The effects of fewer projection tomographic scans on the image reconstruction

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

2015

MIMS EPrint: **2015.84**

ISSN 1749-9097

The effects of fewer projection tomographic scans on the image reconstruction

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

June 19, 2015

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, this type of methods fall short on reconstructing the image due to the severe artefacts introduced by the insufficiency of the data. Presented work shows the effects of taking tomographic scans with fewer projections on the quality of the reconstructed images. The advantages of the iterative reconstruction methods over the analytical methods 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 projections at large angle intervals to capture rapid changes in a sample. There could also be limitations that restrict the number of angles a sample can be rotated over, which could be due to the equipment used, the sample scanned, or the experiment set up. Another reason for taking a portion of projections rather than a full scan is the increasing demand in the computational memory, which becomes a challenge to store and reconstruct 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 reconstructions, and the advantages of using iterative reconstruction methods in these cases. We compare the quality of the reconstructed results obtained with the popular analytical method FDK [9], and the iterative methods SART [2] and CGLS [3], using an experimental glass bead pack dataset [6]. This dataset is based on the framework introduced in [7, 8]; acquiring 1 frame for each of 2048 projections; 2 frames at 1024, 4 frames at 512, 8 frames at 256, 16 frames at 128 and 32 frames for 64 projections. 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 [10], situated in the Henry Moseley X-ray Imaging Facility at the University of Manchester. The FDK results were obtained by the in-house reconstruction black box available with the scanner.

* School of Mathematics, † School of Materials,
The University of Manchester, Manchester, M13 9PL, United Kingdom.
sophia.coban@manchester.ac.uk, www.maths.manchester.ac.uk/~scoban/;
p.j.withers@manchester.ac.uk;
bill.lionheart@manchester.ac.uk, www.maths.manchester.ac.uk/~bl.

The results of SART and CGLS were obtained using MATLAB R2014b, with the forward and back projector codes written in C [4], and the segmentation and quantification of the results were carried out using the image-measuring techniques available in Avizo Fire 8 [1, 5]. The quantification technique used in the paper is SHAPE3D, which parameterizes how close the reconstructed beads are (in shape) to a perfect sphere. The results given in Figure 1 show that the iterative methods deal better with datasets with fewer projections, whereas the FDK method is adequate for scans with 256 projections or higher. The reconstructed beads in boxes **1** (FDK64) and **3** (FDK128) show that the FDK results for 64 and 128 projections are not segmented successfully to classify as full spheres, so these are counted as infeasible solutions.

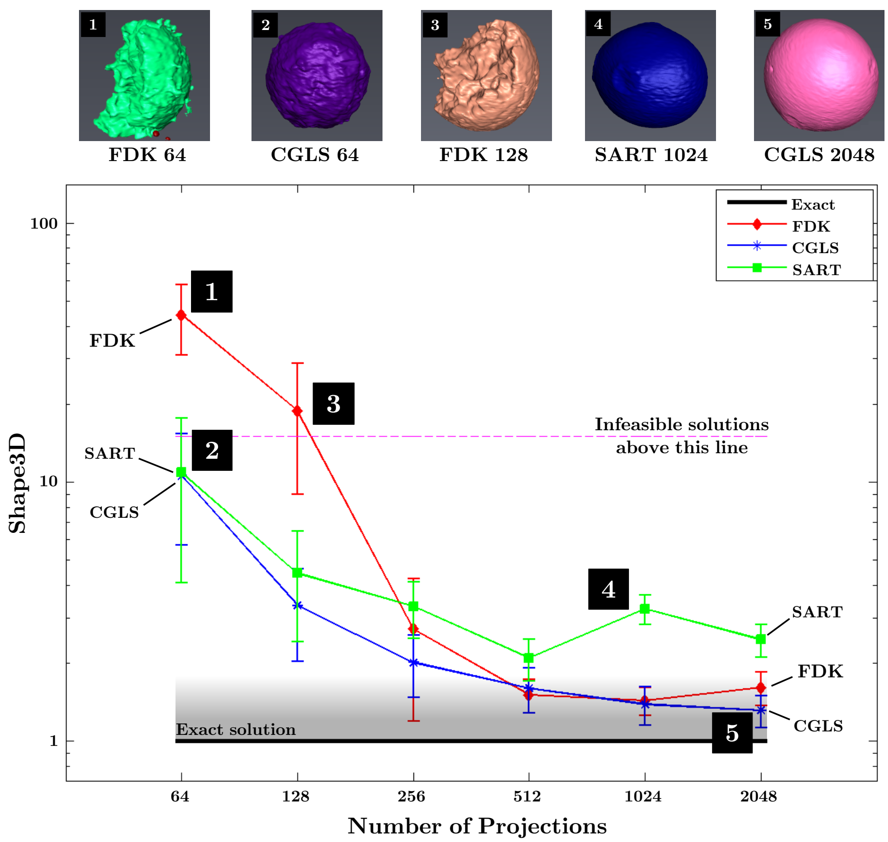

Figure 1: Results of the SHAPE3D analysis plotted with errorbars in MATLAB. The black line denotes the 'perfect solution', while the shaded section denotes the acceptable results due to the standard deviation in the size of the glass beads.

Acknowledgment

This project is funded by the School of Mathematics, EPSRC CCPi (EP/J010456/1), and BP through the ICAM framework.

References

[1] Avizo 8. *Avizo User's Guide*. English. FEI Visualization Sciences Group.

[2] A.H. Andersen and A.C. Kak. "Simultaneous Algebraic Reconstruction Technique (SART): a superior implementation of the ART algorithm". In: *Ultrason. Img.* 6 (1984), pp. 81–94.

[3] Å. Björck, T. Elfving, and Z. Strakos. "Stability of conjugate gradient and Lanczos methods for linear least squares problems". In: *SIAM J. Matrix Anal. Appl.* 19(3) (1998), pp. 720–736.

[4] S.B. Coban. *SophiaBeads Datasets Project Codes*. Apr. 2015. DOI: `10.5281/zenodo.16539`. URL: `http://dx.doi.org/10.5281/zenodo.16539`.

[5] S.B. Coban. *SophiaBeads Datasets Project Documentation and Tutorials*. Tech. rep. MIMS Technical Report. School of Mathematics, University of Manchester, United Kingdom, 2015.

[6] S.B. Coban and S.A. McDonald. *SophiaBeads Dataset Project*. Mar. 2015. DOI: `10.5281/zenodo.16474`. URL: `http://dx.doi.org/10.5281/zenodo.16474`.

[7] S.B. Coban et al. "A framework for exploring the limits of reconstruction algorithms". In: *(to appear)* (2015).

[8] S.B. Coban et al. "When do iterative reconstruction methods become worth the effort?" In: *the proceedings of The 13th International Meeting of Fully Three-Dimensional Image Reconstruction in Radiology and Nuclear Medicine*. 2015.

[9] L.A. Feldkamp, L.C. Davis, and J.W. Kress. "Practical cone-beam algorithm". In: *JOSA A* 1.6 (1984), pp. 612–619.

[10] *Manchester X-Ray Imaging Facility – Nikon Custom Bay*. `http://www.mxif.manchester.ac.uk/resources/imaging-systems/nikon-custom-bay`. Accessed: 20-MAR-2015.