Reconstructing High-Quality CT From Limited-Angle Scans For Accurate Diagnosis With Deep Learning Techniques

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Background

- A CT scanner produces projection data over 360^{o} to reconstruct CT for clinical diagnosis
- However, a CT scanner is expensive to afford in low/middle income countries
- A C-Arm scanner is usually three times cheaper than a CT scanner[1]
- A C-Arm scanner can only scan a limited-angle range less than 180^{o}
- Due to incomplete projection data, the reconstructed CT contains heavy artifacts using a conventional filtered-backprojection algorithm[2]
- Deep learning algorithms can be considered to remove the artifacts

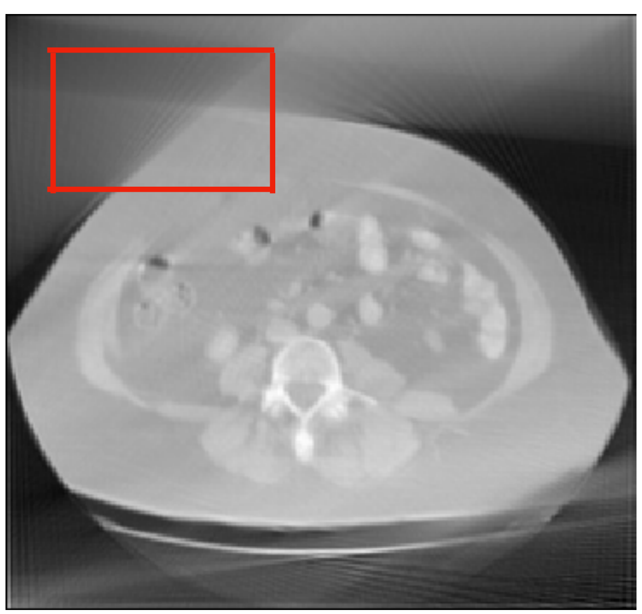


Figure 1. CT reconstruction from 145 degrees

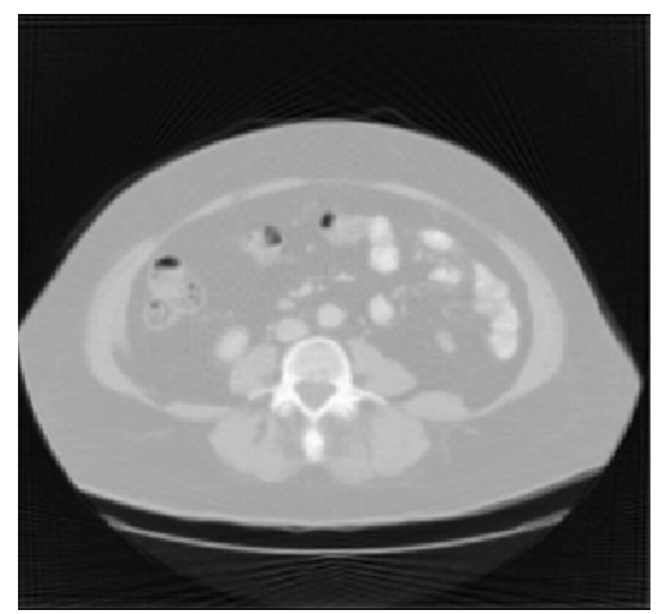


Figure 2. CT reconstruction from 360 degrees

[1] From LBN Medical and PrizMed Imaging
[2] Gu and Ye, 2017

Methods

- Map a filtered-backprojection algorithm to a neural network[1]
- Enable an end-to-end training (from projection to reconstruction)
- Convolutional Neural Network is particularly good for deep nuanced features extraction
- U-Net is based on Convolutional Neural Network and can help recover missing features
- So additionally add a U-Net in projection or reconstruction domain

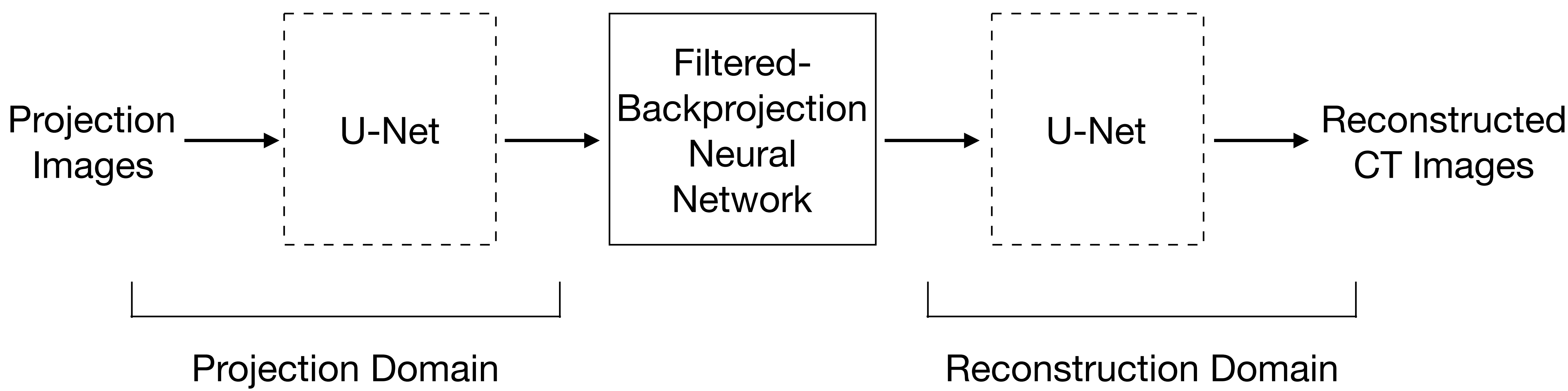


Figure 3. An overview of my deep learning network

[1] Würfl et al., 2018

Results (Based on limited angle of 145)

