Image processing in physics

Image Segmentation

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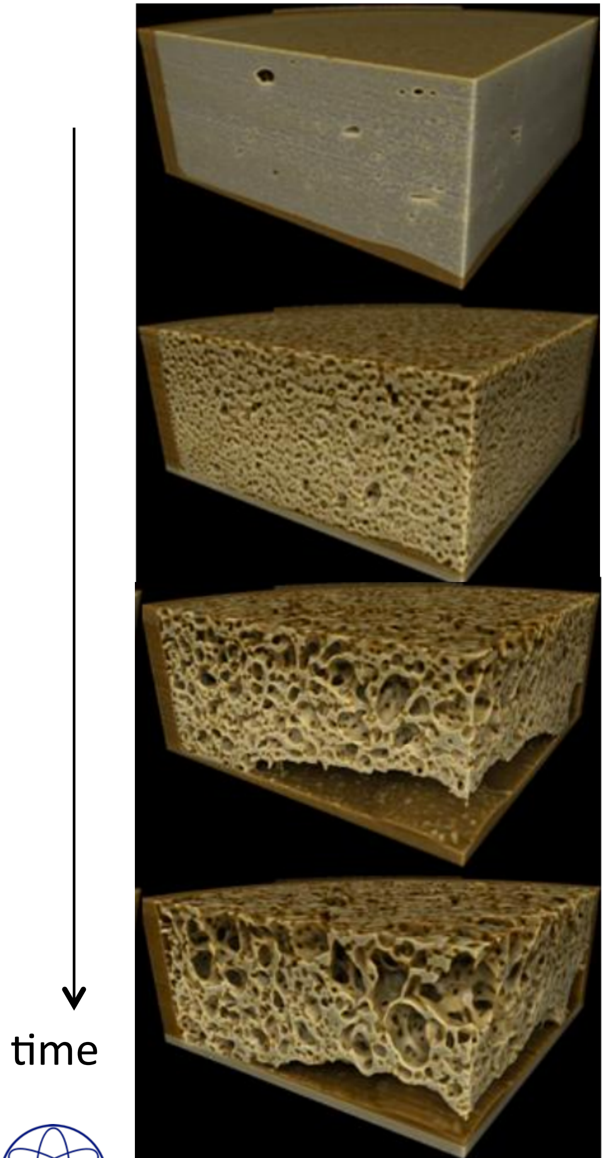
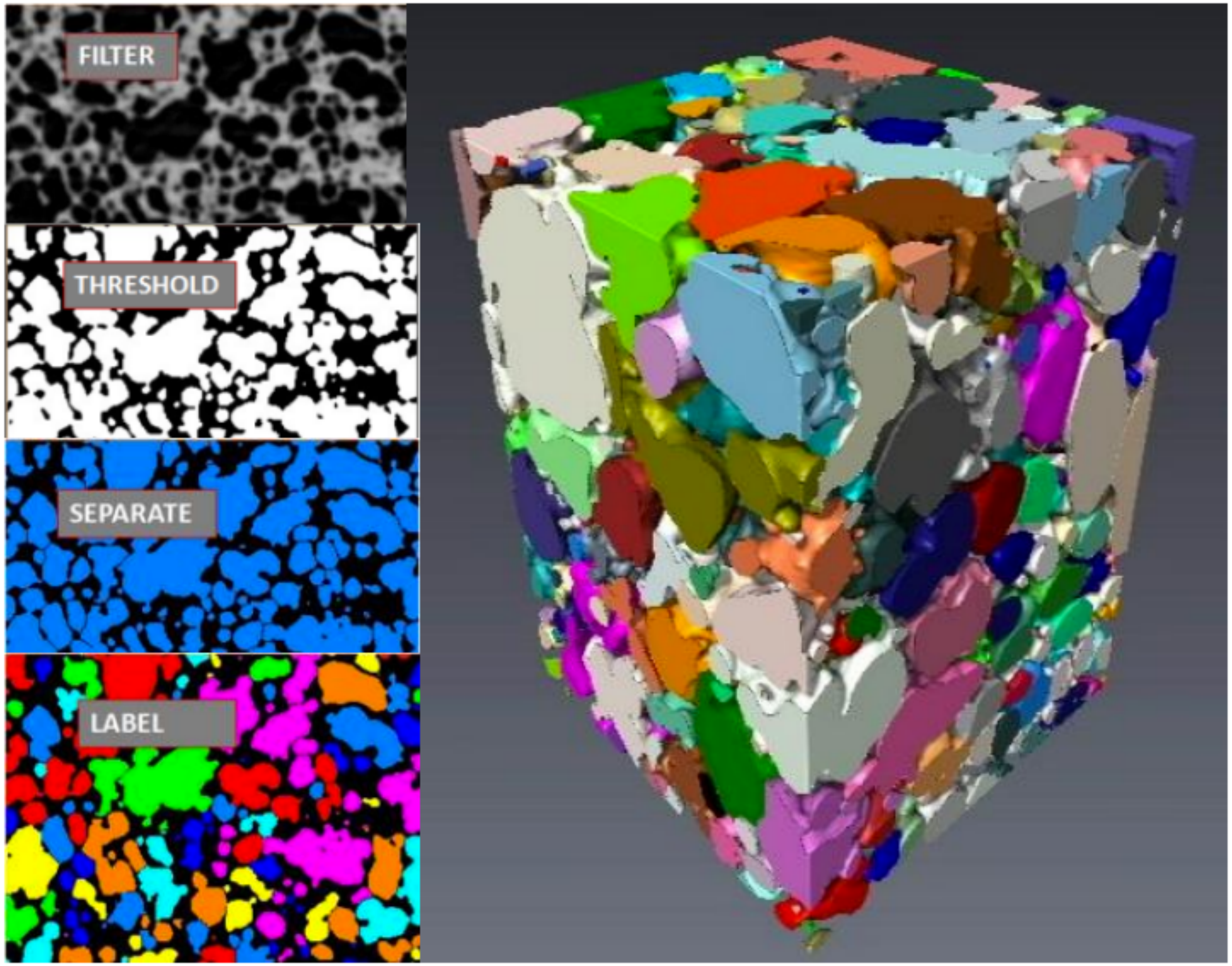
Overview

- Segmentation motivation
- Segmentation
    - By intensity
    - By region growth
    - By boundaries
- Morphological operations

