

Spiral-CT

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1 Motivation

Spiral-CT offers reconstruction of long objects compared to circular filtered backprojection, where reconstruction is limited in z-direction. While the object moves constantly through and rotating source, the acquired data is distributed along a spiral around the object. For this helical movement the known reconstruction techniques had to be changed. The talks so far presented also physics, fan-beam geometry, parallel rebinning and the filtered backprojection.

2 3D helical reconstruction algorithms

2.1 Algorithms

Many reconstruction algorithms were developed for the 3D helical case. They are divided into two classes, exact and approximative reconstruction. This is a short overview of the 3D helical reconstruction algorithms development:

- exact reconstruction algorithms
 - Kudo *et al.* 1998
 - Tam *et al.* 2000
 - Schaller *et al.* 2000
 - Katsevich *et al.* 2002
- approximative algorithms
 - Larson *et al.* 1998
 - Kachelriess *et al.* 2000
 - Bruder *et al.* 2000
 - Schaller *et al.* 2001
 - Flohr *et al.* 2003
 - **Stiersdorfer** *et al.* 2004

2.2 Challenges

This presentation focus the reconstruction algorithm by Stiersdorfer et al. . He has formulated the challenge to develop such a algorithm, because the computational complexity for exact algorithms is significantly higher compared to approximative ones. Also exact algorithms are not able to deal with redudant data. Stiersdorfer also wanted to improve the quality of approximative algorithms concerning the cone angle, because most approximative algorithms produces good images up to a cone angle of 3.2° .

3 3D Weighted FBP

3.1 Goales for Stiersdorfer

For Stiersdorfer a multislice spiral algorithm for medical applications should satisfy the following criteria:

1. good image quality (clinical)
2. dose efficient
3. able to use variable pitch
4. capable to cope redudant or missing data
5. reconstruction time should be suitable for clinical needs

The segmented multiple plane reconstruction algorithm (SMPR), developed also by Stiersdorfer et al. fulfils these demands for cone angles up to 6.4° , but is computationally not very effective. To improve this he developed the WFBP.

3.2 WFBP

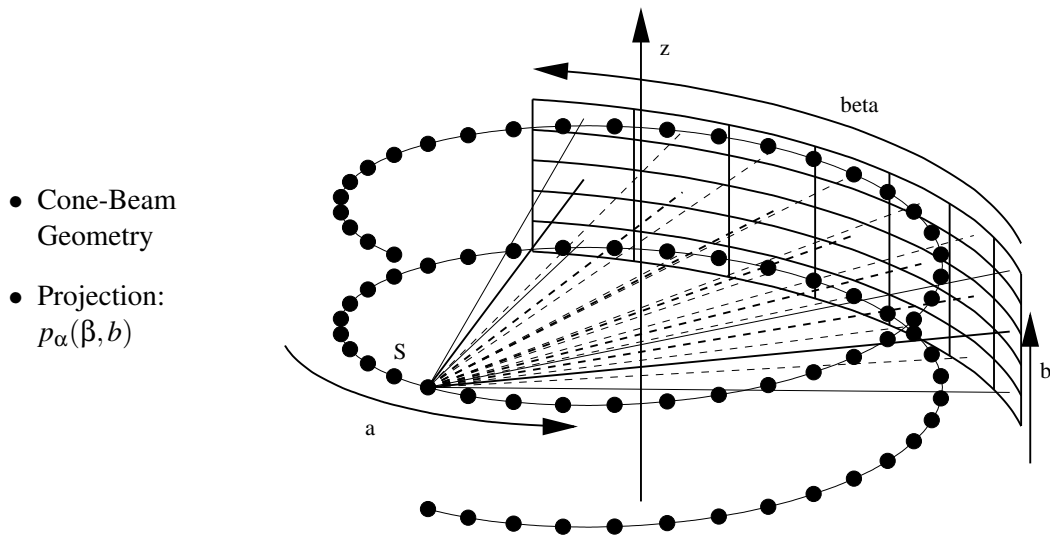
Weighted filtered backprojection (WFBP) was published in 2004 by Karl Stiersdorfer, Annabella Rauscher, Jan Boese, Herbert Bruder, Stefan Schaller and Thomas Flohr. The WFBP algorithm fulfills Stiersdorfer goal and has the following structure:

- rebinning
- filtering
- weighted backprojection

To introduce how the algorithm works first the geometry has to be shown.

3.3 3D Geometry

The 3D Geometry for helical reconstruction algorithms consists of an object along the z-axis. This object moves constantly in z-direction while the source is rotating. So the acquisition data based on several cone-beams also named projections. Each projection-beam is defined by the rotation angle α for source-point s , the fan-angle β and the row component.

