# Implementation and evaluation of Otsu's thresholding

Final presentation

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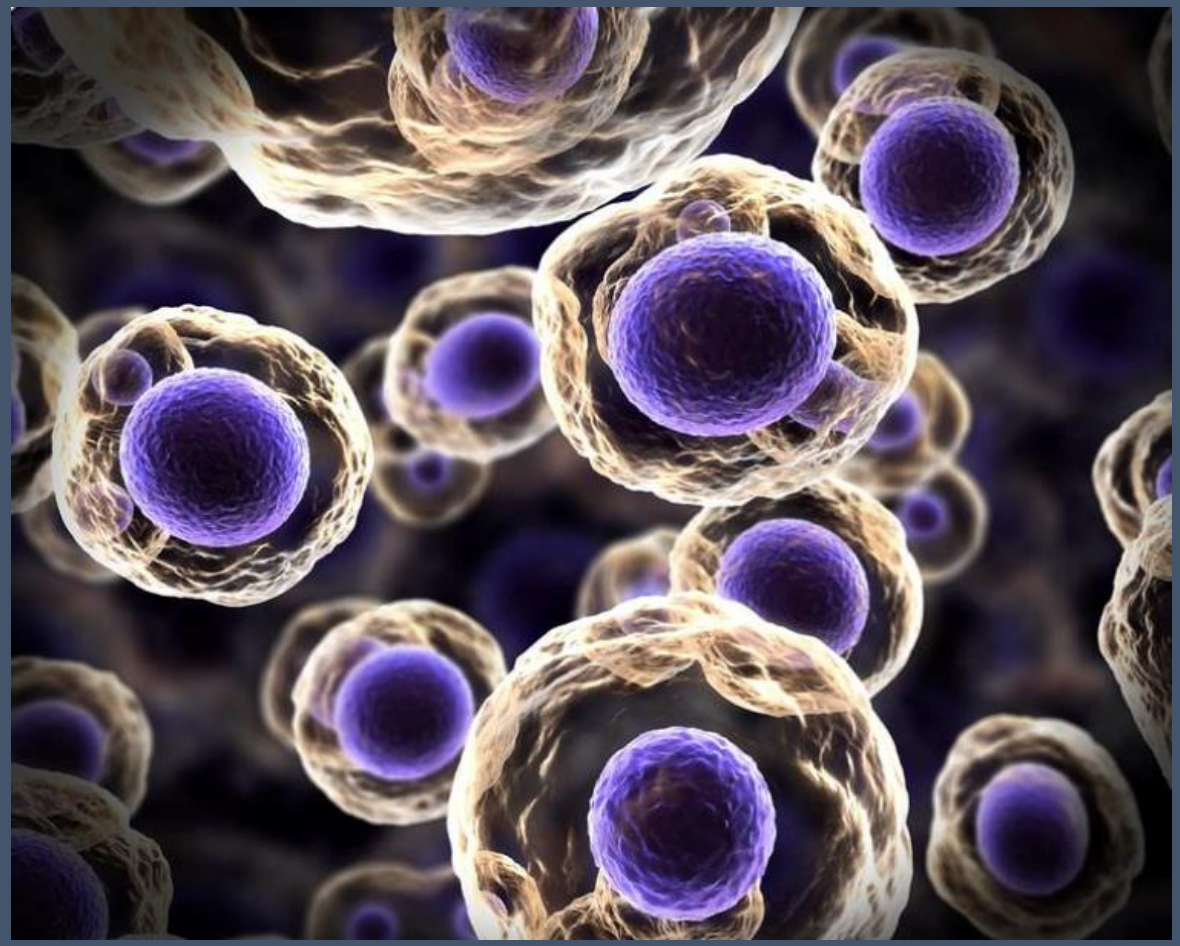


