Background Matters: A Correction Scheme for Dynamic Iterative CBCT with Limited Grid Size

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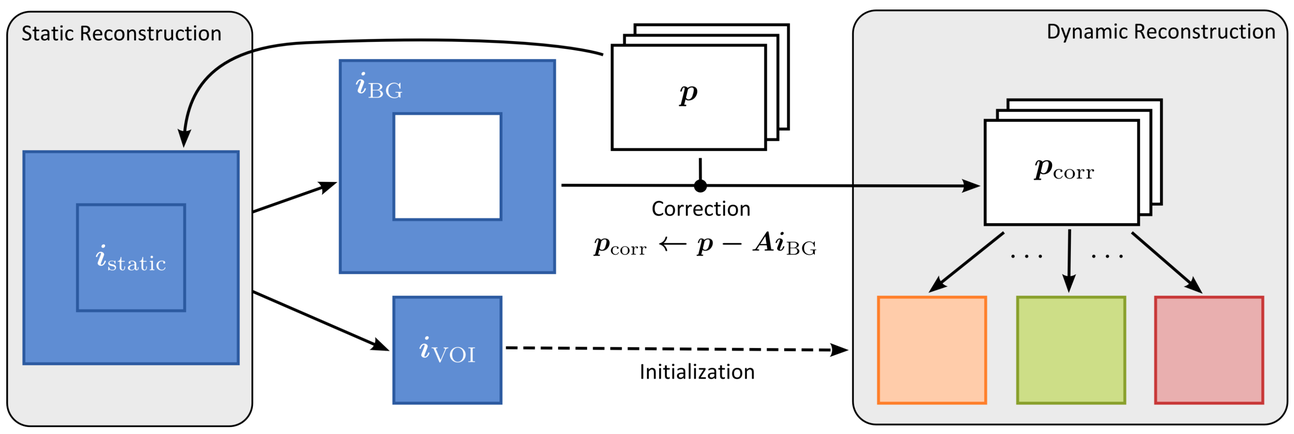
Introduction

- Truncation of the object in image space (volume of interest, **VOI**) and/or on the detector (field of view, **FOV**) is detrimental to **iterative reconstruction** (cupping, streaks, …)
- A **large reconstruction grid** (VOI) can help alleviate these problems, but may be prohibitive in complex **dynamic reconstruction** tasks [1]

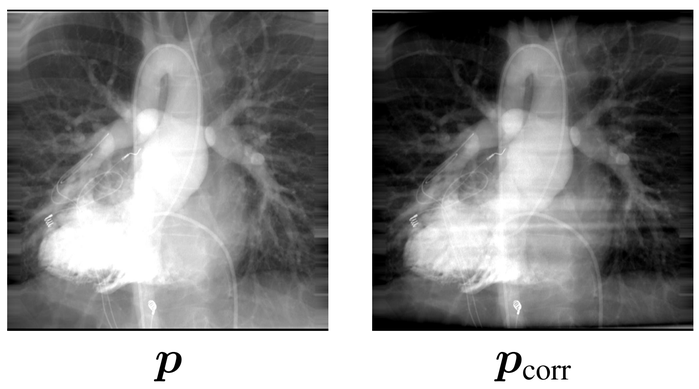
Materials and Methods

- Simplifying **model assumptions**:
  i. Dynamic content is inside VOI, outside (“background”) is static
  ii. Background can be (pre-)computed with static reconstruction
- **Method** derived from these assumptions:



a. Reconstruct static image from all data on grid larger than VOI
b. Separate static image into VOI and background (BG)
c. Perform dynamic reconstruction on VOI incorporating BG into forward projection of current image estimate i:

$$\overbrace{A(i + i_{\mathrm{BG}}) - p}^{\text{Residual error}} =$$
$$= Ai + Ai_{\mathrm{BG}} - p =$$
$$= Ai - \underbrace{(p - Ai_{\mathrm{BG}})}_{\text{Corrected data } p_{\mathrm{corr}}}$$



p $\qquad$ p_{corr}

Efficiently precomputable, dynamic reconstruction remains unaltered!

