Segmentation-Assisted DECT Material Quantification

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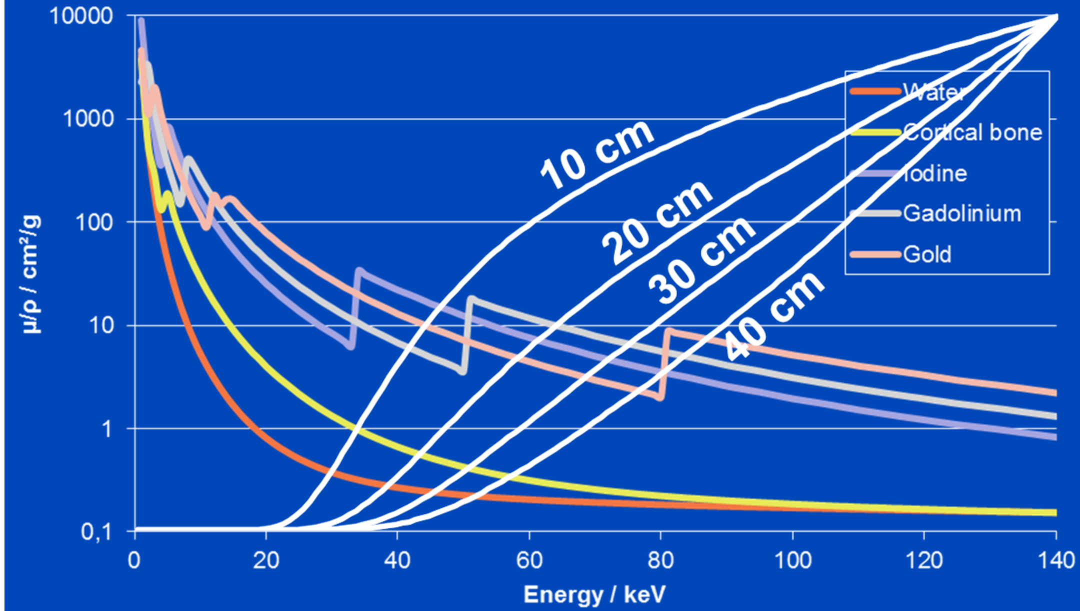
