

Streak Artifact Reduction in Limited Angle Tomography Using Machine Learning

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Introduction

Limited angle tomography

- **Definition:** Insufficient scan angle during data acquisition
- **Scenario:** Intervention in C-arm CT systems
- **Challenge:** Data incompleteness causing streak artifacts
- **Technique:** Machine learning techniques

Method And Materials

I. Machine Learning Algorithms

- **Input:** images reconstructed from limited angle data
- **Output:** residual artifact images
- **Learning:** an image patch from the input image to the center pixel of that patch in the output image
- **Feature extraction:**
 - **MVM:** mean-variance-median statistic of an image patch
 - **Hessian:** the two eigenvalues and the orientation of the main eigenvector of the Hessian matrix at each pixel
- **Regression models:**
 - **Linear regression (LR):** linear models
 - **Multi-layer perceptron (MLP):** artificial neural network, learn nonlinear functions
 - **Reduced-error pruning tree (REPTree)**^[1]: decision tree, pruning to reduce overfitting

II. Experimental Set-up

- **Experimental data**
 - **Shepp-Logan phantom:** 75 slices from a 3-D Shepp-Logan volume for training and another 75 slices for testing
 - **CT data:** 7 patients for training and 7 patients for testing, 10 slices selected from each patient
- **Simulated acquisition systems:**
 - **Parallel-beam:** 160° angular range, 0.5° angular step
 - **Fan-beam:** 170° angular range, 0.5° angular step, 20° fan-angle
- **Algorithm Framework:** Weka^[2]

Conclusions

- REPTree reduces streak artifacts best.
- REPTree has the potential for clinical applications.

References

- [1] Quinlan JR. Simplifying decision trees. *Int J Man Mach Stud.* 1987;27(3):221-234
 [2] E. Frank, et al., The WEKA Workbench. Online Appendix for "Data Mining: Practical Machine Learning Tools and Techniques". Morgan Kaufmann, 2016.

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Disclaimer

The concepts and information presented in this paper are based on research and are not commercially available.

