GEORG-AUGUST-UNIVERSITÄT
GÖTTINGEN

Segment Anything for Microscopy

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https://user.informatik.uni-goettingen.de/~pape41/

@cppape

https://github.com/constantinpape

https://github.com/stardist/stardist
https://github.com/MouseLand/cellpose
https://volume-em.github.io/empanada.html

Deep Learning for Segmentation

Current methods:
trained on narrow dataset for specific segmentation task

- StarDist: nucleus segmentation in light microscopy
- CellPose: cell segmentation in light microscopy
- MitoNet: mitochondria segmentation in electron microscopy
- etc.

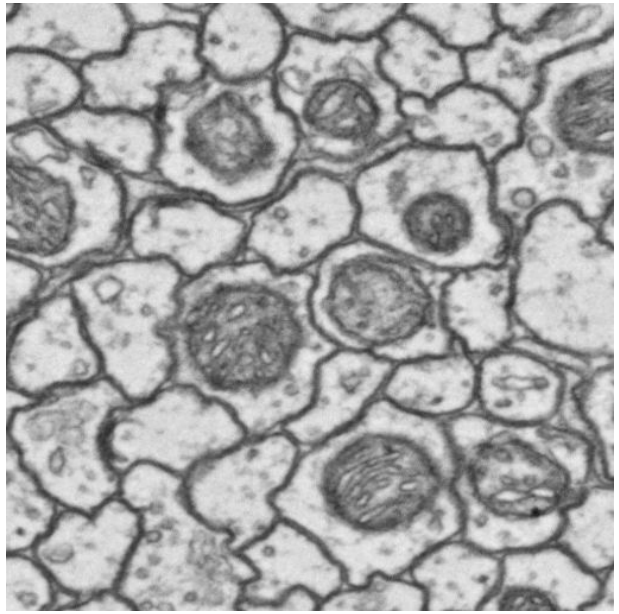
https://volume-em.github.io/empanada.html

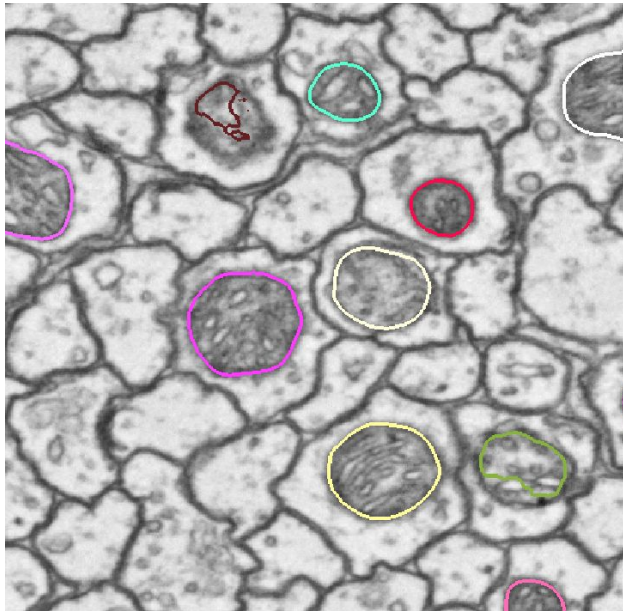
Mitochondria Segmentation

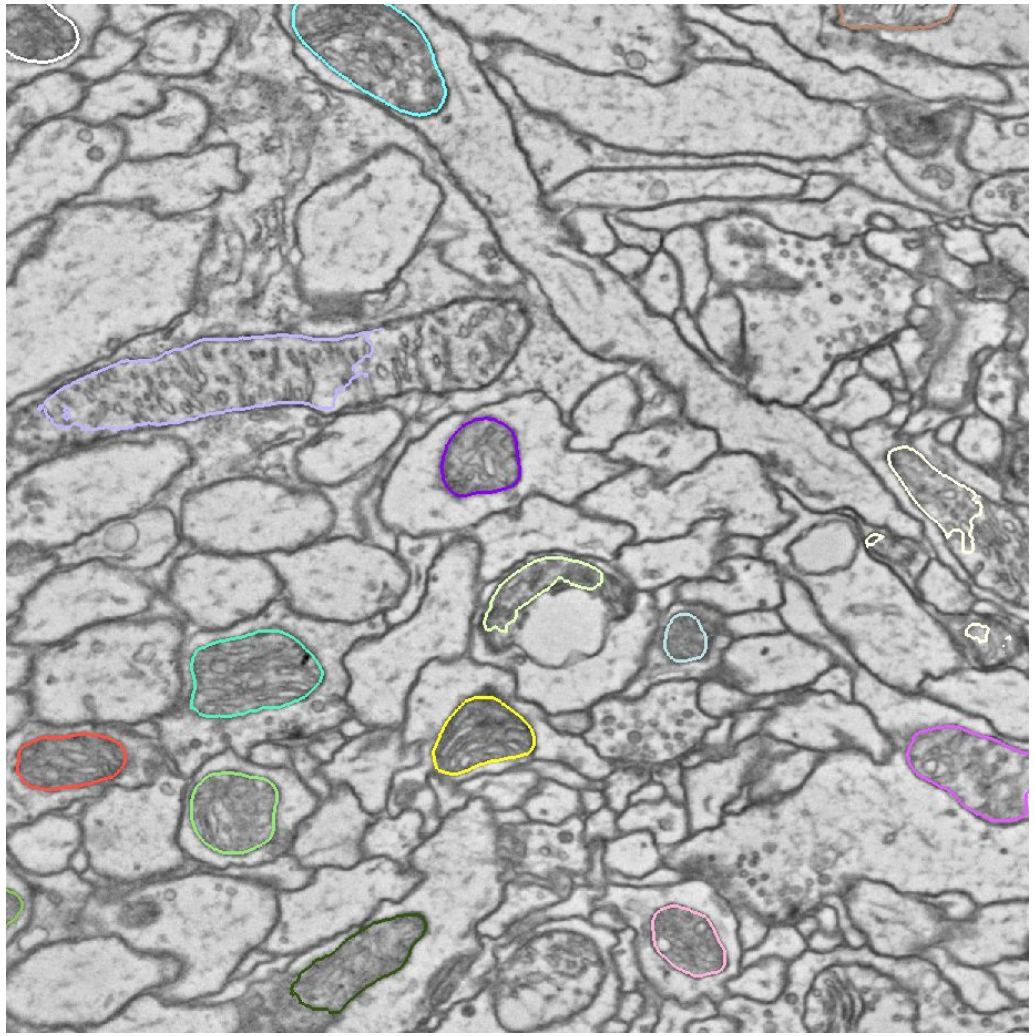
Data from https://cremi.org/

MitoNet: Good results for “typical” mitochondria (similar to training set)

Inferior quality for irregular shapes







Deep Learning for Segmentation

Pretrained networks for segmentation

- It works? :-)
  - Fast and accurate segmentation result.

