Segmentation of nuclei in Microscopy Imaging
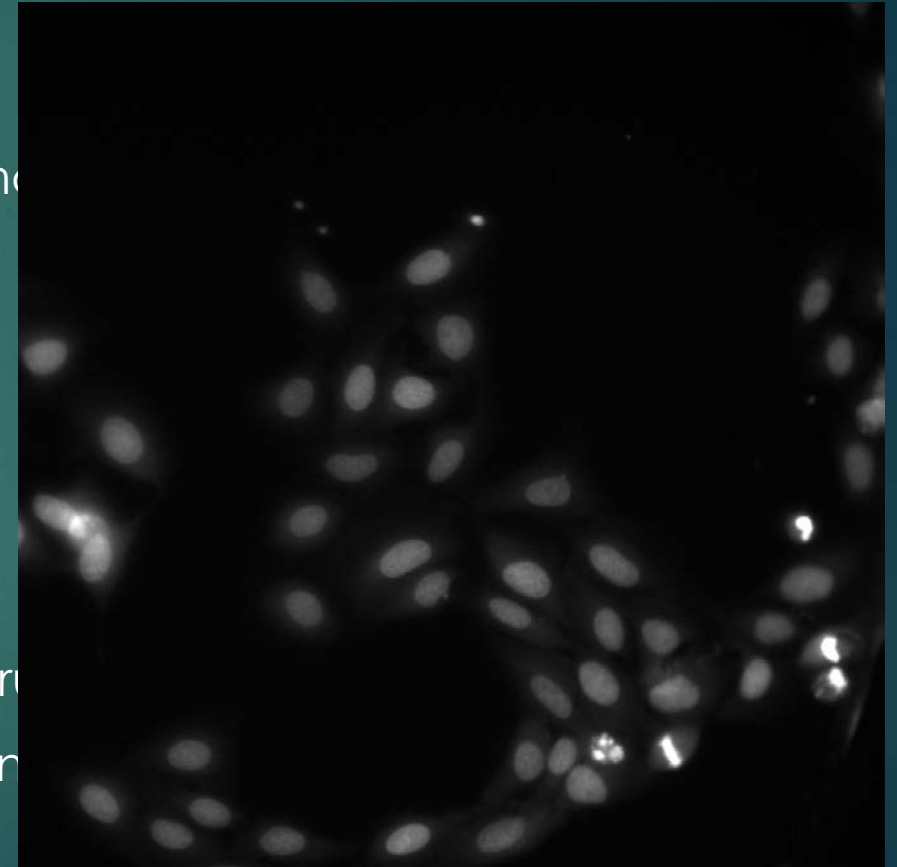
USING THE U-NET ARCHITECTURE

Sonja Aits – Queen of lysosomes

- What are lysosomes?
- Cancer research
- Fluorescent microscopy imaging (FMI)
- The biggest bottleneck right now

Detection of nuclei in FMI

- My task
  - Identify the outlines of nuclear objects in Sonjas im[age]

- Previous work
  - U-net
  - Broad Institute

- Data
  - Image set from Broad Institute (including ground tr[uth])
  - Image set from Sonjas lab (without ground truth an[...])

