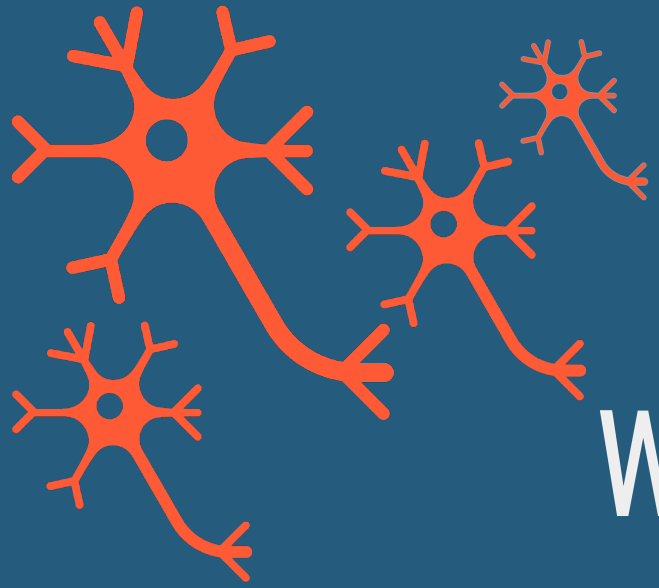


What the cell...
...and where?

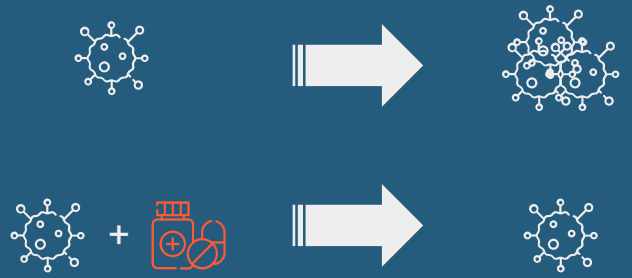
Cell classification and segmentation in nervous tissue microscopy images

Background

- Neuroblastoma: third most common cancer type in children
- Cells in nervous tissue

Drug response characteristic

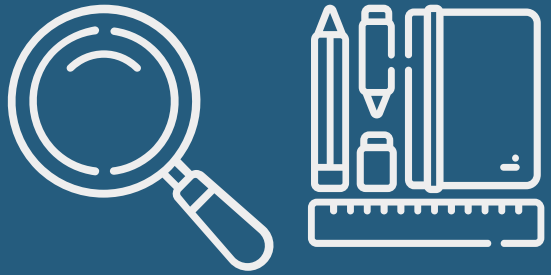
- Anticancer drugs aim to stop neuroblastomas from multiplying



Why AI?

Manual analysis of drug efficacy

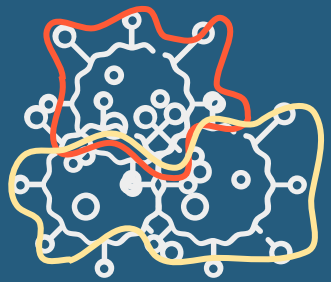
- Expensive
- Time consuming
- Requires concentration



Instance segmentation

- Automatized counting of cell bodies
- Challenge: complex structures of neurons

➡ inaccurate segmentation



Ronnerberg et al.:
U-Net: Convolutional Networks for Biomedical Image Segmentation
https://arxiv.org/abs/1505.04597

Why AI?

Manual analysis of drug efficacy

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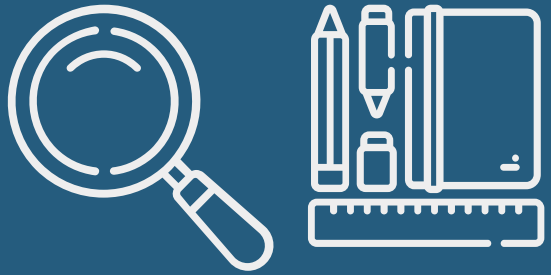
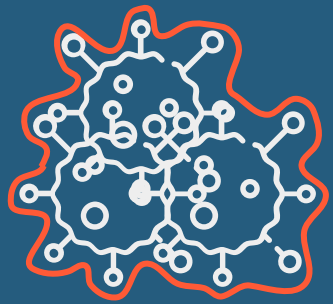


