Bewegungskorrektur in der tomographischen (3D+Zeit) Niedrigstdosis-Fluoroskopie mittels Running Prior

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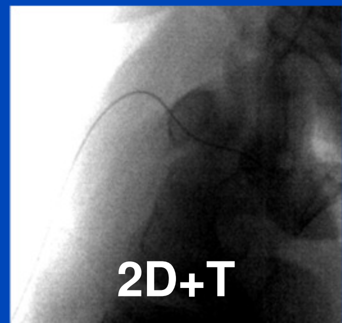
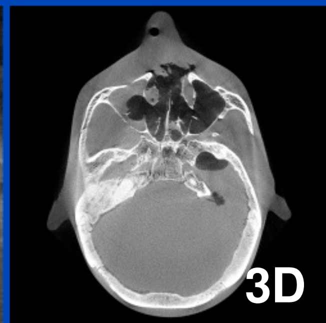
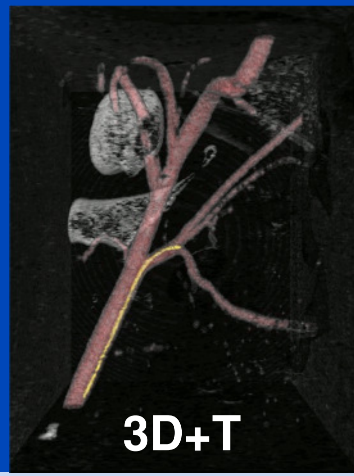
DEUTSCHES KREBSFORSCHUNGSZENTRUM IN DER HELMHOLTZ-GEMEINSCHAFT

Interventional Radiology

- Interventional radiology:
  - Minimally invasive interventions guided by x-ray imaging techniques
  - C-arm systems
- Projective fluoroscopy:
  - 2D projections
  - Position of interventional material is often ambiguous.
  - To clarify a 3D volume has to be acquired or trial-and-error approaches are applied.
- Low dose tomographic fluoroscopy:
  - 3D volumes
  - For clinical acceptance the dose should be limited to the same level as that of projective fluoroscopy.

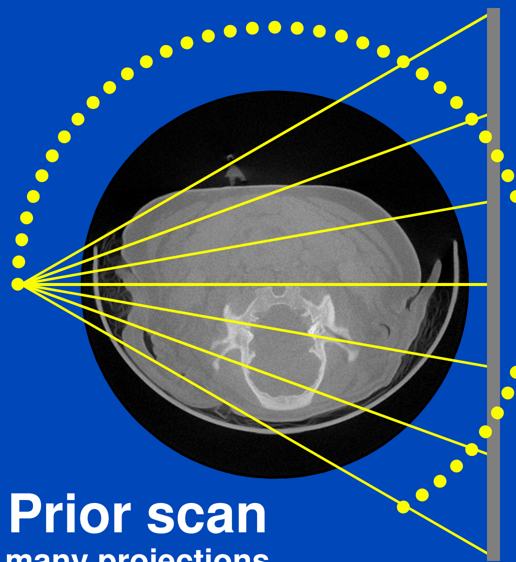




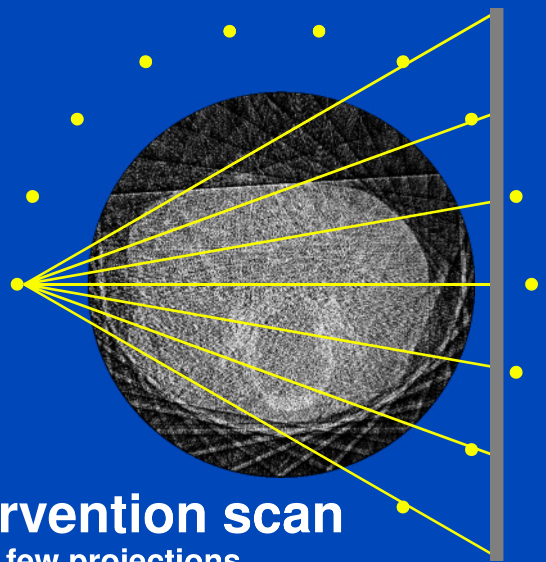


Realization of Low Dose Tomographic Fluoroscopy

- Low dose by:
  - Low tube current
  - Very few projections (pulsed mode)
- Advantages of intervention guidance:
  - Repetitive scanning of the same body region.
  - Interventional materials are fine structures (few voxels) of high contrast (metal).