Cell nuclei segmentation

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

# Outline

**01**
Otsu‘s Thresholding

**02**
Evaluation methods

**03**
Preprocessing

**04**
Results

**05**
Cell counting

# Outline

01
Otsu‘s Thresholding

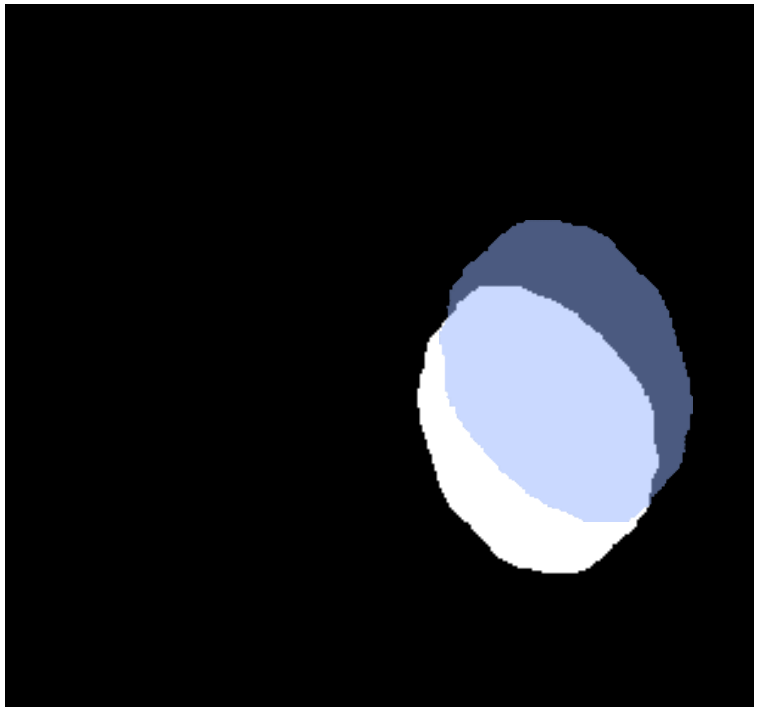
02
Evaluation methods

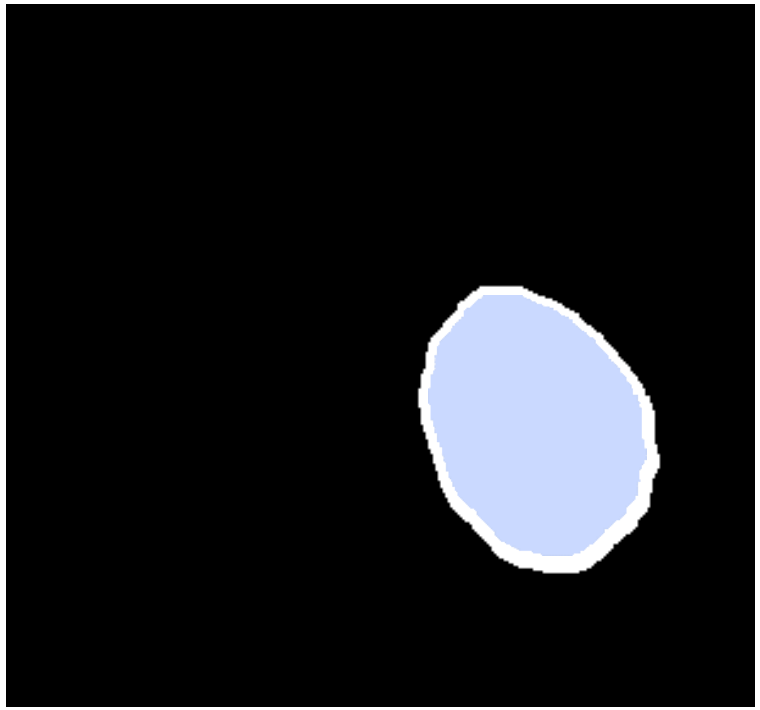
03
Preprocessing

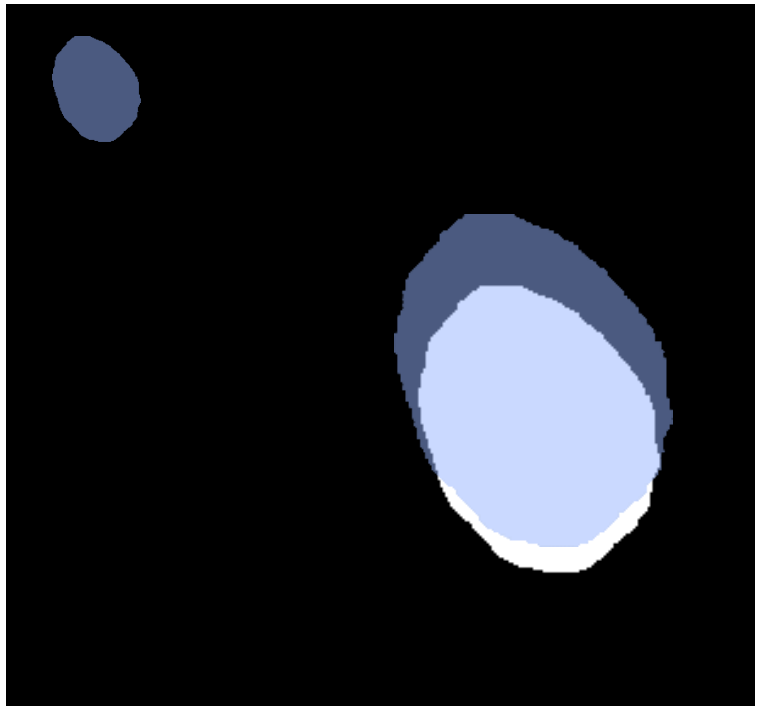
04
Results

05
Cell counting

# DSC vs. MSD vs. HD

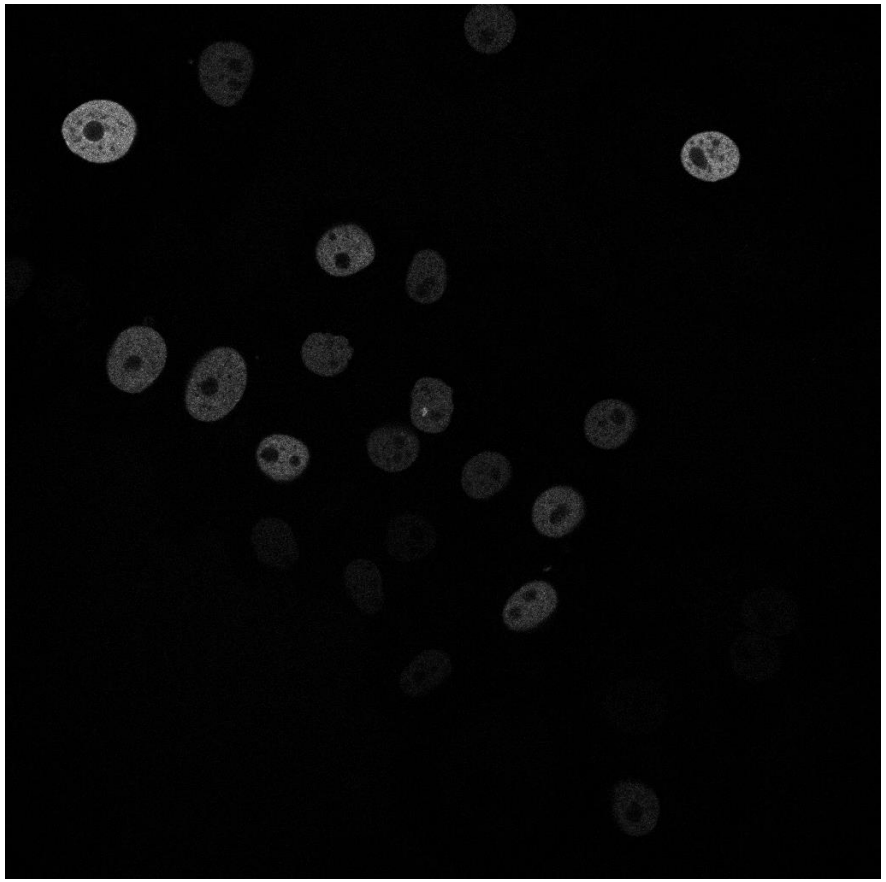




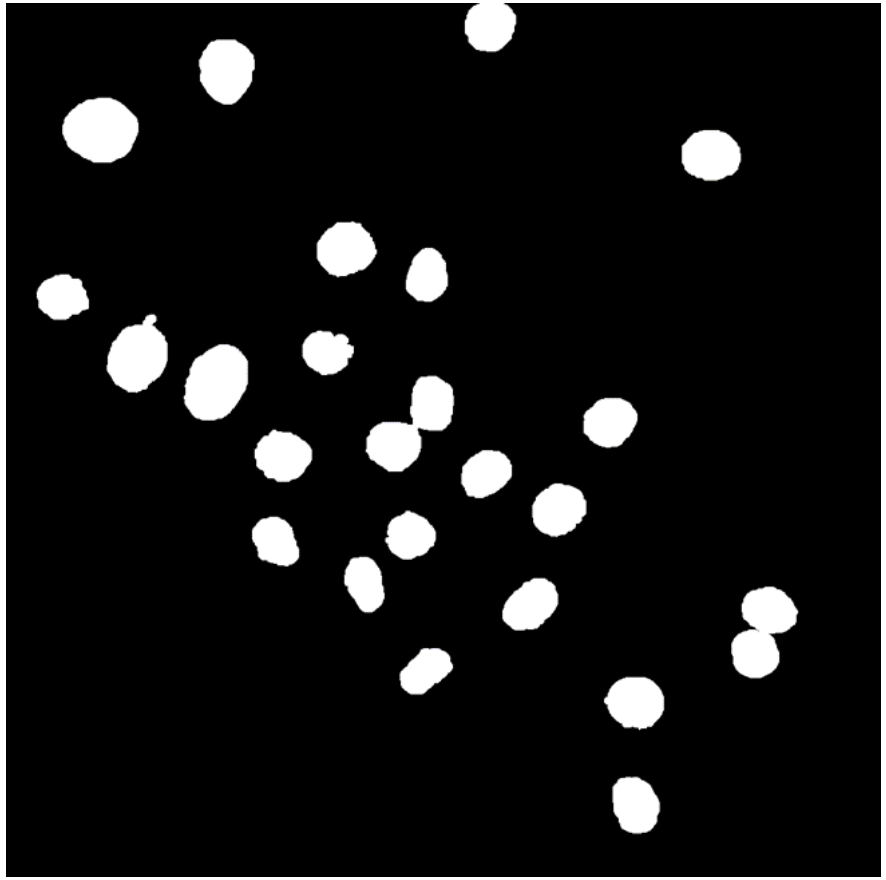


# N2DH-GOWT1

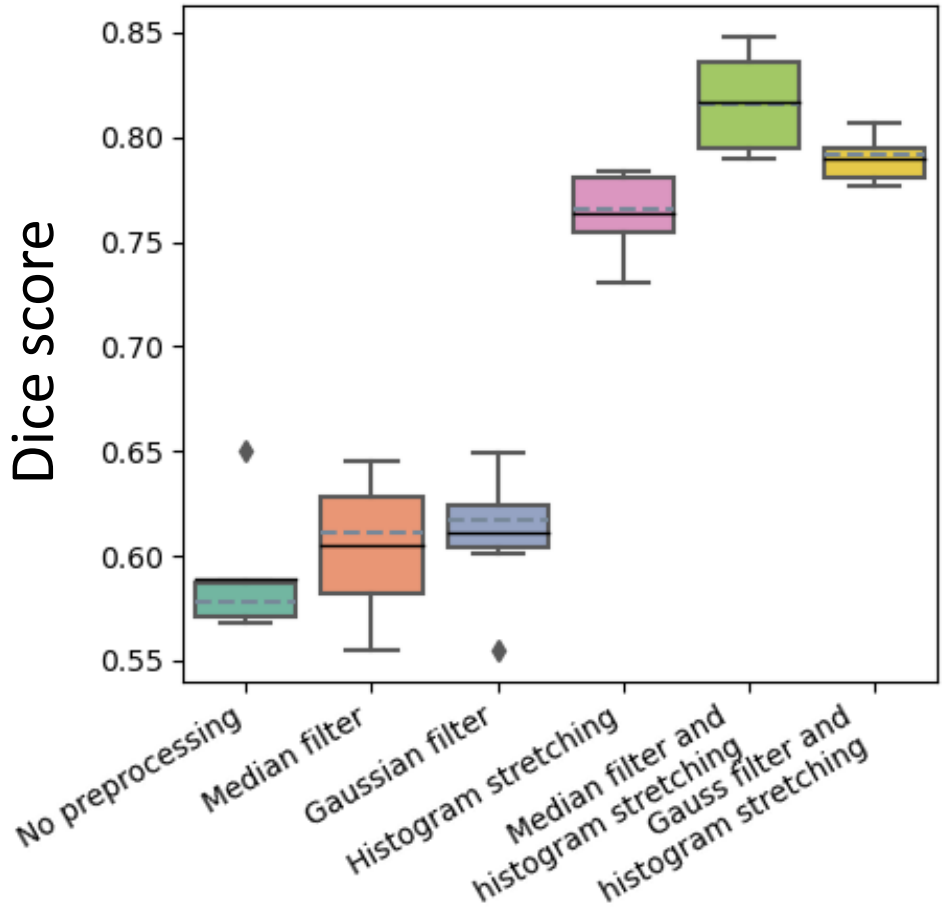
Original Image

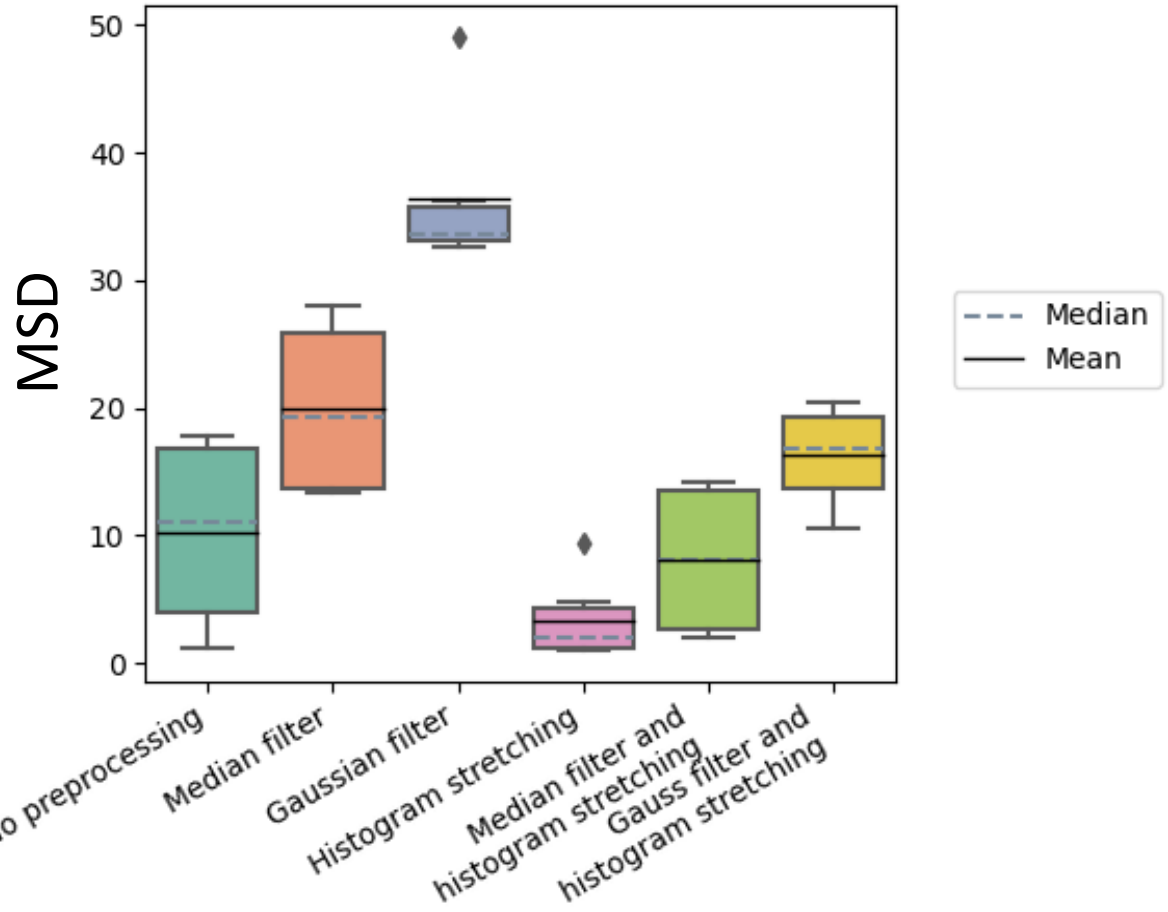


Ground truth



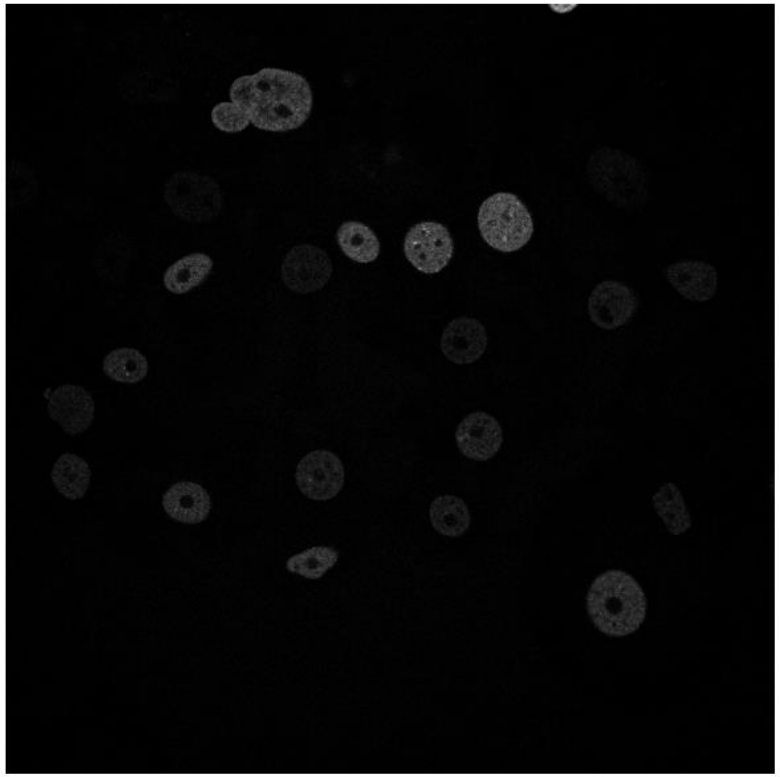
# N2DH-GOWT1


Dice score
0.85
0.80
0.75
0.70
0.65
0.60
0.55
No preprocessing
Median filter
Gaussian filter
Histogram stretching
Median filter and histogram stretching
Gauss filter and histogram stretching

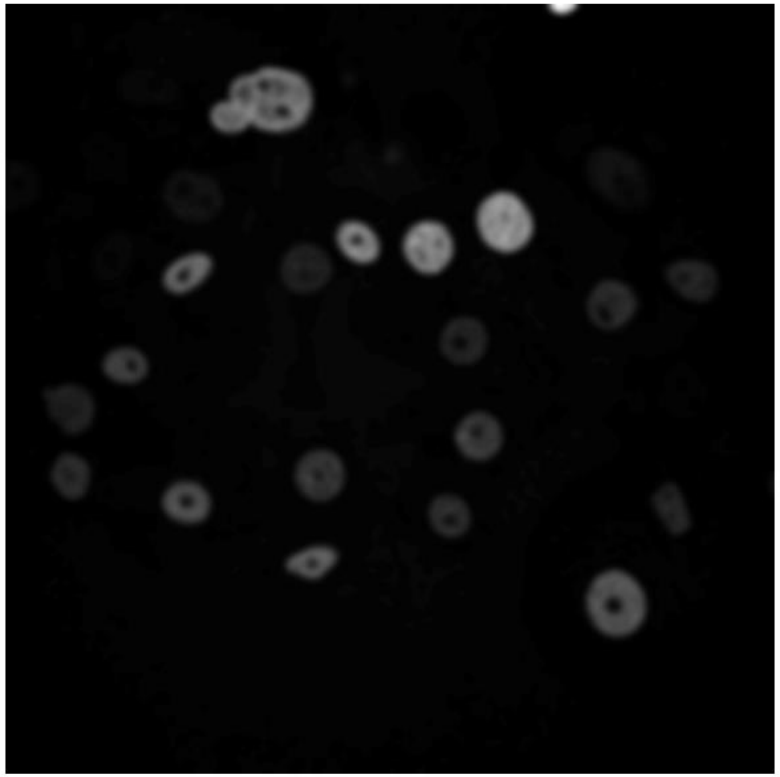

MSD
50
40
30
20
10
0
No preprocessing
Median filter
Gaussian filter
Histogram stretching
Median filter and histogram stretching
Gauss filter and histogram stretching
Median
Mean

