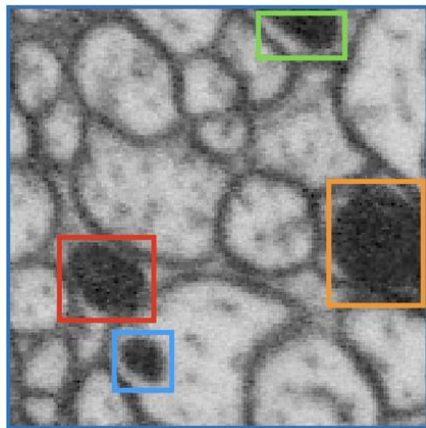
# Segmentation

# Segmentation types

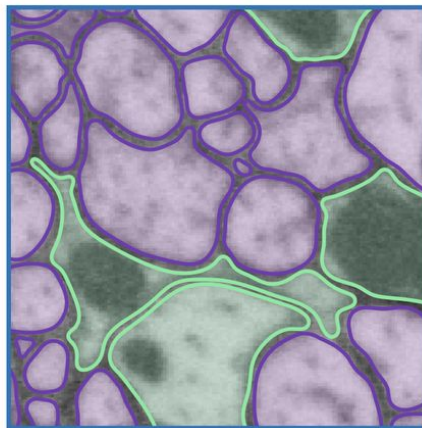
Image



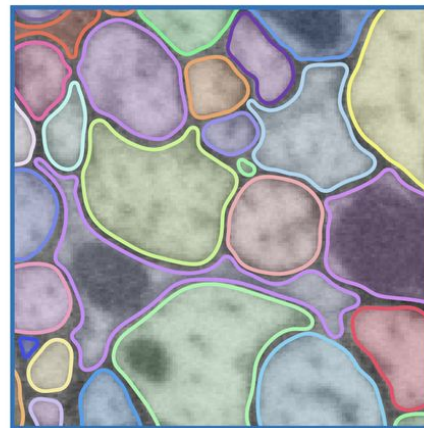
Object Detection



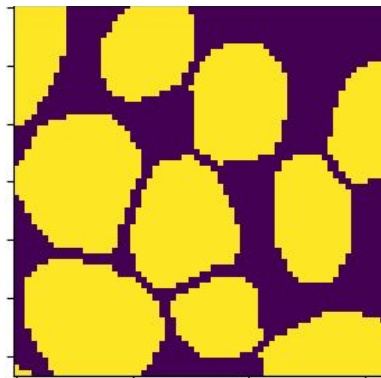
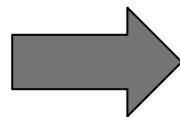
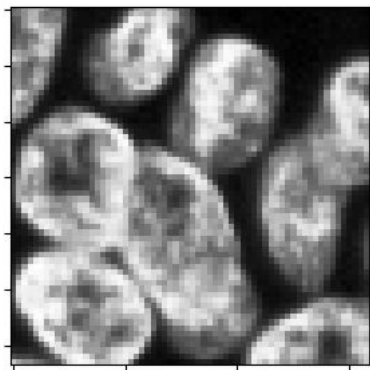
Semantic Segmentation