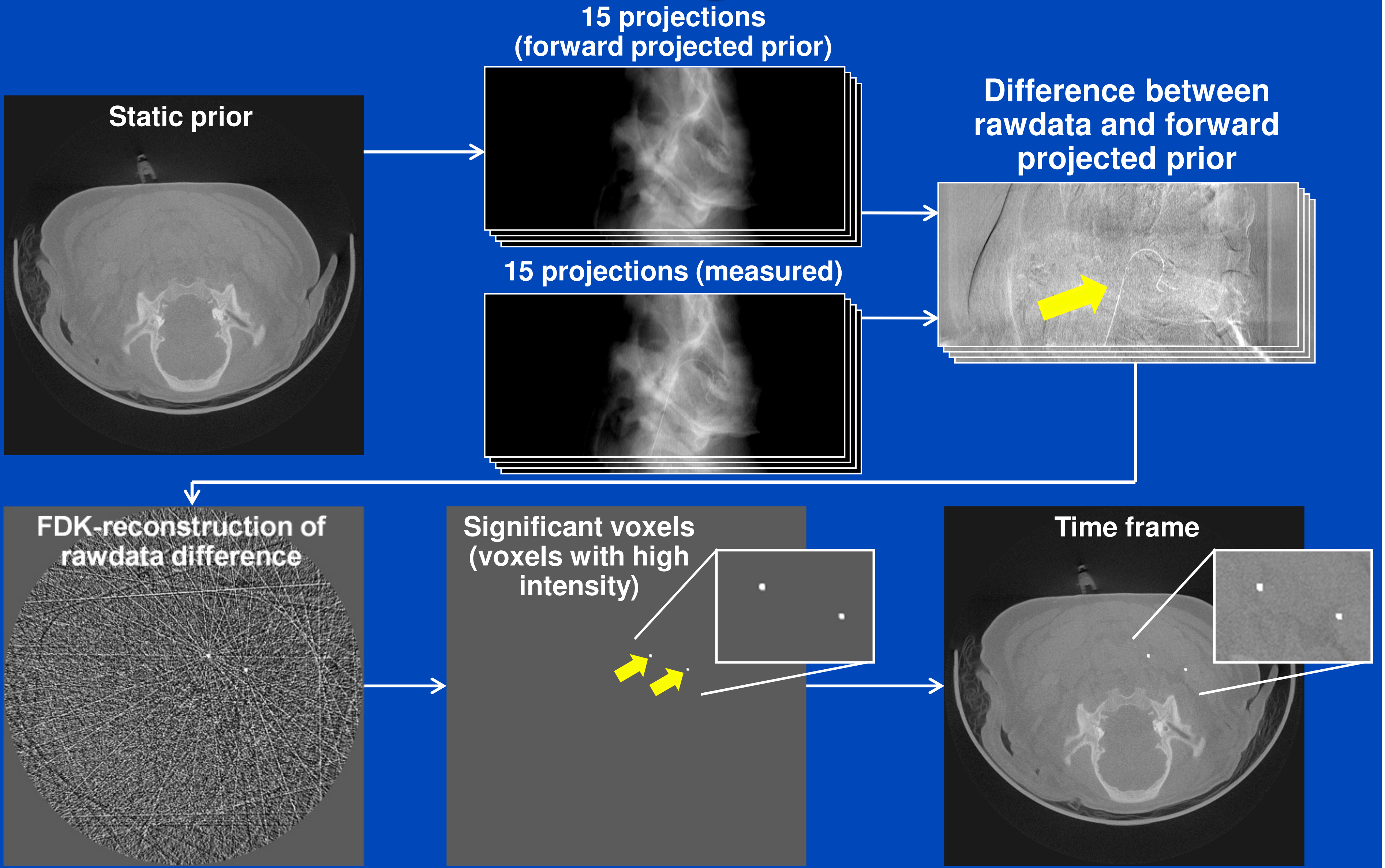


Prior scan
many projections



Intervention scan
few projections

PrIDICT-Algorithm[1,2]



