Detruncation of Clinical CT Scans Using a Discrete Algebraic Reconstruction Technique (DART) Prior

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Introduction

Projection truncation typically occurs for obese patients, patients that are not centered properly, and for C-arm systems, which feature a small field of measurement. Reconstructing truncated data leads to cupping inside the field of view and missing CT values outside.

In order to reduce artifacts, the missing data in the sinogram are extrapolated, e.g. with the adaptive detruncation (ADT) [1]. While conventional algorithms are able to remove the cupping, they are generally not able to restore the CT values in the extended FOV (eFOV). The latter is especially important for secondary algorithms such as metal artifact reduction or beam hardening correction. Another method that has shown promise for reconstructing incomplete data is the discrete algebraic reconstruction technique (DART) [2]. This iterative method was originally developed for non-destructive testing of homogeneous objects with few projections or small angular range.

In this work, we apply DART to clinical CT to obtain a prior image for detrunction, i.e. to fill the missing projections. We compare our method to the established ADT.

Material and Methods

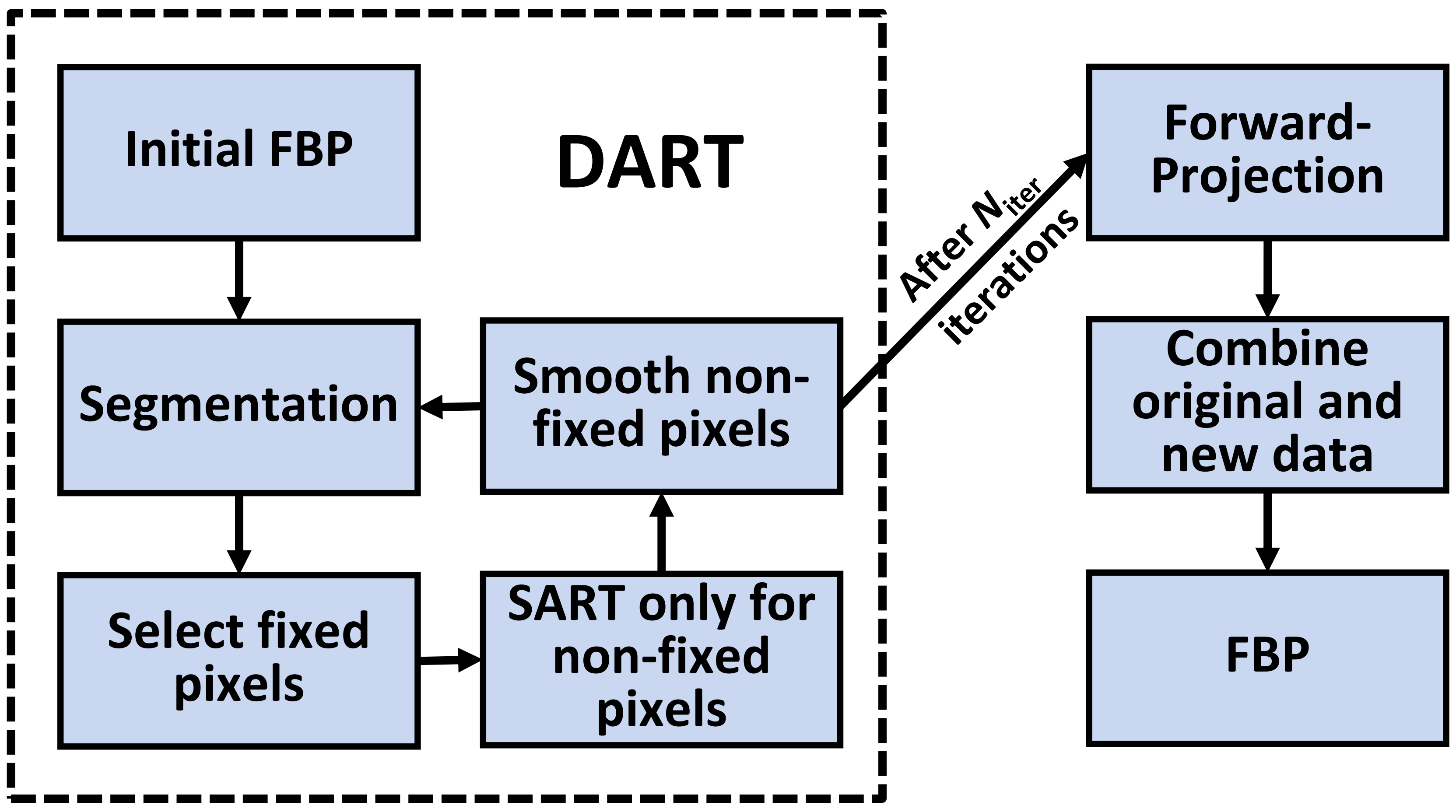

Figure 1: Scheme of the DDT.