# N2DH-GOWT1

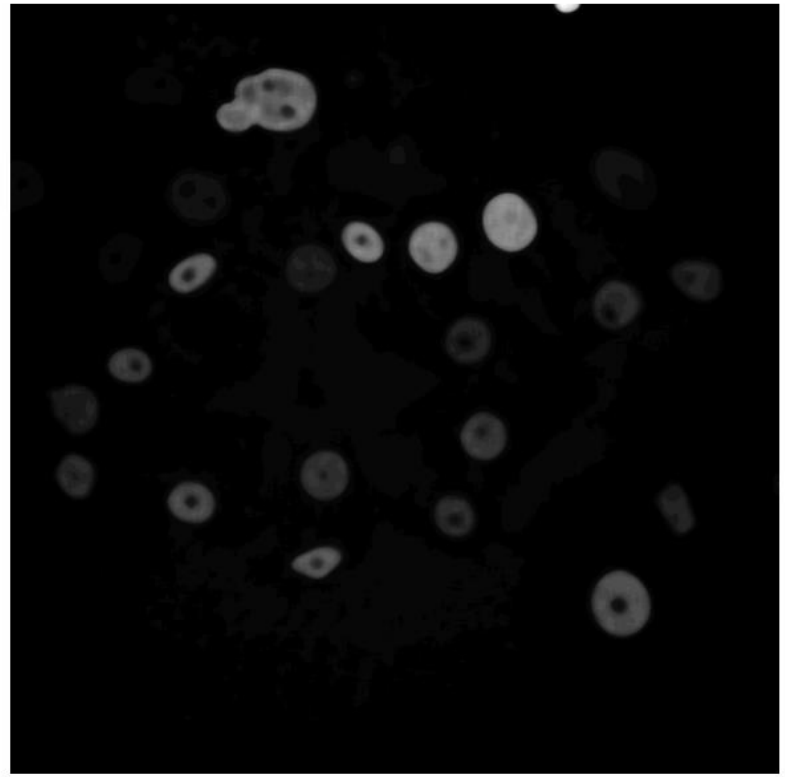
Original Image



Gaussian filter

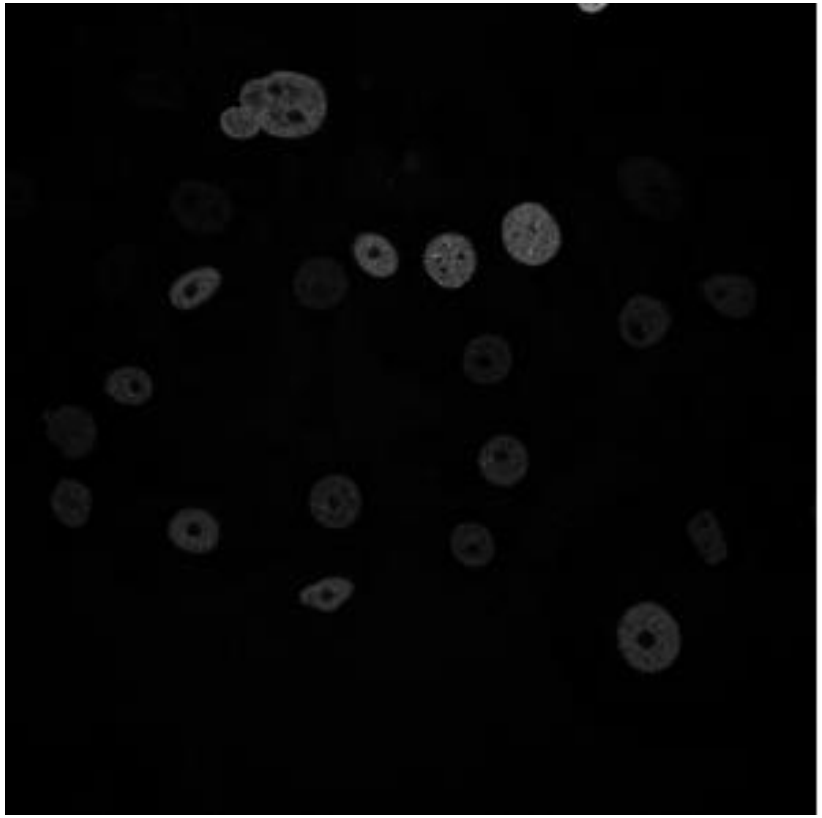


Median filter

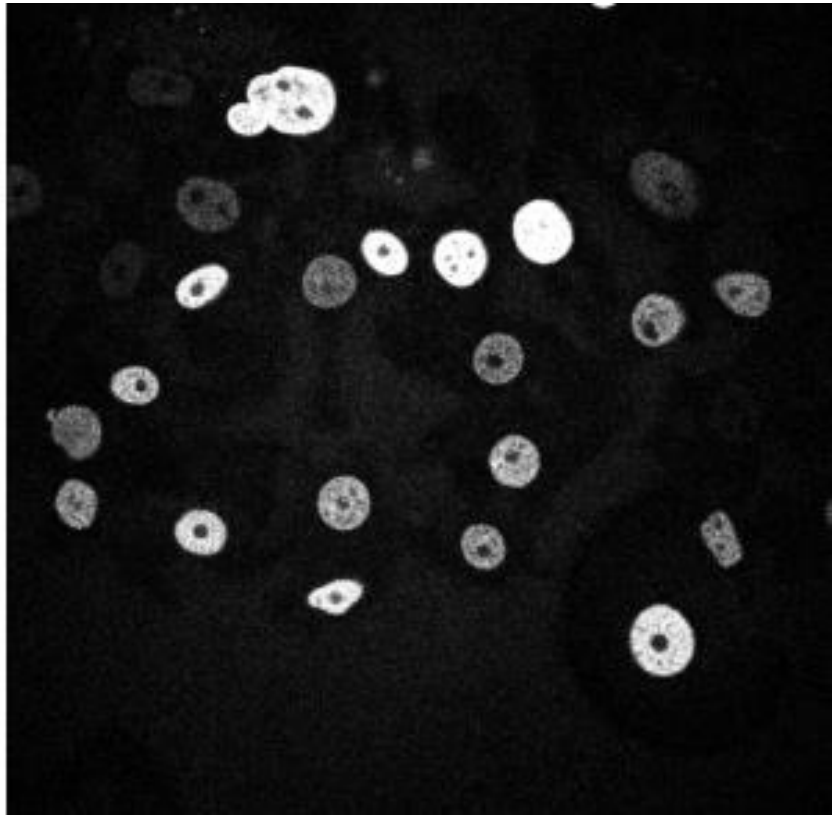


# N2DH-GOWT1

Original Image

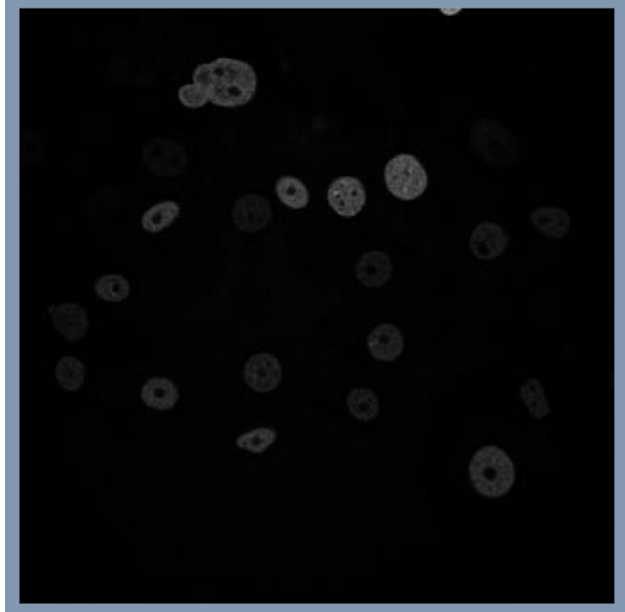


Histogram stretching

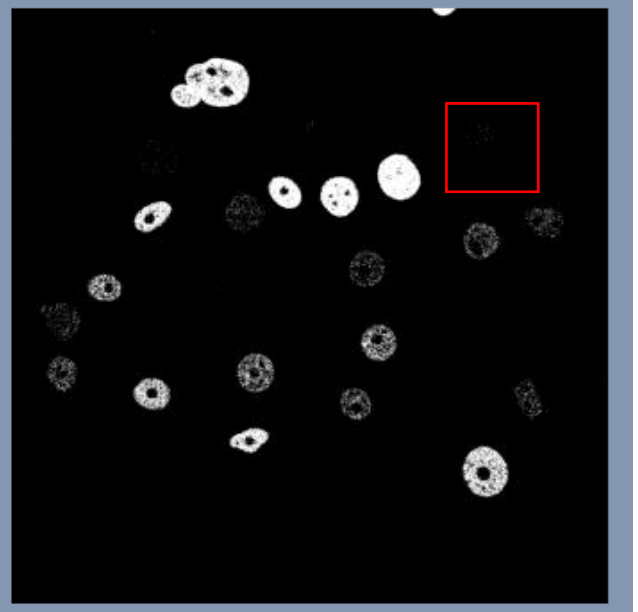


# N2DH-GOWT1

Original image



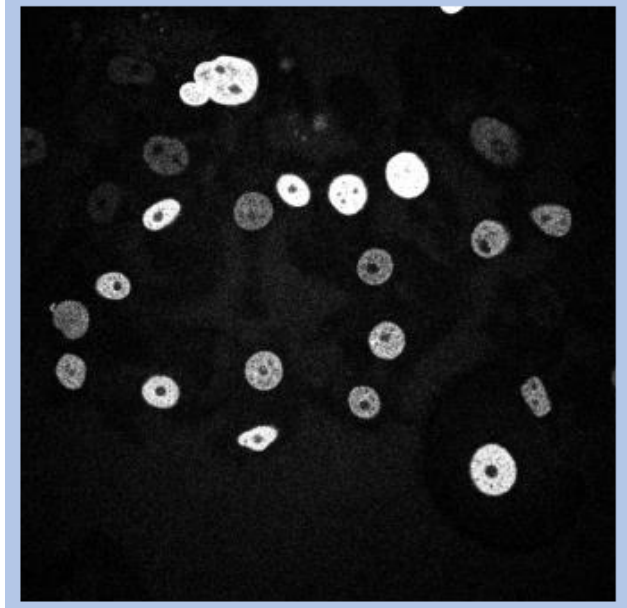
Segmentation



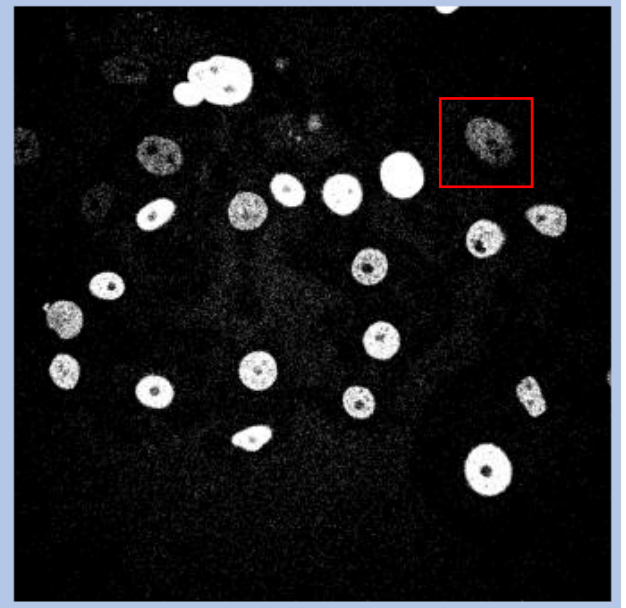
Dice Score

MSD

Histogram streching



Segmentation



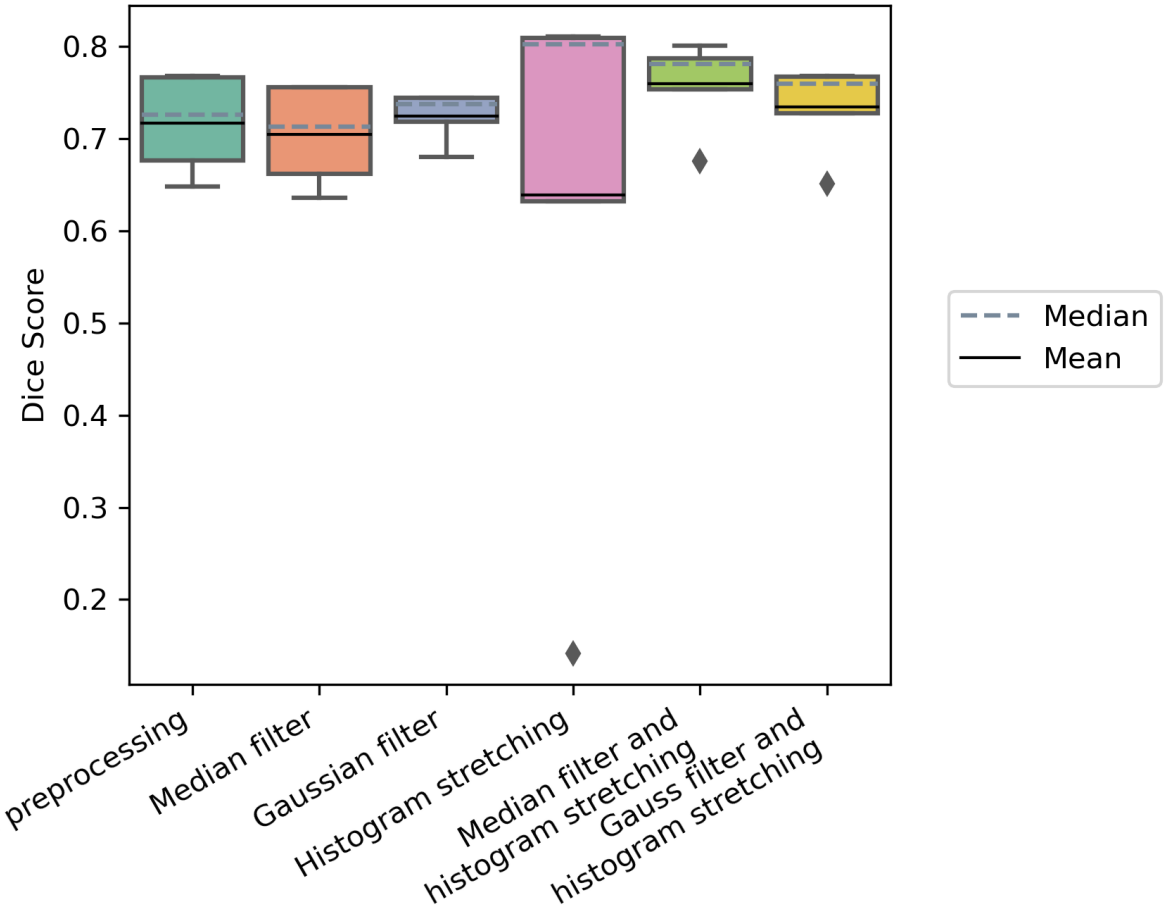
Dice Score

MSD

# N2DL-HeLa

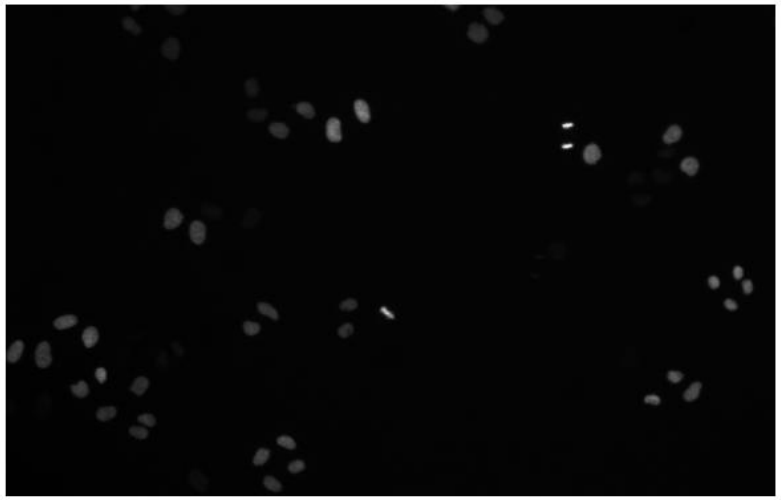
Best strategy:

Median filter and histogram stretching (0.76)

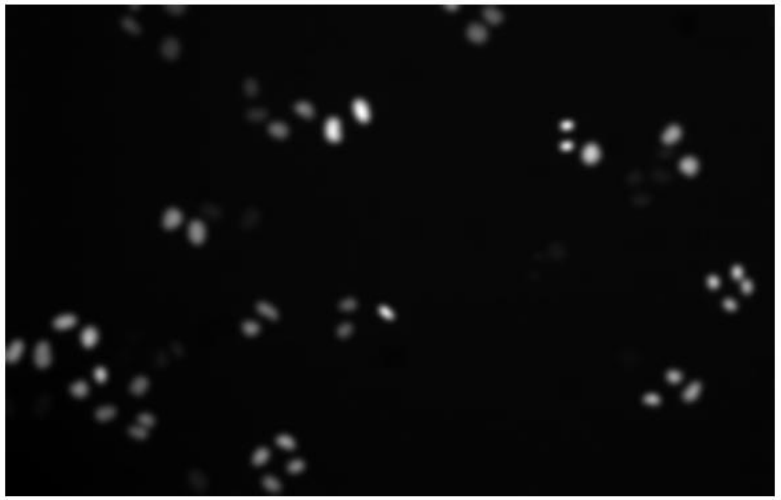


# N2DL-HeLa

Original image



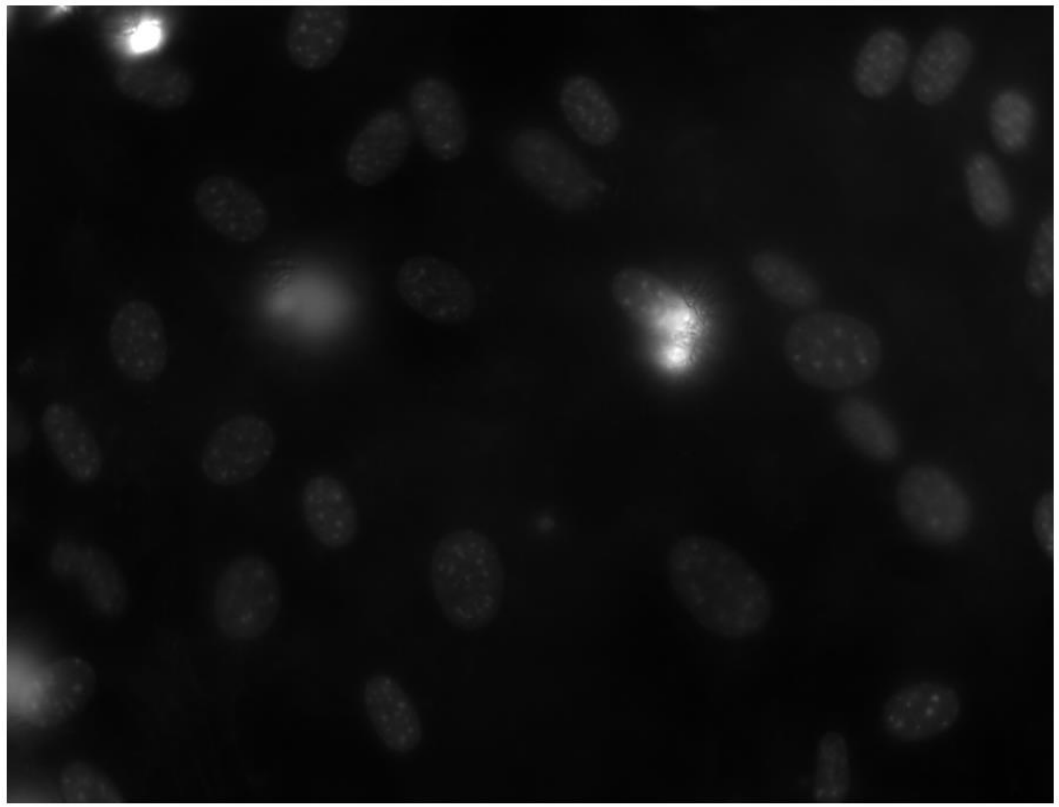
Gaussian filter



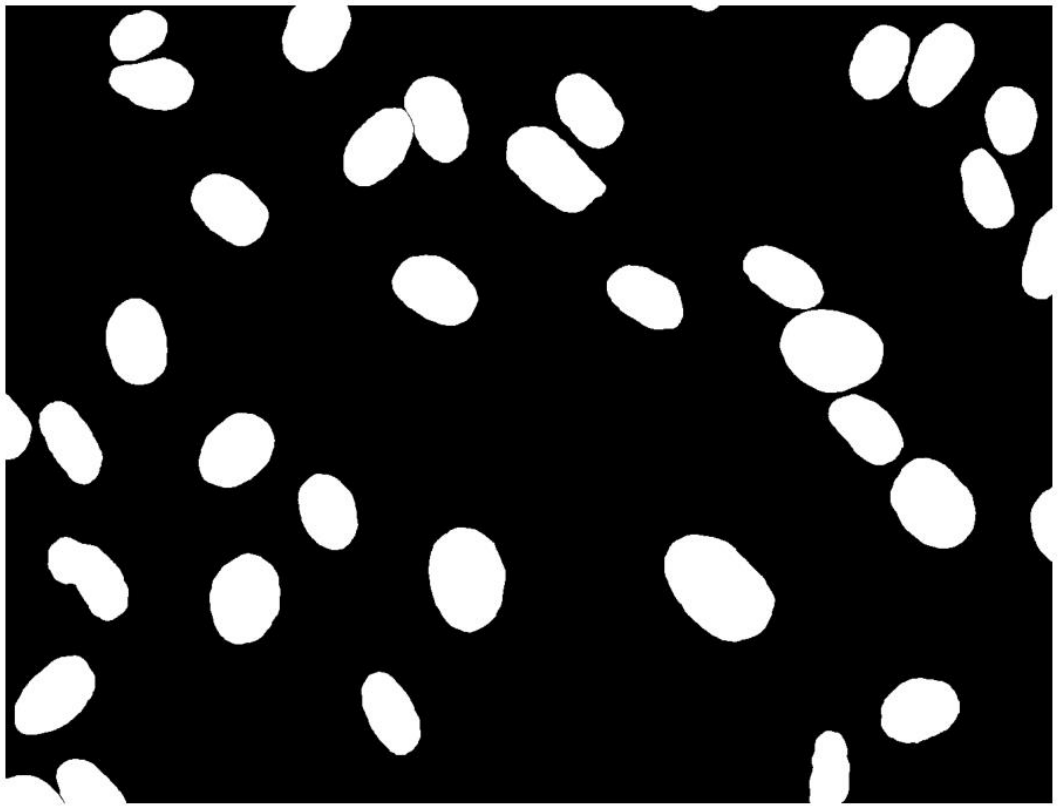
Segmentation

# NIH3T3

Original image



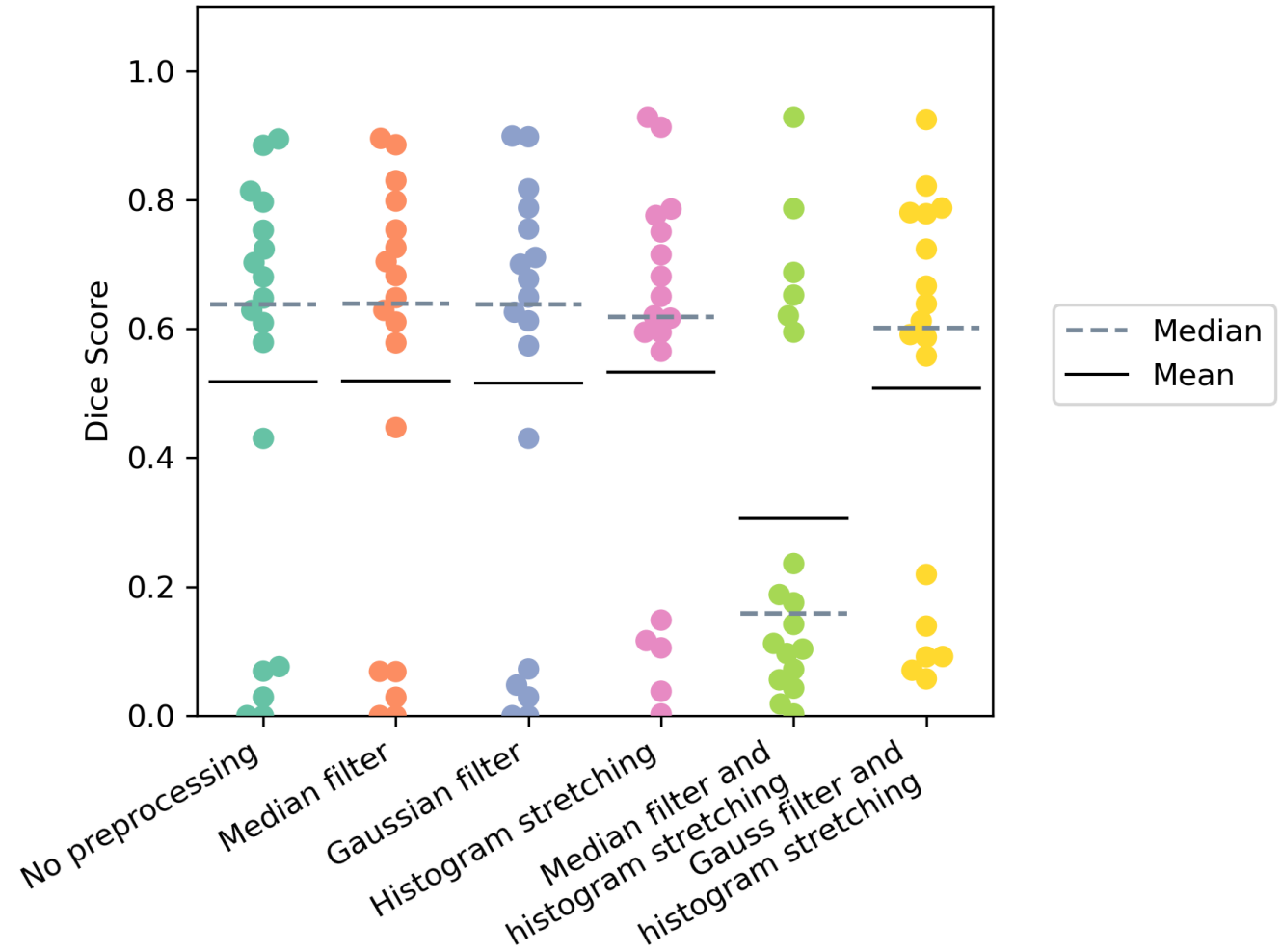
Ground truth



# NIH3T3: One-level Otsu

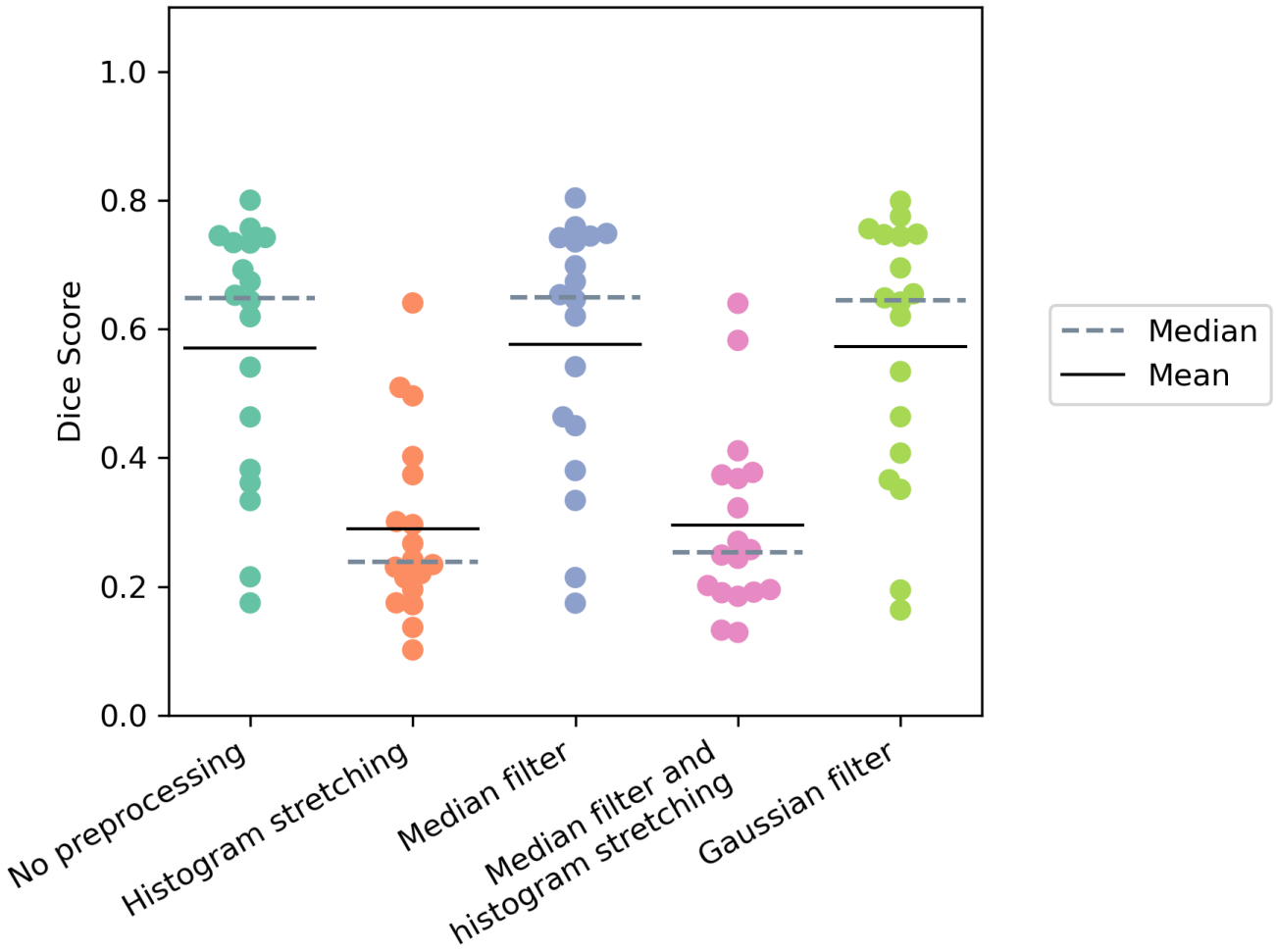
Best strategy:

Histogram stretching (0.533)



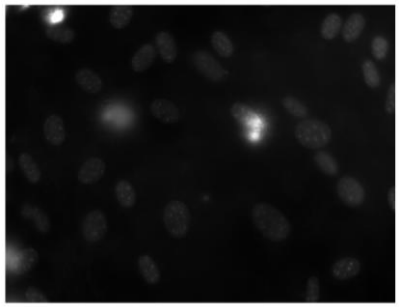
# NIH3T3: Two-level Otsu

Best strategy:
Median filter
(0.577)



