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Quantitative Comparison of Continuous and Step Scan Motions in a micro-Computed Tomography System

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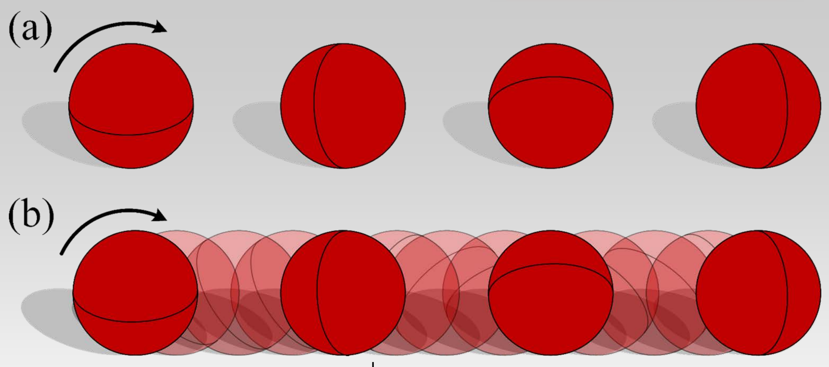
Background and Objectives

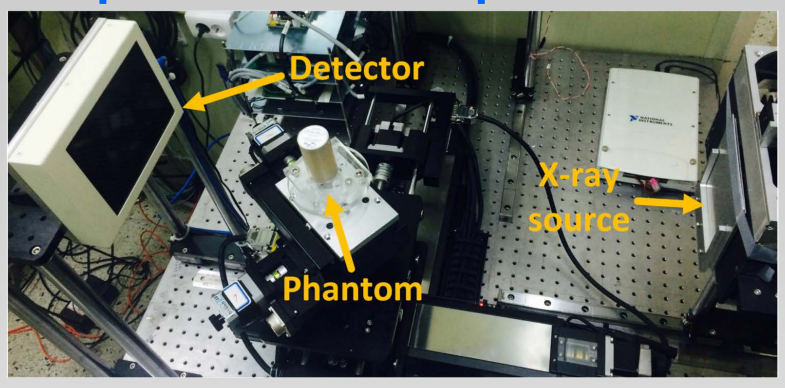
- Small-animal imaging using μ-CT has a critical role in the new drug development and in providing the understanding of disease mechanisms
- For μ-CT scanning, two methods of the step and continuous motion scans can be considered
- Due to the requirements for high spatial resolution in small-animal imaging, selecting a suitable scanning method is important
- In this regard, the investigation of quantitative characteristics of the two scanning methods is required



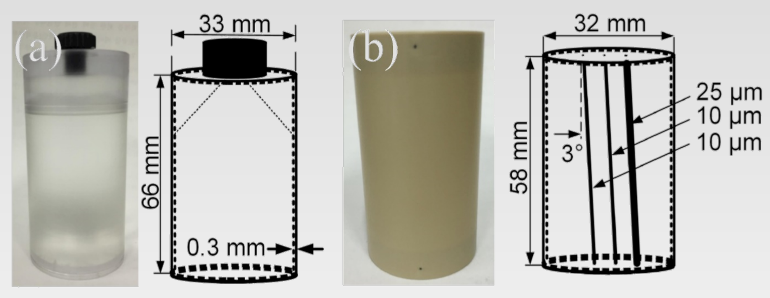
	(a) Step	(b) Continuous
Scanning Time	--	++
Operation Complexity	--	++
Image Quality	??	??

Materials and Methods

- **Experimental Setup**



The computed tomography system for experimental measurements



Phantoms used in this study. The water phantom (a) and the wire phantom (b)

