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The influence of reconstruction methods on measurements in CT-volumes

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Abstract

In industrial Computed Tomography (CT) the state-of-the-art reconstruction method for cone-beam CT is the well-known algorithm developed by Feldkamp, Davis, and Kress (FDK). Beside this standard several alternative strategies exist which involve certain advantages depending on the application of interest, e.g. the usage of prior knowledge or arbitrary trajectories by using algebraic reconstruction techniques (ART). These approaches have a higher computational complexity compared to the FDK. However, with the increasing computational power in the last years, these reconstruction techniques become more and more applicable.
Regarding metrology there are two main influencing factors for accurate measurement results: the projective geometry and the imaging chain. The quality of the projective geometry can be measured by SD and the image quality for example by the modulation-transfer-function (MTF) and contrast-discrimination-function (CDF) following ASTM E 1695. The last part of the imaging chain is the volume reconstruction method. Especially for bidirectional measurement the internal or external boundary surface has to be determined very accurate. Potential X-ray imaging artifacts due to certain material and object shape influences will lead to distortion of the found boundary surface. If a new algorithm is used these distortions might change and it is important to know the expected effect on the final measurements.
In this extended abstract the results of an ART reconstruction are compared with the FDK-results regarding the quality of the projective geometry and the imaging chain as well as varying the number of projection images. Based on this comparison a conclusion is possible how metrological applications may be influenced by a chance of the reconstruction strategy and a reduction of the number of images.

1. Introduction

Recently, metrological applications become more and more popular in industrial computed tomography (CT). The final image quality is important for the surface extraction and the resulting metrological measurements. The surface nature depends on the type of volume reconstruction as well as on the corresponding reconstruction parameters. Depending on the strategy the resulting image quality and the accuracy of the measurements may vary significantly. The number of used projection images has certain influence on the image quality but also on the acquisition time (1). In the ideal case the image quality is optimal while the acquisition time or (equivalent) the number

of projection images is small. In reality, using fewer projection images reduces the image quality if the standard Feldkamp-Davis-Kress (FDK) reconstruction (2) is used.
Figure 1 shows a sequence of FDK-reconstructions with varying number of used projection images (example slice in column 1, surface rendering in column 2). Choosing the number of images too small causes severe sampling artifacts overlaying the object information (e.g. see FDK-results with 40 projection images). With increasing number of projection images these artifacts are reduced until nearly no differences are visible between their reconstructions.

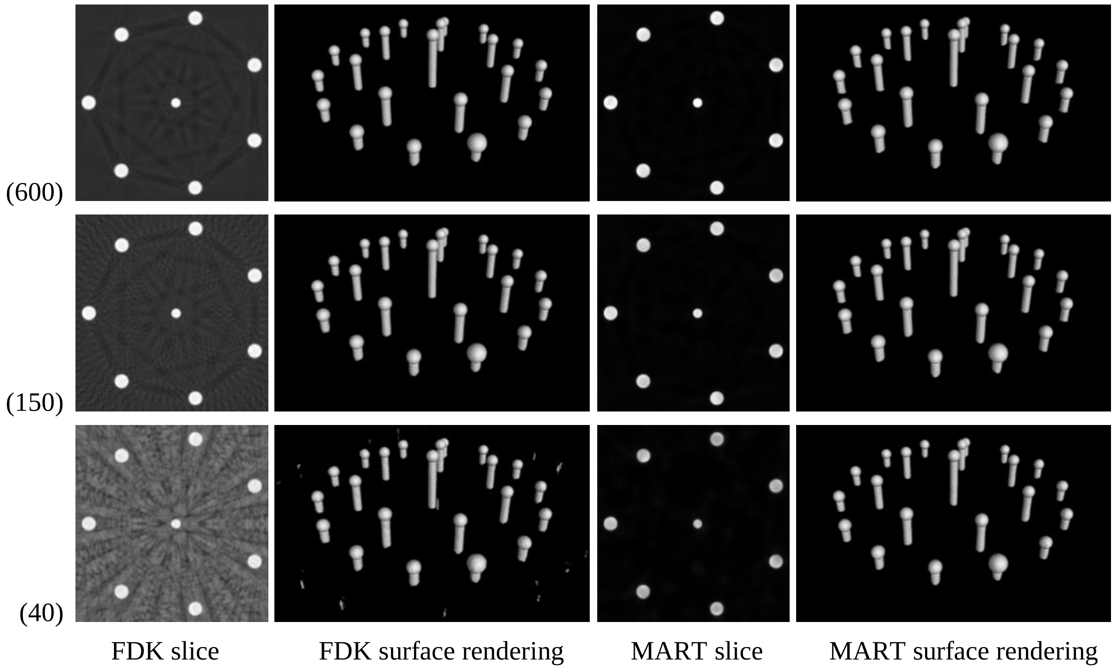

Figure 1. Example of the same CT-scan reconstructed with FDK (first two columns) and MART (second two columns) using varying number of projection images (row-wise 600, 150, and 40). With fewer images the intensity of artifacts increases with FDK.

