Image Analysis (FMAN20) Lecture F12, 2018

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Image Analysis - Motivation

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Overview – image processing

1. **Noise reduction**
2. Anisotropic filtering
3. Application: low light video enhancement
4. Block matching and collaborative filtering
5. Deep learning architectures for image processing
6. Application: low light image processing using learning

Noisy image

Gaussian smoothing

Gaussian smoothing - blurs edges!

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Structure/Orientation Tensor

Construct the matrix

$$M = \begin{bmatrix} W_{xx} & W_{xy} \\ W_{xy} & W_{yy} \end{bmatrix} = \begin{bmatrix} (\frac{\partial f}{\partial x})^2 * G_b & (\frac{\partial f}{\partial x}\frac{\partial f}{\partial y}) * G_b \\ (\frac{\partial f}{\partial x}\frac{\partial f}{\partial y}) * G_b & (\frac{\partial f}{\partial y})^2 * G_b \end{bmatrix},$$

where G_b denotes the Gaussian function with parameter b.
M - orientation tensor.
Note: We construct a matrix for every pixel.

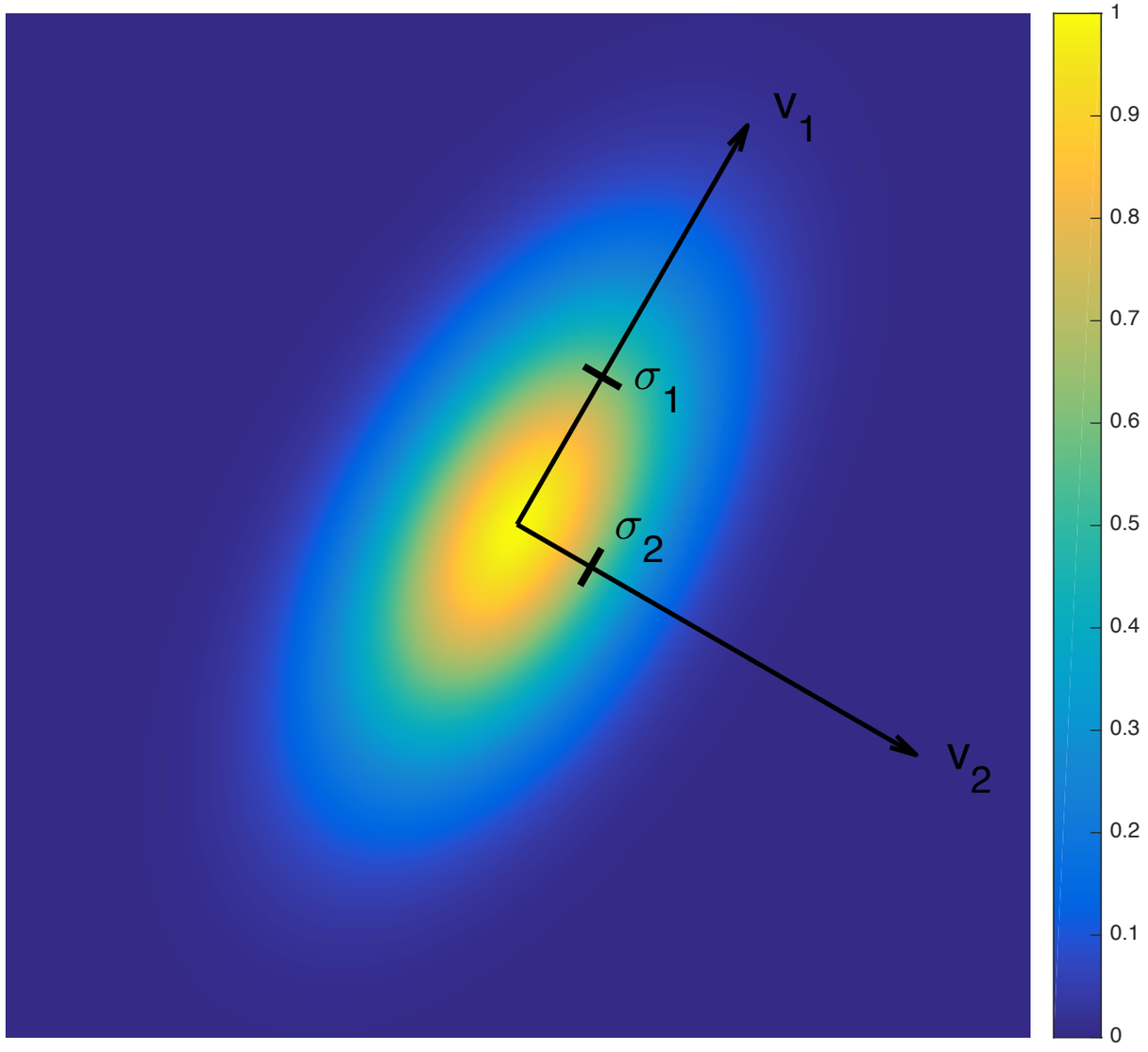
Structure Tensor

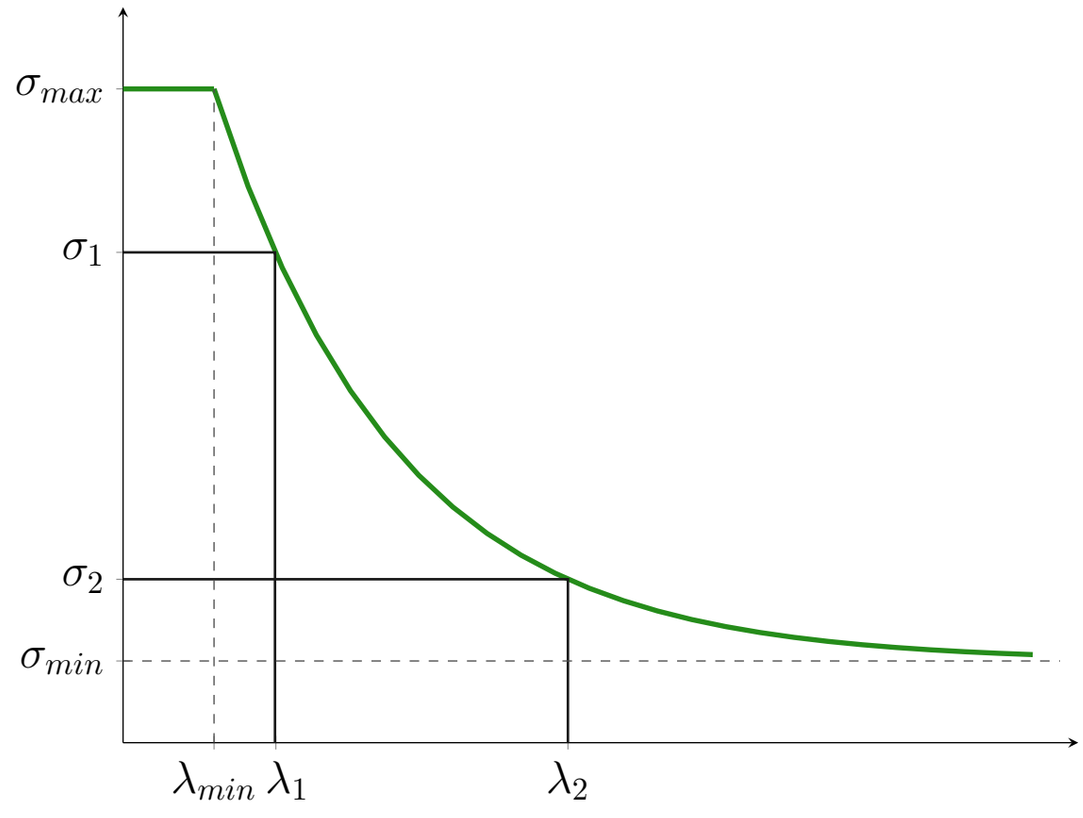
The matrix M has the following properties:

- (Flat) Two small eigenvalues in a region - flat intensity.
- (Flow) One large and one small eigenvalue - edges and flow regions.
- (Texture) Two large eigenvalues - corners, interest points, texture regions.

This can be used in algorithms for segmenting the image into (flat, flow, texture).

