

Introduction to Medical Image Segmentation

Булат Ибрагимов

INNOOLIS
UNIVERSITY

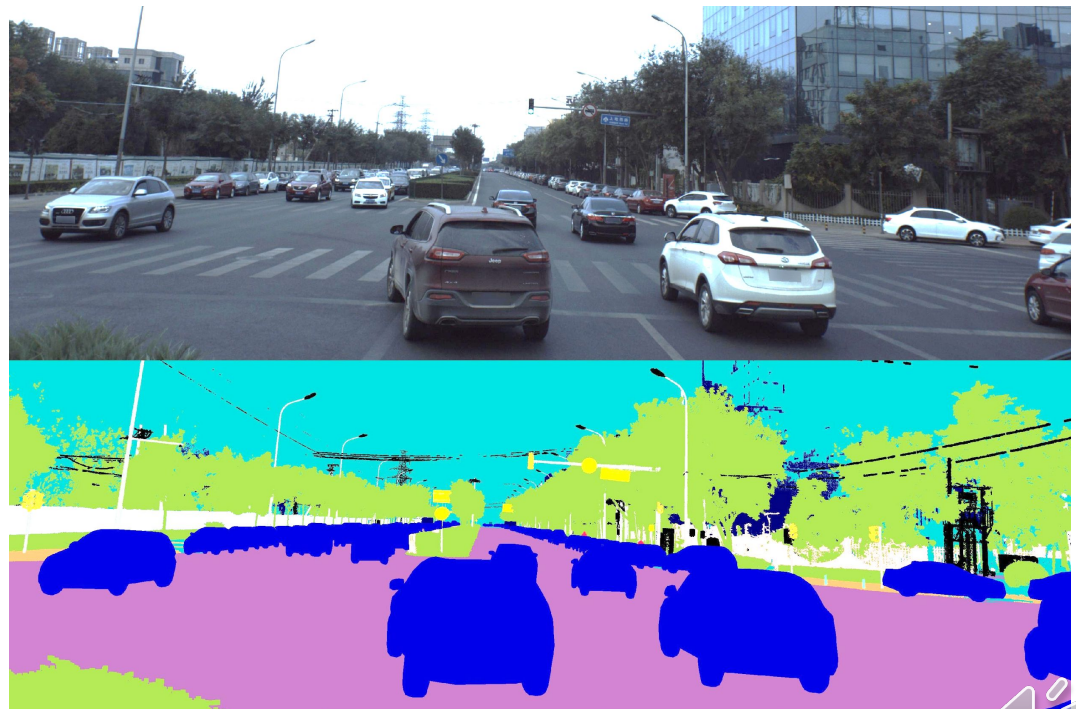


Learning objectives

- The idea of image segmentation
- Image segmentation in medical imaging
- Thresholding
- Connected component decomposition
- Morphological operations

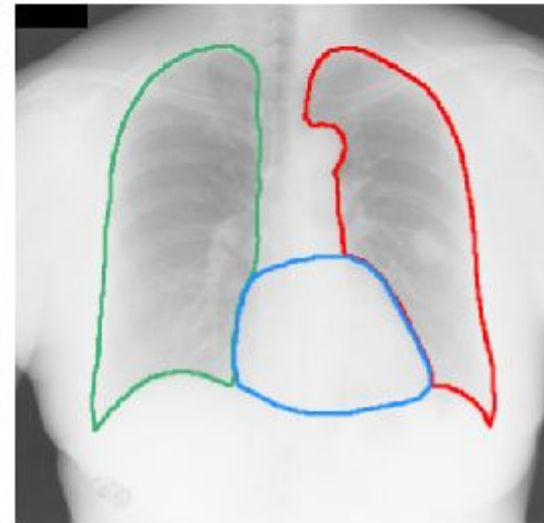
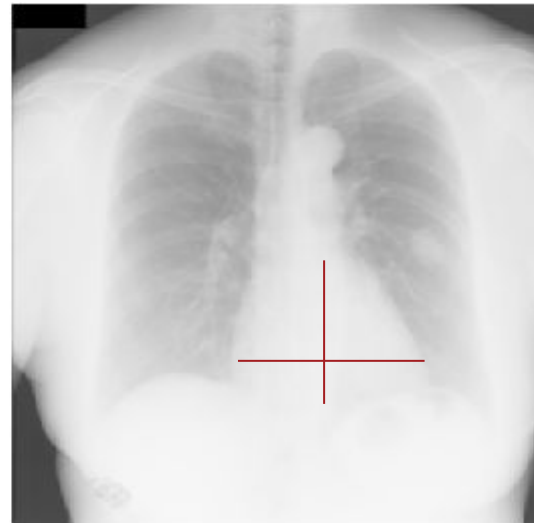
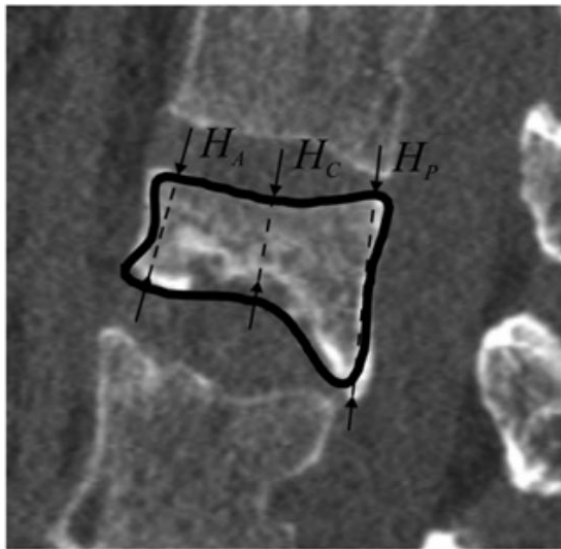
Segmentation

- Process of partitioning an image into distinct regions
- How segmentation can be used?



