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Coban, S.B. and Withers, P.J. and Lionheart, W.R.B.

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The effects of tomographic scans with fewer radiographs on the image reconstruction

S.B. Coban [*], P.J. Withers [†], W.R.B. Lionheart [*]

Abstract

Reconstructing a 2D slice or a 3D volume from a set of insufficient tomographic data is a difficult problem, and it is often tackled with analytical reconstruction algorithms. However, these types of methods fall short on delivering a quality image due to the severe artefacts introduced by the insufficiency of the data. Presented work shows the effects of taking tomographic scans with fewer radiographs on the quality of the reconstructed images. The aim here is to show the advantages of using iterative reconstruction methods over analytical methods, which are demonstrated by a quantitative comparison.

In many tomography experiments, collecting insufficient tomographic data is unavoidable; in others, it is the goal of the experiment. Depending on the application, the objective of the tomography experiment can be scanning of a patient at a lower dose to reduce the radiation exposure; or taking fast radiographs at large angle intervals to capture rapid changes in a sample. There could also be limitations that restrict the number of angles of illumination, which could be due to the hardware, the sample, or the conditions of the experiment. Another reason for taking a portion of radiographs rather than a full scan is the increasing demand in the computational memory, which becomes a challenge to store as more data is acquired.

Working with insufficient data introduces new artefacts that deteriorate the quality of the reconstructed images obtained with analytical methods. In this paper, we show the effects of insufficient data on the image reconstruction, and the advantages of using iterative methods in these cases. We compare the quality of the reconstructed results obtained with the popular analytical method FDK [Feldkamp1984], and the iterative methods SART [Andersen1984] and CGLS [Björck1998]; using an experimental glass bead pack dataset[1] where the measurements of the sample and the beads are known. This dataset is based on the framework introduced in [Coban2015]; acquiring 1 frame for each of 2048 radiographs; 2 frames at 1024, 4 frames at 512, 8 frames at 256, 16 frames at 128 and 32 frames for 64 radiographs. This enables a wide range of algorithm comparisons and information content optimizations to be examined. The SophiaBeads dataset are taken using the The Nikon Metris Custom Bay, situated in the Manchester X-ray Imaging Facility at the University of Manchester. The FDK results were obtained using the in-house reconstruction software available with the scanner. The methods SART and CGLS were implemented in MATLAB R2014b, with the forward and back projector codes written in C[2]. The segmentation and quantification of the results were carried out using the image-measuring techniques available in Avizo Fire 8. The quantification technique used in this paper is SHAPE3D, which parameterizes how close the reconstructed beads are

[*] School of Mathematics, [†] School of Materials,
The University of Manchester, Manchester, M13 9PL, United Kingdom.
sophia.coban@manchester.ac.uk; p.j.withers@manchester.ac.uk; bill.lionheart@manchester.ac.uk.

[1] *SophiaBeads Dataset Project, Mar. 2015.* DOI: `10.5281/zenodo.16474`.
[2] *SophiaBeads Dataset Project Codes, Apr. 2015.* DOI: `10.5281/zenodo.16539`.

(in shape) to a perfect sphere. The results given in Figure 1 show that the iterative methods deal better with dataset with fewer radiographs, whereas the FDK method is adequate for scans with 256 radiographs or higher. Examining the differences between solutions FDK64 (Box **1**) and CGLS64 (Box **2**) in Figure 1: despite the dataset reconstructed is the same, the results differ significantly. In fact, the fewer radiograph artefacts are so severe that both FDK64 and FDK128 solutions (Boxes **1** and **3**, respectively) are not segmented correctly, and thus show volumetric reconstructions of broken beads.

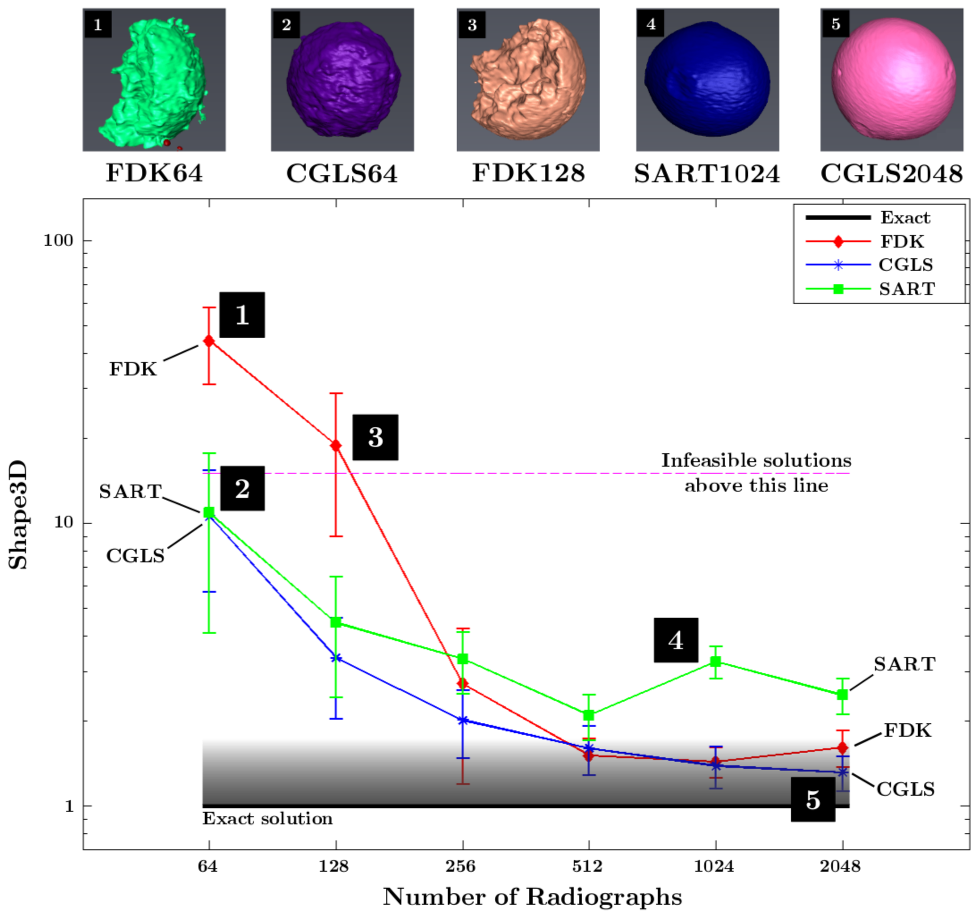

Figure 1: Results of the Shape3D analysis plotted with errorbars in MATLAB. The black line denotes the 'perfect solution', while the shaded section denotes the acceptable results due to the standard deviation in the size of the glass beads.

Analytical methods are fast, reliable, and popularly used by the tomography community. However, the results indicate that analytical methods cannot deal with the insufficiency in tomographic data, and the compensation of the missing data in a reconstructed image is achieved with the use of iterative reconstruction methods.

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