Rotate Gaussian kernels using eigenvectors of the structure tensor





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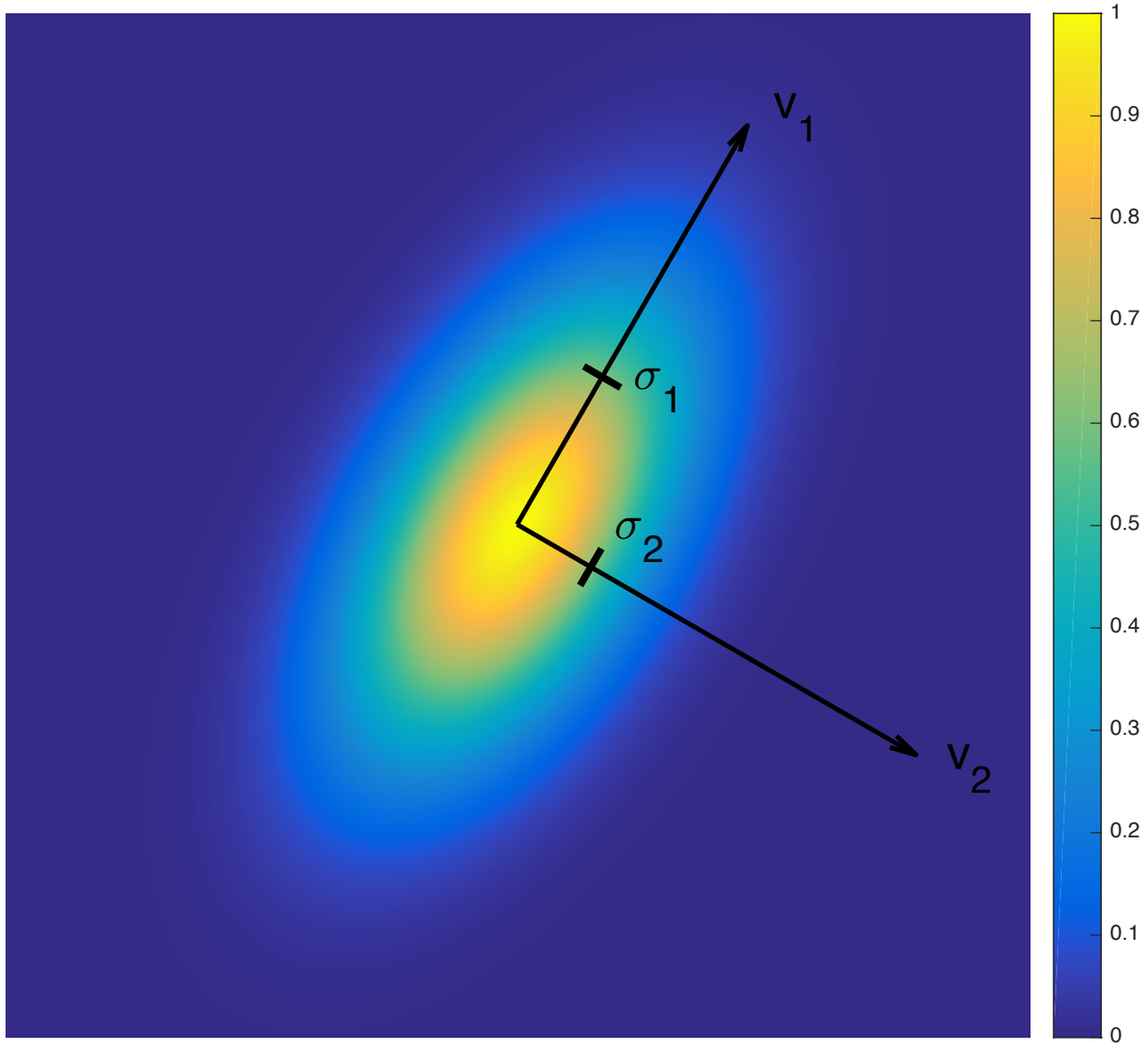
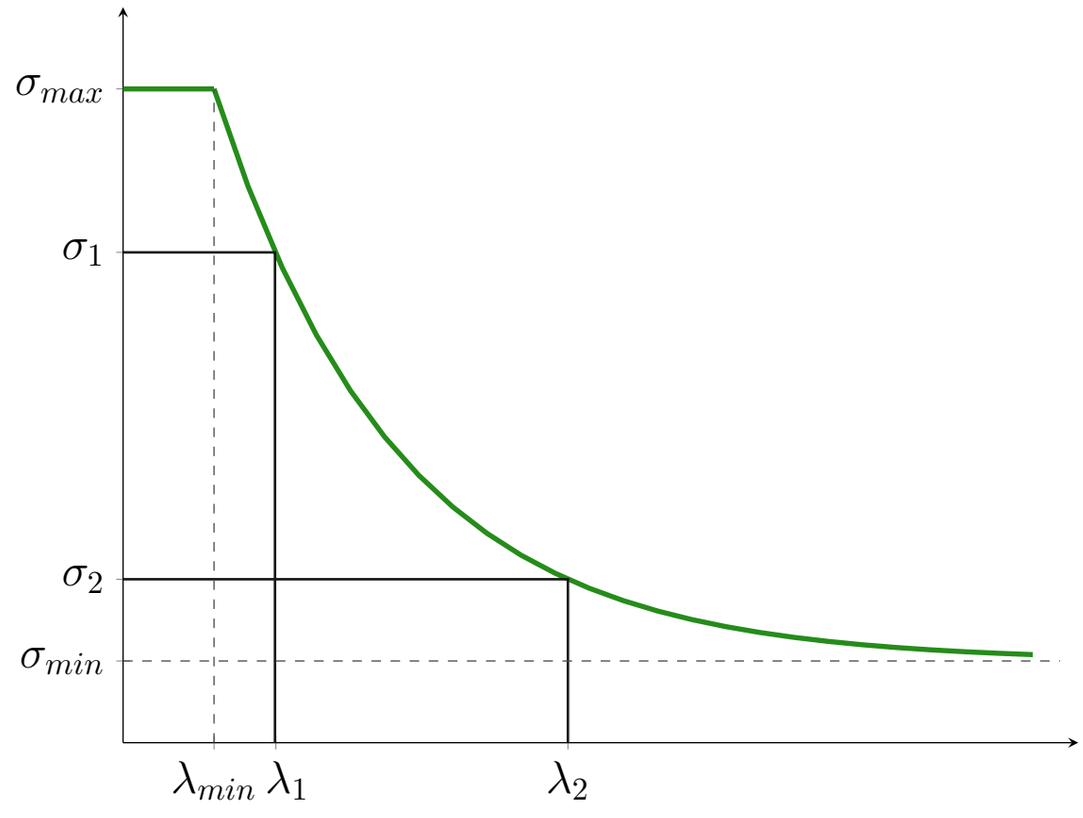
