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Feasible 4D Intervention Guidance: Initial Concept Evaluation

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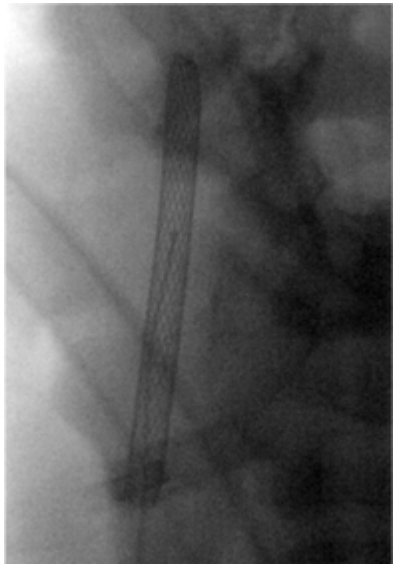
FAU

dkfz. DEUTSCHES KREBSFORSCHUNGSZENTRUM IN DER HELMHOLTZ-GEMEINSCHAFT

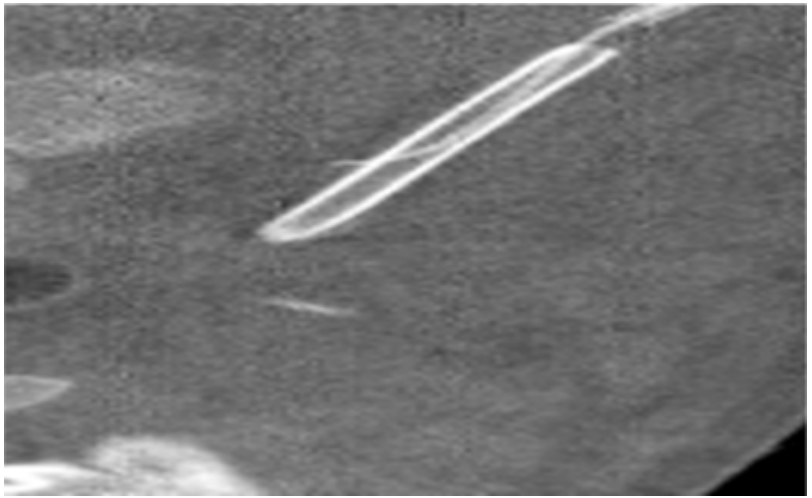
Introduction

- Today's interventional X-ray fluoroscopy usually is limited to 2D projections
- Even in bi-plane mode complex settings remain unclear
- Interventional CT can solve these problems

2D acquisition



3D acquisition



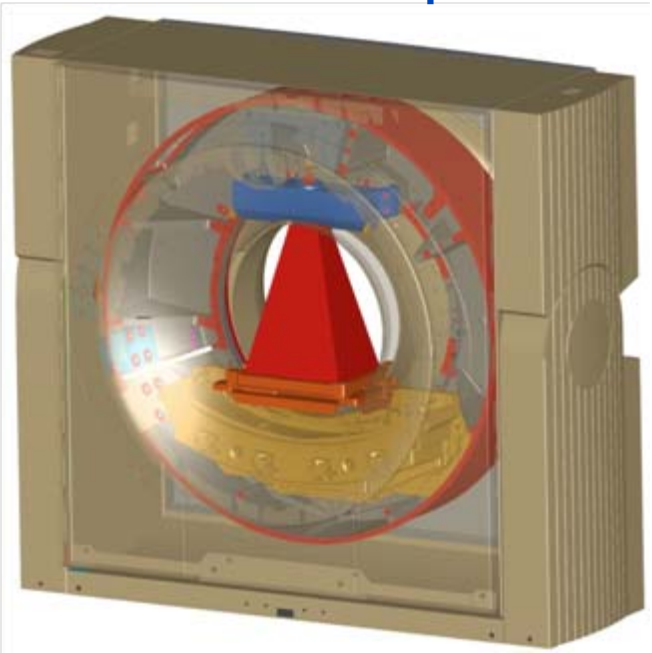
Introduction

- Single interventional CT scans can be performed with today's C-arm systems
- For 4D intervention guidance a continuous data acquisition is necessary

