Implementation and evaluation of Otsu's thresholding

Project proposal

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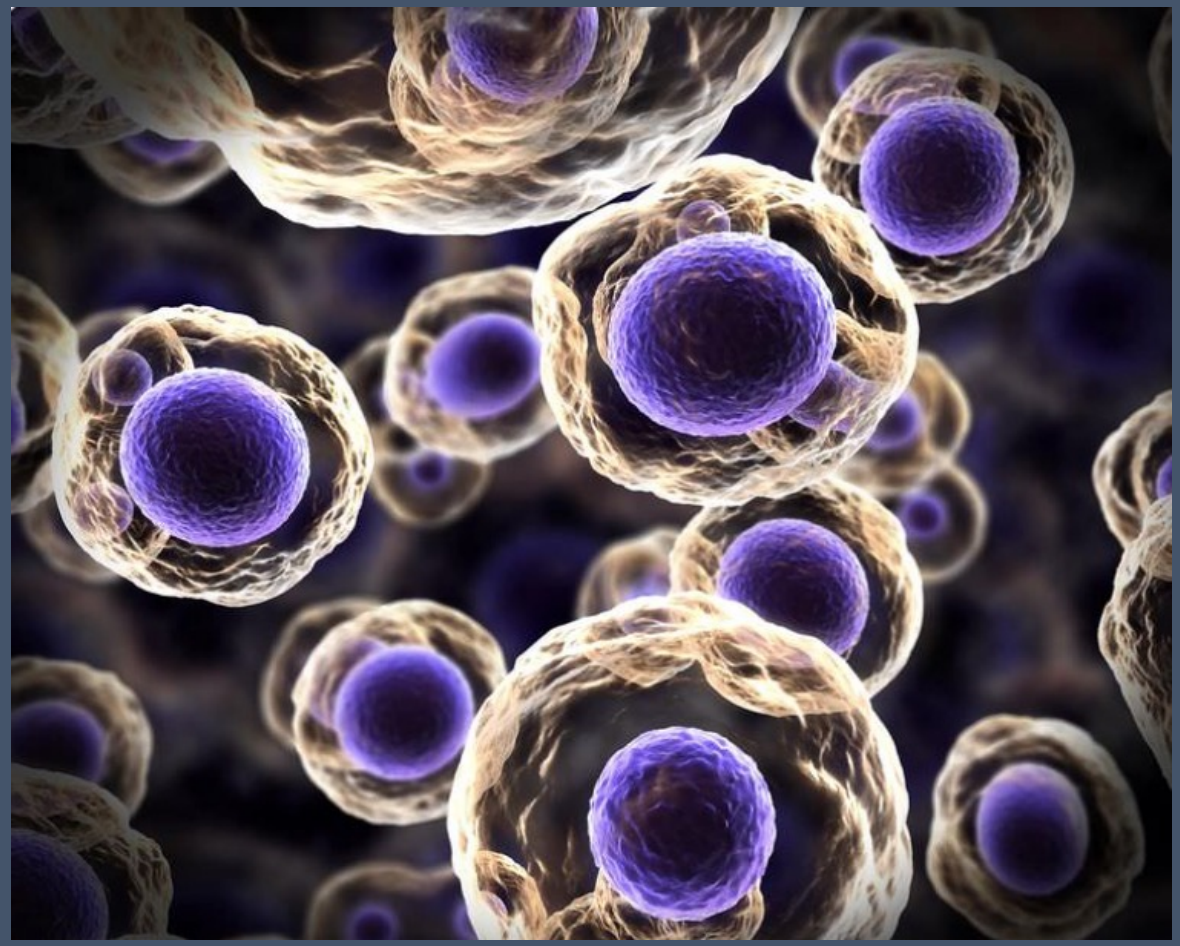
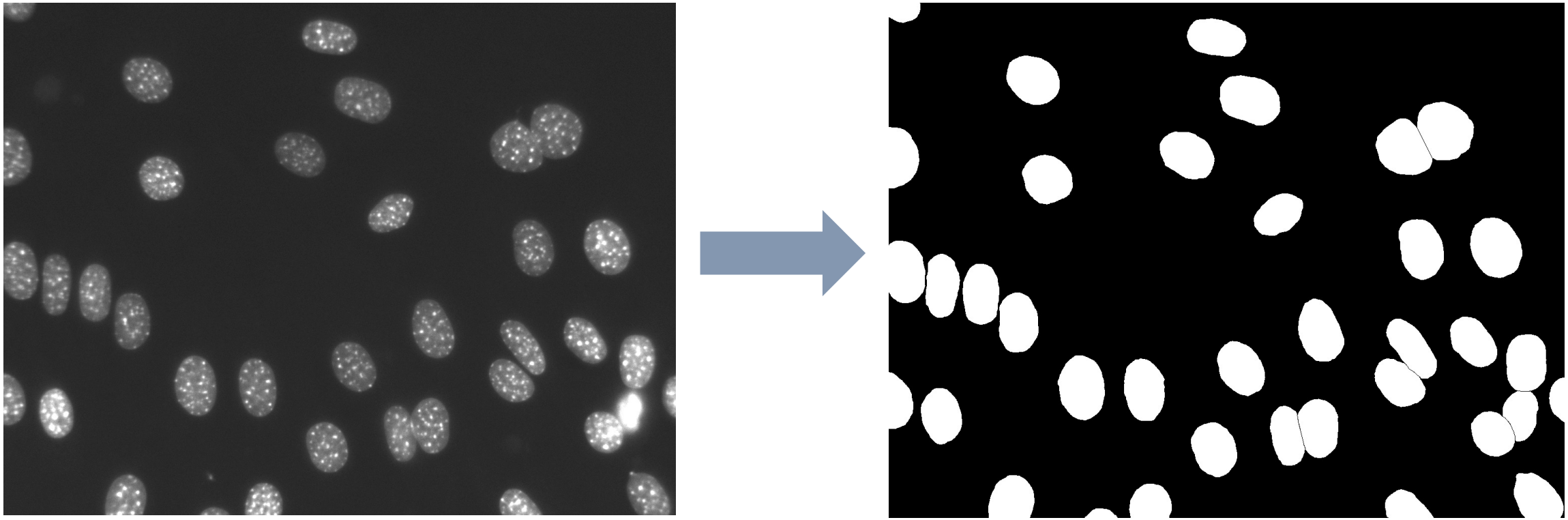


Cell nuclei segmentation

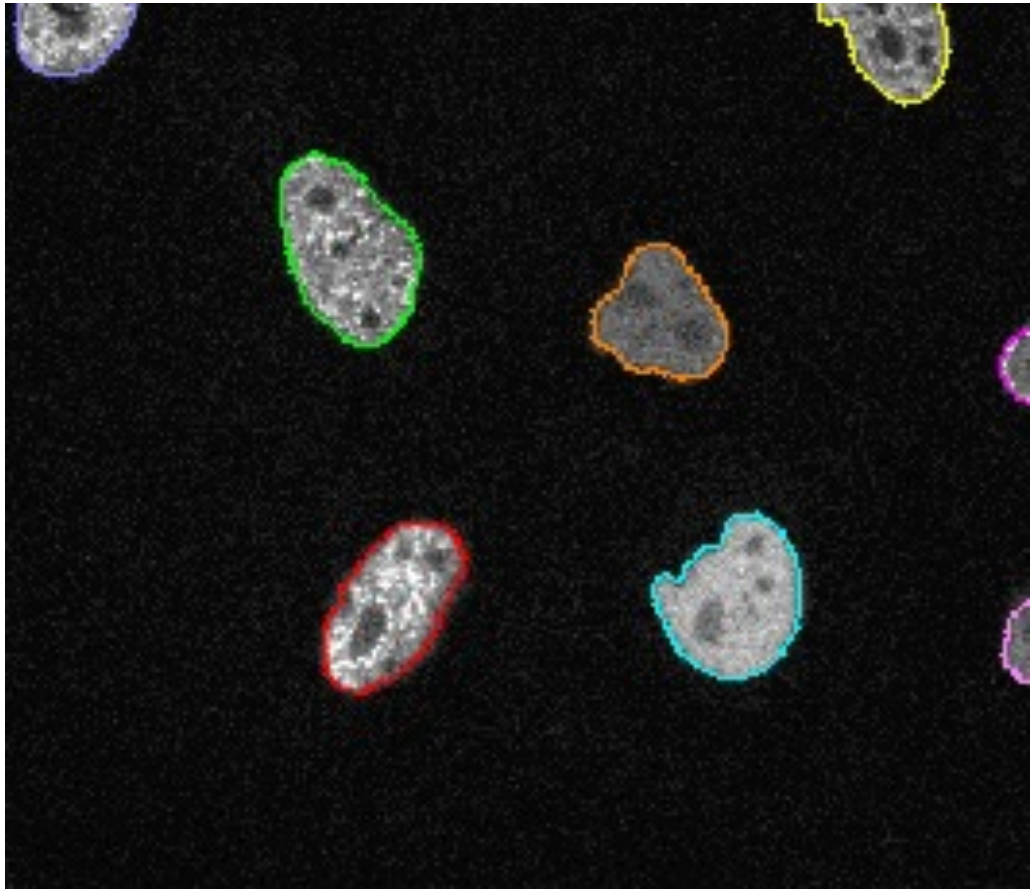
https://bio.libretexts.org/Bookshelves/Introductory_and_General_Biology/Book%3A_Introductory_Biology_(CK-12)/02%3A_Cell_Biology/2.08%3A_Cell_Nucleus