Segmentation: Motivation

E.g. Bread properties during baking

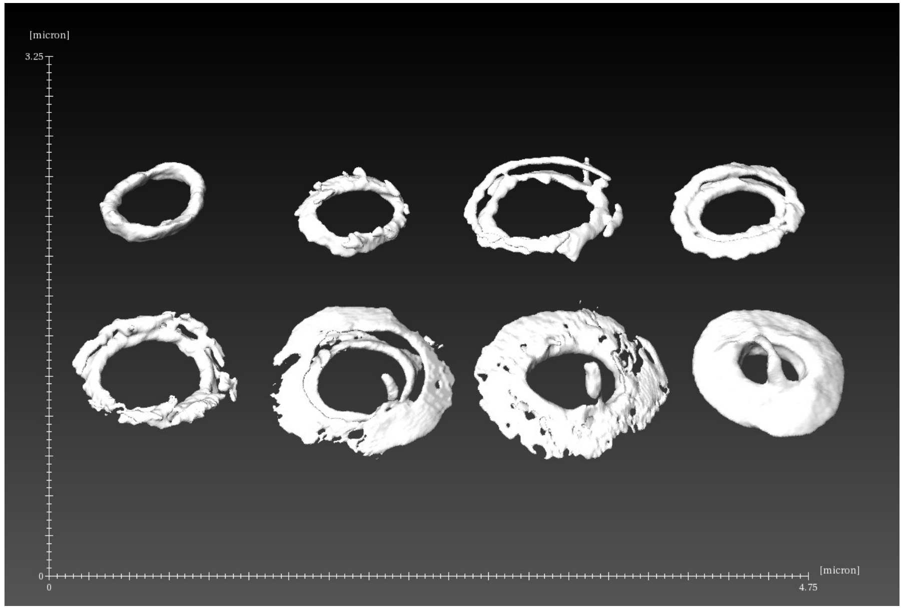


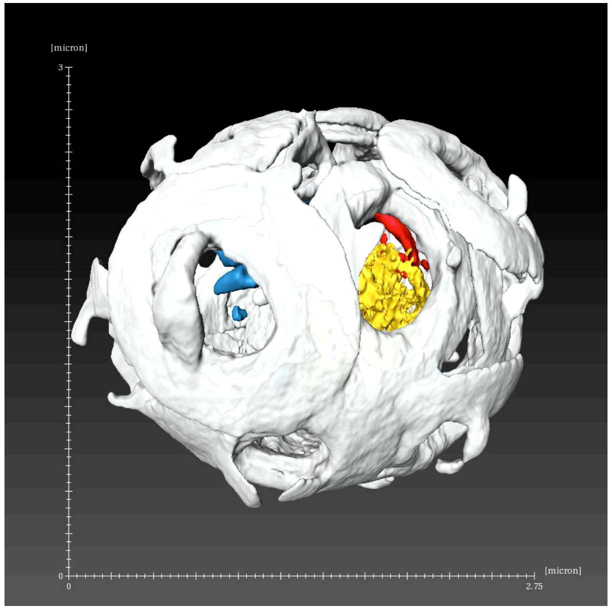


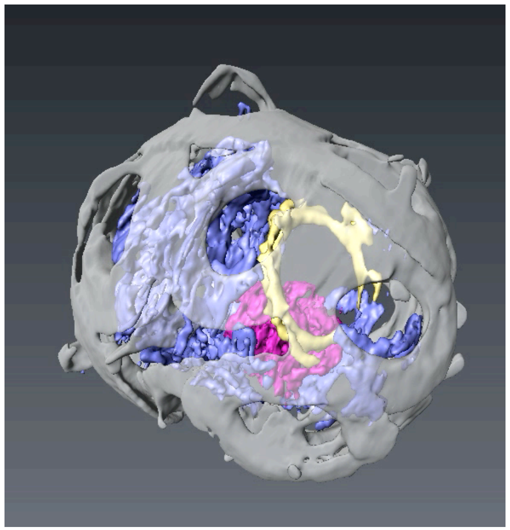
Sherry Mayo, CSIRO, Australian Synchrotron

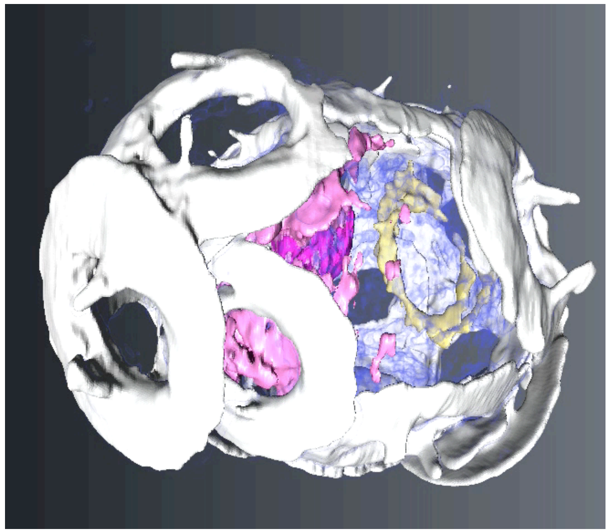
Segmentation: Motivation

E.g. Volume of calcite in single cell organisms with growth









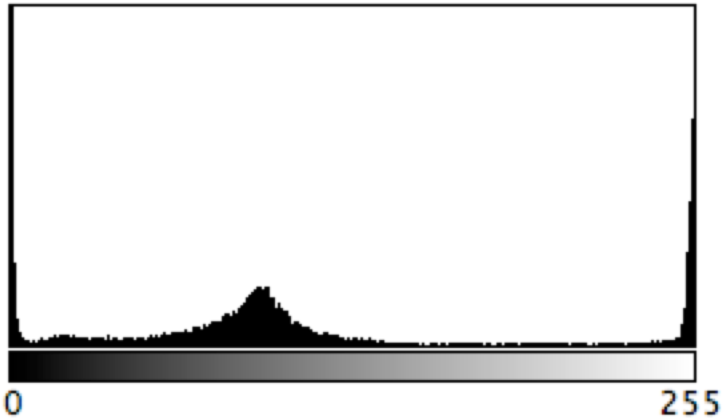
Coccolithosphores,
Kaye Morgan,
Monash University

Segmentation: Motivation

- partitioning of image into regions-of-interest

- various methods available
  - by intensity
  - by region
  - by boundary
  - by morphology