- It doesn’t work? :-(
  - How can it be fixed?
  - Retraining / fine-tuning
    - Correct segmentation results
    - Re-train method on corrected data

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Drawbacks:

- **Painstaking correction effort**
- **Retraining can be technically challenging**
- **Value of fine-tuning unclear**

Democratizing DL for microscopy

ModelZoo

BioImage.IO

Provide models ↕ Submit models

#ZeroCostDL4Mic

Training and prediction

QuPath

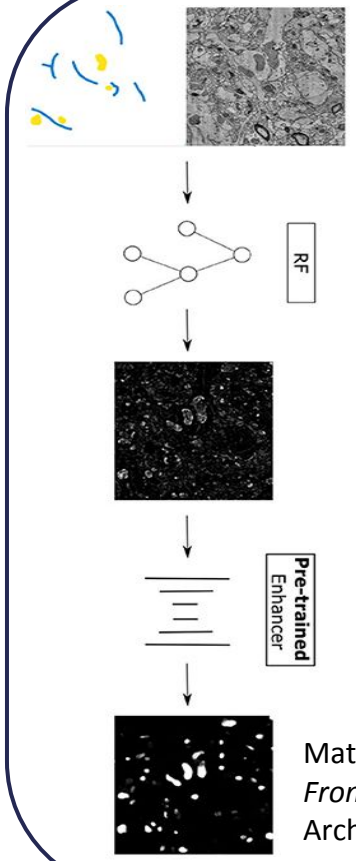
ilastik

deepImageJ

StarDist

Ouyang, Beuttenmüller, Gomez di Mariscal, **Pape**, *et al.* bioRxiv (2022)

Domain Adaptation



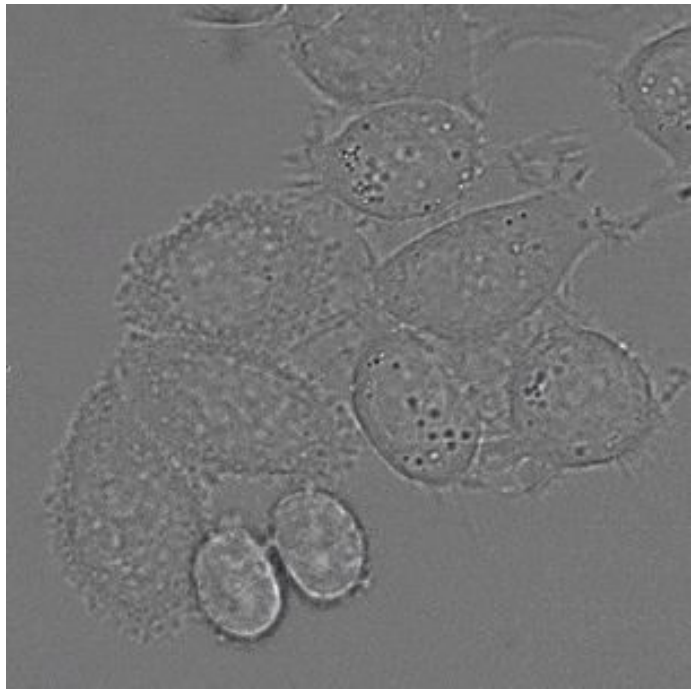
Adapt a model trained on similar data to new dataset

Shallow2Deep: using predictions from ilastik

Recent work: Probabilistic Domain Adaptation

Matskevych, Wolny, **Pape**, Kreshuk, *Frontiers in Comp. Sci.* (2021)
Archit & **Pape**, *arXiv* (2023)

Interactive Segmentation



https://github.com/computational-cell-analytics/micro-sam

Segment Anything

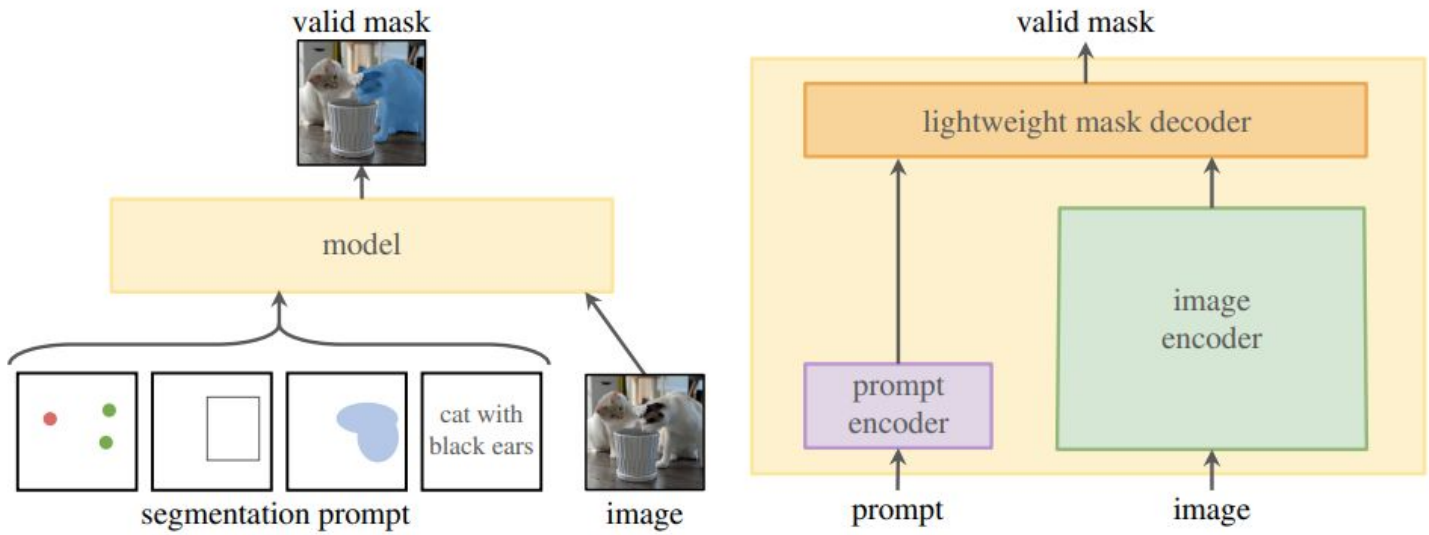
Towards universal interactive segmentation