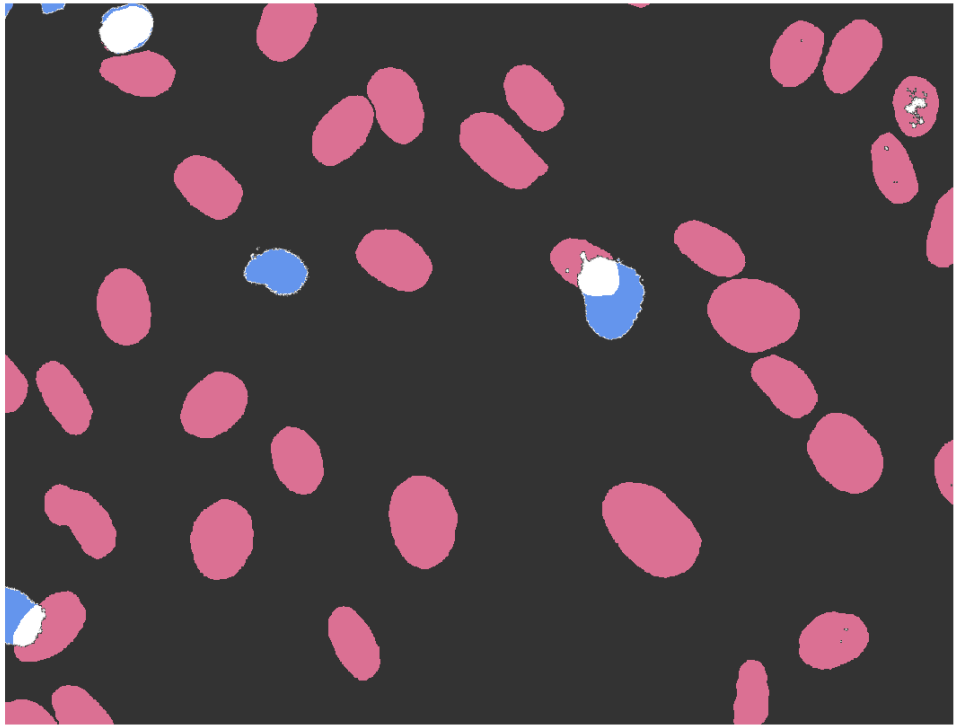
# NIH3T3: Two-level Otsu

Original image

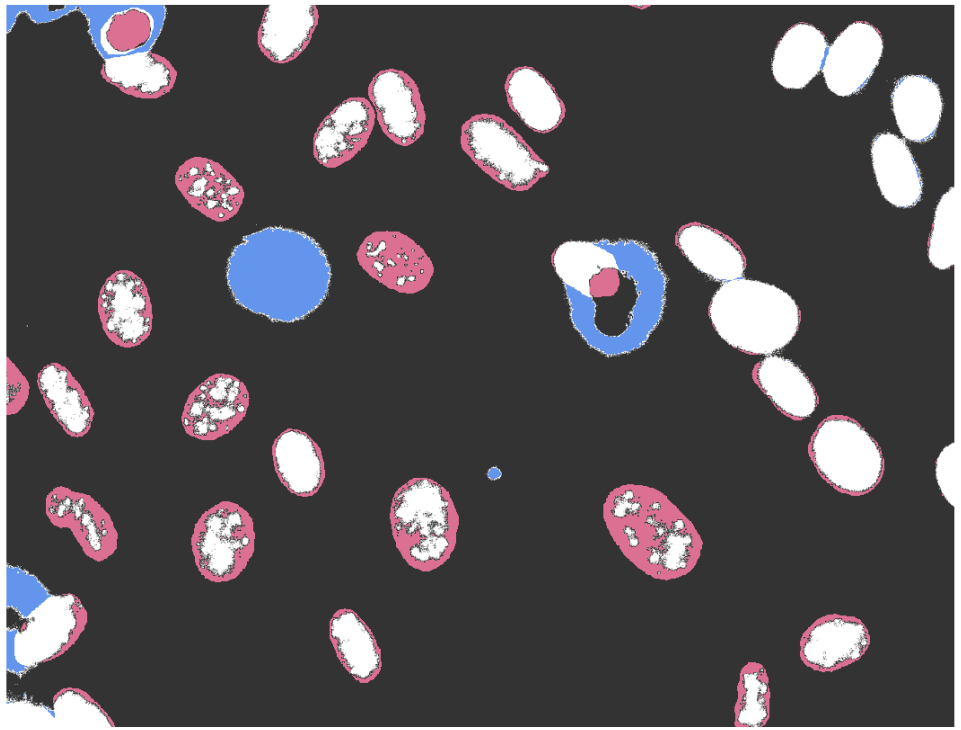


Ground truth

One-level Segmentation



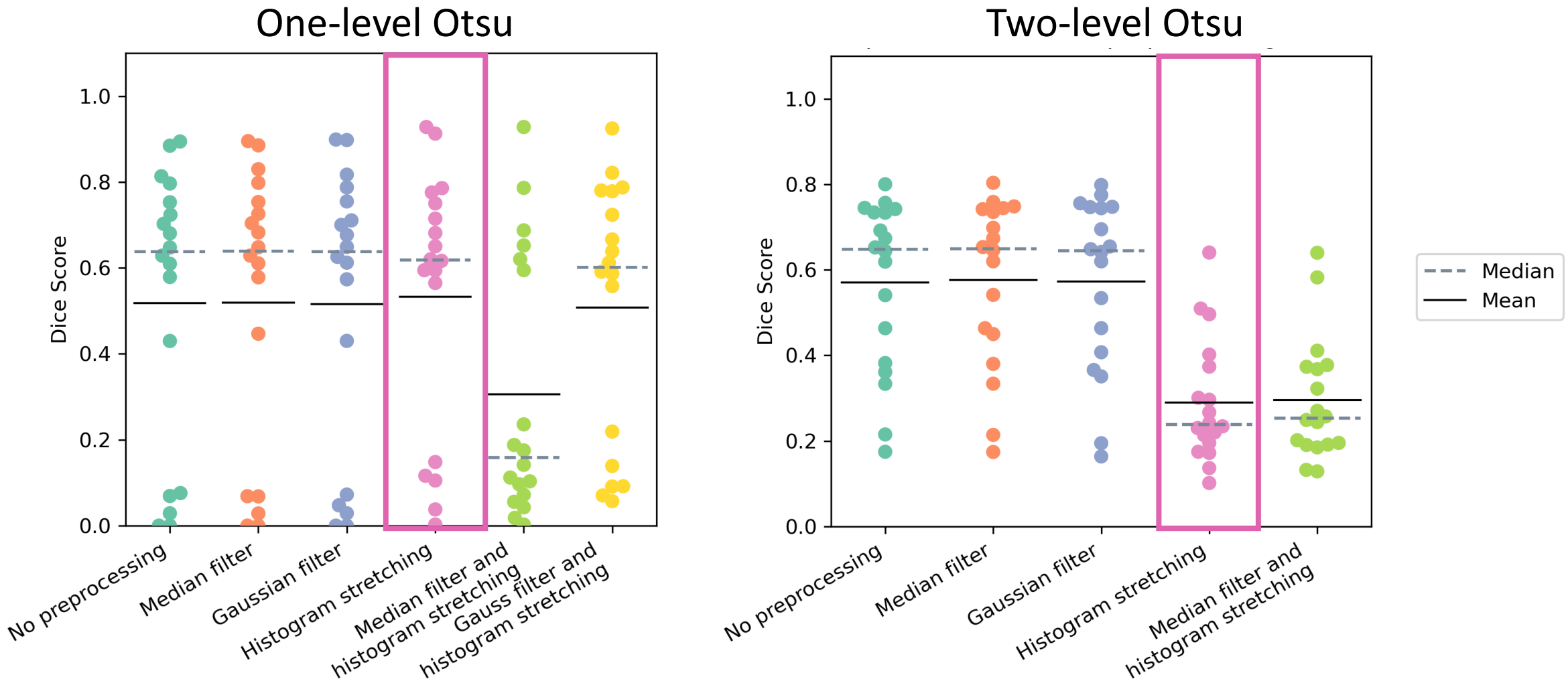
Two-level Segmentation



**False negatives**

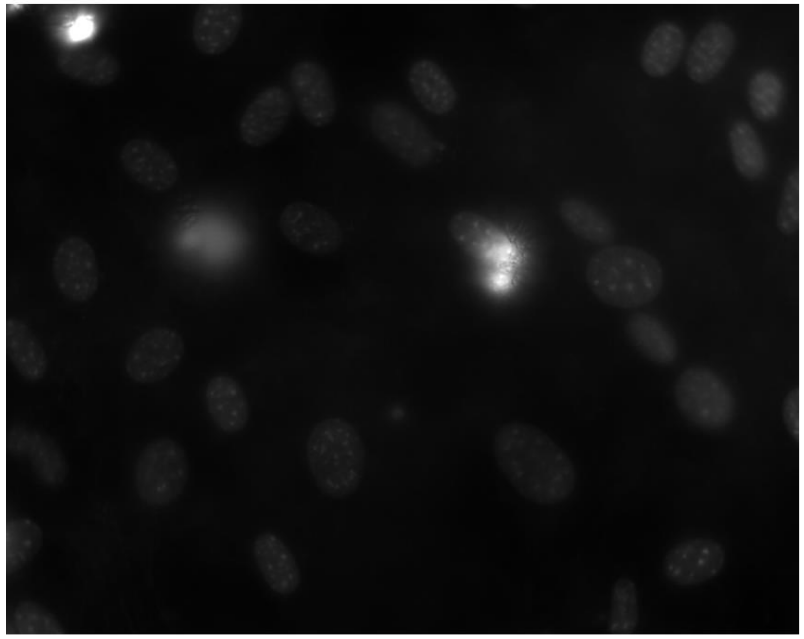
**False positives**

# NIH3T3: Two-level Otsu

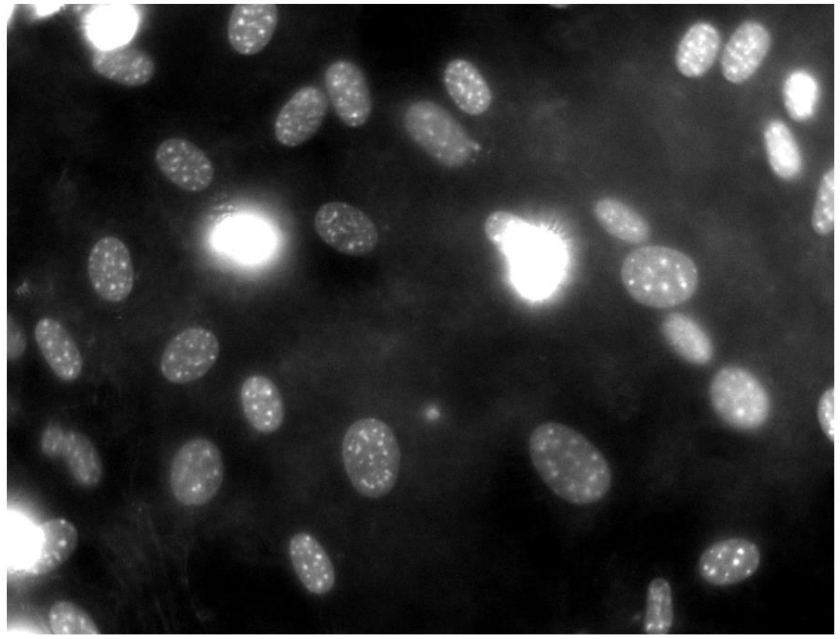


# NIH3T3: Two-level Otsu

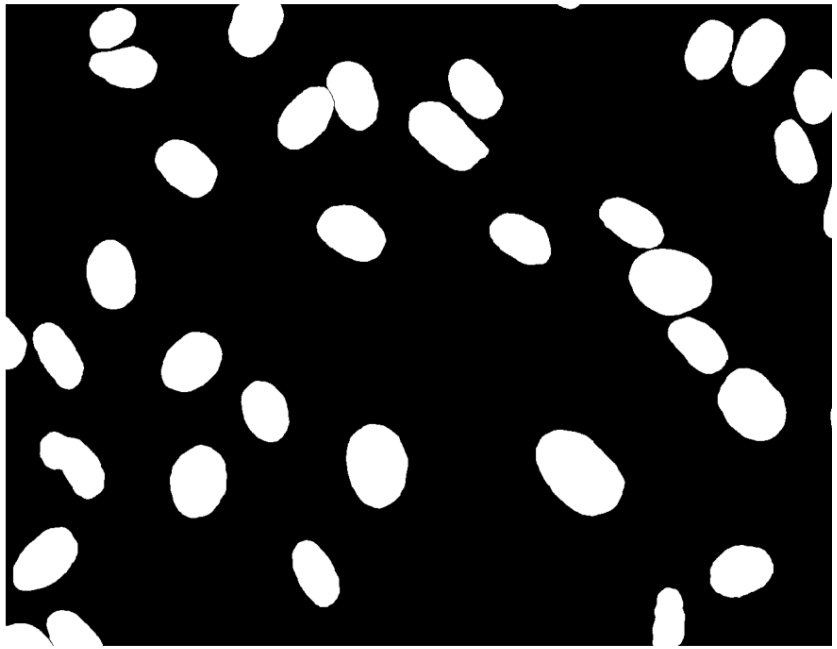
Original image



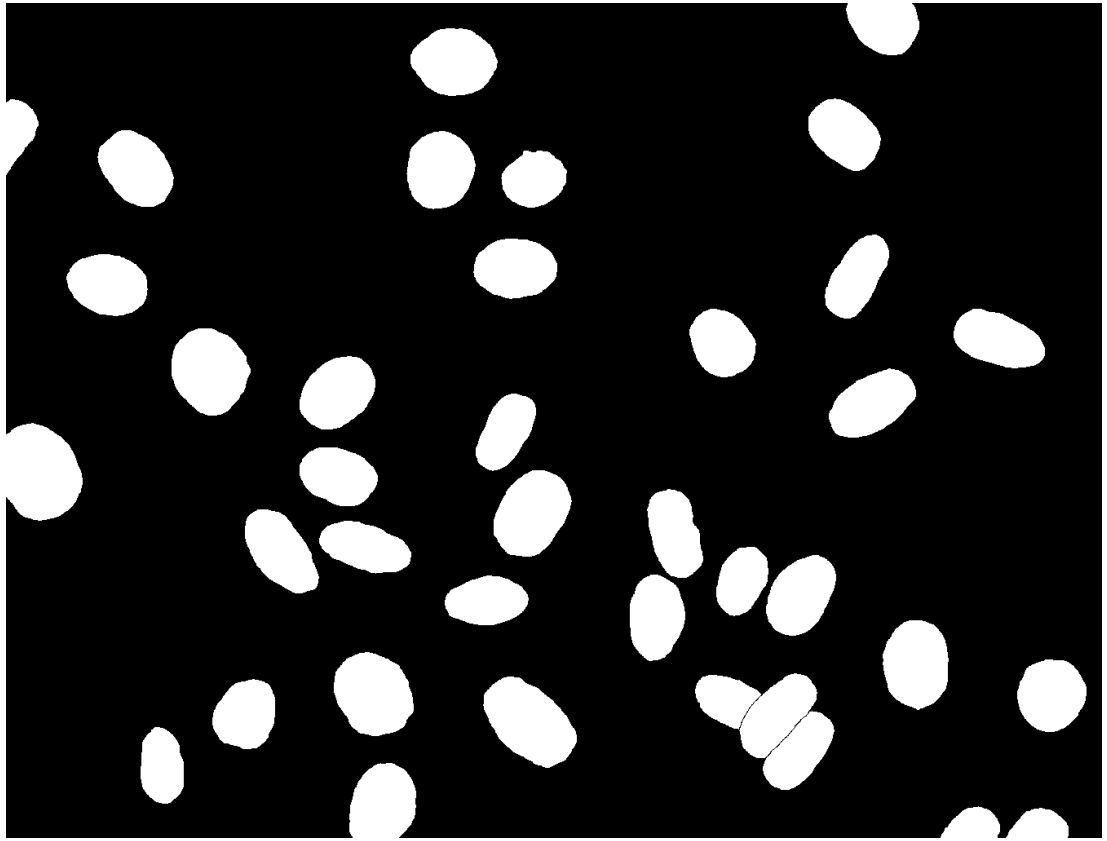
Histogram stretching

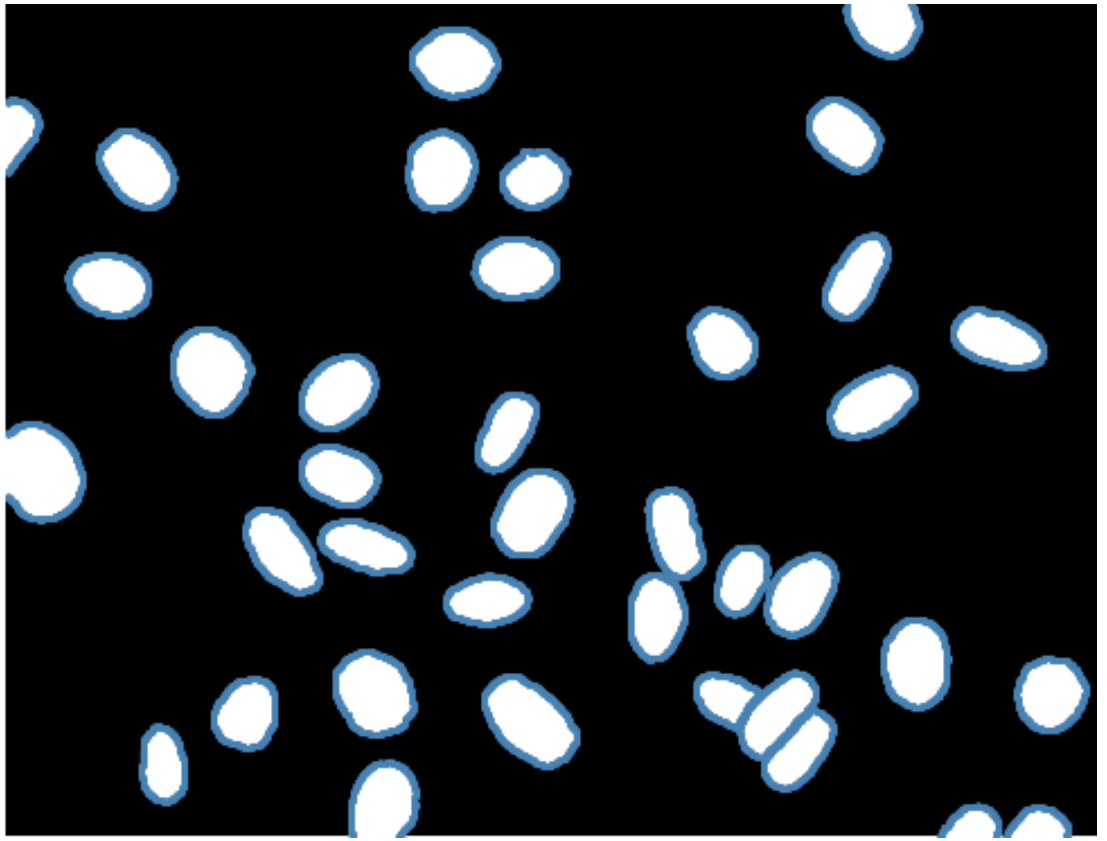


Ground truth

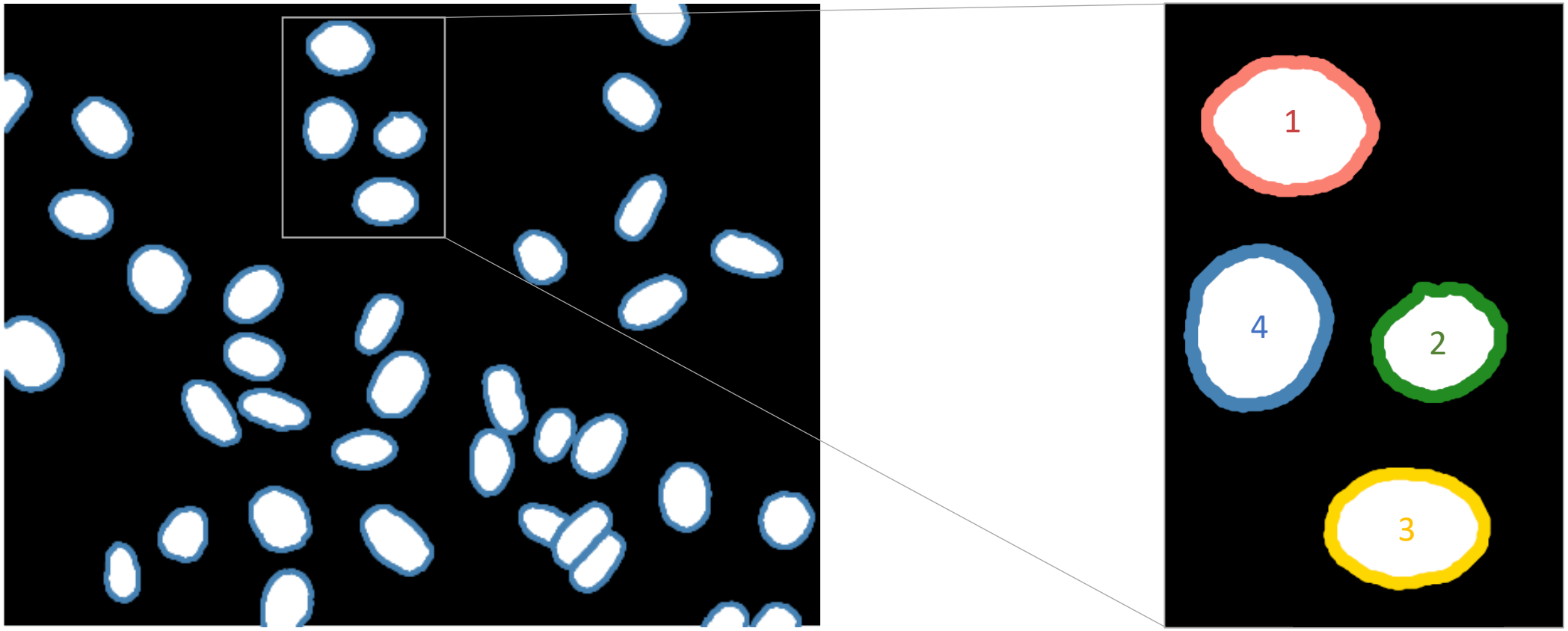