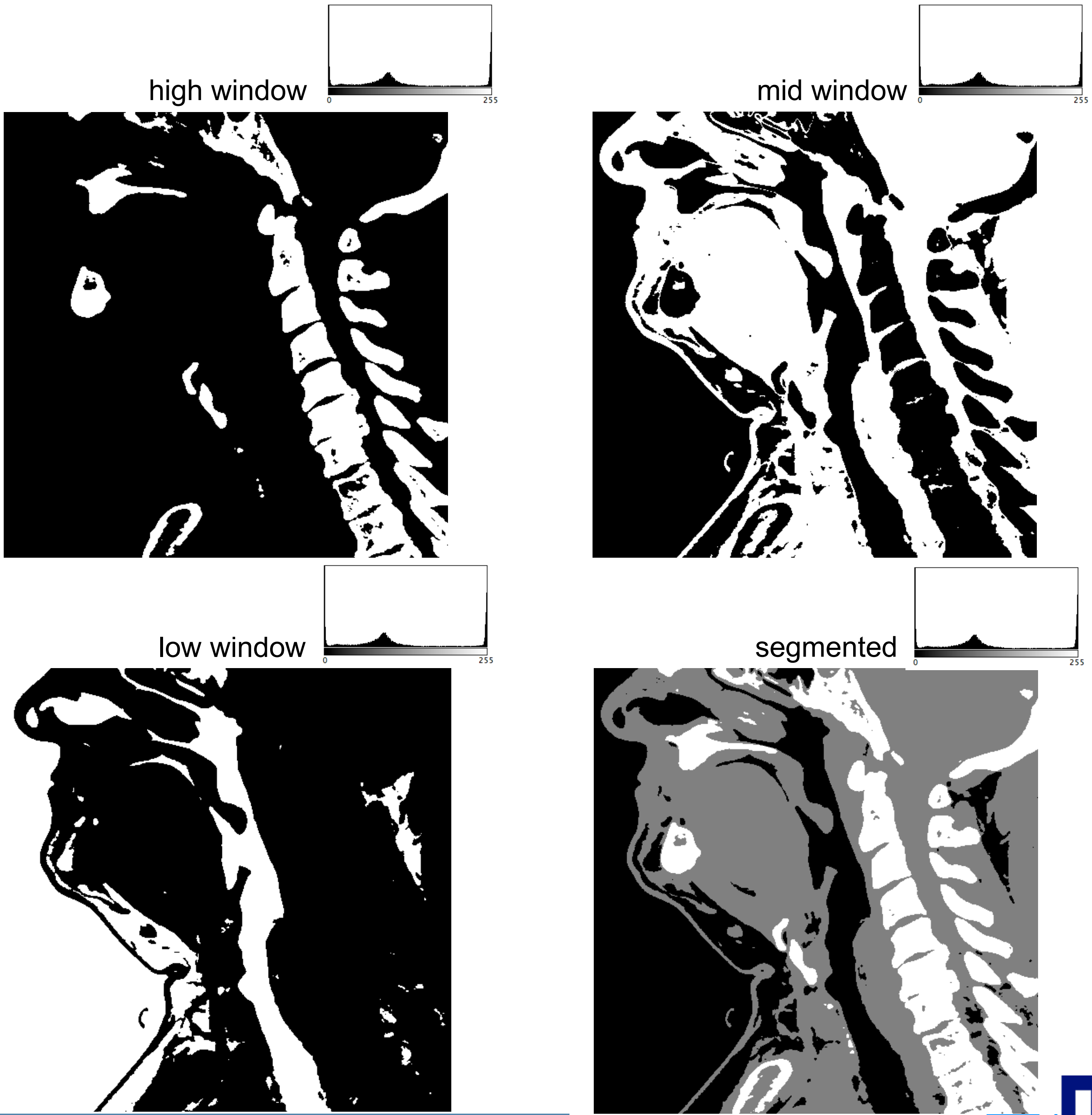
Segmentation by intensity



Segmentation by intensity

- easy
- widely used
- Histogram based

original

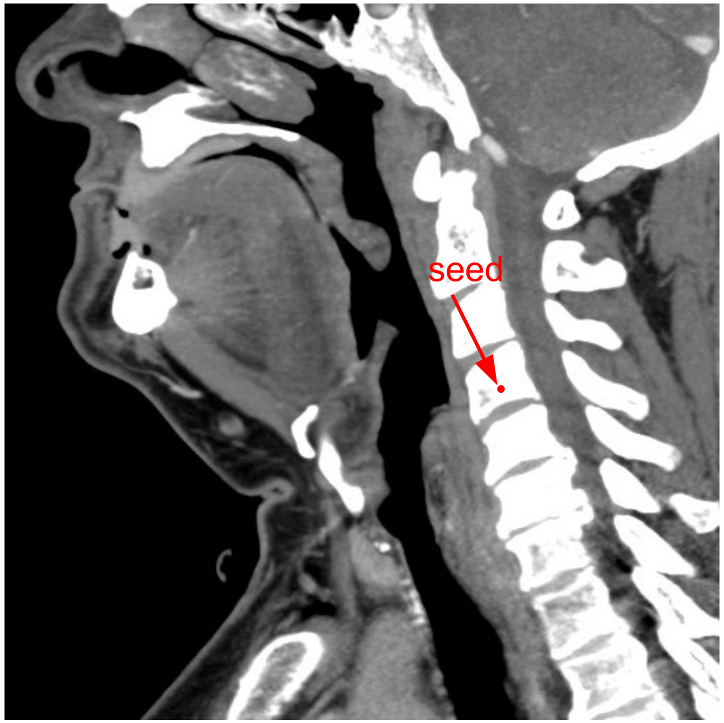


- noise prone
- no connectivity

Segmentation by region growth

- start with seed
- check intensity in neighborhood
- if intensity within window, set to 1
- iterate until no change

original



Segmentation by boundaries

- look for sharp changes in intensity

- can be achieved by spatial filtering

original

Segmentation by boundaries

original

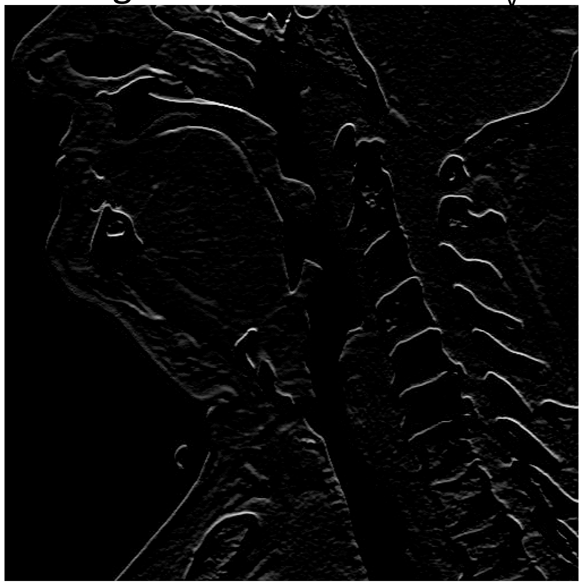
e.g. Sobel filter

$$G_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \qquad G_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$$

$$|G| = \sqrt{G_x^2 + G_y^2}$$

Original convolved with G_x

Original convolved with G_y



$|G|$

Morphological operations

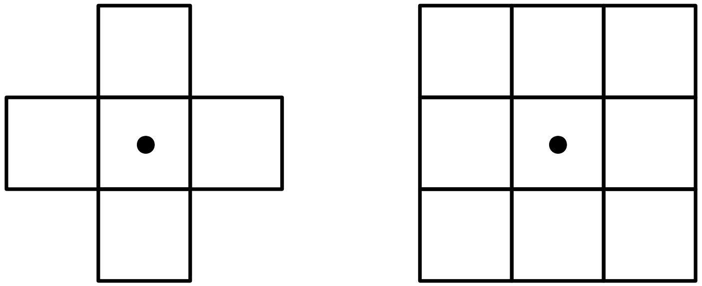
- analyze morphology of image structures
  - based on set theory and topology

- extract image information
  - shape
  - size
  - connectivity
  - number
  - boundary

- mostly on binary images

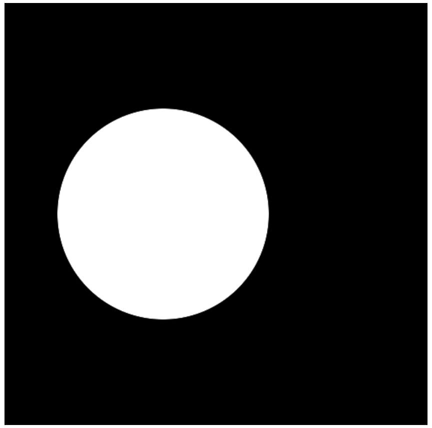
Structuring elements (SE)

- small bitmask to probe the image
- scan origin of SE over image
- check overlap between SE and image
- set pixel(s) to zero (or one)