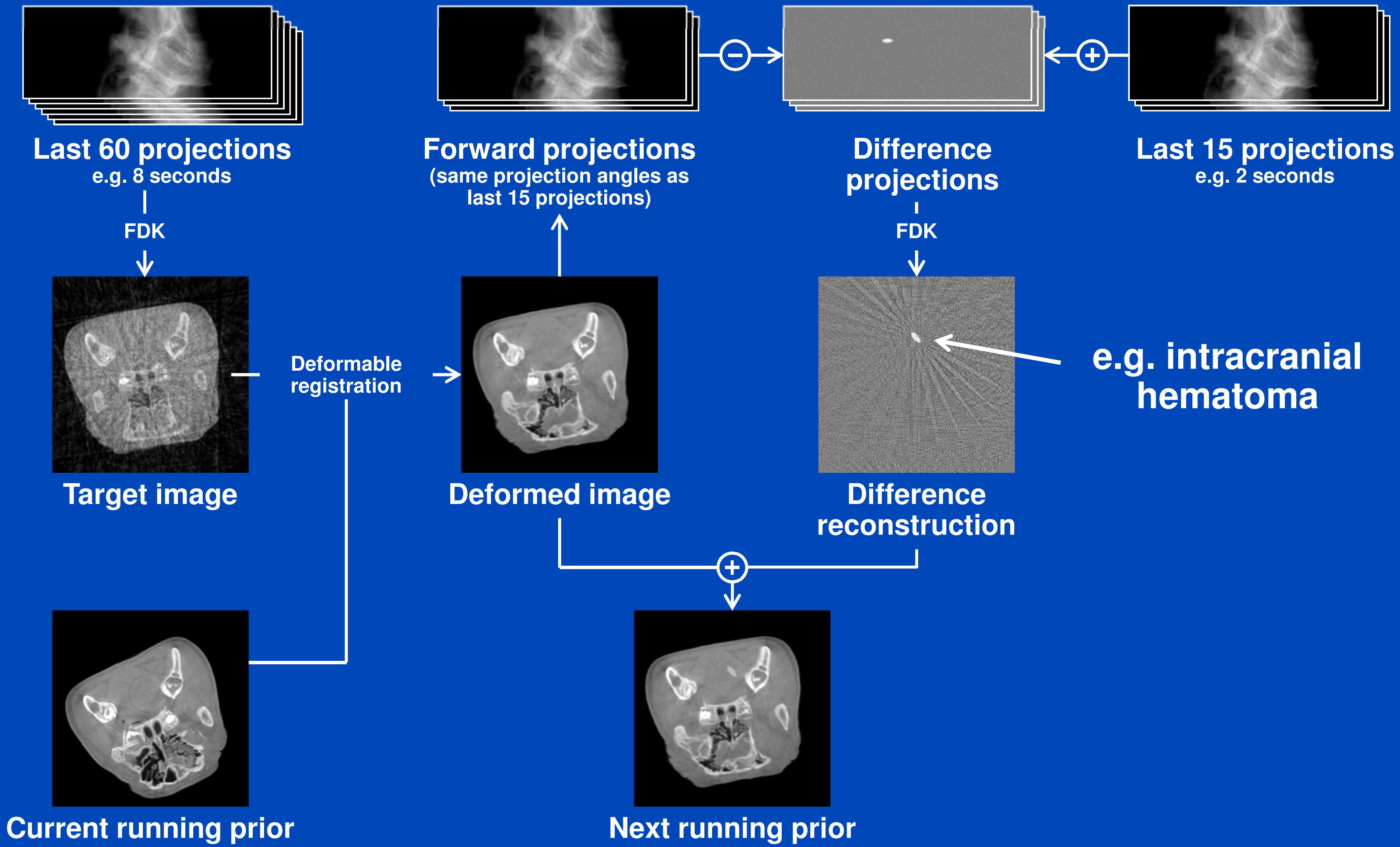
[1] J. Kuntz, R. Gupta, S.O. Schönberg, W. Semmler, M. Kachelrieß, and S. Bartling, “Real-time x-ray-based 4D image guidance of minimally invasive interventions”, Eur. Radiol., 23(6): 1669-1677, June 2013.

[2] J. Kuntz, B. Flach, R. Kueres, W. Semmler, M. Kachelrieß, and S. Bartling, “Constrained reconstructions for 4D intervention guidance”, Phys. Med. Biol., 58(10): 3283-3300, May 2013.