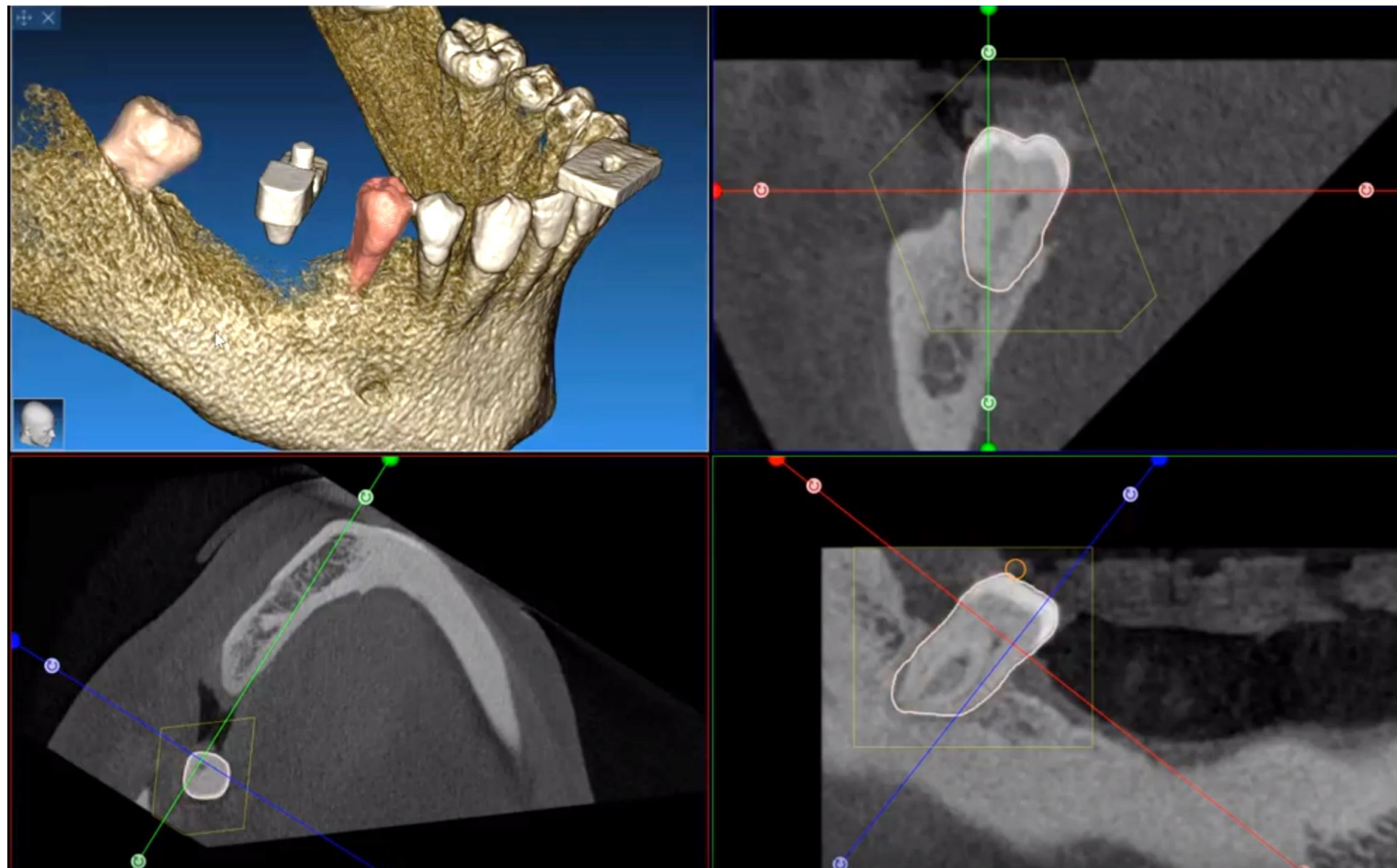
Segmentation of medical images

Computer-aided diagnosis



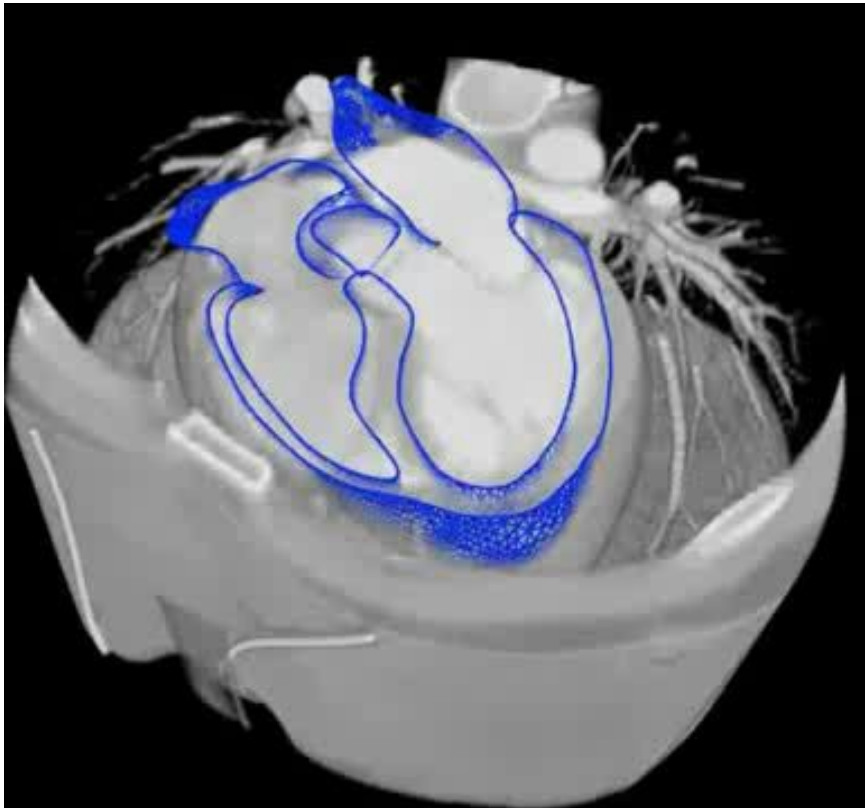
Segmentation of medical images

Image-guided procedures



Segmentation of medical images

Motion analysis

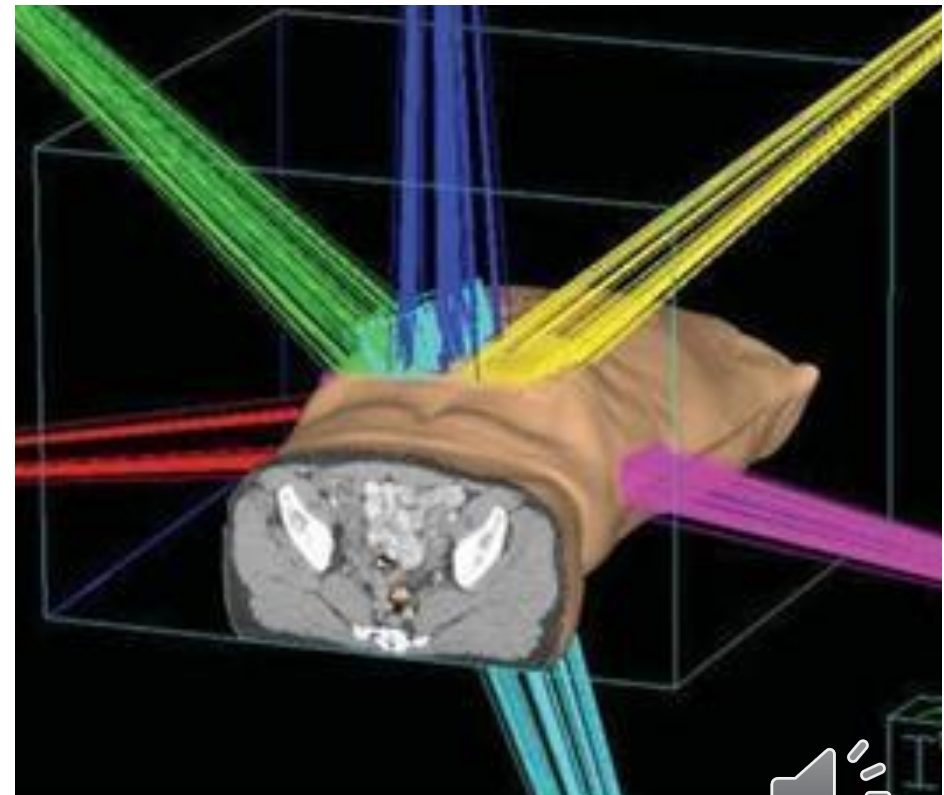
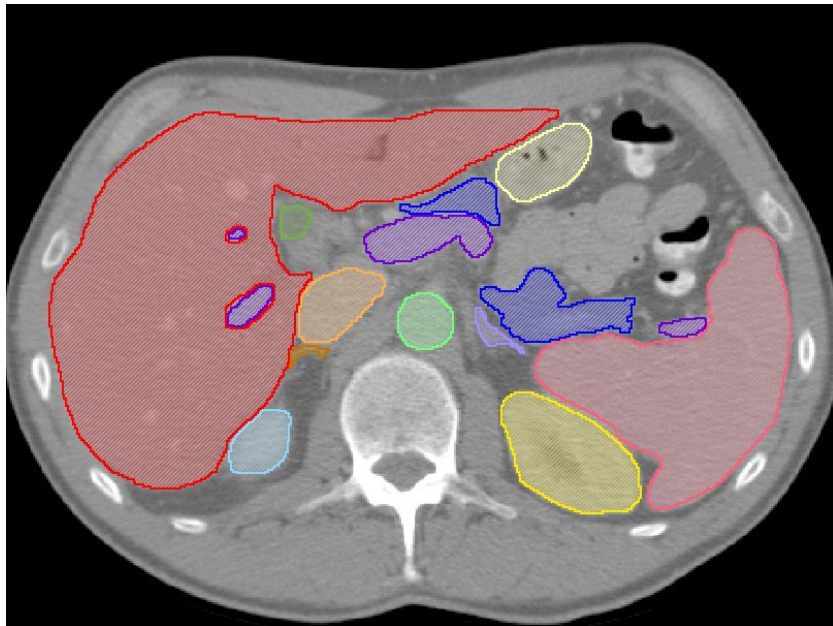


