Spiral-CT

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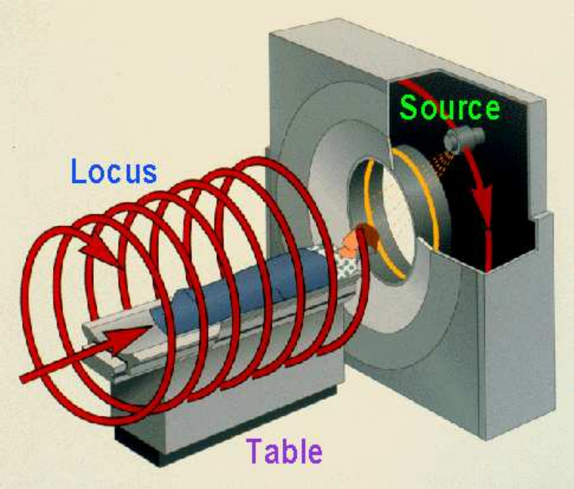
Outline

Motivation Spiral-CT

- Circular FBP is limited in z-direction
- Constant movement throw the rotating source
- This results in a helical movement



Supposition

- Physics
- Fan-Beam-Geometry
- Parallel Rebinning
- Filtered Backprojection

Overview helical reconstruction algorithms

- 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.* 200
  - Bruder *et al.* 2000
  - Schaller *et al.* 2001
  - Flohr *et al.* 2003
  - **Stiersdorfer** *et al.* 2004

Challenges

- computational complexity for exact algorithms is significantly higher
- exact algorithms are not able to deal with redundant data
- most approximative algorithms produces good images up to cone angle of 3.2°

Goales for Stiersdorfer *et al.* 2002

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) fulfils these demands for cone angles up to 6.4°, but is computationally not very effective.

3D Weighted FBP

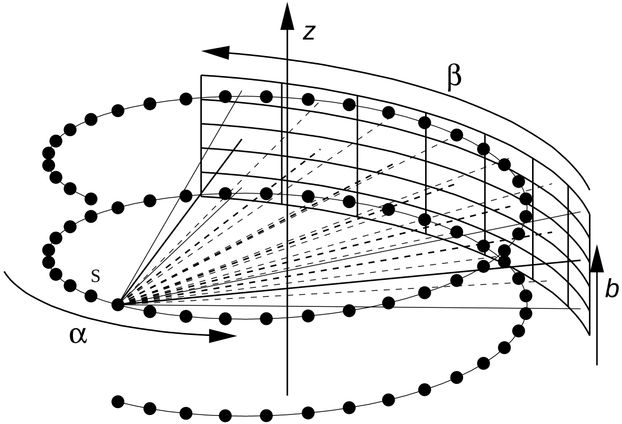
Weighted filtered backprojection (WFBP) published 2004 by Karl Stiersdorfer, Annabella Rauscher, Jan Boese, Herbert Bruder, Stefan Schaller and Thomas Flohr

Algorithm structure:

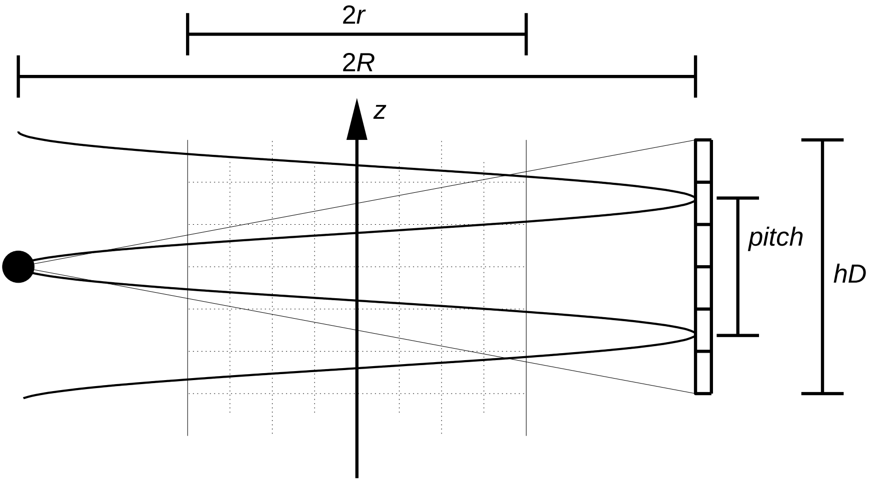
- rebinning
- filtering
- weighted backprojection

3D Geometry (1)

- Cone-Beam Geometry
- Projection: $p_\alpha(\beta, b)$

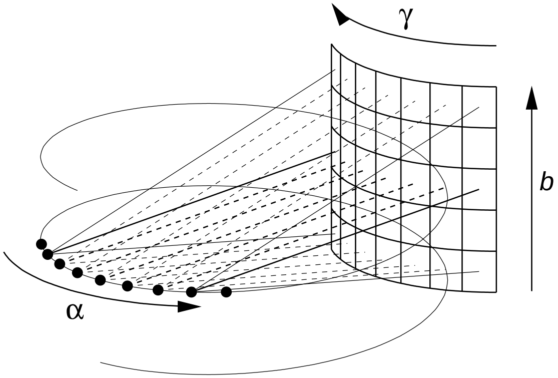


3D Geometry (2)



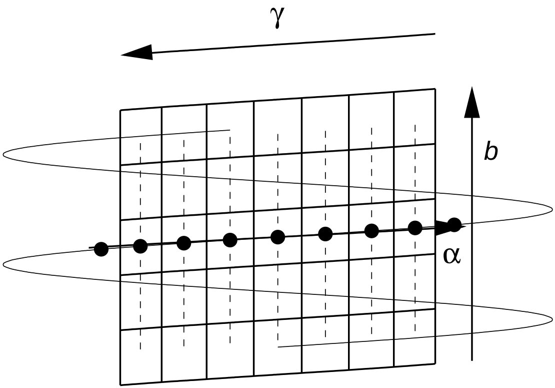
3D Rebinning (1)

