Organ-Specific Context-Sensitive Single and Dual Energy CT (DECT) Image Reconstruction, Display and Analysis

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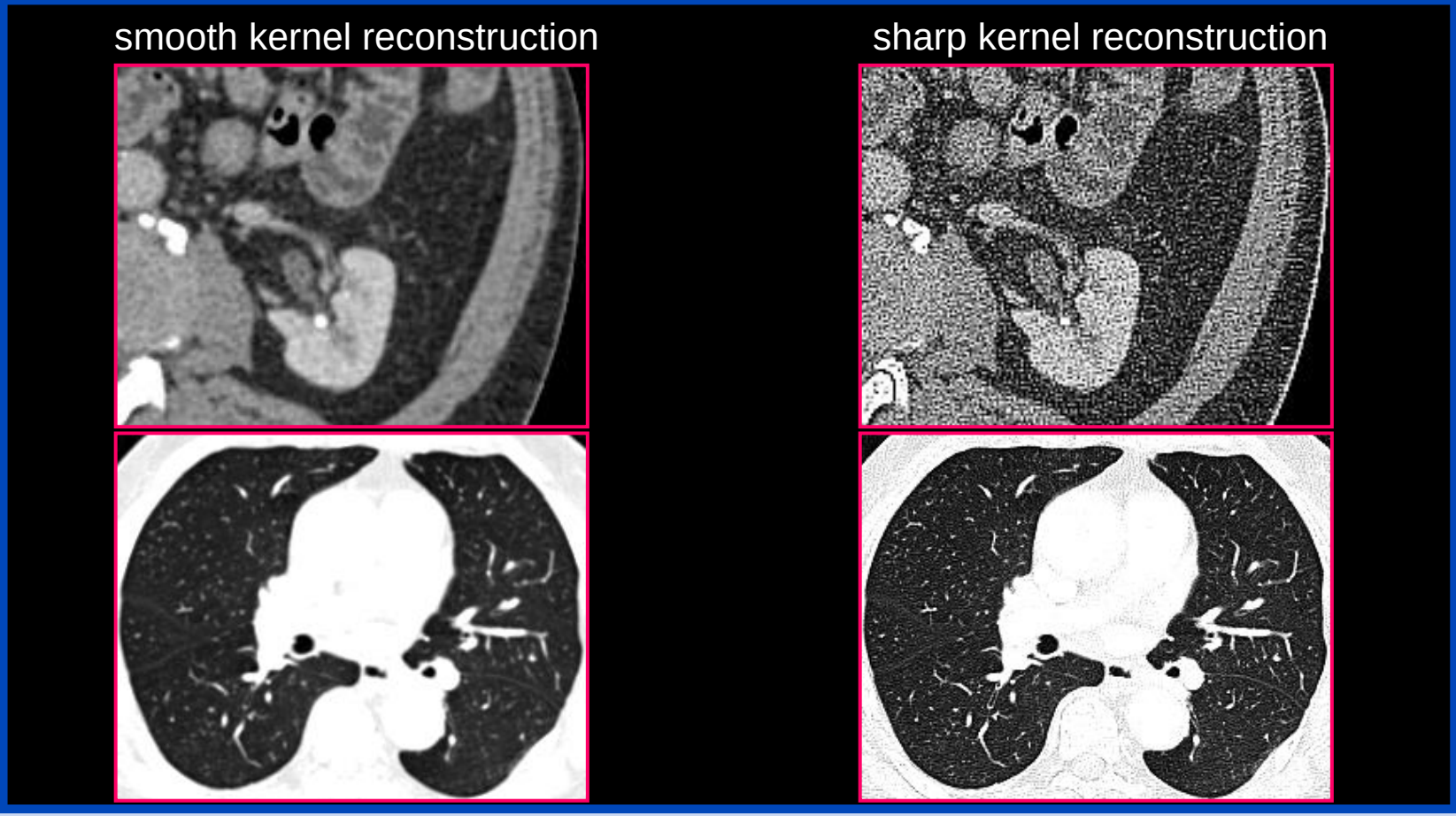
Aim

To combine mutually exclusive CT image properties into a single organ-specific image reconstruction, display and analysis using prior anatomical information.



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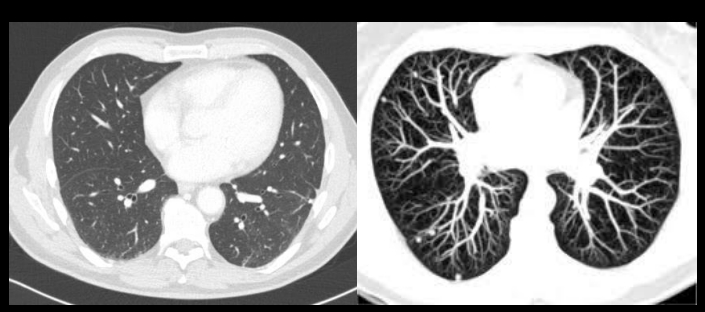
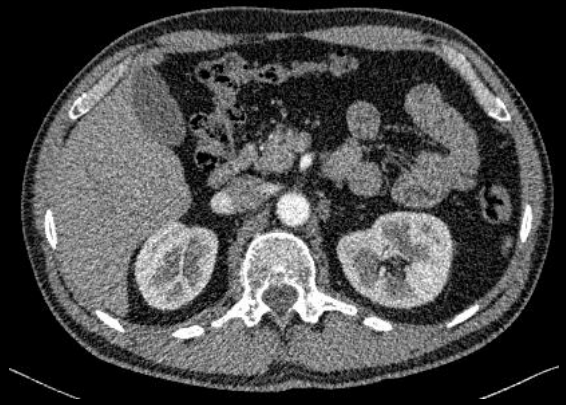


lung window

STS MIP



body window

sliding thin slab (STS) display

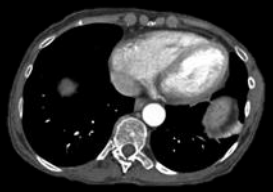
0.5 mm slab

10 mm slab

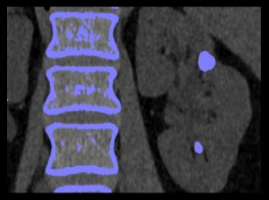
Aim

To combine mutually exclusive CT image properties into a single organ-specific image reconstruction, display and analysis using prior anatomical information.

