Cell nuclei segmentation: support vector machine

Project proposal by
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Second Milestone

Implement Support Vector machine

First Milestone

Implement Dice score

Third Milestone

Implement Pre-processing

Our data

Timeline

Our Data

28 images of nuclei

N2DH-GOWT1

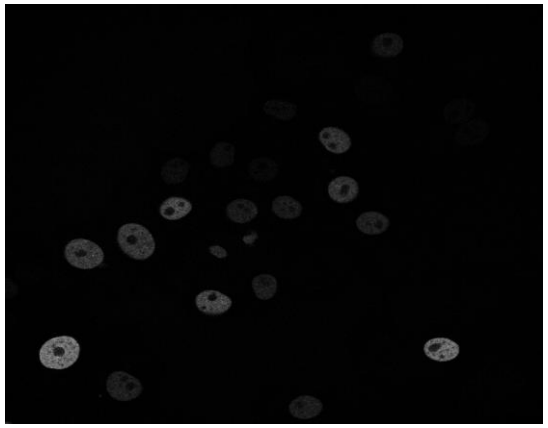
GFP transfected GOWT1 mouse embryonic stem cells

N2DL-HeLa

Histone 2B (H2B)-GFP expressing HeLa cells

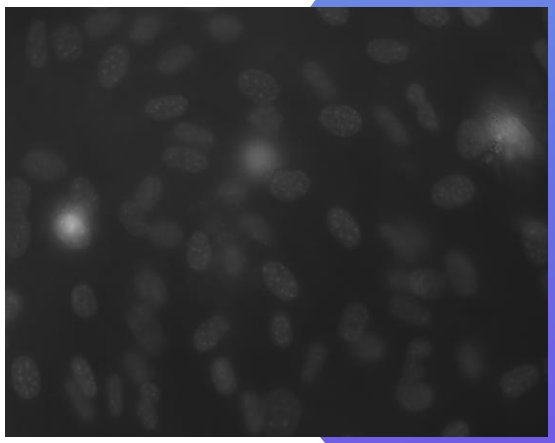
NIH3T3

mouse embyonic fibroblast – CD tagged (EGFP)



N2DH-GOWT1

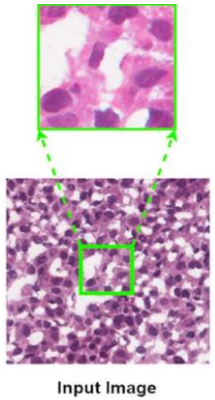
N2DL-HeLa



NIH3T3

(1) Osuna, E. et al. 2007. Large-Scale Automated Analysis of Location Patterns in Randomly Tagged 3T3 Cells
(2) Maska, M. et al. 2014. A benchmark for comparison of cell tracking algorithms

Our goal



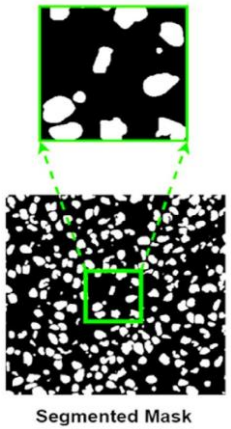
Input: Microscopic images

Preprocessing & filtering

Segmentation:

Support vector machine

Data mining: Counting nuclei



Output: Segmented image & number of nuclei

Lal, S. et al. 2021. NucleiSegNet: Robust deep learning architecture for the nuclei segmentation of liver cancer histopathology images