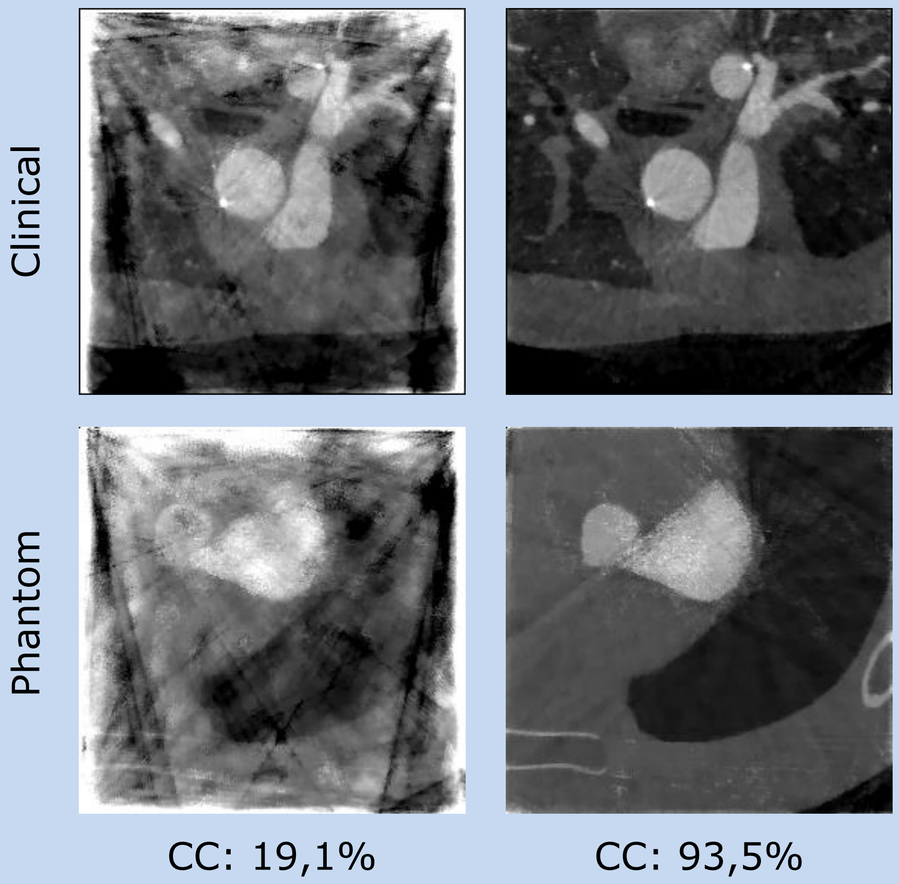
Experiments

- **XCAT phantom**: Correlation coefficient (CC) w. r. t. ground truth
- **Clinical patient data set**: Qualitative comparison
- **Static reconstruction**: Gradient descent (20 iterations)
- **Dynamic reconstruction**: Spatio-temporally total-variation-regularized 4-D method [2] (180 iterations, 8 cardiac phases)
- **VOI-limited**: FOV larger than VOI, grid truncation is limiting
- **FOV-limited**: VOI larger than FOV, data truncation is limiting
- **Comparison**:
  - *Uncorrected* static, then dynamic (both: 256³ voxels)
  - *Corrected* static (512³), correction, then dynamic (256³)