from Siemens
research



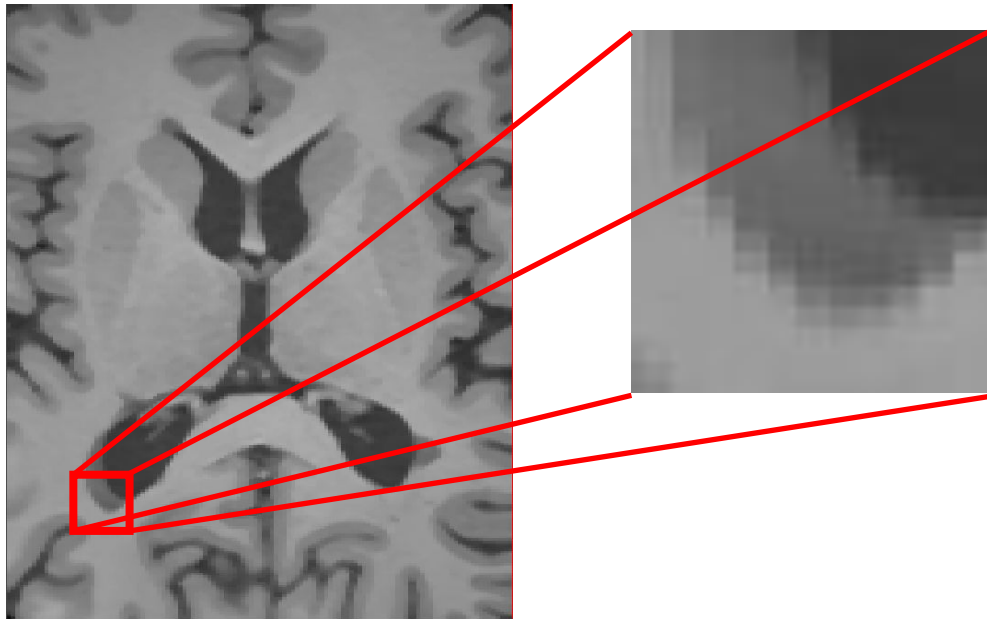
Segmentation of medical images

Radiotherapy planning



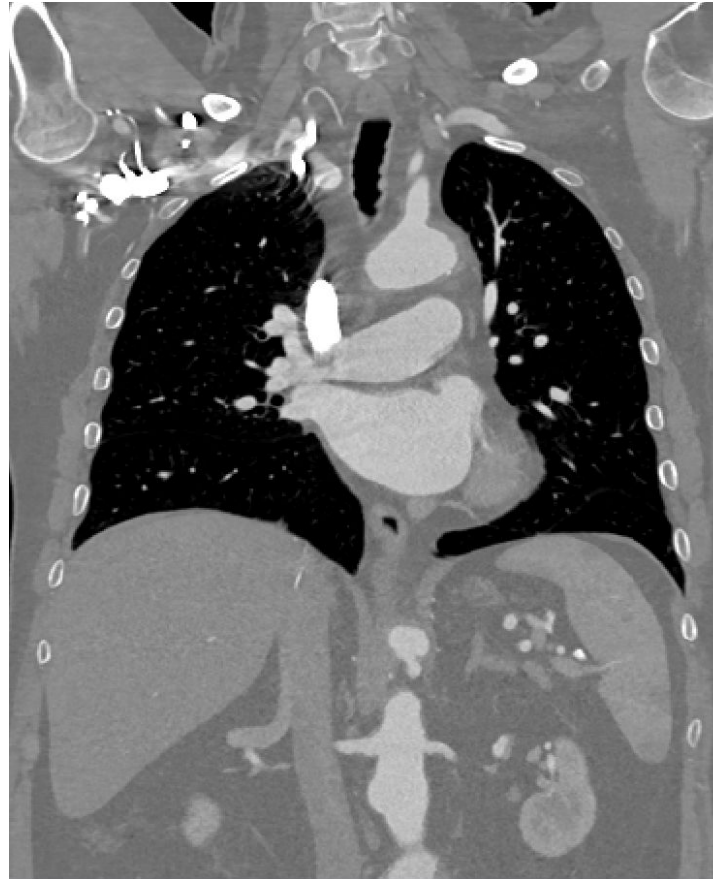
Medical image

- Medical image is an array of numbers:
 - 2D arrays for X-ray and ultrasound images
 - 3D arrays for computed tomography and magnetic resonance images