Image segmentation



Applications

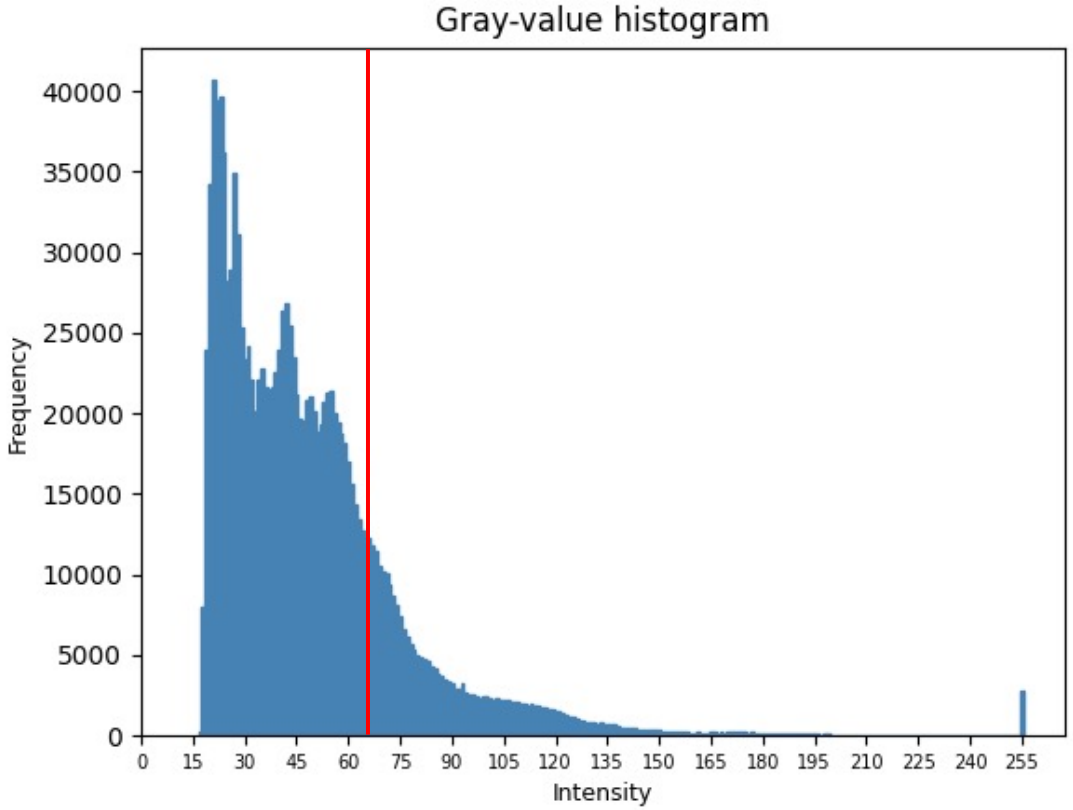
- High-throughput cytometry
  - Cell size
  - Cell counting
  - Cell-cycle determination
- Cell tracking



Methods

- Thresholding → Intensity clipping

Otsu's thresholding



Workflow

01
Input

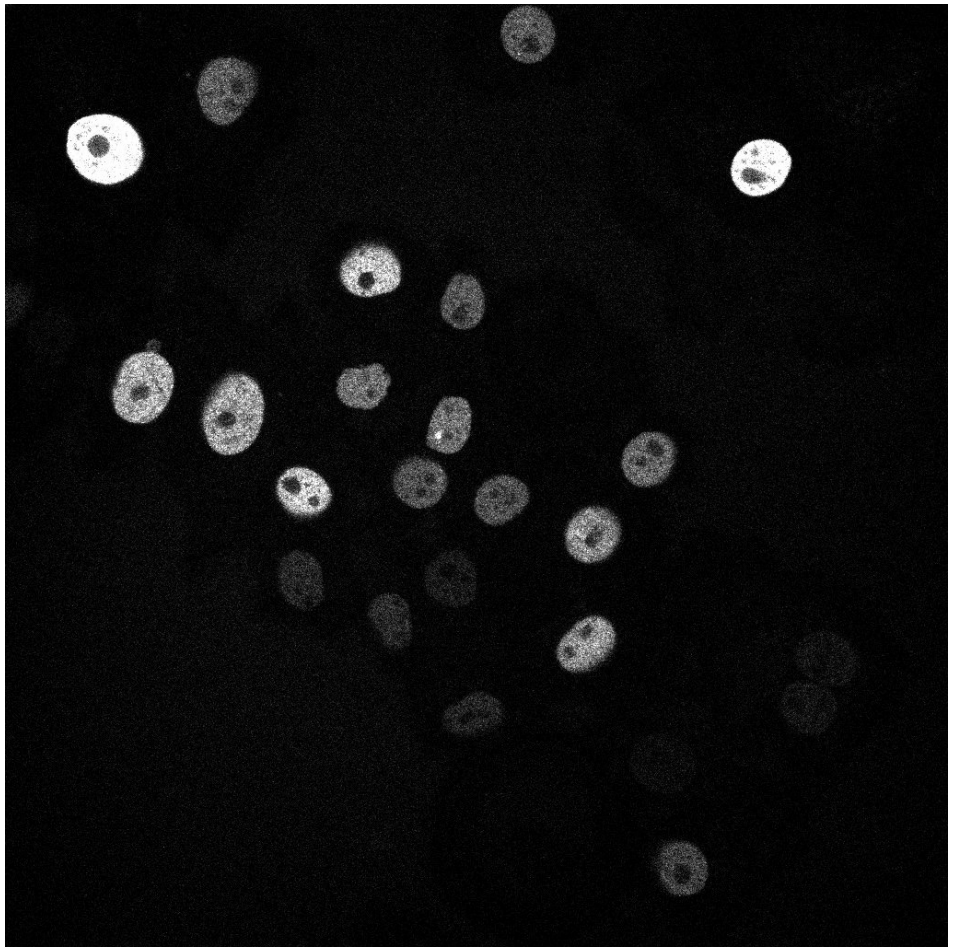
02
Preprocessing

03
Otsu‘s Thresholding

04
Dice Score

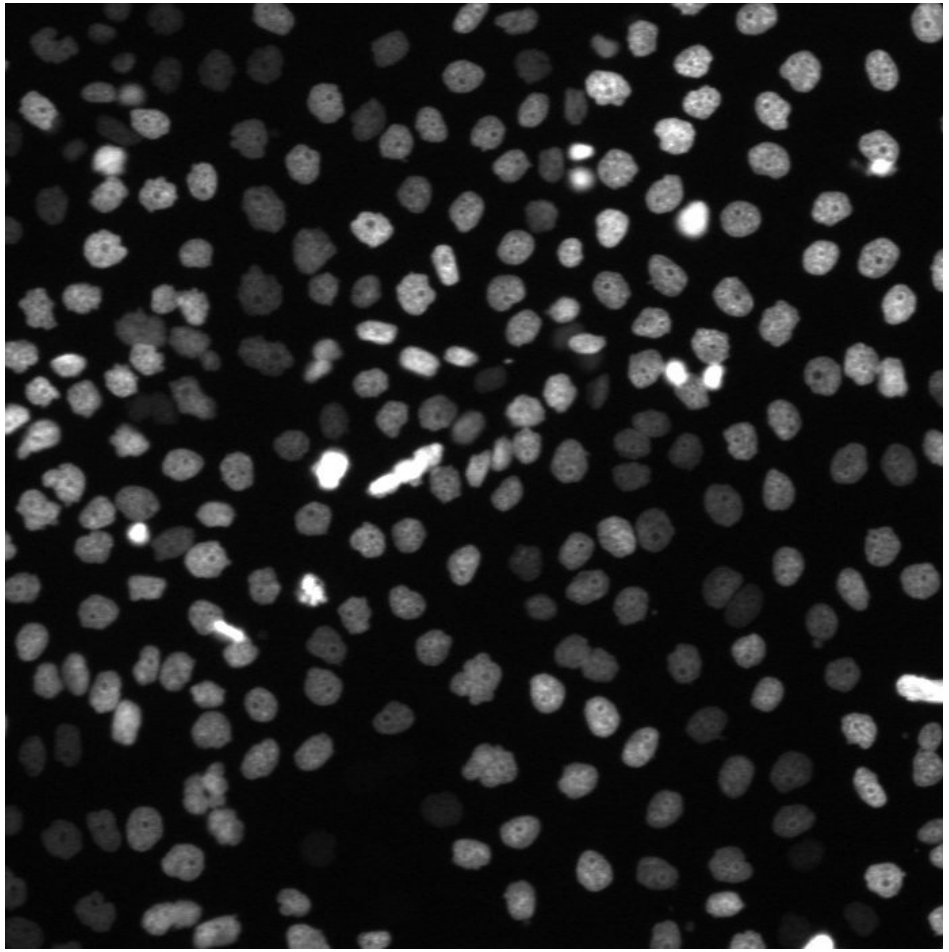
05
Comparison

Input 1: N2DH-GOWT1 cells



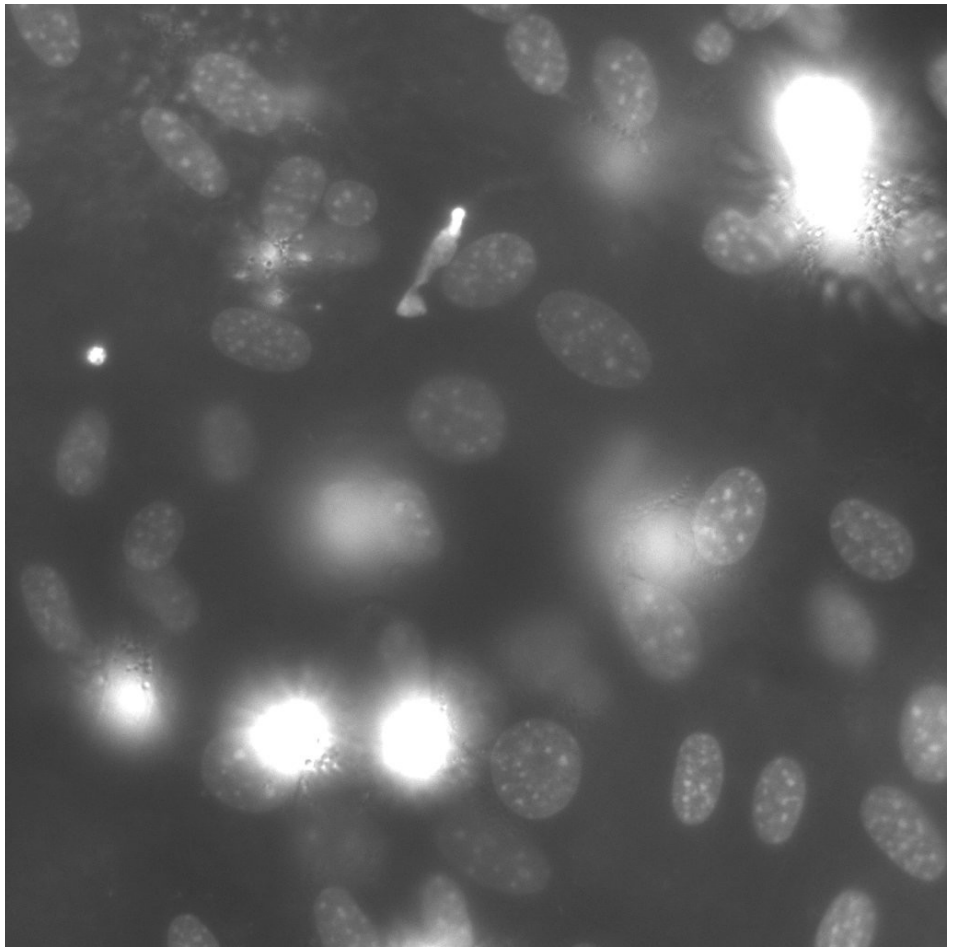
- GFP-Gowt1 mouse embryonic stem cells
- Time-laps confocal microscopy and GFP-staining
- Investigate genomic integrity of the cells

