

Blob-based Algebraic Reconstruction Technique for Computed Laminography

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Computed Laminography (CL) is an X-Ray based technique for acquiring flat samples, meaning one dimension of a sample is much smaller than the others. Tailored to this technique the CLARA geometry setup [1] is used to gather projections of a specimen. These projections are processed by an iterative algorithm based on the Kaczmarz method to obtain a three dimensional dataset of the specimen. This class of algorithms suffers from artifacts, especially for datasets with a poor signal-to-noise ratio (SNR) and when only a limited number of projections is available. We proposed a new method based on the simultaneous algebraic reconstruction technique (SART), where voxel basis functions are replaced with blob basis functions that have band-limiting properties to suppress artifacts [2].

Blobs are spherically symmetric volume elements that have a ball shape as opposed to voxels, which have a cubic shape. In real space blobs have a compact support, that means blobs enforce band-limiting properties and radial symmetry. We implemented SART based on blobs and based on voxels in the framework Ettention [3]. The different geometric setup of CL compared to standard Computed Tomography setups was adapted in the SART formulation, so that forward and backward projections could be implemented easily for iteratively reconstructing the three dimensional volume.

To evaluate the new method, a welded aluminum piece with a crack was recorded using the CLARA geometry. Two datasets were acquired, projections with low noise and a SNR of 9.0, and projections with high noise and a SNR of 6.12. Reconstructions were performed based on 100 and based on 400 projections for both sets. The four different setups were compared for voxel based and for blob based reconstructions. Besides visual inspection two statistical figures of merit were computed for evaluation. For assessment of the reconstruction quality the full width at half maximum (FWHM) of the point spread function and the slope of edge profiles were measured at different positions in the reconstructed volume.

For each setup we determined the optimal reconstruction experimentally. The best results of each setup were then compared. The reconstructions of low noise data were similar in quality with blobs and voxels. However, the high noise data reconstructions for blobs had a significantly higher resolution than those with voxels, which was mirrored by p-values from a two-tailed t-test below $2.3 \cdot 10^{-4}$ for FWHM and below $2.2 \cdot 10^{-16}$ for slopes. A visual comparison (Figure 1) confirmed this result.

The presented blob based reconstruction scheme for laminographic datasets is superior to normal voxel based approaches, especially when a high level of noise is present and with a small number of input projections that does not fulfill the Crowther criterion. The superior reconstruction quality was assessed quantitatively using FWHM, slopes of edge profiles, and SNR. Consequently, it is recommendable to use blobs as basis function for laminography data reconstructions. Blobs deliver equal or better results in all investigated cases in terms of resolution and sharpness, which makes interpretation of reconstructed samples easier due to a facilitated structure identification. Additionally, the presented method may help to save dose for acquiring projections while not losing resolution [4].

References:

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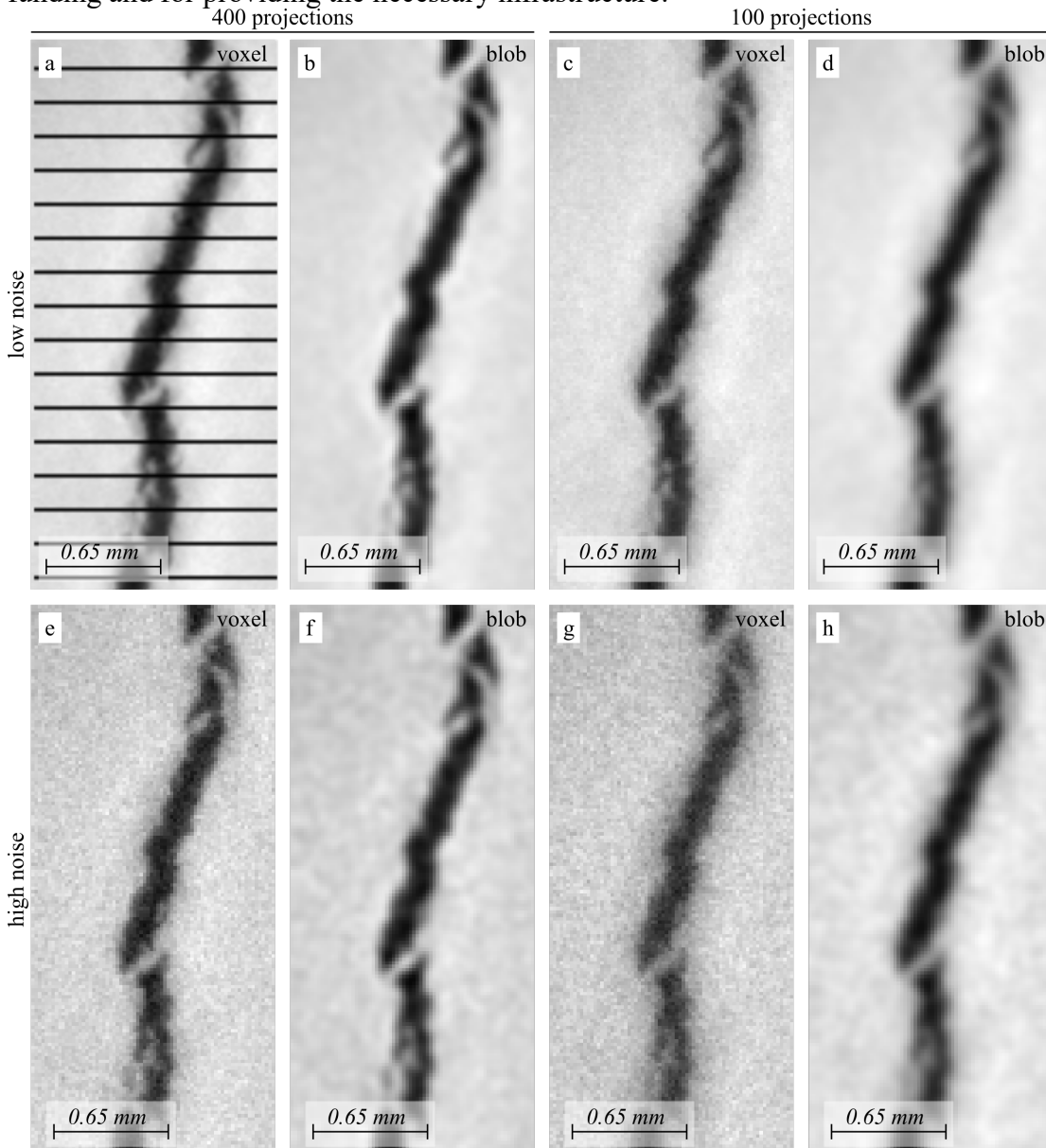


Figure 1. Reconstruction of a crack with different setups. Each image shows the used basis function (voxel or blob). a),b) 400 low noise projections, additionally, line profiles of statistical analysis are given, c),d) 100 low noise projections, e),f) 400 high noise projections, g),h) 100 high noise projections.