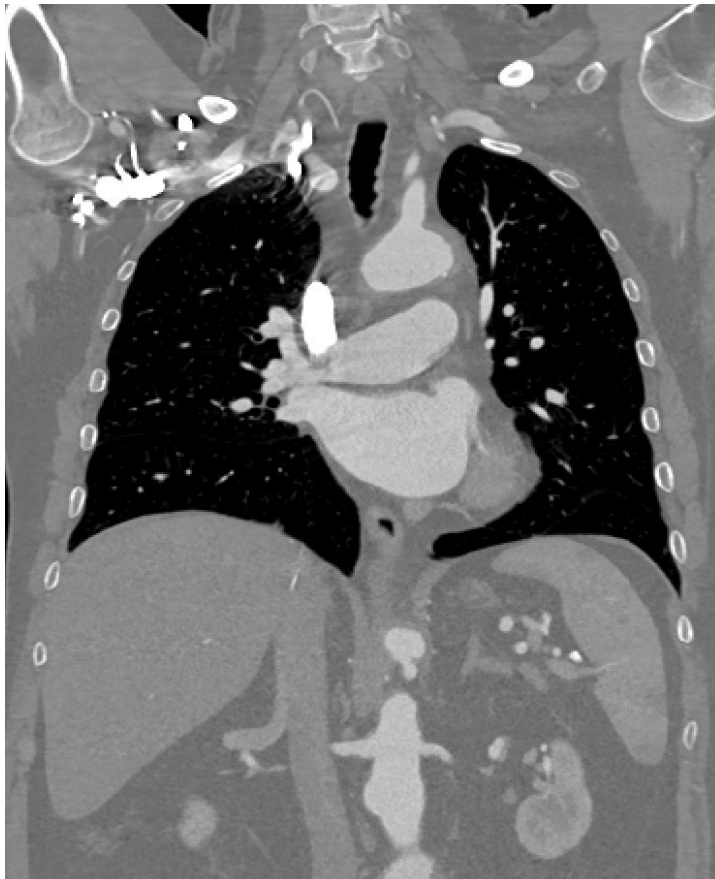
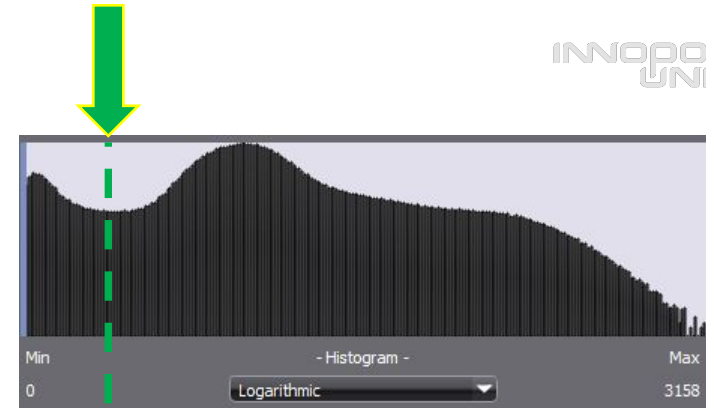
77	49	48	43	29	25	17	11
87	78	54	49	28	24	19	13
97	81	68	46	37	27	21	16
99	84	72	53	37	31	23	18
98	86	78	63	48	38	39	41
96	92	85	73	65	59	61	73
91	95	92	78	74	86	91	81
83	87	99	98	94	92	96	94

How would you segment lung fields?