Our goal

Input: Microscopic images

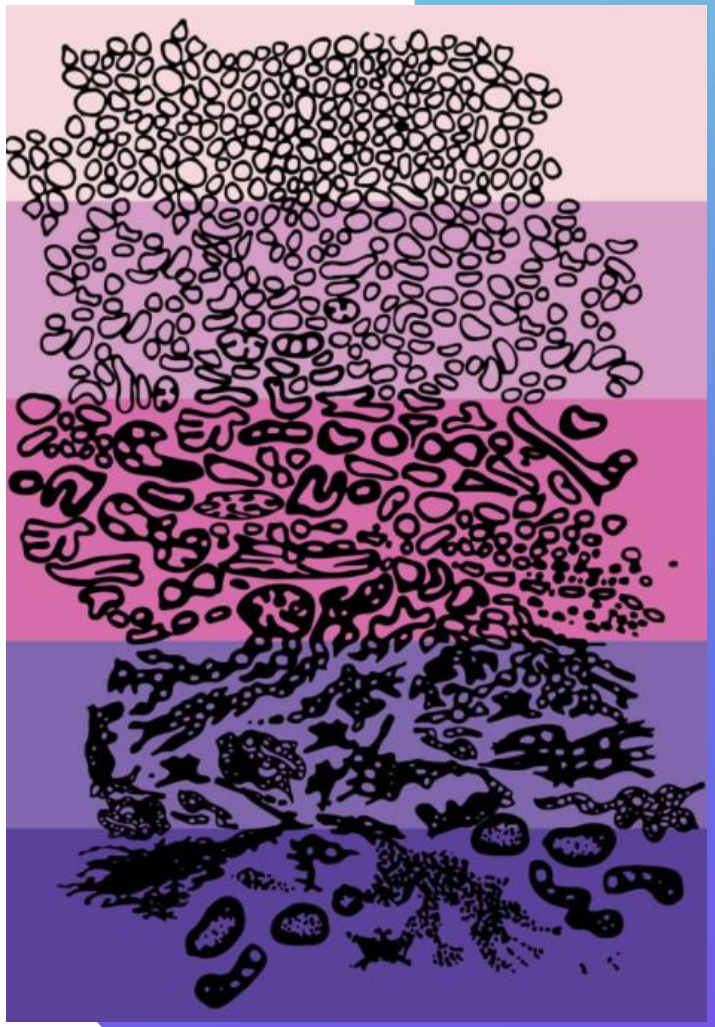
Preprocessing & filtering

Segmentation:
Support vector machine

Data mining: Counting nuclei

Output: Segmented image & number of nuclei

quantify degree of malignancy (= grading)



