

Image Filtering

Image Processing & Analysis for Life Scientists

Olivier Burri, Romain Guiet & Arne Seitz

- What is Filtering
 - Linear Filters
 - Nonlinear Filters
- Uses in Biological Images
 - Artifact/Noise removal
 - Background subtraction
 - Feature enhancement

- Manipulations of the pixel data in order to improve an aspect of the image
 - Increase contrast
 - Remove uneven background
 - Enhance features

Summary: Point Operations

- Mapping pixel values without changing the size, geometry or local structure of the image
- «*homogeneous operation*»
- $a' \leftarrow f(a)$ or $I'(u, v) \leftarrow f(I(u, v))$
- Modifying brightness contrast, adjusting display settings

Filtering

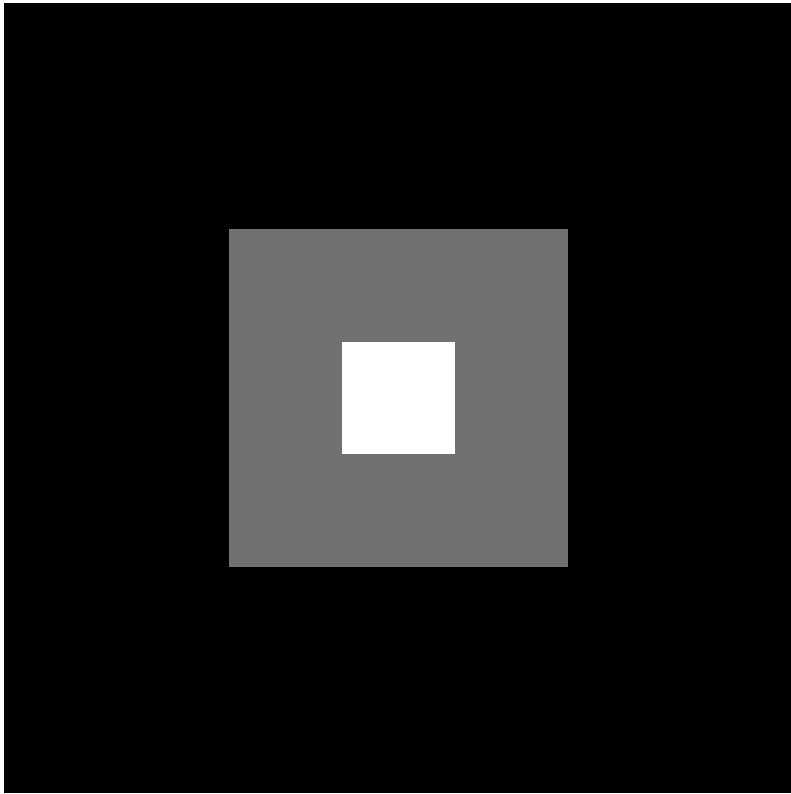


- Sharp image: local intensities rise/drop sharply
- Blurred Image: local intensities rise/drop smoothly

Linear Filters

1	1	1	1	1	1	1
1	1	1	1	1	1	1
1	1	5	5	5	1	1
1	1	5	10	5	1	1
1	1	5	5	5	1	1
1	1	1	1	1	1	1
1	1	1	1	1	1	1

1	1	1
1	1	1
1	1	1



Filter

Output

Linear Filters

1	1	1	1	1	1	1
1	1	1	1	1	1	1
1	1	5	5	5	1	1
1	1	5	10	5	1	1
1	1	5	5	5	1	1
1	1	1	1	1	1	1
1	1	1	1	1	1	1

1	1	1
1	1	1
1	1	1

$1 * 1 + \dots =$

Input

Filter

Output

Linear Filters

1	1	1	1	1	1	1
1	1	1	1	1	1	1
1	1	5	5	5	1	1
1	1	5	10	5	1	1
1	1	5	5	5	1	1
1	1	1	1	1	1	1
1	1	1	1	1	1	1

1	1	1
1	1	1
1	1	1

$1 * 1 + 1 * 1 + \dots =$

Input

Filter

Output

Linear Filters

1	1	1	1	1	1	1
1	1	1	1	1	1	1
1	1	5	5	5	1	1
1	1	5	10	5	1	1
1	1	5	5	5	1	1
1	1	1	1	1	1	1
1	1	1	1	1	1	1

1	1	1
1	1	1
1	1	1

$1 * 1 + 1 * 1 + 1 * 1 + \dots =$

Input

Filter

Output

Linear Filters

1	1	1	1	1	1	1
1	1	1	1	1	1	1
1	1	5	5	5	1	1
1	1	5	10	5	1	1
1	1	5	5	5	1	1
1	1	1	1	1	1	1
1	1	1	1	1	1	1