# Baseline: Otsu's method
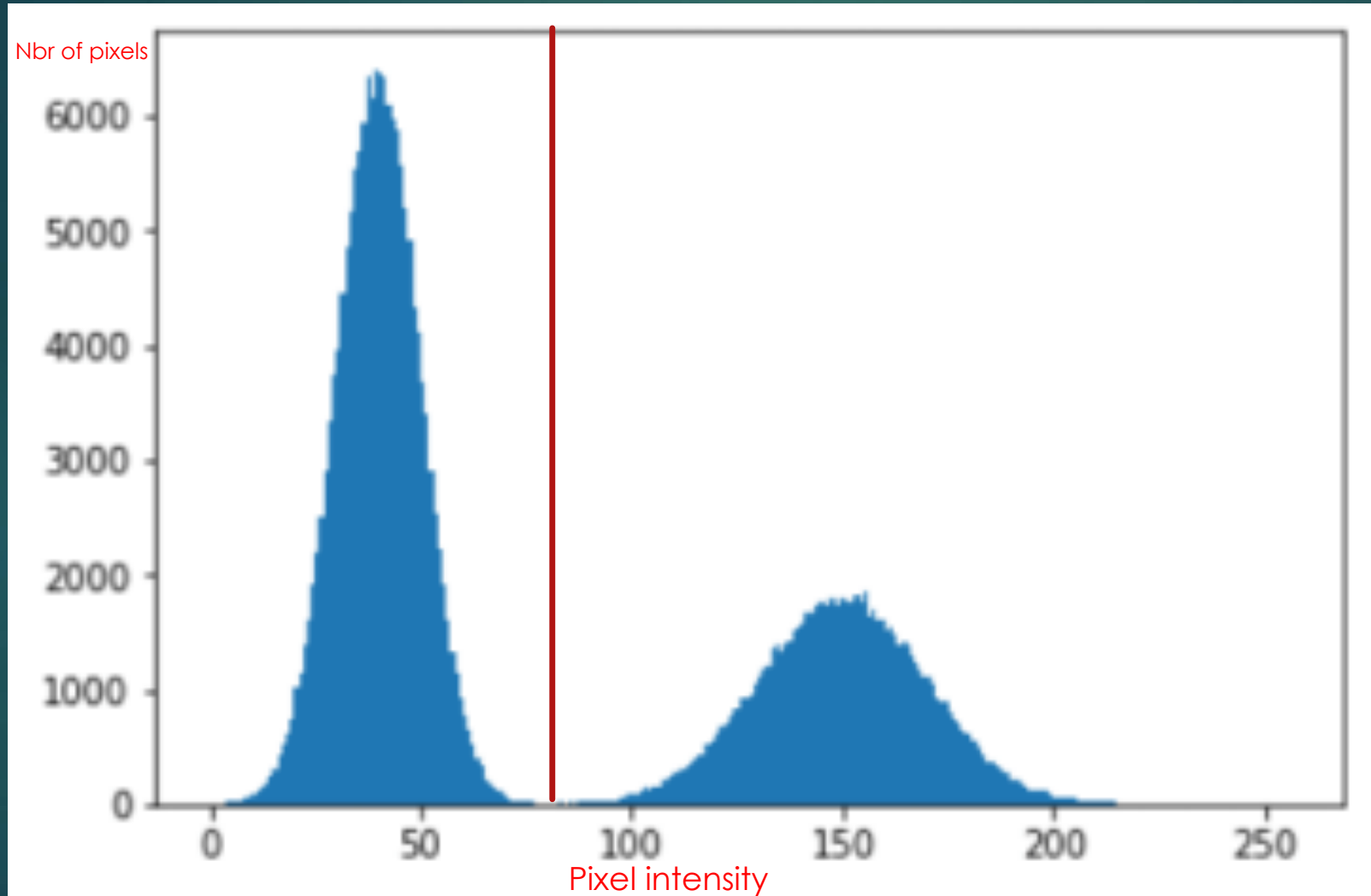
Convolutional Neural Networks & the U-net architecture

- ► Convolutional neural network:
  - ► Resembles the visual cortex in the brain
  - ► Convolution to extract high level features
  - ► Pitfalls

- ► U-net
  - ► Specific objective function (loss function)
  - ► Compatible with augmented images

- ► Broad Institute version of U-net
  - ► Specialized for nuclei detection
  - ► Borders are weighted extra in loss function

Image Augmentation

- ▶ Random Cropping
- ▶ Rotation/Flipping
- ▶ Illumination
- ▶ Affine/Elastic

input

deformed
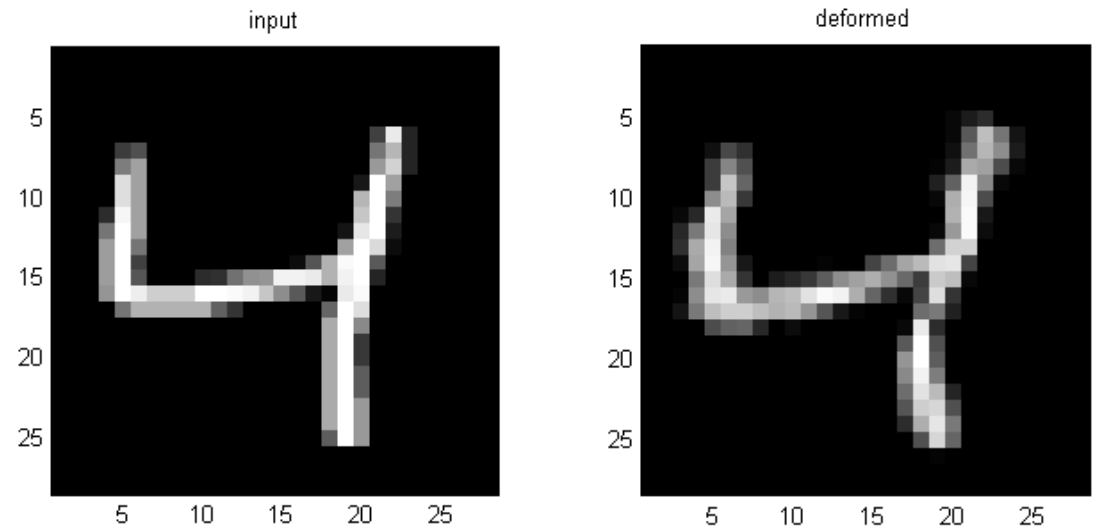
Training

- Train using Broad Institute images → Model 1
- Broad Model + Sonjas images + Augmentation → Model 2
- Leave one out cross-validation when training with Sonjas images