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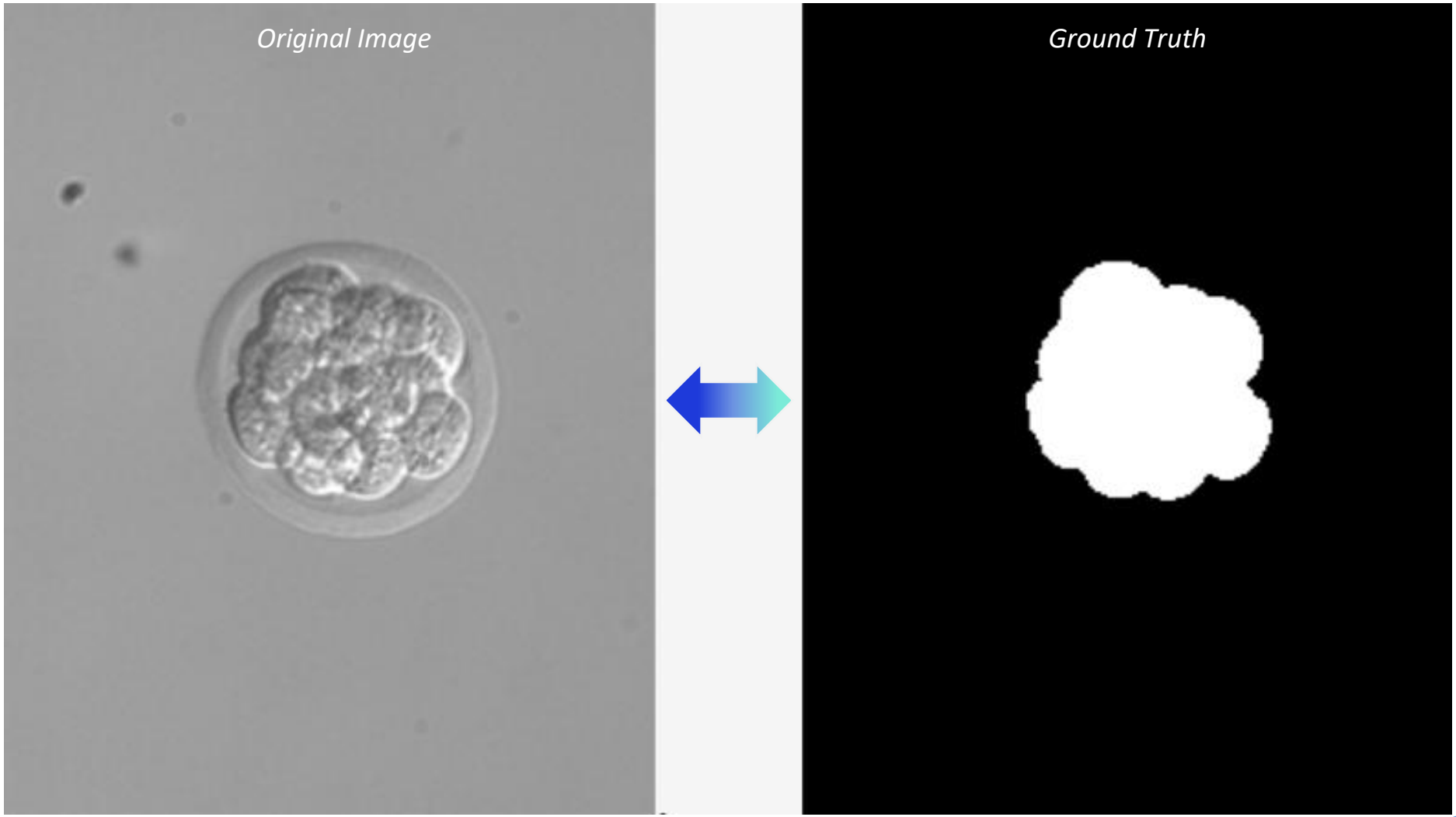
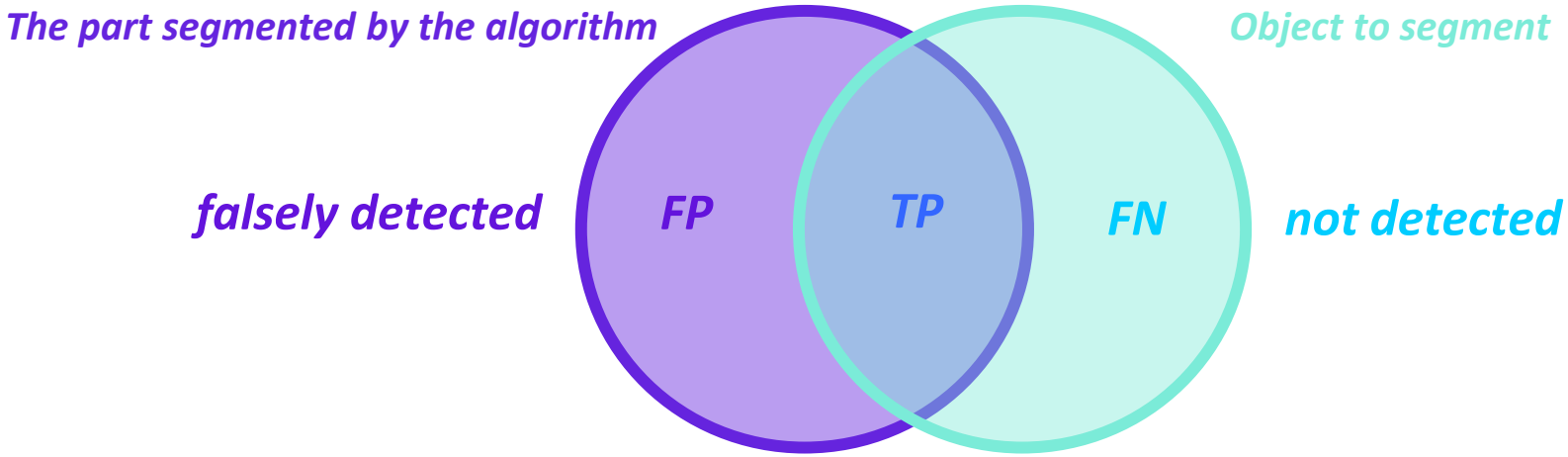
Determining Our Image Segmentation Quality



