

PHASE-SENSITIVE REGION-OF-INTEREST COMPUTED TOMOGRAPHY

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Abstract

X-Ray Phase-Contrast Imaging can provide high soft-tissue contrast. Unfortunately, all grating-based systems are limited by the grating sizes of a few centimeters. This leads to truncation in the projection images and therefore artifacts in the reconstruction. We propose a system and a reconstruction algorithm to correct for phase truncation artifacts, and to obtain quantitative phase values. Our method is robust, and shows high-quality results on simulated data and on a biological mouse sample.

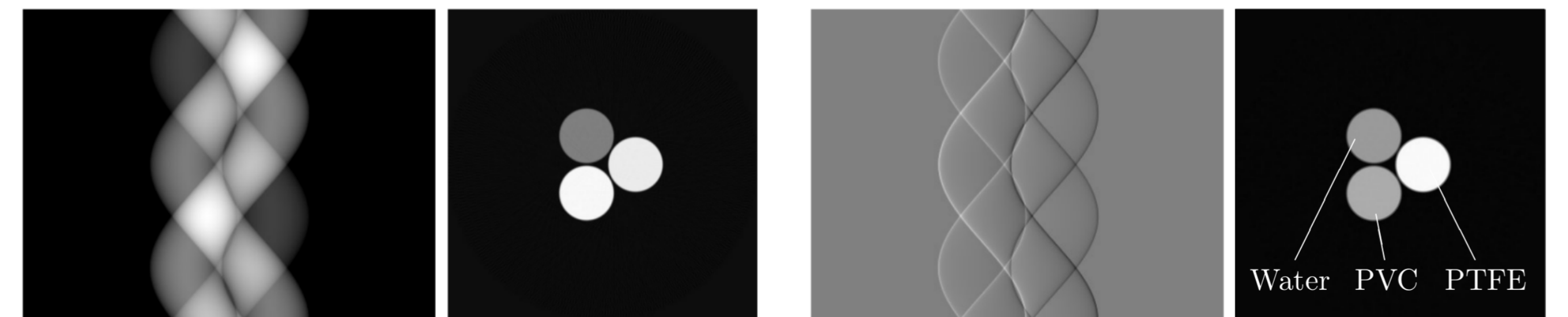


Figure 1: Sinograms and tomographic reconstructions of three cylinders at 82 keV. Left: absorption image. Right: differential phase image.

Introduction

X-ray Phase Contrast Imaging (PCI)

- Novel imaging technique: implemented with grating interferometer [1]
- Provides absorption plus highly sensitive differential phase
- Absorption and phase show complementary material parameters (Fig. 1)

Challenges

- Small gratings enforce region-of-interest (ROI) tomography
- For clinical use: difficult localization, truncation artifacts in reconstruction

Contributions [2]

- Integrated full-field absorption CT and region-of-interest PCI system
- Truncation correction for quantitative phase reconstruction

Materials and Methods

System Setup

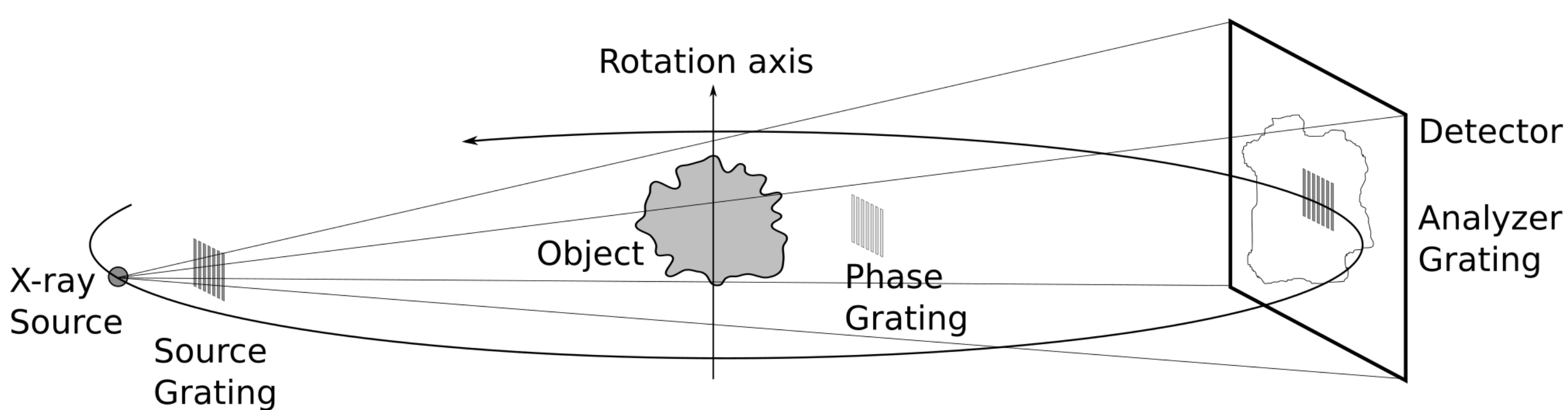


Figure 2: Proposed phase-sensitive region-of-interest imaging in standard CT

Truncation Correction

- Segmentation of reconstructed absorption into k materials
- In ROI: estimation of phase value per material from phase ROI reconstruction and segmentation
- Extrapolation of phase values across segmentation
- Reconstruction of extrapolated phase sinogram

