Optimization of micro-tomographic experiment and reconstruction parameters at low signal-to-noise ratio.

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Abstract

Algebraic Reconstruction Technique (ART) is a widely employed method in computed tomography since it has certain advantages, such as opportunity to reconstruct data with missing projections in some angle ranges, over other techniques such as Filtered Back Projection (FBP). Recently a regularization technique RegART was introduced which provides to reduce greatly reconstruction noise levels . However, a serious drawback of both ART and RegART is the computational complexity of the methods. In this work, we present a fast version of RegART, which makes use of NVIDIA CUDA technology, and shows that this approach is more beneficial compare to FBP.

Keywords

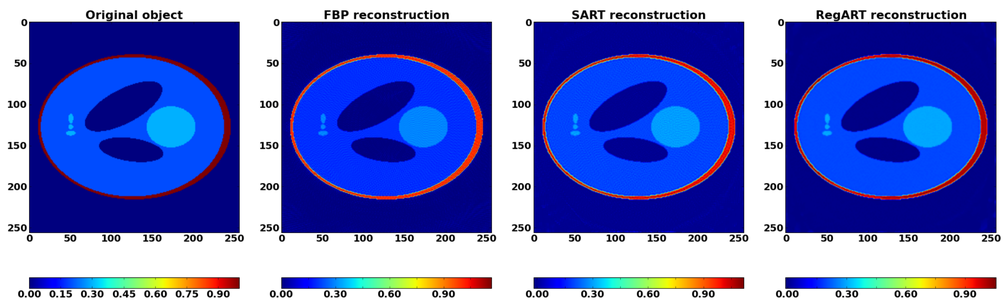
ART reconstruction technique, NVIDIA CUDA, GPGPU computing, SIMD-optimized algorithms, Fast Hough Transform, laboratory X-ray microtomography

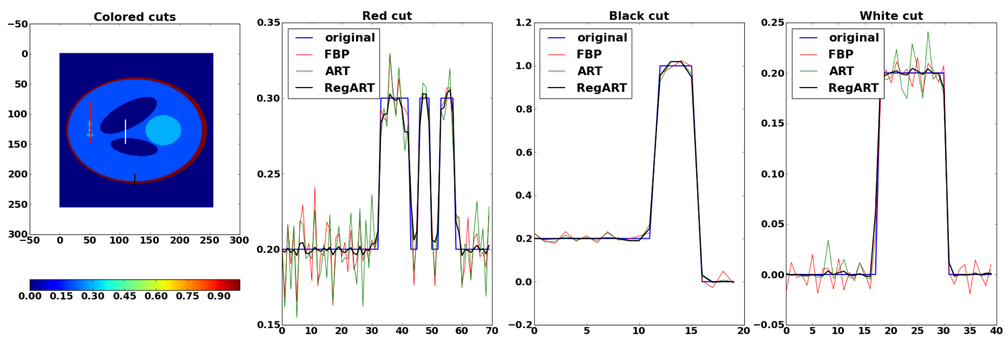
Motivation

- Low Signal/Noise ratio on laboratory sources
- X-ray flux instability
- Low quality reconstruction using FBP with real experimental data

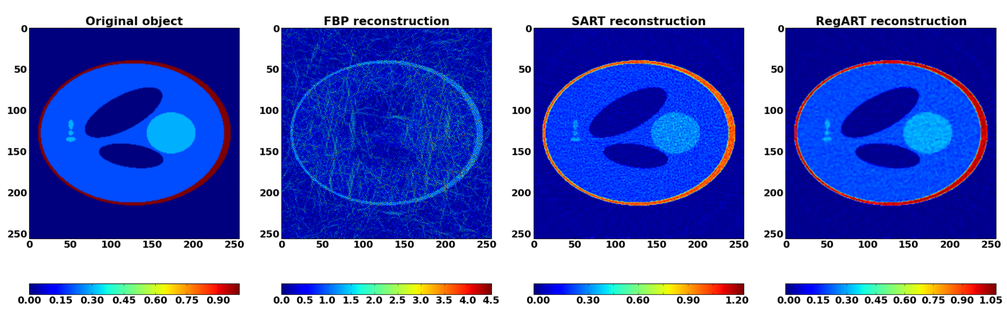
Reconstruction quality comparison (FBP, ART, RegART)