Semantic segmentation

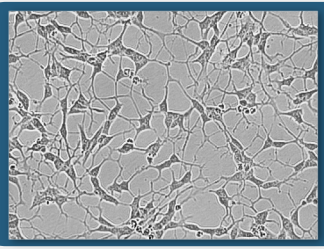
- Allows for localization of cell masses
- Analyzes the breakdown of cells by quantifying cell areas



Cell Types

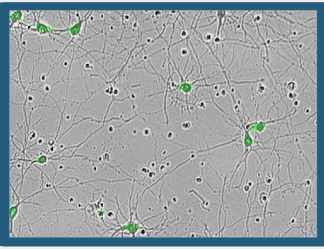
Data consists of 606 supervised light microscope images (704 x 520 pixels)

kaggle.com/c/sartorius-cell-instance-segmentation/data



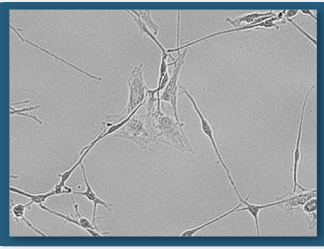
Neuroblasts

- high cell density
- concave cell shape



Neurons (green)

- small circular cells
- size: few 10 pixels



Astrocytes

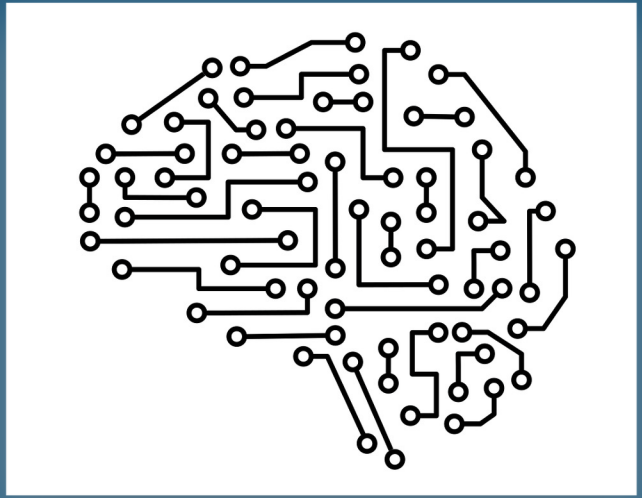
- elongated cells

Segmentation Model

Deep neural network

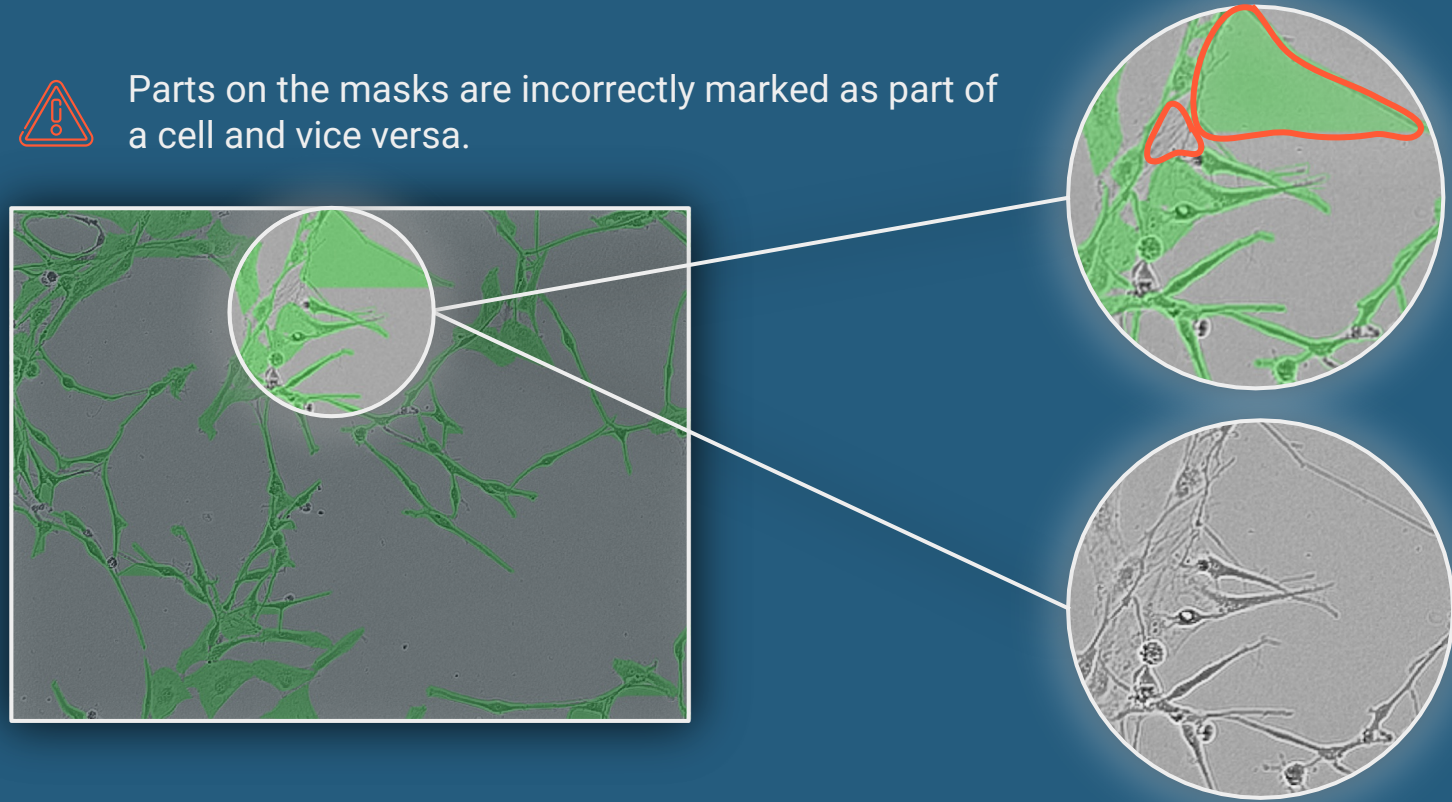
➡ U-net architecture:

- Capable of recognizing objects in image (cells)
- Able to determine the position of objects in the image



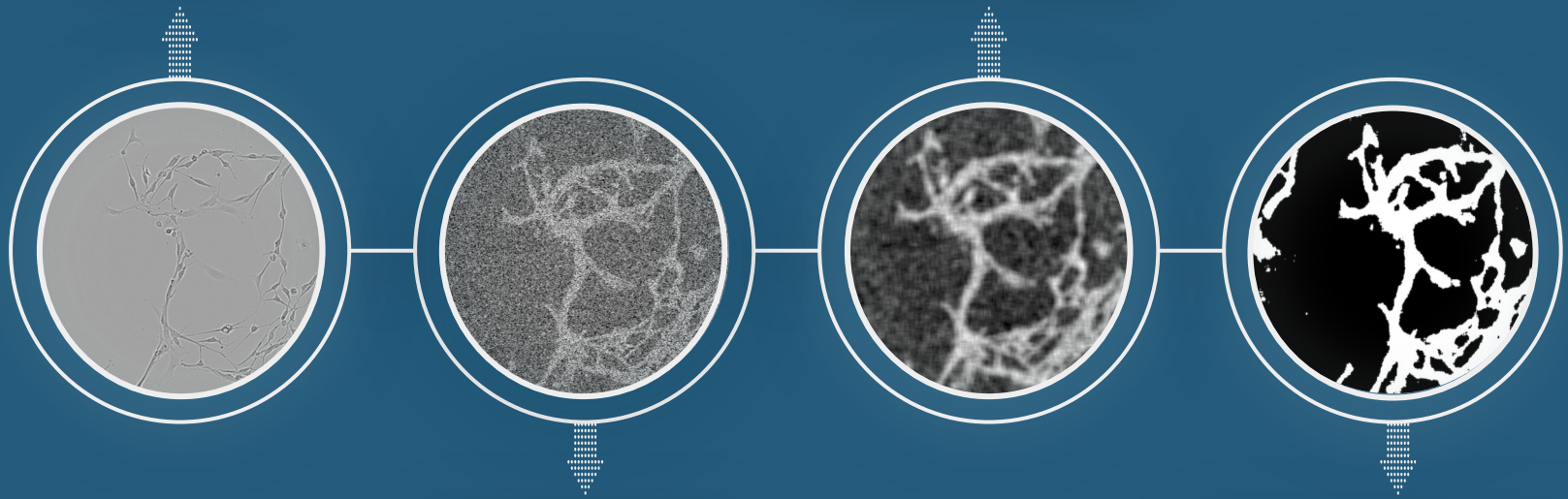
Problem ➡ Inaccurate Masks for Astrocytes

Parts on the masks are incorrectly marked as part of a cell and vice versa.