Segment Anything

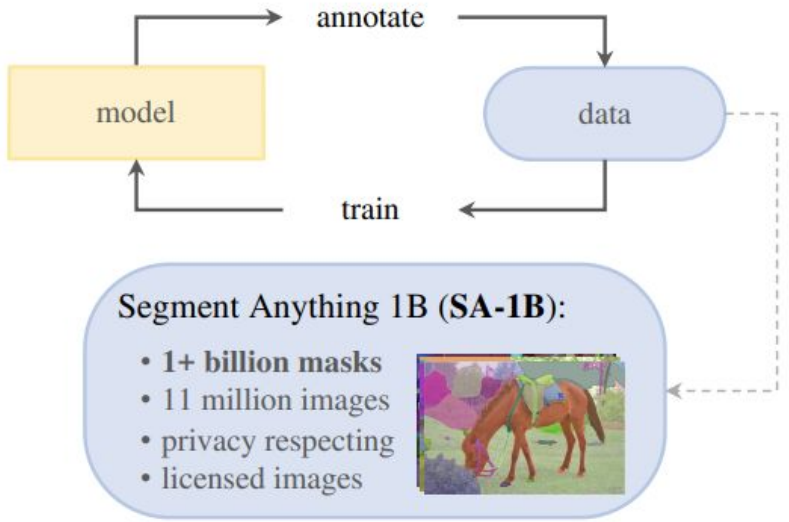
https://arxiv.org/abs/2304.02643

Pretrained model for interactive segmentation from Meta.AI

Model for interactive segmentation



Very large dataset



Segment Anything

https://segment-anything.com/

Learns general object prior

Can be used for automatic and **interactive** segmentation

Segment Anything for Microscopy

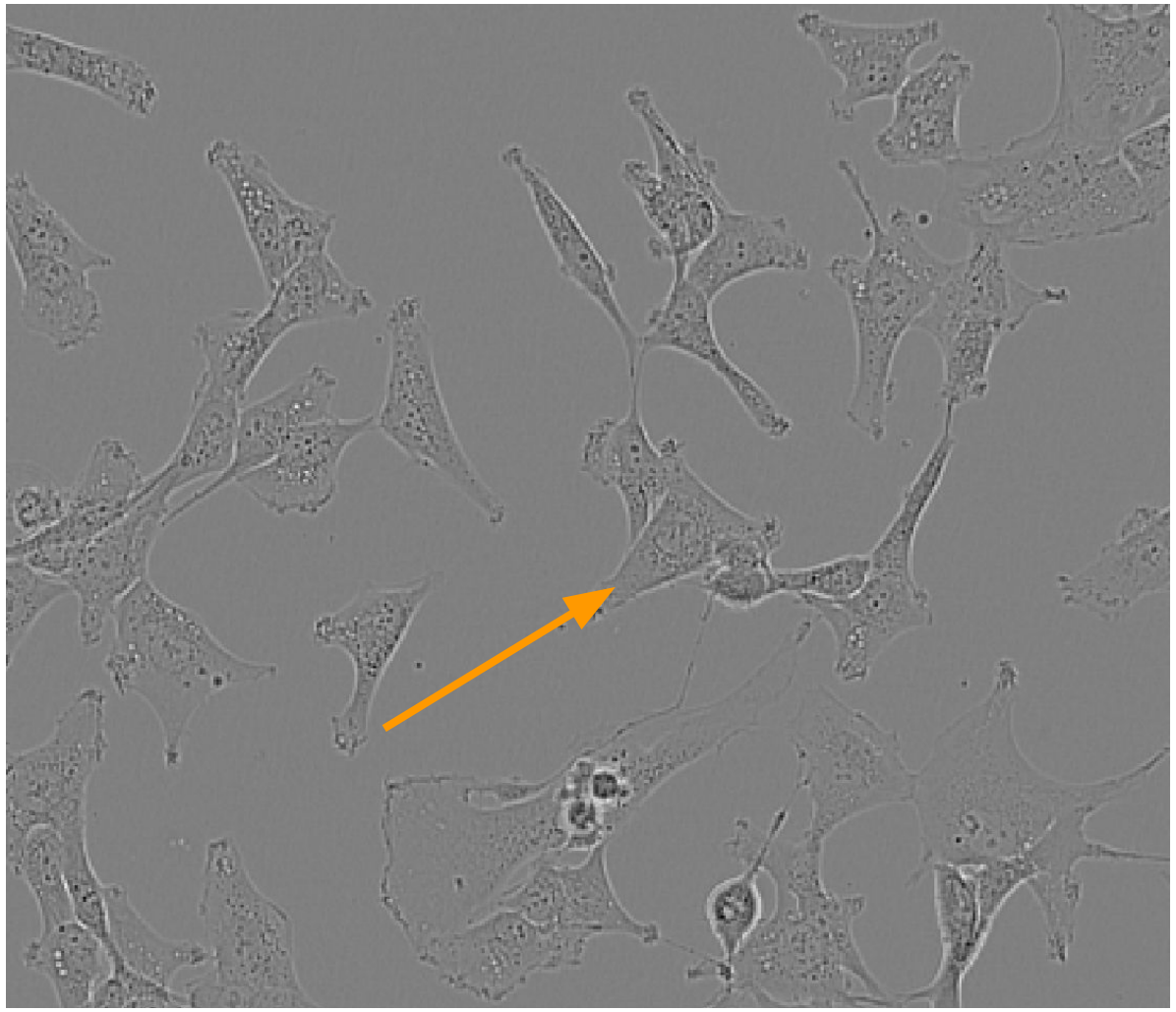
Preliminary quantitative results

SegmentAnything on LiveCELL

LiveCELL Dataset:
https://www.nature.com/articles/s41592-021-01249-6

Preliminary evaluation for
Live-cell microscopy:

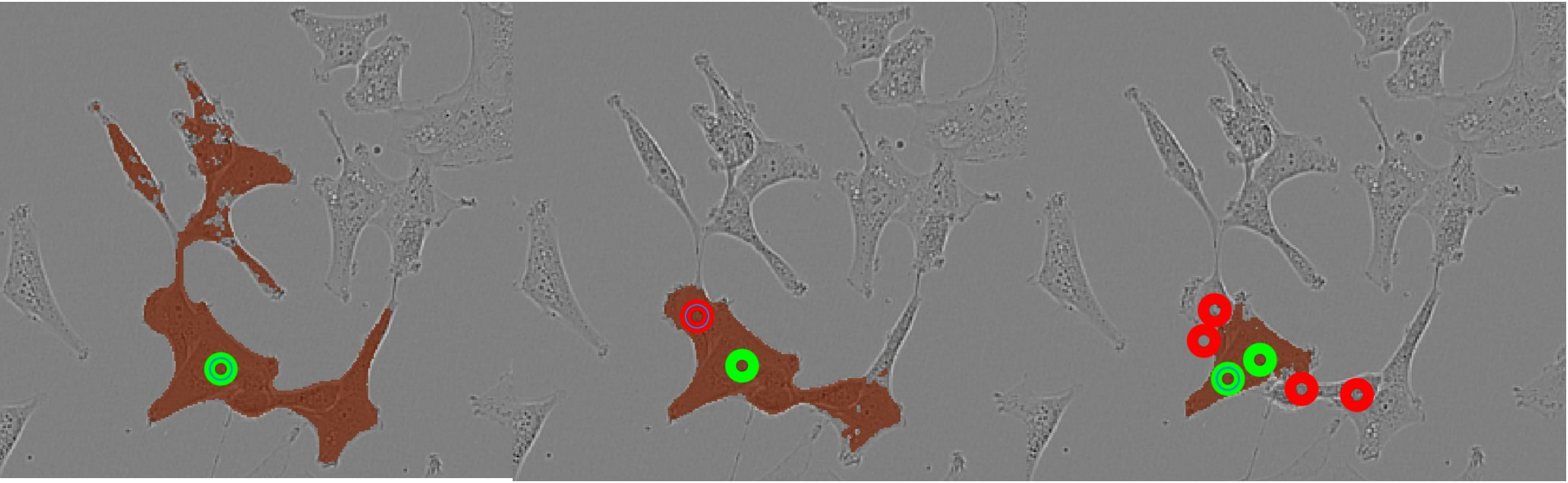
Can we segment cells from a few points interactively?



