Interior CT Reconstruction Based on Piecewise-Constant-Model

Ohsung Oh[a], Ge Wang[b], Seung Wook Lee[a*]
[a]*School of Mechanical Engineering, Pusan National University, Busan, Republic of Korea*
[b]*Department of Biomedical Engineering, Biomedical Imaging Center, Rensselaer Polytechnic Institute, Troy, NY 12180, United States of America*
[*]*Corresponding author: seunglee@pusan.ac.kr*

1. Introduction

X-ray CT (computed tomography) has a great advantages that it is possible to see the section of the objects in a non-destructive way. Whereas classic CT reconstructs the objects through scanning the whole body, in the real-world, it sometimes focuses on the parts of the objects. But, it is known that internal Region of Interest (ROI) of the objects cannot be reconstructed completely, because it doesn't have a unique solution. So when applying conventional CT algorithms for interior tomography reconstruction from the transversely truncated data, it may result in high errors inside the ROI.

In this paper, numerical results was simulated using filtered backprojection(FBP) and iterative reconstruction.

2. Simulation

2.1 Simulation geometry

In this simulation, a circular orbit of radius 50 cm was assumed around an object. And 720 equiangular projections were collected during a full scan. The detector array was set to 12 cm and 240 detector elements having equidistance. The center of the detector array was located on the line through the x-ray source and the rotating axis. The diameter of projected ROI was 3 cm on the detector. The reconstructed image is 256x256 pixels in a field of view of radius 5 cm.

2.2 Numerical phantom

In this numerical simulation, two type of phantoms were used. One is Shepp-Logan phantom and another is contrast-enhanced Shepp-Logan phantom.

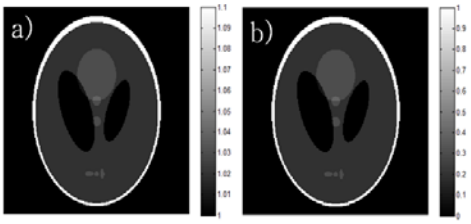

Fig.1. Numerical phantoms used in this paper, a) Shepp-Logan phantom, b) Contrast-enhanced Shepp-Logan phantom

3.3 Algorithm

The program was coded in MATLAB. A FBP and iterative reconstruction were used for comparison, aided by a distance-driven technique to make a system matrix. And SART-TV minimization was used for iterative reconstruction.

SART was iterated 100 times while TV minimization was iterated 5 times.

3. Results

3.1 Contrast-enhanced Shepp-Logan phantom

Fig. 2 shows the image using FBP and SART-TV minimization, and fig. 3 shows the typical profiles of the images. In these figures, the image using FBP showed high DC values compared reference image and SART-TV minimization image showed the better quality. This is because the image are completely reconstructed using SART-TV minimization theoretically, if the phantom is piecewise-constant or piecewise-polynomial model.

Table 1. Iteration and relative error when the contrast-enhanced Shepp-Logan phantom

	Iteration	Relative error(%)
FBP		33.50
SART-TV minimization	100	13.36

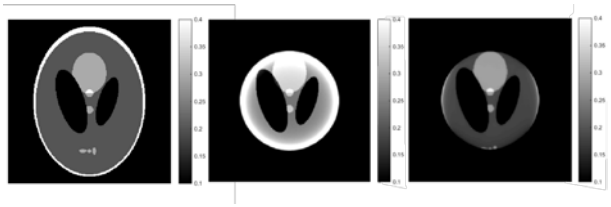

Fig.2.The reconstructed images of contrast-enhanced Shepp-Logan phantom in x-ray interior tomography, a) reference, b) Filtered backprojection, c) Conventional SART-TV minimization

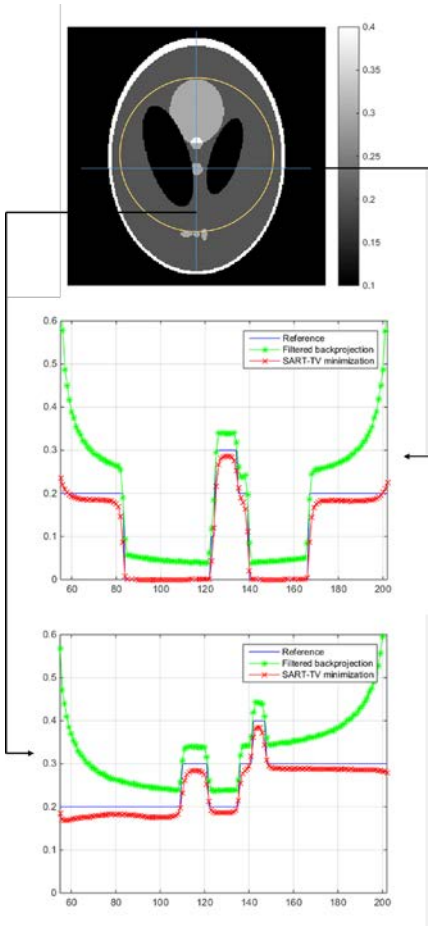

Fig.3. Typical profiles along the lines in fig.2.