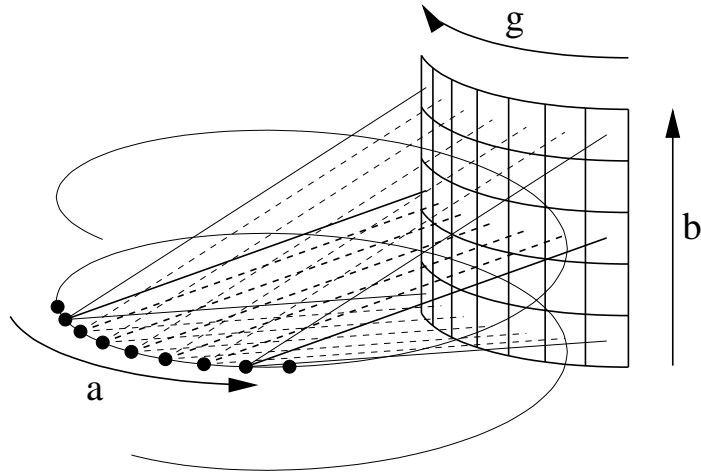


The difference in z-direction per rotation is defined by the pitch. While the source is rotating around the object with radius R .

3.4 3D Rebinning

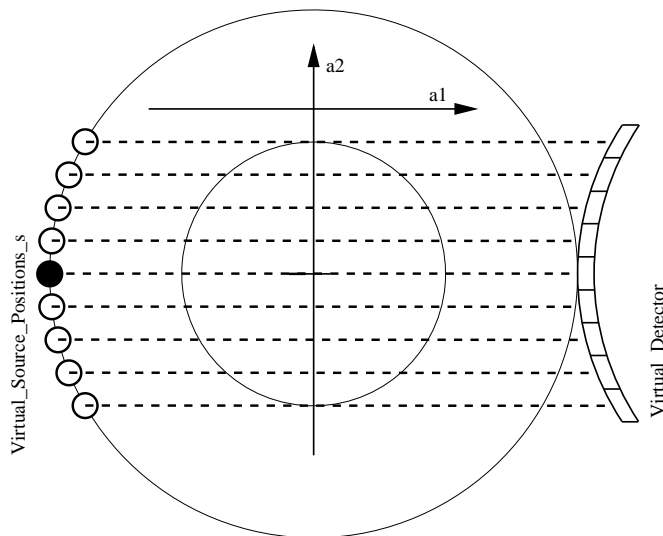
The rebinning of projection is done similar like in the 2D case. For this algorithm azimuthal rebinning technique is used. The rebinning results in an array of parallel fan-projections. So the rebinned projection data is filtered line by line.

- 3D Rebinning is done like 2D Rebinning, but per detector row.
- The picture shows Azimuthal Rebinning.



3.5 Filtering

WFBP is similar to filtered backprojection. So normal high-pass filtering is done in row-direction. Because of rebinning the resulting pseudo parallel projections looks like the following situation.



The presented algorithm differs from the FBP in the last step, the backprojection.

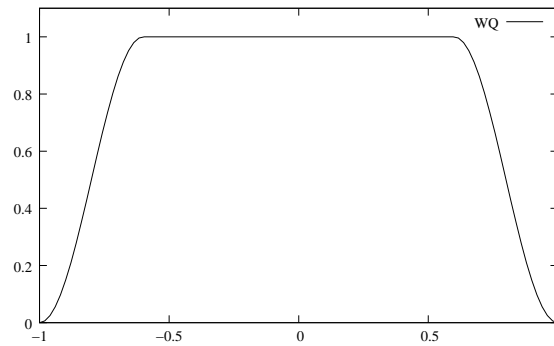
3.6 Backprojection

In Mario Körners talk about 3-D Cone-Beam reconstruction, the backprojection was already explained in detail. The normal backprojection is done by backprojecting each projection in the volume. Here Stiersdorfers introduced weighting takes place. Instead of adding up the calculated increment directly to the volume it is weighted with the following weighting function $w_Q(q)$.

$$q = \frac{2b}{h_D}$$

b is row component

h_D hight of the detector



Practicle this means, that the projection data, recieved in the upper and lower rows of the detector, is attenuated.

4 References

K. Stiersdorfer, A. Rauscher, J. Boese, H. Bruder, S. Schaller and T. Flohr, Weighted FBP - a Simple Approximate 3D FBP Algorithm for Multislice Spiral-CT with Good Dose Usage for Arbitrary Pitch. *Physics in Medicine and Biology*, 49(11):2209-2218, 2004

Marion Körner, 3D Cone-Beam Reconstruction. Presentation MB-JASS, 2006

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