Mask Creation with k-Means

Original image



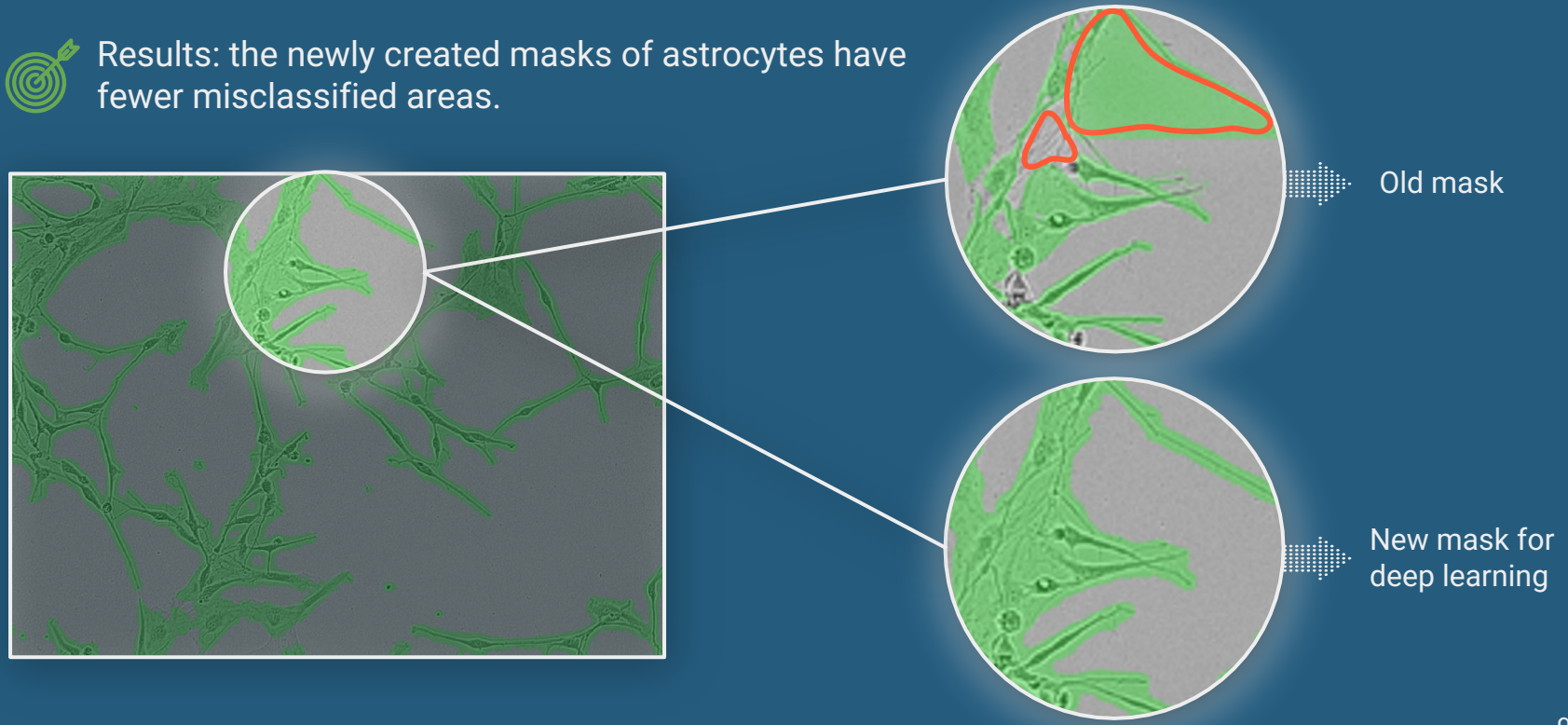
Gaussian filter to reduce noise and motion in the image

Pixels grouped by their brightness (k-Means)

Pixels assigned to "cell" or "no cell" categories based on brightness values

Comparison of New and Old Masks

Results: the newly created masks of astrocytes have fewer misclassified areas.