Input 2: N2DH-HeLa cells



- Human epithelial cells of cervical cancer
- Live imaging of fluorescently labelled chromosomes
- Phenotypic profiling of the human genome

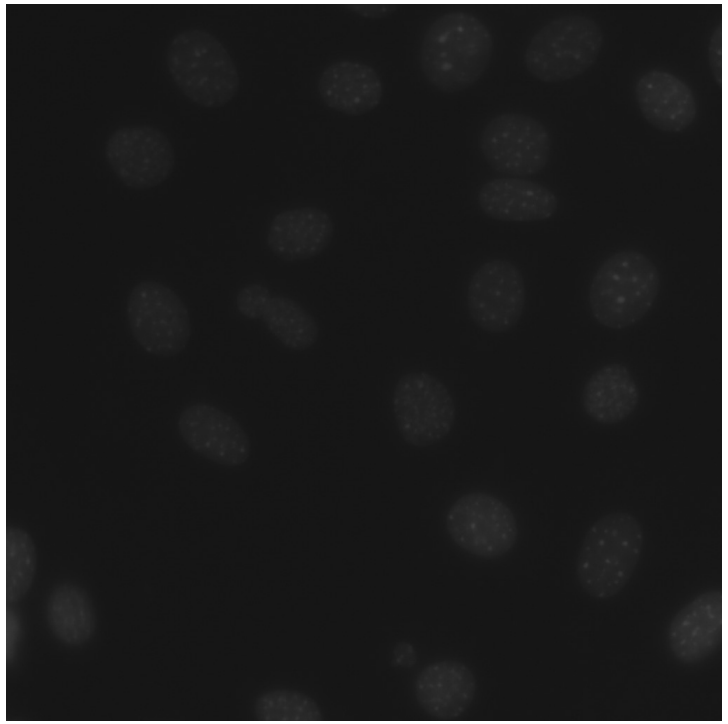
Input 3: NIH3T3 cells



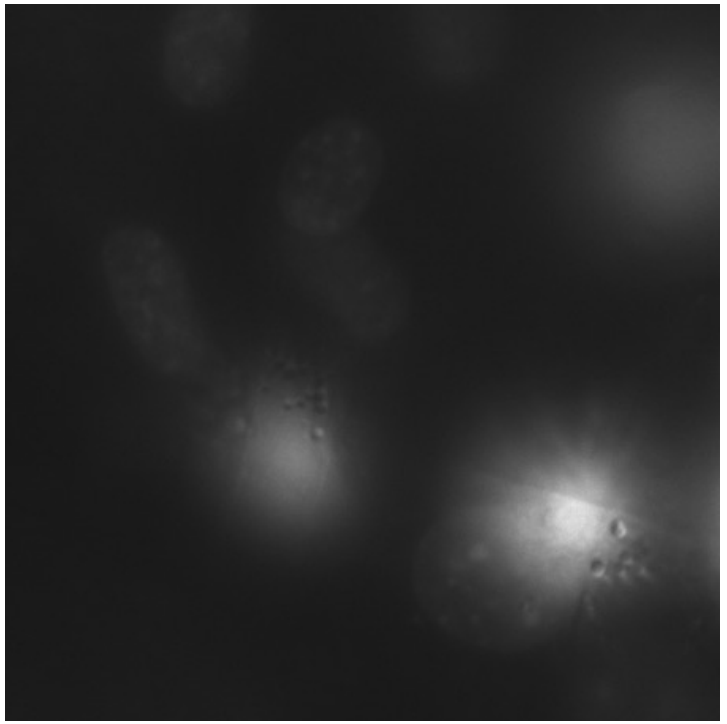
- Several mouse embryonic fibroblast cells
- Fluorescence microscopy images
- Evaluation of image analysis pipelines

Problems

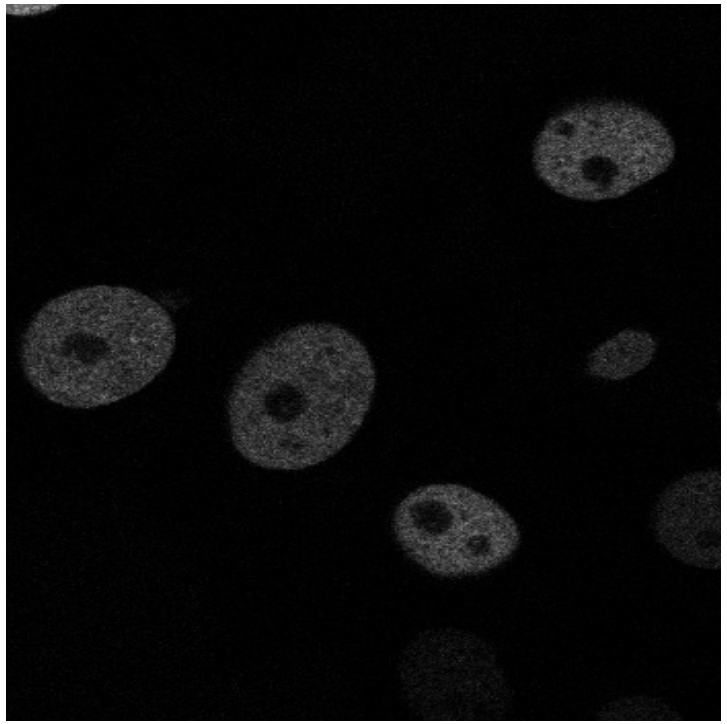
Low contrast



Reflections



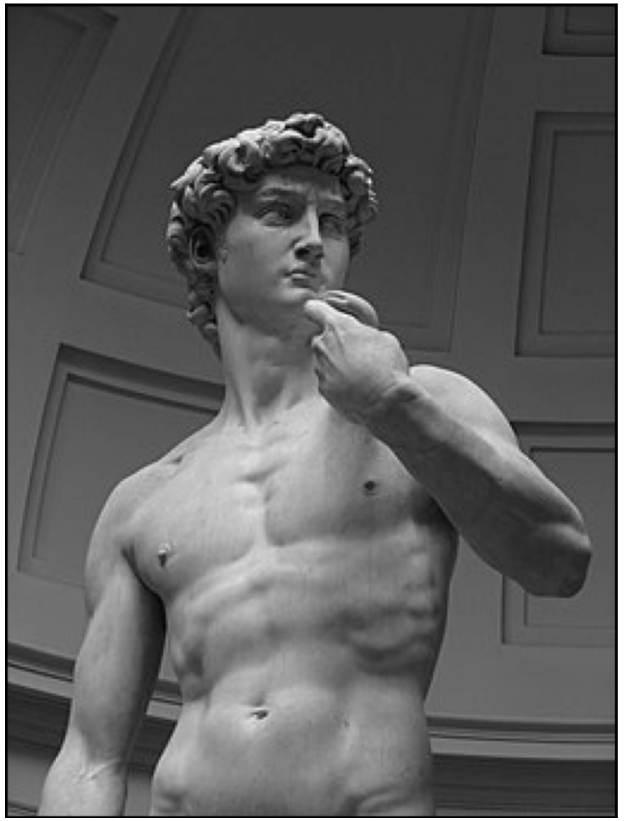
Random noise



Preprocessing

Solutions:

- Random noise
- → **Gauss filter**
- Reflections
- Low contrast



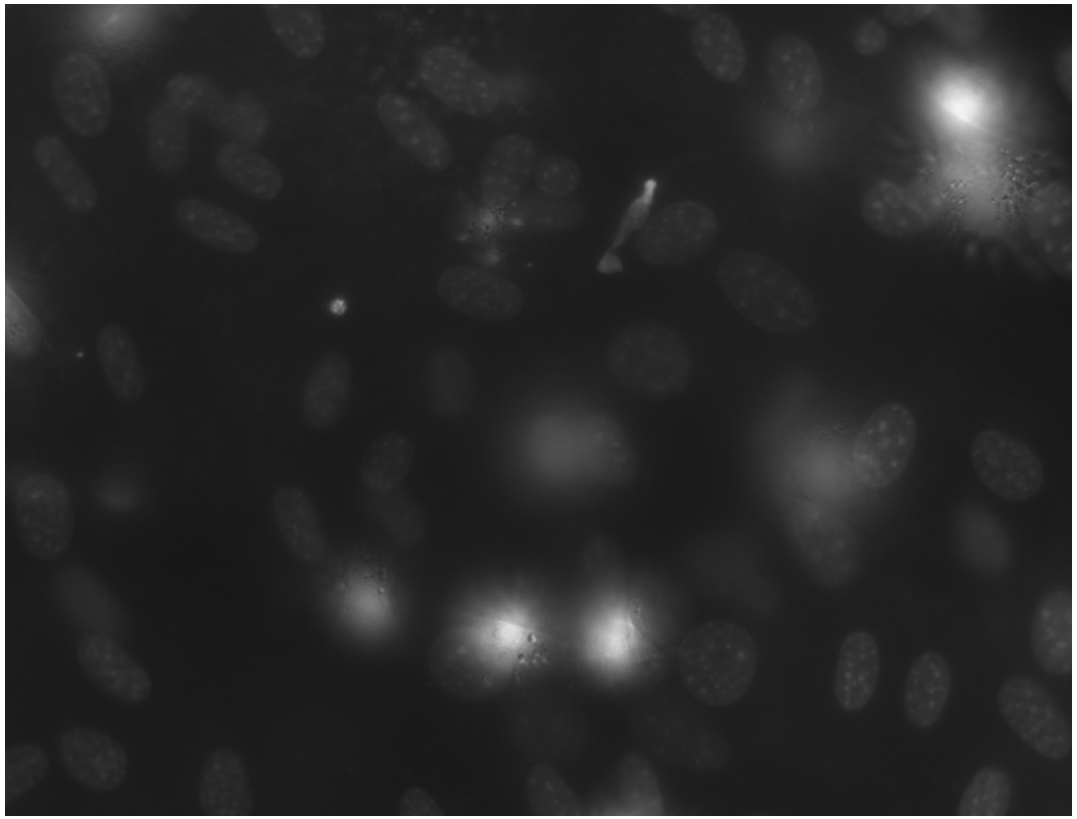
Original

Gauss filter (σ = 3)

Preprocessing

Solutions:

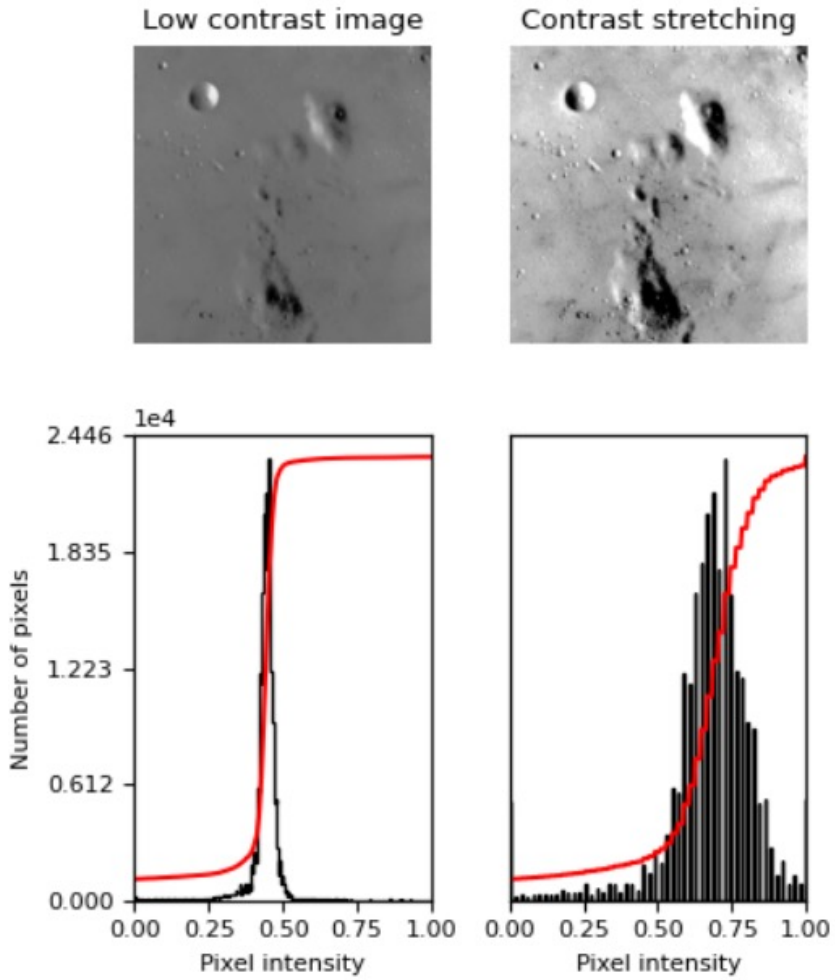
- Random noise
  → **Gauss filter, median filter**
- Reflections
  → **Thresholding**
- Low contrast



Preprocessing

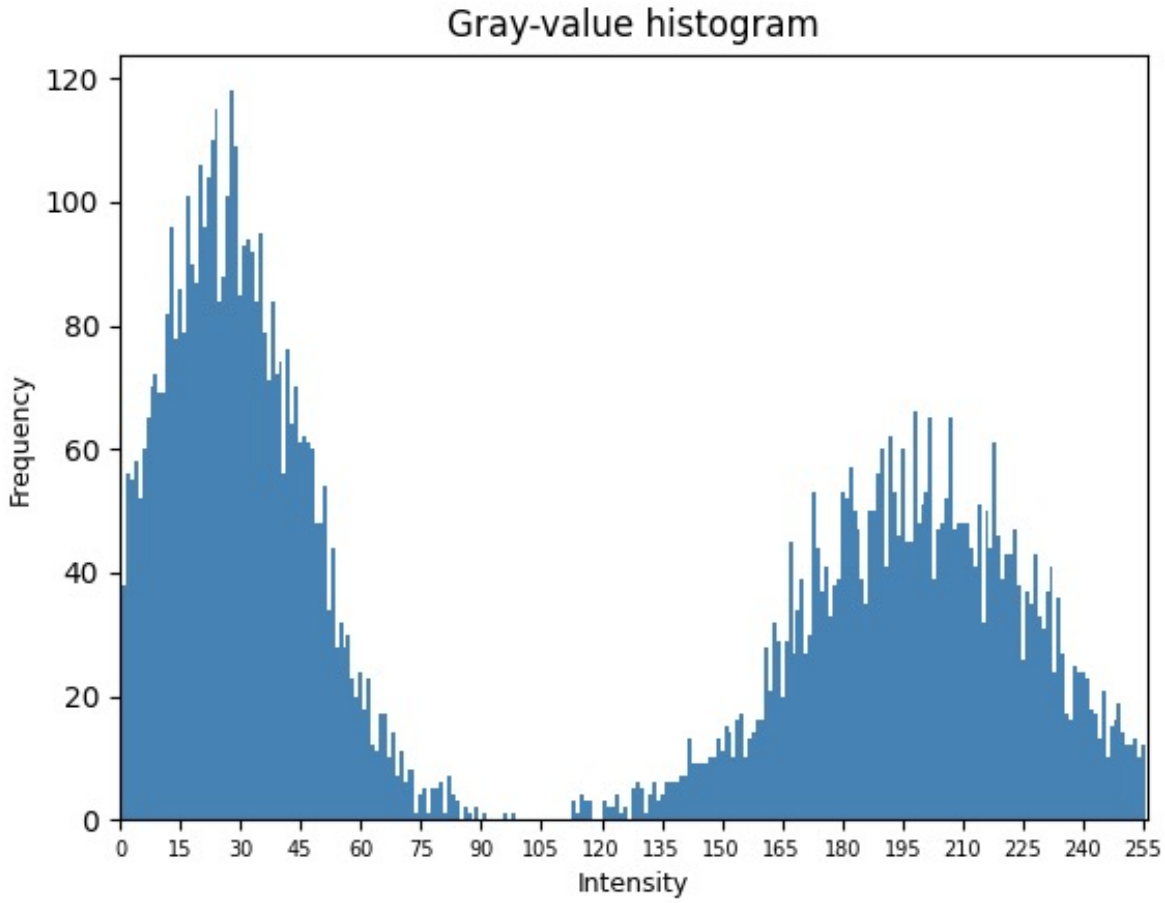
Solutions:

- Random noise
  → **Gauss filter, median filter**
- Reflections
  → **Thresholding**
- Low contrast
  → **Histogram stretching**

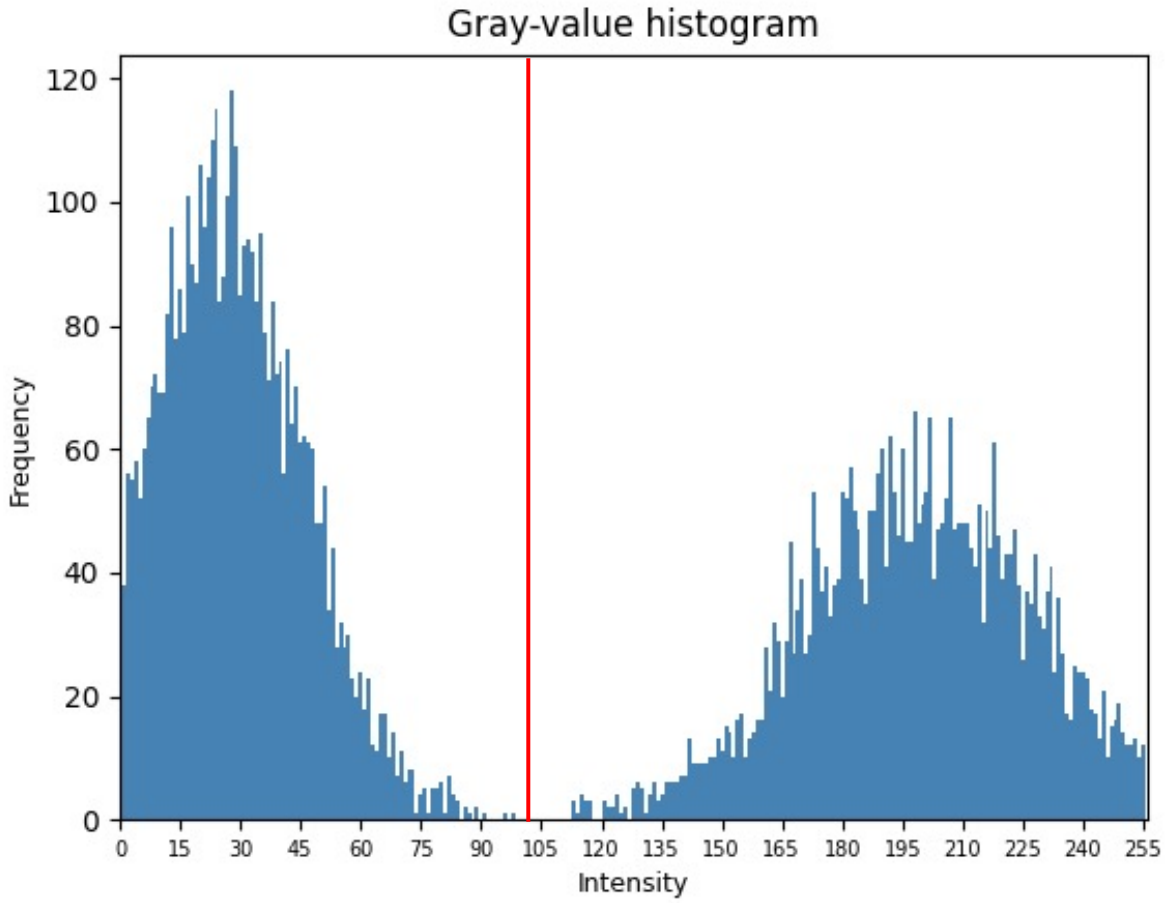


Adapted from: https://scikit-image.org/docs/dev/auto_examples/color_exposure/plot_equalize.html