# Cell nuclei counting

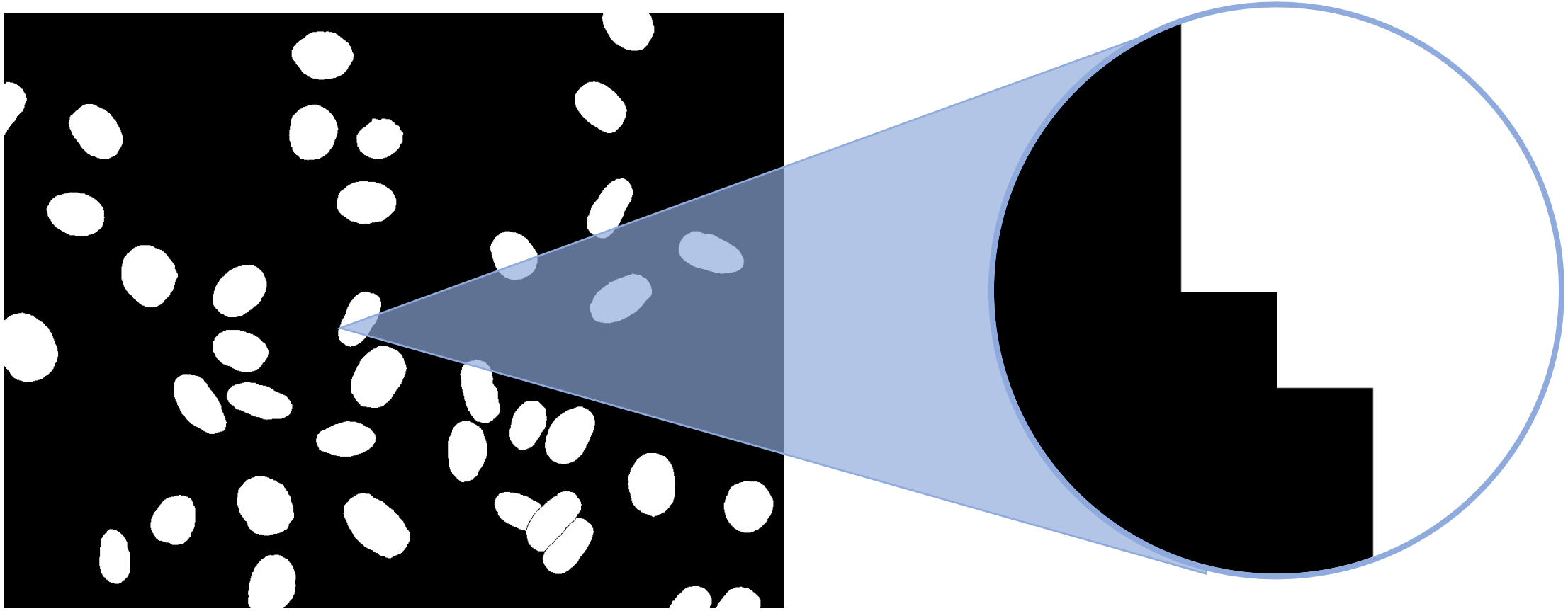




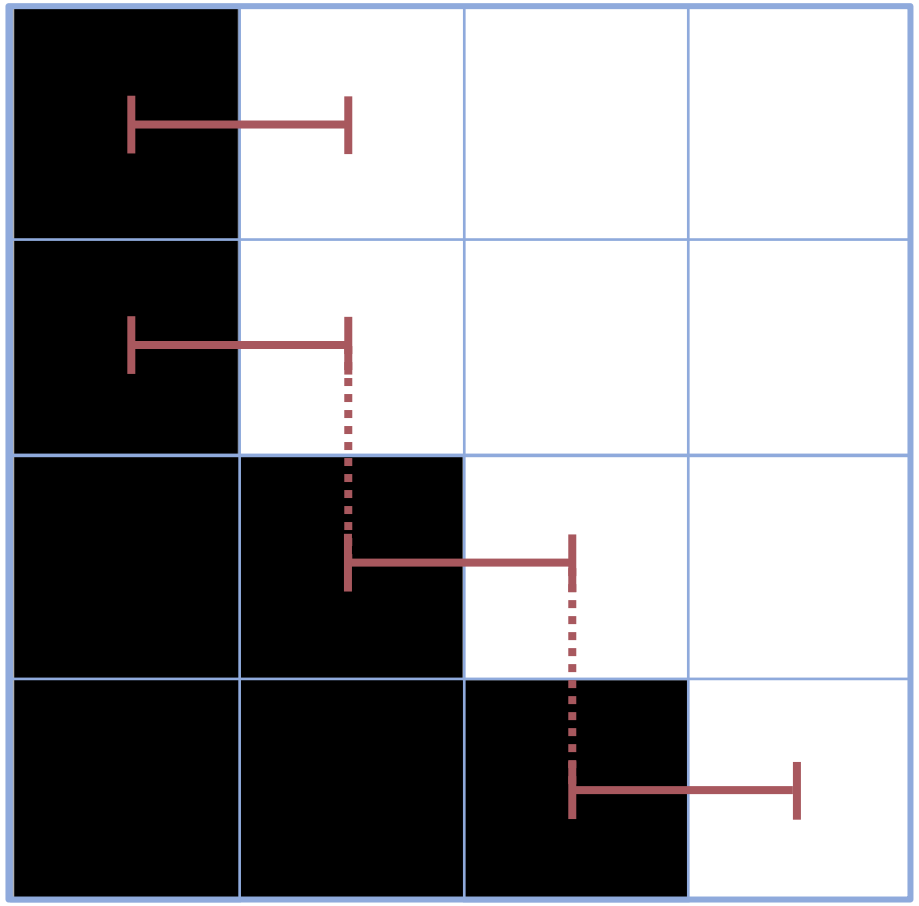
# Cell nuclei counting



# Cell nuclei counting



# Cell nuclei counting



$d = 1$

# Cell nuclei counting

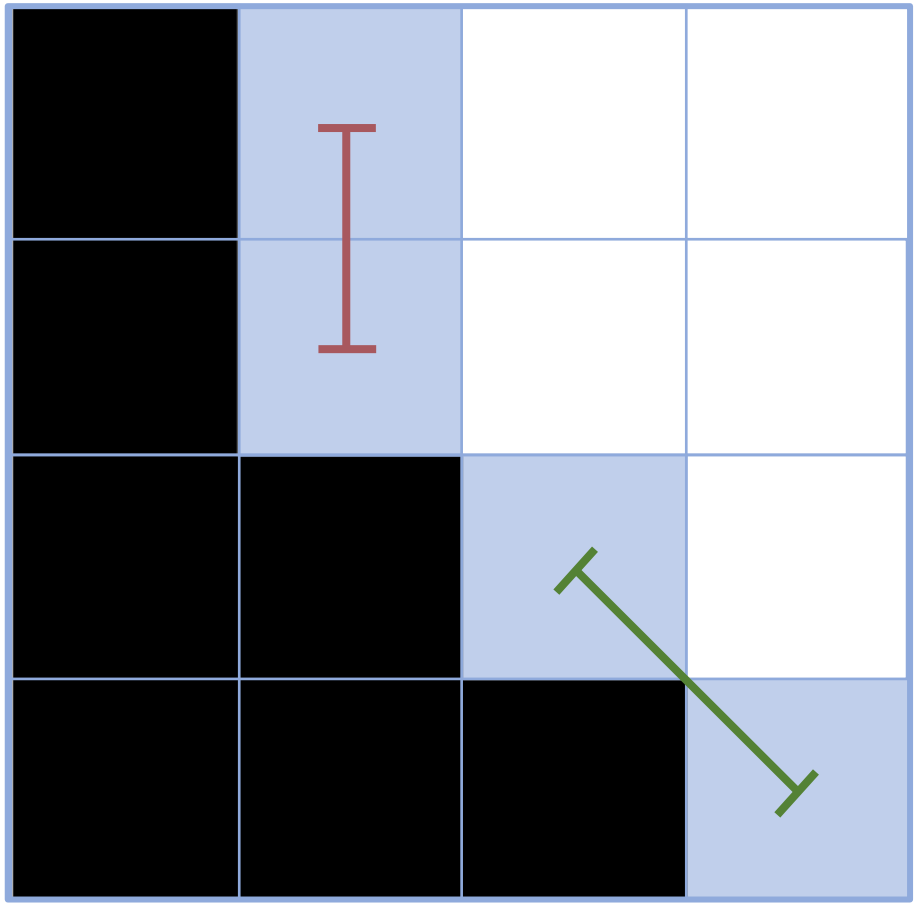
```
edge_pixels = []

for index in np.ndindex(img.shape):
    if workimg[index[0]][index[1]] == 1:
        if 0 in workimg[(index[0] - 1):(index[0] + 2), (index[1] - 1):(index[1] + 2)]:
            edge_pixels.append(index)

return edge_pixels
```

$d = 1$

# Cell nuclei counting

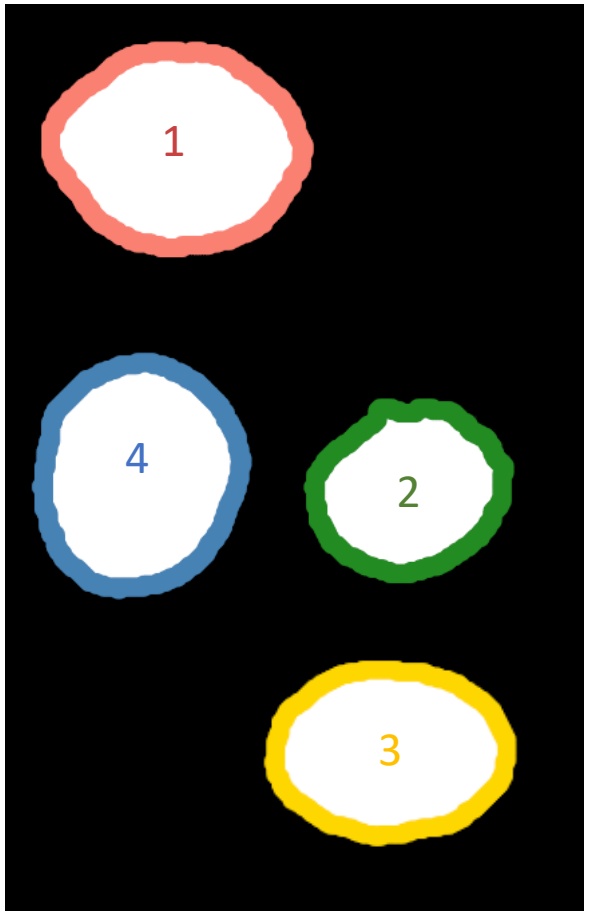


$d = 1$

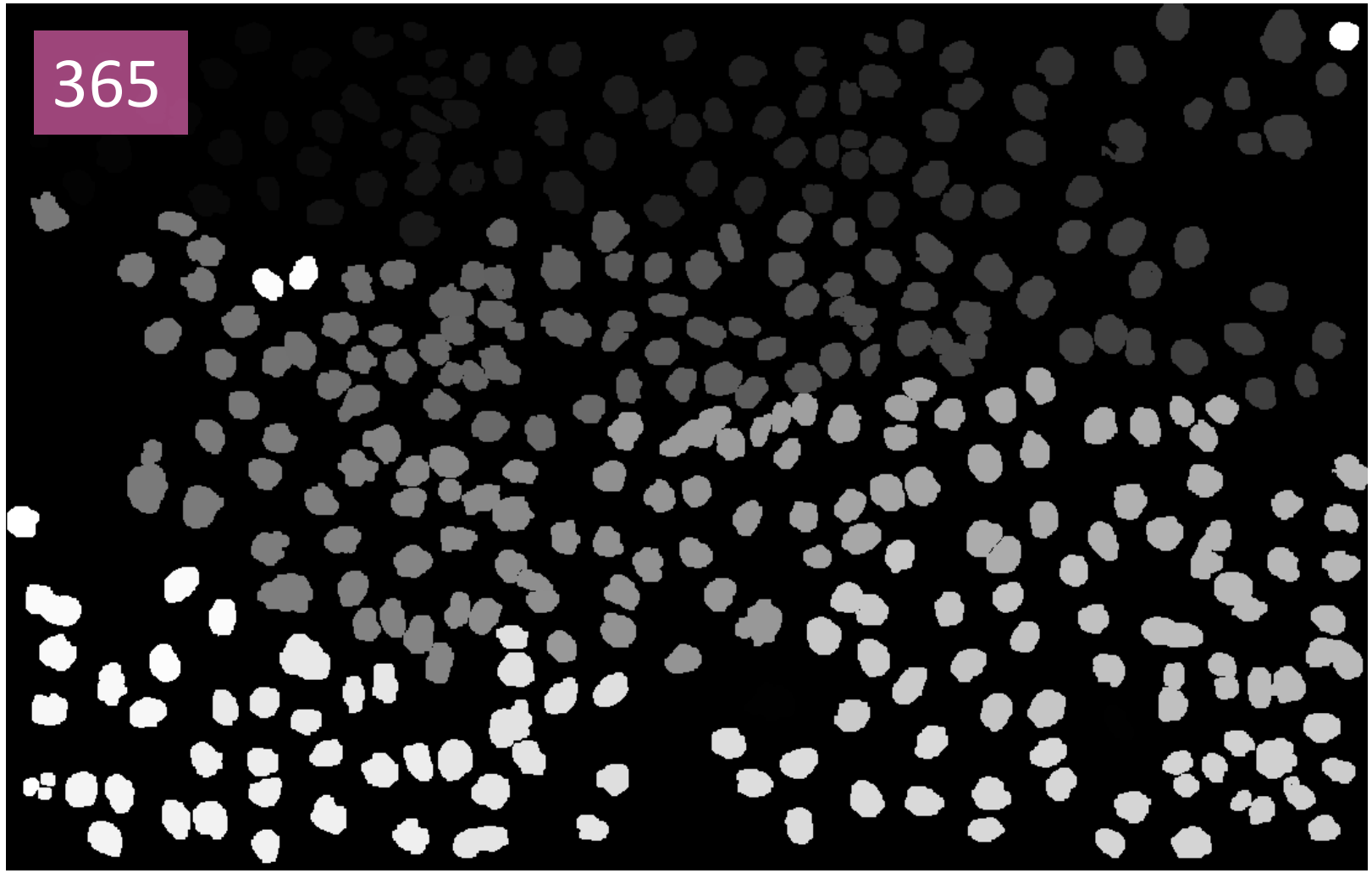
$d = \sqrt{2}$

# Cell nuclei counting

```
for start_pixel in border_pixels:
    old_group = [start_pixel]
    new_group = []
    first_run = True
    while old_group != new_group:
        if not first_run:
            old_group = new_group
        first_run = False
        for pixel in old_group:
            for other_pixel in border_pixels:
                if math.dist(pixel, other_pixel) < 2:
                    new_group.append(other_pixel)
                    border_pixels.remove(other_pixel)
            if pixel in border_pixels:
                border_pixels.remove(pixel)
    all_groups.append(new_group)
```