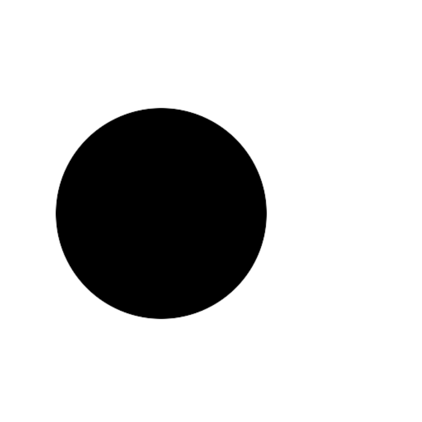


Set operations

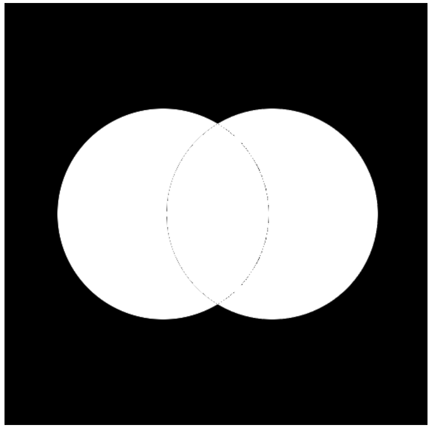
binary mask
A



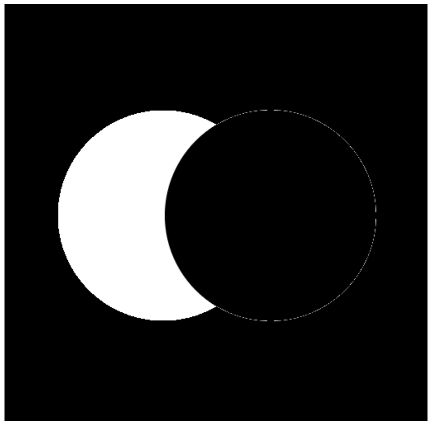
complement (background)
A^c



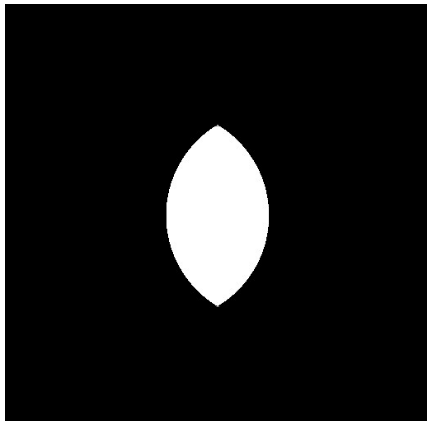
union
A ∪ B



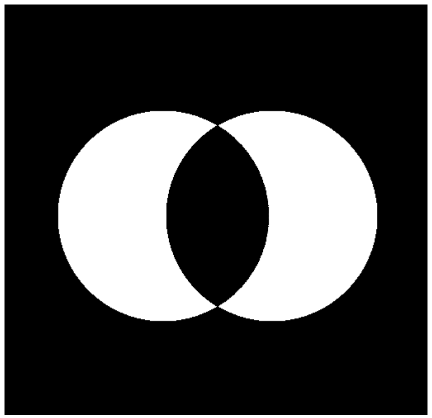
difference
A \ B



intersection
A ∩ B

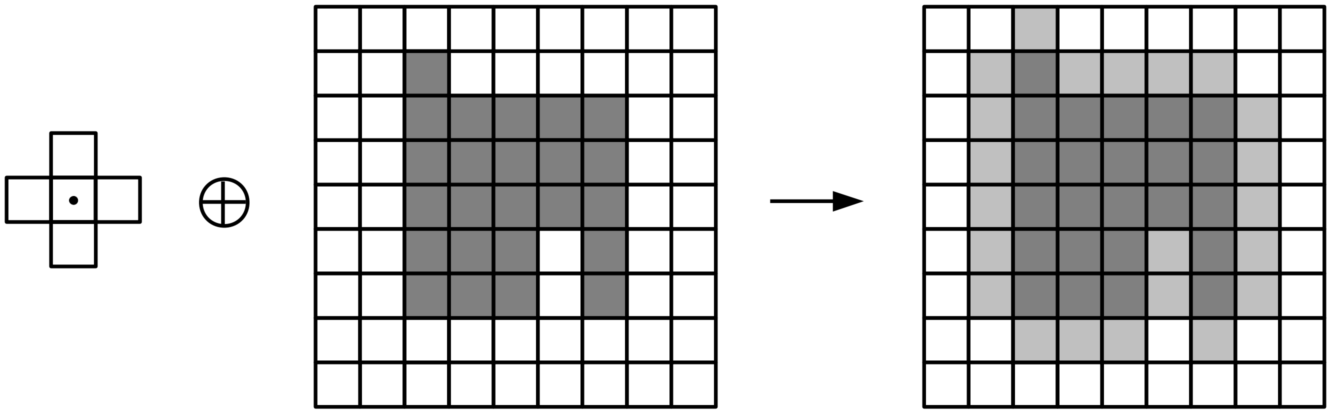


symmetric difference