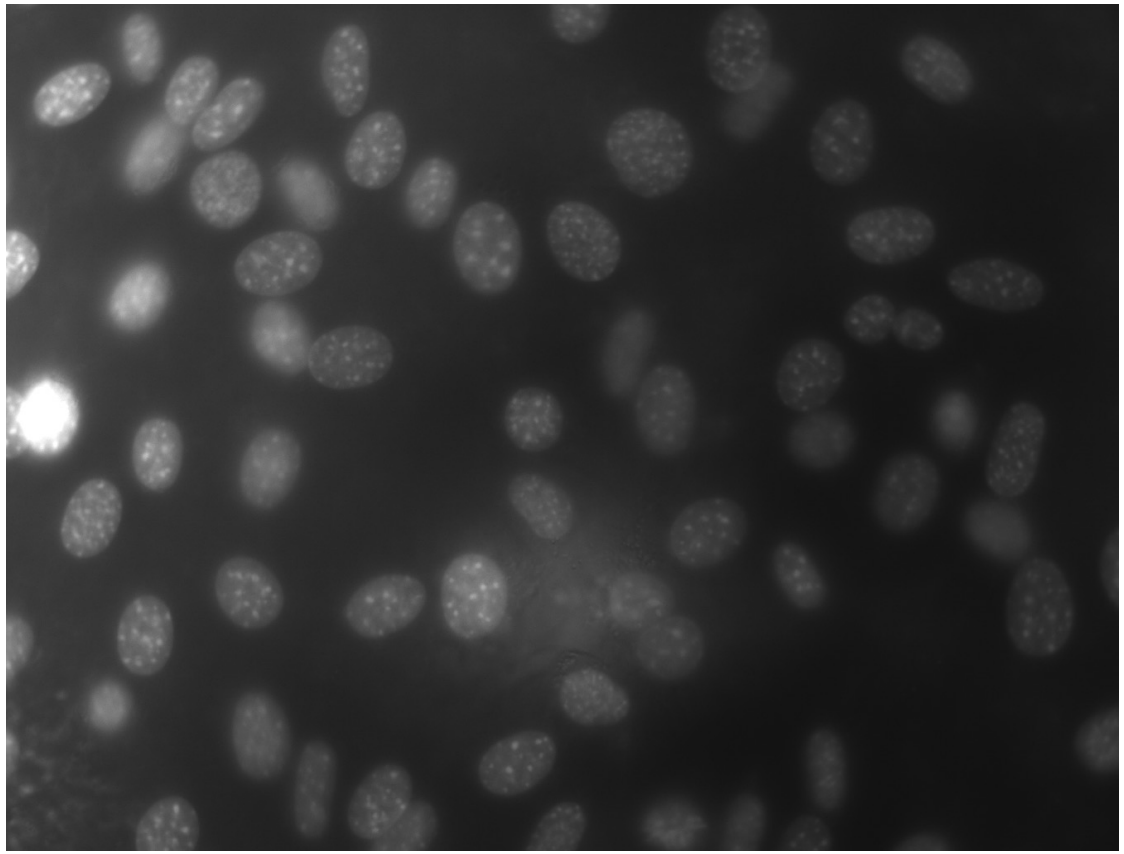
Otsu's Thresholding

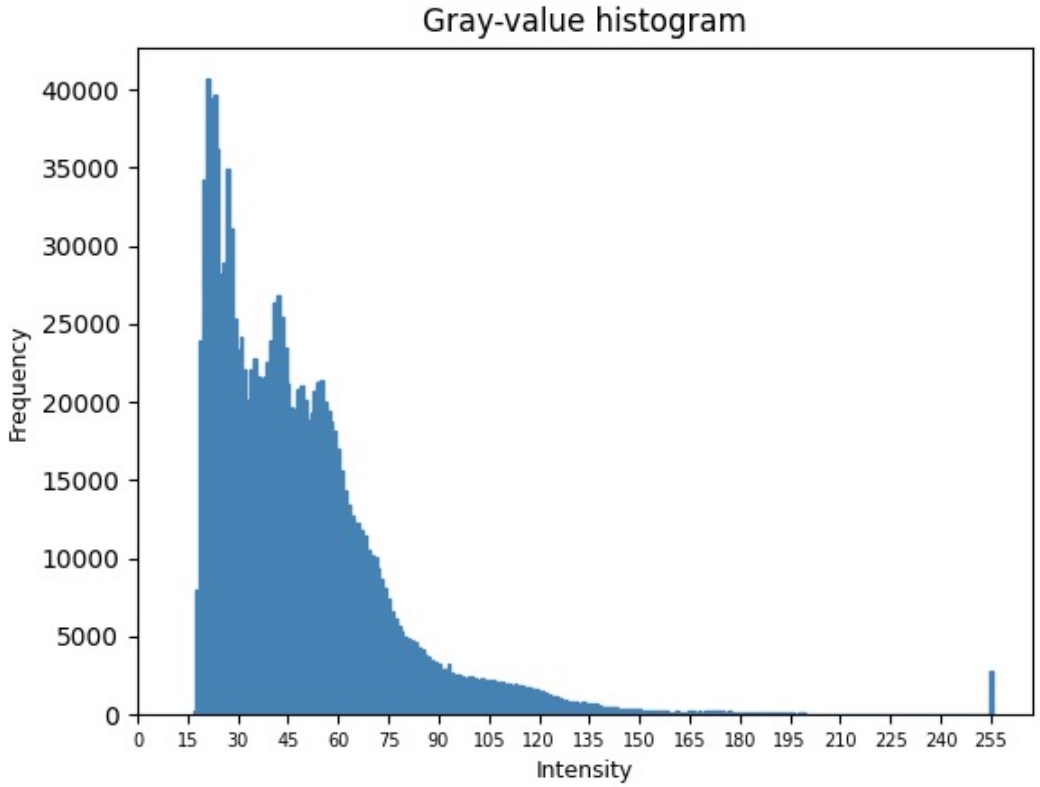


Otsu's Thresholding



Otsu's Thresholding





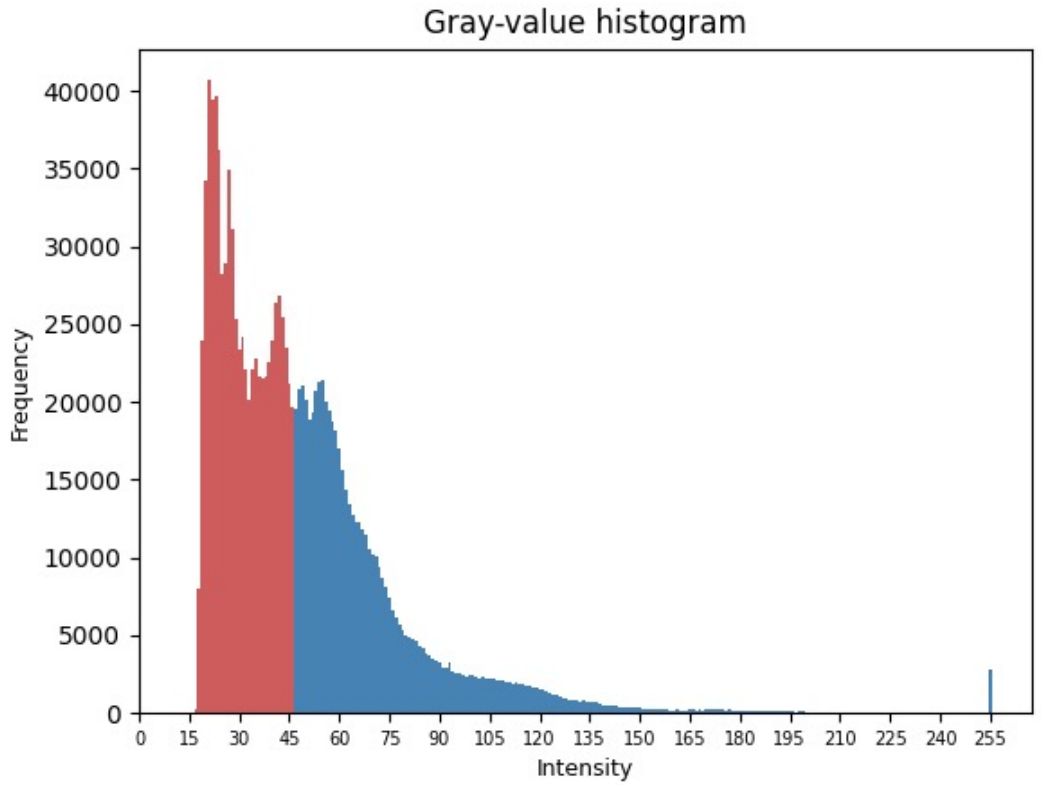
Threshold value k $\in [0,255]$

Otsu's Thresholding

Between-class variance

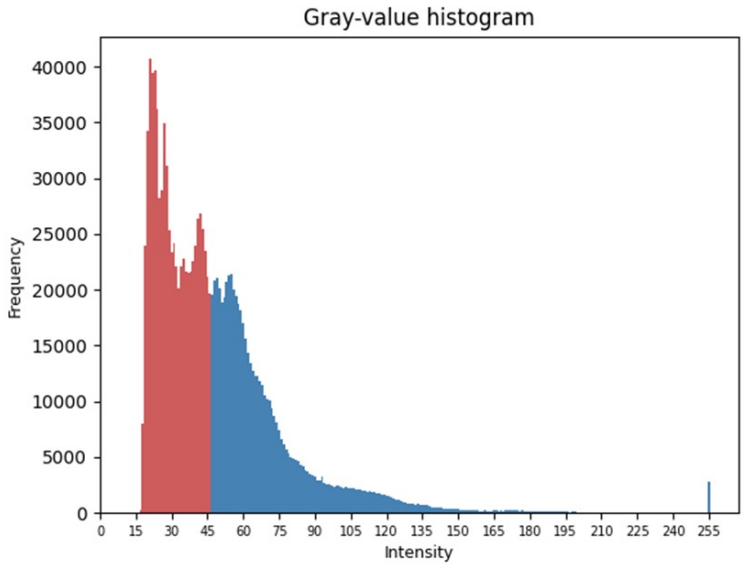
$$\sigma_B = \omega_0\omega_1(\mu_1 - \mu_0)^2$$

$\omega_{0,1}$ = probability of class occurrence
$\mu_{0,1}$ = mean intensity values