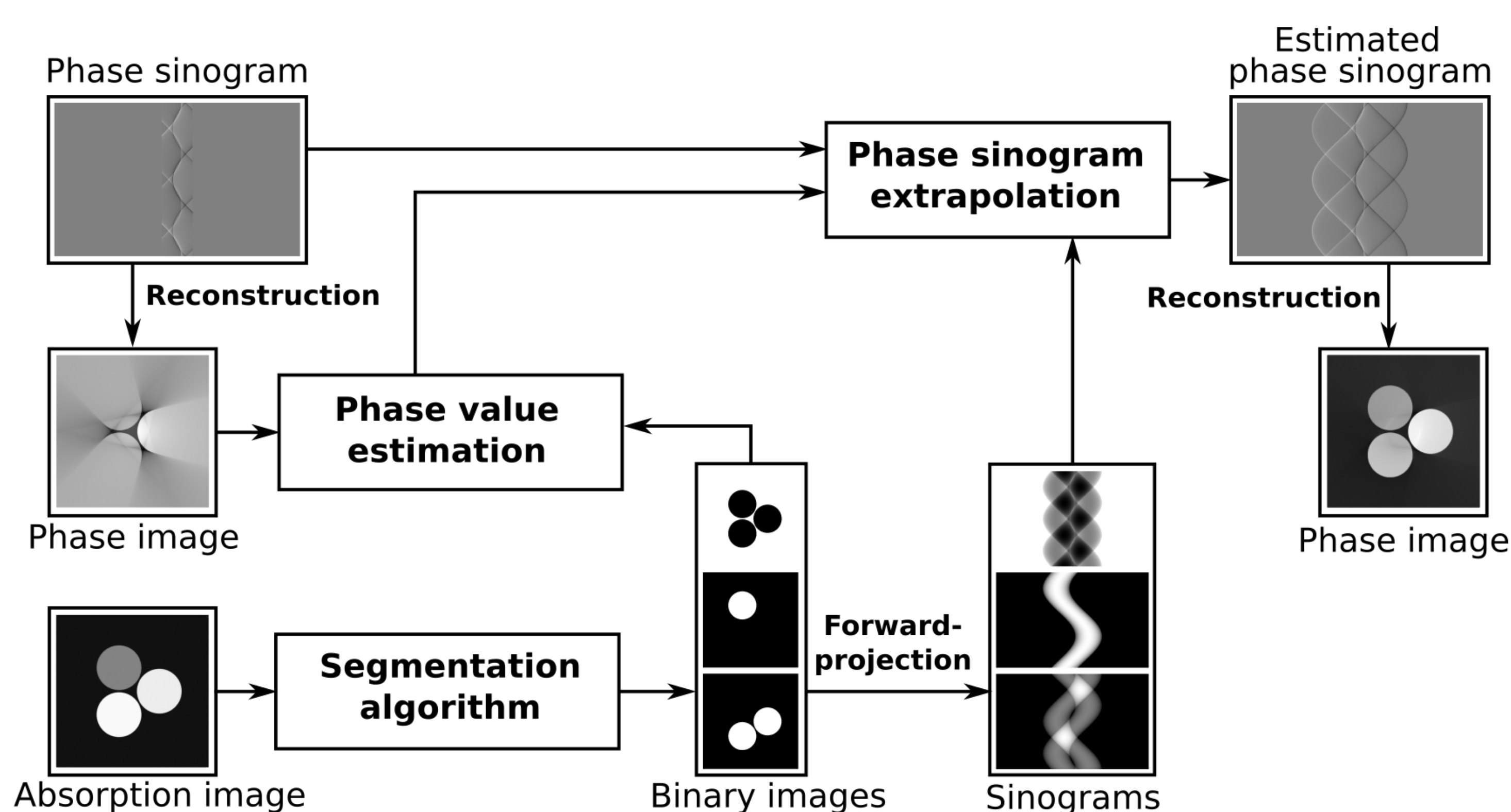


Figure 3: Proposed truncation correction for ROI phase volume.