Evaluation

$$IoU = \frac{\text{Area of Overlap}}{\text{Area of Union}}$$

- Common in image processing: Solely pixel based (IoU)

- Better for nuclei detection: Pixel & object based:
  - IoU for each individual object + minimum area coverage threshold
  - Recall: $\dfrac{TP}{FN + TP}$
  - Precision: $\dfrac{TP}{FP + TP}$
  - F1-score: Harmonic mean of Precision and Recall
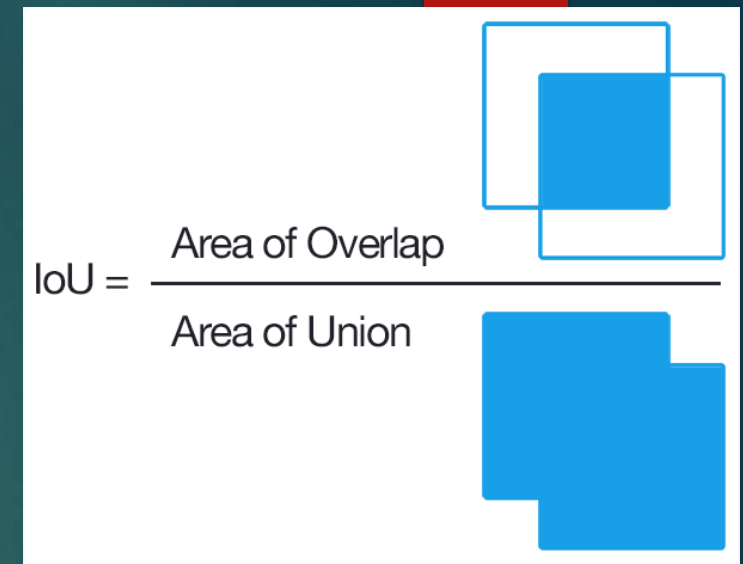
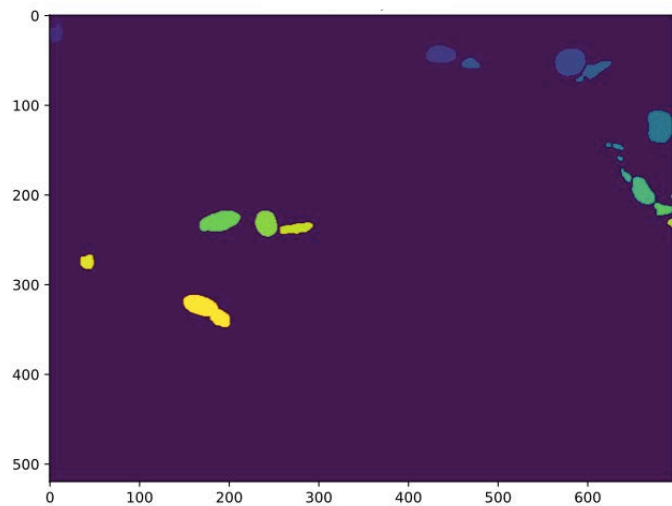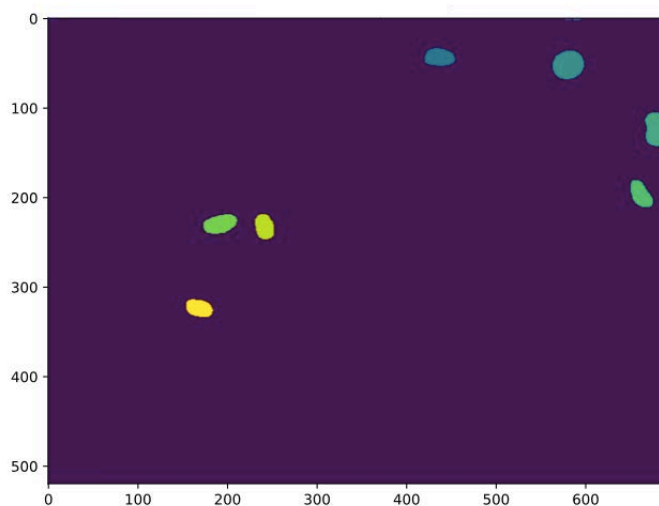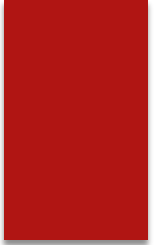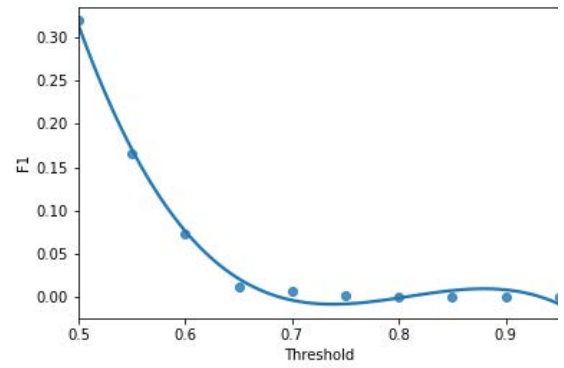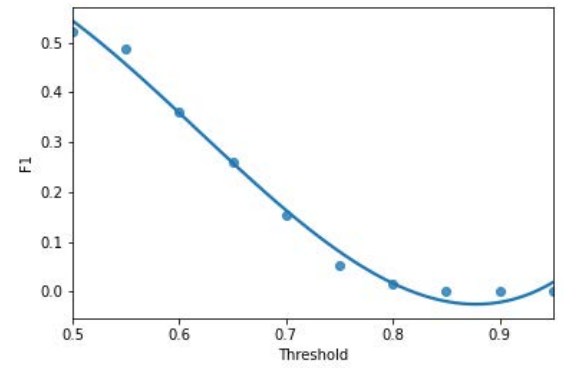Ground Truth