Anwai

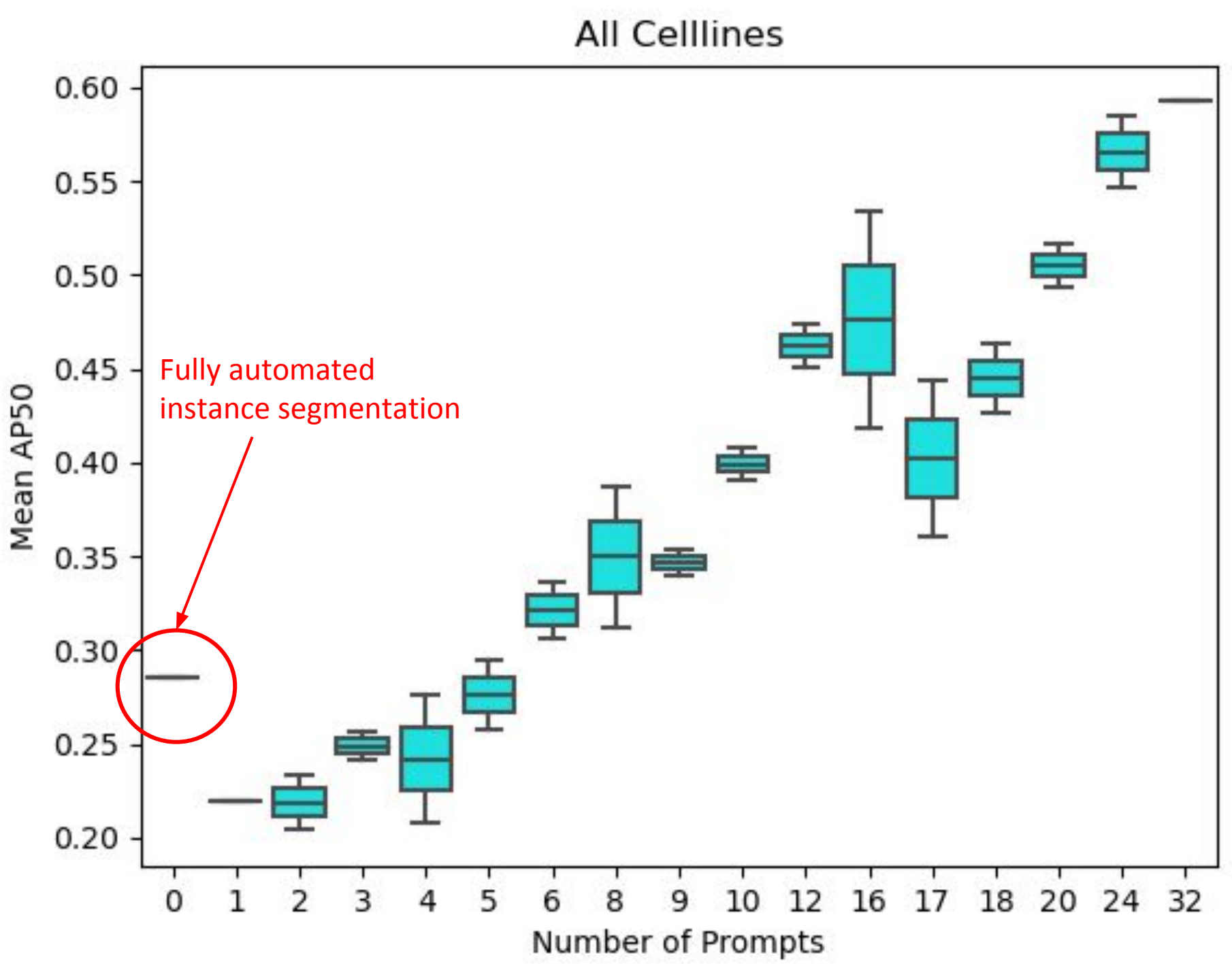
SegmentAnything on LiveCELL

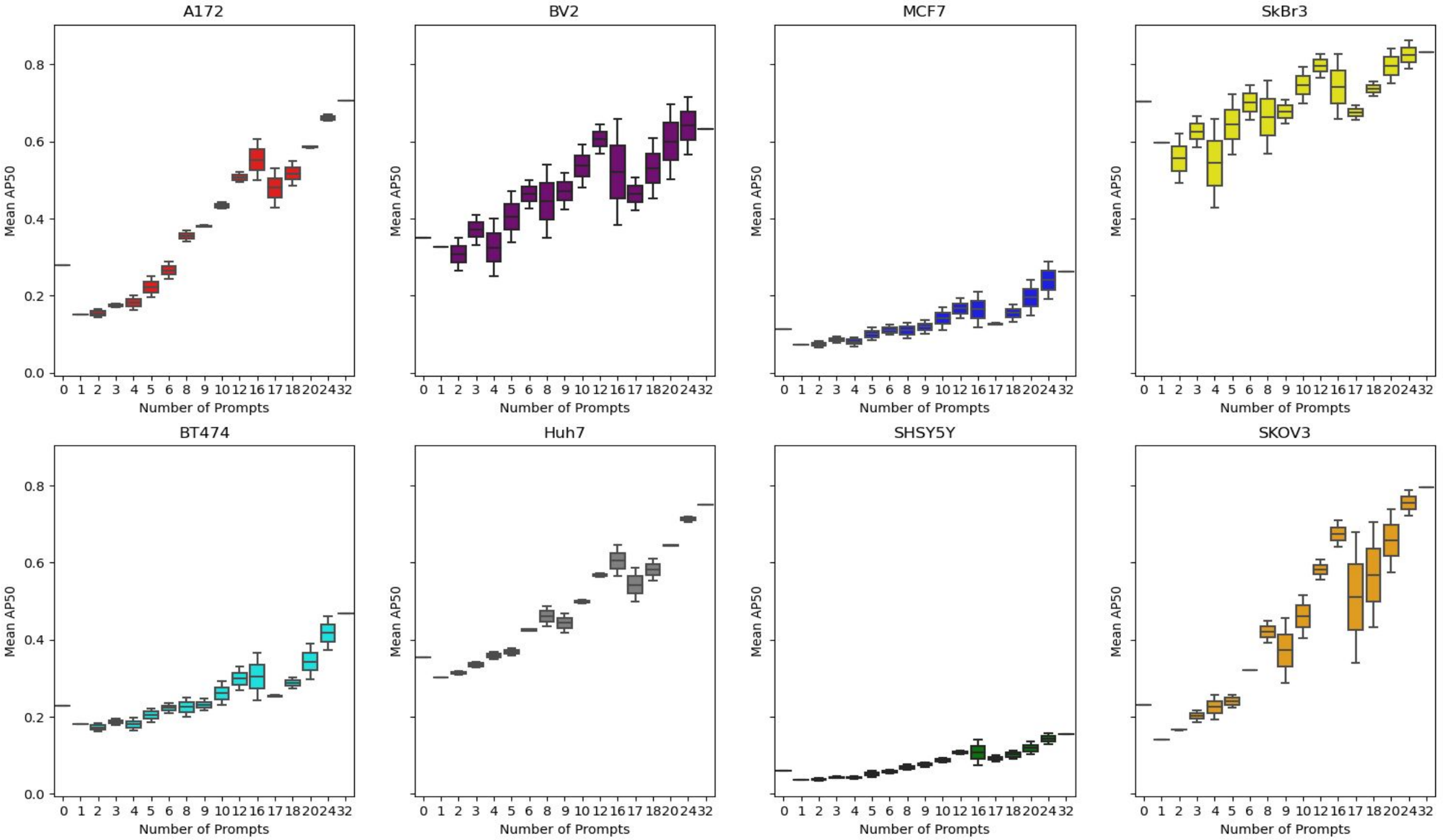
LiveCELL Dataset:
https://www.nature.com/articles/s41592-021-01249-6

