4D Guidance in Interventional Radiology: Prototype Development and Feasibility Study

Kuntz J¹, Sawall S², M. Socher¹, Semmler W¹, Kachelrieß M¹,² and Bartling SH¹,³

1. German Cancer Research Center (DKFZ), Heidelberg, Germany
2. Friedrich-Alexander-University Erlangen-Nürnberg, Germany
3. Institute for clinical radiology and nuclear medicine, University Medical Center, Mannheim, Germany
Introduction

Current X-ray intervention guidance

2D + time

3D manipulate and shoot
Introduction

4 D (3D +t) Intervention guidance

• Spatial relationships would always be clear
• Interventions would become faster and safer
• More complex interventions could be developed

But: It is currently not considered possible because of prohibitively high radiation doses

Aim: To suggest a solution to this and enable 4D intervention guidance
**Introduction**

Conventional tomographic data acquisition

Compressed sensing (CS)

Tomographic reconstruction for 4D intervention guidance

Full dose prior

Low dose time frames

Iterative CS reconstruction

Material & Methods

- Phantom and pig (n=5) experiments
- Simulated catheter interventions
- 3D angiographic road mapping through arterial contrast media injection
- Continuous flat-panel data acquisition
- Retrospective dose reduction
- Compressed sensing reconstruction (incl. custom developed PRIDICT (Prior image dynamic interventional CT algorithm))
- Dose comparison to fluoroscopy
Results

Prior scan (FDK)  
Full dose time frame (FDK)  
Low dose time frame (FDK)

Simulated radiation dose reduction
Dose similar to X-ray fluoroscopy
Results

Prior scan (FDK)  Full dose time frame (FDK)  Low dose time frame (FDK)

Simulated radiation dose reduction
Dose similar to X-ray fluoroscopy

4D intervention guidance using compressed sensing

ASD-POCS  PICCS  PRIDICT
Results

Dose comparison

X-ray fluoroscopy (2D + t):

21 \mu Gy/s

4D Intervention guidance (3D + t):

47 \mu Gy/s

CTDI-Phantom

Artis Zee,
Zero magnification
7.5 frames/s,
Biplane
Exposure automatic

VCT
1 volumes/s
18 cm z coverage
80kV, 50 mA,
17 projections
Added noise
Results

Guide wire in pig carotis

anterior-posterior

lateral

$t$
Results

Guide wire in pig carotis + Angio

anterior-posterior

lateral

$\text{t}$
Results

Guide wire in pig carotis + Angio
Results

Unfolding stent in pig carotid
Results

Unfolding stent in pig carotid + Angio

16 low dose projections
47 μGy/s
1 frame/s
Conclusion

- Using compressed sensing algorithms, sparse sampling and prior knowledge 4D intervention guidance is realistic without exceeding acceptable dose levels.
- This initial results suggest that this approach is promising and worth to pursue.
- The potential impact on intervention guidance and minimal-invasive medicine is high.