Scale Gaussian kernels using a function of the eigenvalues of the structure tensor





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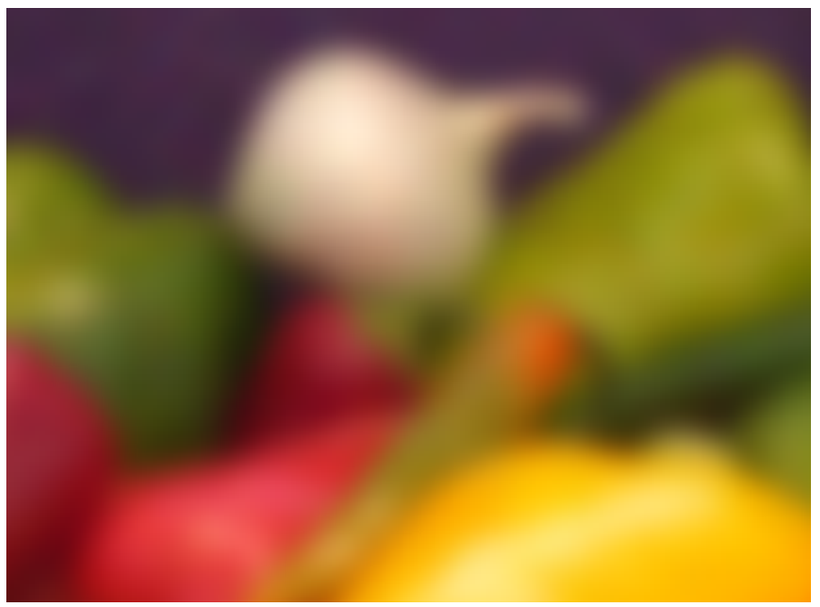
Structure adaptive smoothing