Our aim was to

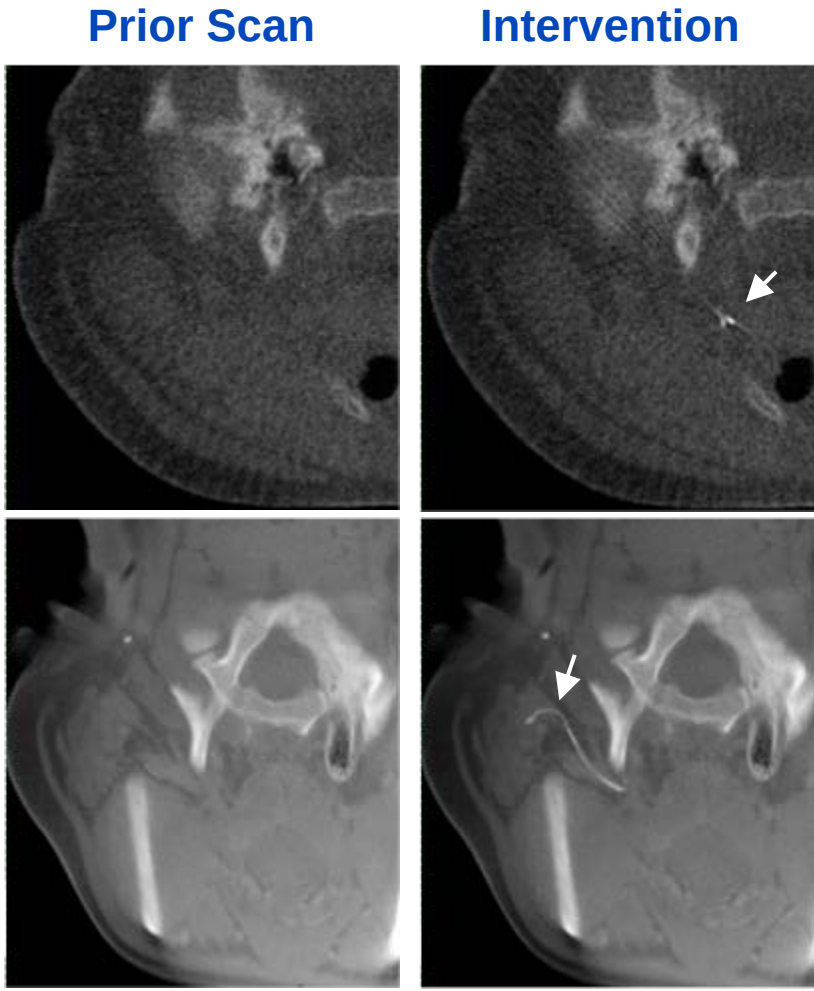
- enable 4D intervention guidance
- use continuous rotating flat panel CT systems
- comply with current 2D fluoroscopy dose

Continuous 4D acquisition



Introduction

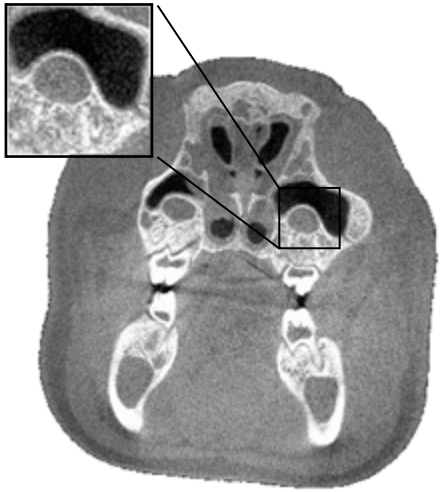
- Interventional radiology features:
  - Availability of high quality prior images
  - Sparse temporal changes
  - High contrast elements
  - Minor relevance of soft tissue contrast
  - Little relevance of consistent CT values



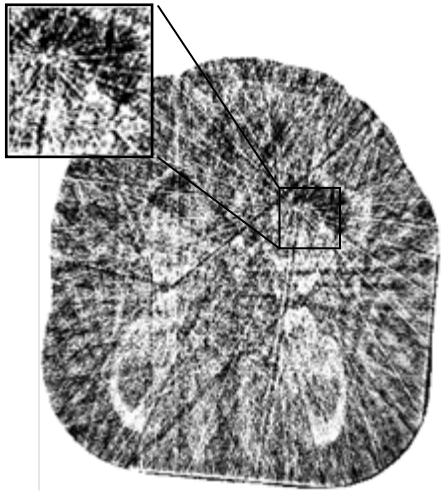
Methods

- Interventional radiology perfectly fits to compressed sensing
- **PrIDICT**: **Pr**ior **I**mage **D**ynamic **I**nterventional **C**omputed **T**omography