Results

I. Results of the Shepp-Logan phantom

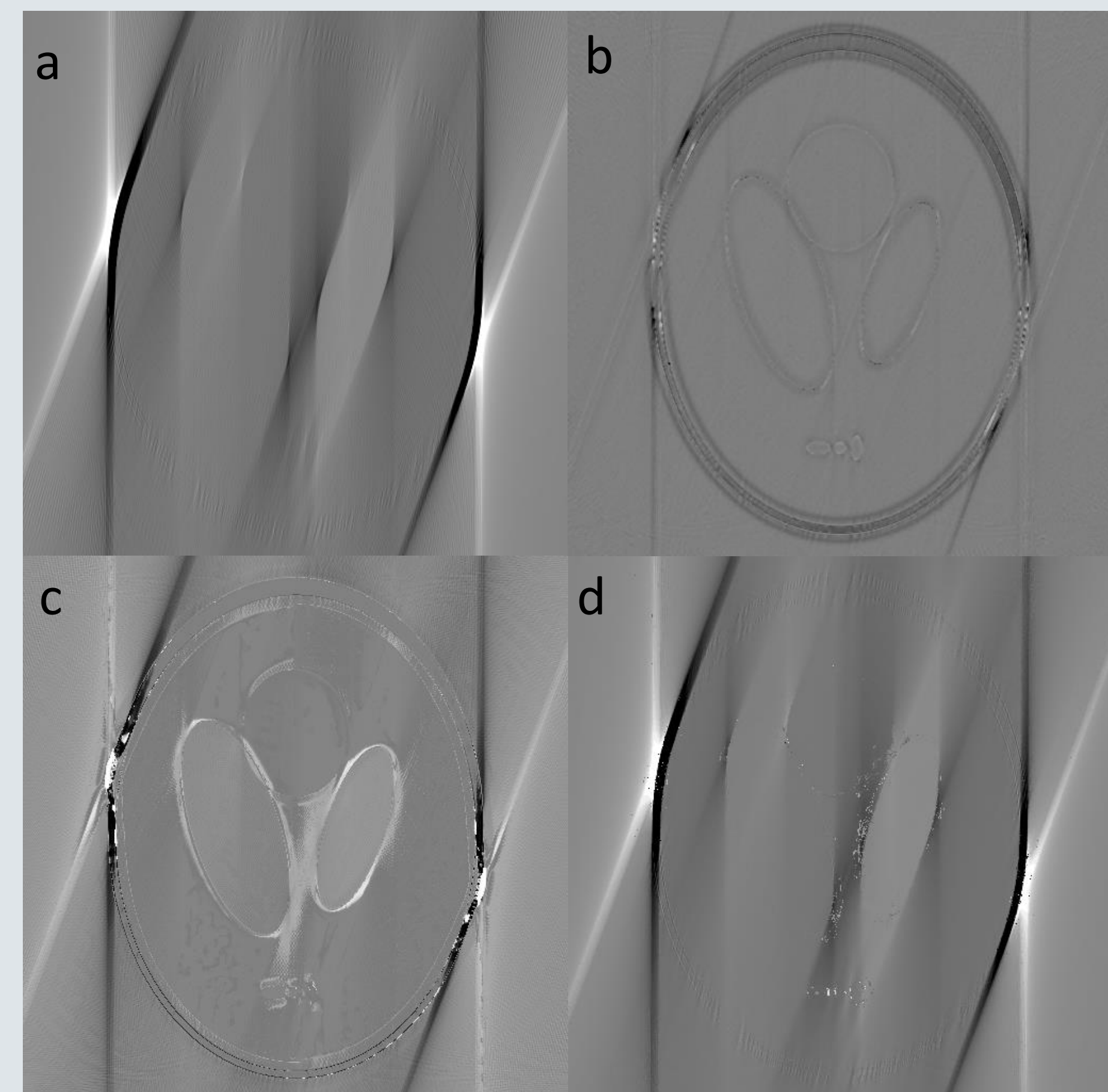


Fig. 1. Learnt streak artifacts using different machine learning algorithms in parallel-beam: (a) reference; (b) LR; (c) MLP; (d) REPTree. Window width: 1200 HU.