https://bbbc.broadinstitute.org/BBBC003

Dice Score

Evaluating the quality of the segmentation quantitatively



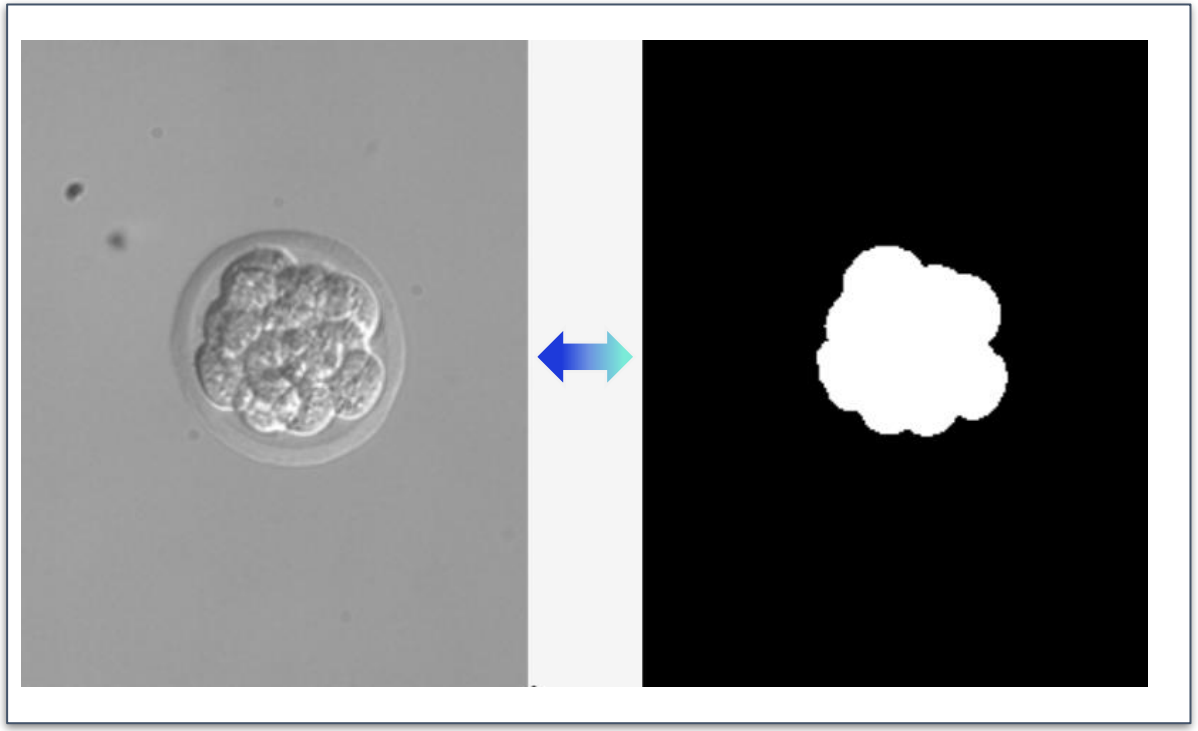
$$\text{IoU} = \frac{Intersection}{Union} = \frac{TP}{TP+FP+FN}$$

$$\text{Dice} = \frac{2*Intersection}{Union+Intersection} = \frac{2\,TP}{2\,TP+FP+FN}$$

$$\text{Loss} = 1 - Dice \quad \epsilon\,[0;1]$$

Bertels, J. et al. 2019. Optimizing the Dice Score and Jaccard Index for Medical Image Segmentation: Theory & Practice

Dice Score



Planned analysis steps

- *Write code for Dice-Score function*
- *Unit-testing*
- *Write code for synthetic images*

Characteristics of the first Milestone

- *Measure for evaluating our model*

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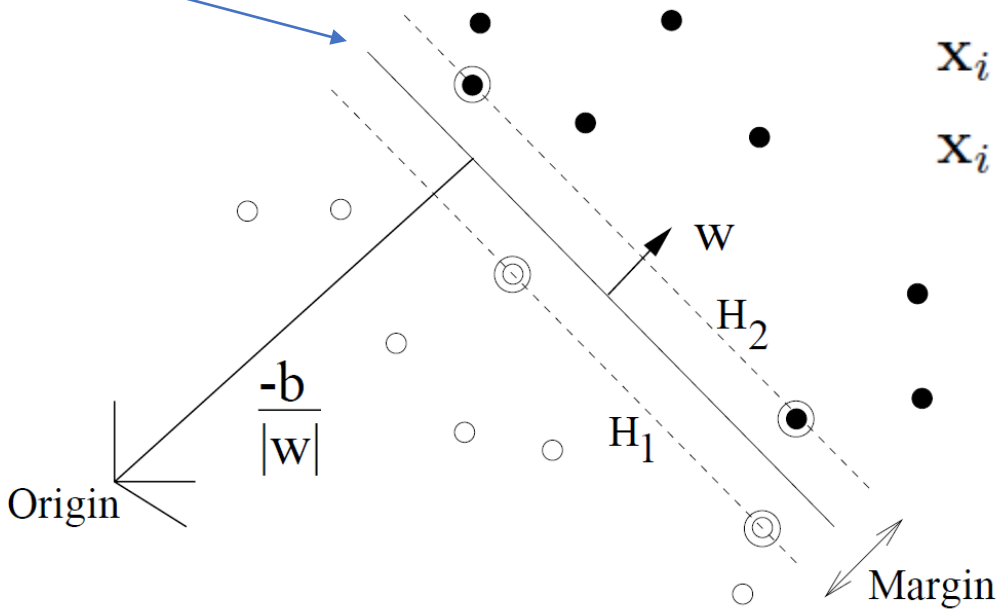
Support Vector machine