Close-up comparison

Noisy input



Gaussian

Structure adaptive

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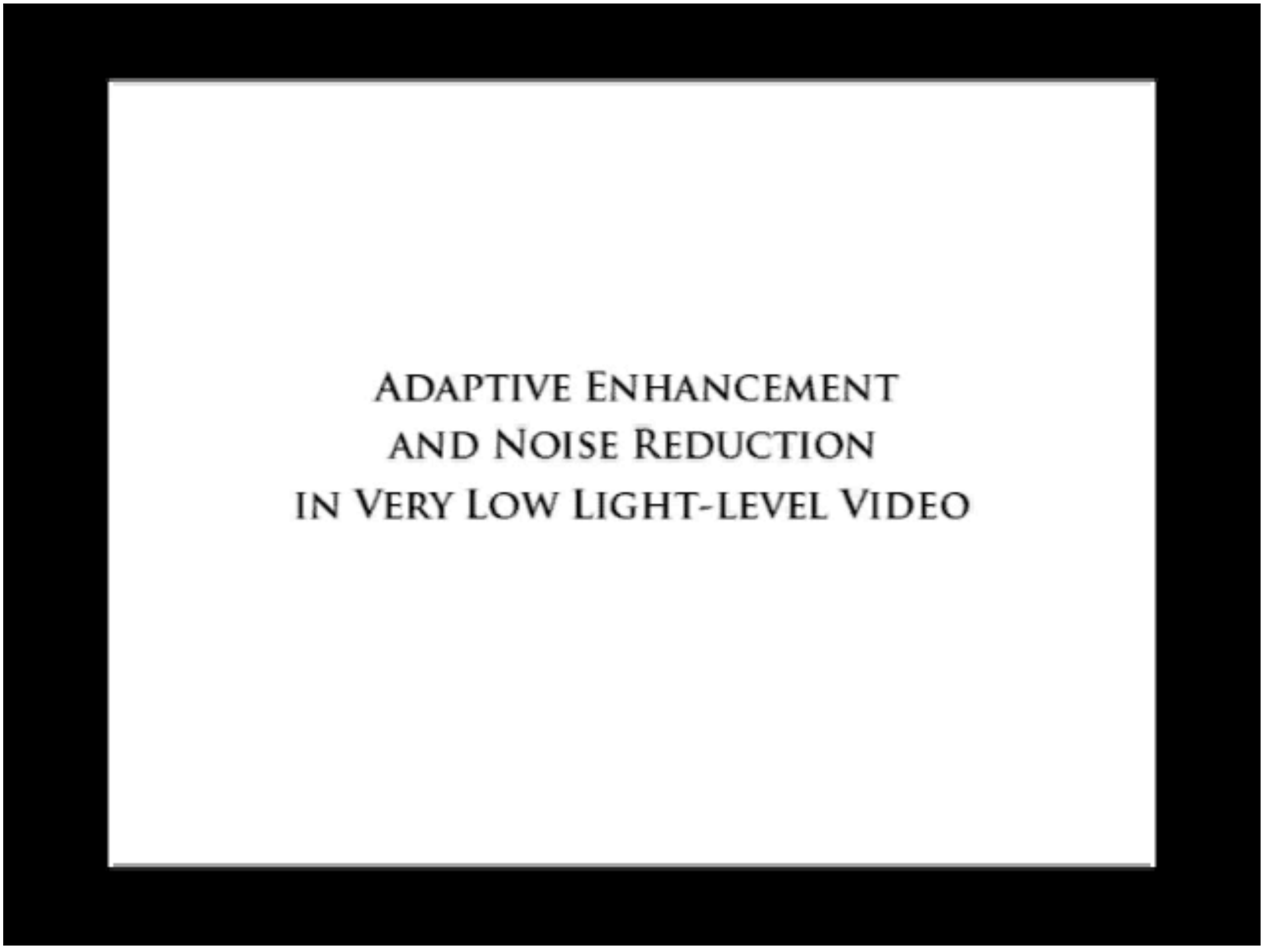
Low light enhancement

1. Amplify signal
   using eg scaling or histogram equalization
   Introduces noise

2. Anisotropic filtering of noise


BRIO
Dragon
Mint

Low light video enhancement



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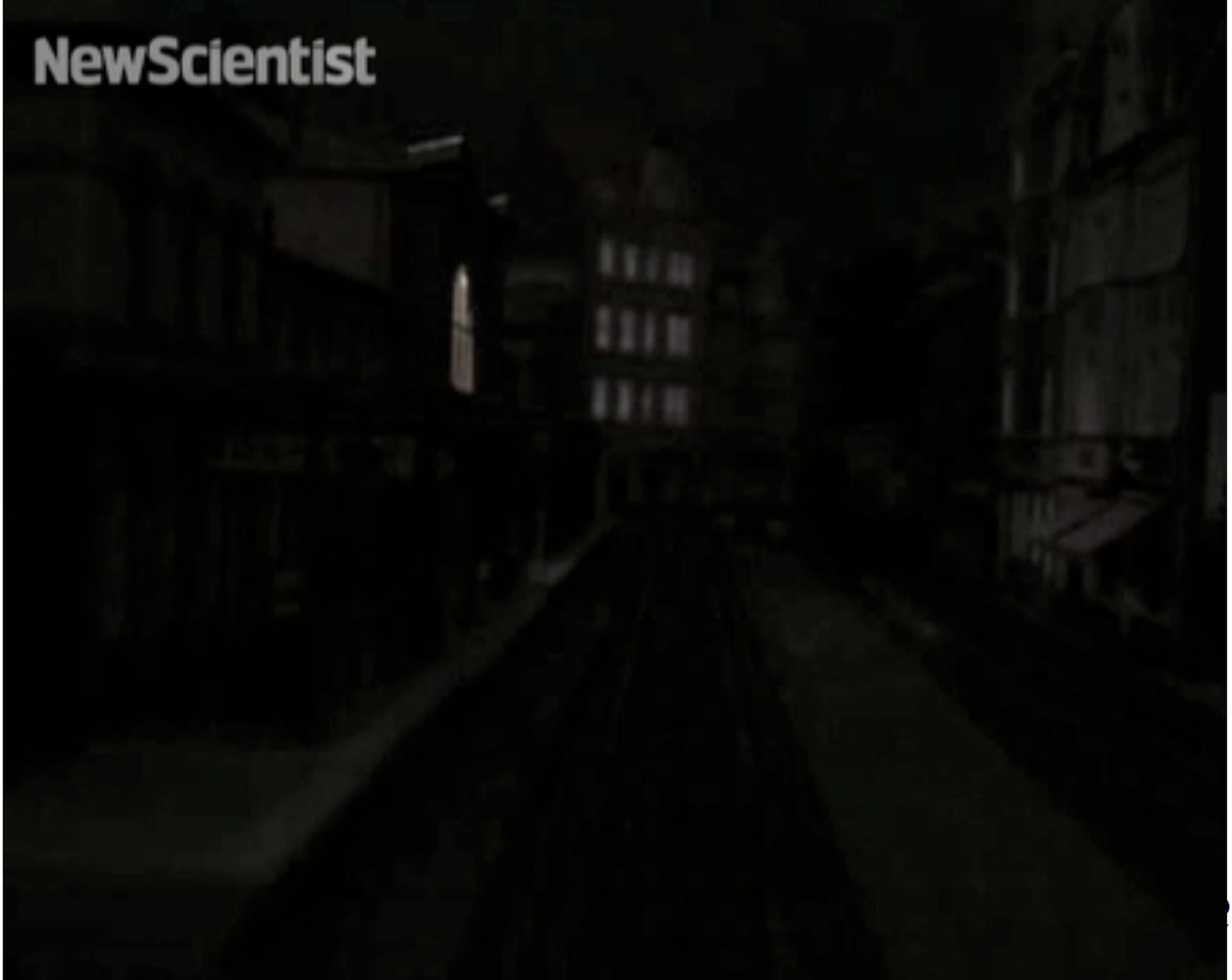
NewScientist