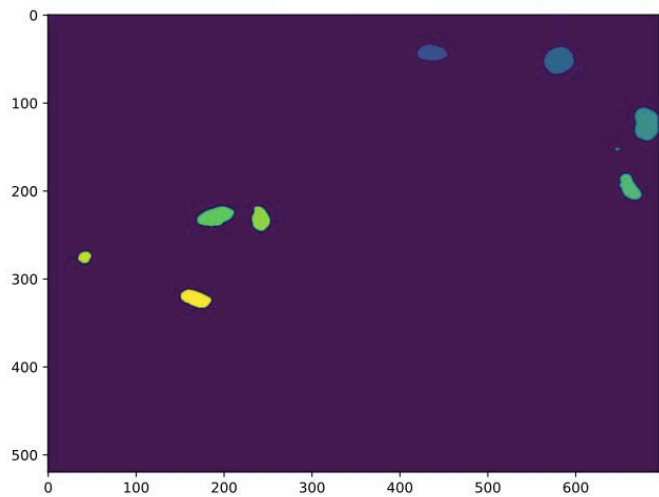
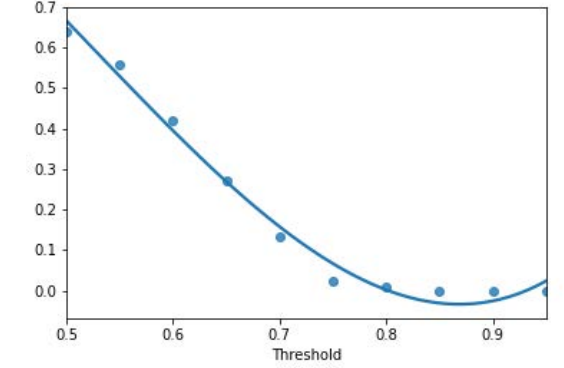Otsu's method
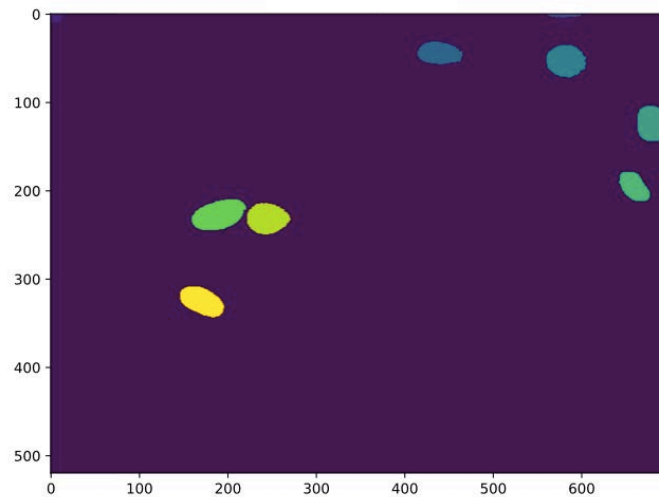
Model 1: Broad Inst.

Model 2

Results: visual inspection

Otsu's method | Model 1 | Model 2

Otsu's method	Model 1	Model 2
IoU: 0.389	IoU: 0.356	IoU: 0.496

Results: F1-score

Conclusion & Continued work

▶ Finding an object is easy, finding it's correct outline is hard

▶ Addition of manually annotated images really improves the performance

▶ Image augmentation also increases performance

▶ To improve:

    ▶ Add more manually annotated images

    ▶ Try elastic transformations (& others)