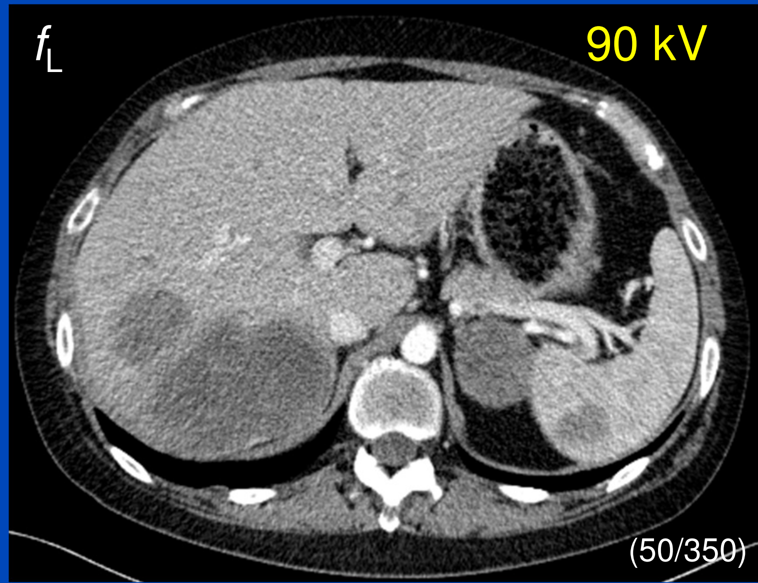
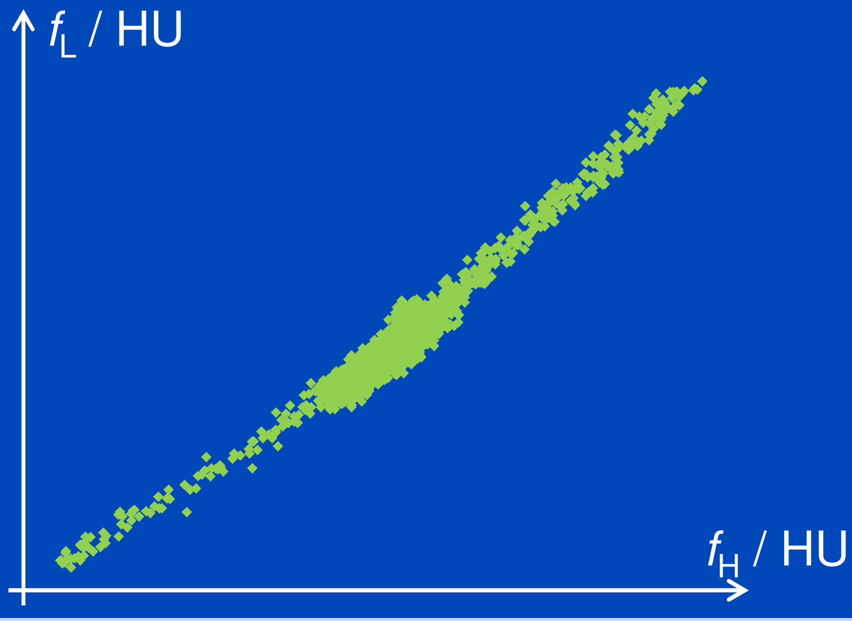
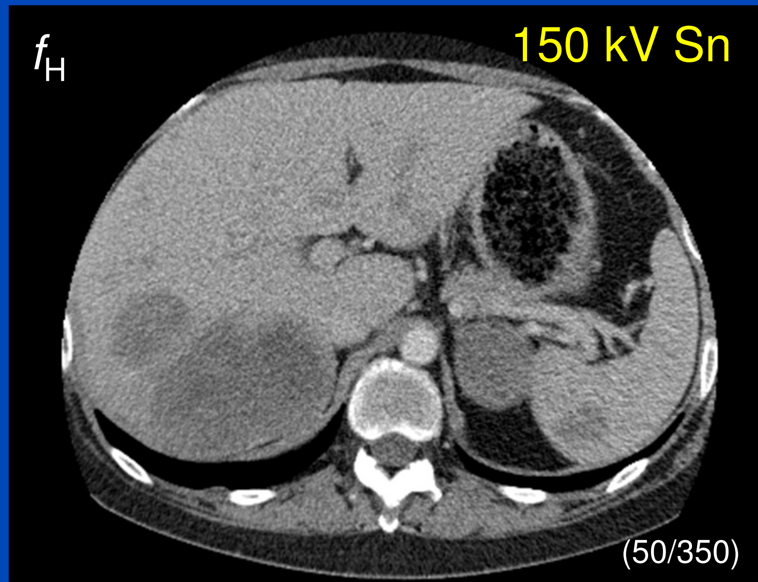
DEUTSCHES KREBSFORSCHUNGSZENTRUM
IN DER HELMHOLTZ-GEMEINSCHAFT