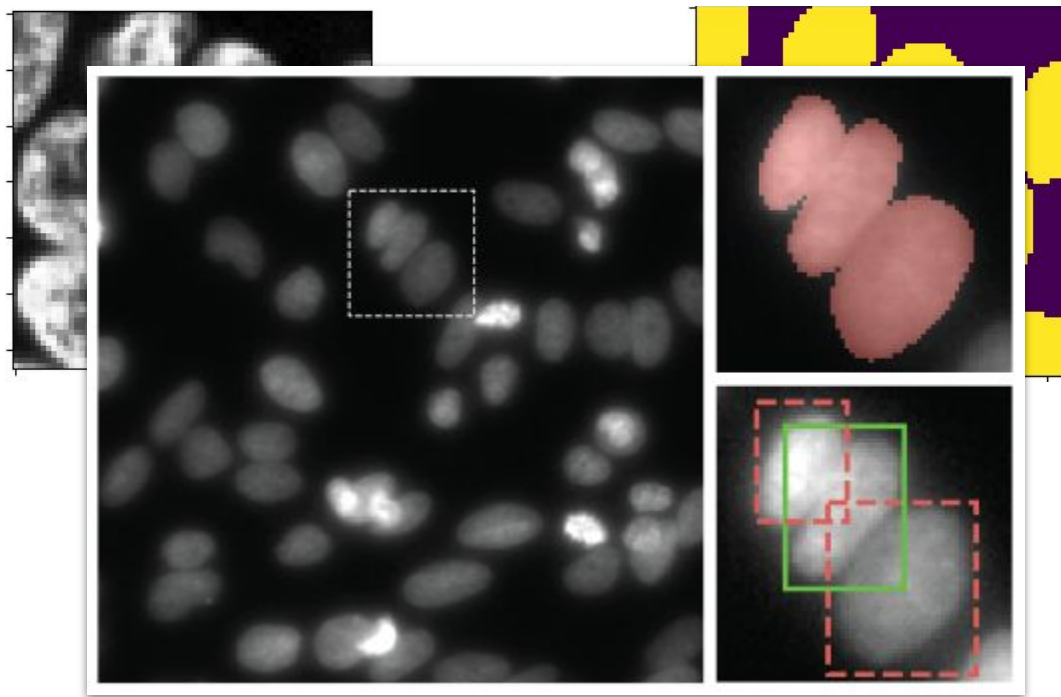
Instance Segmentation



## 2-class segmentation

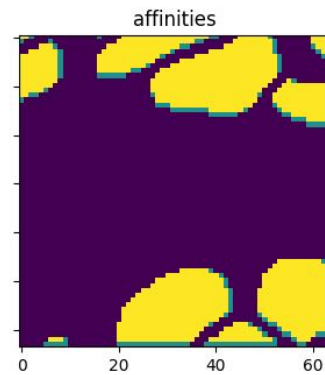
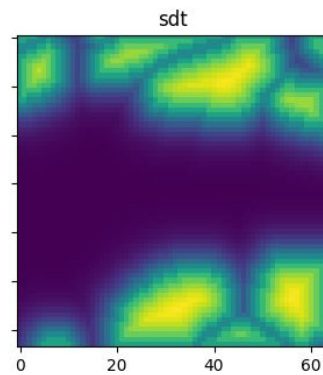
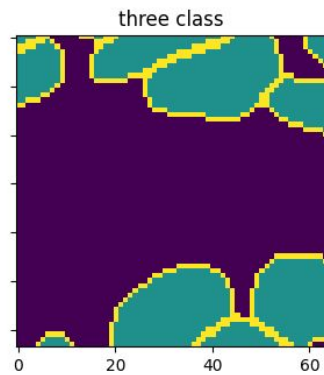
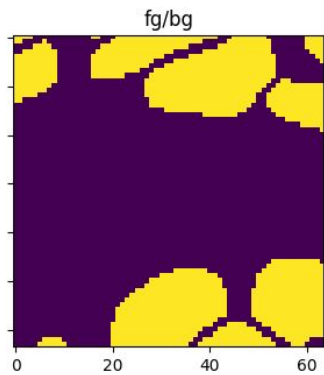
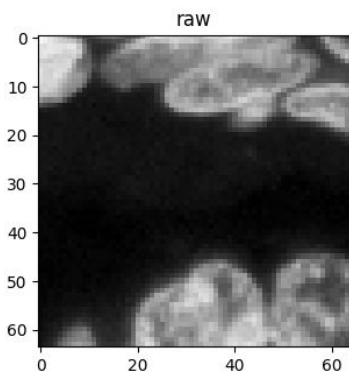


# 2-class segmentation

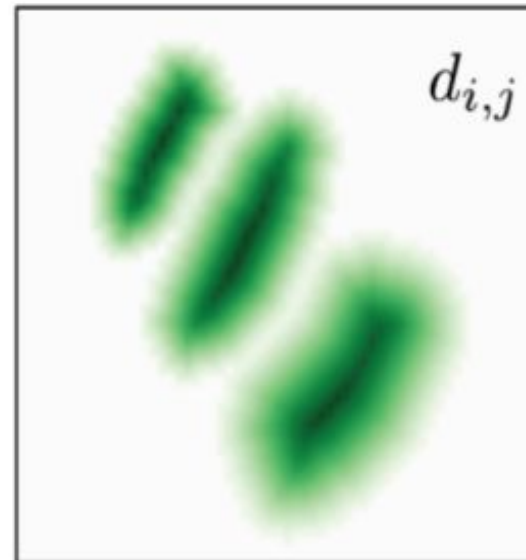
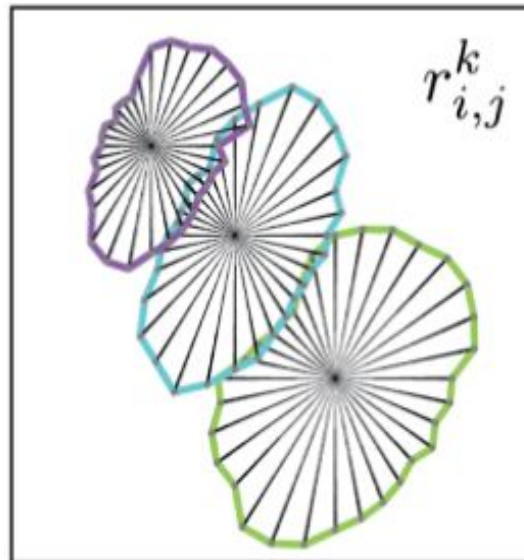
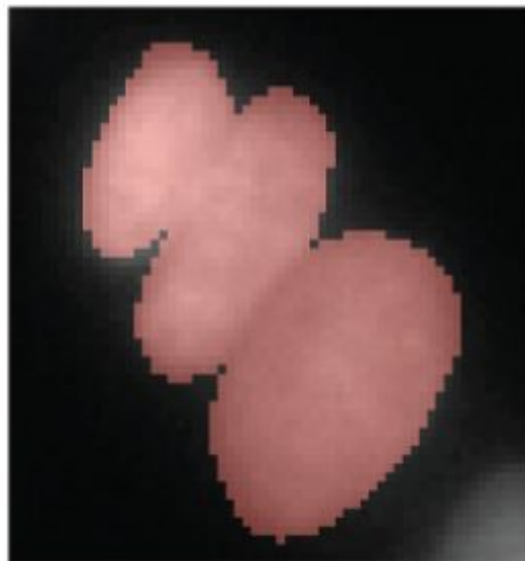