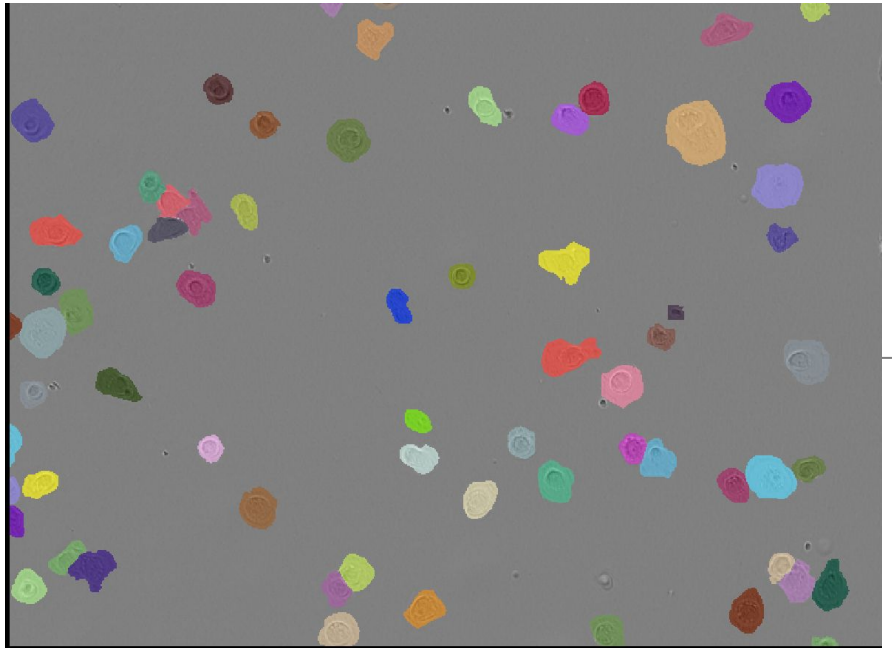


Quantitative results for all 8 cell lines in LiveCELL

Anwai

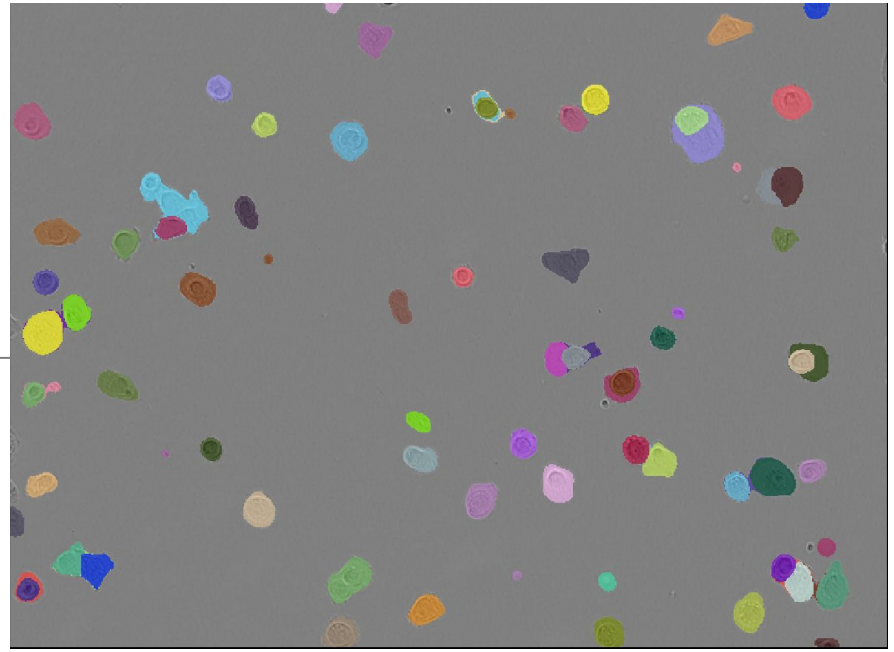



A172
BV2
MCF7
SkBr3
BT474
Huh7
SHSY5Y
SKOV3
Mean AP50
0.0
0.2
0.4
0.6
0.8
0 1 2 3 4 5 6 8 9 10 12 16 17 18 20 24 32
Number of Prompts