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



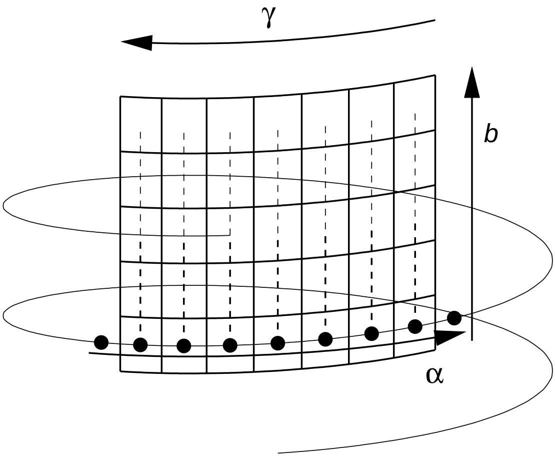
3D Rebinning (2)

- The view parallel to the horizontal rays shows almost no error.
- The sources are on the helix shaped trajectory, so the rays can't be on one plane.
- The Virtual Detector is in the background, the sources are in the foreground.



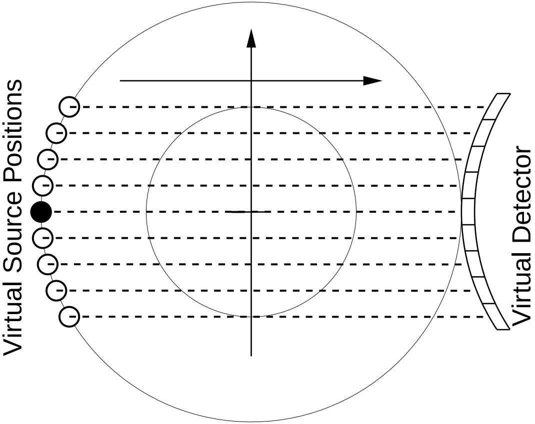
3D Rebinning (3)

- Looking parallel to the rays through the lowest row of the Virtual Detector
- The rays are not in a plane, but are filtered along this curve. That's why it's called a inexact reconstruction.



Filtering

- Filtering is done in row-direction
- Each row of the pseudo-parallel projections is filtered with a high-pass filter



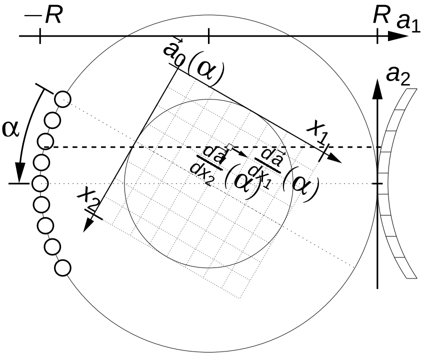
3D Backprojection (1)

- $\frac{da_1}{dx_i}$ in Detector Columns
- $\frac{da_2}{dx_i}$ in *mm*
- x_i in Voxel
- $\vec{a}(\alpha, x_1, x_2) =$

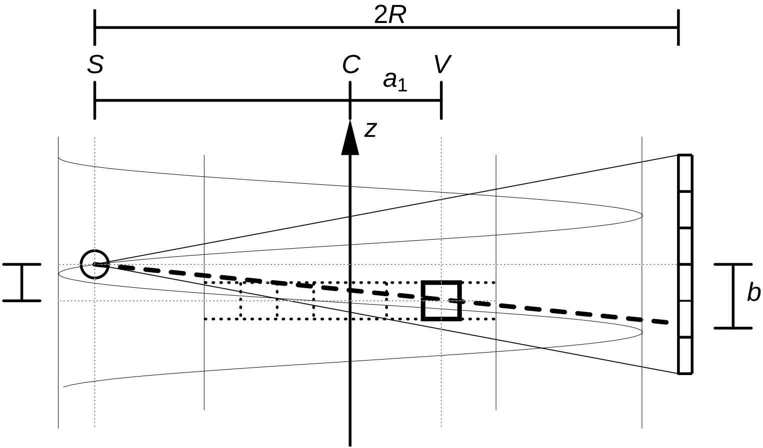
$$= \vec{a}_0(\alpha) + \\ + x_1 \frac{d\vec{a}}{dx_1}(\alpha) + x_2 \frac{d\vec{a}}{dx_2}(\alpha)$$

- $\vec{a}(\alpha, x_1 + 1, x_2) =$

$$\vec{a}(\alpha, x_1, x_2) + \frac{d\vec{a}}{dx_1}(\alpha)$$



3D Backprojection (2)



3D Backprojection (3)

Backprojection in principle the same:

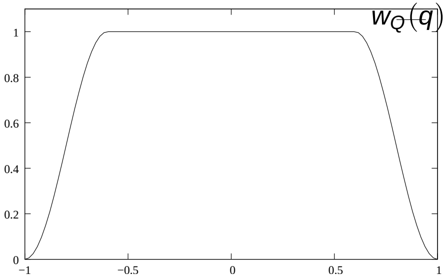
- Transform $v = (x_1, x_2, z)^T$ to rotated coordinate $v' = (a_1, a_2, z)^T$
- Calculate virtual source position $s_\alpha(a_2)$ through the voxel v'
- Interpolate corresponding projection value $p_\alpha(a_2, b)$
- Add up this value to voxel's result

3D Backprojection (4)

But $p_\alpha(a_2, b)$ is not add up directly, it's weighted by function w_Q(q) before.

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

b is row component
h_D hight of the detector



Thank you for Attention

Any Questions?