- **Experimental Conditions**

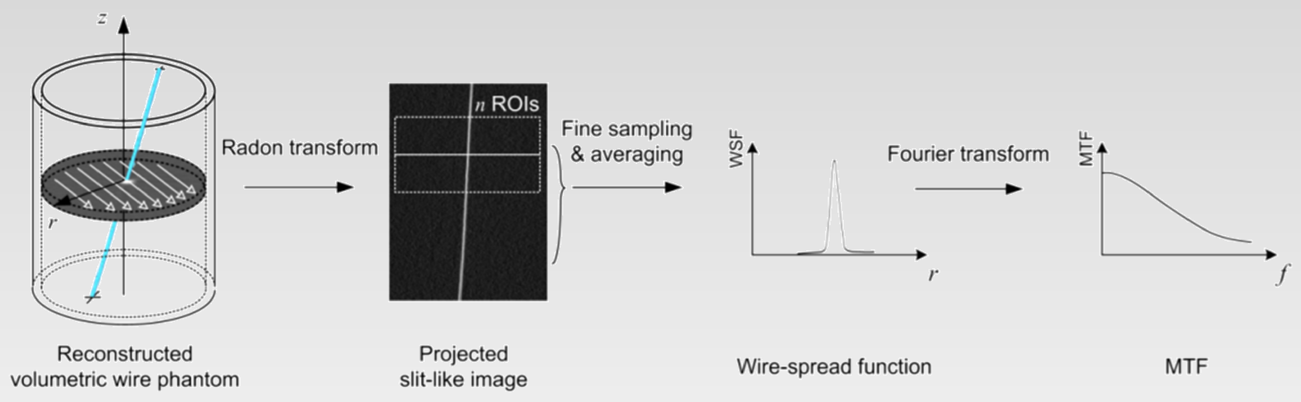
Tube Voltage (kVp)	45
Tube Current (mA)	0.9
Al Filtration (mm)	2.5
Number of projections	360
Exposure time (ms)	275
Magnification	1.5
Rotation Speed† (rpm)	0.62
Reconstruction Filter	Hanning window

† For Continuous Motion

- **Quantitative Characteristics**

<MTF>

- The spatial resolution performance is evaluated by measuring the modulation transfer function (MTF), which is an indication of contrast transfer performance of the system
- The MTF is obtained by applying fast Fourier transform to the wire spread function



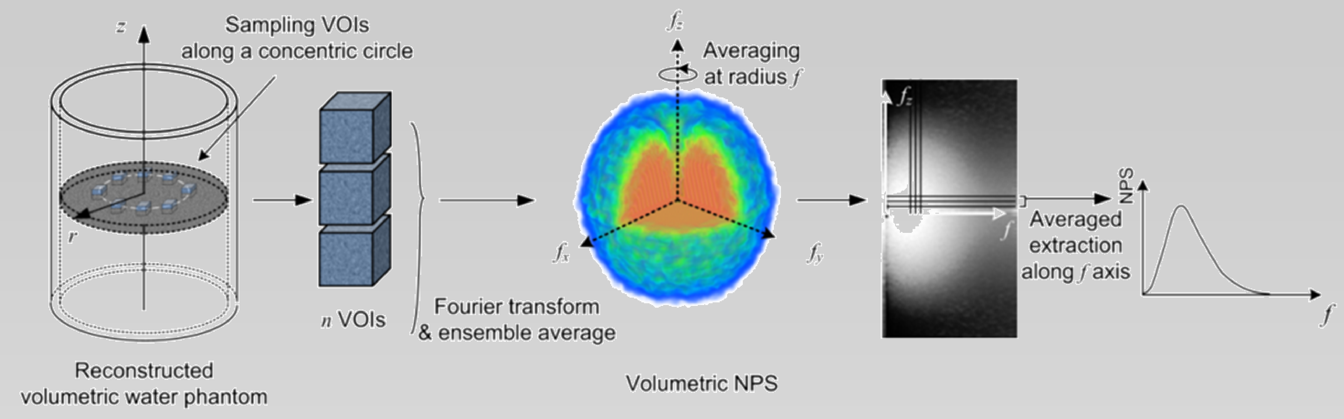
MTF evaluation

<NPS>

- The noise power spectrum (NPS) describes the noise transfer performance in the spatial frequency domain

$$\mathrm{NPS}(f_x, f_y, f_z) = \frac{a_x a_y a_z}{L_x L_y L_z} \left\langle \left| \mathrm{FT}\{\Delta d(x,y,z)\} \right|^2 \right\rangle$$

where L is the number of elements of the volume of interest. $\Delta d(x,y,z)$ is a noise-only image



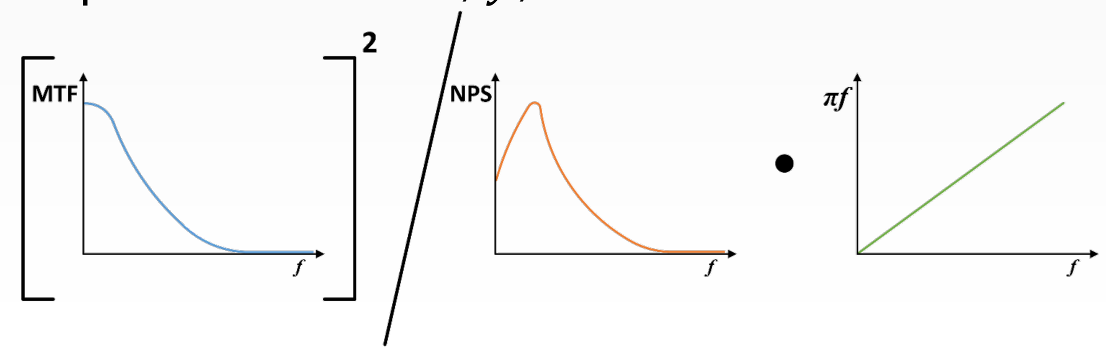
NPS evaluation

<NEQ>

- The NEQ implies the image quality of the practical system compared to that of an ideal system
- Based on the measured MTF and NPS, the NEQ is calculated as follows