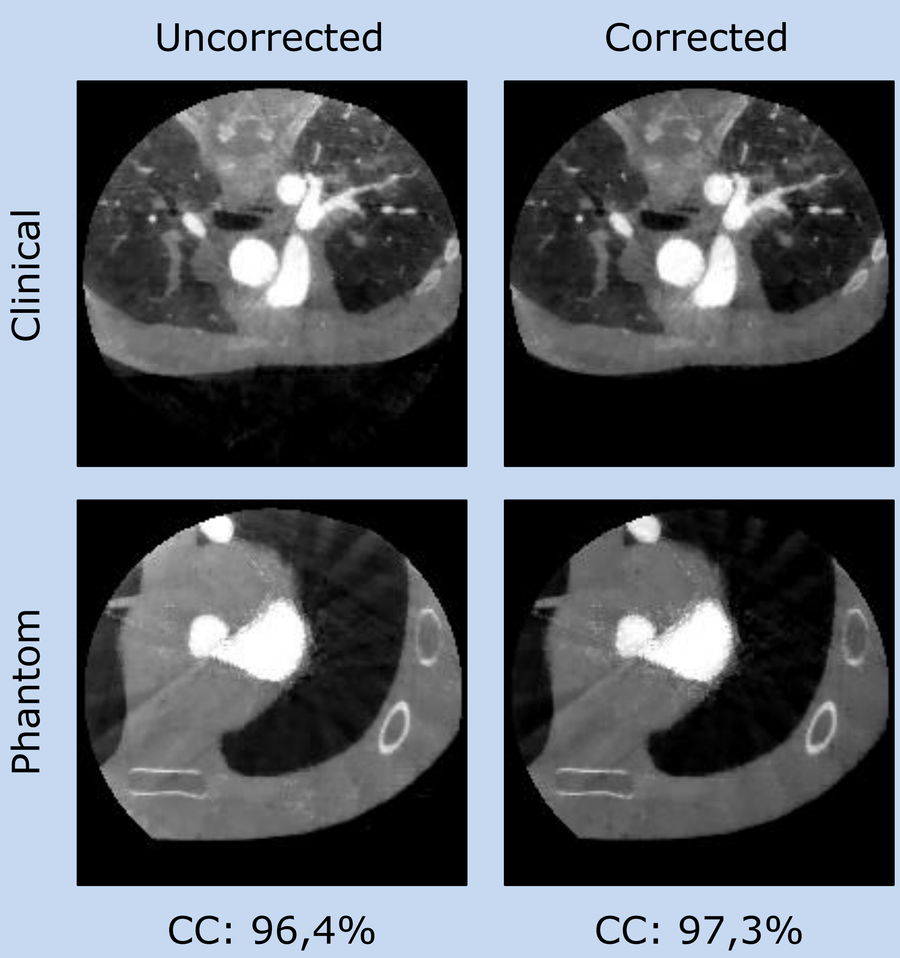
[1] Rit, S. et al., *Fully3D’09*, p. 49–52 (2009)
[2] Taubmann, O. et al., *Phys Med Biol* **62** 2762 (2017)

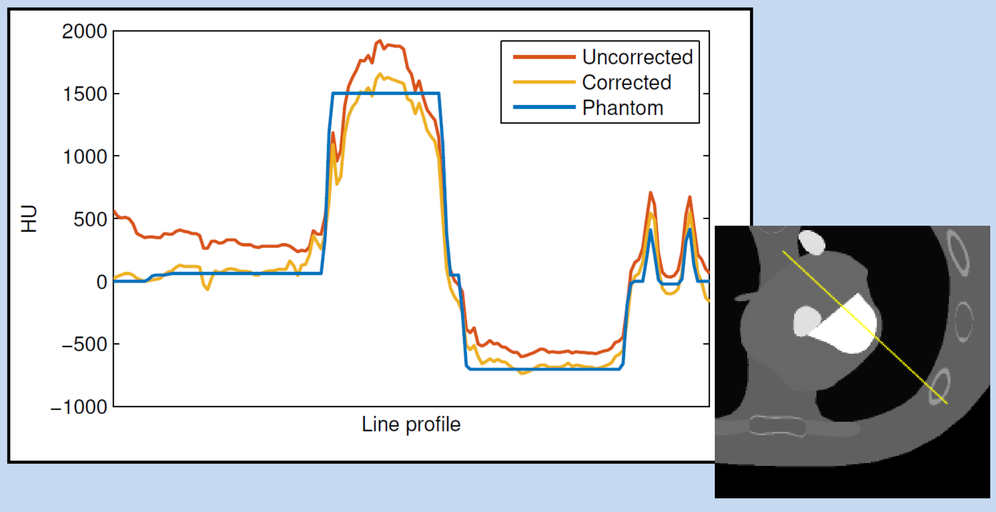
Results

VOI-limited case (in end-diastole)



FOV-limited case (in end-diastole)





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