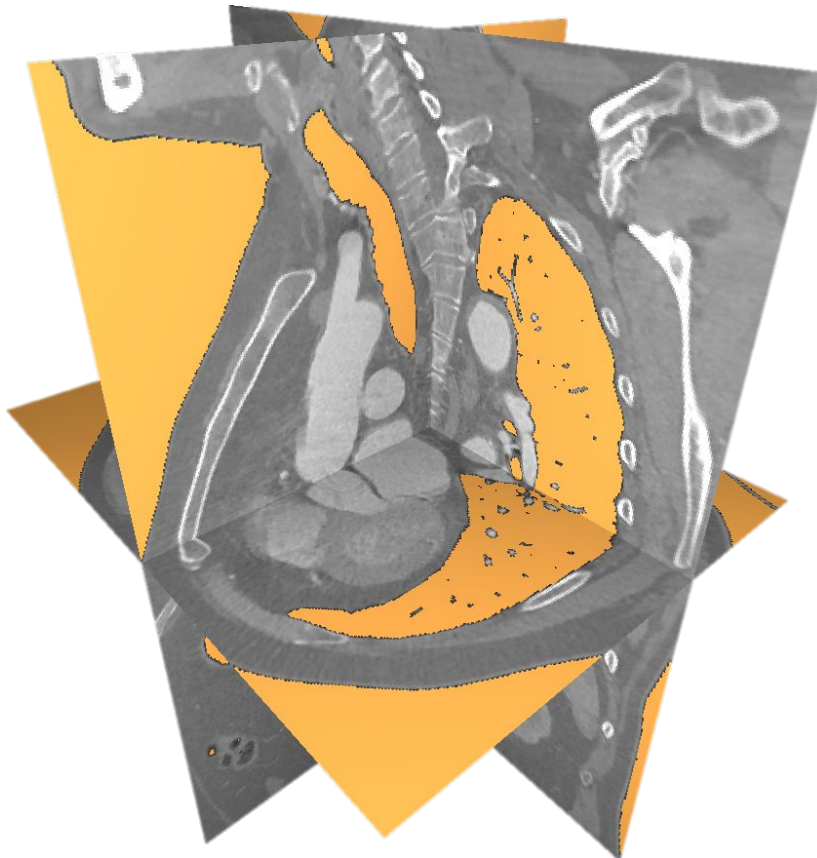
Thresholding

- Histogram of intensity distribution

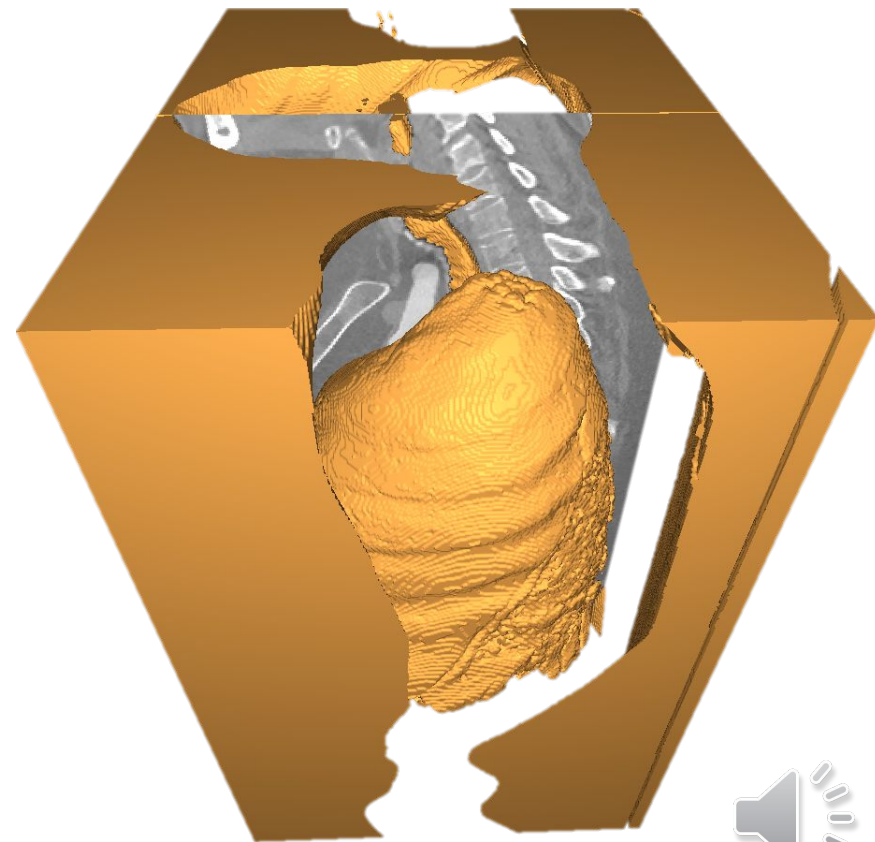


Thresholding

3D images with the threshold mask superimposed



Rendered threshold mask



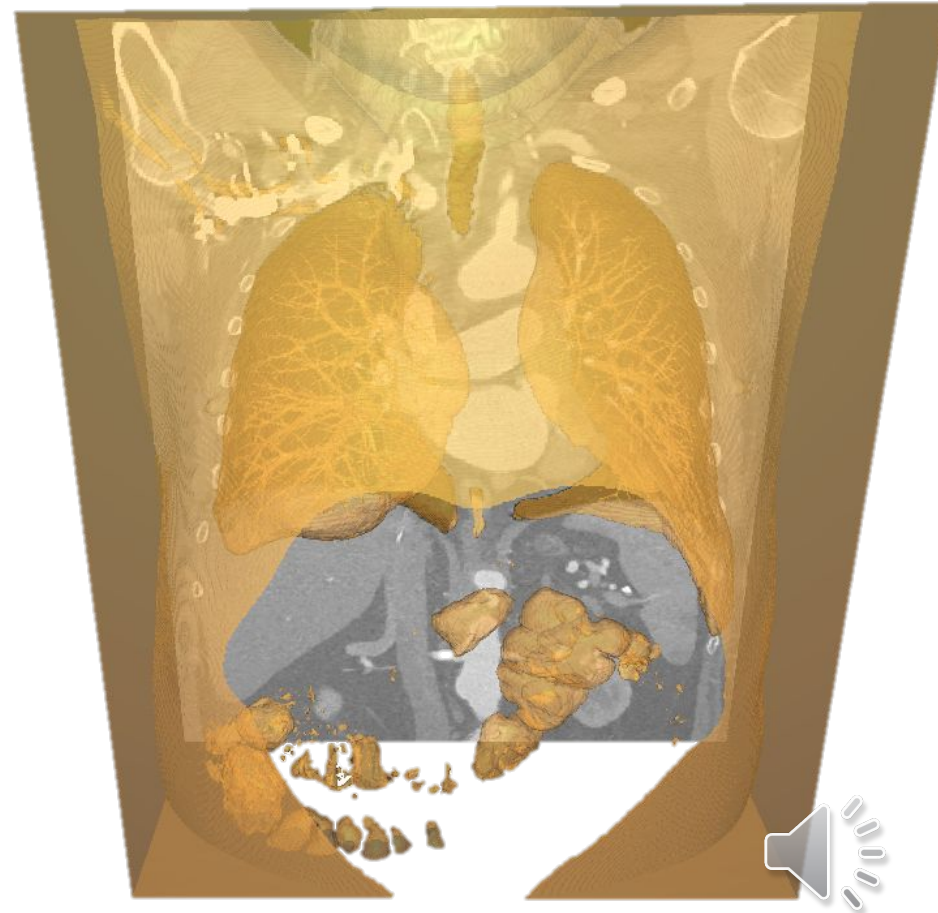
Connected component decomposition (CCD)

Thresholding generates a binary array with:

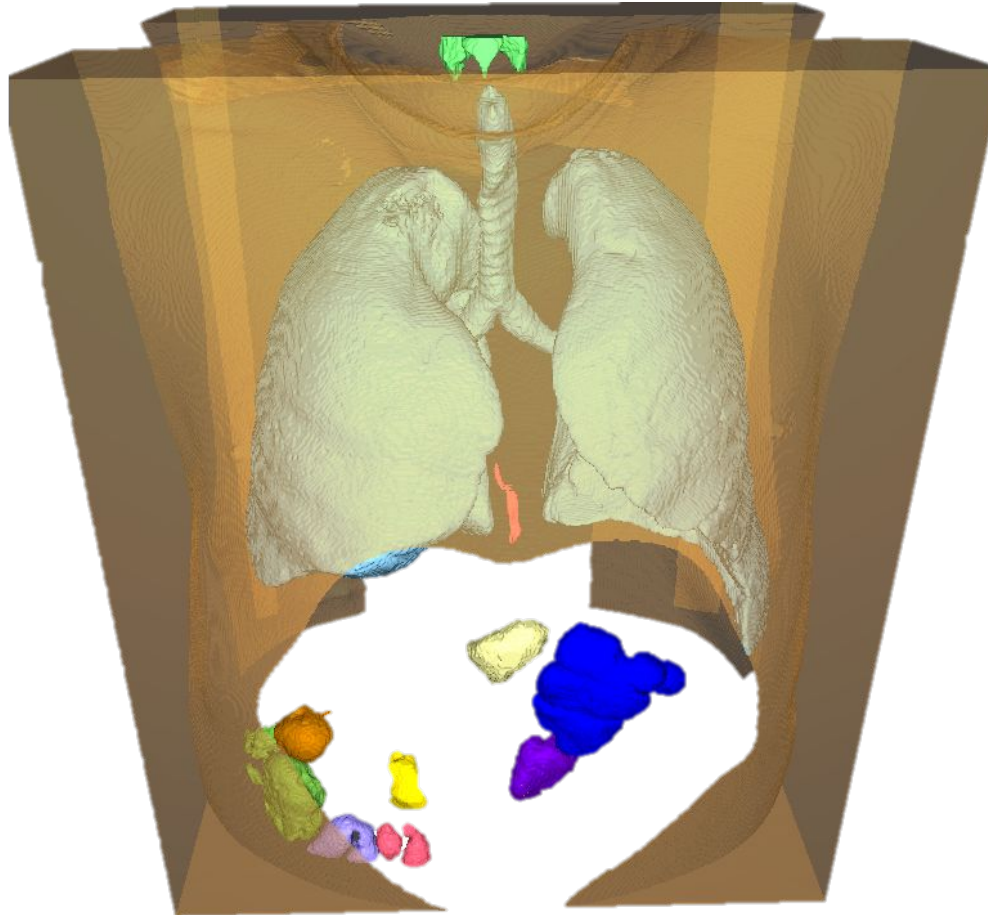
- Ones for image pixels with intensity above the threshold
- Zeros for image pixels with intensity below the threshold

Thresholding segmented lungs, but also other “dark” regions.

How can you get the lung fields from the binary array?