1	1	1
1	1	1
1	1	1

$1 * 1 + 1 * 1 + 1 * 1 + 1 * 1 + 1 * 1 + 1 * 1 + 1 * 1 + 1 * 1 + 5 * 1 =$

Input

Filter

Output

Linear Filters

1	1	1	1	1	1	1
1	1	1	1	1	1	1
1	1	5	5	5	1	1
1	1	5	10	5	1	1
1	1	5	5	5	1	1
1	1	1	1	1	1	1
1	1	1	1	1	1	1

1	1	1
1	1	1
1	1	1

13				

$1 * 1 + 1 * 1 + 1 * 1 + 1 * 1 + 1 * 1 + 1 * 1 + 1 * 1 + 1 * 1 + 5 * 1 = 13$

Input

Filter

Output

Linear Filters

1	1	1	1	1	1	1
1	1	1	1	1	1	1
1	1	5	5	5	1	1
1	1	5	10	5	1	1
1	1	5	5	5	1	1
1	1	1	1	1	1	1
1	1	1	1	1	1	1

1	1	1
1	1	1
1	1	1

13	17			

$1 * 1 + 1 * 1 + 1 * 1 + 1 * 1 + 1 * 1 + 1 * 1 + 1 * 1 + 5 * 1 + 5 * 1 = 17$

Input

Filter

Output

Linear Filters

1	1	1	1	1	1	1
1	1	1	1	1	1	1
1	1	5	5	5	1	1
1	1	5	10	5	1	1
1	1	5	5	5	1	1
1	1	1	1	1	1	1
1	1	1	1	1	1	1

1	1	1
1	1	1
1	1	1

13	17	21		

$1 * 1 + 1 * 1 + 1 * 1 + 1 * 1 + 1 * 1 + 1 * 1 + 5 * 1 + 5 * 1 + 5 * 1 = 21$

Input

Filter

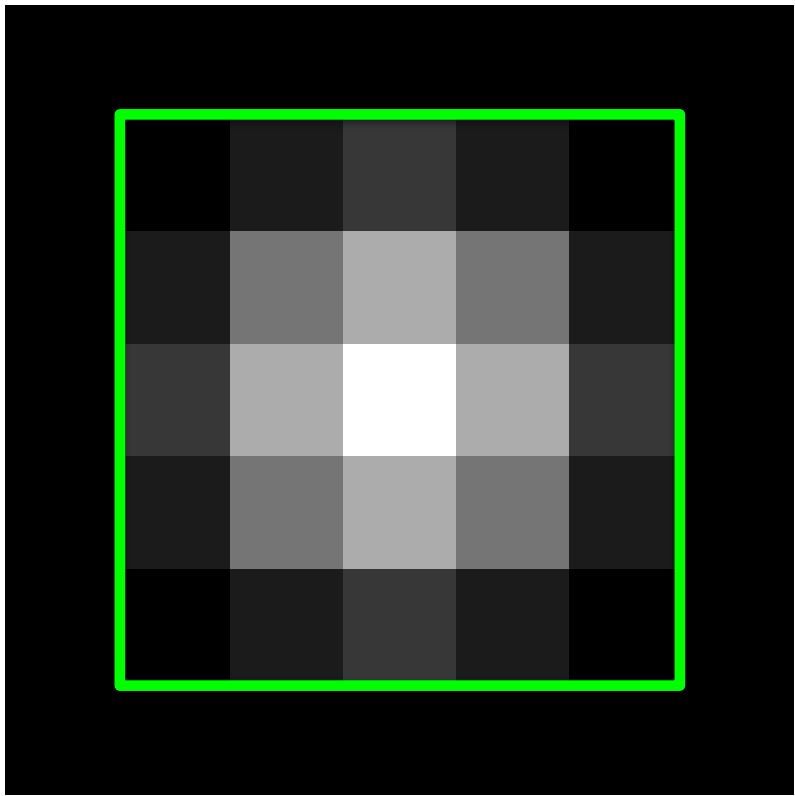
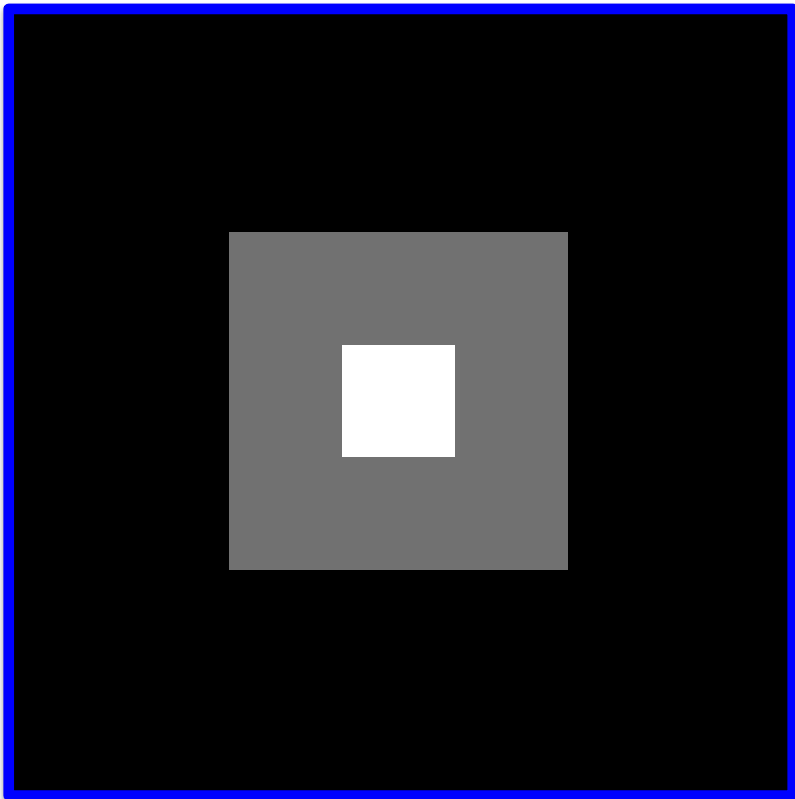
Output