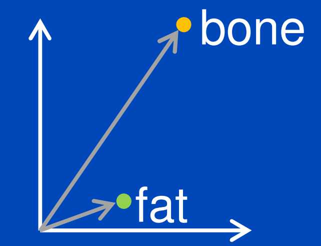

10000
1000
100
10
1
0,1
μ/ρ / cm²/g
0
20
40
60
80
100
120
140
Energy / keV
10 cm
20 cm
30 cm
40 cm
Water
Cortical bone
Iodine
Gadolinium
Gold


f_L
90 kV
(50/350)


f_L / HU
f_H / HU

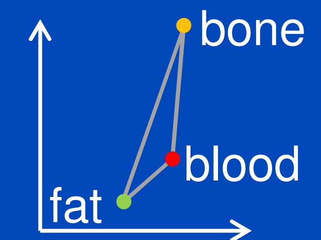

f_H
150 kV Sn
(50/350)

Common Material Decompositions



Two material decomposition (2-MD)

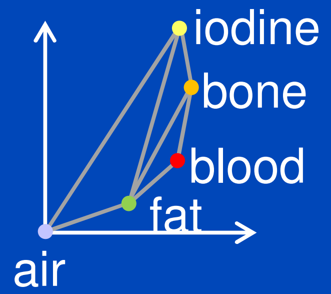
$$\begin{pmatrix} f_{\mathrm{L}} \\ f_{\mathrm{H}} \end{pmatrix} = \begin{pmatrix} f_{\mathrm{L,\ fat}} & f_{\mathrm{L,\ bone}} \\ f_{\mathrm{H,\ fat}} & f_{\mathrm{H,\ bone}} \end{pmatrix} \cdot \begin{pmatrix} f_{\mathrm{fat}} \\ f_{\mathrm{bone}} \end{pmatrix}$$



Three material decomposition (3-MD)

$$\begin{pmatrix} f_{\mathrm{L}} \\ f_{\mathrm{H}} \\ 1 \end{pmatrix} = \begin{pmatrix} f_{\mathrm{L,\ fat}} & f_{\mathrm{L,\ blood}} & f_{\mathrm{L,\ bone}} \\ f_{\mathrm{H,\ fat}} & f_{\mathrm{H,\ blood}} & f_{\mathrm{H,\ bone}} \\ 1 & 1 & 1 \end{pmatrix} \cdot \begin{pmatrix} f_{\mathrm{fat}} \\ f_{\mathrm{blood}} \\ f_{\mathrm{bone}} \end{pmatrix}$$

constraint of ideal solution

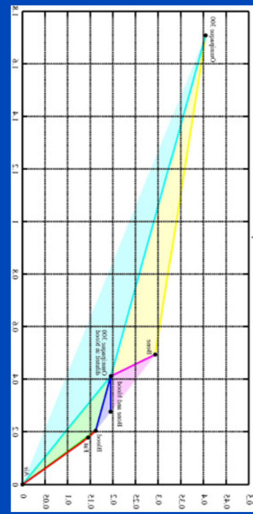


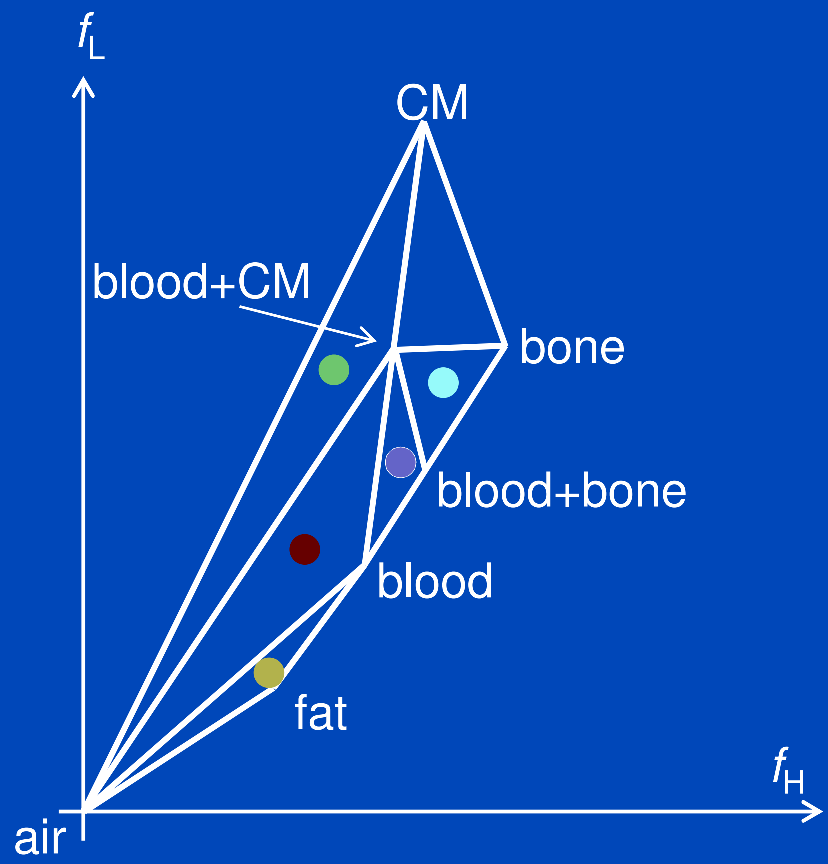
Multi material decomposition* (MMD)