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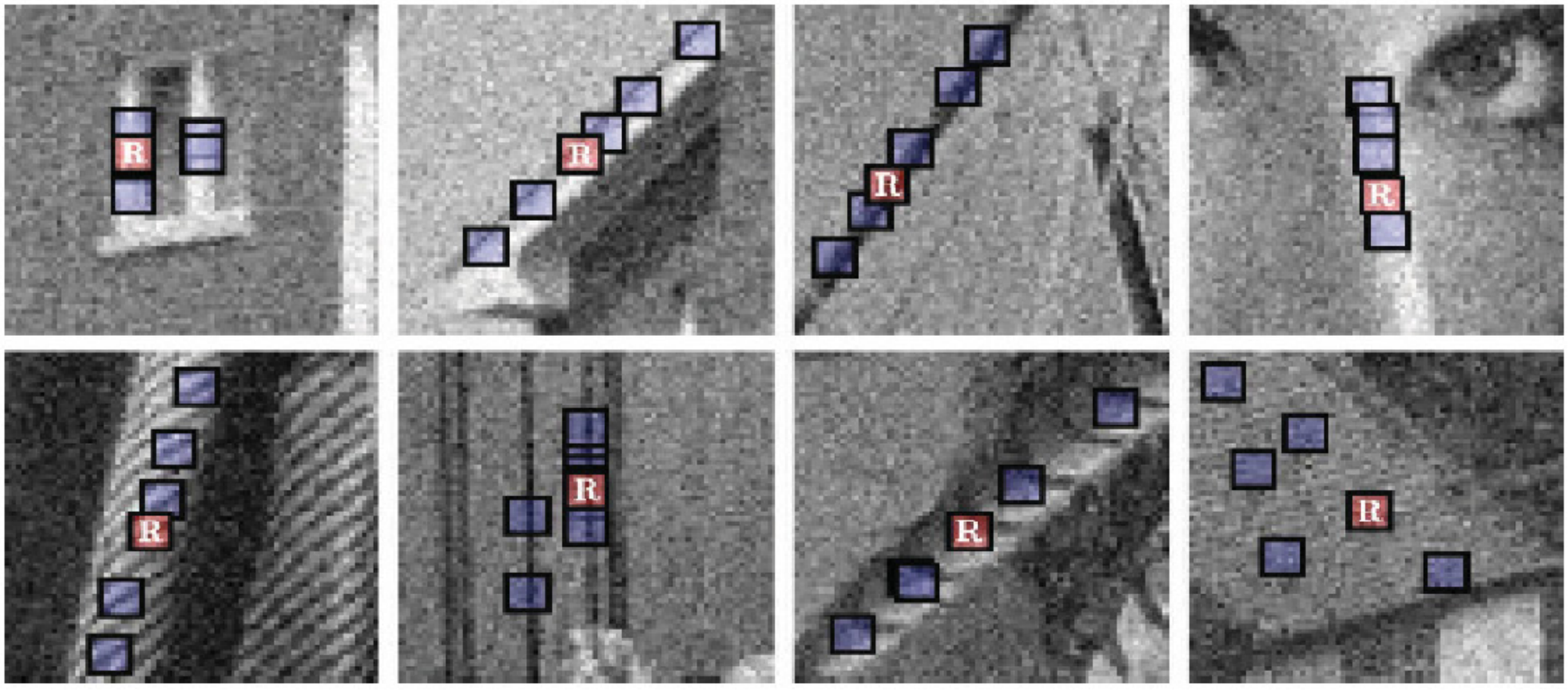
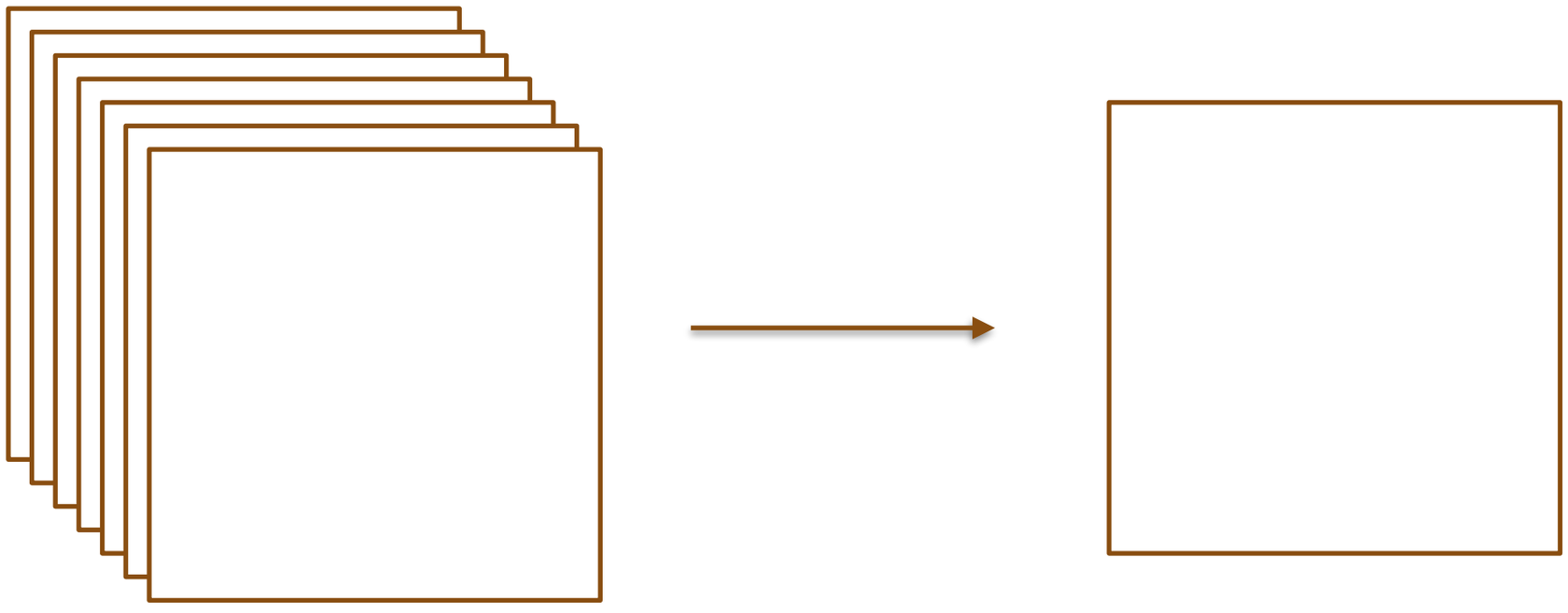
Block matching