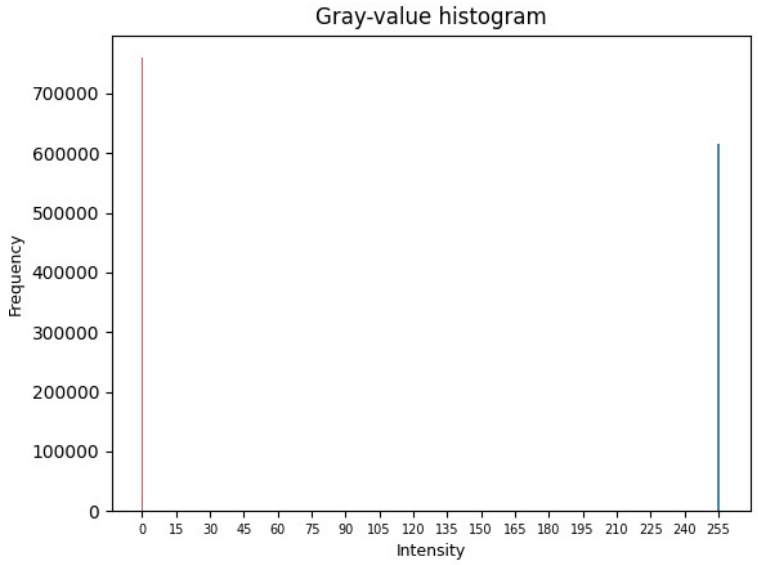


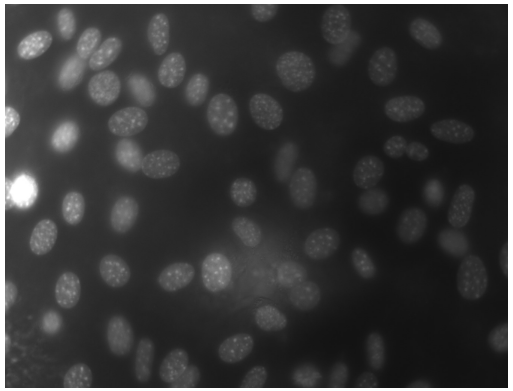
Threshold value k $\in [0,255]$

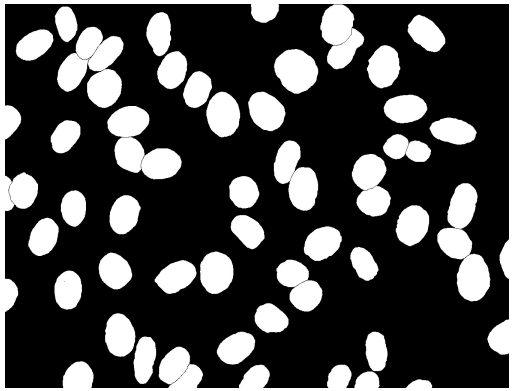
Image clipping



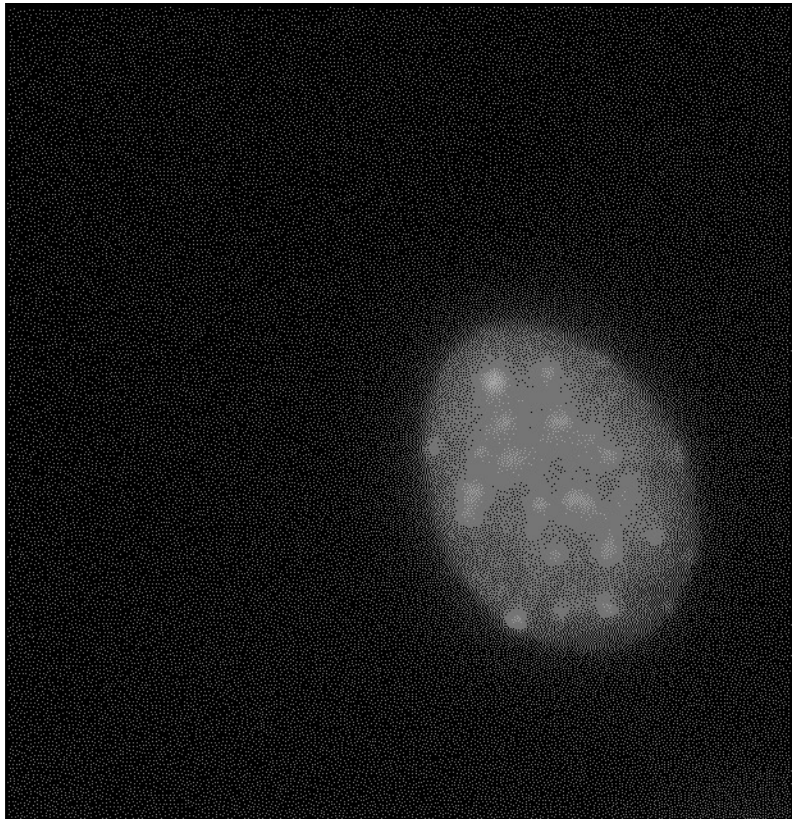
$$g_{clip}(x,y) = \begin{cases} 0 & \text{if } g(x,y) \leq k \\ 255 & \text{if } g(x,y) > k \end{cases}$$