Connected component decomposition (CCD)



The lung fields almost always belong to the second largest component

 $I =$

1	1	0	0	0	1
1	1	0	1	1	1
0	1	0	1	0	0
0	0	0	0	0	0
0	1	1	0	0	0
0	0	1	0	0	0

 $V =$

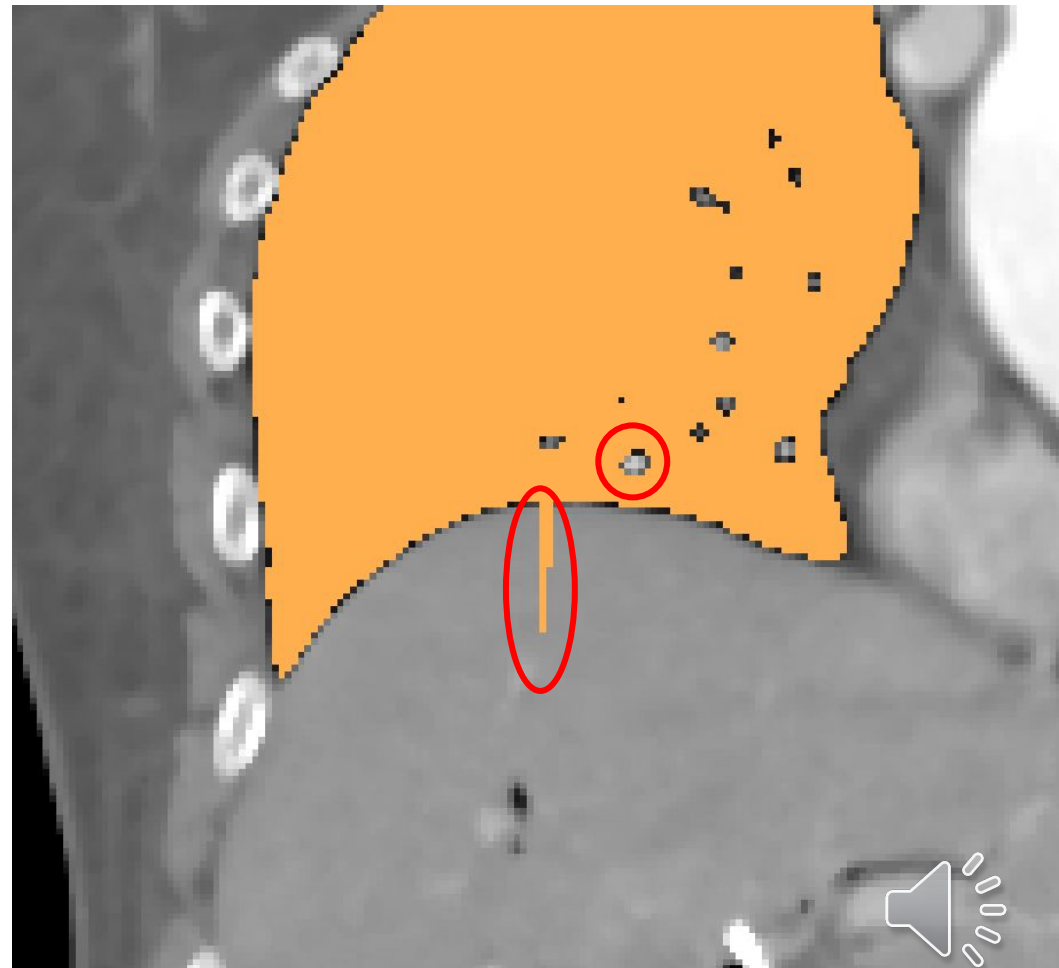
1	1	0	0	0	2
1	1	0	2	2	2
0	1	0	2	0	0
0	0	0	0	0	0
0	3	3	0	0	0
0	0	3	0	0	0

Morphological dilation/erosion

The lung field mask is imperfect:

- Where are holes in the mask due to vessels in the lungs
- There may be leaks outside lungs

How to remove them?



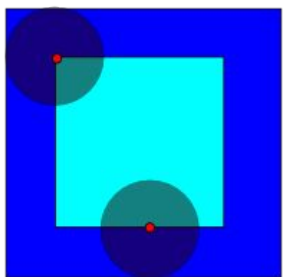
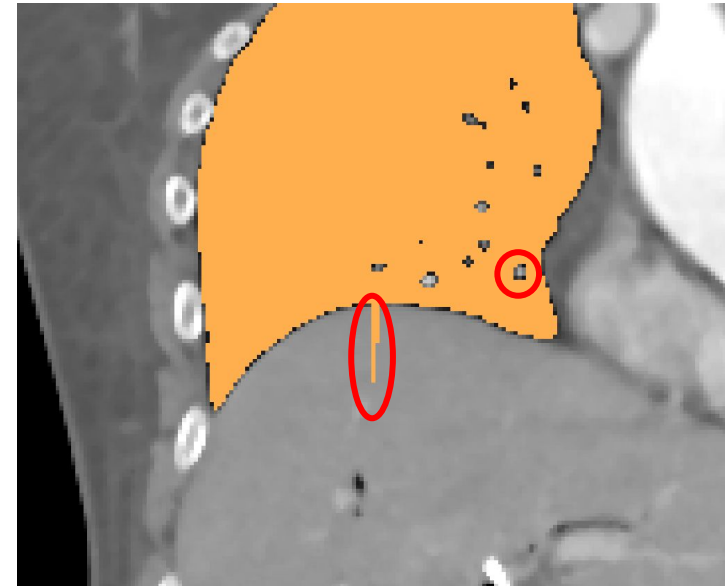
Morphological dilation/erosion

Informally:

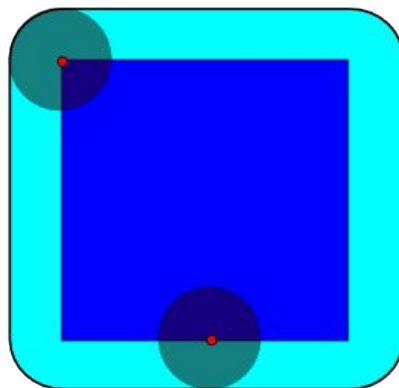
- Dilation – expanding of binary mask
- Erosion – shrinking of binary mask

Dilation/erosion is useful:

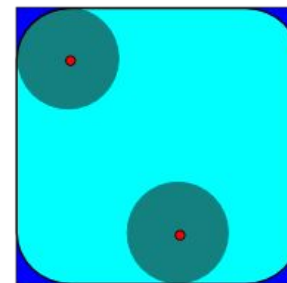
- To remove all internal noise pixels in segmentation mask
- To remove all boundary artifacts
- To smooth the boundaries



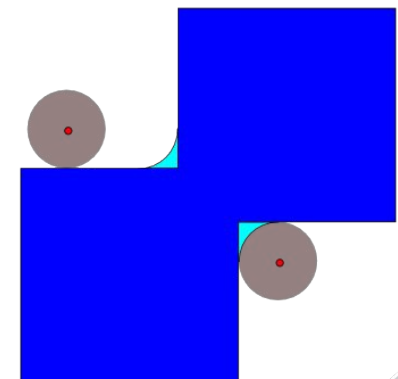
Erosion



Dilation



Erosion/Dilation



Dilation/Erosion



Dilation->Erosion

1) Dilation (1-mm)

$$I =$$

0	0	0	0	0	0
0	1	1	1	0	0
0	1	0	1	0	0
0	1	1	1	0	0
0	1	1	0	0	0
0	0	0	0	0	0

$$V =$$

0	1	1	1	0	0
1	1	1	1	1	0
1	1	1	1	1	0
1	1	1	1	1	0
1	1	1	1	0	0
0	1	1	0	0	0

2) Erosion (1-mm)

$$I =$$

0	1	1	1	0	0
1	1	1	1	1	0
1	1	1	1	1	0
1	1	1	1	1	0
1	1	1	1	0	0
0	1	1	0	0	0

$$V =$$

0	0	0	0	0	0
0	1	1	1	0	0
0	1	1	1	0	0
0	1	1	1	0	0
0	1	1	0	0	0
0	0	0	0	0	0



Must-have tools: Erosion->Dilation

1) Erosion (1-mm)