A further increase of the number of images would result only in an extension of the acquisition time and a slight increase of the signal-to-noise-ration (SNR). However, the overall quality impression will not change any more.

2. Material and Methods

Since the FDK-reconstruction results in artifacts for fewer projection images one approach is to achieve fast acquisition time and optimal image quality by using alternative reconstructions. Here, an algebraic reconstruction technique (ART) (3) is regarded as FDK-alternative. The here used ART-method uses an multiplicative update term, also named as multiplicative ART (MART) (5) since previous publications showed promising image quality if less projection data is available (6).
In the field of metrology the main task is to know how accurate a measurement is. This can be determined using standard objects and measurement procedures, e.g. a sphere standard with corresponding sphere distances errors (SD) (4). This kind of object (see Figure 1) has been used to determine the following analysis of the modulation-transfer-function (MTF), SNR (each at the largest sphere), and an SD-evaluation for all spheres.

3. Results and Conclusion

The same CT-data has been reconstructed with varying number of projection images using FDK and MART. The MTF (Figure 2 first plot) is higher for MART which corresponds to a higher spatial resolution. Furthermore, the SNR is higher for all MART reconstructions so that a surface extraction is more accurate than using the FDK (Figure 2 second plot). Finally, the SD-values converge to similar SD-values with increasing number of projection images (Figure 2 third plot). It was also noticed that the MART yields results with too high object edges. This behavior becomes less intense with increasing number of projection images. Future evaluations should take bidirectional measures into account as well.

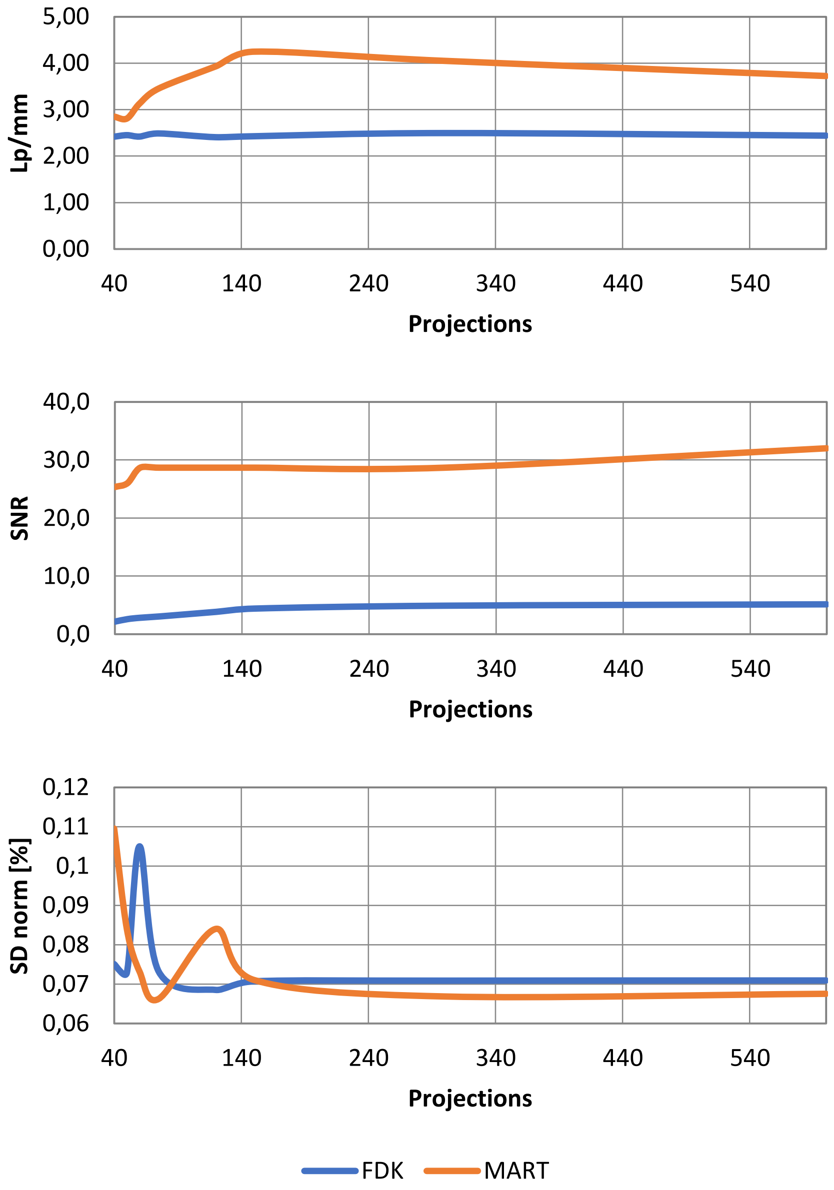

Figure 2. (first) MTF at 10% in line pairs per mm, (second) SNR-values and (third) SD-values for FDK and MART with varying number of projection images used for reconstruction.

References and footnotes

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