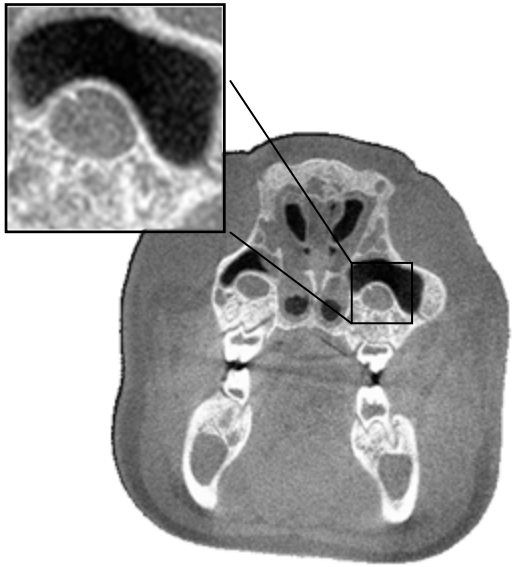
Prior Scan



Update Scan



Timeframe



Methods

- Interventional radiology perfectly fits to compressed sensing
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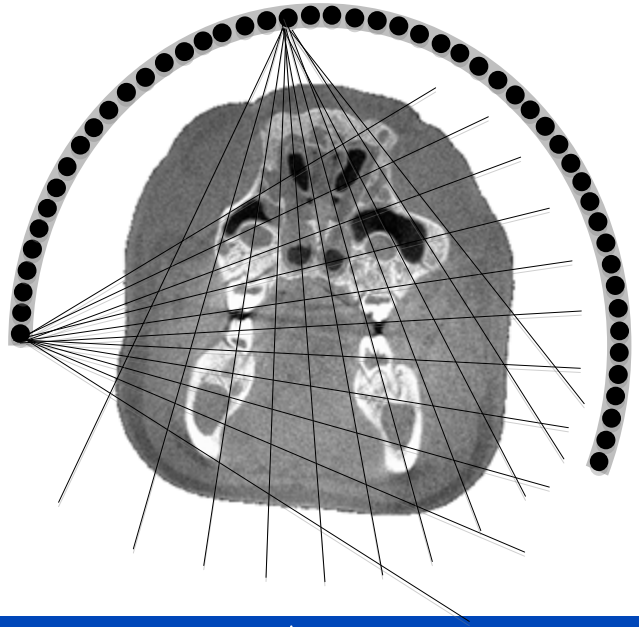
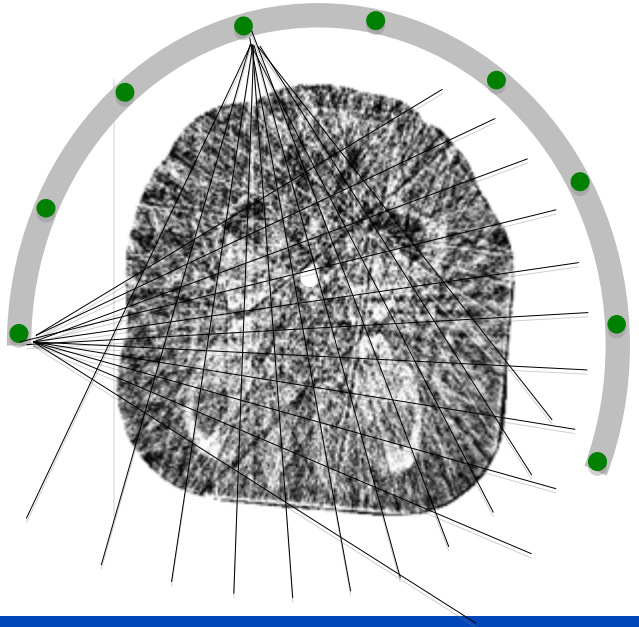
Prior Scan



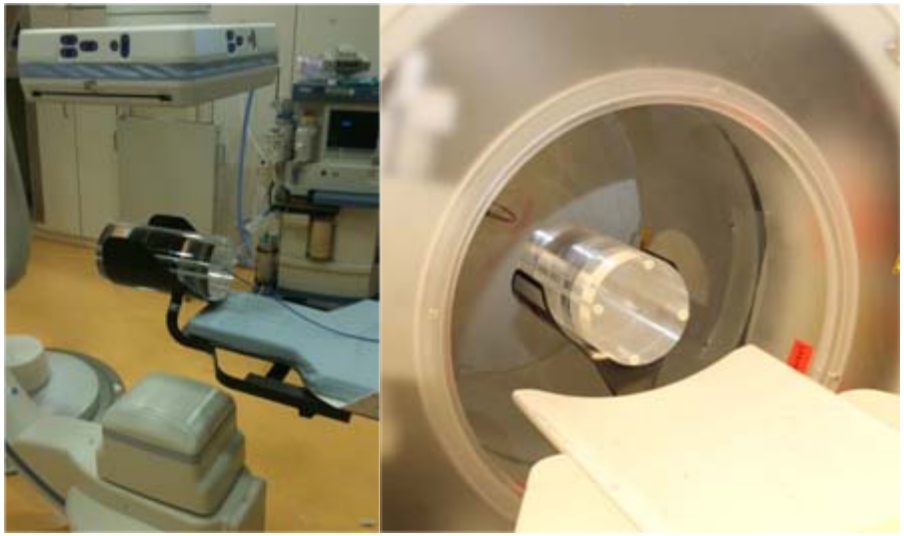
Update Scan



Timeframe

Methods

- Phantom studies and in vivo experiments (pigs) were performed in a prototype flat panel CT
- Dose of the 4D modality and conventional biplane fluoroscopy was compared



