Introduction

Visualization and quantification of Computed Tomography (CT) scans is ideally performed on artifact free images. Materials with a high linear attenuation coefficient, such as metal, cause significant artifacts in the reconstructed image. Unfortunately, the use of metal is unavoidable in some orthopaedic and dental models and with some animal tracking systems.

Many iterative reconstruction approaches used in the past remove metal from the sinogram before the final reconstruction. These sinograms are geometry dependent, but the algorithms have not been tested for the rotating turntable geometries used in some preclinical uCT systems. These preclinical uCT systems also have specific image processing needs to facilitate specific co-registration applications.

The key features of this work include:

• Evaluating sinogram interpolation approaches for the rotating turntable uCT geometry
• Comparison of sinogram interpolation algorithms
• Assessment of the impact that metal artifact reduction has on automatic processing of the subject surface

2D Simulations to Compare Artifact Reduction & Interpolation Methods

The DRASIM simulation package was used to assess artifacts in images that include tissue, metal (iron) and, in some cases, bone. Four different sinogram interpolation methods were evaluated:

1. Karimi et al.2 – 3 layer model (bone, tissue, metal), 3 reconstructions, artifact deletion
2. Basic – Sinogram inpainting using isotropic diffusion, 2 reconstructions (see Section 3 below)
3. Wei et al.3 – 2 layer model (bone, metal), 3 reconstructions, image addition
4. Mazzin et al.4 – 2-layer model (bone, tissue), 3 reconstructions

Images showing the original image before forward projection (left column), the results with no correction (second column) and the subsequent correction approaches. Methods #2 and #4 appear to correct the metal artifacts well. Similar results were seen for other use cases of either 3 metal beads and/or without the skeleton.

Interpolation on 3D CT Image

To test the image inpainting algorithms on a real dataset, the basic interpolation approach (Method #2) was implemented using this general algorithm:

1. Acquire CT scan
2. Threshold Metal on reconstructed CT image
3. Forward project metal mask into original sinogram
4. Interpolate metal on 2D slice of sinogram
5. Iterate interpolation until convergence
6. Next Slice
7. No
8. All Slices Finished?
9. Yes
10. Backproject modified sinogram

Surface Generation

For multimodality imaging in the IVIS® Spectrum CT, the skin surface is segmented from the CT volume (and subsequently input into diffuse optical tomography reconstructions) using the following algorithm:

1. Acquire HU calibrated CT scan
2. Crop & Threshold
3. Surface Generation
4. Volume Processing
5. Image

An imaging phantom with a simulated metal implant placed subcutaneously was imaged. Surfaces generated from images reconstructed with the image inpainting methods show a much smoother surface.

Summary

The rotating turntable geometry uses a different geometry than traditional gantry based CT systems. In this work, metal artifact reduction algorithms used in traditional CT systems were compared in simulations and appear to work well for this geometry. An iterative reconstruction algorithm with a basic interpolation approach was implemented and, when iterated across all sinogram slices, also appears to reduce artifacts for a 3D CT dataset. The resulting surface generated from these images with reduced artifacts are smoother and more accurate, which is important when mapping optical signals onto these surfaces in the subsequent diffuse optical tomography reconstruction algorithms.

References

1) Fung et al., Proc SPIE 7961, Med Imaging 2011: Phys Med Imaging, 79613D2
4) Mazzin et al., Am Assoc Phys Med 2005 SU-EE-A4-03