Experiments and Results

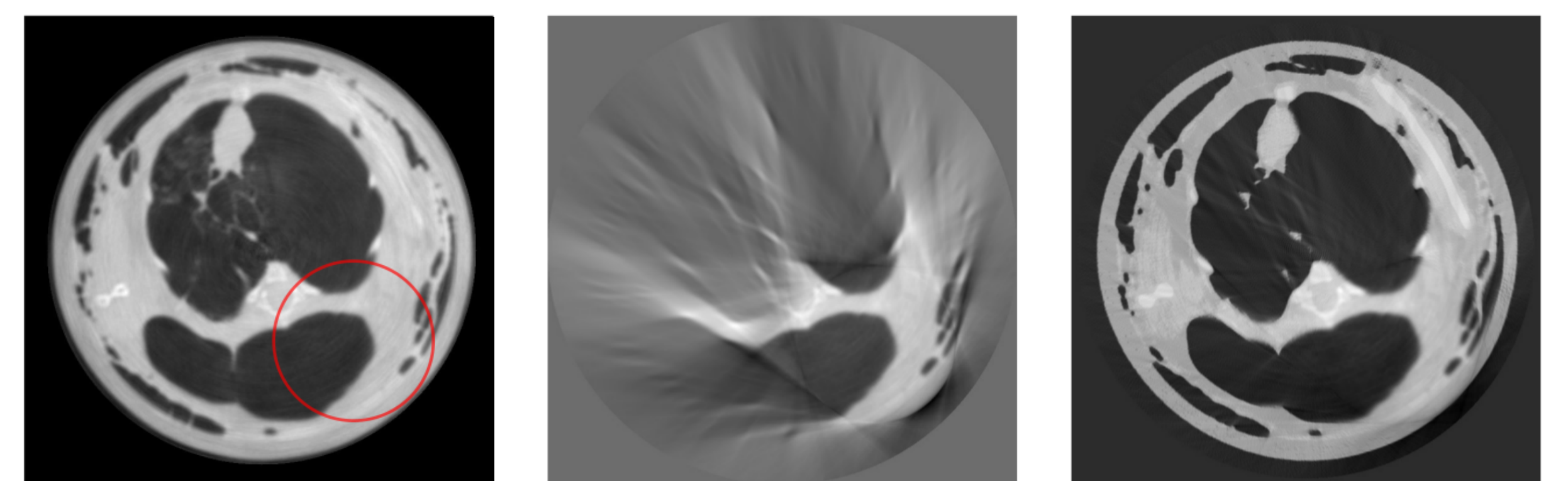


Figure 4: Mouse sample. Left: ground truth with ROI (red). Center: truncated phase reconstruction. Right: proposed phase reconstruction.

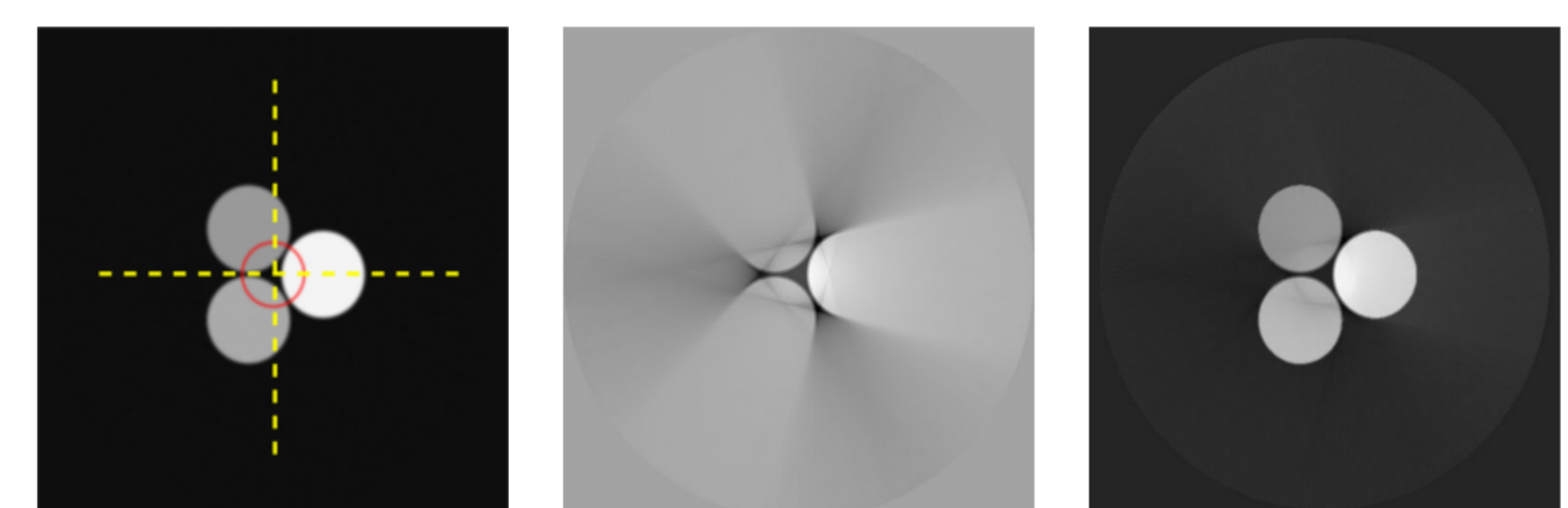


Figure 5a: Simulated sample. Left: ground truth with ROI (red) and line profile (yellow). Center: truncated phase reconstruction. Right: proposed phase reconstruction.