Modular U-Net Options

Model

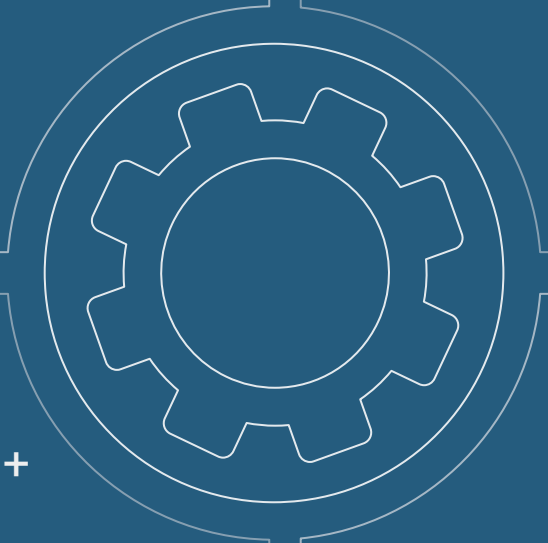
- Non-pre-trained U-net

Pre-trained Models

- MobileNetV2
- VGG16

Model type

- One model for each cell type
- All cells per model



Which masks ?

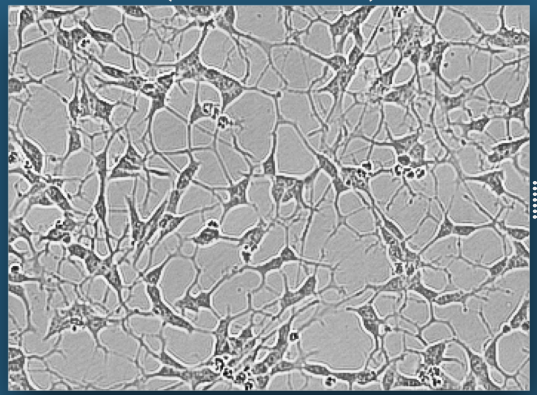
- Astrocytes: clustering + Gauss filter
- Astrocytes: SIFT + clustering
- Original

Data augmentations

- Quartering images before usage
- Mirroring, rotation

Image Segmentation with Deep Learning

Input: original image (neuroblasts)

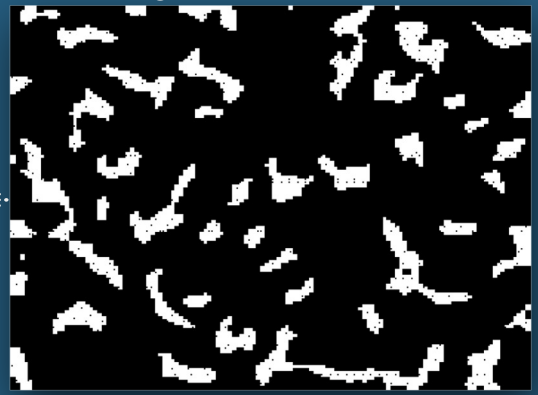


Neural network (U-net):

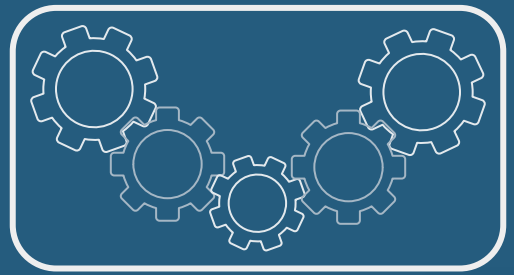
Recognition of:

- simple structures
- more complex structures
- cells

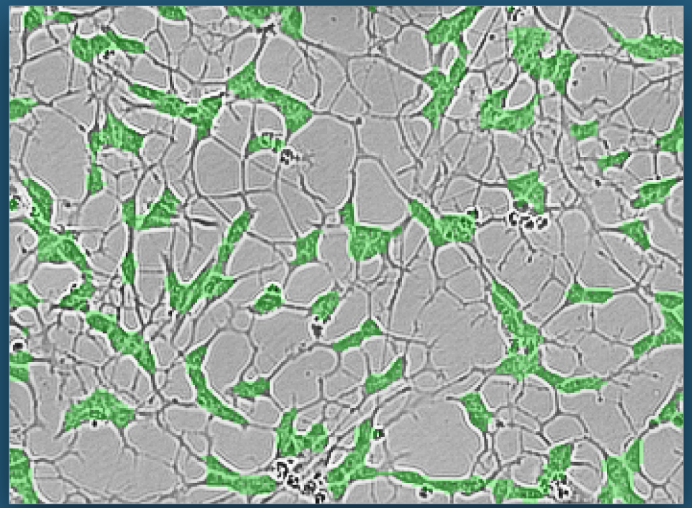
Output: segmentation mask



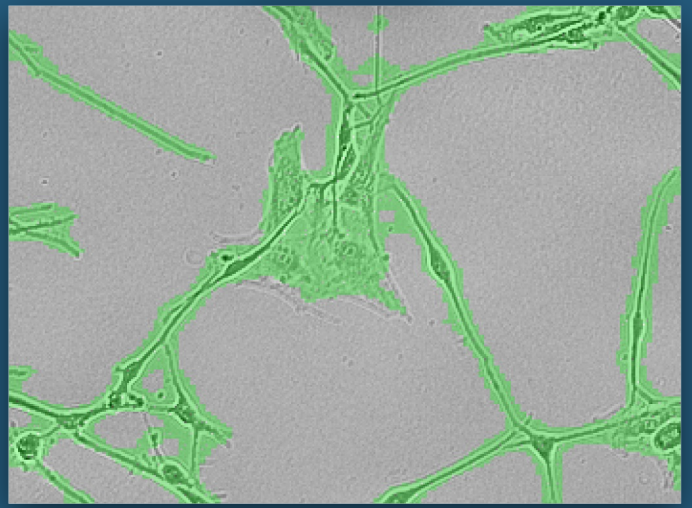
Overlayed Segmentation Masks



Neuroblasts



Astrocytes

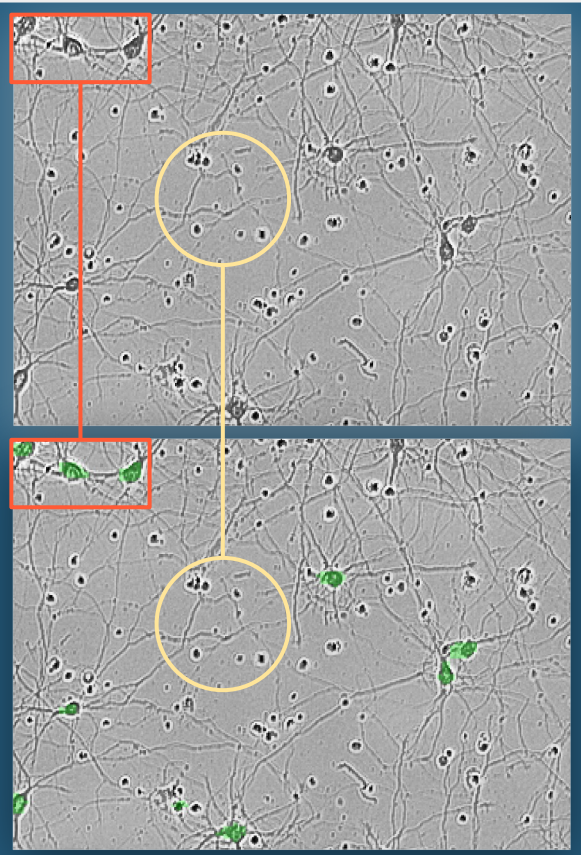


Comparison: Original vs Overlayed Neuron Image

Artifacts (black dots) do not belong to the cell

- Neural network separates cells (red) from artifacts (yellow)

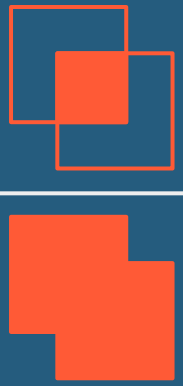
How do we quantify the overlap between model prediction and original mask?



Quantifying the Prediction Quality via IoU

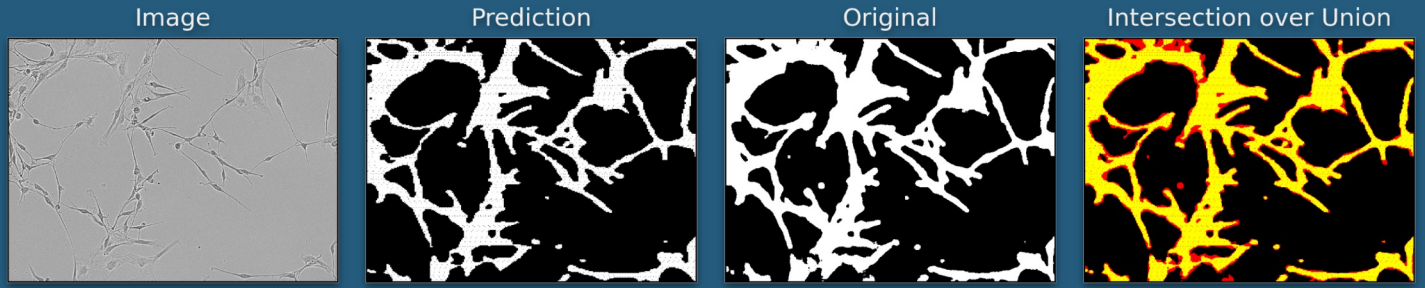
Intersection over Union (IoU)