Results

Prior: Pig's neck; native scan (600 projections, 80 kV, 50 mA, pulsed)

Update: Pig's neck with guidewire in carotid artery
(16 projections, 180°, 4 s, 80 kV, 50 mA, pulsed)



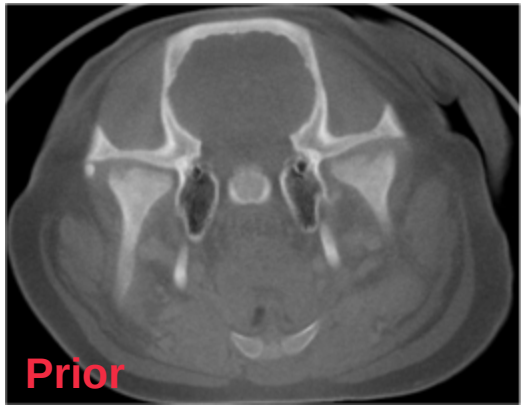
Results

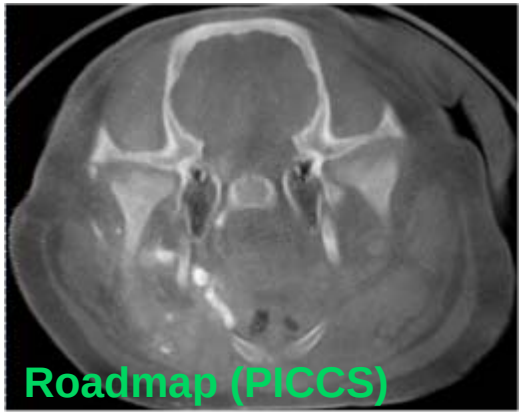
Prior: Pig's neck; native scan (630 projections, 80 kV, 50 mA, pulsed)

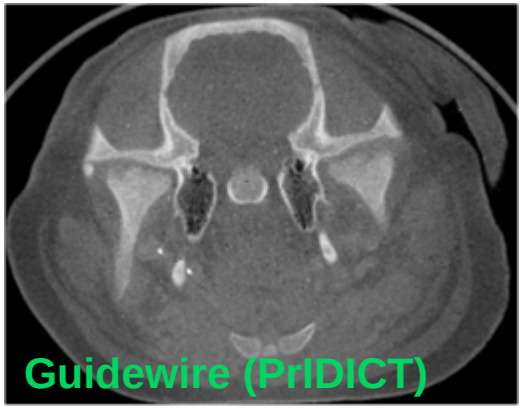
Update: Pig's neck with guidewire in carotid artery
(16 projections, 180°, 4 s, 80 kV, 50 mA, pulsed)

Results

- Controlled 4D intervention guidance requires information about the vascular tree and guidewire position







Prior: Pig's head prior to the intervention (600 projections, 80 kV, 50 mA, pulsed)

Update1: Pig's head with contrast agent injected (16 projections, 80 kV, 50 mA, pulsed)

Update2: Pig's head with dynamic guidewire (16 projections, 80 kV, 50 mA, pulsed)

Results

- For controlled 4D intervention guidance information about the vascular tree and the guidewire position are necessary

Results

Dose comparison

(CTDI phantom)

X-ray fluoroscopy (2D + t):

Artis Zee,

No magnification,

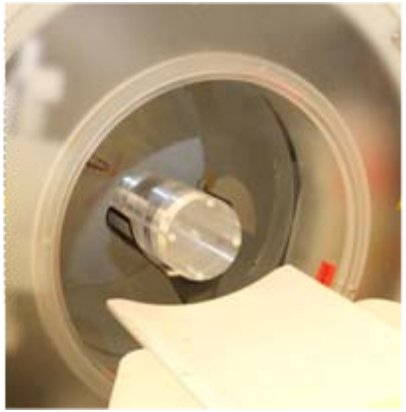
7.5 frame/s,

biplane mode

18 cm z-coverage, automatic exposure control

21 µGy/s

4D intervention guidance (3D + t):



VCT

No magnification,

1 volume/s

18 cm z-coverage

80 kV

Pulsed wave

16 projections

27 µGy/s

Conclusion

- 4D intervention guidance is technically feasible
- Dose level does not violate dose restrictions
- PrIDICT reconstructions provide good results in cases where
  - high contrast structures are changed in the temporal update
  - temporal changes are sparse in the image domain
- Real 3D roadmapping can be combined with 4D intervention guidance for an effectively controlled guidance
- Real 4D intervention guidance might account for accelerated and saver procedures with significant benefit for patients health

Acknowledgement

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