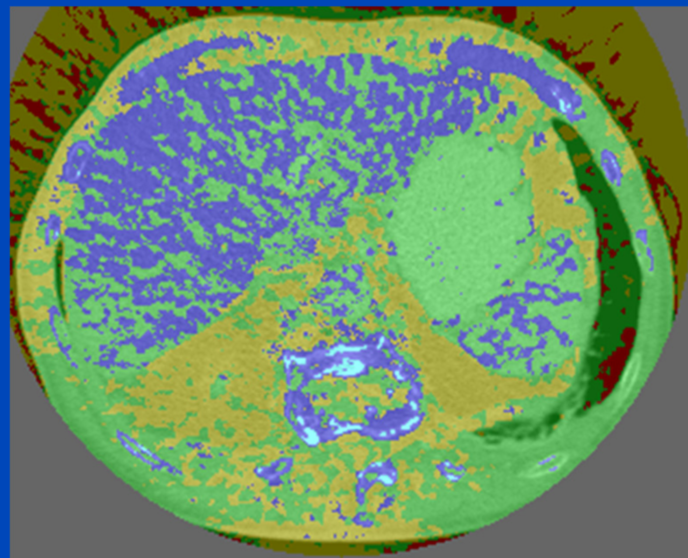
- Tessellation of multiple triangles
- “A library of material triplets”
- Each voxel is assigned to one triangle

* Mendonça, Lamb, Sahani. A Flexible Method for Multi-Material Decomposition of Dual-Energy CT Images. IEEE TMI 33(1):99-116, 2014