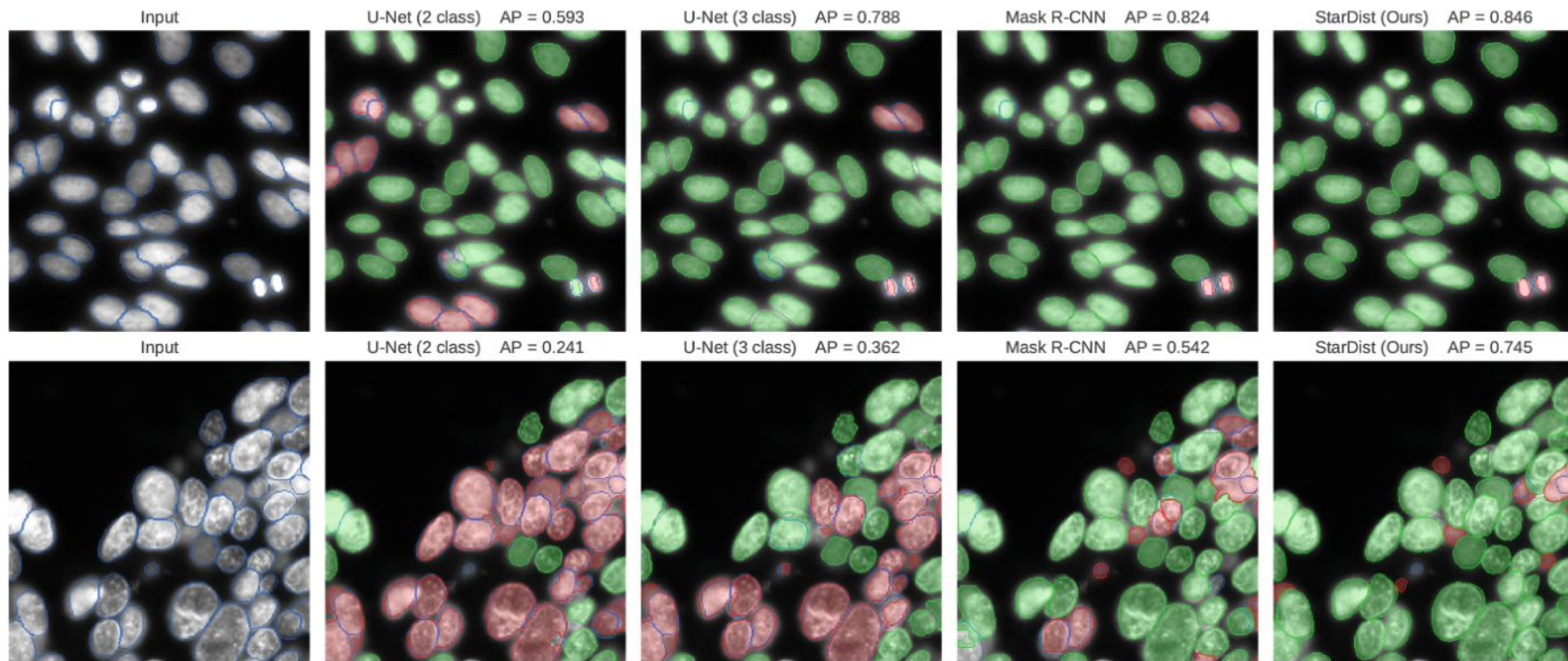
# Segmentation improvements



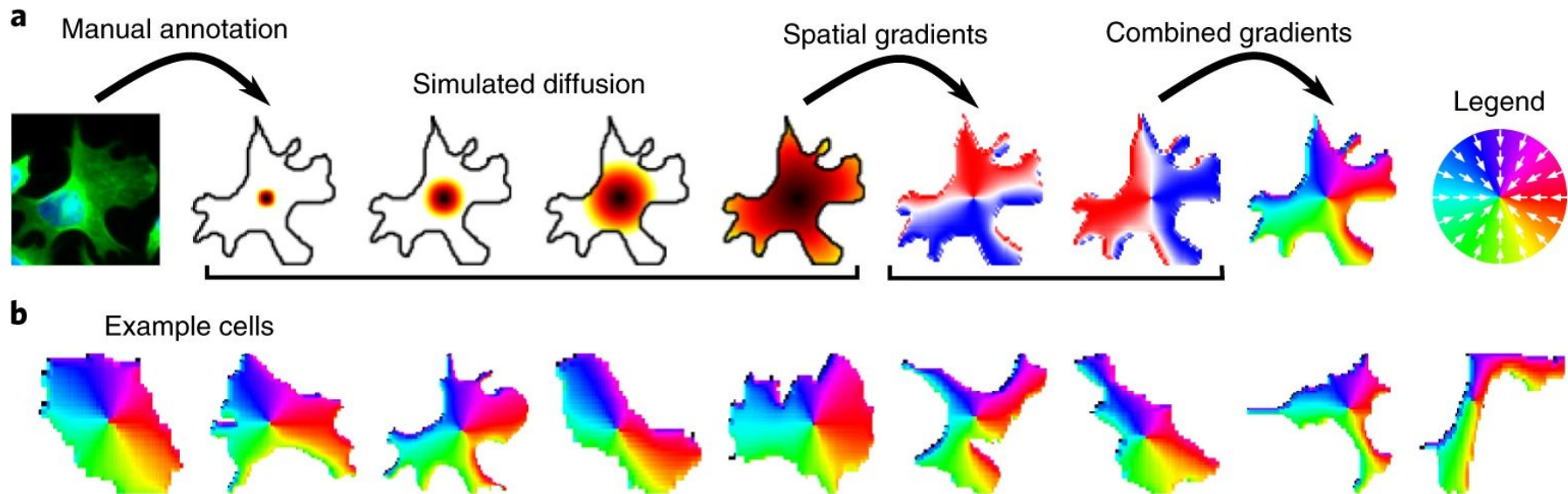