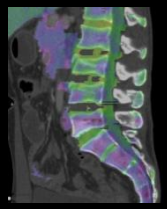
Rho/Z



Optimum Contrast

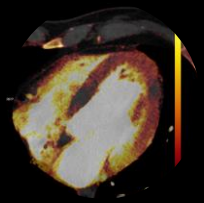


Calculi Characterization



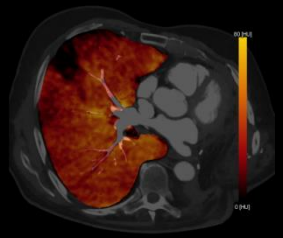
Bone Marrow

Xenon



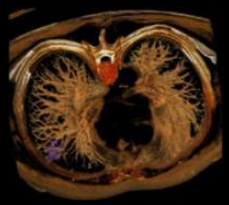
Heart PBV

Direct Angio

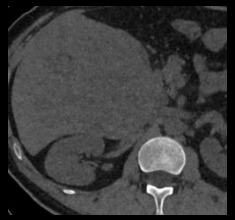


Lung Analysis

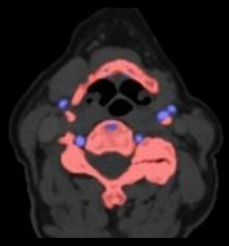
Monoenergetic Plus



Lung Nodules



Virtual Unenhanced



Hardplaque Display

Syngo.CT DECT application examples. Virtual unenhanced contains liver VNC, lung analysis contains lung PBV.
Courtesy of Siemens Healthineers, Forchheim, Germany

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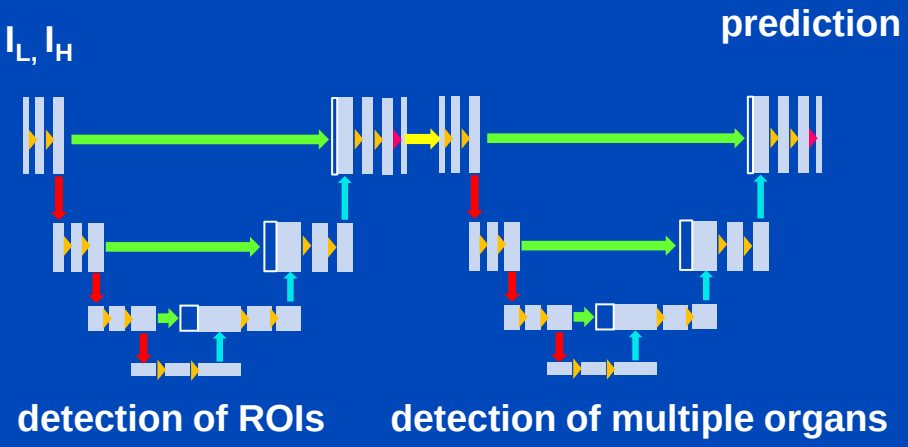
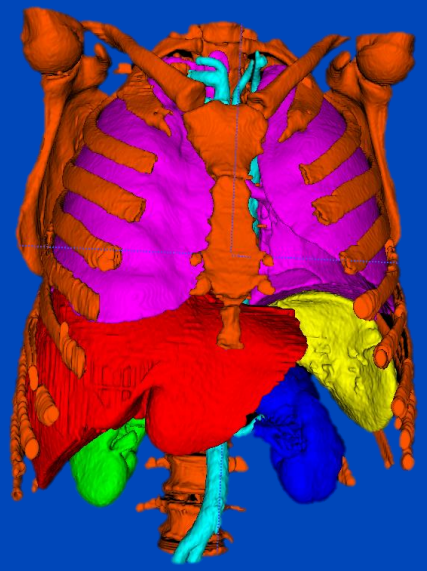
Method

- **Prior anatomical knowledge: 3D fully convolutional network[1]**
  - **Segmentation of dual energy data**
  - **Cascaded neural network architecture**
    1. **Detection of the region of interest (ROI)**
    2. **Final detection of organ boundaries**





- **Automatic segmentation: liver, kidneys, spleen, lung, bone, aorta.**
- **Thresholding remaining voxels into the following tissue types: muscles, fat, vasculature.**
- **Currently, manual corrections are necessary (until today).**

[1] S. Chen, H. Roth, S. Dorn, M. May, A. Cavallaro, M. Lell, M. Kachelrieß, H. Oda, K. Mori, and A. Maier. Towards Automatic Abdominal Multi-Organ Segmentation in Dual Energy CT using Cascaded 3D Fully Convolutional Network. *CoRR*, 2017

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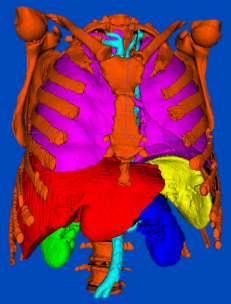
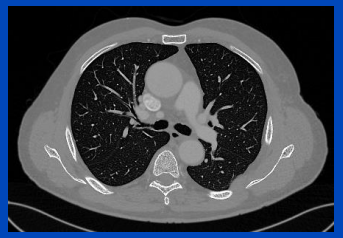
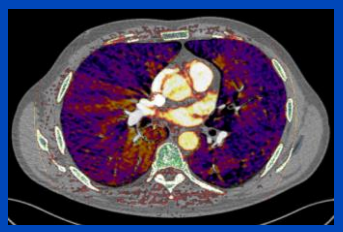
Method

Segmentation delivers a binary mask for each organ.