Multi Material Decomposition







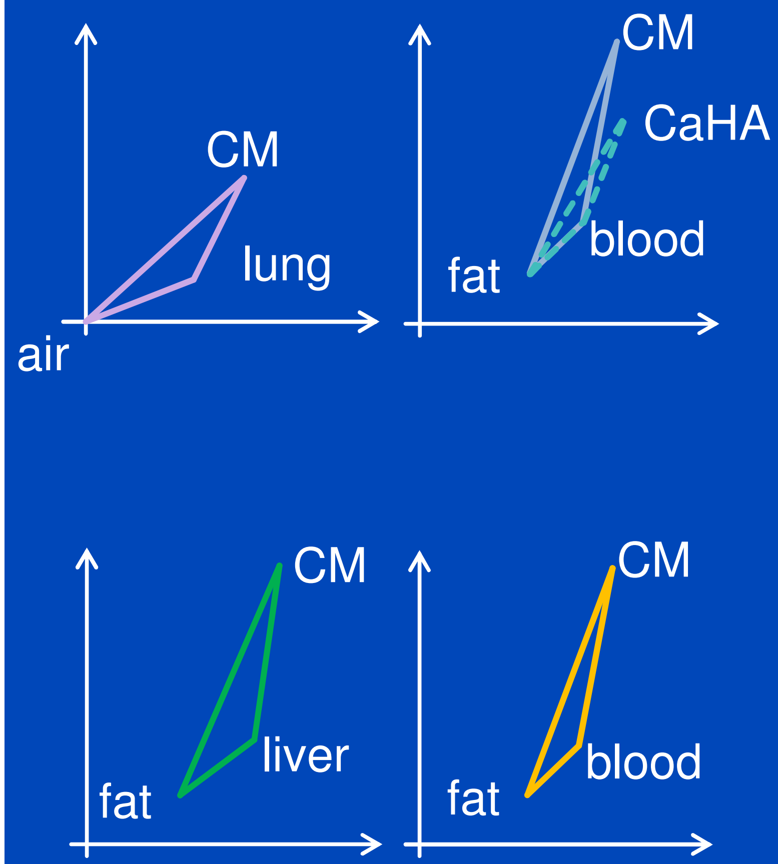
CM = contrast media

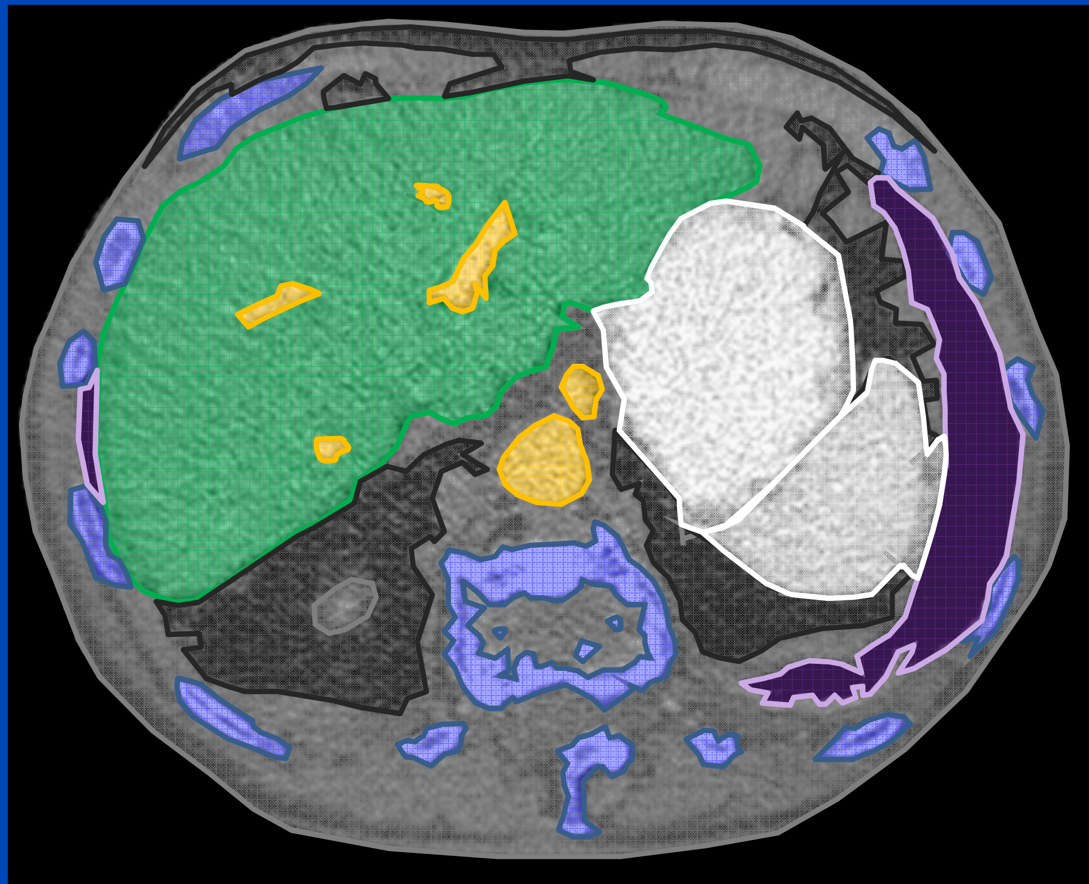
* Mendonça, Lamb, Sahani. A Flexible Method for Multi-Material Decomposition of Dual-Energy CT Images. IEEE TMI 33(1):99-116, 2014

Purpose

- Current methods:
  - Some voxels are misrepresented by the basis materials
  - Every voxel is evaluated more or less isolated
  - No location information is taken into account
- Segmentation-assisted material quantification (SAMQ):
  - Segmentation of the data set into anatomical structures
  - Context-sensitive (locally adapted) material decomposition
  - Many basis materials: air, fat, liver/blood, CM, CaHA, …
- Future: Atlas-assisted material quantification
  - Segmentation supported by an anatomical atlas
  - Context-sensitive
  - Many basis materials