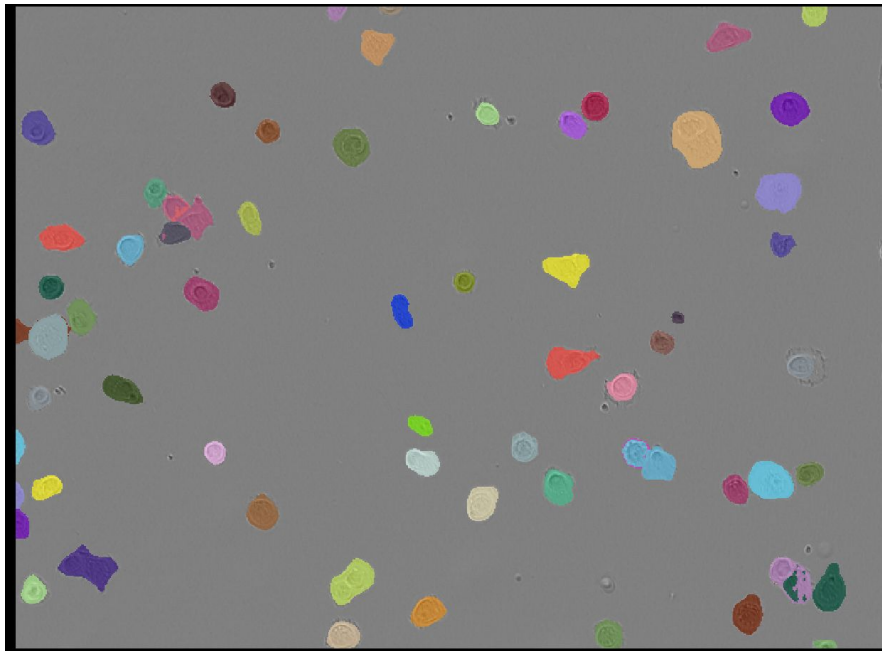


Groundtruth

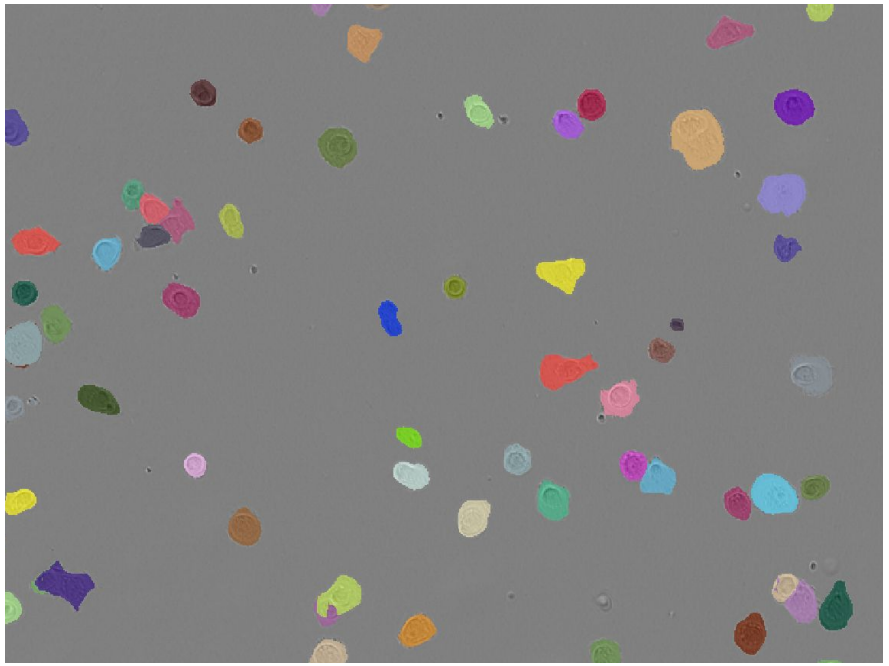
Cell line A172



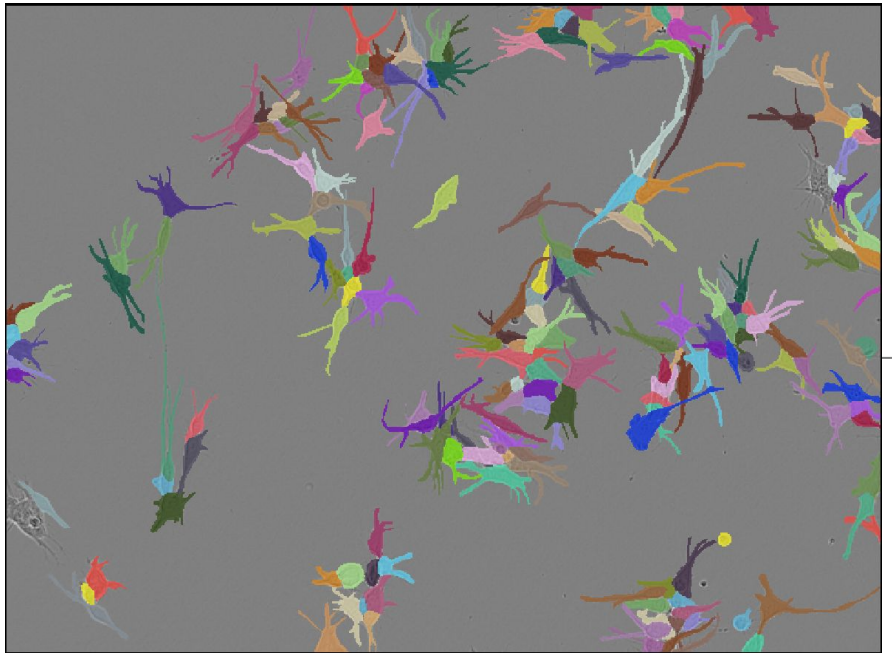
Automatic Segmentation



1 prompt

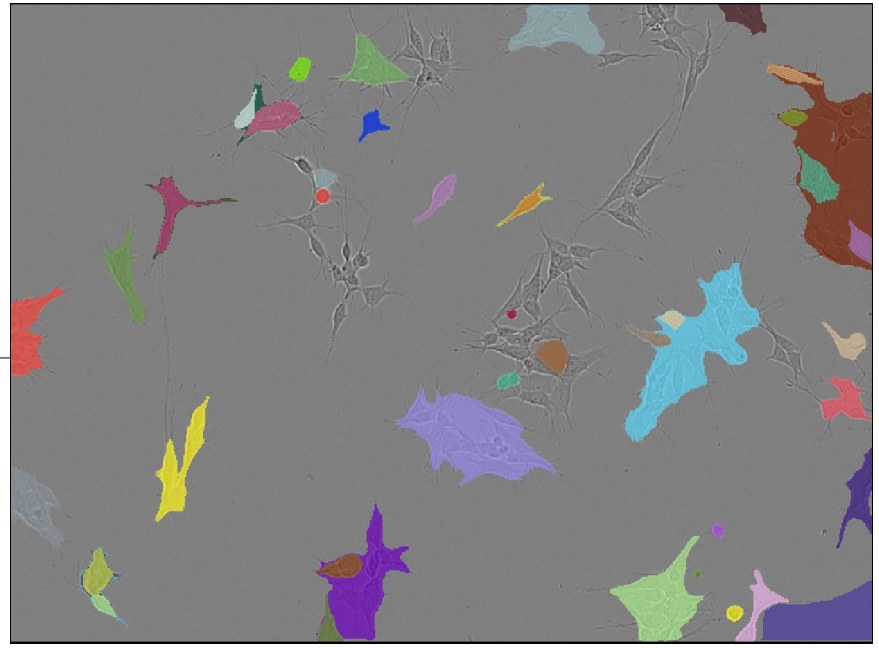


16 prompts



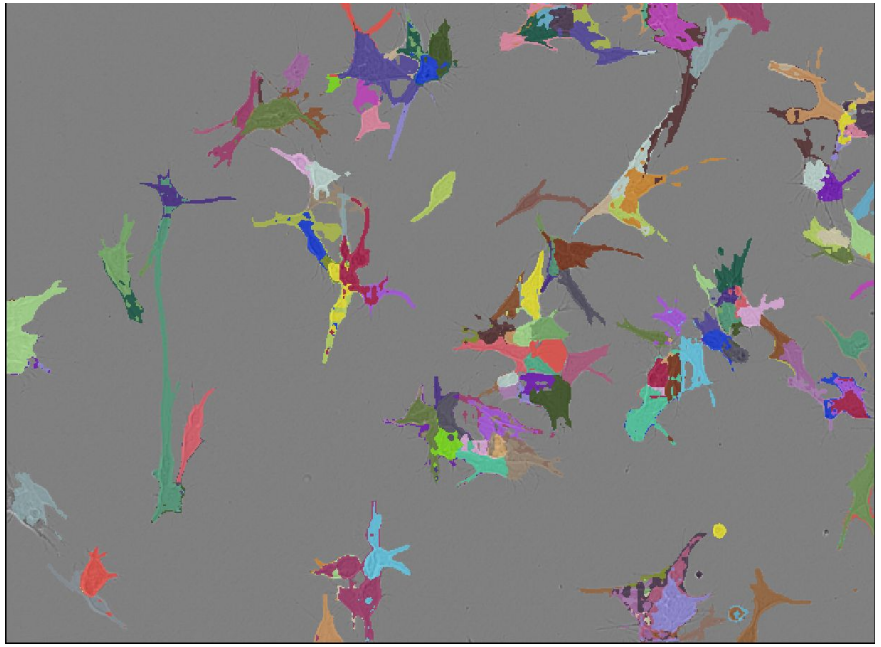
Groundtruth

Cell line SHSY5Y



Automatic Segmentation

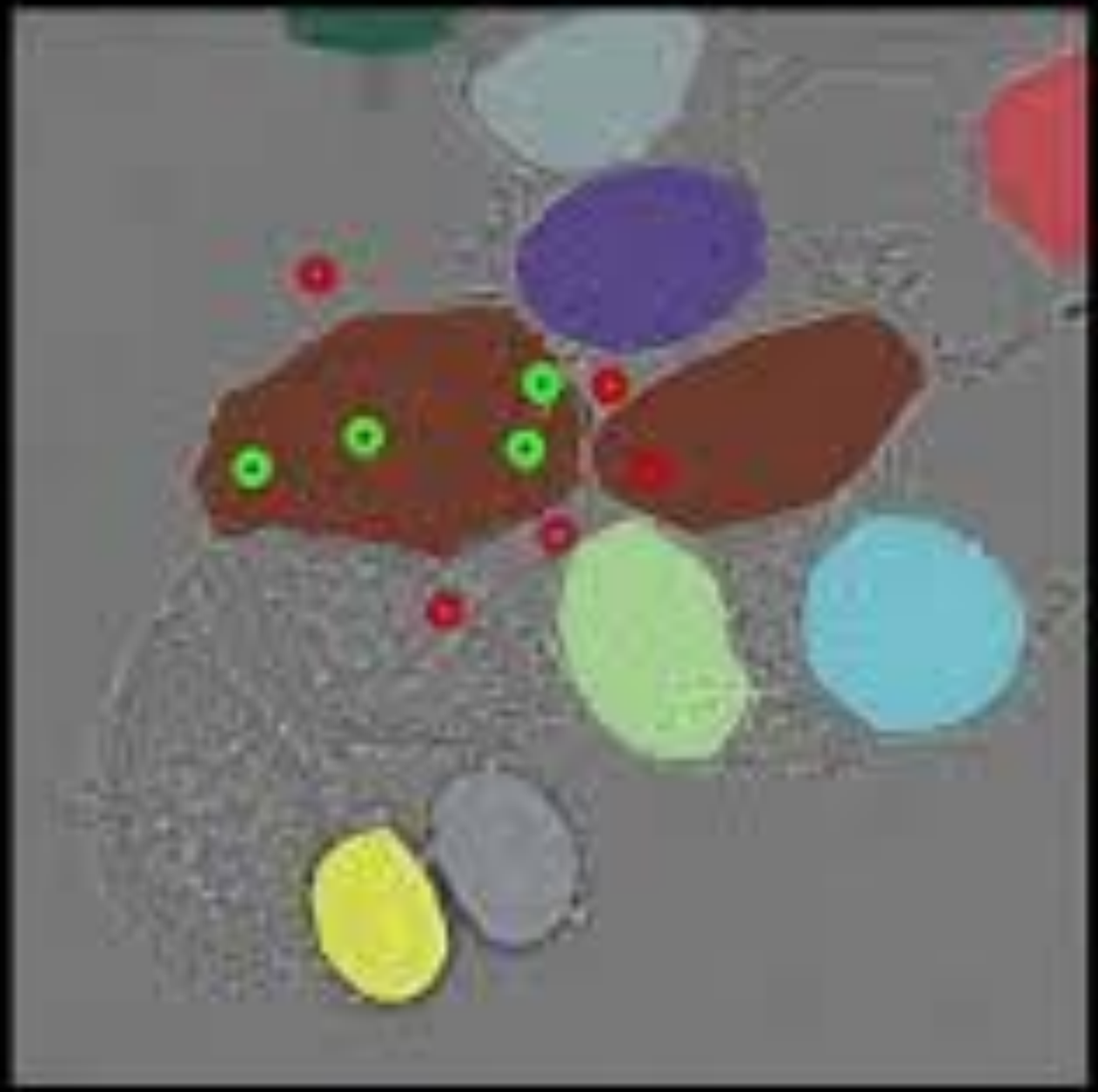
1 prompt

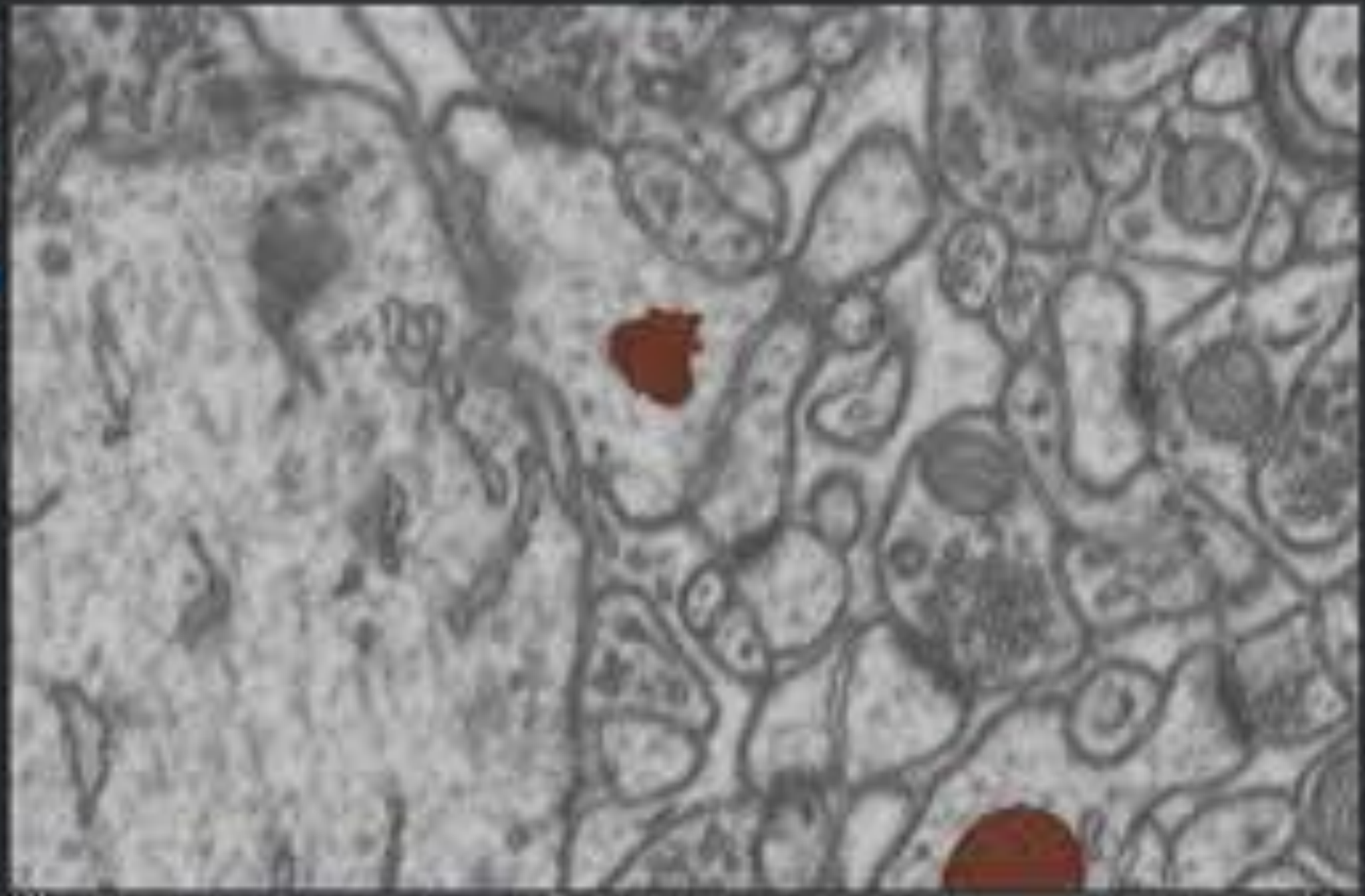


16 prompts

Segment Anything for Microscopy