Linear Filters

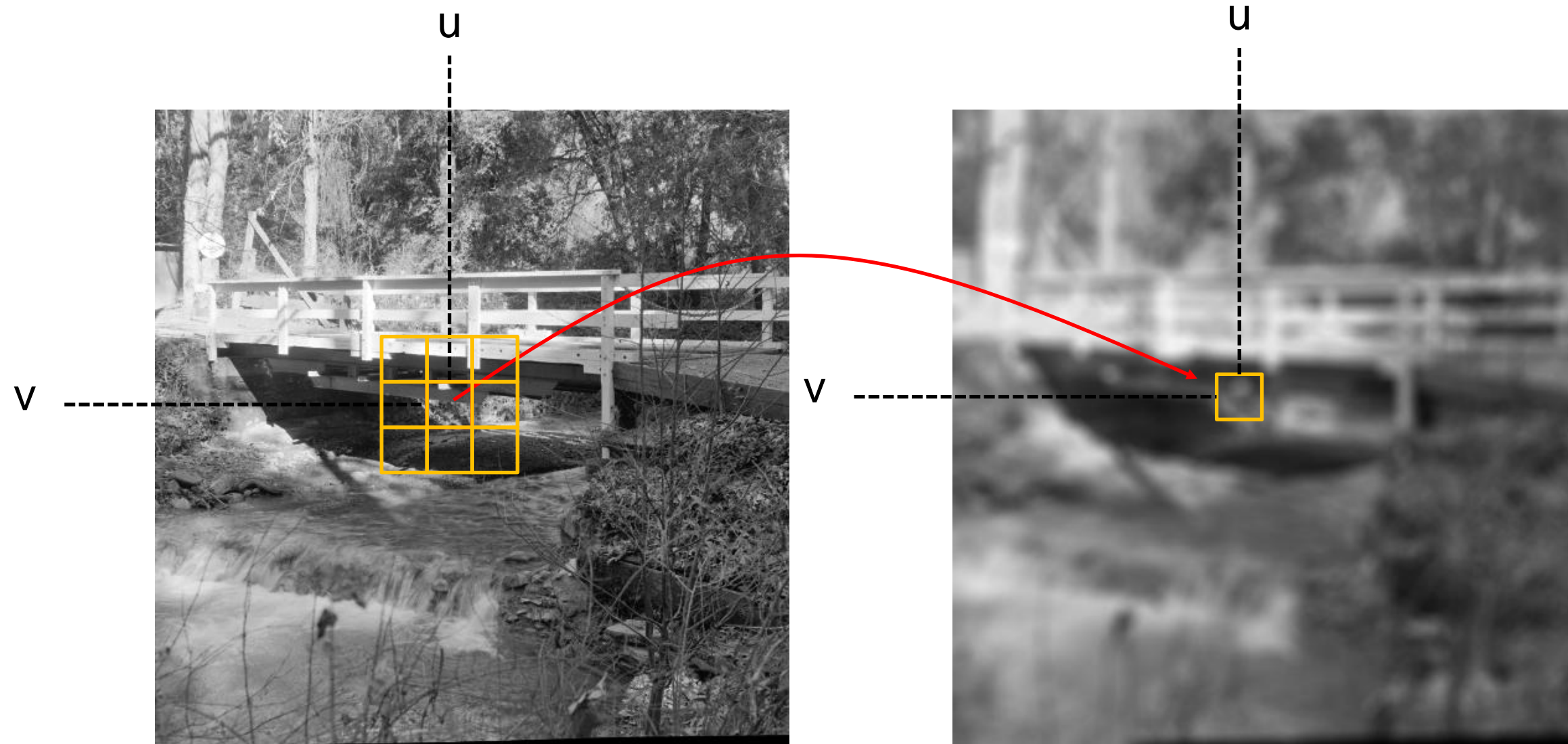
1	1	1	1	1	1	1
1	1	1	1	1	1	1
1	1	5	5	5	1	1
1	1	5	10	5	1	1
1	1	5	5	5	1	1
1	1	1	1	1	1	1
1	1	1	1	1	1	1