$$\text{IoU} = \frac{\text{Area of intersection}}{\text{Area of union}}$$

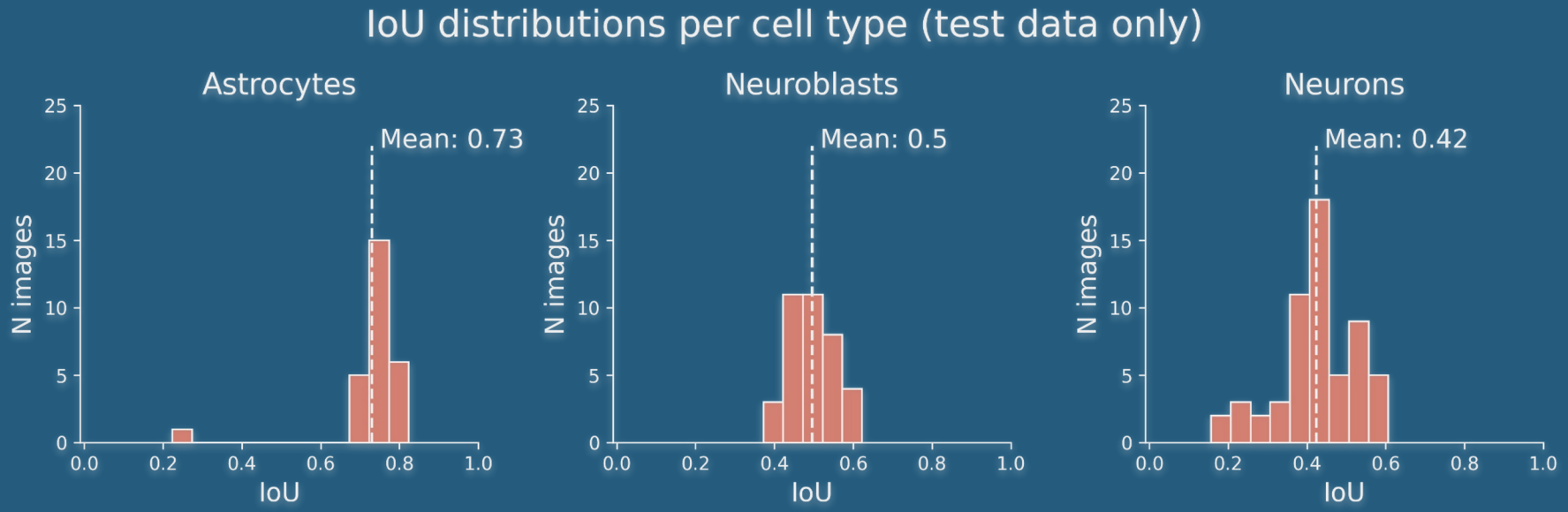


- Quantifies the overlap between original and predicted mask
- Values between 0 and 1:
  0 = no overlap
  1 = perfect overlap

Cell type: astrocytes, intersection over union: 0.77



Quantifying the Prediction Quality via IoU



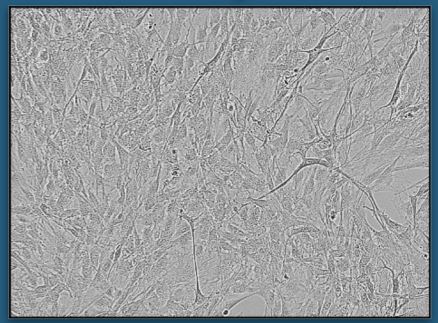
Benchmark IoU = 0.56 (different data, partially similar approach)