A Δ B

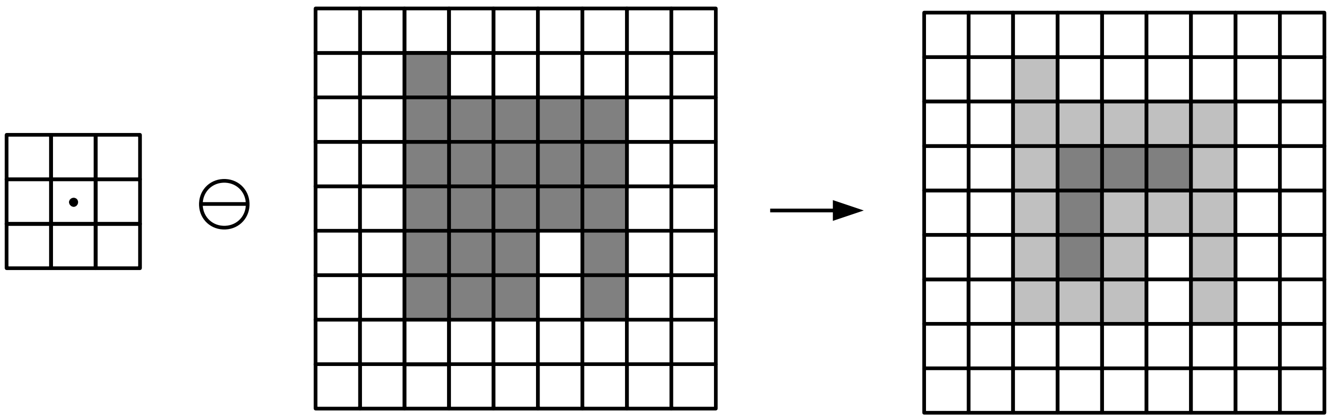


Basic operations

- Dilation: expand region



- Erosion: shrink region



Basic operations

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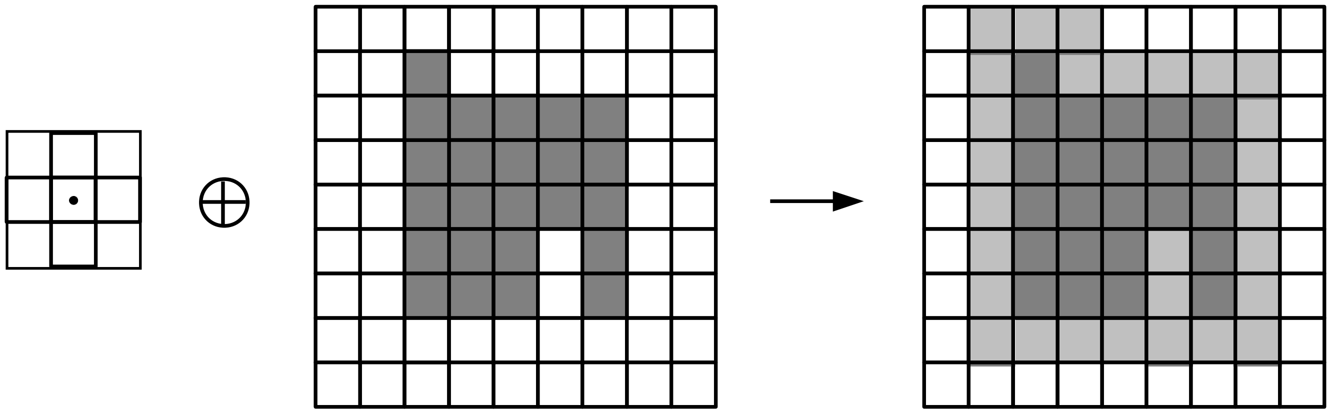

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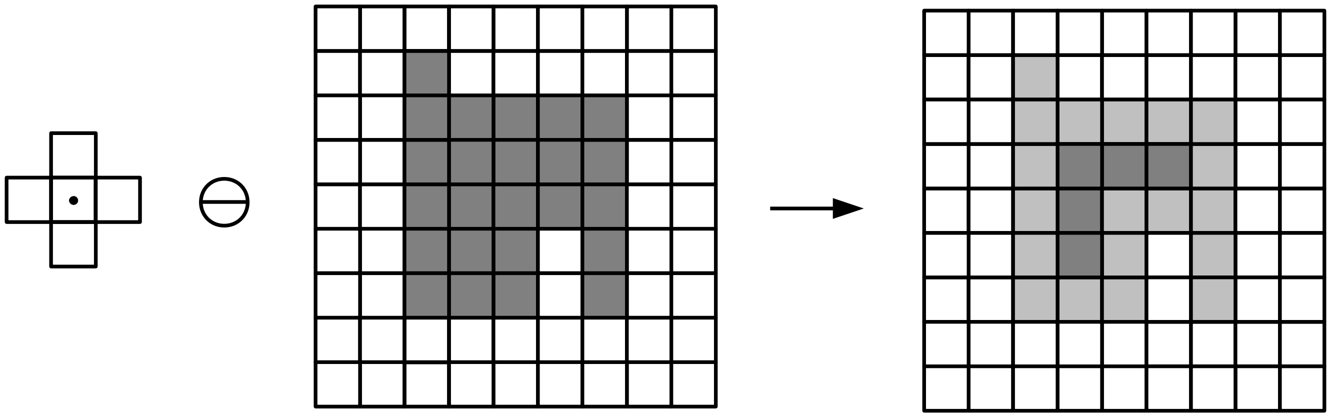
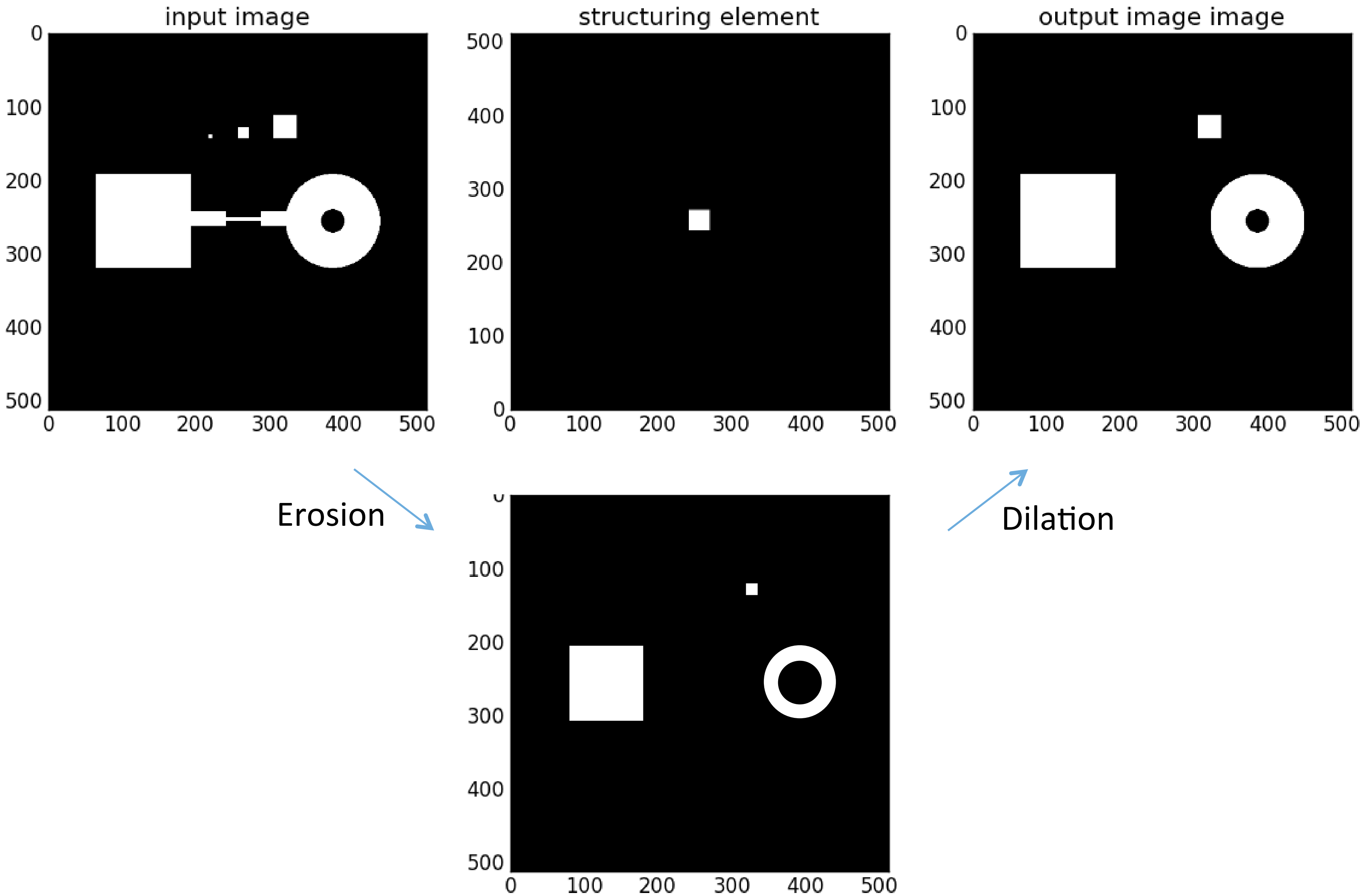