1	1	1
1	1	1
1	1	1

13	17	21	17	13
17	30	38	30	17
21	38	50	38	21
17	30	38	30	17
13	17	21	17	13



Filtering



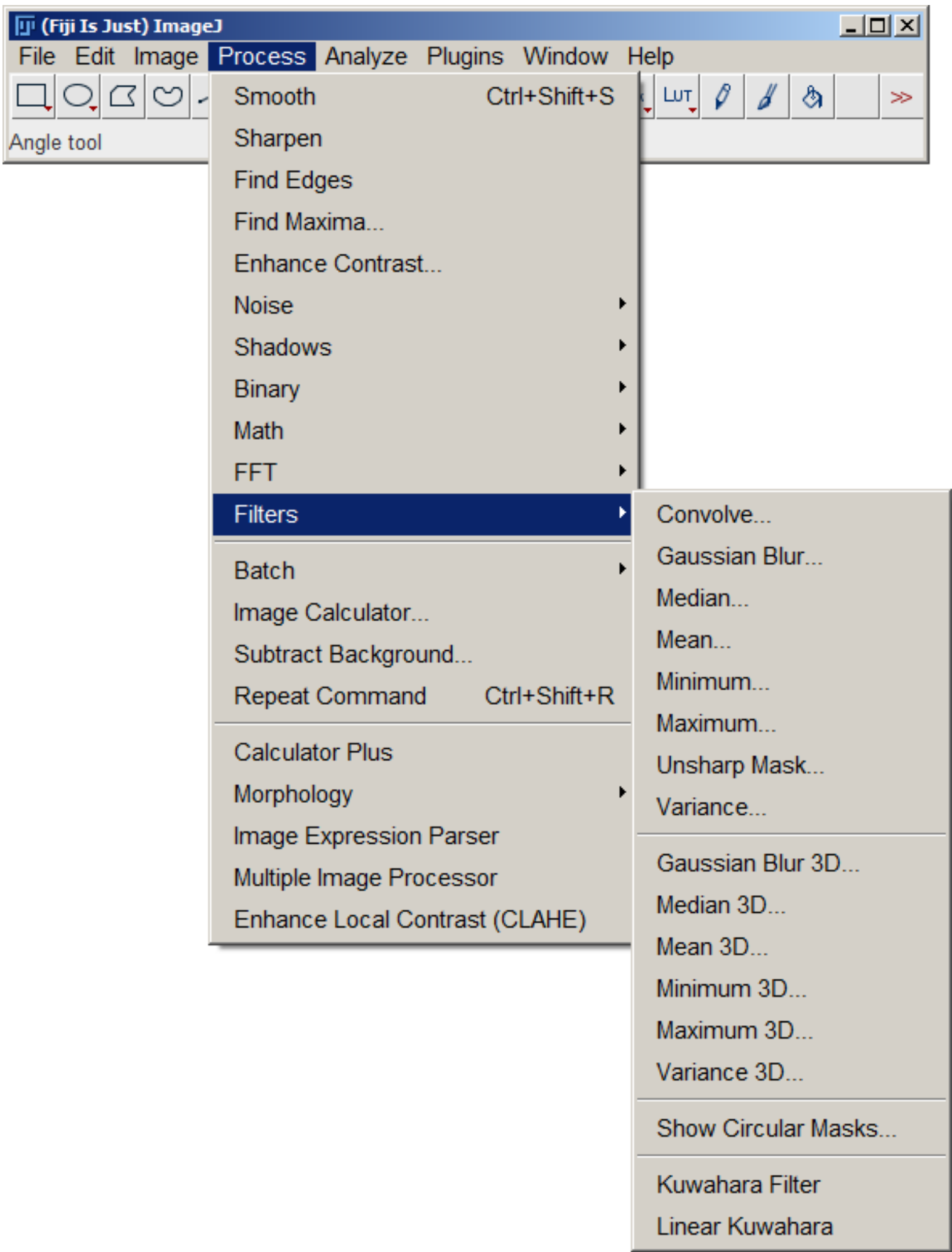
$$I'(u, v) = \frac{p_1 + p_2 + p_3 + p_4 + p_5 + p_6 + p_7 + p_8 + p_9}{9}$$

$$I'(u, v) = \frac{1}{9} \sum_{j=-1}^1 \sum_{i=-1}^1 I(u + i, v + j)$$

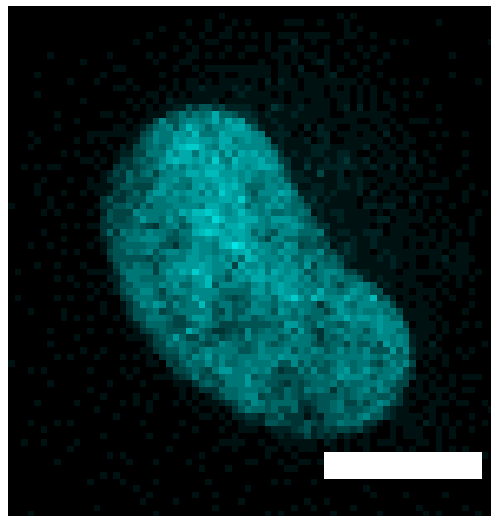
Filter Matrix:

$$H(i, j) = \frac{1}{9} \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

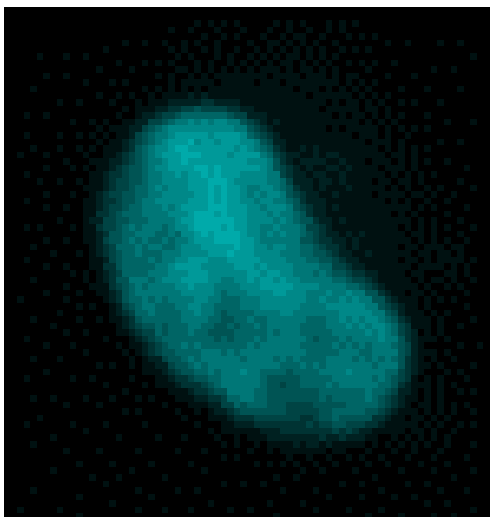
Image Filtering in Fiji



Linear Filters - Examples

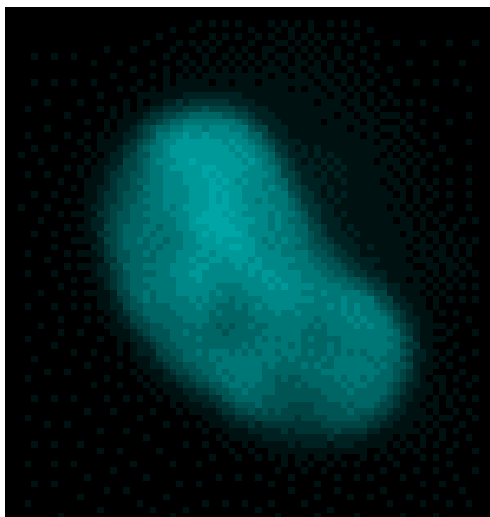


Original
(DAPI)
Scale: 5um