decision function → hyperplane



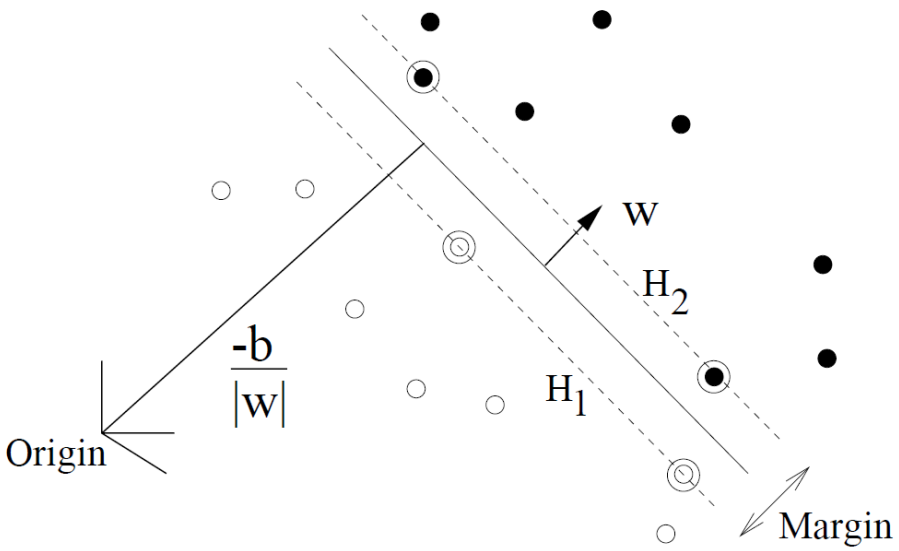
$$\mathbf{x}_i \cdot \mathbf{w} + b \geq +1 \quad \text{for } y_i = +1$$
$$\mathbf{x}_i \cdot \mathbf{w} + b \leq -1 \quad \text{for } y_i = -1$$

Phase 1: training phase

Phase 2: generalization phase

Burges, C. 1998. A Tutorial on Support Vector Machines for Pattern Recognition

Support Vector machine



$$\mathbf{x}_i \cdot \mathbf{w} + b \geq +1 \quad \text{for } y_i = +1$$
$$\mathbf{x}_i \cdot \mathbf{w} + b \leq -1 \quad \text{for } y_i = -1$$

Planned analysis steps

- *Implement a support vector machine*
- *evaluate the performance of our SVM*

Characteristics of the second Milestone

- *label pixels as ‚cell nucleus‘ or ‚background‘*

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Implement Pre-processing

Our data

Timeline

Pre-processing

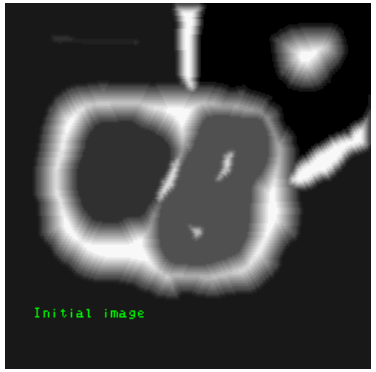
https://www.mathworks.com/help/images/ref/imgaussfilt.html

- Pre-processing steps:
  1. Noise reduction
  2. Super-pixel segmentation

- Desired effect:
  1. Average local pixel intensity values
  2. Separate nuclei which appear fused

Krig, S. 2014. Computer Vision Metrics. Survey, Taxonomy, and Analysis.