Why Running Prior?

- Patient motion after prior scan
- Allow for patient motion by continuously updating the prior
- Do this with the available projection data
  - Deformation via registration
  - Incorporation of current projections into the prior

Workflow of Running Prior Technique[1]



[1] B. Flach, J. Kuntz, M. Brehm, R. Kueres, S. Bartling, and M. Kachelrieß, "Low dose tomographic fluoroscopy: 4D intervention guidance with running prior", Med. Phys. 40:101909, 11 pages, October 2013.

Measurement

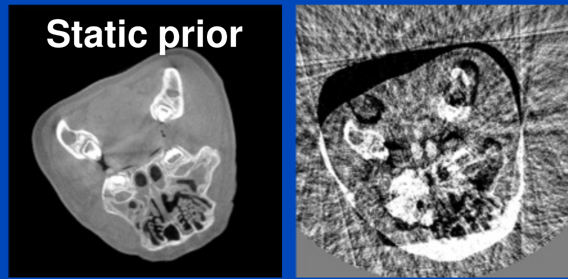
- **System:**
  Volume CT prototype
  - Flat detector on clinical CT gantry
  - Geometry like C-arm systems

Experimental setup

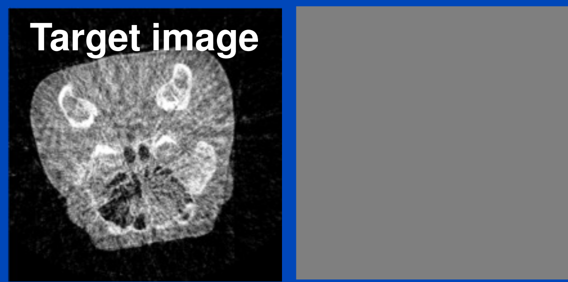
- **Prior scan:**
  - Before intervention
  - N_{360} = 600 projections per 360°
  - T_{rot} = 19 s/360°
  - 1 single rotation

- **Intervention scan:**
  - During intervention
  - N_{180} = 15 projections per 180°
  - T_{rot} = 4s (= 2 s/180°)
  - Many rotations (depending on time needed for intervention)
  - Guide wire inserted into the carotid of the pig's head during the scan