Fig. 1 sketches the workflow of our proposed DART detruncation. The DART algorithm is initialized with an FBP image with cosine detruncation. Then, the image is segmented into tissue and air. Pixels that are fully surrounded by pixels of the same class are fixed and set to -1000 HU or 100 HU for air and tissue, respectively. Each fixed pixel has an additional probability of 65% to be non-fixed. Subsequently, we perform five SART iterations for the non-fixed pixels only. One SART iteration is defined as

$$f_{\text{new}} = f + \lambda \frac{1}{X^T 1} X^T \left(\frac{p - Xf}{X1} \right),$$

where f is the current estimate, f_{new} is the new estimate, p are the raw data, λ is a relaxation factor, and X and X^T are forward- and back-projection. Finally, the new pixels are smoothed and the next iteration starts with the segmentation. The maximum number of iterations is 5000.

Results and Discussion

Fig. 2 and Fig. 3 show the results of the detruncation. For mild truncation with 2/3 detector size, both ADT and DART detruncation yield good results. For strong truncation with 1/3 detector size, ADT is able to reduce the cupping artifacts and estimate a rough patient shape. In contrast, our method is able to restore the CT values in the eFOV much more accurately. Notably, the fat at the bottom is turned into soft tissue, simultaneously reducing the patient thickness. With a more sophisticated segmentation, this artifact would likely be avoided.

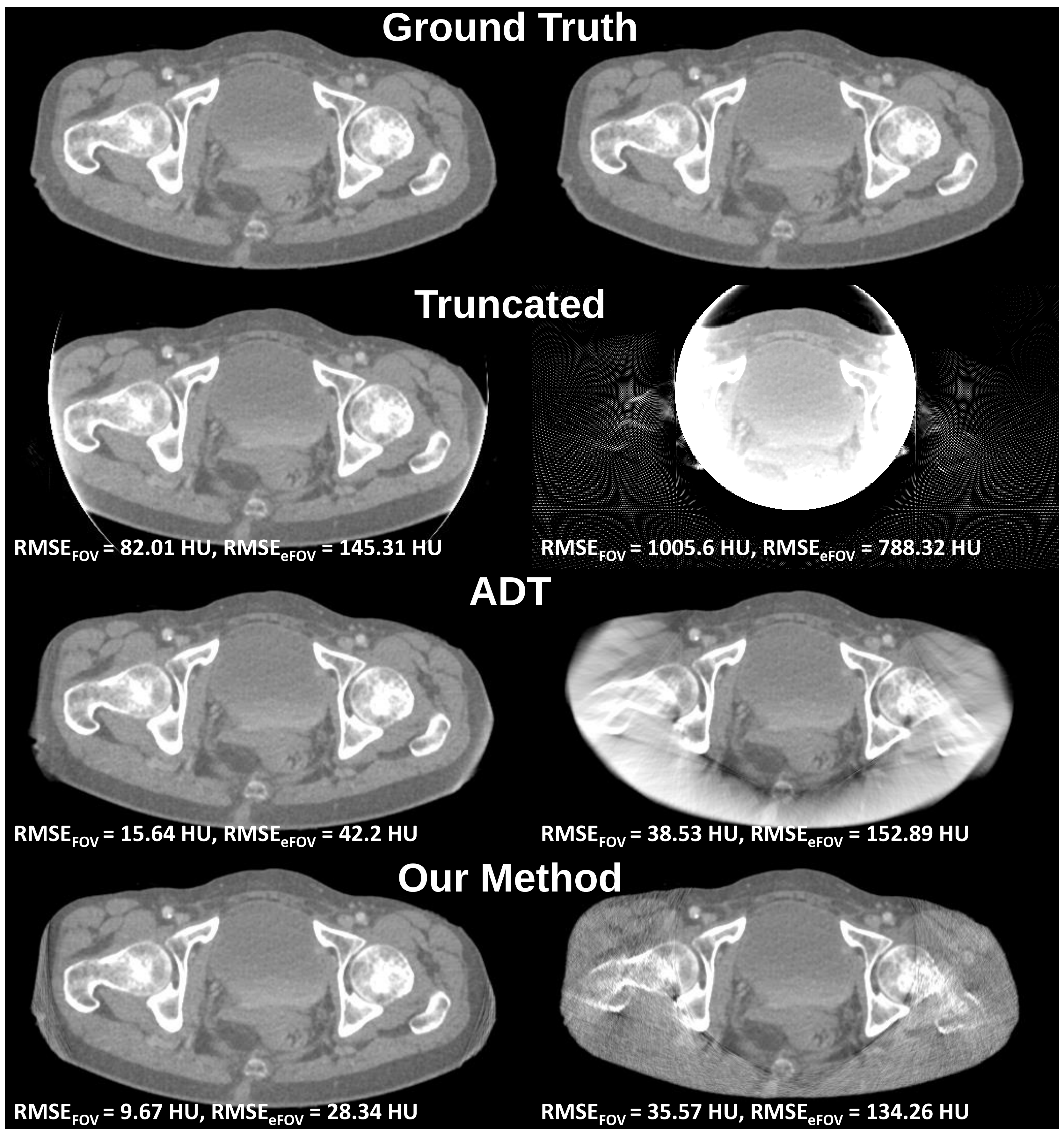

Figure 2: Detruncation results. Left column shows truncation of 1/3, right column of 2/3.