$I =$

0	1	1	1	0	0
0	1	1	1	0	0
0	1	1	1	0	0
0	0	1	0	0	0
0	0	1	0	0	0
0	0	1	0	0	0

$V =$

0	0	1	0	0	0
0	0	1	0	0	0
0	0	1	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

2) Dilation (1-mm)

$I =$

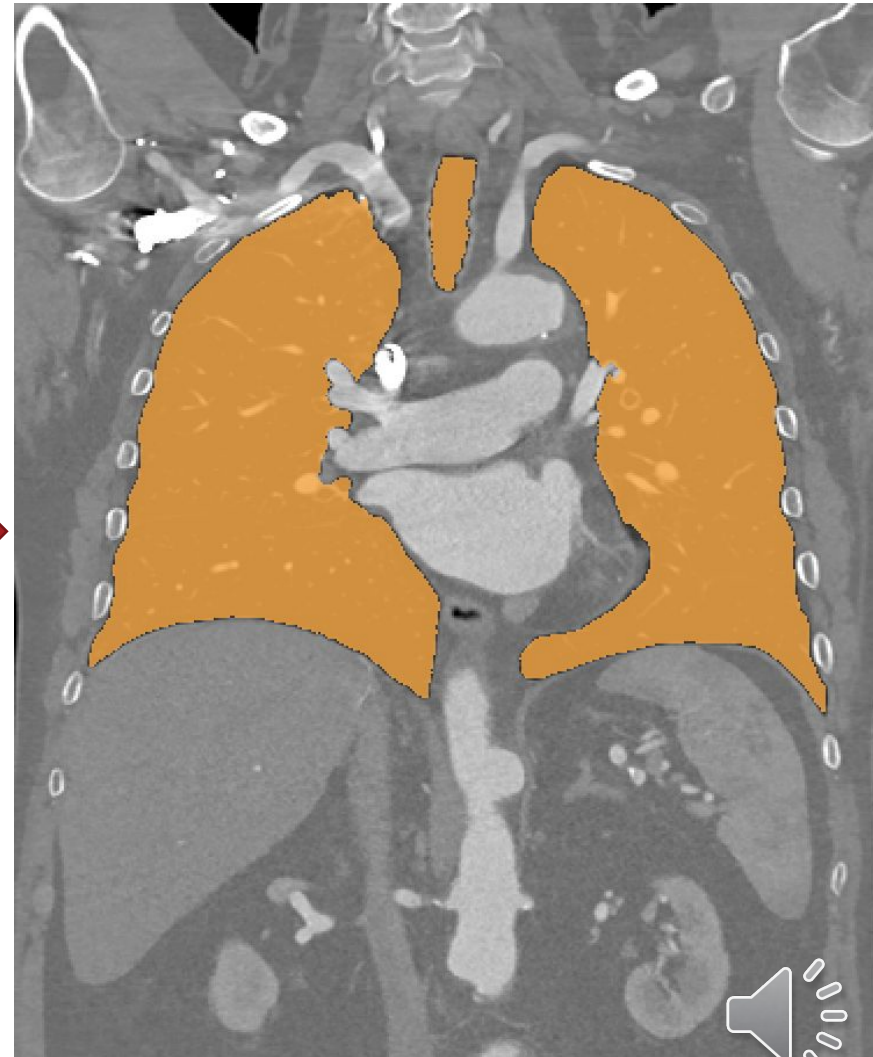
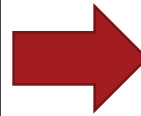
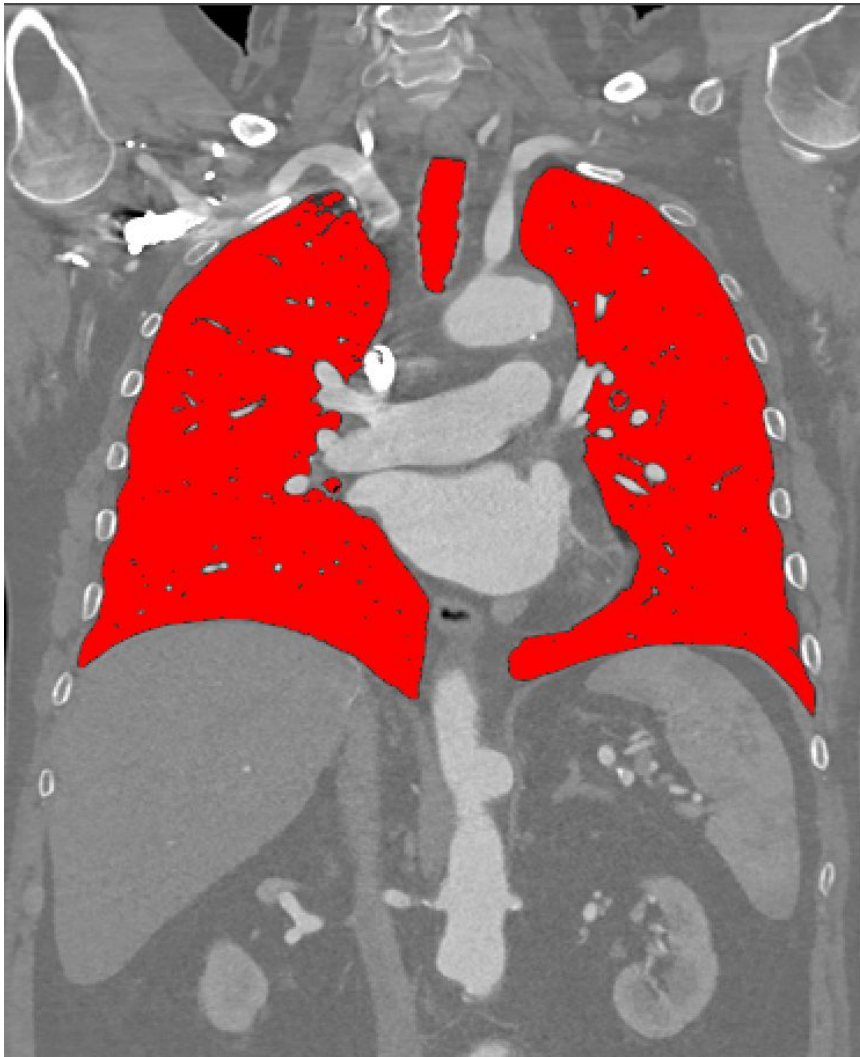
0	0	1	0	0	0
0	0	1	0	0	0
0	0	1	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

$V =$

0	1	1	1	0	0
0	1	1	1	0	0
0	1	1	1	0	0
0	0	1	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0



