Feasibility study on many-view under-sampling (MVUS) using spiral beam filter

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Introduction
- Low-dose imaging capability of a CT system is now becoming a must rather than an option. We have earlier proposed a moving beam-blocker-based sparse sampling approach which we named many-view under-sampling (MVUS) for low-dose CT imaging.
- However, one critical caveat of the MVUS approach is the sacrifice of the data due to penumbra. In this work, we propose a new MVUS filter that has a spiral aperture to minimize the effects of penumbra.
- Additionally, a hybrid approach to low-dose CT that combines with the low tube current method has been investigated.

Methods
Spiral filter for many-view under-sampling (MVUS)

Fig. 1 Diagram of MVUS spiral filter.

Sampling density
- Sampling density was calculated to explain the reconstructed image quality from the sampling point of view.

Fig. 2 Sinogram from mid-plane of MVUS spiral filter. (Fig. of slits: 12, opening rate: 20)

Fig. 3 Double-slit spiral MVUS filter for penumbra reduction.

Results
- A comparative study was also conducted that includes both mAs and opening rate of spiral MVUS.

TABLE 1. Simulation condition and geometry

<table>
<thead>
<tr>
<th>Trajectory</th>
<th>Circular trajectory</th>
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<tbody>
<tr>
<td>Phantoms</td>
<td>Low contrast numerical phantom</td>
</tr>
<tr>
<td>Poisson noise</td>
<td>considered</td>
</tr>
<tr>
<td>Electronic noise</td>
<td>considered</td>
</tr>
<tr>
<td>Reconstruction algorithm</td>
<td>POCS-TV</td>
</tr>
<tr>
<td>Projection views</td>
<td>720</td>
</tr>
<tr>
<td>Detector size (mm)</td>
<td>320/1.56</td>
</tr>
<tr>
<td>Detector pixel</td>
<td>1024x512</td>
</tr>
<tr>
<td>Recon image size</td>
<td>512x512</td>
</tr>
<tr>
<td># of slits</td>
<td>8, 12, 16</td>
</tr>
<tr>
<td>Rotation speed (rot/scan)</td>
<td>10, 20, 30, 40</td>
</tr>
</tbody>
</table>

Fig. 4 A representation of a 2D image array with orthogonal set of equispaced parallel lines in shown. The rows and the columns are indexed by i and j, respectively.

Fig. 5 2D sampling density distribution and reconstructed images depending on various parameters of proposed filter.

Fig. 6 Reference image using 180 mAs without MVUS filter.

Fig. 7 ROIs of reconstructed images depending on mAs and opening rate.

Conclusions
- We proposed a new type filter for many-view under-sampling technique. Spiral MVUS filter is easy to implement in a diagnostic CT gantry and provides useful data in the sparse sampling context. Our feasibility study examined optimal parameters of the spiral MVUS filter. In addition, from a comparative study, a combination of low tube current and sparse sampling has been investigated in the TV minimization image reconstruction framework.

References