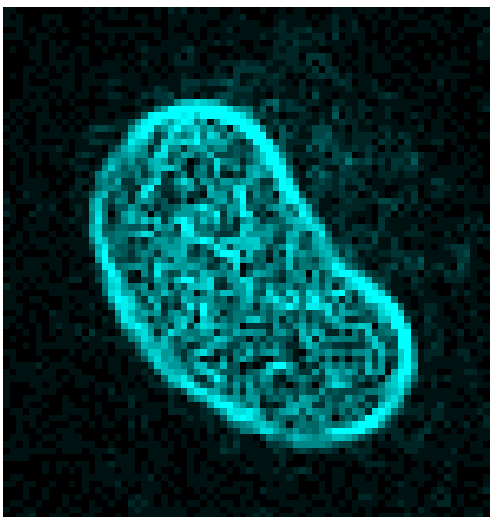
Mean

1	1	1
1	1	1
1	1	1



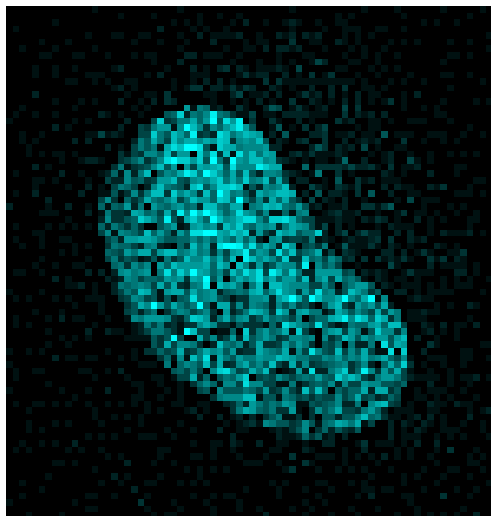
Gaussian

1	2	1
2	4	2
1	2	1



Edge Finder

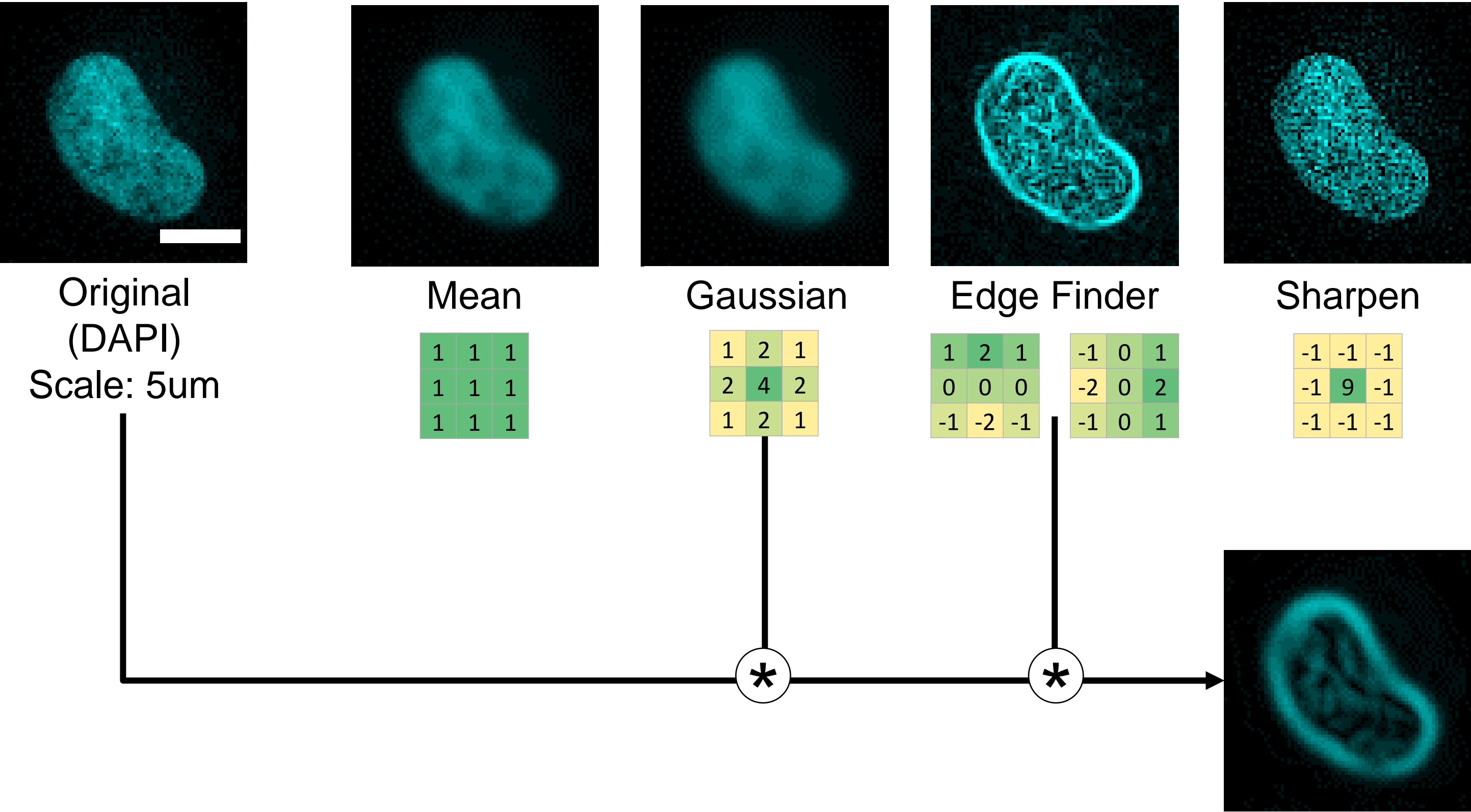
1	2	1	-1	0	1
0	0	0	-2	0	2
-1	-2	-1	-1	0	1