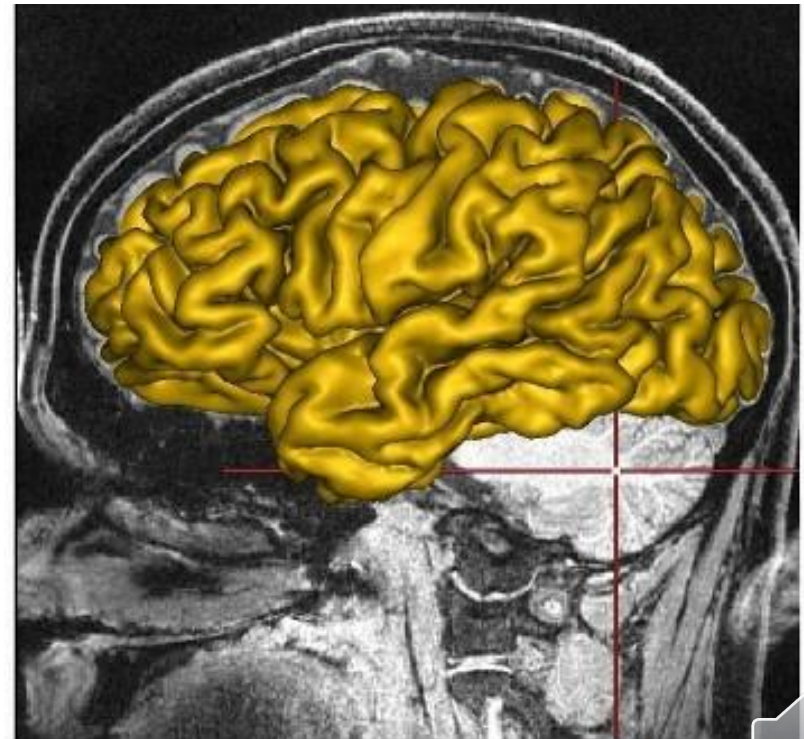
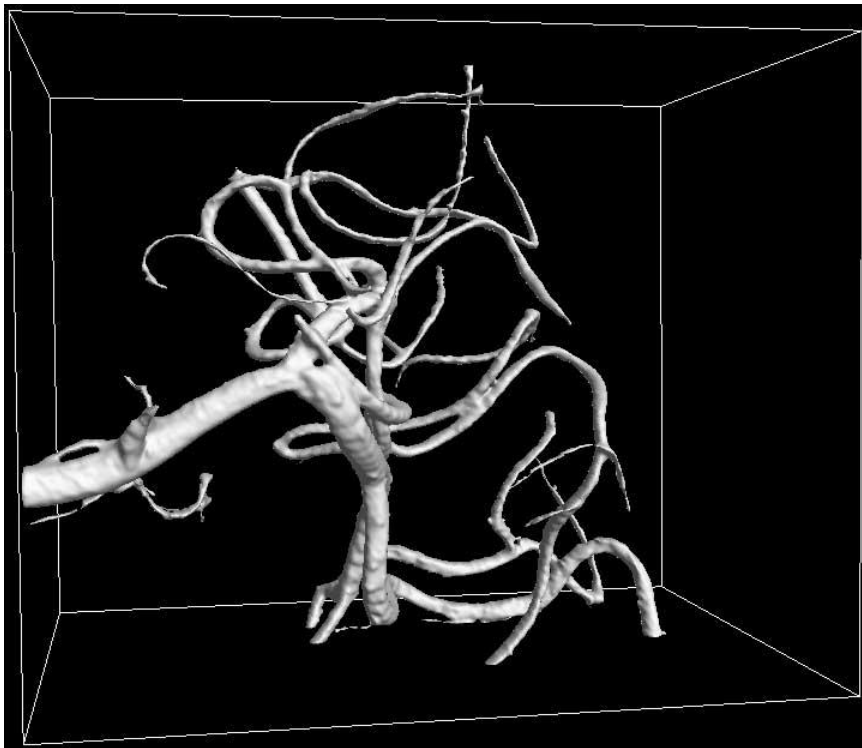
Morphological dilation/erosion



Morphological dilation/erosion

Which one is more suitable:

- dilation->erosion
- erosion->dilation



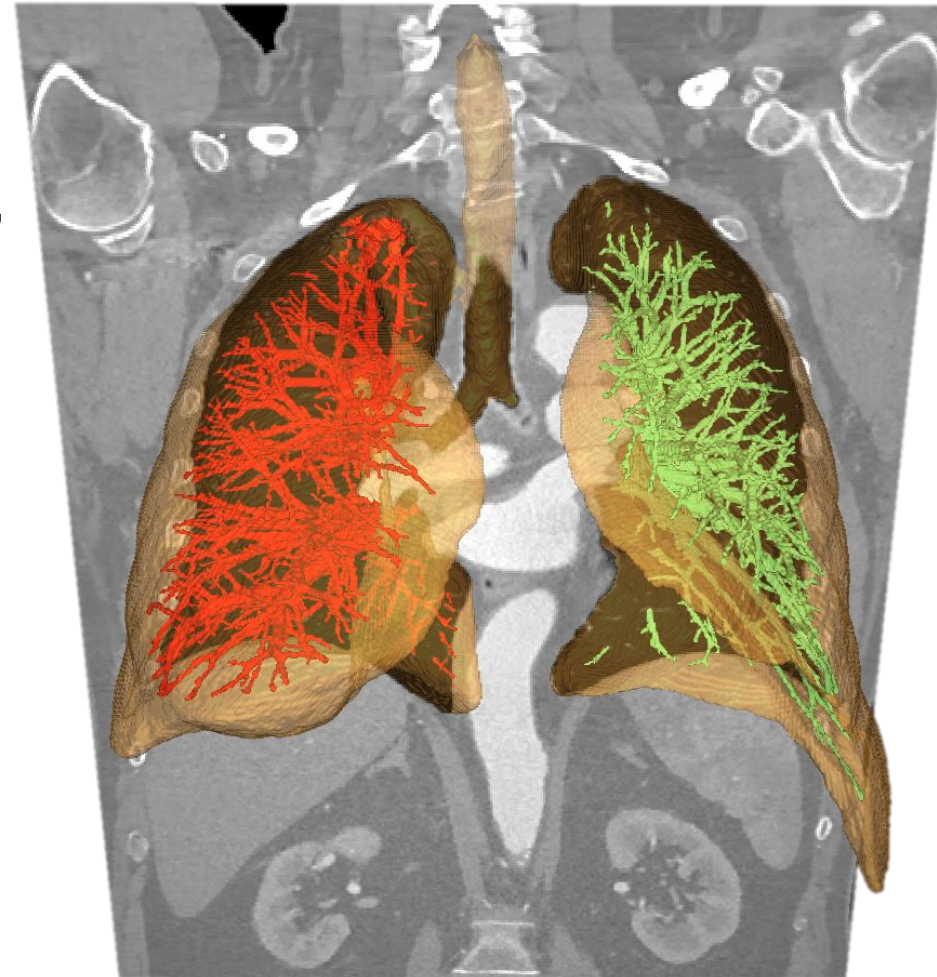
Complete segmentation framework

Lung segmentation:

- Thresholding
- CCD, second largest component, save the results to array **A**
- 4 dilations->4 erosions, array **B**

Lung vasculature segmentation

- Subtract: **$C = A - B$**
- CCD, two largest components



Lesson summary

We learned:

- Segmentation in medical imaging
- Thresholding
- Connected component decomposition
- Morphological dilation/erosion

