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Comparison of methods of projection and backprojection for CT Simulation

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1. Introduction

In CT(Computed Tomography) technology, image reconstruction is important and necessary process. And today, for better image quality even if low dose and limited angle, iterative reconstruction is becoming significant part.

In order to adjust iterative reconstruction, projection/backprojection processes are essential parts. Therefore in this paper, 3 approaches for projection/backprojection simulation study are introduced and compared.

2. Theory

2.1 Phantom

In order to make the numerical phantoms for simulation study, locations, sizes, tilting angles, densities of figures are needed. So to express these parameters, homogeneous coordinate was used. By using homogeneous coordinate, all transition, rotation, scaling matrices can be converted to a simple multiplication of matrices. So it results in a reduction of the phantom generation time. Therefore if all conditions are met, phantoms like rectangles, ellipses are generated.

$$P' = T(t_x, t_y) \cdot R(\theta) \cdot P \qquad (1)$$

2.2 Projection & backprojection

In this paper, three projection/backprojection methods were used. Fig.1 shows the three projection/backprojection methods; pixel-driven approach, ray-driven approach, distance-driven approach. In case of pixel-driven approach, it focuses on the lines passing through center of pixels. So when backprojected, all values are weighted, integrated next to the detector value. But when projected, it makes high frequency artifacts.

Another approach is ray-driven approach. It focuses on the lines passing through center of detector cells. So when doing projection, all values are weighted and integrated next to the pixel value. And also in the same manner as in pixel-driven projection, ray-driven backprojection results in high frequency artifacts.

The other approach is distance-driven approach. Unlike the previous two approach, it checks pixel and detector boundaries onto a common axis, the overlapping parts are used as a weighting factors for projection/backprojection. Because it doesn't have interpolation processes, the high frequency artifacts are almost removed.

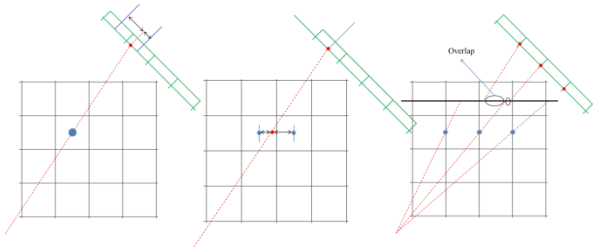

Fig. 1 3 approaches for projections/backprojections; left : pixel-driven, middle : ray-driven, right : distance-driven

3. Simulation

3.1 Simulation setup

This simulation was developed in MATLAB. It is based on fan-beam geometry (Fig.2).

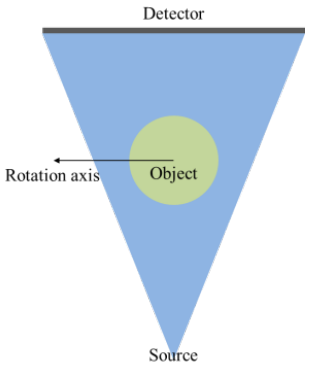

Fig. 2 Fan-beam CT geometry

3.2 Phantom

For this numerical simulation, 2-type phantoms were used in Fig.3.

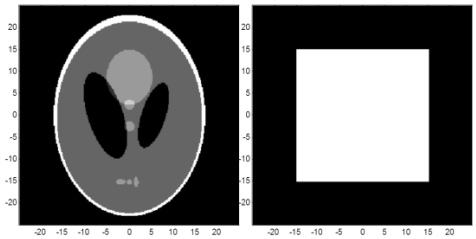

Fig. 3 Two phantoms using MATLAB ; left : Shepp-Logan phantom, right : simple rectangle phantom.

3.3 Projection

Fig.4.a) shows projection images using 3 projection approaches and Fig.4.b) shows graph at θ=180°. For ray-driven projection and distance-driven projection,

there are no artifacts, but high frequency oscillation is shown in pixel-driven projection image.

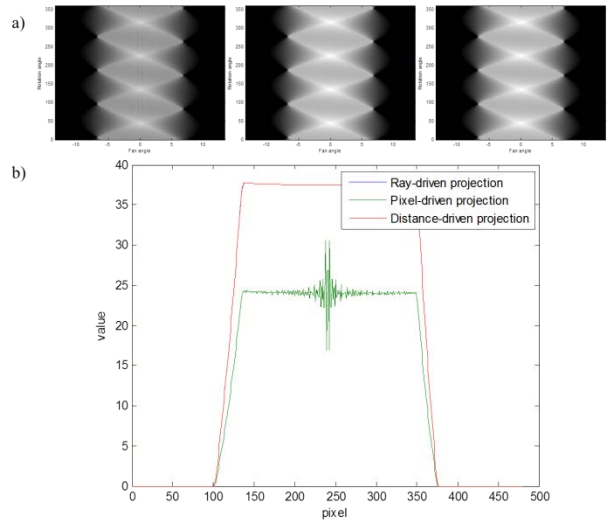

Fig. 4 Projection images of simple rectangle phantom; left : pixel-driven projection, middle : ray-driven projection, right : distance-driven projection, bottom : graph at θ=180°

3.4 Backprojection

Fig.5 shows backprojection images at θ=45° using 3 backprojection approaches. For ray-driven backprojection, there are high frequency artifacts, but it is eliminated in pixel-driven backprojection and distance-driven backprojection.

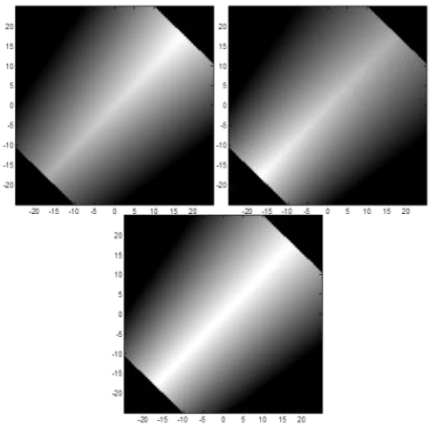

Fig. 5 backprojection images of simple rectancle phantom at θ=45°; left : pixel-driven backprojection, right : ray-driven backprojection, bottom : distance-driven backprojection

3.5 Filtered backprojection(FBP)

Fig.6 shows FBP images of Shepp-Logan phantom. For the pixel-driven and distance-driven backprojection, there are few differences compared to reference images. But for ray-driven backprojection, it is hardly seen because too many artifacts.

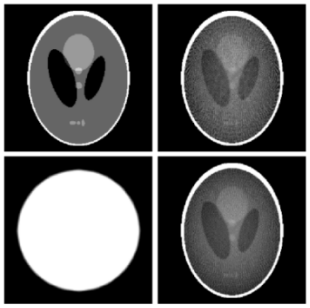

Fig. 6 FBP reconstruction of a Shepp-Logan phantom; reference, pixel-driven, ray-driven, distance-driven.

4. Conclusions

Projection/backprojection were successfully implemented in 3 approaches. In this result, distance-driven approach showed the images having no artifacts compared to pixel-driven and ray-driven approaches. So it is expected to get images having better quality when using iterative reconstruction.

REFERENCES

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