many structures are repeated at multiple locations in an image



Collaborative filtering

Do hard filtering on each set of similar matched blocks



BM3D

Uses two pass version of block-matching and filtering

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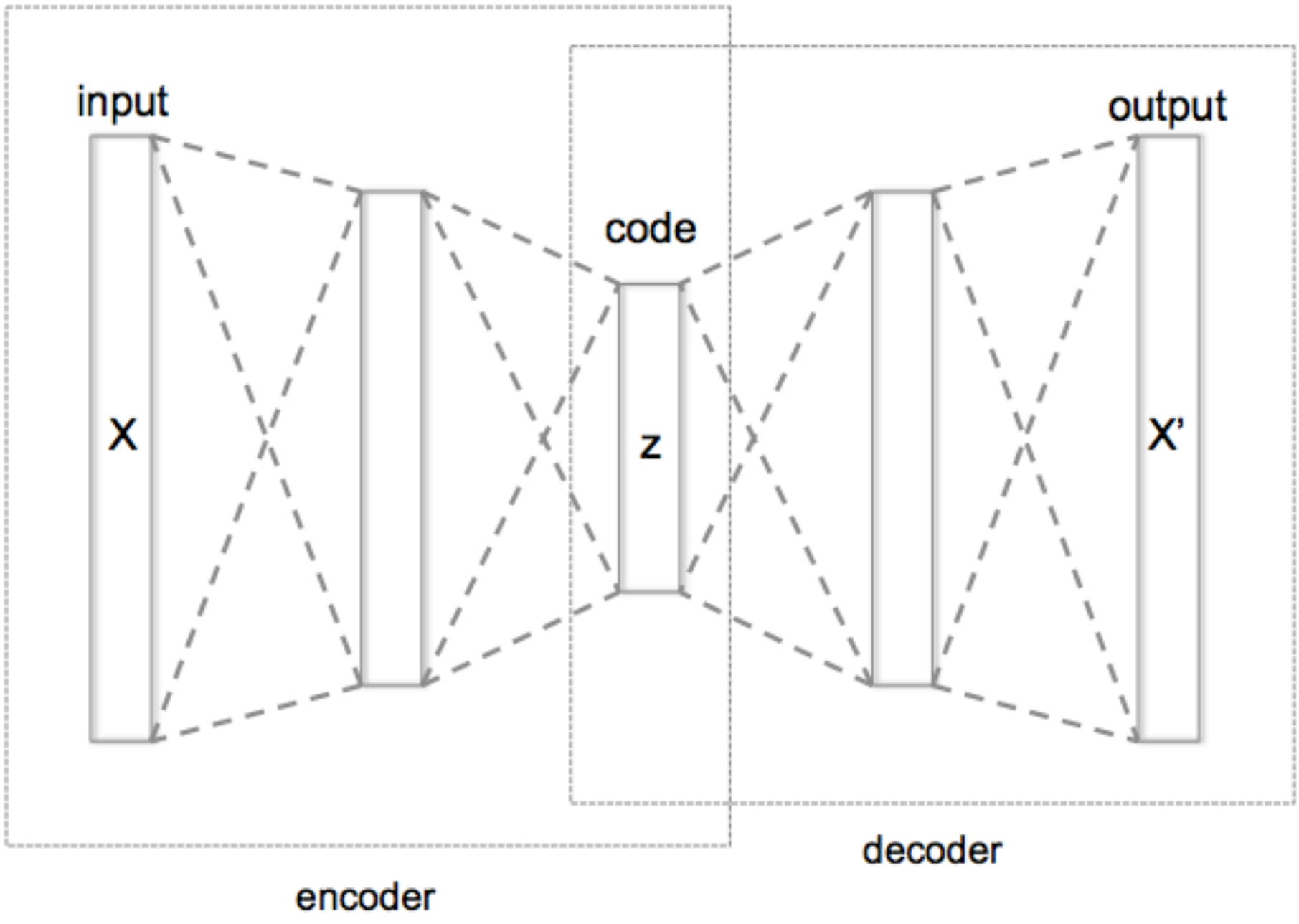
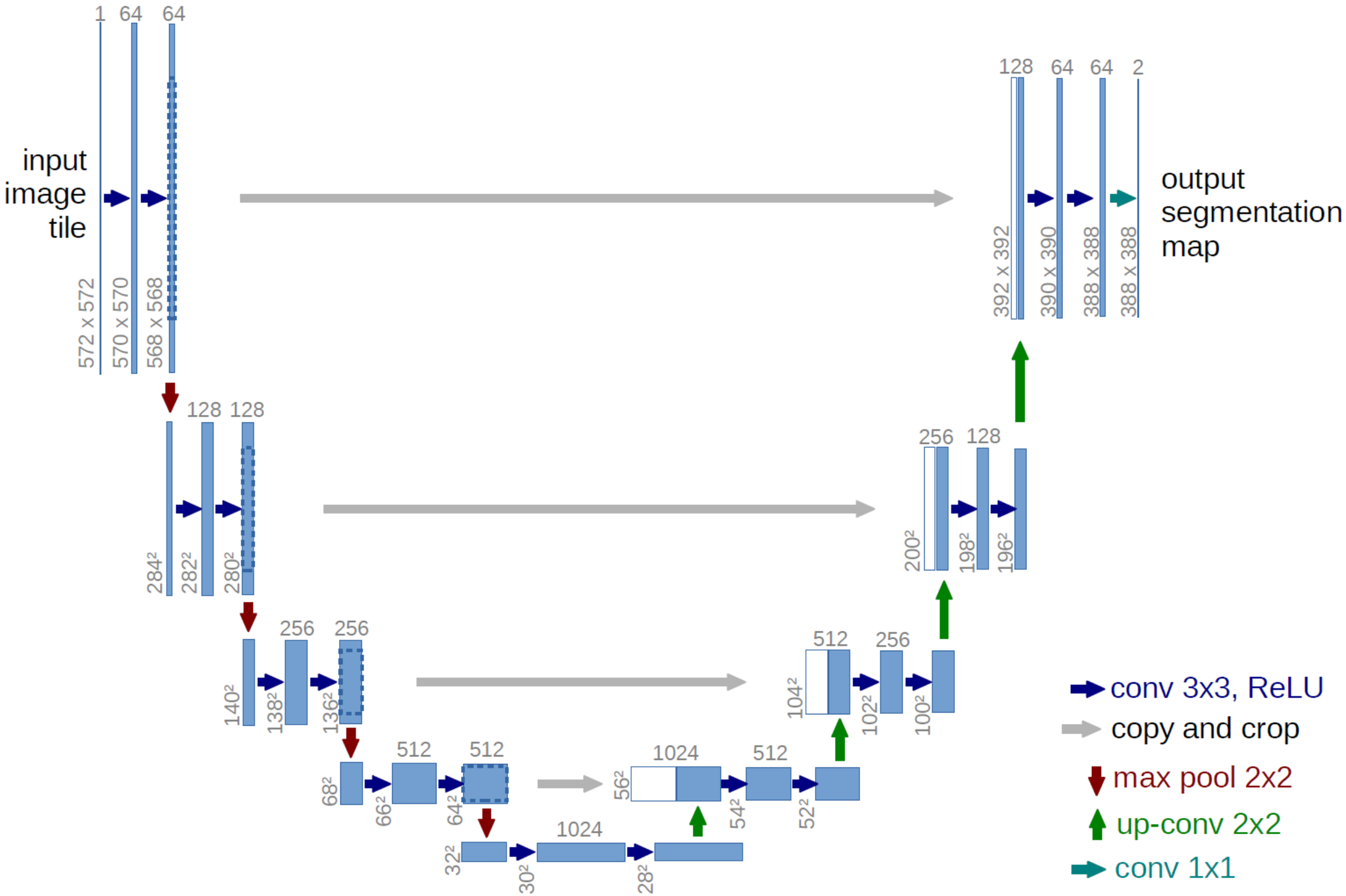
Autoencoders



U-net


input image tile
output segmentation map
conv 3x3, ReLU
copy and crop
max pool 2x2
up-conv 2x2
conv 1x1

