Digital X-ray Tomosynthesis of Planar Objects Using the View-Interpolation Method

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Background

- In the manufacturing process, the defects detection in thin-slab objects is regarded as an indispensable procedure and the digital tomosynthesis (DTS) method can be appropriately used for this application.
- The DTS method needs a wide scan angular scope and a small step angle for less out-of-plane artifact and less noise in the reconstruction image [Timothy et al. SPIE. (2007)].
- The method in a step-and-shoot fashion can suffer from the trade-off between the image quality and the inspection time.

Objective

- Augmenting a few number of projection images by view-interpolation (VI) method
  1. To reduce the time for the inspection of planar objects
  2. To gain higher image quality than the conventional reconstruction image

View-interpolation method

- For the interpolation, two projection images are used.
- However, when the arbitrary voxels of object are irradiated, they are positioned on the detector plane depending on the projection angle.
- For this reason, the re-position process is required for the interpolation.

Re-position process

- Coordinates conversion relation
  \[ \begin{align*}
  \mathbf{u} &= \mathbf{x} \sin \alpha + \mathbf{y} \cos \alpha, \quad \mathbf{u} = \mathbf{z} \\
  \mathbf{v} &= \mathbf{x} \cos \alpha - \mathbf{y} \sin \alpha \\
  \mathbf{u} &= d \left( \mathbf{x} \sin \alpha + \mathbf{y} \cos \alpha \right) \\
  \mathbf{v} &= d \left( \mathbf{x} \cos \alpha - \mathbf{y} \sin \alpha \right)
  \end{align*} \]
- Position of a target voxel on the detector plane
  \[ (u, v) = \left( d \mathbf{x} \sin \alpha + d \mathbf{y} \cos \alpha \right) \]
- Correlation of the coordinates at \( \alpha' \) with \( \theta' \)
  \[ (u', v') = \left( d \mathbf{x} \sin \alpha' + d \mathbf{y} \cos \alpha' \right) \]
- Re-positioning operator
  \[ R_{\theta}^d(P_a(u, v)) = P_a \left( m_a \frac{m_a \cos \alpha}{d}, m_a \frac{m_a \sin \alpha}{d}, m_a \frac{m_a}{d} \right) \]

Interpolation process

- Applying the weighting factor to neighboring images
  \[ p_d(u, v) = w_{\theta} R_{\theta}^d (P_a(u, v)) + (1 - w_{\theta}) R_{\theta - \Delta\theta}^d (P_a(u, v)) \]

Results

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source to detector distance (SDD)</td>
<td>665.86 mm</td>
</tr>
<tr>
<td>Object size (SOD)</td>
<td>4 mm</td>
</tr>
<tr>
<td>Voxel size</td>
<td>0.099 mm</td>
</tr>
<tr>
<td>Pixel size</td>
<td>0.066 mm</td>
</tr>
<tr>
<td>Scan angle</td>
<td>443.91 mm</td>
</tr>
<tr>
<td>Step distance</td>
<td>2.5 mm</td>
</tr>
<tr>
<td>Reconstructed size</td>
<td>1548 x 1032</td>
</tr>
<tr>
<td>Step angle</td>
<td>0.9 mA</td>
</tr>
<tr>
<td>Integration time</td>
<td>275 ms</td>
</tr>
<tr>
<td>Reconstruction time</td>
<td>1 mm</td>
</tr>
</tbody>
</table>

Discussion & conclusion

- The VI method can improve the signal characteristic but not beneficial enough to compare with the reference reconstruction image. Therefore, it is proper to use the VI method where the top priority is the inspection time.
- As scan angle increases, the SDNR increases as well. Using this information, we expect that the VI method can be applied to the computed tomography.

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP) (No. 2013M2A2A9014313).