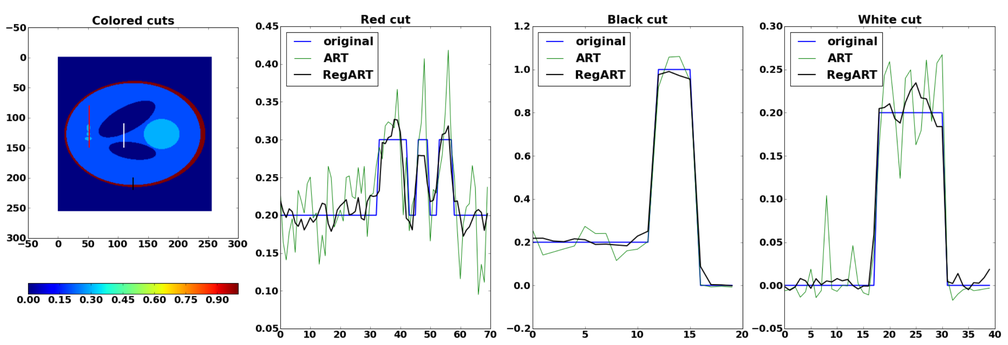
Ideal Shepp-Logan phantom reconstruction





Shepp-Logan phantom reconstruction used noised data



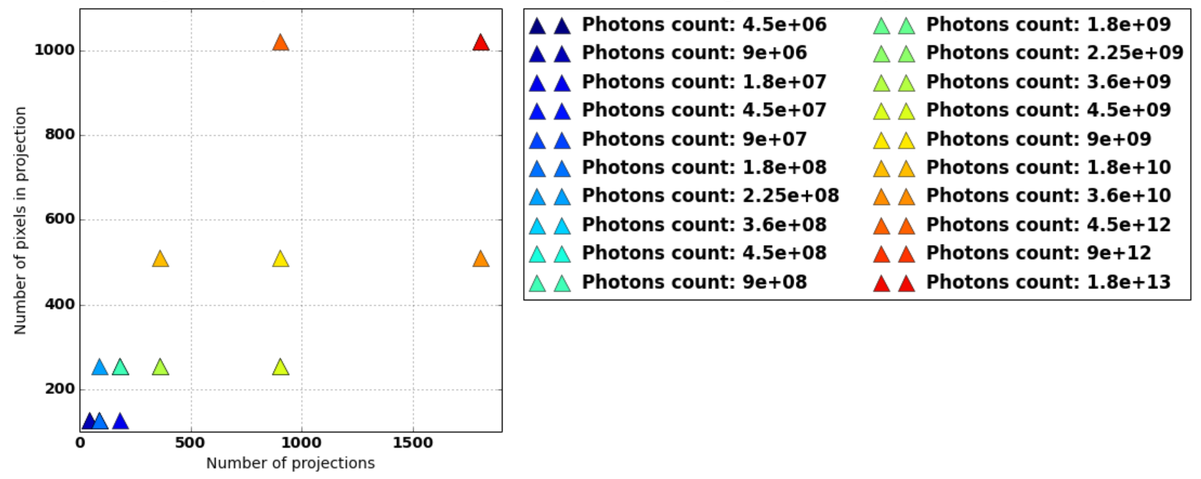


Regularization methods in RegART

- Median filtering.
- Threshold for filter non-physical values.
- Adaptive mean filtering (in the future) - for better edges reconstruction.

Optimization of micro-tomographic experiment parameters at low signal-to-noise ratio

To reach the acceptable resolution we should balance between number of measured projections and exposure time for each projection. If exposure time is too short at the fixed photons flow, the signal-to-noise ratio for each acceptable projection will be low. This leads to unacceptably high noise level at reconstructed tomograms. Increasing exposure time of on projection leads to reduction of the amount of registered projections. This often results in the degradation of spatial resolution.