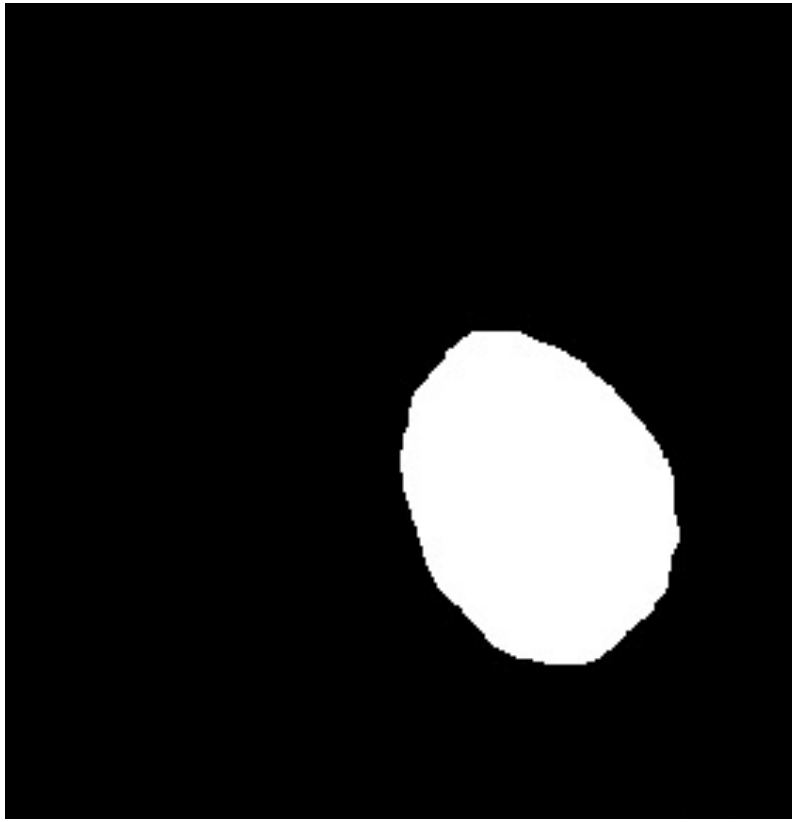




Implementation of the Dice Score



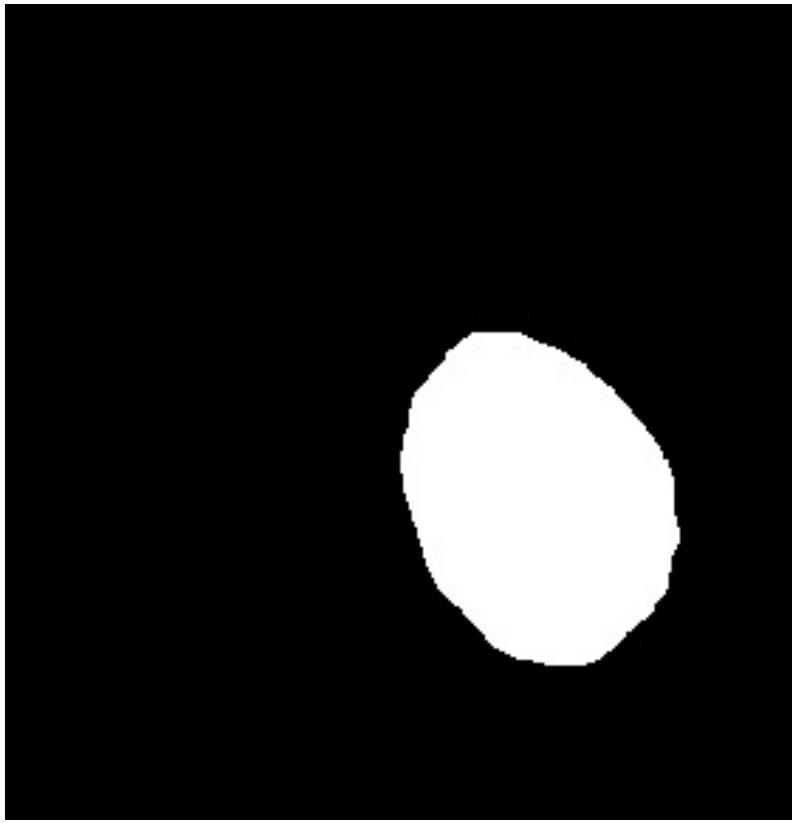
Original image

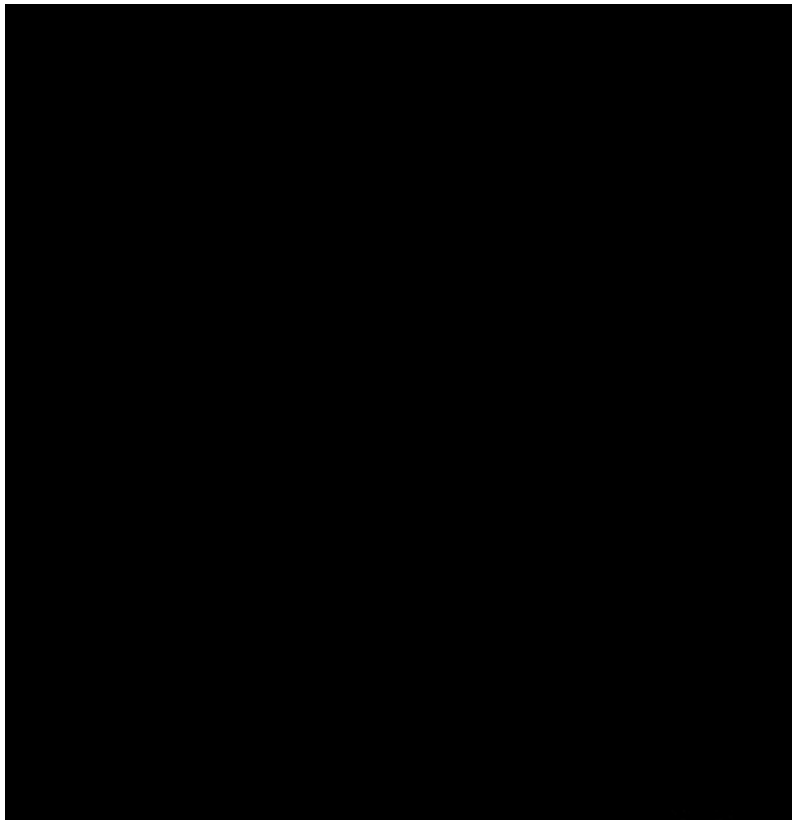


Ground truth

Implementation of the Dice Score

≈80 % accuracy



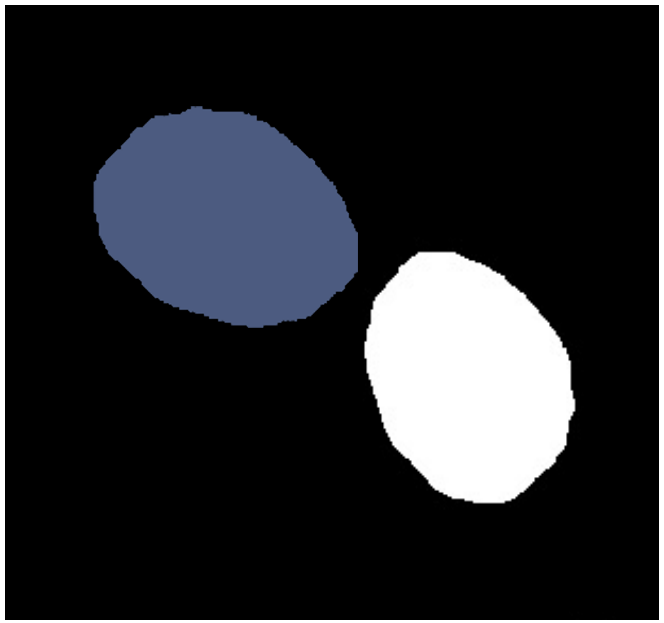


Ground truth

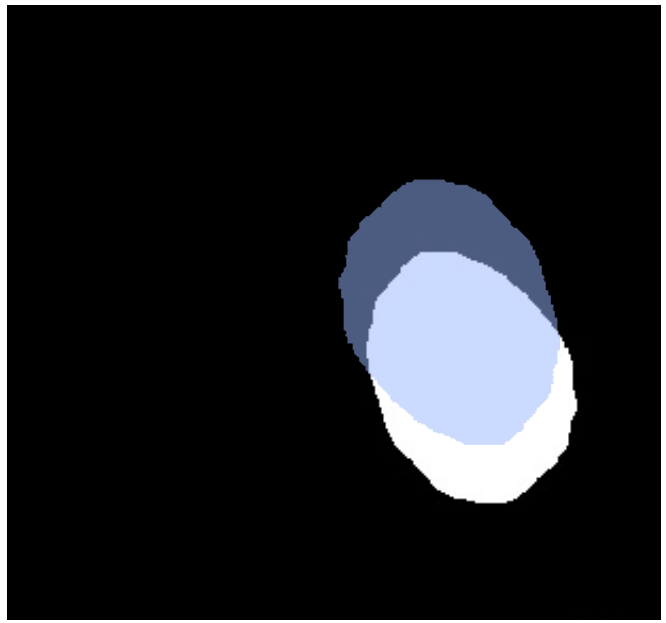
Prediction

Implementation of the Dice Score

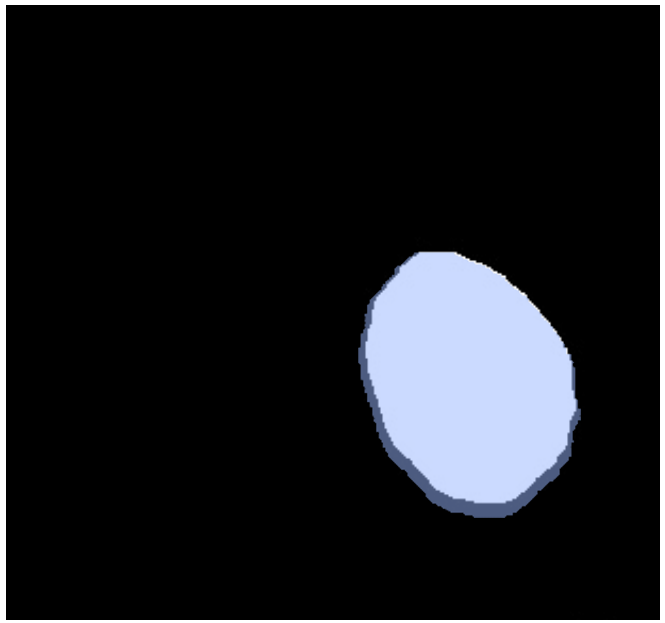
Bad prediction



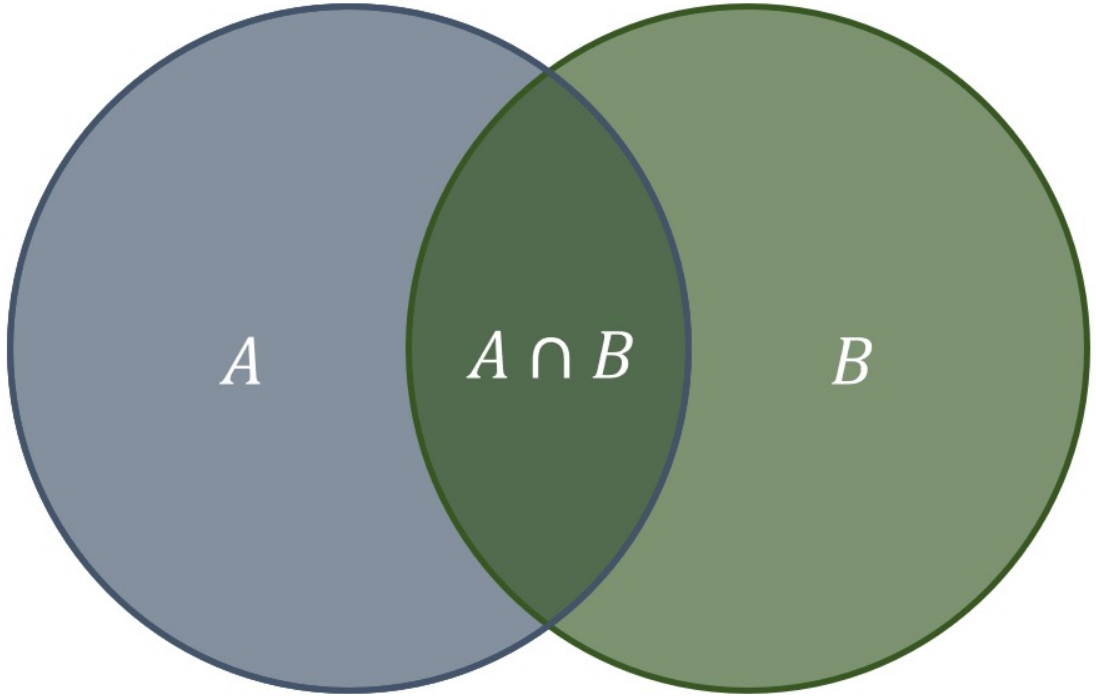
Better prediction



Good prediction



Implementation of the Dice Score

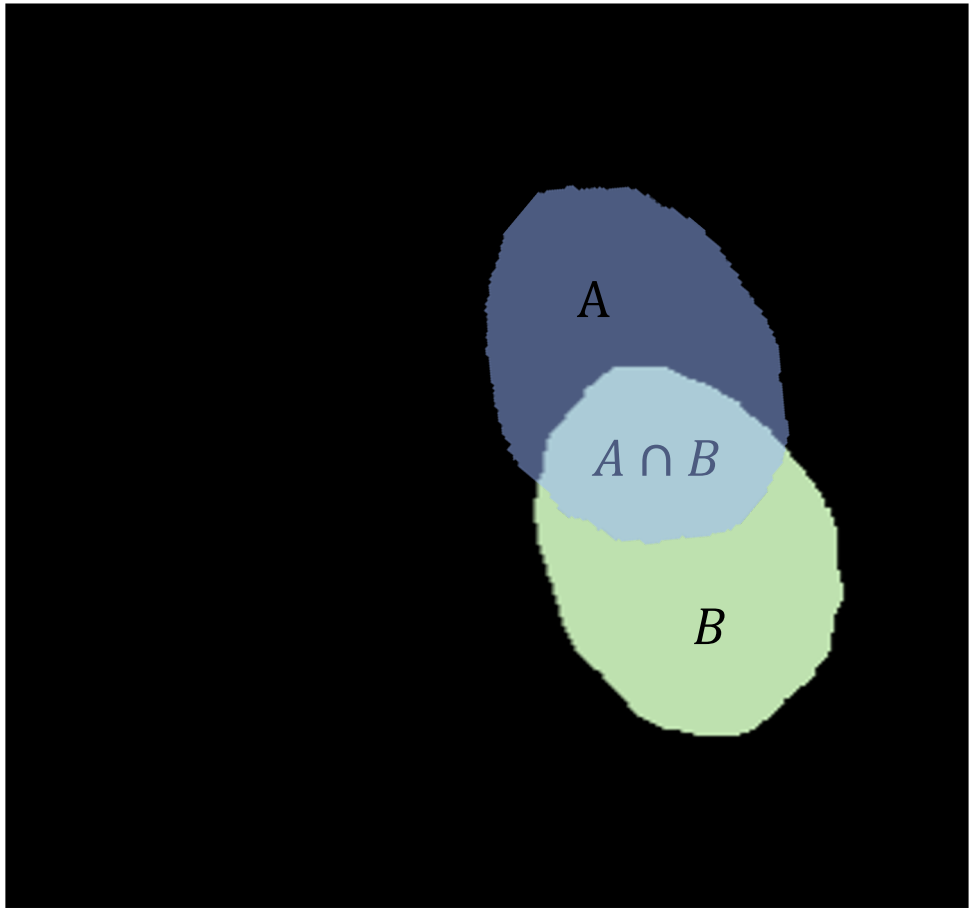


$$DSC = \frac{2 \times |A \cap B|}{|A| + |B|}$$

A: Predicted shape

B: Ground truth

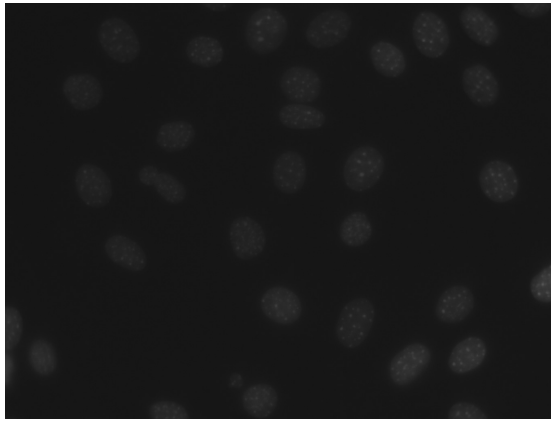
Implementation of the Dice Score



$$DSC = \frac{2 \times |A \cap B|}{|A| + |B|}$$

Implementation of the Dice Score

Our goal: compare ground truth images with our results



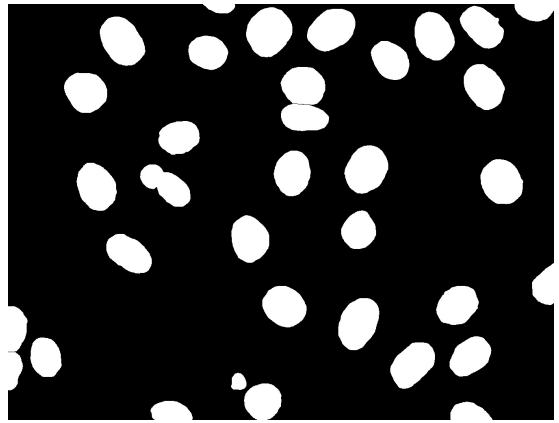
Original image

Otsu's thresholding

?