1. **Smoothing of the binary masks to cope with the boundaries of adjacent anatomical structures.**
2. **Use smoothed masks to allow for individual settings for each organ.**
   - **Context-sensitive (CS) resolution**
   - **CS display**
   - **CS dual energy evaluation**





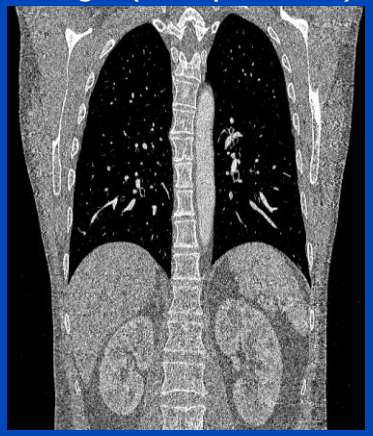


Context-sensitive (CS) = organ-dependent parameter adaptation

Context-Sensitive Resolution

standard low resolution image (smooth kernel)

standard high resolution image (sharp kernel)



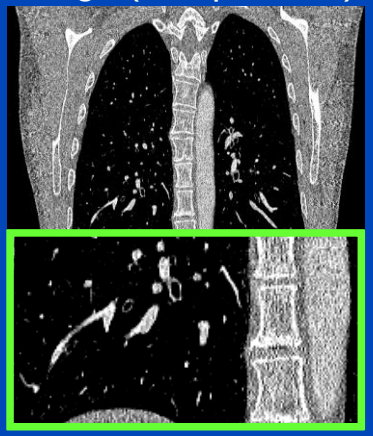
resolution-mixed image (high resolution in lung and bone, low noise in soft tissue)

CS resolution

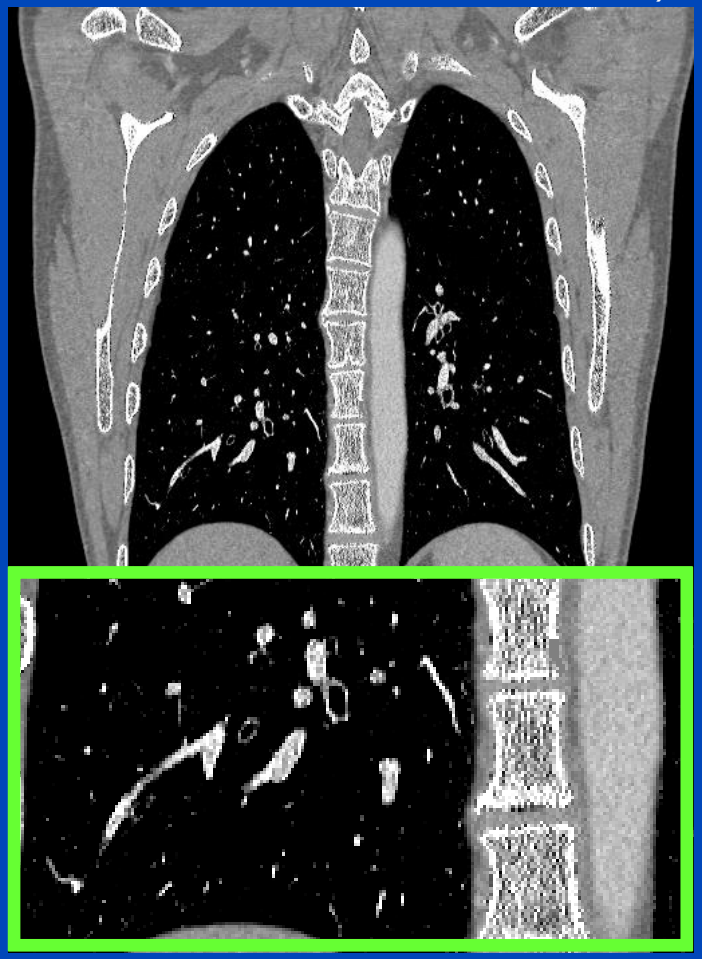
Context-Sensitive Resolution

standard low resolution image (smooth kernel)

standard high resolution image (sharp kernel)



resolution-mixed image (high resolution in lung and bone, low noise in soft tissue)



CS resolution

- ✓ **increased spatial resolution in bone and lung**
- ✓ **decreased noise level in soft tissue**

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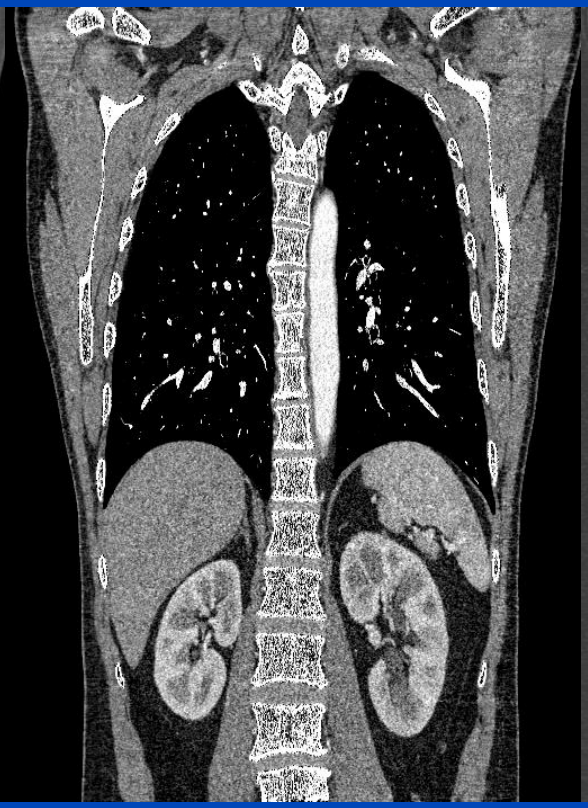
Context-Sensitive Display