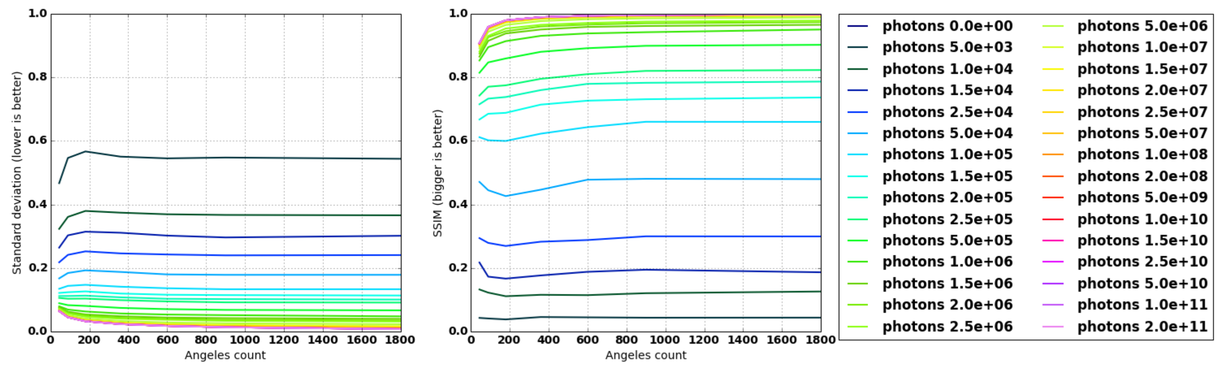


The position of the best reconstruction in dependence of projections amount and number of the pixels in each projection. The different colors indicate different total amount of photons in one tomogram.

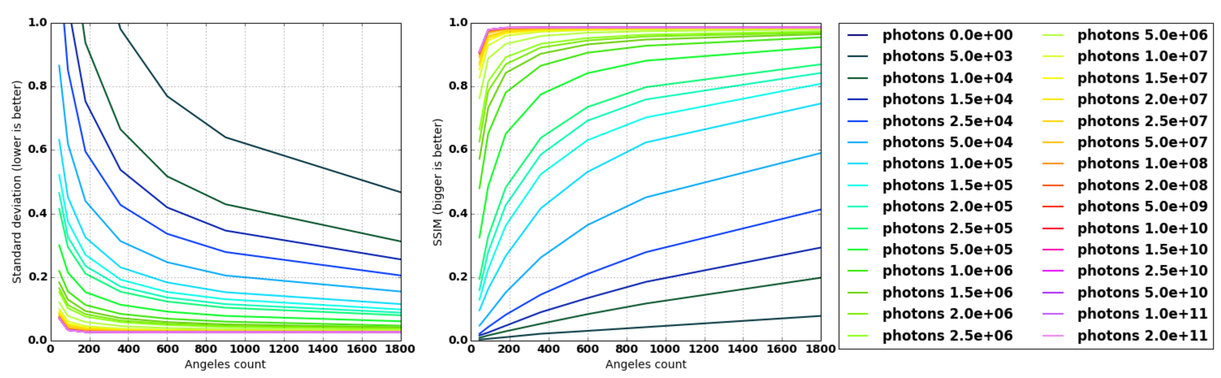
Reconstruction quality for noised signal

The estimation of the reconstruction quality of RegART and FBP methods using standard deviation (lower is better) and SSIM metrics (closer to 1.0 is better) at the different number of photons per total sinogram is shown on figures below.

RegART reconstruction



FBP reconstruction



Conclusion

We have performed image reconstruction using three different methods. In conditions of high noise, each of the methods has its own advantages. FBP provides better and faster reconstruction of boundaries, ART and RegART shows lower dispersion upon reconstruction within prolonged areas. Future including morphological analysis will better in reconstruction of inclusions.
A new modified version of RegART was used in our experiments and shown to give good results. Currently, we are planning to perform rapid image reconstruction by combining the above methods.

References

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