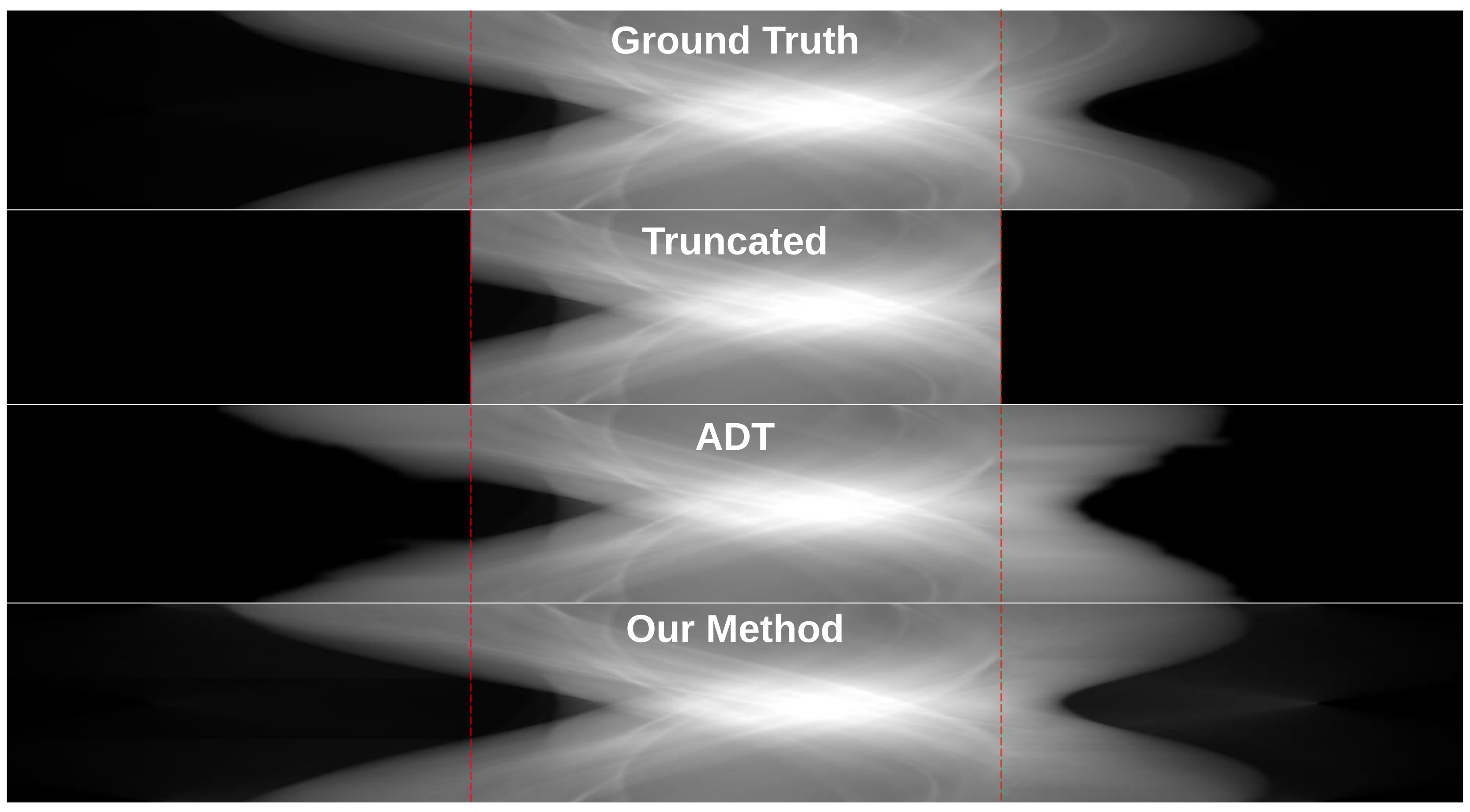

Figure 3: Projections before and after detruncation.

Conclusions

The DDT is capable of removing cupping artifacts in the FOV, as well as restoring CT values in the eFOV, for two levels of truncation. It outperformed the conventional ADT. However, some tissue inconsistencies remained in the final image.

[1] Sourbelle, Kachelrieß, et al. Reconstruction from truncated projections in CT using adaptive detruncation, Eur. Radiol. 2005;15.5:1008-1014

[2] Batenburg, Sijbers. DART: a practical reconstruction algorithm for discrete tomography. IEEE .Trans. Image Process. 2011;20.9:2542-2553..

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