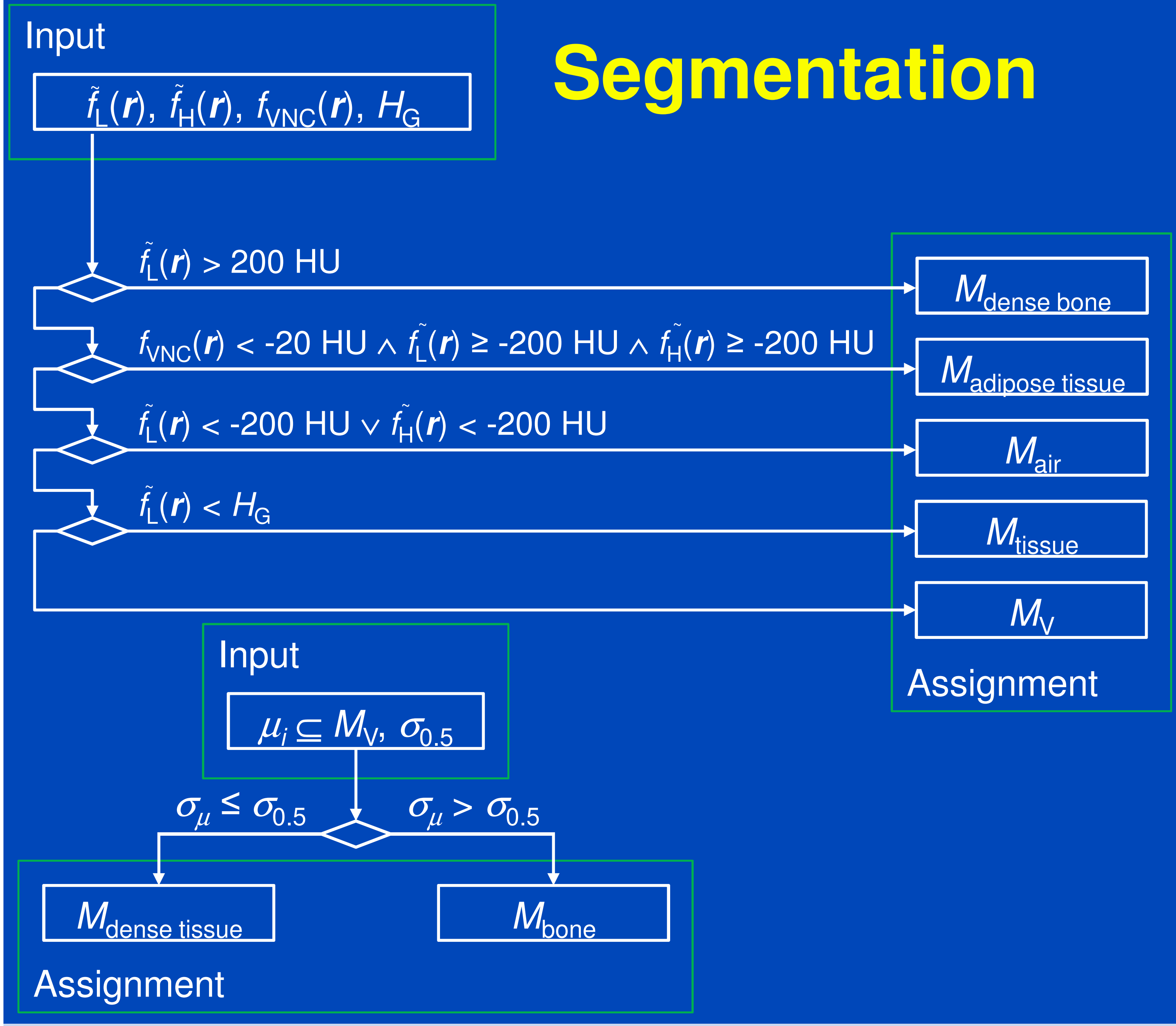
Purpose – Showcase





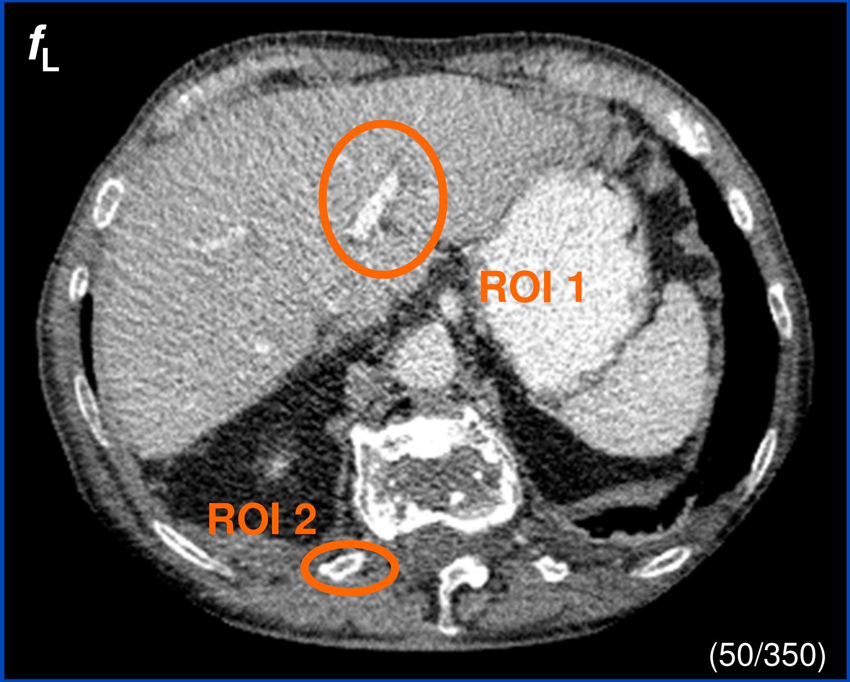
hand-drawn segmentation
of selected anatomical regions