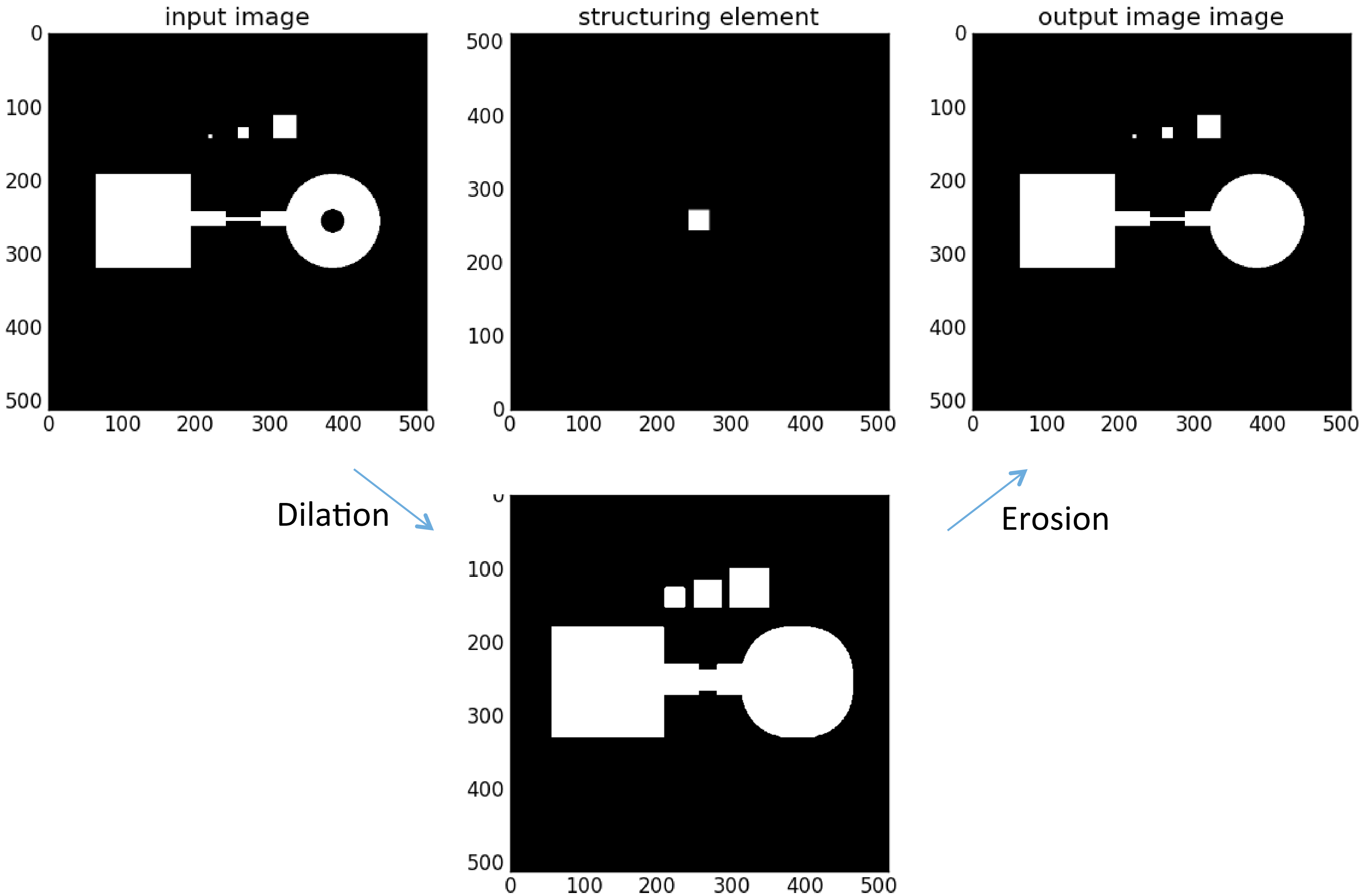
Morphological operations

Opening: first erosion, then dilation



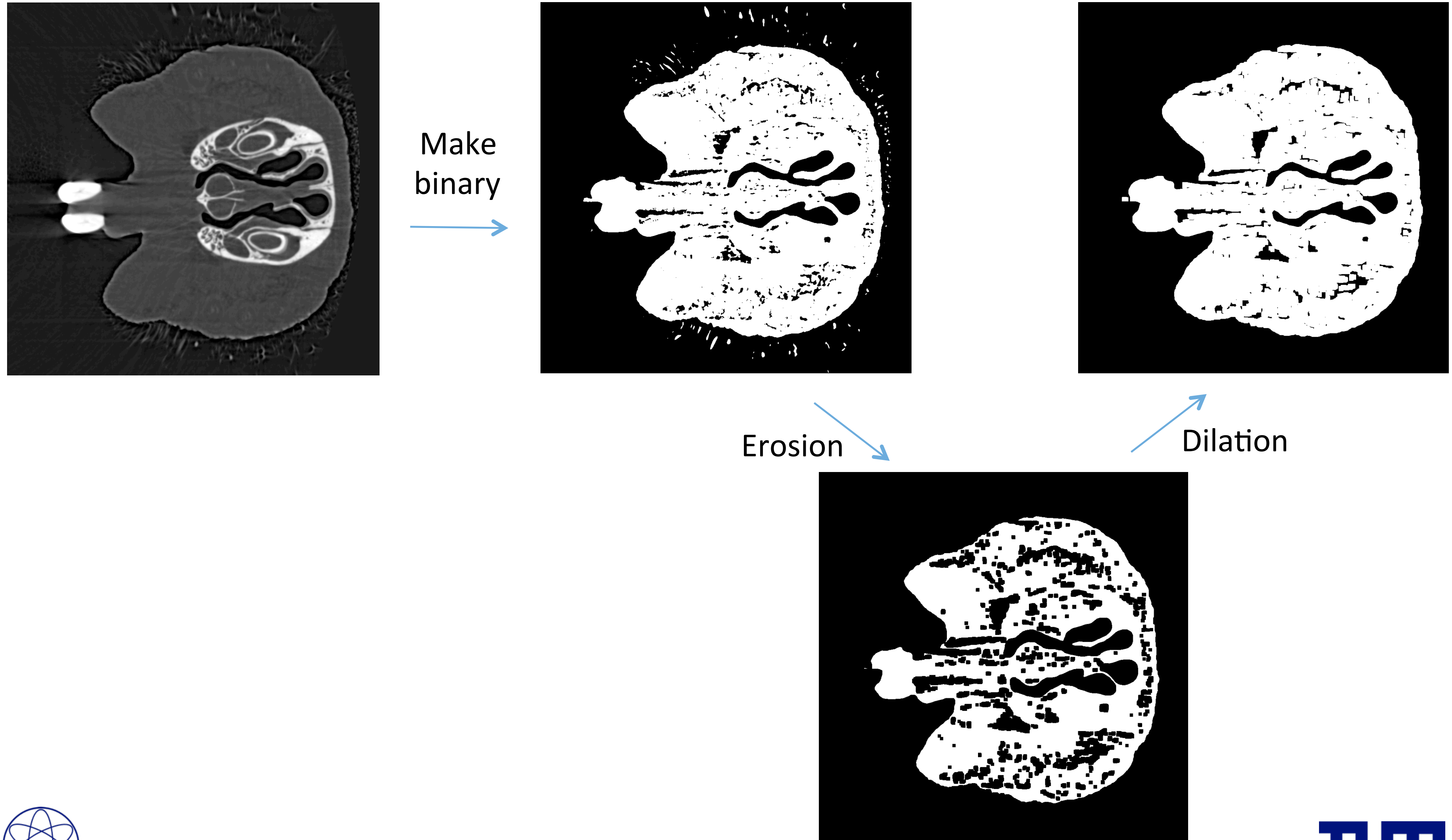
Morphological operations

Closing: first dilation, then erosion



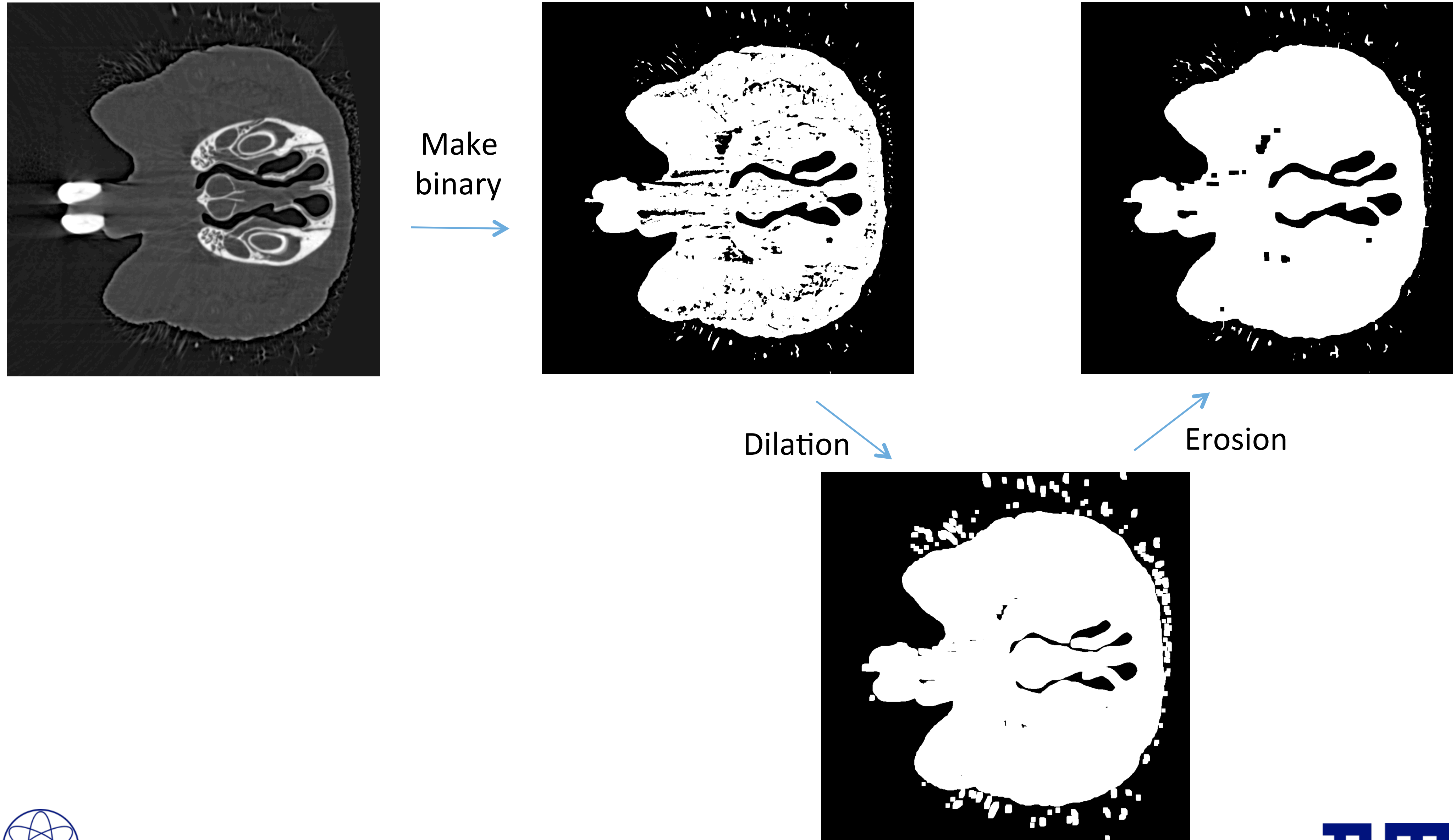
Morphological operations

Opening: first erosion, then dilation

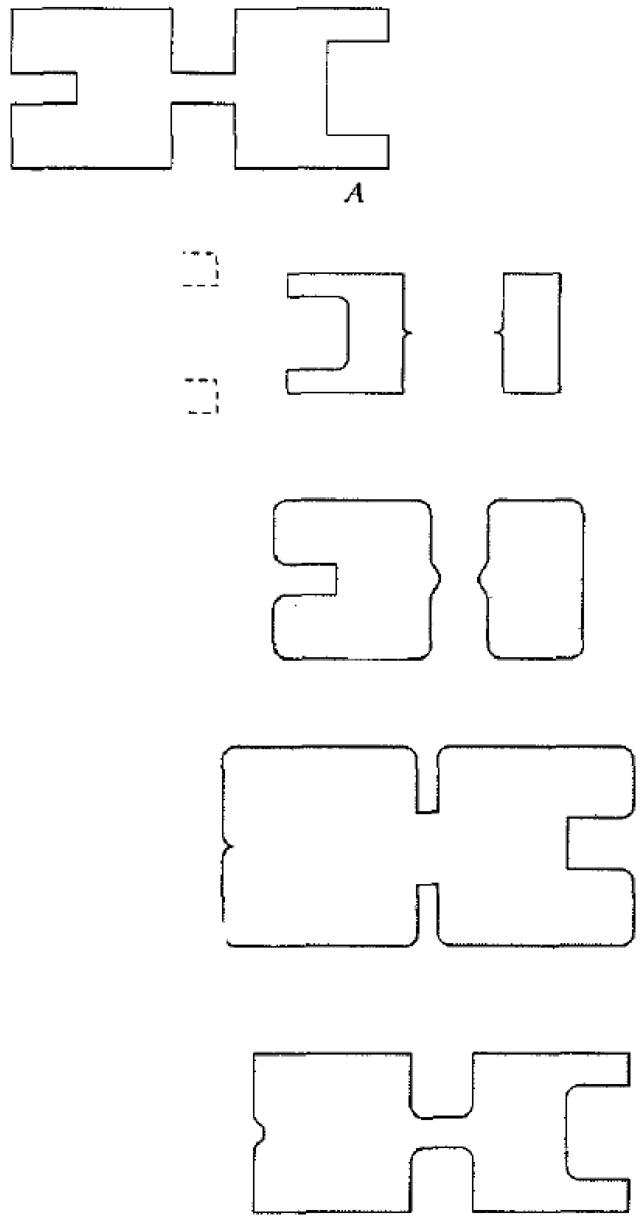