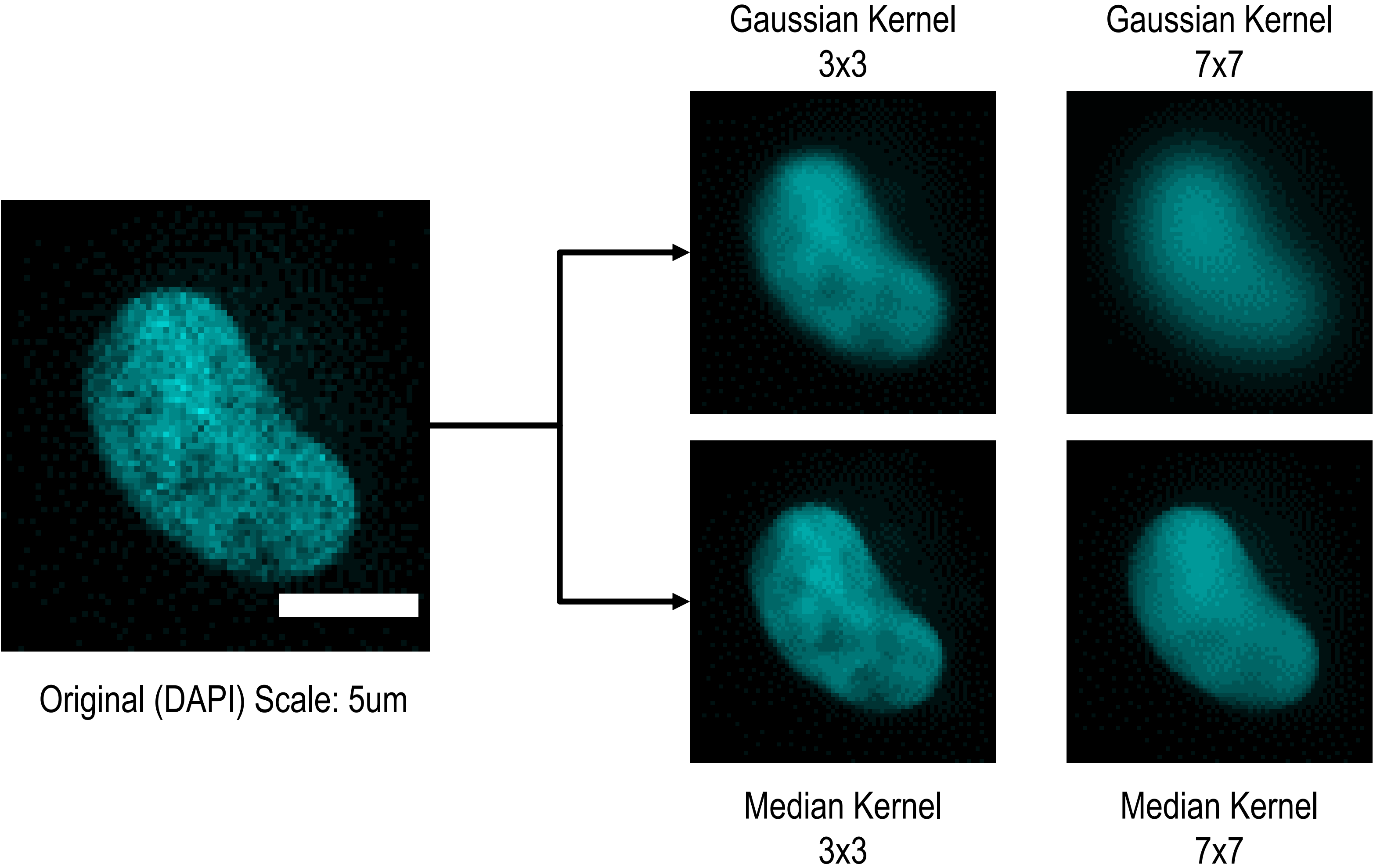
Sharpen

-1	-1	-1
-1	9	-1
-1	-1	-1

Linear Filters - Examples



Non-Linear Filters

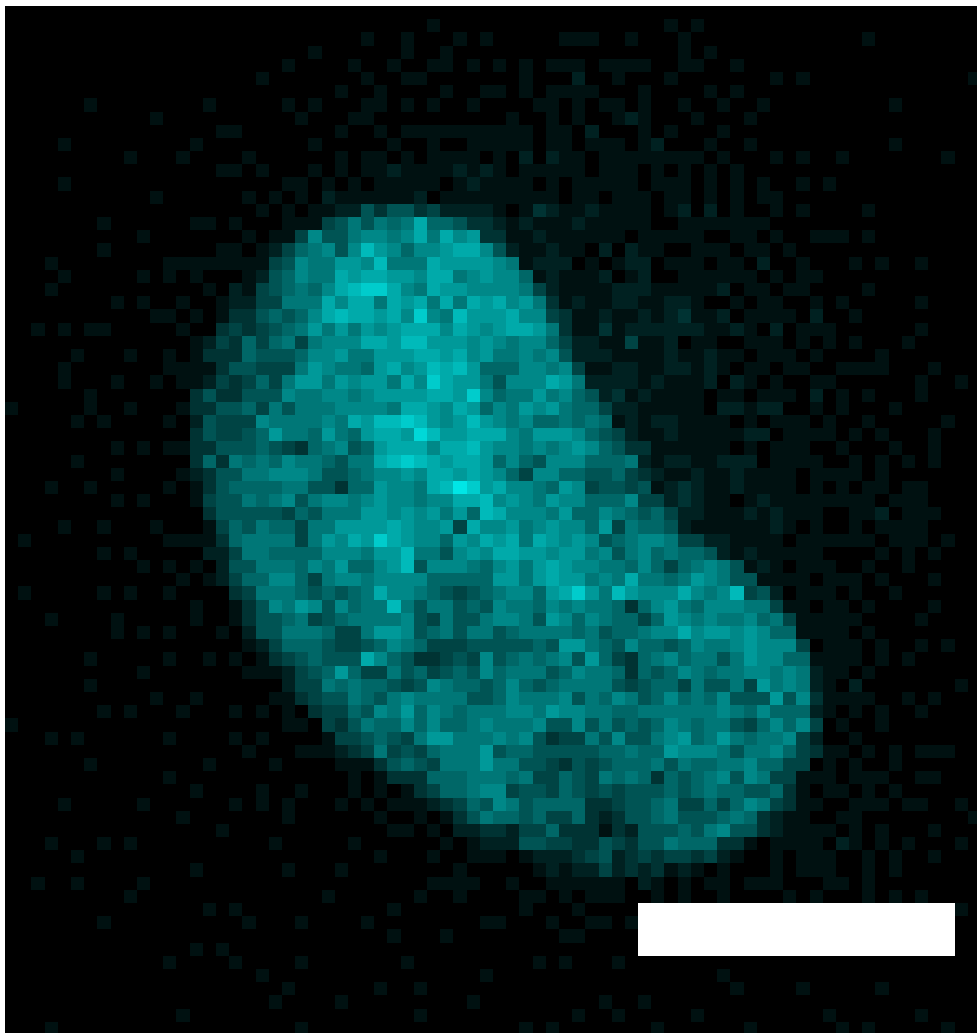


1	1	1	1	1	1	1
1	1	1	1	1	1	1
1	1	5	5	5	1	1
1	1	5	10	5	1	1
1	1	5	5	5	1	1
1	1	1	1	1	1	1
1	1	1	1	1	1	1