$$\mathrm{NEQ}(f_x, f_y, f_z) = \pi f \frac{\mathrm{MTF}^2(f_x, f_y, f_z)}{\mathrm{NPS}(f_x, f_y, f_z)}$$

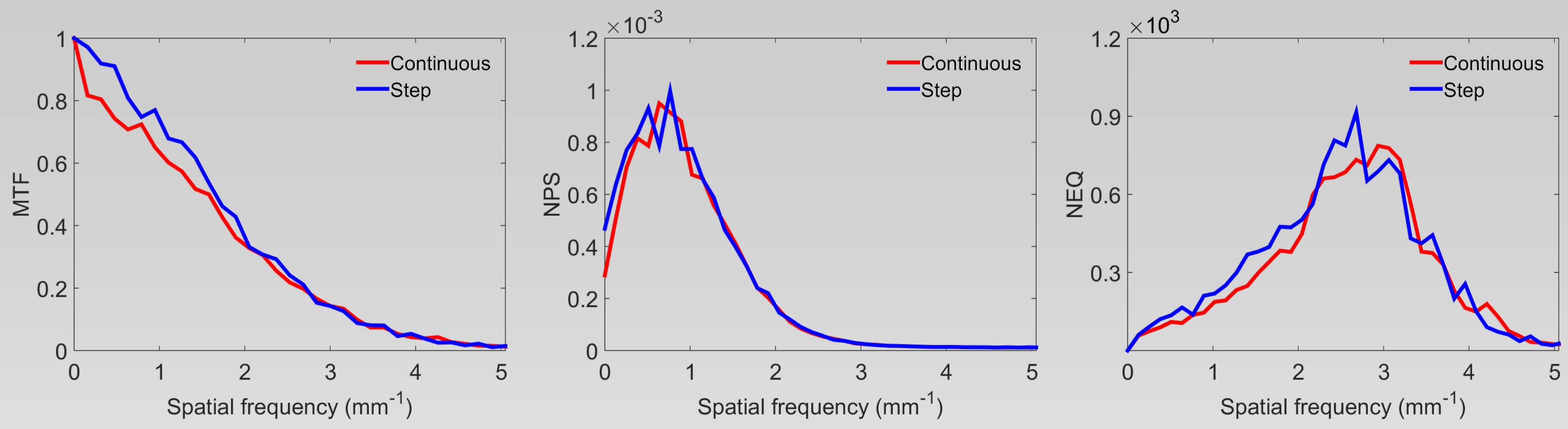
where πf accounts for radial sampling density. f_x, f_y, and f_z are the spatial frequency variables corresponding to the spatial variables x, y, and z