# StarDist



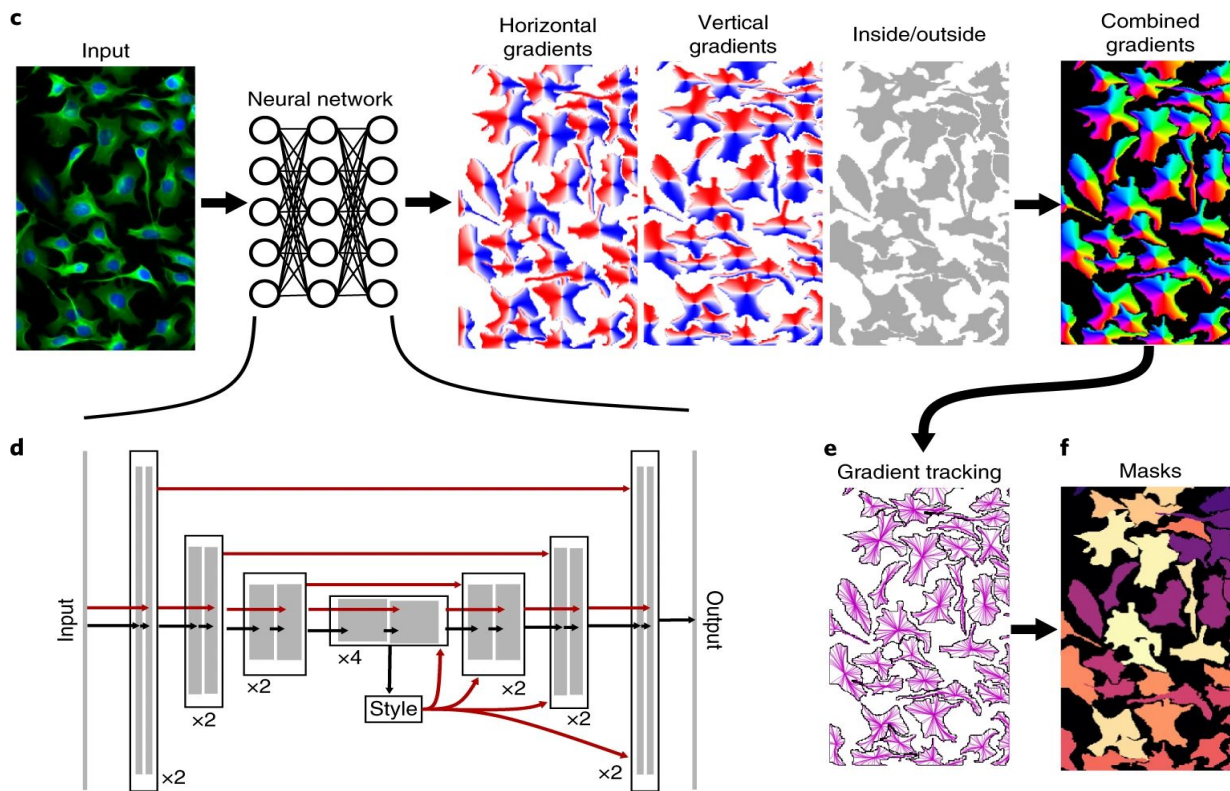
# StarDist



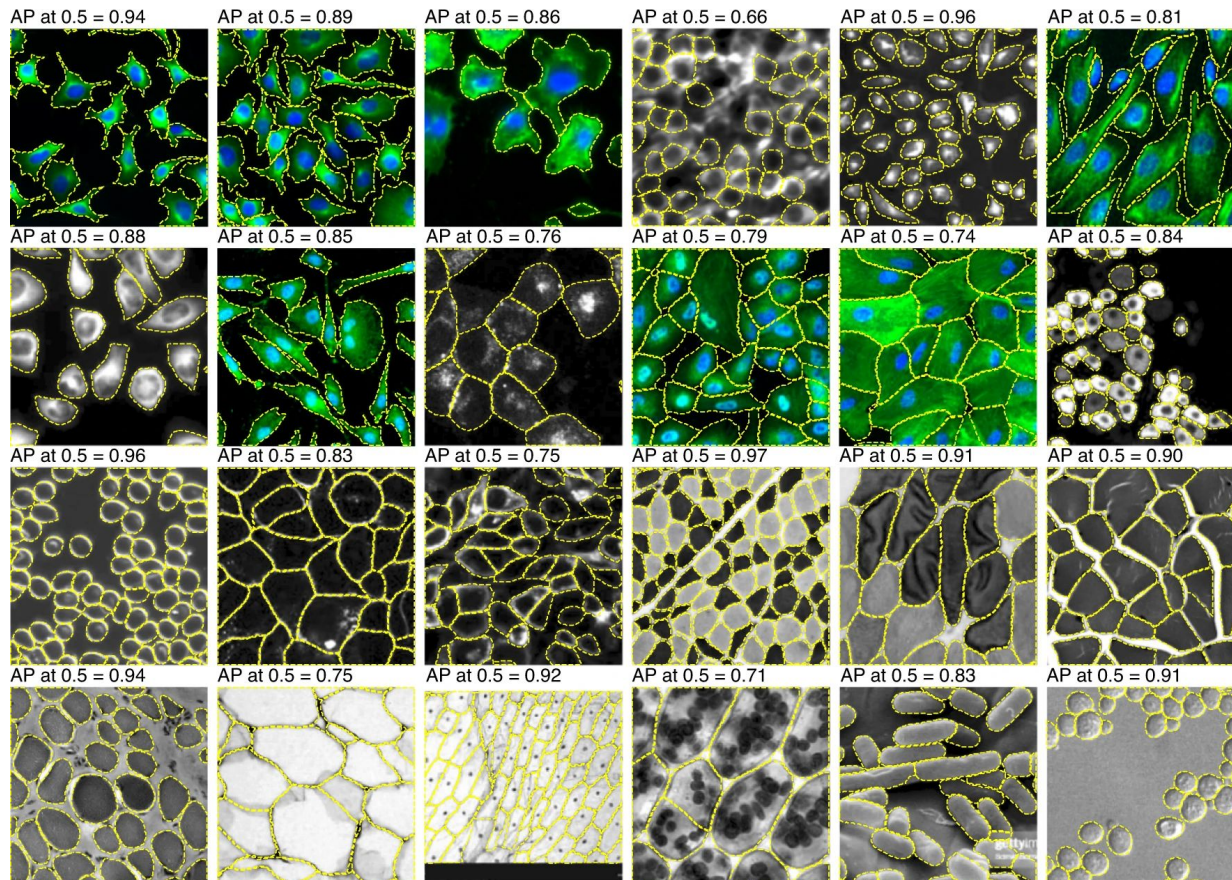
# CellPose



# CellPose