Interactive 2d, 3d segmentation + tracking





Conclusion: SegmentAnything

- Interactive segmentation for microscopy works very well.
  - Automatic segmentation works ok,
    but worse than specialized models (e.g. CellPose).

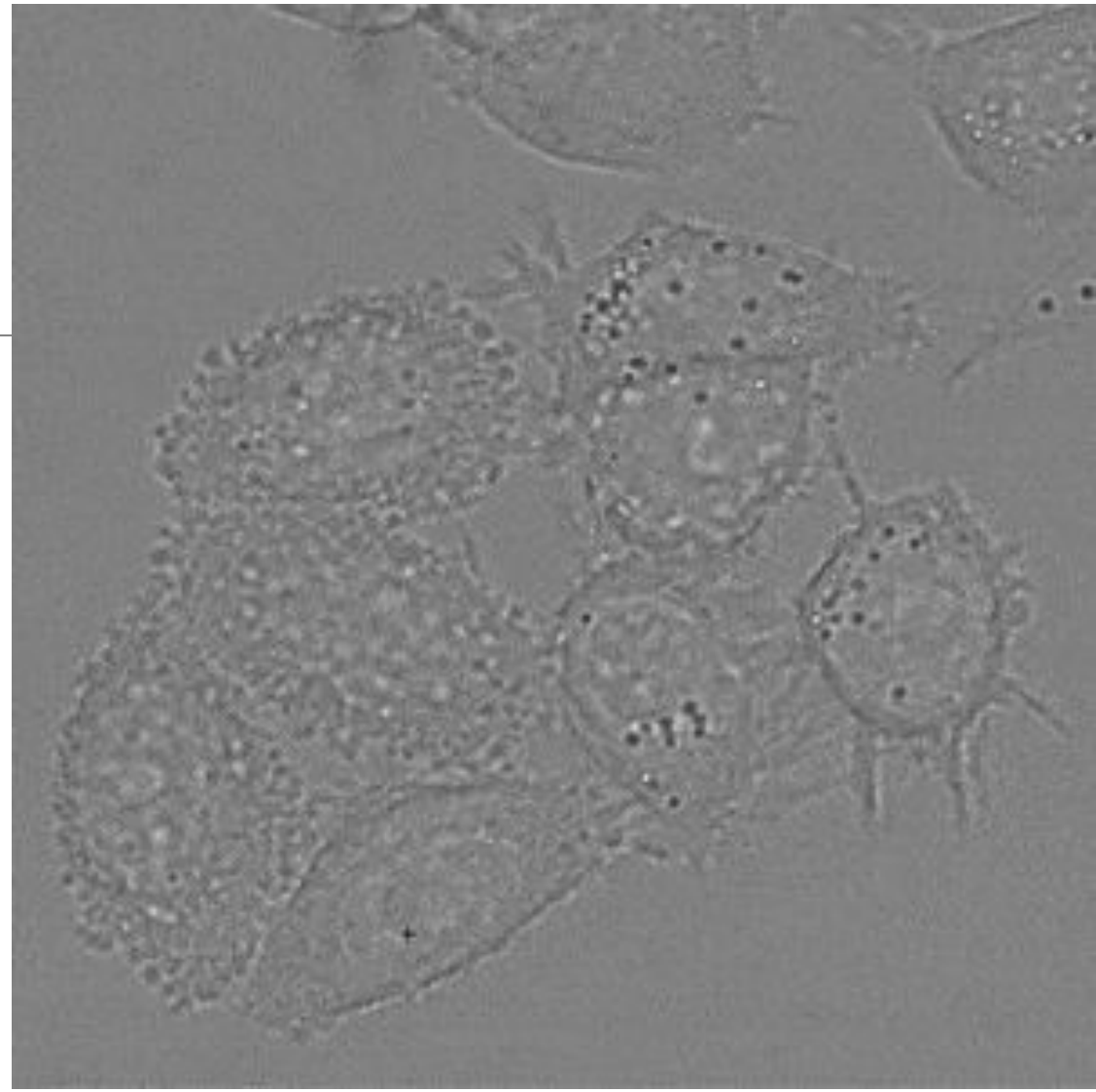
- It can revolutionize how we annotate data!
  - Already much faster for some applications?!

- Future steps:
  - Publish napari plugins for easy installation
  - Specialize the weights for microscopy (Fine-tuning)

Try it yourself!

Prototype versions built with napari for

- interactive 2d segmentation
- interactive 3d segmentation
- interactive tracking



available at
https://github.com/computational-cell-analytics/micro-sam

Acknowledgments

Need to visualize large multi-modal image data? Check out MoBIE @ OSL

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Uni Göttingen
Alex Ecker

Göttingen Campus
Wiebke Möbius
Leonie Schadt
Lukas Cyganek
Fabian Koitka
(and more)

My group
Anwai Archit

CIDAS Campus-Institut Data Science

SARTORIUS