conventional windowing

CS resolution

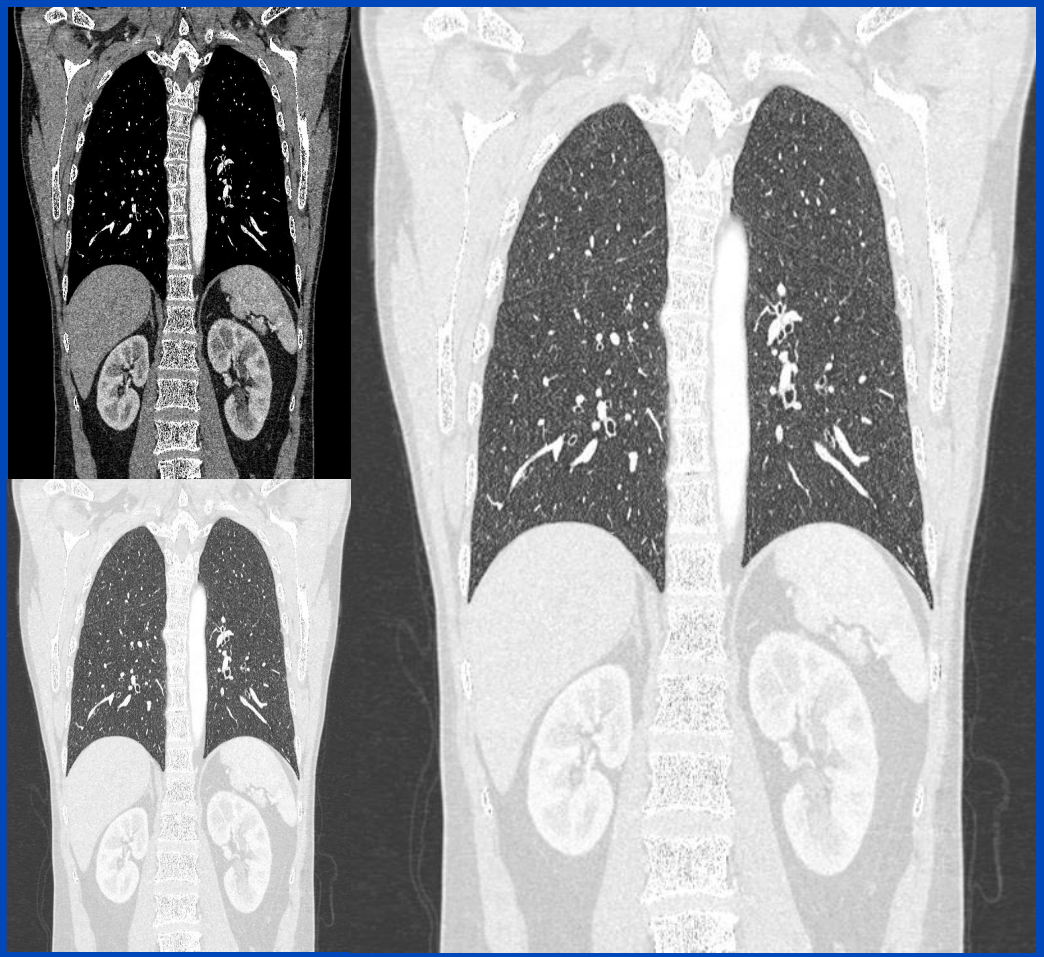
bone window



body window

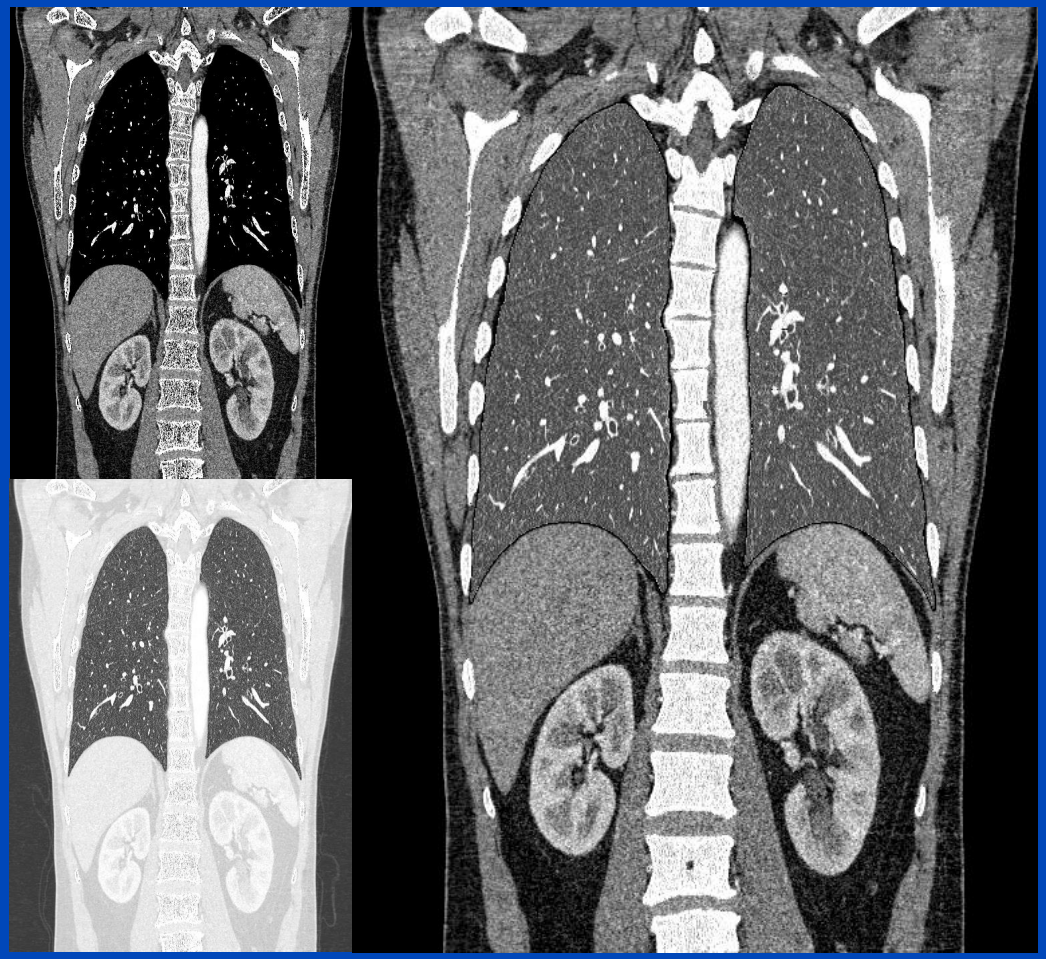
lung window

Context-Sensitive Display