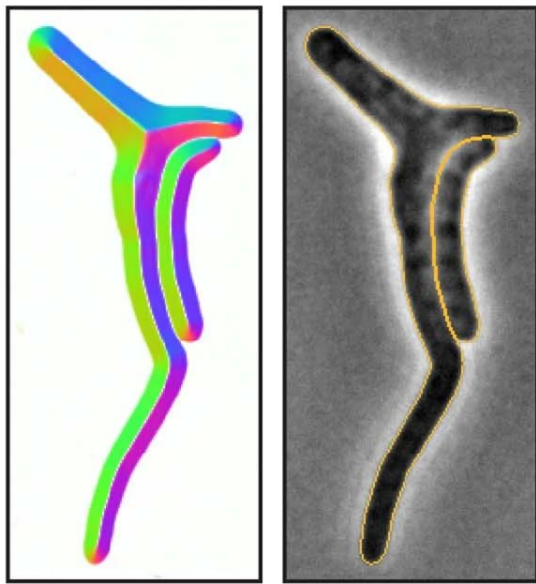
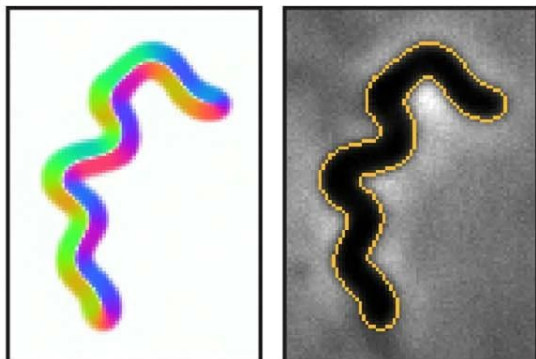
# CellPose



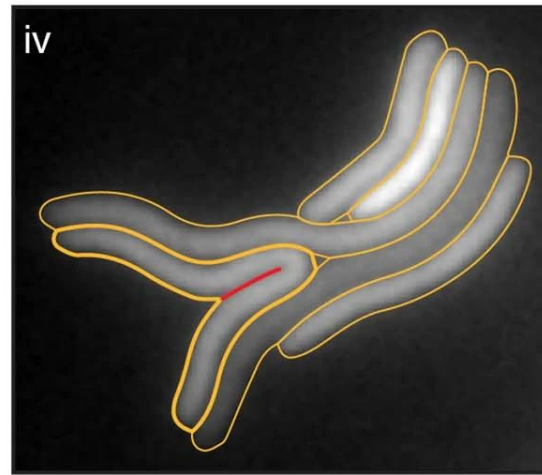