Pre-processing



http://www.cmm.mines-paristech.fr/~beucher/wtshed.html

Planned analysis steps

- *Methods:*
  1. *2D Gaussian filter*
  2. *Gradient-ascend-based super pixel algorithms, e.g. Watershed*

Characteristics of the third Milestone

- *Improve Dice Score of segmentation method through better image quality*

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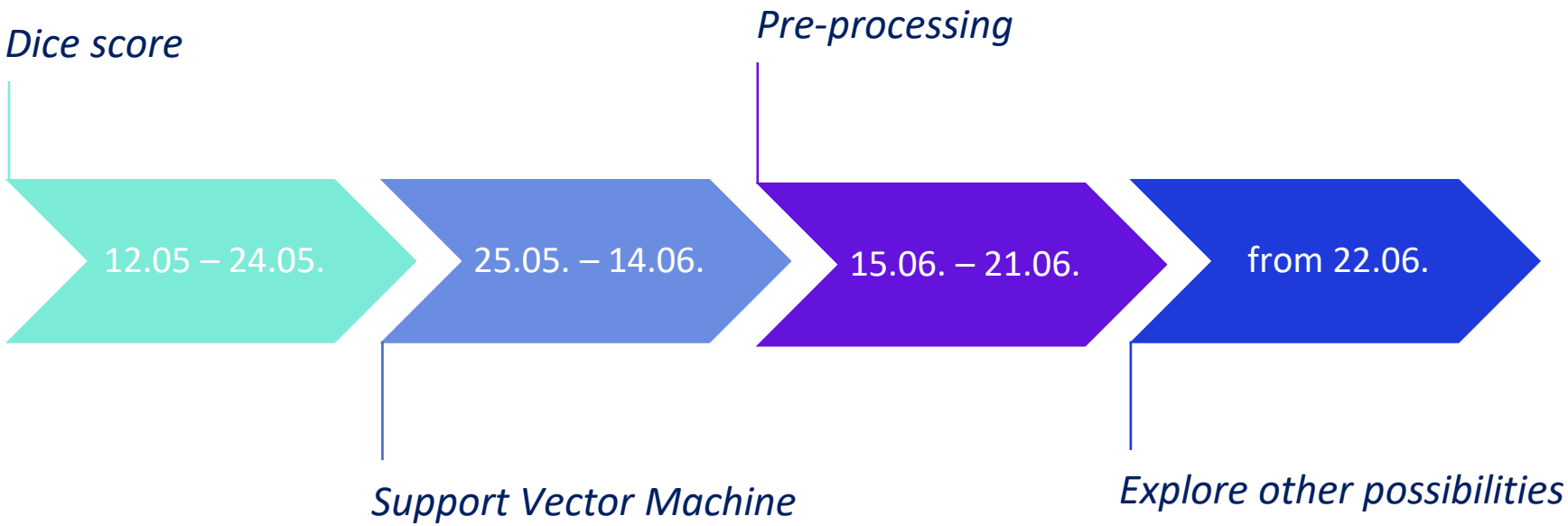

Dice score
12.05 – 24.05.
Support Vector Machine
25.05. – 14.06.
Pre-processing
15.06. – 21.06.
Explore other possibilities
from 22.06.

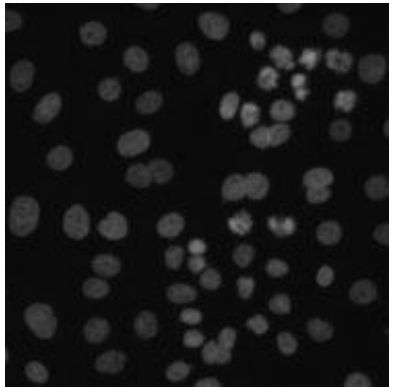
Thank you for listening!

Other options to be explored

- testing model on further data → compare results

(e.g. Broad Bioimage Benchmark Collection 001)

→ used in: Nosova SA, Turlapov VE (2019) Detection of Brain Cells in Optical Microscopy Based on Textural Features with Machine Learning Methods. Program Comput Soft 45, 171–179



https://bbbc.broadinstitute.org/BBBC001

- advanced pre-processing

e.g. high-pass filter