Head imaging with C-arm CT: Investigation on the impact of data redundancy handling and orientation of the scanning plane on image quality

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Motivation

- FDK-type algorithms like SS-FDK do not properly handle data redundancy.
- Location/shape of bones within the skull (e.g., petrous bone) relative to scanning plane can yield significant CB artifacts.
- Can image quality in C-arm CT imaging of the head be improved by:
  - employing a reconstruction algorithm that properly accounts for data redundancy, like the ACE* method
  - applying a change in the orientation of the scanning plane to emulate the gantry-tilt geometry used in diagnostic CT

FDK and data redundancy

- FDK is based on fan-beam reconstruction
- Rays that lie in the same transaxial plane are assumed to be redundant
- The assumption only applies to the rays in the trajectory plane, or when the object is constant in z
Proper handling of data redundancy

- CB projections are related to plane integrals, as expressed by Grangeat’s formula
- Any plane integral intersecting the source trajectory is measured: planes that have two intersections are measured twice; others are measured once
- FBP reconstruction using equal weighting for all measured planes is possible: e.g. ACE algorithm
Tilted geometry

- Data acquisition with a tilted source trajectory changes the set of measured plane integrals, hence can change image quality
Experiment set-up (conventional head scan protocol)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from source to isocenter (R)</td>
<td>786 mm</td>
</tr>
<tr>
<td>Distance from source to detector (D)</td>
<td>1198 mm</td>
</tr>
<tr>
<td>Radius of the FOV (r)</td>
<td>120 mm</td>
</tr>
<tr>
<td>Scanning range</td>
<td>198°</td>
</tr>
<tr>
<td>Number of projections</td>
<td>496</td>
</tr>
<tr>
<td>Tube voltage</td>
<td>109 KVP</td>
</tr>
<tr>
<td>Detector pixel size</td>
<td>0.308 mm</td>
</tr>
<tr>
<td>Detector size</td>
<td>1240×960</td>
</tr>
<tr>
<td>Volume voxel size</td>
<td>0.49 mm</td>
</tr>
</tbody>
</table>
SS-FDK v.s. ACE
Gray scale: [-200,200] HU
SS-FDK

ACE

Gray scale: [-200,200] HU
Non-tilted v.s. tilted geometry
non-tilt  

tilt
Gray scale: [-200,200] HU
non-tilt
SS-FDK

Gray scale: [-200,200] HU

tilt
SS-FDK
SS-FDK
Non-tilt ACE

Tilt ACE

Gray scale: [-200,200] HU
Gray scale: [-200, 200] HU
ACE

Graph showing Hounsfield Units (HU) with ACE non-tilt and ACE tilt compared.
Conclusion and discussion

- C-arm CT imaging of the head can be significantly improved using an algorithm that properly accounts for data redundancy.
- Orienting the scanning plane to emulate a gantry tilt is not beneficial for reconstruction with SS-FDK.
- Impact of the tilt on reconstructions with ACE was shift-variant: the tilt provided benefits at some locations at the cost of degraded image quality at other locations.
- If a region-of-interest is a-priori known, a better image quality can benefit from a tilted scanning plane with ACE.
- Further experiments on tilted scanning planes are needed.
Thank you!

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