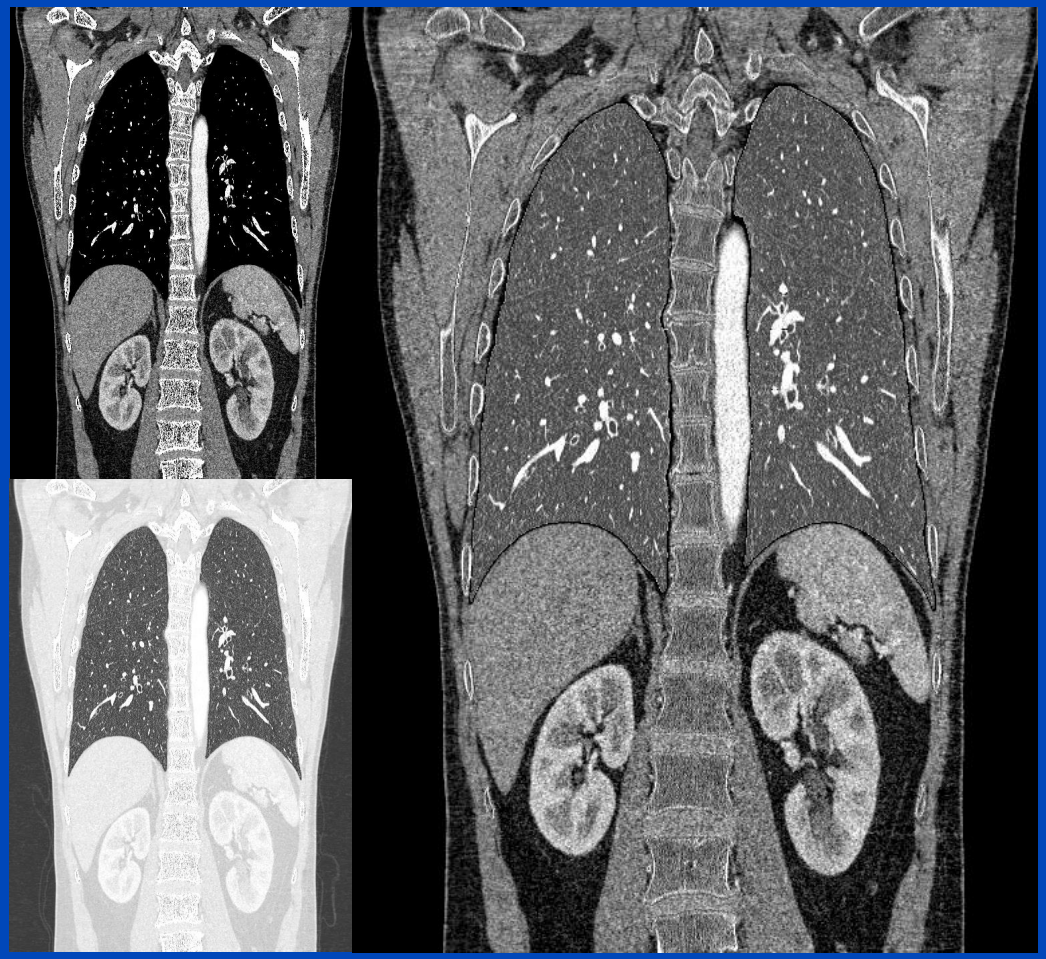
- CS resolution
- CS display
  - windowing

Context-Sensitive Display



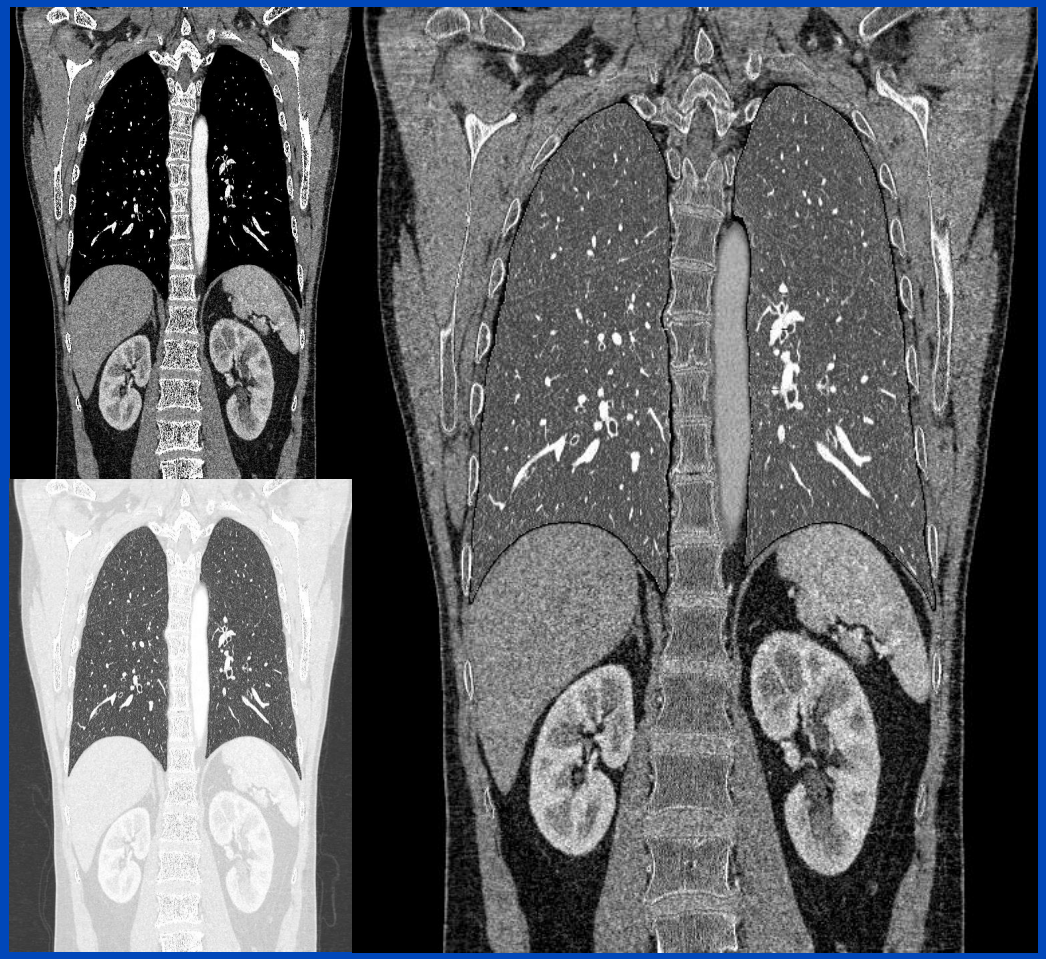
- ☑ CS resolution
- ☑ CS display
  - ☑ windowing