Segmentation

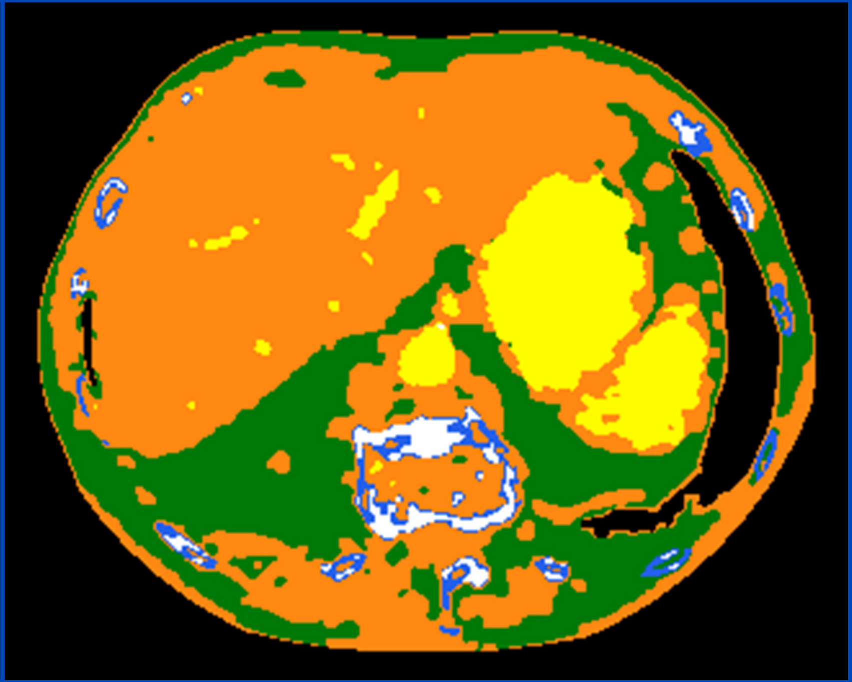


Patient Data Set

CT Image



Segmentation



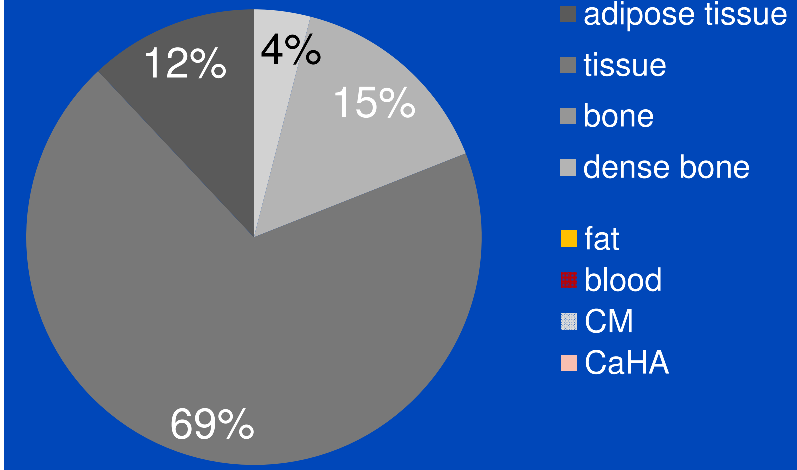
Results ROI 1

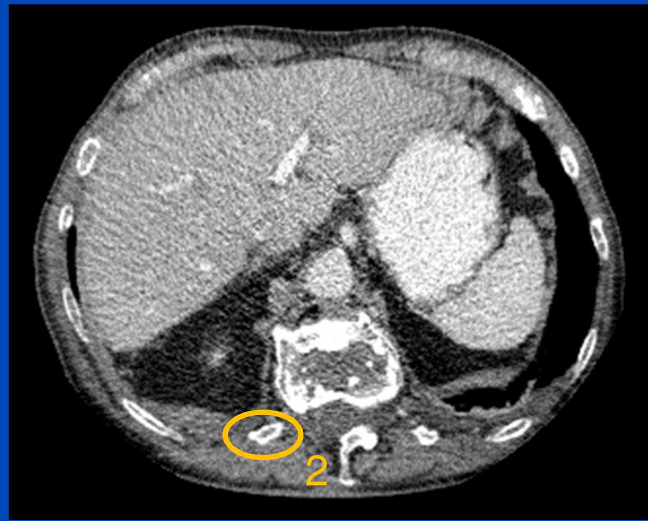
ROI 1

			f_{air}	f_{fat}	f_{blood}	f_{iodine}	f_{bone}	γ_{iodine}	
MMD			0.01	1.76E-03	0.98	3.70E-04	7.82E-03	1.83	
	type	V_R	f_{air}	f_{fat}	f_{liver}	f_{CM}	f_{CaHA}	γ_{iodine}	γ_{CaHA}
3-MD				1.78E-02	0.97	7.29E-03		2.19	
SAMQ	dense tissue	0.16	0.00	0.04	0.94	1.47E-02	0.00	4.40	0.00
	tissue	0.84	0.00	0.01	0.98	5.92E-03	0.00	1.78	0.00
	total	1.00	0.00	0.02	0.97	7.29E-03	0.00	2.19	0.00

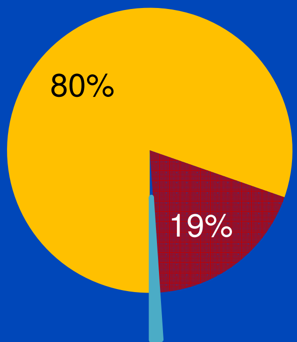
γ : mass concentration in mg/mL
f : volume fraction

patient: ROI 2