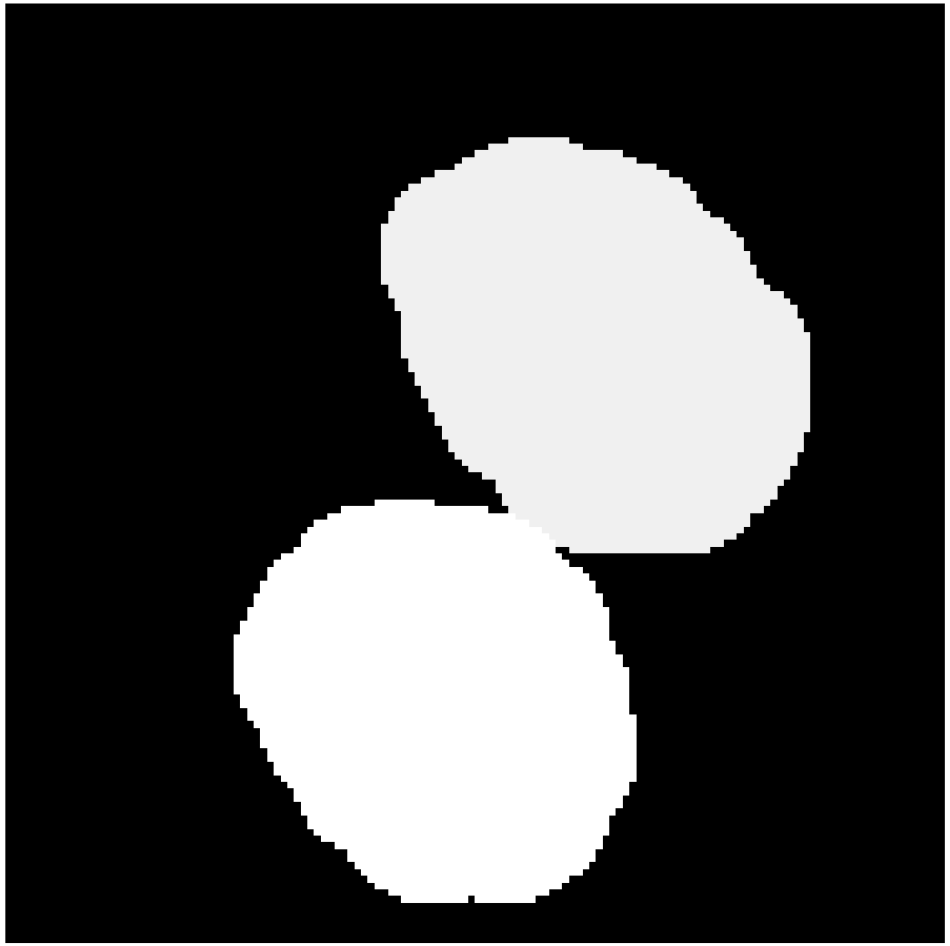


# Evaluation cell nuclei counting

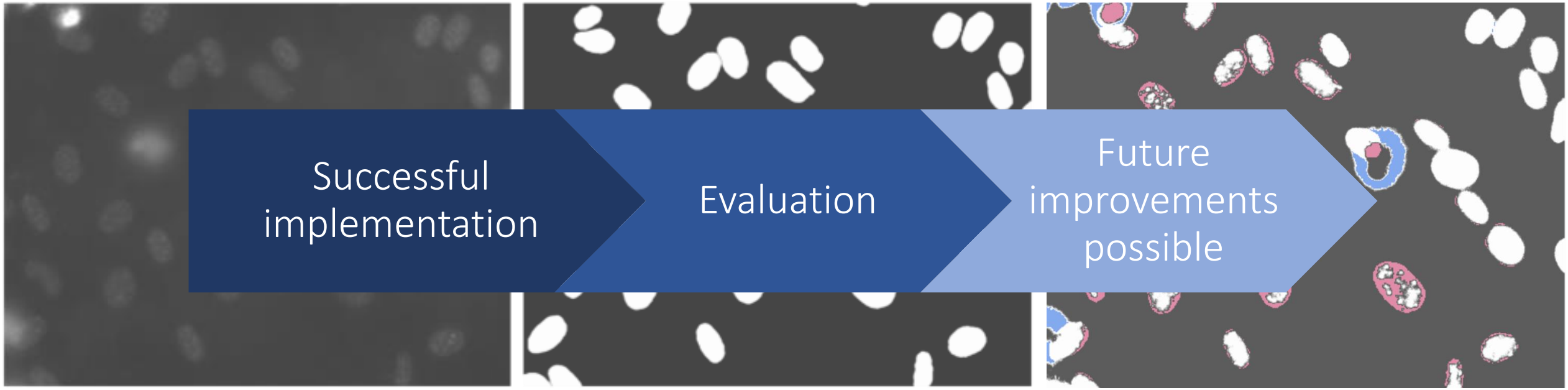



349

# Evaluation cell nuclei counting



# Conclusion


Successful implementation
Evaluation
Future improvements possible

# Thank you for your attention!

Laura Wächter, Veronika Schuler, Elizaveta Chernova, Hannah L. Winter

# Additional slide – MSD code

```
# calculate minimum distances for each point in seg to the sets of points in gt
tree_seg_gt = spatial.cKDTree(gt_array)
mindist_seg_gt, minid_seg_gt = tree_seg_gt.query(seg_array)

# calculate sum and length of arrays with minimal distances
sum_seg_gt = np.sum(mindist_seg_gt)
size_seg_gt = len(mindist_seg_gt)
```

```
mean_surface_distance = (1/(size_gt_seg+size_seg_gt))*(sum_gt_seg + sum_seg_gt)

return mean_surface_distance
```

# Additional slide – HD code

```
# calculate minimum distances for each point in seg to the sets of points in gt
tree_seg_gt = spatial.cKDTree(gt_array)
mindist_seg_gt, minid_seg_gt = tree_seg_gt.query(seg_array)

# calculate sum and length of arrays with minimal distances
sum_seg_gt = np.sum(mindist_seg_gt)
size_seg_gt = len(mindist_seg_gt)
```

```
hausdorff_distance = max(max_gt_seg,max_seg_gt)

return hausdorff_distance
```

# Additional slide - cell counting dataset 1

Table 1: Results of the cell counting on the N2DH-GOWT1 dataset.

| | Calculated number | Ground truth number | Absolute difference | Relative difference |
|---|---|---|---|---|
| **man_seg01.tif** | 24 | 23 | 1 | 0.043478 |
| **man_seg21.tif** | 23 | 24 | -1 | -0.041667 |
| **man_seg31.tif** | 24 | 22 | 2 | 0.090909 |
| **man_seg39.tif** | 23 | 25 | -2 | -0.080000 |
| **man_seg52.tif** | 30 | 30 | 0 | 0.000000 |
| **man_seg72.tif** | 28 | 28 | 0 | 0.000000 |

# Additional slide – cell counting dataset 2

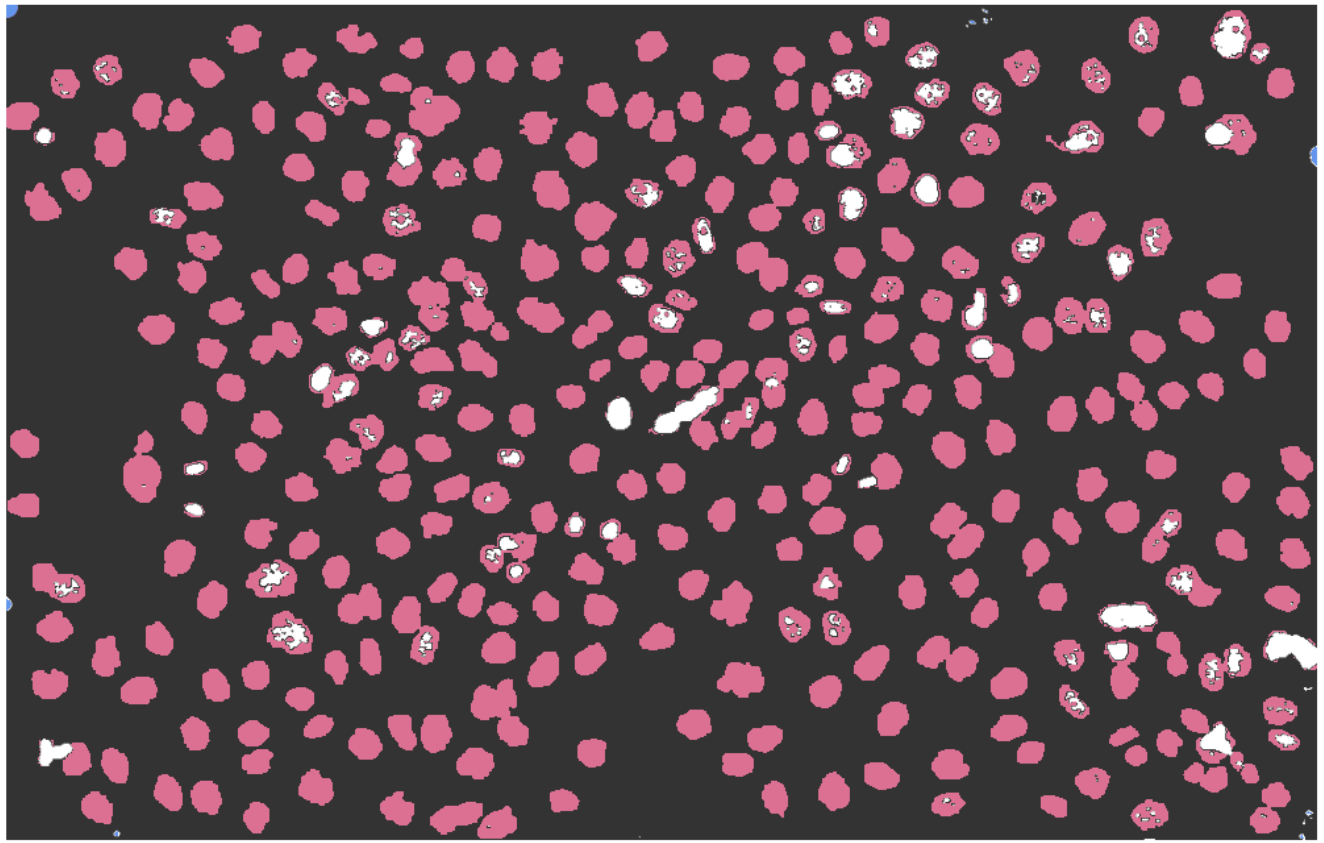
| | Calculated number | Ground truth number | Absolute difference | Relative difference |
|---|---|---|---|---|
| **man_seg13.tif** | 58 | 59 | -1 | -0.016949 |
| **man_seg52.tif** | 107 | 109 | -2 | -0.018349 |
| **man_seg75.tif** | 365 | 349 | 16 | 0.045845 |
| **man_seg79.tif** | 329 | 342 | -13 | -0.038012 |

# Cell Counting

```
for start_pixel in border_pixels:
    old_group = [start_pixel]
    new_group = []
    first_run = True
    while old_group != new_group:
        if not first_run:
            old_group = new_group
        first_run = False
        for pixel in old_group:
            for other_pixel in border_pixels:
                if math.dist(pixel, other_pixel) < 2:
                    new_group.append(other_pixel)
                    border_pixels.remove(other_pixel)
            if pixel in border_pixels:
                border_pixels.remove(pixel)
    all_groups.append(new_group)
```

# N2DL-HeLa: Outlier

Overlay of ground truth and test image



# Additional slide – Histogram stretching