Sum: 13
Mean: 13/9
Median:1
Max: 5
Min:1

Non-Linear Filters

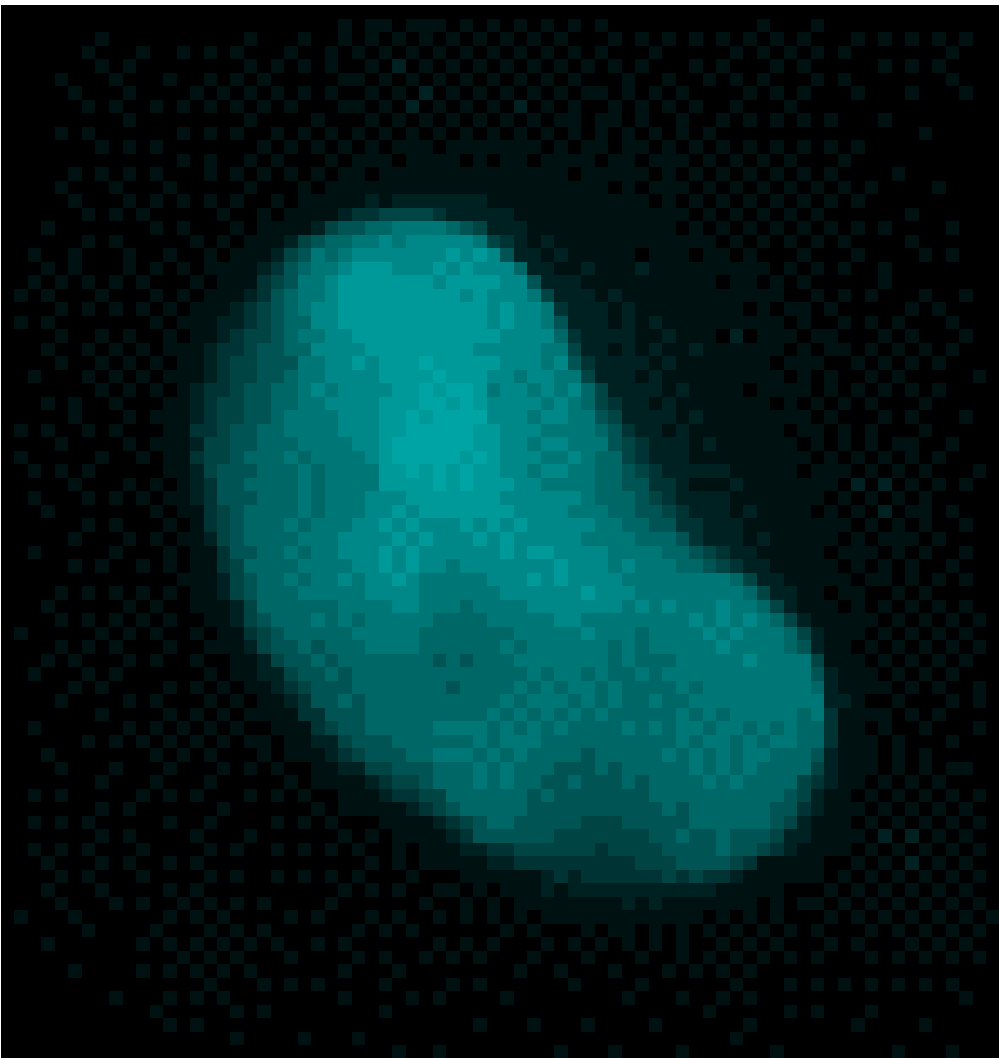
Original (DAPI) Scale: 5um



Kuwahara



Anisotropic Diffusion



But more settings

2D Anisotropic Diffusion Tschumperle-Deric... X

Number of iterations

Smoothings per iteration

Keep each iteration

a1 (Diffusion limiter along minimal variations)

a2 (Diffusion limiter along maximal variations)

dt (Time step)

edge threshold height

☐ Show filter stats ☐ Show time stats

☐ Add labels

Incorrect values will be replaced by defaults.
Labels are drawn in the foreground color.
Press Esc to stop processing.

OK Cancel

- Linear Filters
 - Convolution
 - Modifies pixels as a linear function of their neighbors
 - Super fast operation (Parallelizable)
- Non Linear Filters
 - High performance
 - Better tunable (parameters)