Context-Sensitive Display



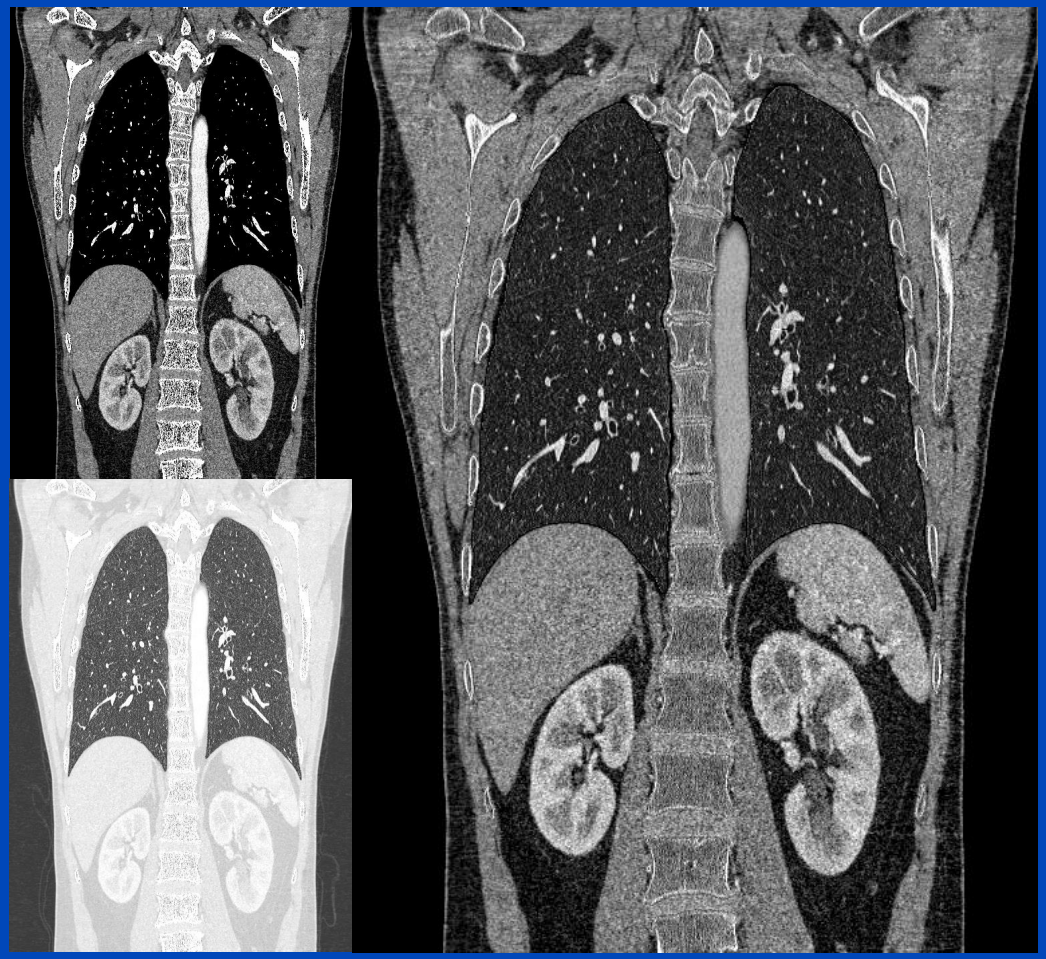
- [x] CS resolution
- [x] CS display
  - [x] windowing

Context-Sensitive Display



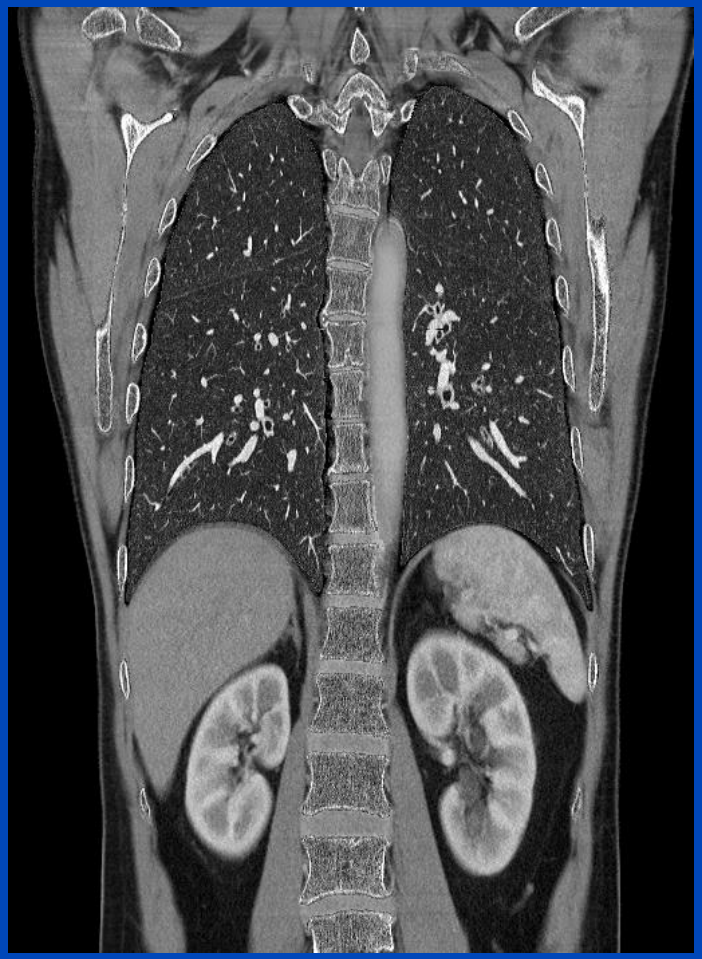
- CS resolution
- CS display
  - windowing