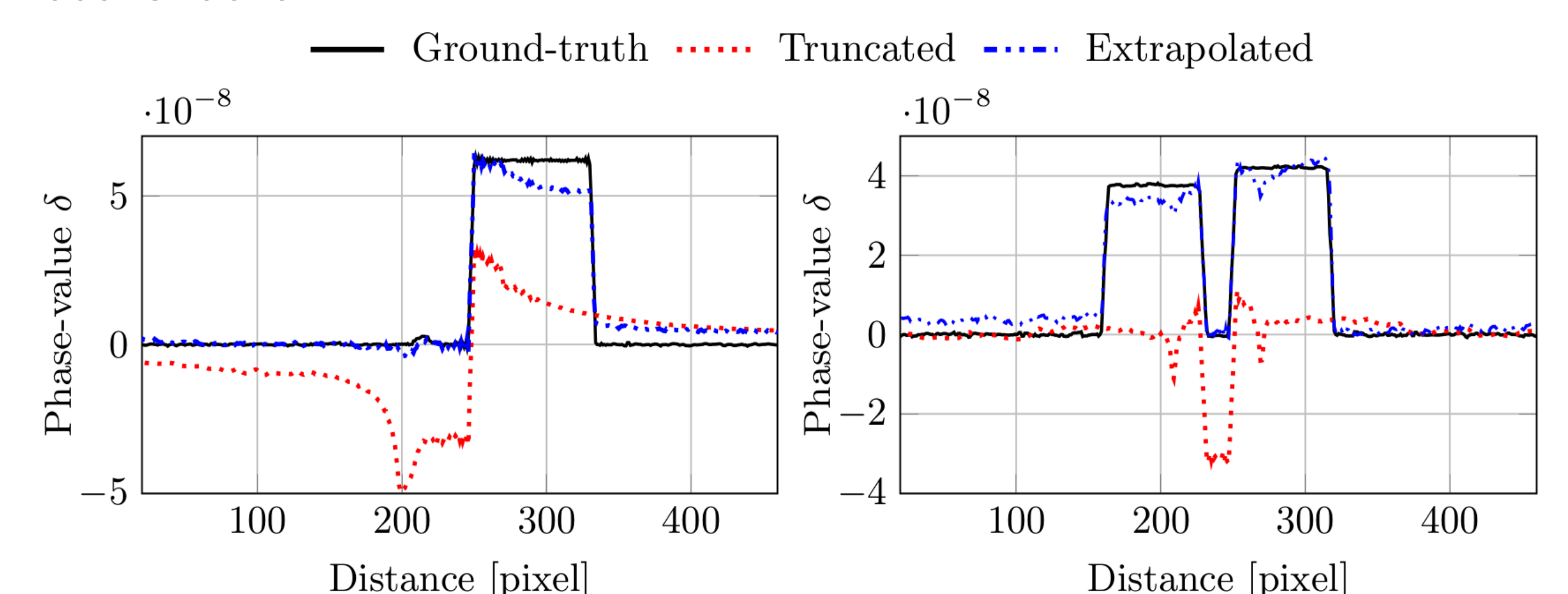


Figure 5b: Line plots of simulated sample. Horizontal (left) and vertical direction (right).

Table 1: Root mean square error (RMSE) and structural similarity (SSIM) with respect to the ground truth inside of the ROI's. Mean and standard deviation over 16 ROI's (simulated data) and 9 ROI's (mouse data).

	Simulation		Mouse	
	RMSE	SSIM	RMSE	SSIM
Truncated	$2.88E-08 \pm 6.59E-09$	0.46 ± 0.30	2.08 ± 0.27	0.30 ± 0.33
Estimated	$3.00E-09 \pm 1.17E-09$	0.99 ± 0.00	0.66 ± 0.14	0.94 ± 0.05

Conclusion

- Quantitative ROI reconstruction of phase CT
- Important step towards using PCI for larger samples in a clinical setup

References

- 1 Pfeiffer, F., Weitkamp, T., Bunk, O., David, C. Nature Physics 2(4) (2006) 258
- 2 Felsner et al., arXiv (2018)



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