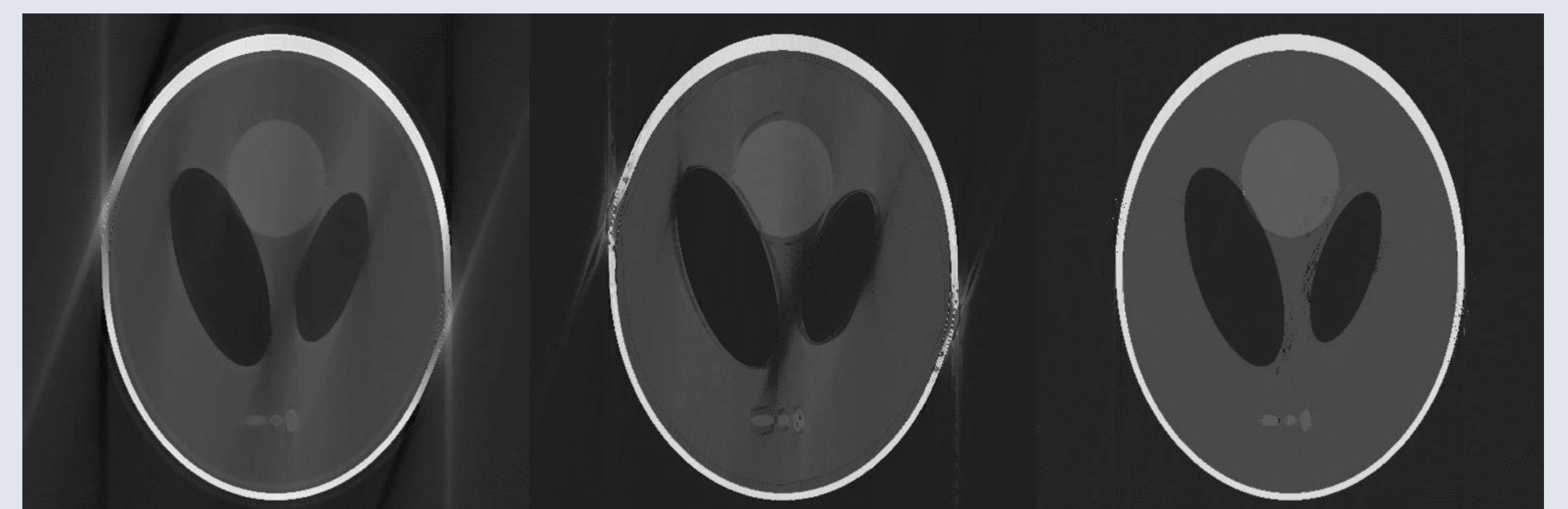
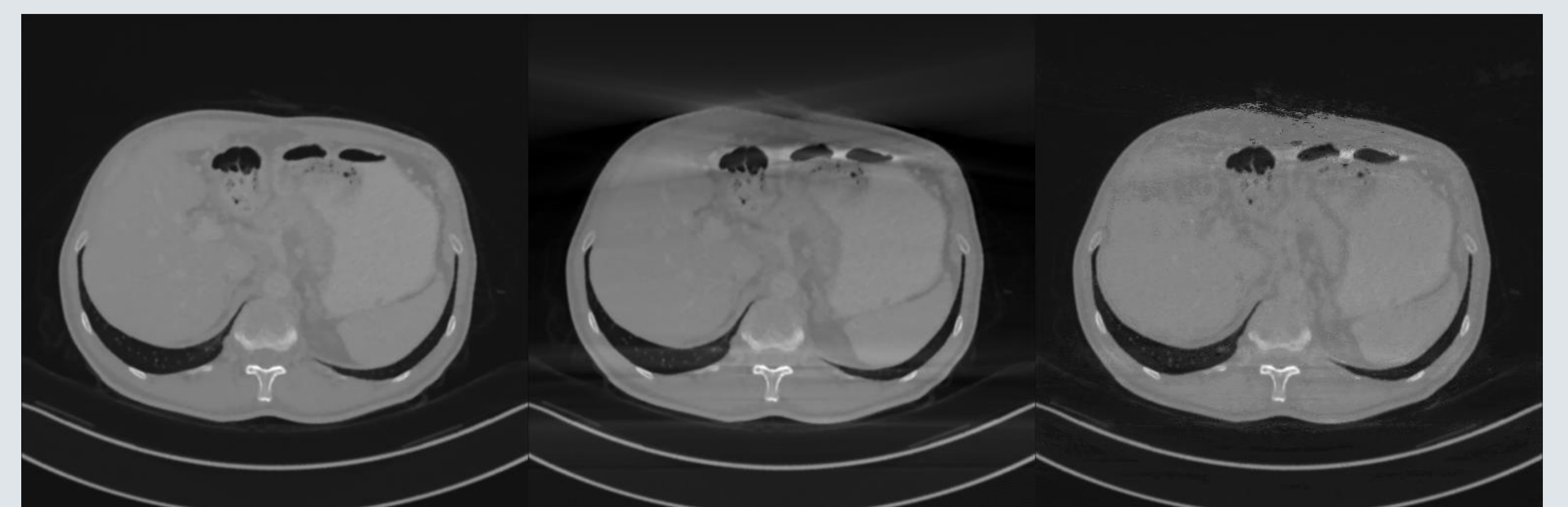


Fig. 2. "Destreaked" images using different machine learning algorithms in parallel-beam: (a) LR, (RMSE =) 139 HU; (b) MLP, 136 HU; (c) REPTree, 29 HU. Window: [-1150, 1300] HU.

II. Results of the CT data



(a) Reference (b) f_{limited} , 96 HU (c) REPTree, 46 HU



(d) Reference (e) f_{limited} , 113 HU (f) REPTree, 58 HU

Fig. 3. The reference images, the 170° limited angle reconstructions (f_{limited}), and the REPTree results in fan-beam. Window: [-1150, 1300] HU.