Context-Sensitive Display



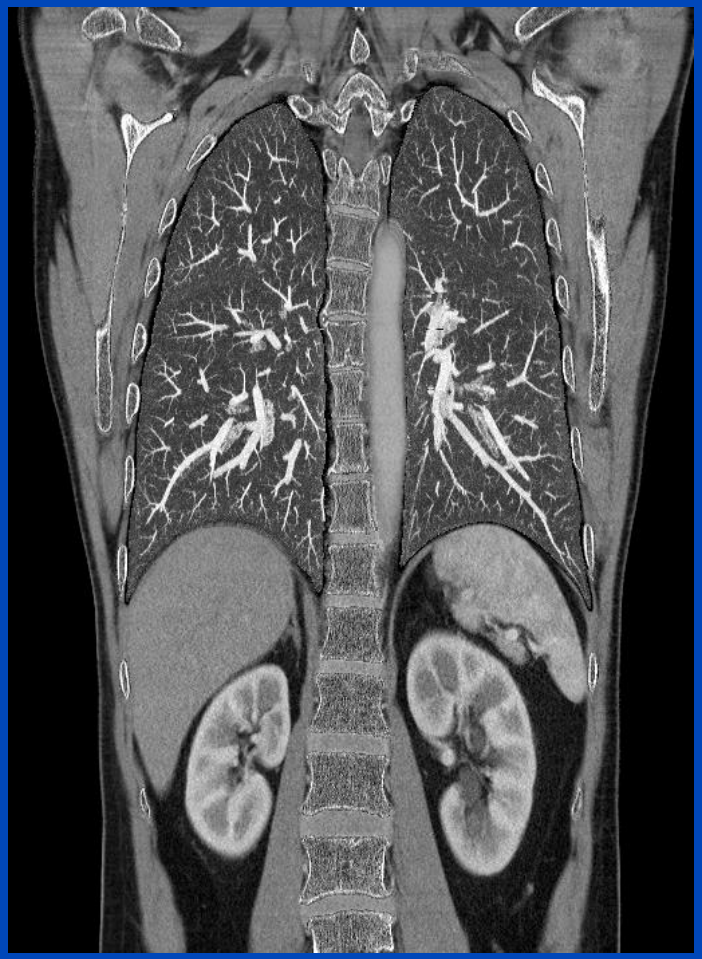
- CS resolution
- CS display
  - windowing

Context-Sensitive Display



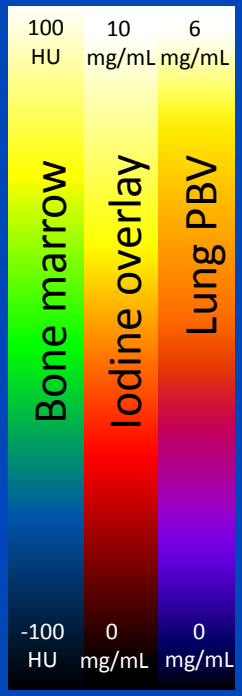
- [x] CS resolution
- [x] CS display
  - [x] windowing
  - [x] STS mean in soft tissue (5 mm)

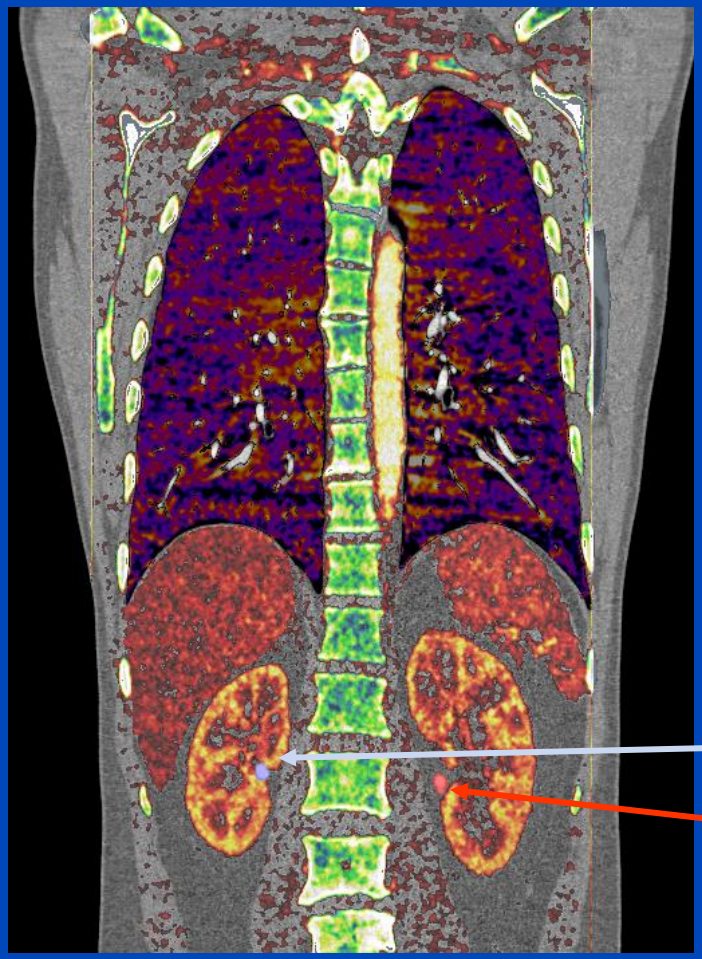
Context-Sensitive Display



- ☑ CS resolution
- ☑ CS display
  - ☑ windowing
  - ☑ STS mean in soft tissue (5 mm)
  - ☑ STS MIP in lung (10 mm)