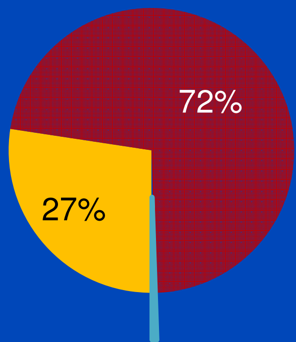


adipose tissue



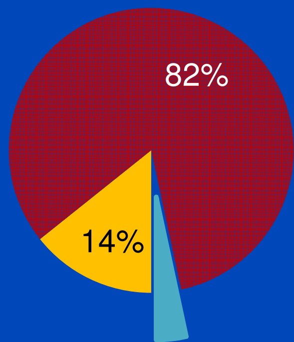
CaHA 1.1%
33.9 mg/mL
CM *0.3%*
0.8 mg/mL

tissue



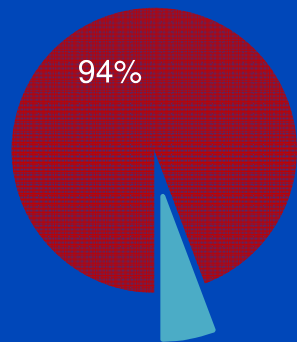
CaHA 0.5%
16.5 mg/mL
CM *0.1%*
0.4 mg/mL

bone



CaHA 3.4%
106.4 mg/mL

dense bone



CaHA 5.7%
181.1 mg/mL

Conclusions

- It is important to perform DECT evaluation organ-specific.
- Location information enhances the decomposition results.
- With context-specific information numerous DECT applications (VNC, gout, liver, kidney stone, …) may be combined into a single tool.

Outlook:

- Combination with anatomical atlas potentially enables automatic organ-specific evaluation.

Thank You!

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dkfz.