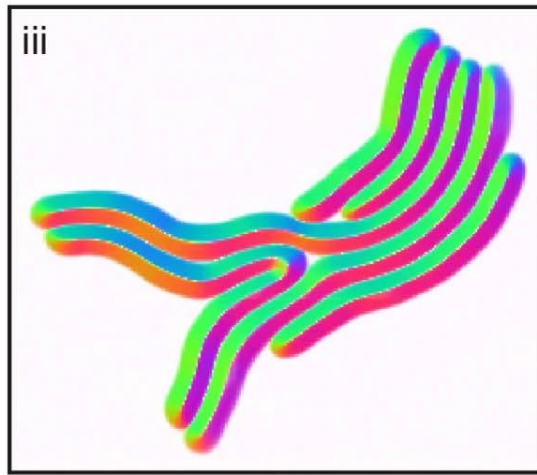
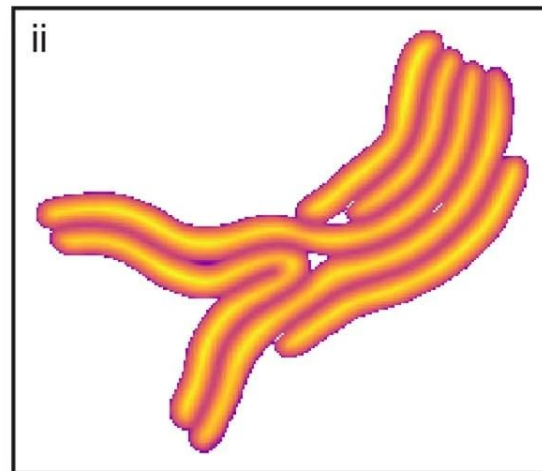
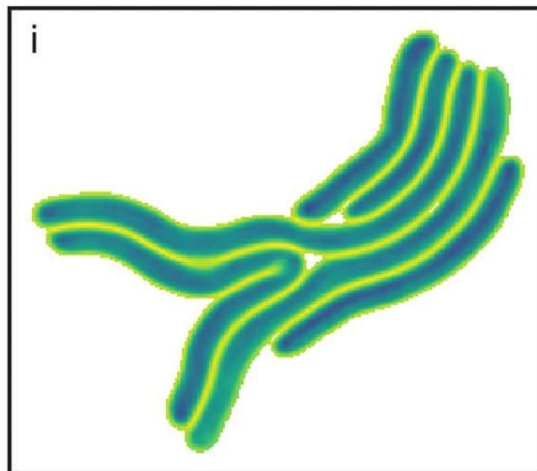
# OmniPose