Context-Sensitive Dual Energy





simultaneous DE evaluation with commonly used applications

Calcium-oxalate-stone

Uric acid-stone

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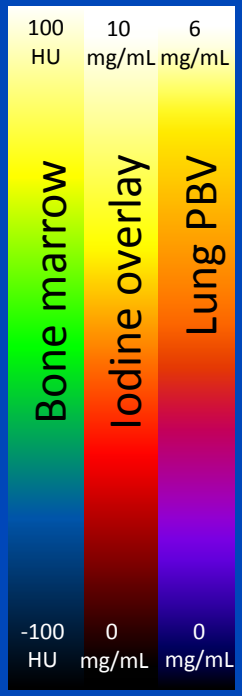
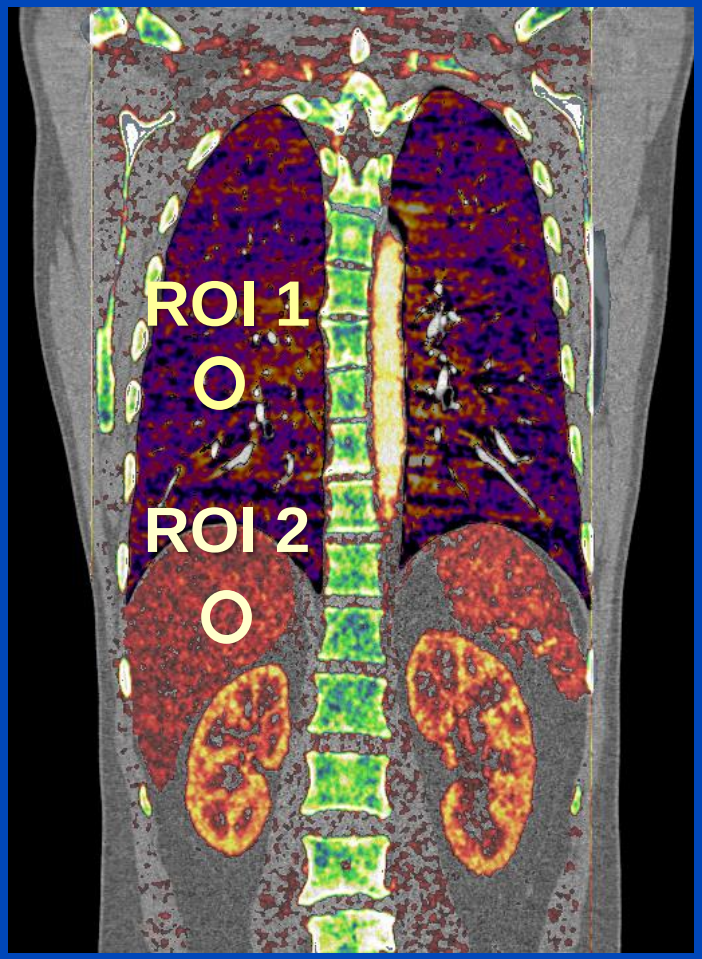
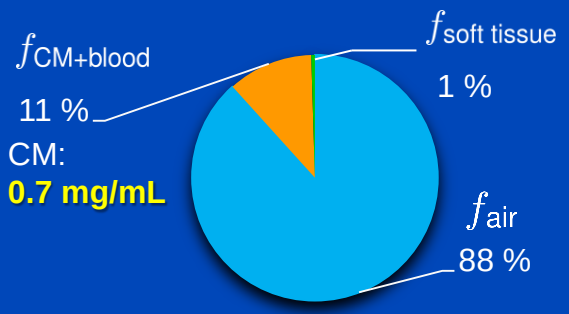
Context-Sensitive Dual Energy



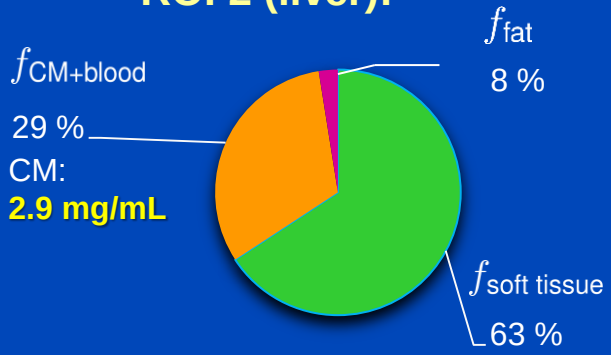


3 material decomposition with organ-dependent basis materials

ROI 1 (lung):



ROI 2 (liver):



f : volume fractions

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Conclusion

- Method strongly depends on segmentation accuracy
  - still needs improvement
- Context-sensitive resolution-mixing
  - combines mutually exclusive image properties
    - » high spatial resolution in bone and lung
    - » low noise in soft tissue
- Context-sensitive display
  - able to present significantly more information to the reader simultaneously
- Organ-specific DE evaluation
  - potential to facilitate the diagnosis

Thank You!

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This presentation will soon be available at www.dkfz.de/ct.

Job opportunities through DKFZ's international PhD or Postdoctoral Fellowship programs (www.dkfz.de), or directly through Marc Kachelriess (marc.kachelriess@dkfz.de).

Parts of the reconstruction software were provided by RayConStruct® GmbH, Nürnberg, Germany.