Projection acquisition condition of slow gantry rotation for respiratory correlated 4D inverse geometry computed tomography

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I. Introduction

The inverse geometry computed tomography (IGCT) has been developed to overcome the several limitations in conventional cone beam computed tomography (CBCT). We intend to present the projection acquisition condition for respiratory correlated 4D IGCT with the slow gantry rotation technique of conventional 4D CBCT.

II. Material and Method

The projection groups (PG) acquired over a single gantry rotation in several minutes and a gridding was performed to transform the sorted PG to cone beam geometry. Each PG covered the radon space with specific angular width, and the angular distance between successive PGs should be less than 0 degree to perform the accurate gridding without vacancy in radon space.

•Projection acquisition condition

✓$FR = \frac{NPW}{RP}$, FR: frame rate, NPW: the number of phase windows, RP: respiratory period

✓$Angular\ width\ of\ swath\ (AWS) = \pi - 2tan^{-1}(\frac{2DOD}{D})$, DOD: detector to object distance , D: detector width

✓$Angular\ distance\ between\ succesive\ swaths\ (ADCS) = GRS \times RP - AWS$, GRS: gantry rotation speed

✓$ADCS < 0$

✓$GRS < \frac{AWS}{RP}$

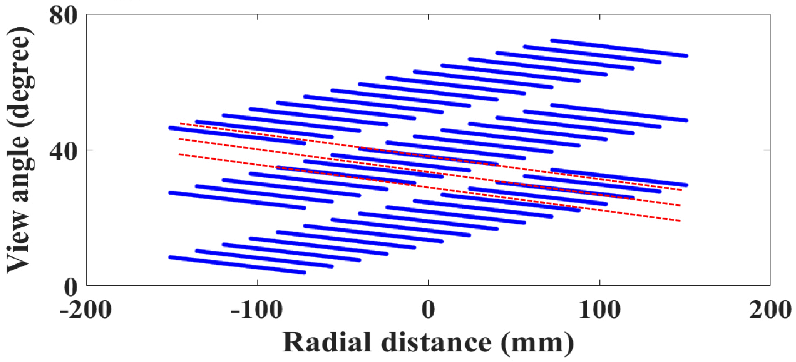

Figure 1: Radon space. (blue line: IGCT data swath, red line: gridding distribution)

•Simulation

✓Regular breathing: Sine wave (4 s period)

✓Phantoms: defrise, modified Shepp-Logan, and XCAT torso

✓10 phase images

✓FDK reconstruction

✓Two trial

1. GRS = 3 degree/s, FR = 2.5 fps (defrise, modified Shepp-Logan, XCAT torso), **Satisfying condition**
2. GRS = 5 degree/s, FR = 2.5 fps (defrise, modified Shepp-Logan), **Failed condition**

III. Results

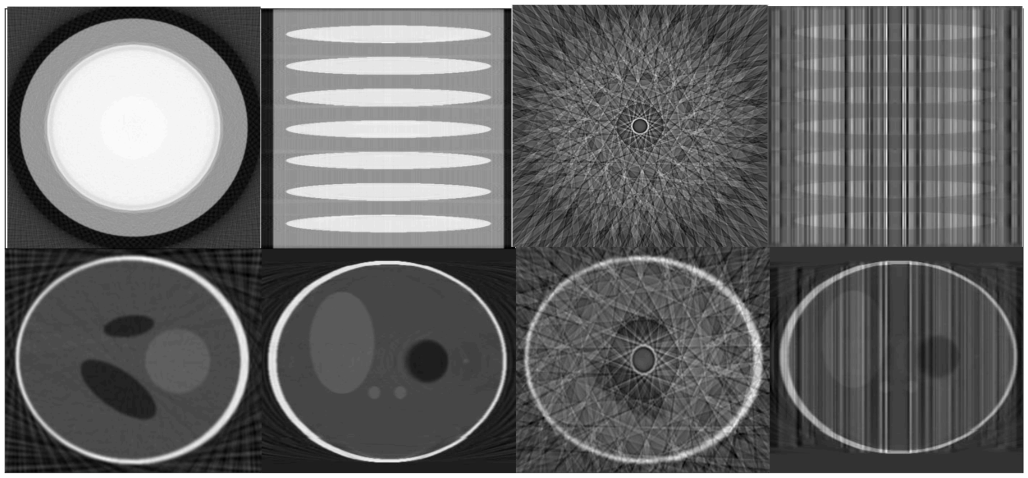

Figure 2: Defrise and mSL reconstruction image (axial, coronal view of phase 50%)

Figure 3: XCAT reconstruction image (axial, coronal, sagittal view)

Under the acquisition condition, the 4D IGCT had uniform image without cone-beam artifact and motion. On the other hand, the gridded projection showed inaccurate interpolation, especially in the large radial distance area, and the image quality was poor under the failed condition.

	defrise			mSL		
Phase (%)	axial	coronal	sagittal	axial	coronal	sagittal
MES	0.0056	0.0021	0.0021	0.0064	0.0054	0.0038
PSNR	22.5228	26.7647	26.7965	21.9260	22.6654	24.2166
R	0.9858	0.9944	0.9944	0.7791	0.8651	0.8508
RMSE	0.0748	0.0459	0.0457	0.0801	0.0736	0.0615

Table 1: Image quality evaluation of trial 1 case at the phase of 50%

IV. Conclusion and Discussion

The 4D IGCT demonstrated its imaging ability without cone beam artifact and motion artifact. In order to obtain a fine image quality without significant artifacts, it is necessary to satisfy the projection acquisition condition of IGCT.

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