Artefact reduction by the incorporation of a priori compositional information into the tomographic reconstruction

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Summary: We present a case study of the implementation of an iterative reconstruction method where *a priori* information about the sample composition is used to suppress artefacts due to beam hardening and Compton scattering. This allows for the defects/porosity within the sample to be easily segmented out.

1. INTRODUCTION

As lab-based cone-beam micro-CT systems have become more broadly adopted in materials science research, there is an increasing focus on artefact free high quality 3D data that can be used for quantitative analysis of samples, such as typical metal parts (*e.g.*, 3D printed metals or welded metal connections). Complex interactions between different physical phenomenon, such as beam hardening and Compton scattering in such samples, cause inconsistencies between the underlying physical model used in standard tomographic reconstruction, and in the projection data. This inconsistency will in turn frequently lead to significant artefacts that cannot be properly corrected for during post processing analysis. Because of such artefacts, there is a need to adapt the reconstruction method to deal with such artefacts. The most natural choice is then to use an iterative reconstruction scheme, where modifications to the underlying physical model, geometric and compositional *a priori* information can be incorporated into the X-ray propagation model.

We present here a case study where *a priori* compositional information about the sample is used as part of an iterative reconstruction to identify and suppress the effects of scatter and beam hardening. We demonstrate significant improvement in the ability to perform defect detection and porosity analysis based on the resulting tomographic images.

2. EXPERIMENTAL METHOD

The HeliScan micro-CT, a lab based cone beam system, was used to acquire a helical space-filling trajectory [1] scan of a Inconel 718 nickel chromium alloy metal sample. The sample studied has a cross section of ~4.5mm x ~6.5mm, which at full resolution resulted in a final tomogram with a voxel size of 3.2µm. Due to the density of the sample, 5mm of aluminum was used as a beam filter. The scan was taken with a large cone angle of ~60 degrees to maximize the signal and the ~8000 projections of the scan were collected over 15 hours.
Angle dependent variation of filter thickness (due to an ~60° cone angle), beam hardening due to the sample density/thickness, and inconsistencies between projected thickness of the sample and the measured X-ray intensity due to Compton scattering only visible at particular angles of rotation due to the cross sectional sample geometry(figure 1), were all identified as contributing to significant artefacts in the reconstructed data (Figure 2a). This complex overlay of artefacts caused contrast variation in the bulk material, and subsequent analysis of the data was abandoned.
To correct for this an iterative reconstruction method that explicitly uses information about the single-material nature of this sample, was applied to the same scanned data.

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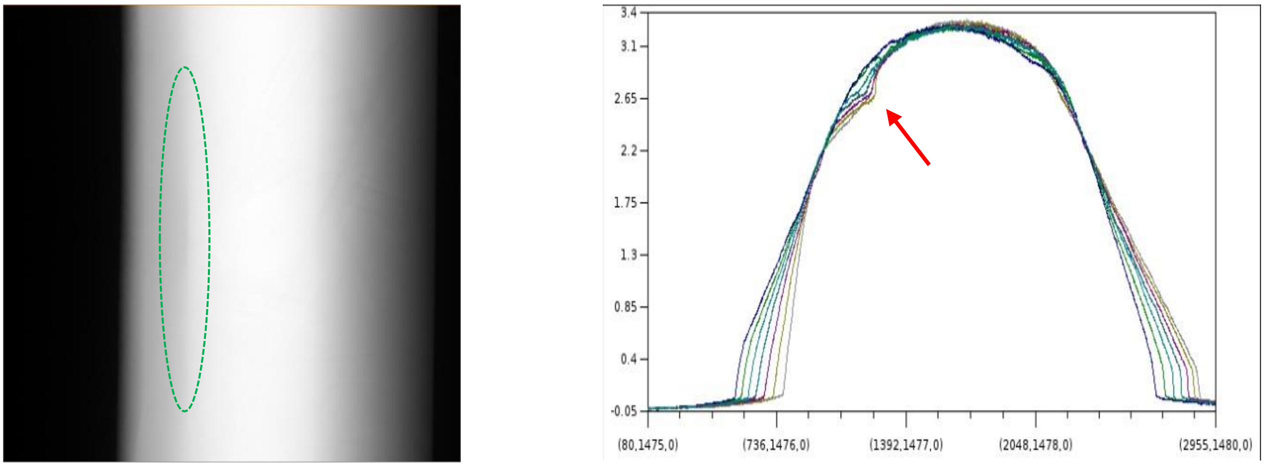
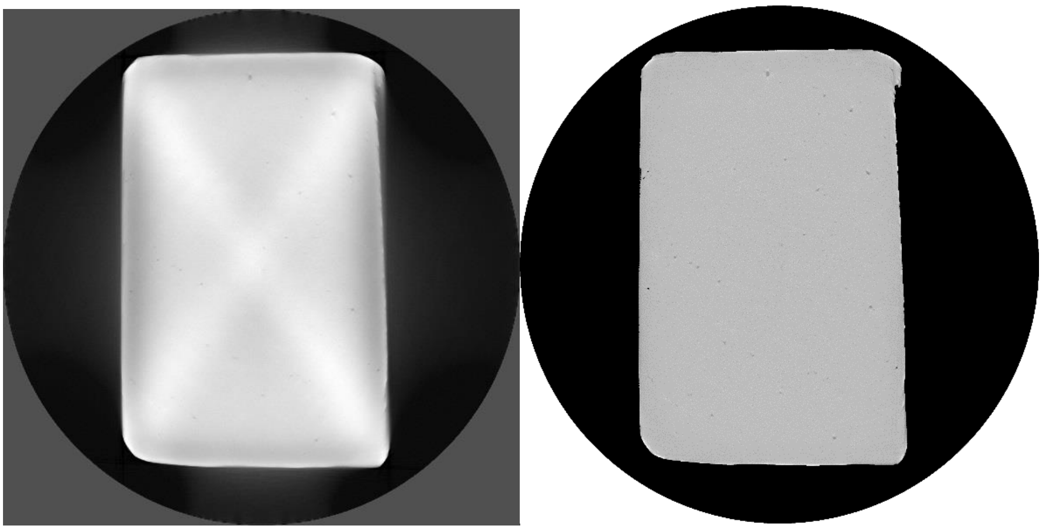
3. RESULTS

The resulting tomogram using the normal iterative approach with an empty volume as the initial starting point (with no beam hardening correction applied) contained significant artefacts (figure 2a) that prevented the segmentation of the porosity within the sample. The new method of iterative reconstruction resulted in a uniform contrast throughout the 3D data (Figure 2b), allowing for the porosity within the sample to be analyzed.



(a) **(b)**

Figure 1: (a) Linearized projection showing a darkening inconsistency (green oval) due to compton scattering. (b) graph of linearized attenuations from consecutive projections showing the bump (red arrow) due to Compton scattering



(a) **(b)**

Figure 2: (a) central Z orthogonal slice from the normal iterative reconstruction showing the variation of contrast across the sample due to the artefacts and (b) Same central Z orthogonal slice from improved iterative reconstruction method.

References

[1] Kingston A, Myers G, Latham S, Recur B, Li H, Sheppard A; Space-Filling X-Ray Source Trajectories for Efficient Scanning in Large-Angle Cone-Beam Computed Tomography
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