3.2 Shepp-Logan phantom

Fig. 4 shows images of FBP and SART-TV minimization. In these results, both reconstruction images show that these methods don't reconstruct the original image well. The image using FBP had high DC values and shapes like a cup. And the image using SART-TV minimization had low DC values and shape like a cap. It is because Shepp-Logan phantom has high DC value, so piecewise-constant model is not satisfied.

Table 2. Iteration and relative error when Shepp-Logan phantom

	Iteration	Relative error(%)
FBP		16.07
SART-TV minimization	100	11.09

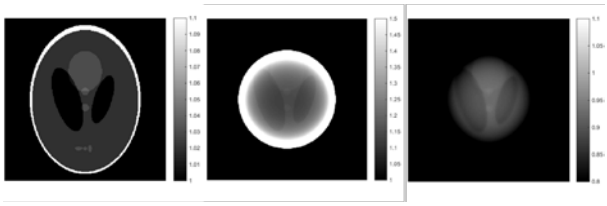

Fig.4. The reconstructed images of Shepp-Logan phantom using x-ray interior tomography. a) Reference, b) Filtered backproojection, c) SART-TV minimization

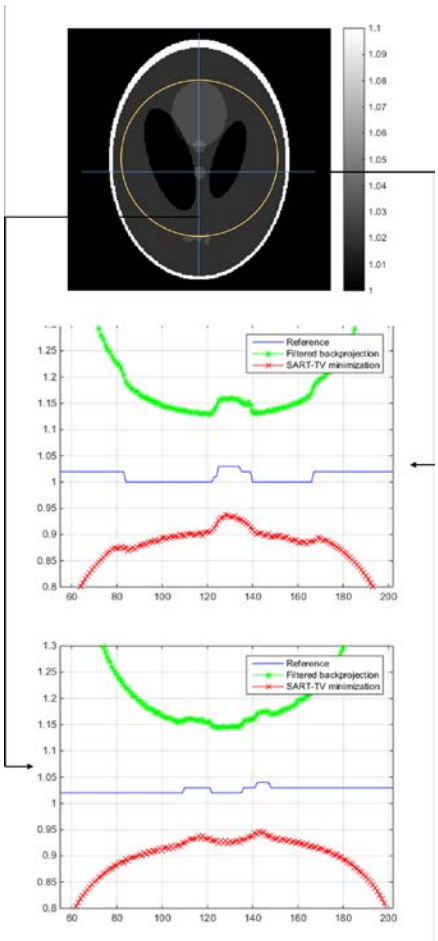

Fig.5. Typical profiles along the lines in fig.4.

4. Conclusions

X-ray interior tomography simulation was carried out using various type of numerical phantoms. In this paper, SART-TV minimization showed better quality compared to FBP for contrast-enhanced Shepp-Logan phantom (low DC level).

REFERENCES

[1] A. C. Kak and M. Slaney, Principles of computerized tomographic imaging, IEEE Press, 1988.
[2] H. Yu and G. Wang, "Compressed sensing based interior tomography," Physics in Medicine and Biology, vol. 54, no. 9, pp. 2791–2805, 2009.
[3] G. Wang and H. Yu, "The meaning of interior tomography",Phys. Med. Biol. 58 R161–R186, 2013
[4] B. De Man and S. Basu, "Distance-driven projection and backprojection in three dimensions", Phys. Med. Biol. 49 2463–2475, 2004
[5] G. Wang and M. Jiang, "Ordered-subset simultaneous algebraic reconstruction techniques (OS-SART)", Journal of X-Ray Science and Technology. 12(3):169–177. 2004
[6] P. He, B. Wei, S. Wang, S.R. Stock, H. Yu and G. Wang " Piecewise-Constant-Model-Based Interior Tomography Applied to Dentin Tubules", Computational and Mathematical Methods in Medicine, Volume 2013, Article ID 892451, 8 pages, 2013