Cutler, Kevin J. and Stringer, Carsen, et al., 2022

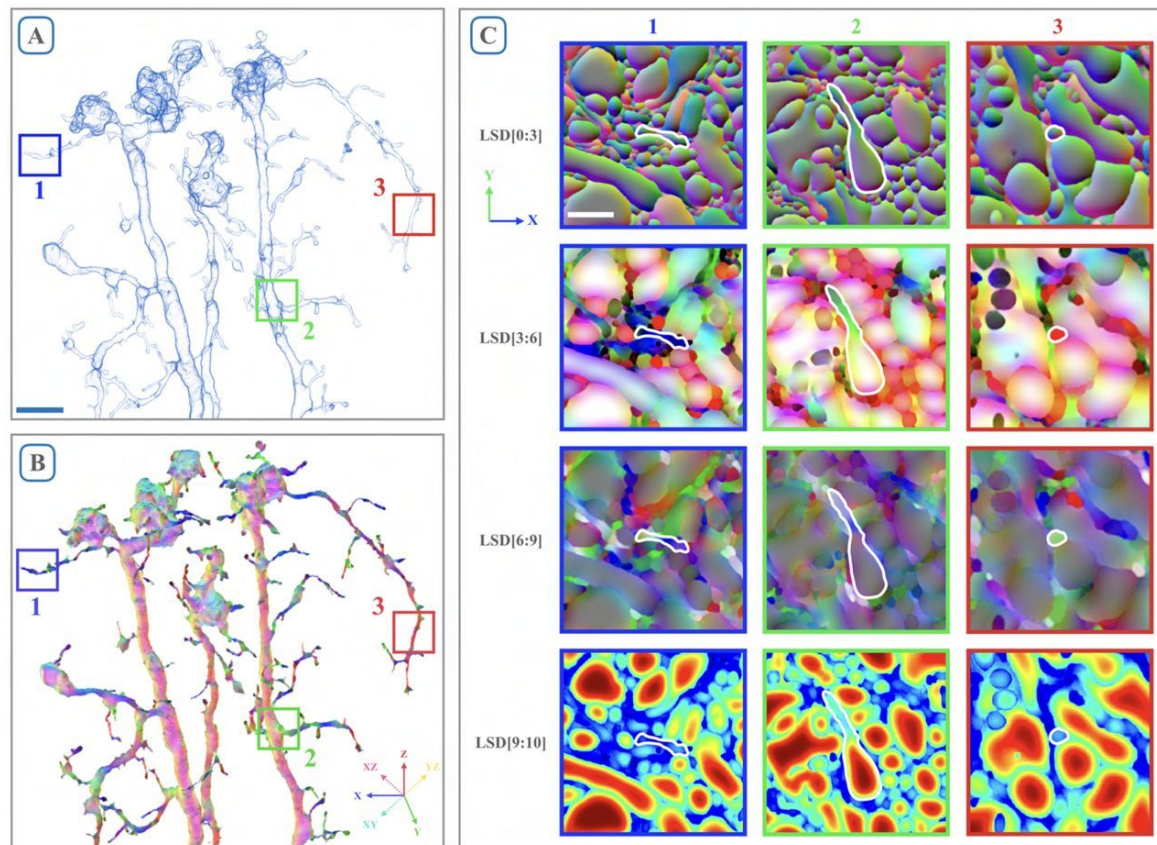
**a**



**b**

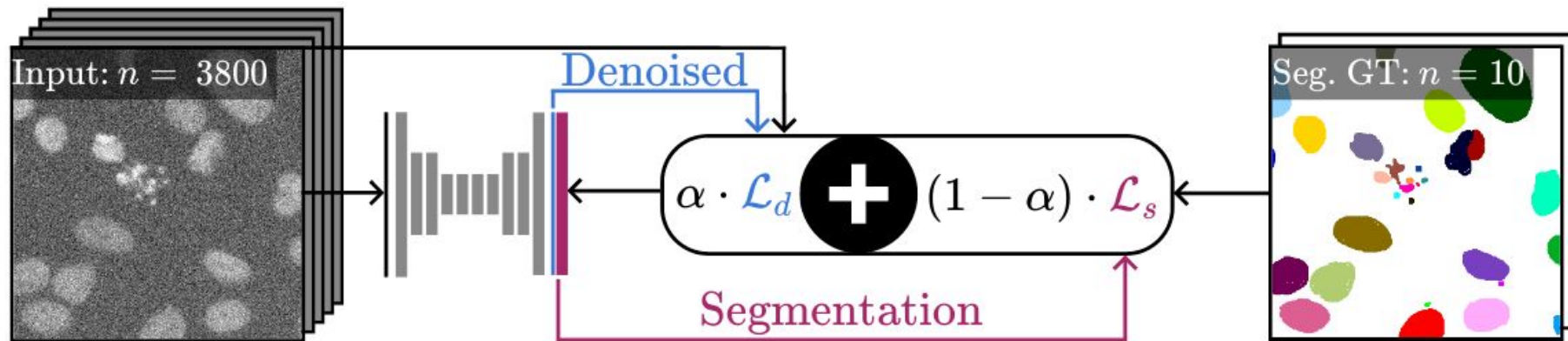


# Local Shape Descriptors

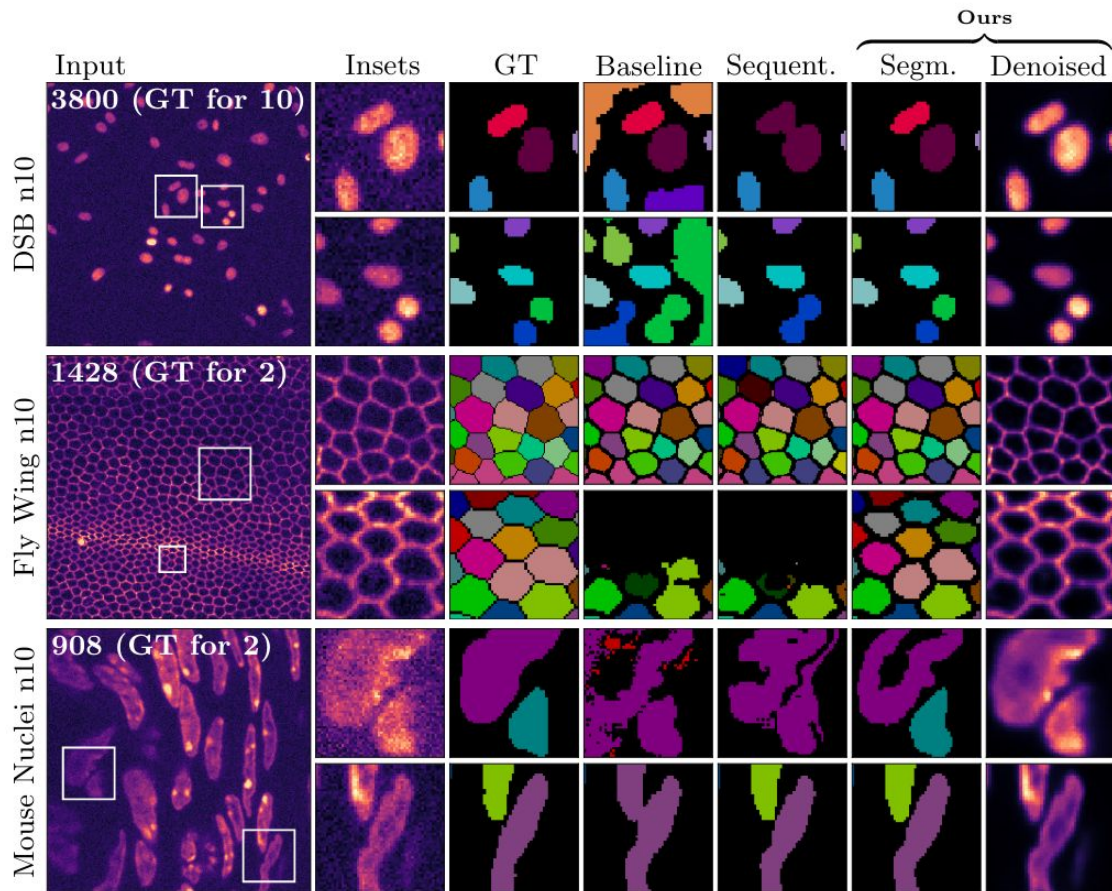




# DenoiseSeg



# DenoiseSeg



# Key takeaways

- Microscopy biological data is very different from natural images
  - U-Net is just very effective
  - Denoising can be done without any ground truth
  - Harder segmentation targets lead to better results
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**Thank you for your attention!**  
**Any questions?**

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