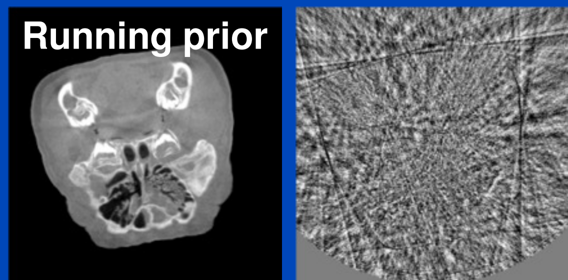
Difference to target image



Position before intervention



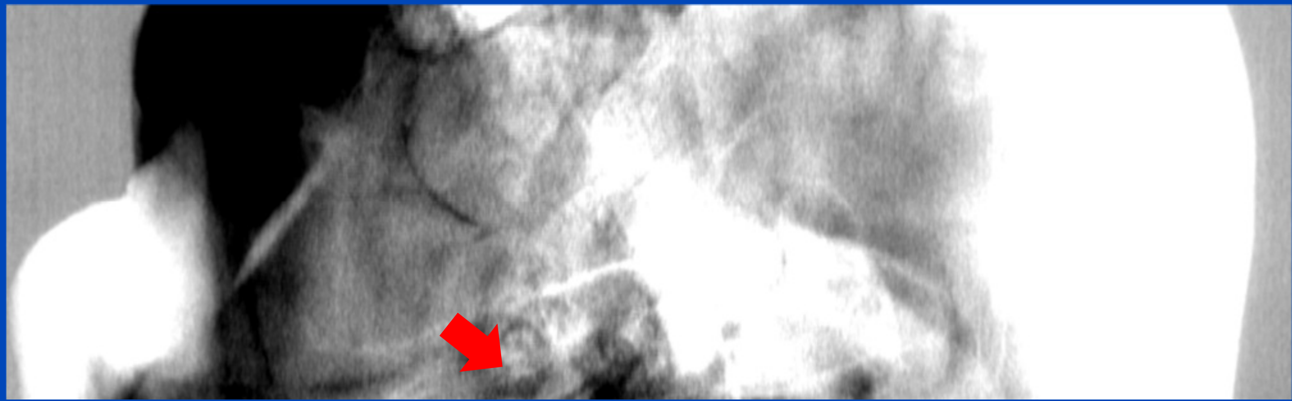
Position during intervention



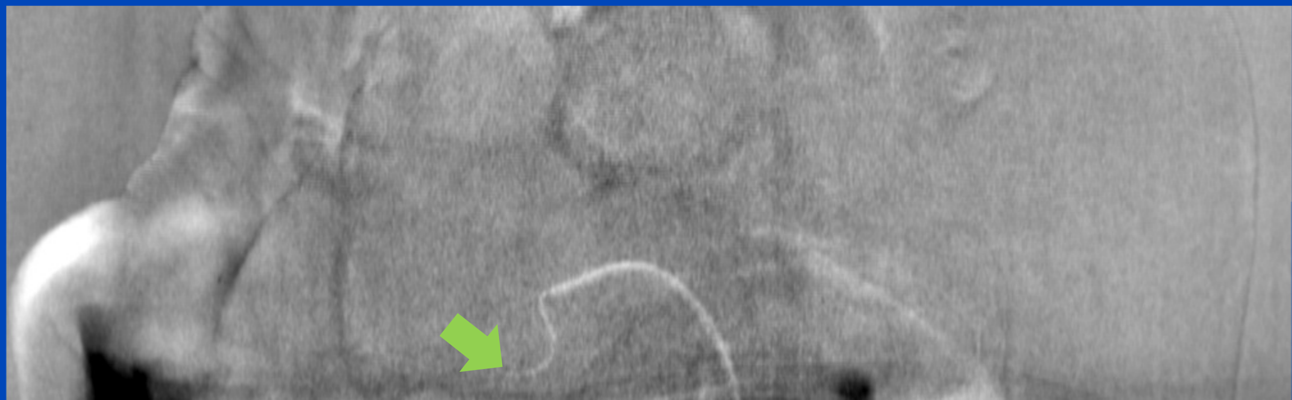
Position after deformation

Improvement in Rawdata Difference

Difference between measured rawdata and forward projected static prior



Difference between measured rawdata and forward projected running prior

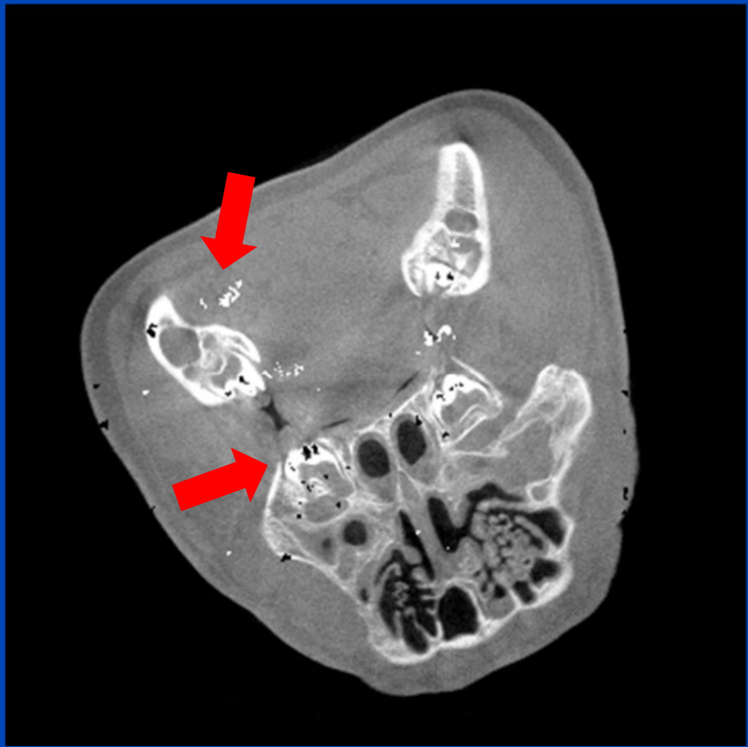


C/W = 0.0/0.5

dkfz.