Morphological operations

Closing: first dilation, then erosion

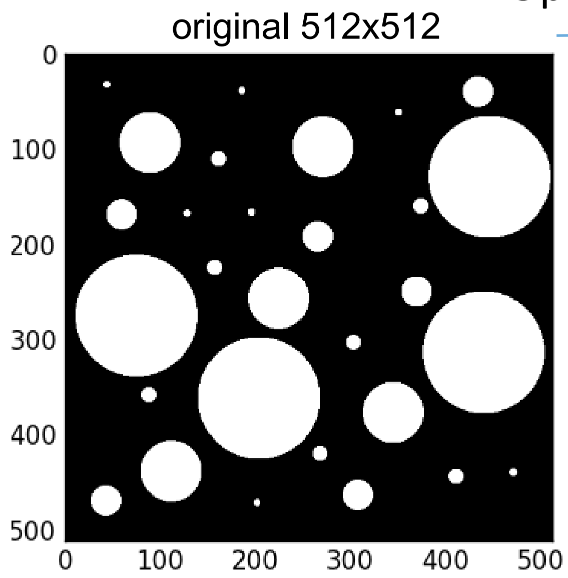


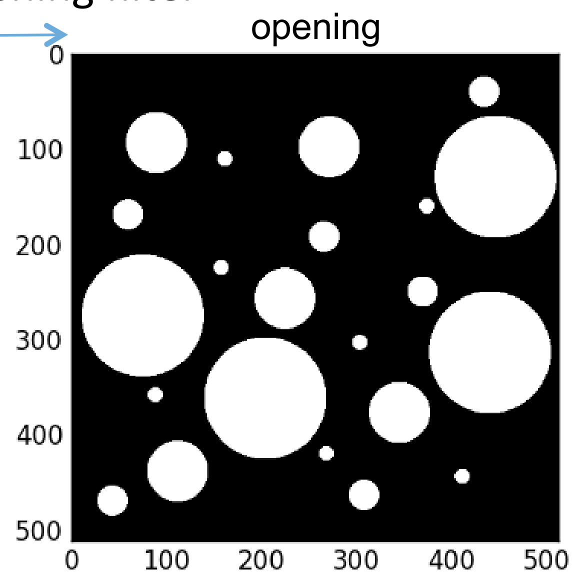
Morphological operations



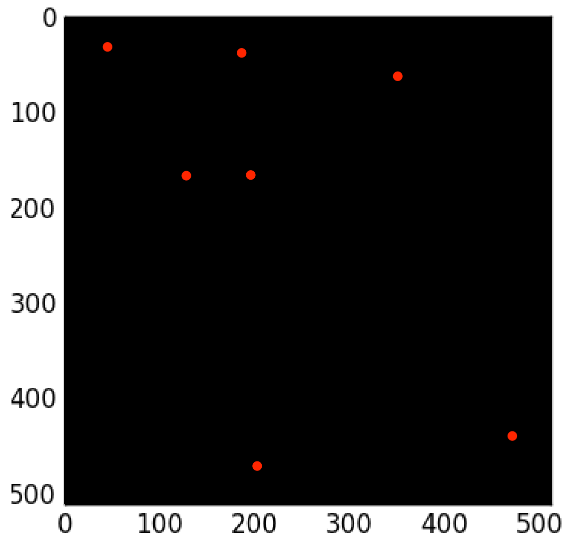
Segmentation by morphology

Opening filter

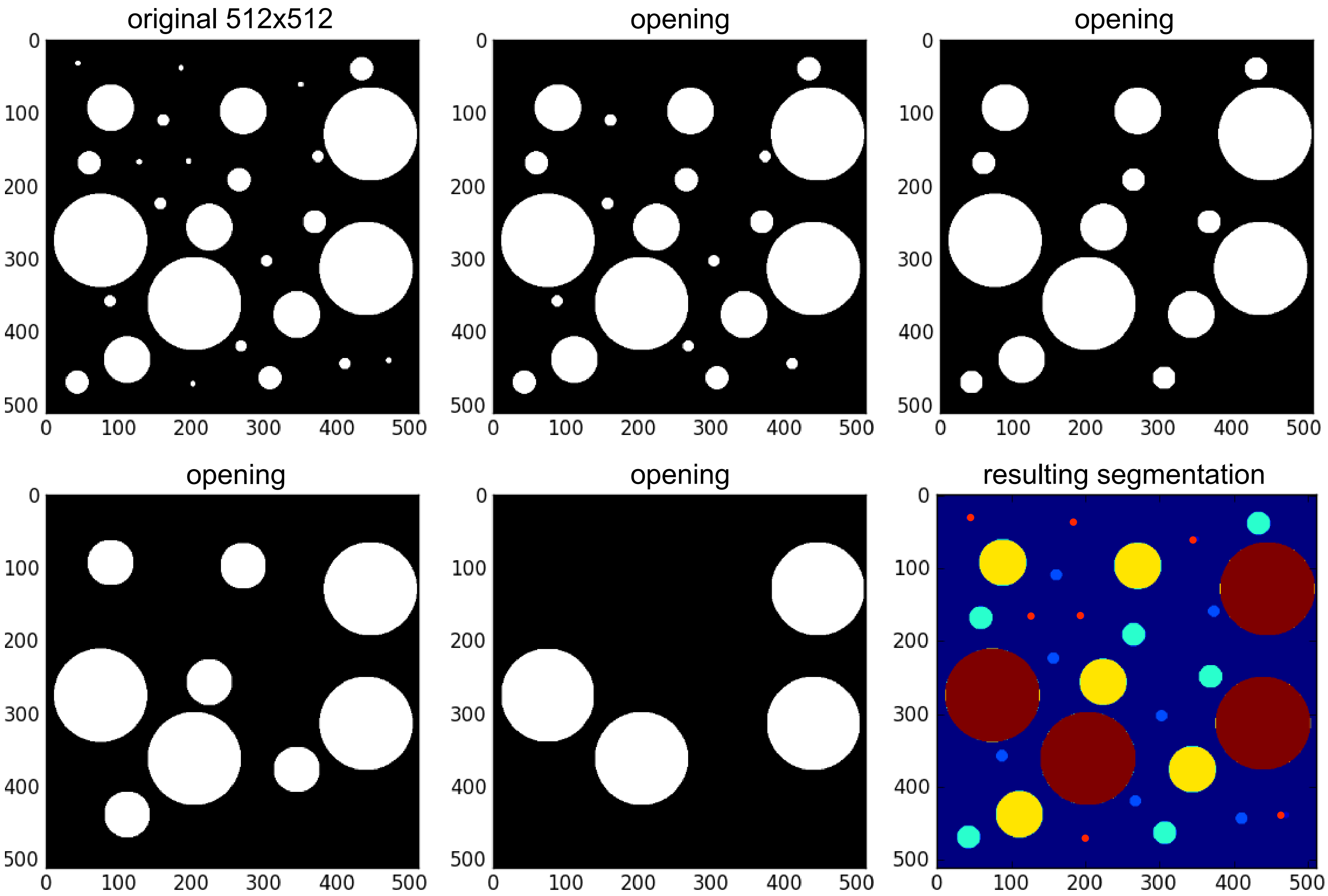




Original – Result of opening filter =



Segmentation by morphology



Summary

- Segmentation is important for visualisation and for quantitative measurements (volume/area, number of volumes/areas)
- Segmentation can be done
  - By intensity
  - By region growth
  - By boundaries
- Morphological operations can assist in segmenting samples by size, rather than by grey-level