Segmentation using U-net

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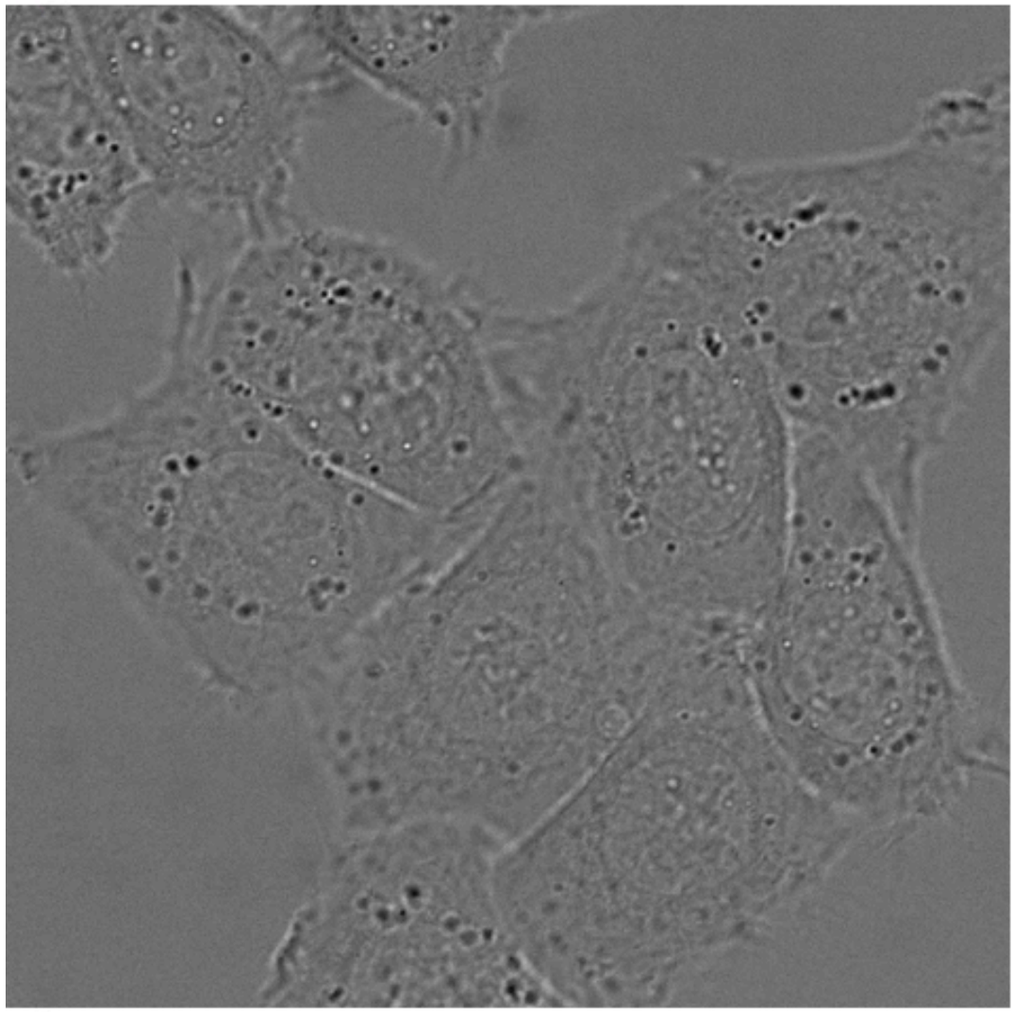
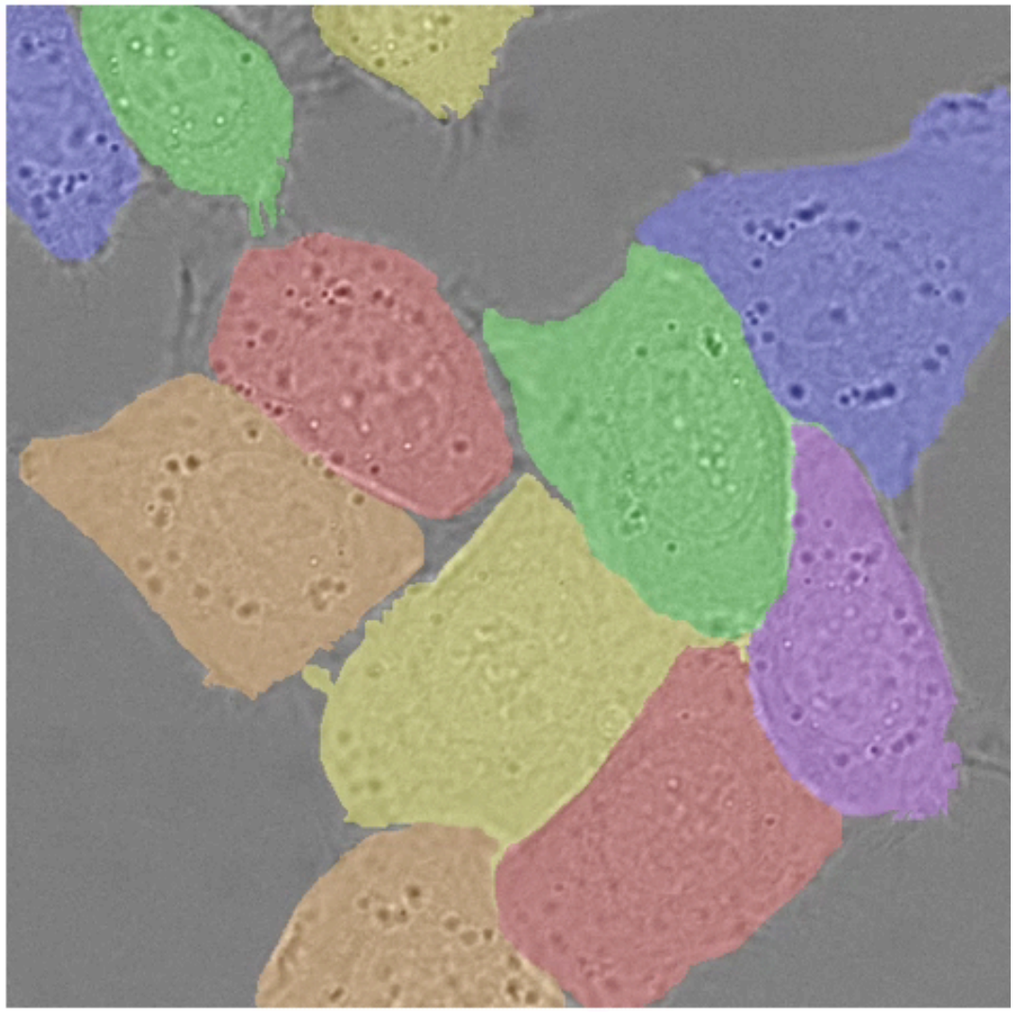
Segmentation of Touching Objects of the Same Class



HeLa cells recorded with DIC microscopy



manual segmentation
(colors: different instances)

[Data provided by Dr. Gert van Cappellen, Erasmus Medical Center. Rotterdam. The Netherlands]

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Low light image enhancement using a U-net

Results


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