Results

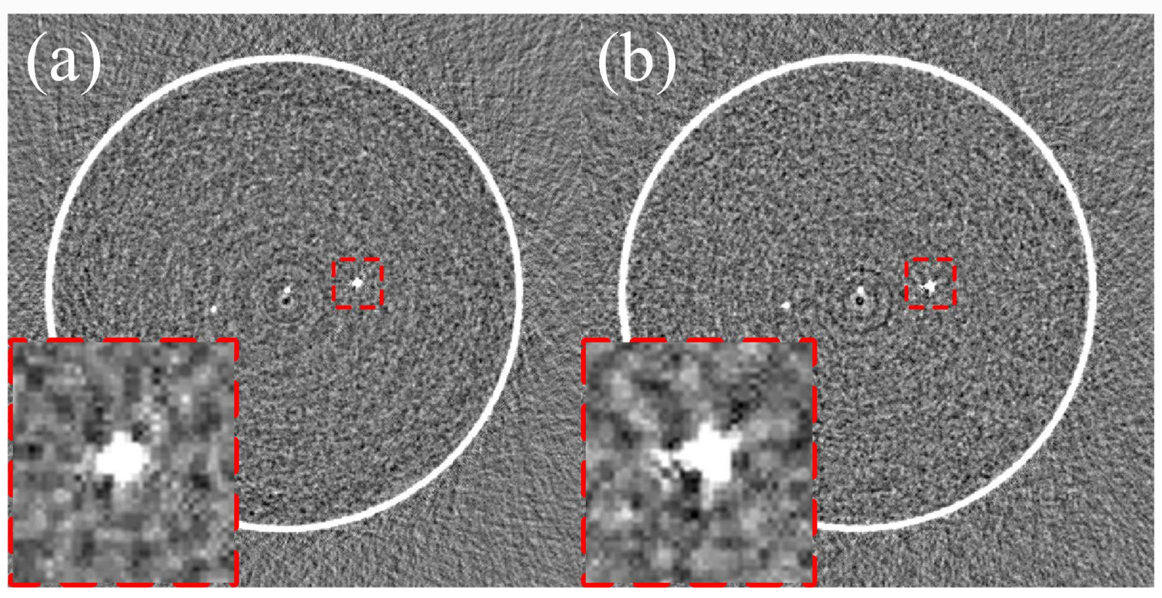
- **Characteristics Investigation**

- The experimental results for the quantitative investigation according to the two scanning methods are shown



<MTF>

- The step-motion scan shows better MTF characteristic than the continuous motion scan because of focal spot blur
- Especially, there are considerable differences in the low-frequency region
- The cross-sectional image of wire acquired by continuous motion scan is blurrier than that by the step-motion



Reconstructed tomographic wire image samples. (a) step-motion scan and (b) continuous motion scan

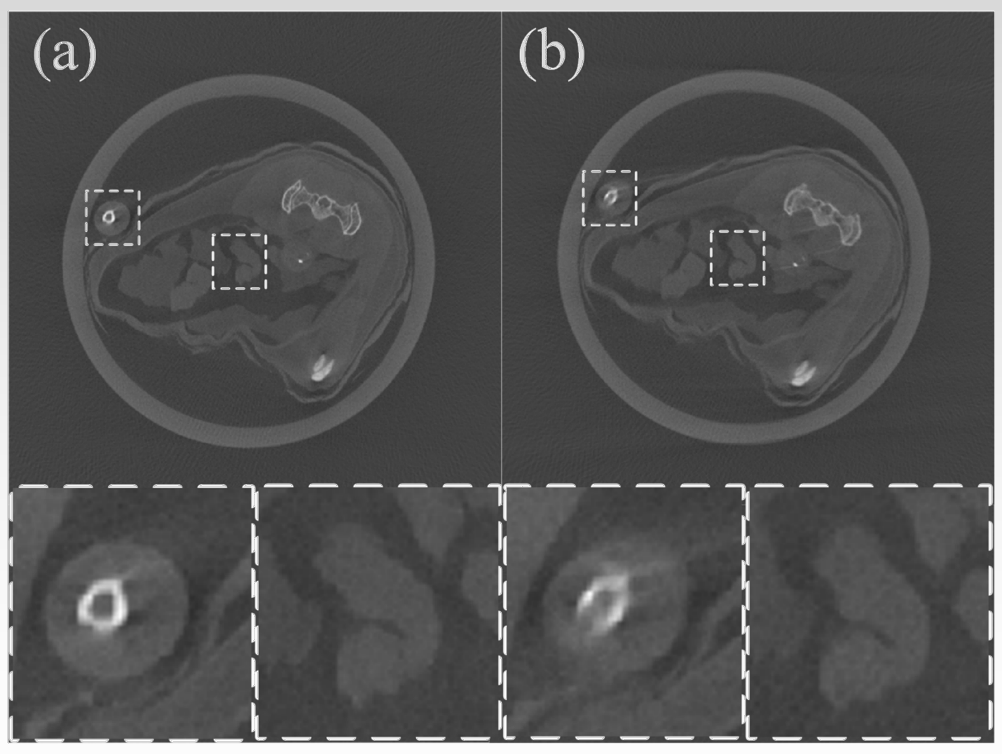
<NPS>

- The difference in trends of NPS between the two methods is marginal

<NEQ>

- The step-motion scan shows the better NEQ performance than that of continuous motion scan
- Since the difference of NPS between the two motions is negligible, the MTF performance dominates the difference in NEQ
- Therefore, the NEQ performance shows the difference in the low-frequency region

- **Mouse Tomographic Images**
  - Mouse images are acquired under the experimental conditions
  - A significant resolution degradation at the bony region can be observed in continuous scan motion



Reconstructed mouse images from step-motion scan (a) and continuous motion scan (b)

Discussion and Conclusion

- In this study, continuous motion scan shows worse MTF performance than the step-motion scan.
- However, there is no significant difference of NPS between two scanning methods
- Therefore, the MTF performance dominates the performance of NEQ
- It is necessary to study further the effect of motion artifacts on image quality by scanning method

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