Our result

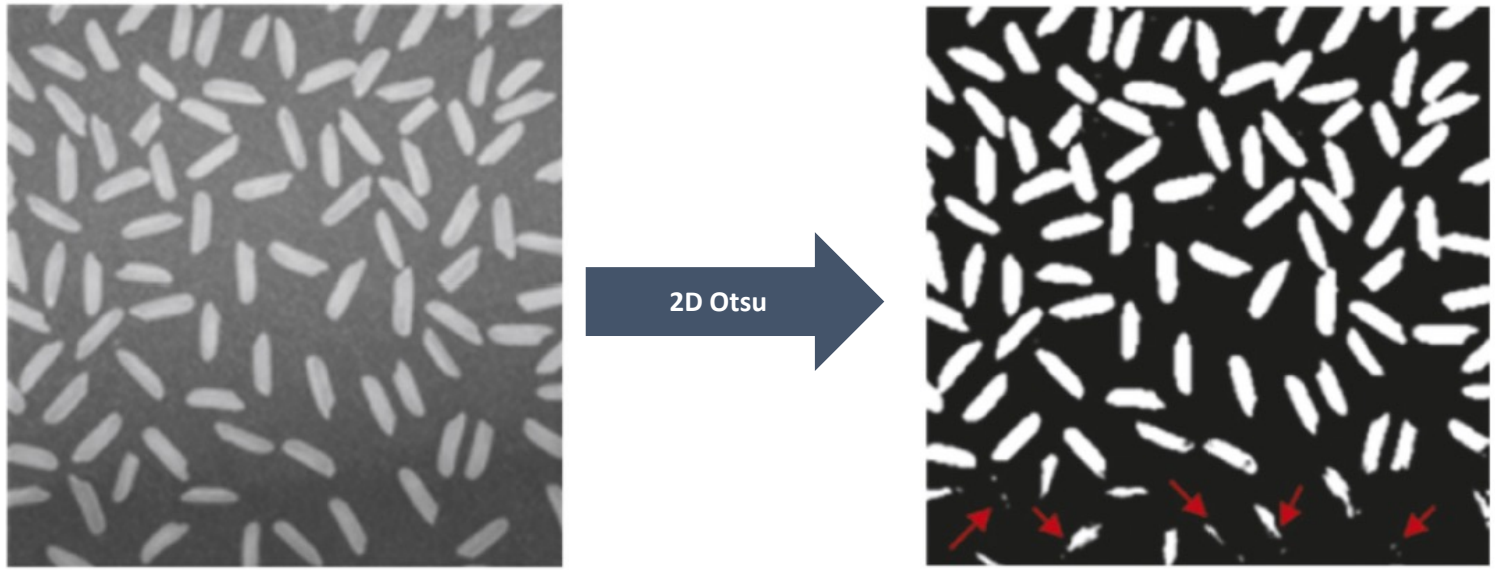
comparison



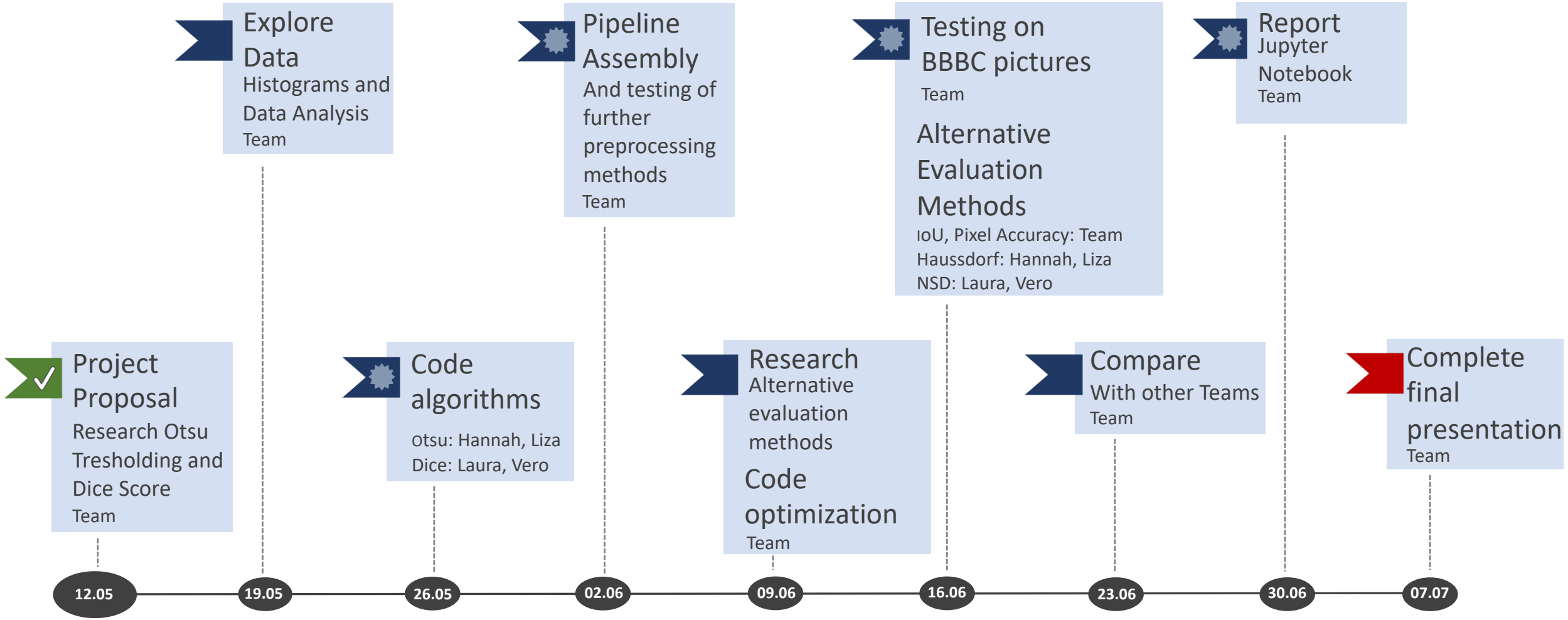
Ground truth

Further ideas

- 2D Otsu
- Algorithm for counting cells



Timeline


Project Proposal
Research Otsu Tresholding and Dice Score
Team
Explore Data
Histograms and Data Analysis
Team
Code algorithms
Otsu: Hannah, Liza
Dice: Laura, Vero
Pipeline Assembly
And testing of further preprocessing methods
Team
Research
Alternative evaluation methods
Code optimization
Team
Testing on BBBC pictures
Team
Alternative Evaluation Methods
IoU, Pixel Accuracy: Team
Haussdorf: Hannah, Liza
NSD: Laura, Vero
Compare
With other Teams
Team
Report
Jupyter Notebook
Team
Complete final presentation
Team
12.05
19.05
26.05
02.06
09.06
16.06
23.06
30.06
07.07

Laura Wächter, Hannah Winter, Elizaveta Chernova, Veronika Schuler

Thank you for your attention!

Additional slide – Histogram stretching

a = 0, b =255

c – lowest pixel intensity in the image

d – highest pixel intensity in the image

$$P_{out} = (P_{in} - c)\left(\frac{b-a}{d-c}\right) + a$$

https://homepages.inf.ed.ac.uk/rbf/HIPR2/stretch.htm

Additional slide – Gaussian distribution

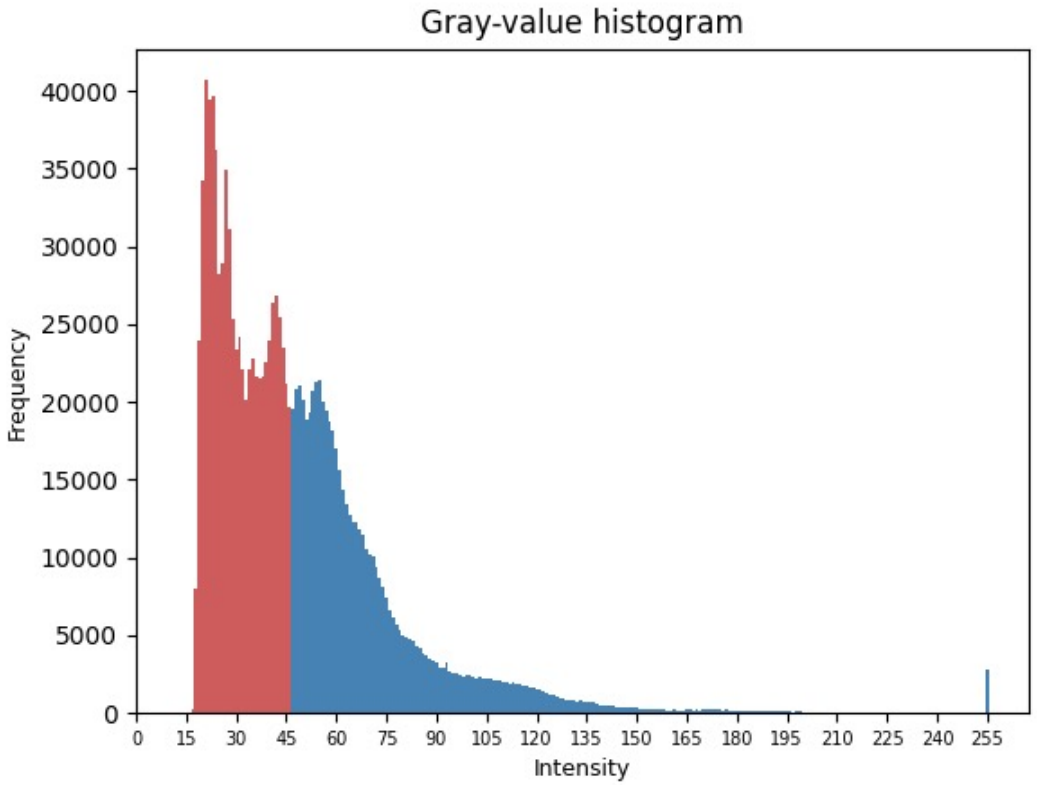
- TO DO

Additional slide – criterion measure

Criterion measure

$$\eta(k) = \frac{{\sigma_B}^2(k)}{{\sigma_T}^2}$$

σ_B = between-class variance
σ_T = total variance
$\eta(k) \in [0,1]$



Threshold value $k \in [0,255]$