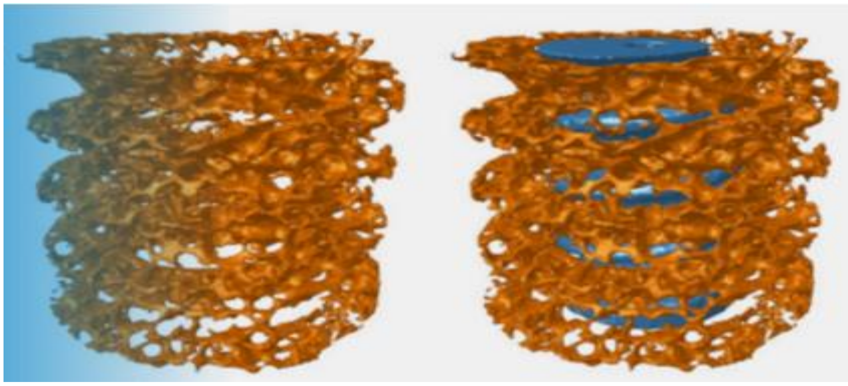

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Scanning Trajectories and Reconstruction Algorithms

By Bruker microCT, Belgium

In this microCT article, we focus on scanning trajectories and the associated topic of reconstruction algorithms. The differences between circular and helical scanning are highlighted. You will see how the quality of reconstruction and reconstruction speed are affected by using different scanning trajectories and reconstruction algorithms.

To get suitable tomographical reconstruction data, movement of the object or source-detector pair can be done in different ways. In the simplest case, the object or source-detector pair is just rotated during the scan, creating a circular trajectory for acquisition geometry. Using more complicated movements, with simultaneous or sequential rotation and translation, creates non-circular acquisition geometries. With special reconstruction algorithms appropriate for a particular acquisition geometry, one can significantly improve the accuracy of the reconstructed results and suppress different artifacts, which may appear on reconstructions from circular scanning. In the SKYSCAN system range, solutions for both circular and non-circular (helical) scanning trajectories exist.

Circular Trajectories

In most situations, the simplest trajectory with fast, but approximate, reconstruction is a circular one. With a relatively small opening angle of the cone beam along the rotation axis, circular trajectories produce reconstruction results very close to the internal structure of scanned objects. The need to scan long objects, which cannot fit in one vertical camera field of view, or to increase the scanning speed by using a short source-detector distance with a big opening angle of the beam, may increase differences between the reconstructed results and the real object structure.

Filtered Back-Projection, the Feldkamp Algorithm

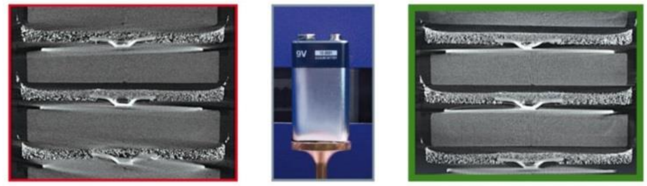
The most popular reconstruction algorithm for cone-beam tomographical systems is a filtered back-projection algorithm originally developed by Feldkamp, Davis and Kress, published in 1984 and later named according to the first letters of the developers' names as an FDK algorithm. NRecon utilizes the FDK algorithm as a standard and performs such reconstruction using CPU with multithreading (NReconServer engine) or acceleration with GPU on graphics cards (GPUReconServer engine). Typically, graphics cards will outperform CPU as can be seen from the table with reconstruction speeds on the website.

Hierarchical Reconstruction

Besides hardware acceleration for reconstruction (by using graphics cards or clusters), another option is to use a more efficient algorithm. The fast, hierarchical back-projection algorithm does precisely this. By dividing the reconstruction volume into smaller ones, requiring fewer projections for reconstruction, significant speed-ups can be achieved. This is especially true for larger datasets, as can be observed from the table. The InstaRecon® together with our partner InstaRecon Inc. For more information on InstaRecon® and interesting further engine for NRecon uses a hierarchical reconstruction algorithm and was developed reading, we kindly refer you to their website. Additional information can also be found in Method Note *MN109 - Reconstruction algorithms and engines for NRecon*.

Helical Trajectory and Exact Reconstruction

A helical scanning trajectory involves simultaneous object rotation and translation along the rotation axis during data acquisition. In contrast to circular scanning, it respects Tuy's data sufficiency condition, which defines possibilities for exact rather than approximate tomographical reconstruction. This implies that in a number of cases, especially in scanners with wide opening of the X-ray beam, certain reconstruction artefacts, such as blurring at surfaces perpendicular to the rotation axis at high cone angles, can be eliminated (as illustrated in the images of the battery below)



Two vertical slices through a 9-V battery are shown from scans made with the SKYSCAN 1272. For the image on the left, a circular trajectory was used; for the image on the right a helical trajectory was used. An exact reconstruction algorithm was used for the reconstruction of the helical scan data.

and long objects can be investigated without stitching of multiple partial scans. To unlock the full potential of helical scanning, an exact reconstruction is required. Bruker microCT recently added this functionality to the NRecon software together with our partner iTomography™ (https://www.itomography.com). For more information on this fascinating topic, we refer you to Method Note *MN106_Spiral Scanning*.

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