Hiramatsu et al., 2018, 10.1109/CVPRW.2018.00296

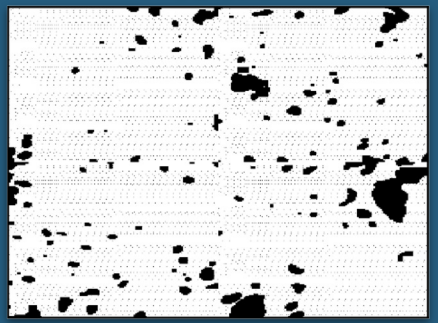
Error Analysis: Worst Astrocyte IoU Score

Cell type: astrocytes, intersection over union: 0.22

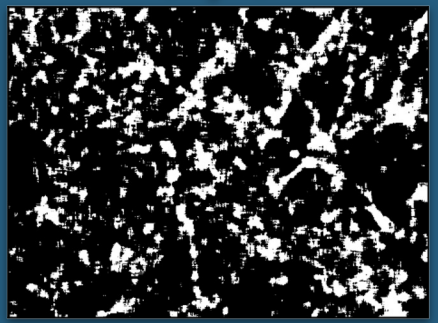
Image



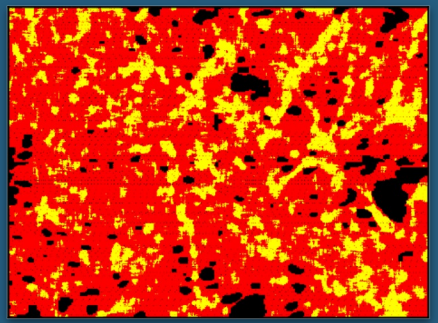
Prediction



Original



Intersection over Union

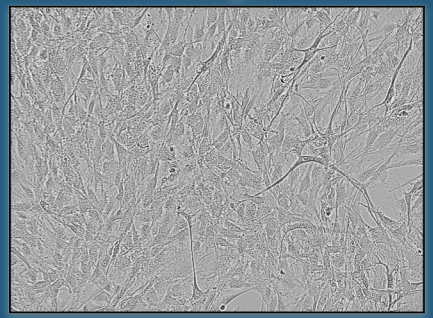


- Worst cell mass prediction for this astro cell image
- Outlier: test image more crowded than typical astro images

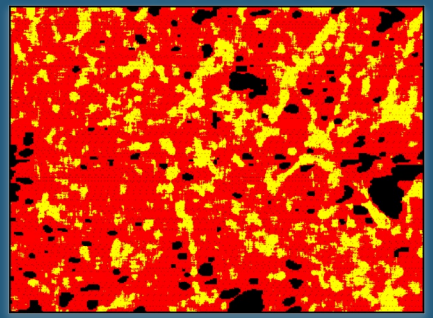
Error Analysis: Worst Astrocyte IoU Score

IoU: 0.22

Image

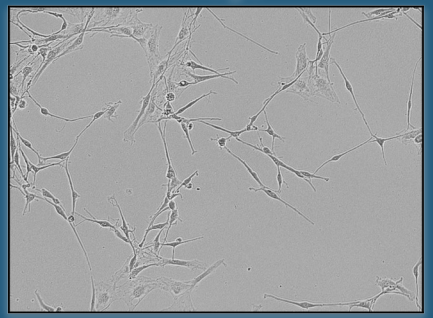


Intersection over Union



IoU: 0.77

Image



Intersection over Union

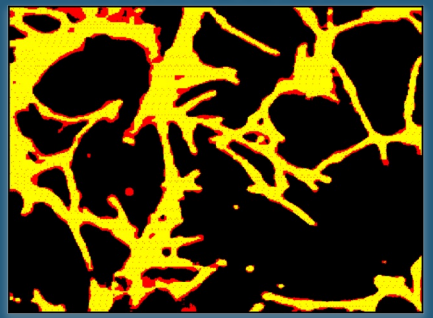
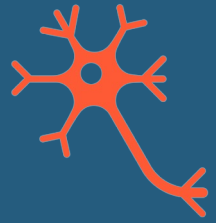


Image with typical cell mass prediction is less crowded

and with clearer, high contrast structures



Conclusions

Summary

- Cell mass localization in microscopy images via AI-driven semantic segmentation
- Non-pre-trained neural network, separately adapted per cell type
- Good results for 2 of 3 cell types (astrocytes and neuroblasts)

Outlook

- Pre-train a model on multiple freely available medical image datasets
  - here: poorer performance of models pre-trained on everyday images
- Estimate cell count from cell mass area

Thank you for your attention!

We are looking forward to questions and discussion
in the breakout rooms.