Static Prior vs. Running Prior

PrIDICT using **static prior**



Artifacts resulting from motion

PrIDICT using **running prior**

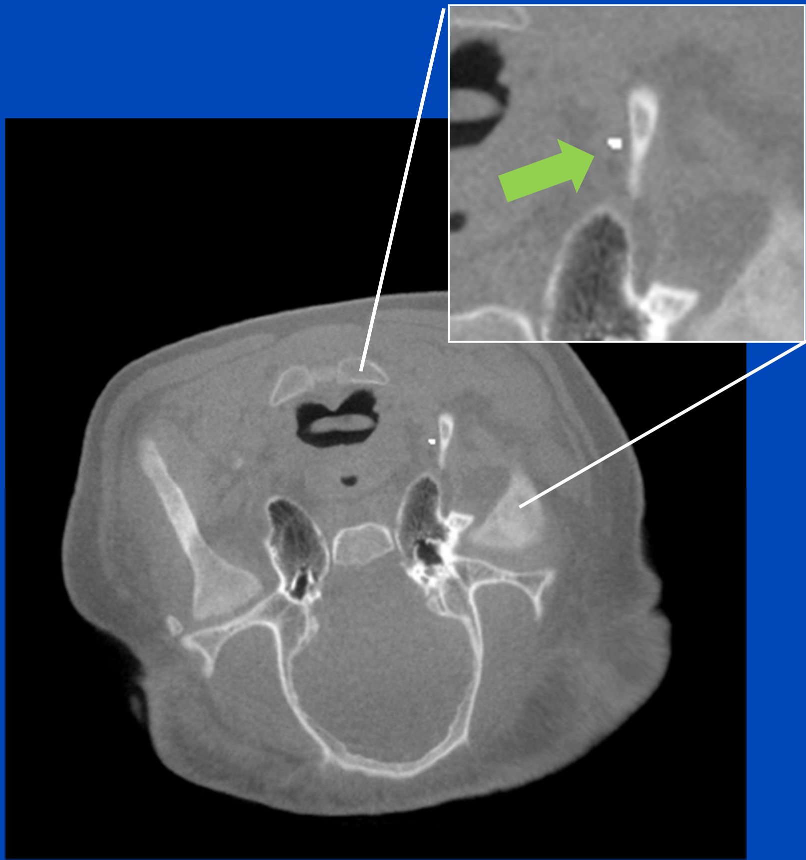
No artifacts

Static Prior vs. Running Prior

PrIDICT using static prior

Wrong wire position

PrIDICT using running prior

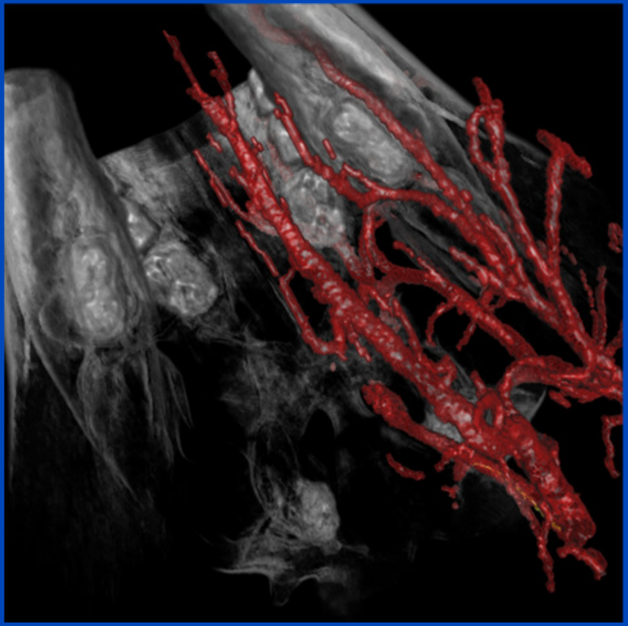


Correct wire position

C = 0 HU, W = 1500 HU

Benefit of Running Prior

- Advantages of the running prior compared to the static prior:
  – Less artifacts in the update volumes resulting from motion between prior scan and intervention scan
  – Higher reliability because interventional material is displayed at correct position
- No additional dose needed for continuously updating the prior.



- 4D intervention guidance at dose level comparable to projective fluoroscopy may become possible also with patient motion by using the running prior technique.

Thank You!

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

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