Streak Artifact Reduction in Limited Angle Tomography Using Machine Learning

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I. Introduction

In limited angle tomography, streak artifacts occur due to missing data. They may cause wrong decisions in clinical applications. Therefore, streak artifact reduction has important clinical value. In this work, three machine learning techniques, namely linear regression (LR), multi-layer perceptron (MLP), and reduced-error pruning tree (REPTree), are investigated to predict streak artifacts.

II. Method And Materials

The input observations are the images reconstructed from the limited angle data. The output labels are the residual artifact images. The mapping of an image patch to a single output value for the center pixel of that patch is learned.

Regarding feature extraction, for each pixel in the input images, we choose its intensity and the mean, variance, and median statistic of the image patch which we call MVM features. Since the streak artifacts have specific orientations, the two eigenvalues and the orientation of the main eigenvector of the Hessian matrix at each pixel are chosen as well.

LR, MLP, and REPTree are evaluated on simulated data generated from the Shepp-Logan phantom and CT images in both parallel-beam and fan-beam. For the Shepp-Logan data, we pick 150 slices from the 3-D volume and one half of them are used for training, the other half for testing. For the CT data, we use 7 patients for training and another 7 patients for testing.

III. Results

The results on the Shepp-Logan data demonstrate that REPTree predicts streak artifacts best (Fig. 1). REPTree also reduces streak artifacts well for the CT data in parallel-beam (Fig. 2). In fan-beam, streaks are reduced as well, even though some artifacts are introduced by misclassification (Fig. 3).

IV. Conclusion

When using the MVM and Hessian features, REPTree classifies streak artifacts better than LR and MLP and shows potential for clinical applications.

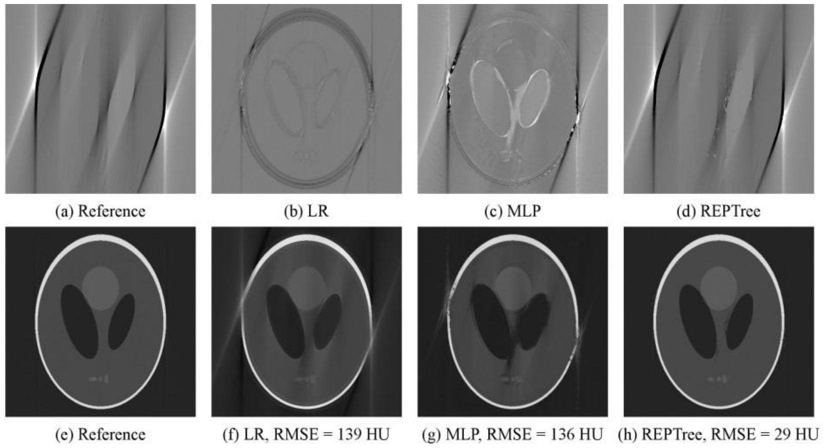

Fig. 1. Learnt streak artifacts using different machine learning algorithms and their corresponding reconstruction images in parallel-beam with a 160º angular range. The root-mean-square errors (RMSE) of images learnt by LR, MLP, and REPTree are shown in subtitles of (f)-(h). Window width for the top row: 1200 HU; window for the bottom row: [-1400, 1400] HU.

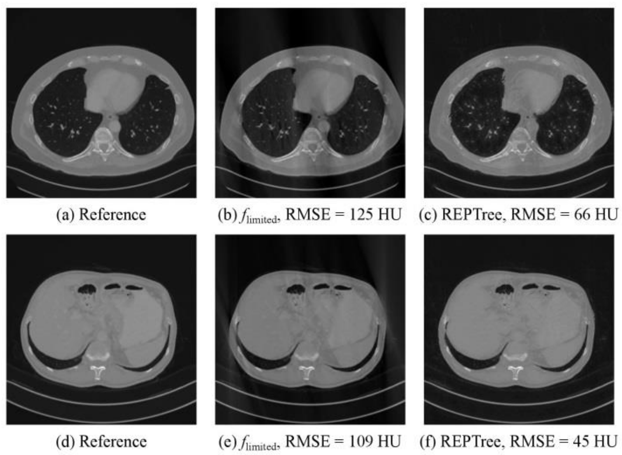

Fig. 2. The reference images, the 160º limited angle reconstructions (f_{limited}), and the machine learning results using REPTree of the low-dose CT data in parallel-beam geometry. Window: [-1150, 1300] HU.

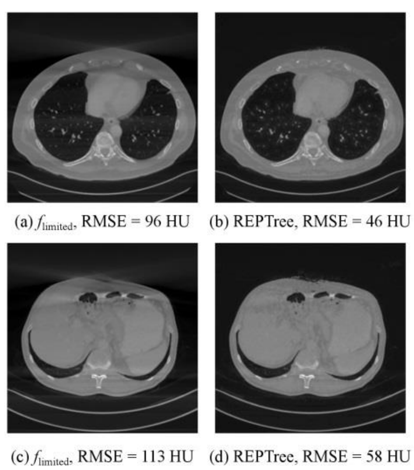

Fig. 3. The 170º limited angle reconstructions (f_{limited}) and the machine learning results using REPTree of the low-dose CT data in fan-beam geometry. Window: [-1150, 1300] HU.