Figure 4. Ground truth

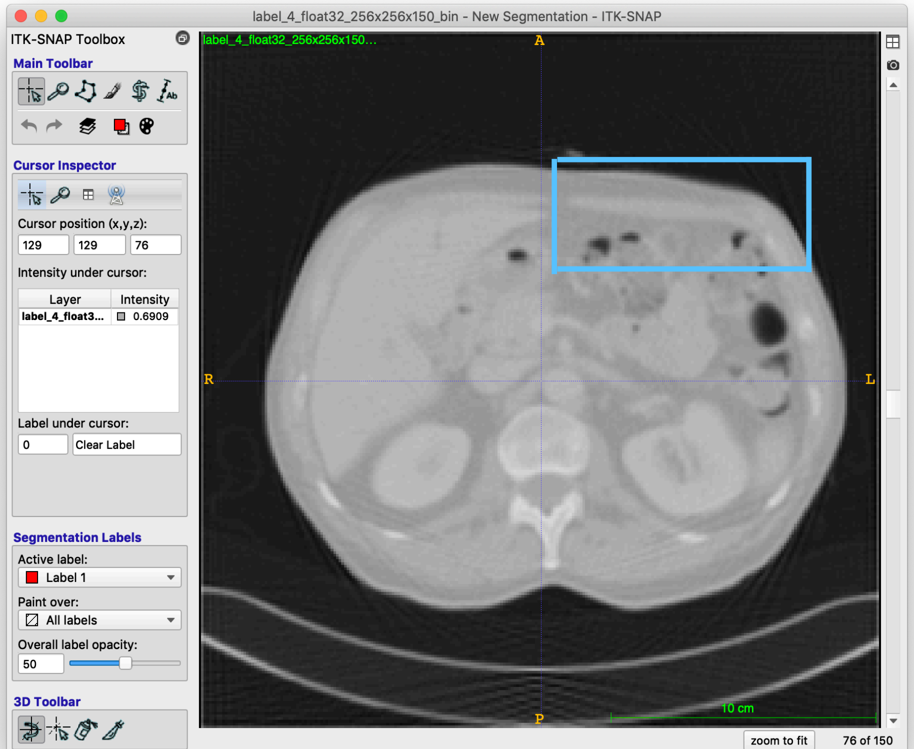


Figure 5. Conventional filtered-backprojection algorithm

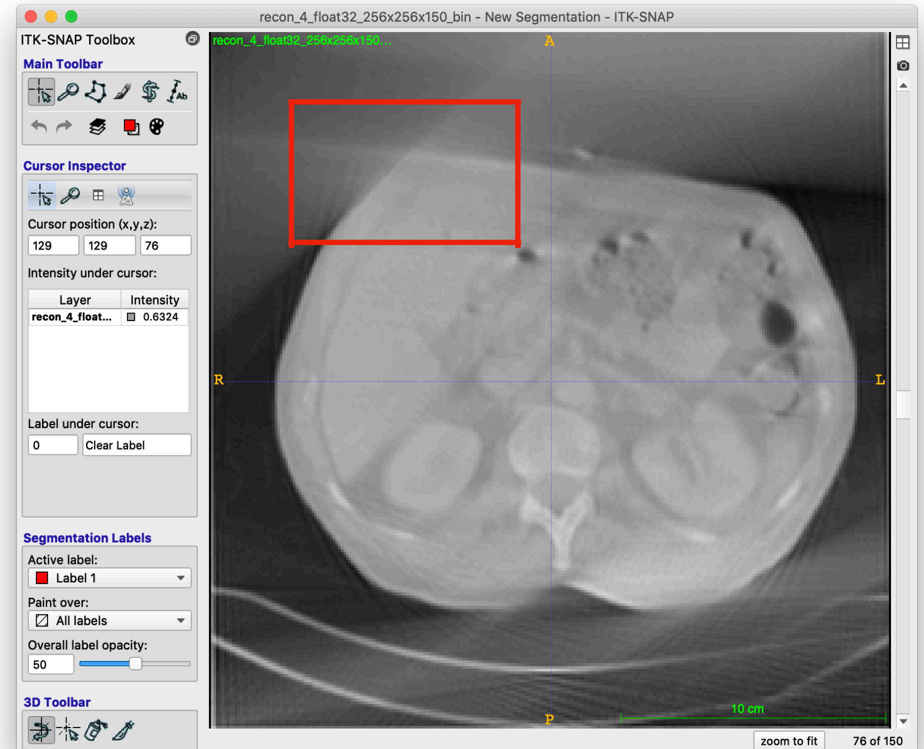


Figure 6. Filtered-backprojection neural network

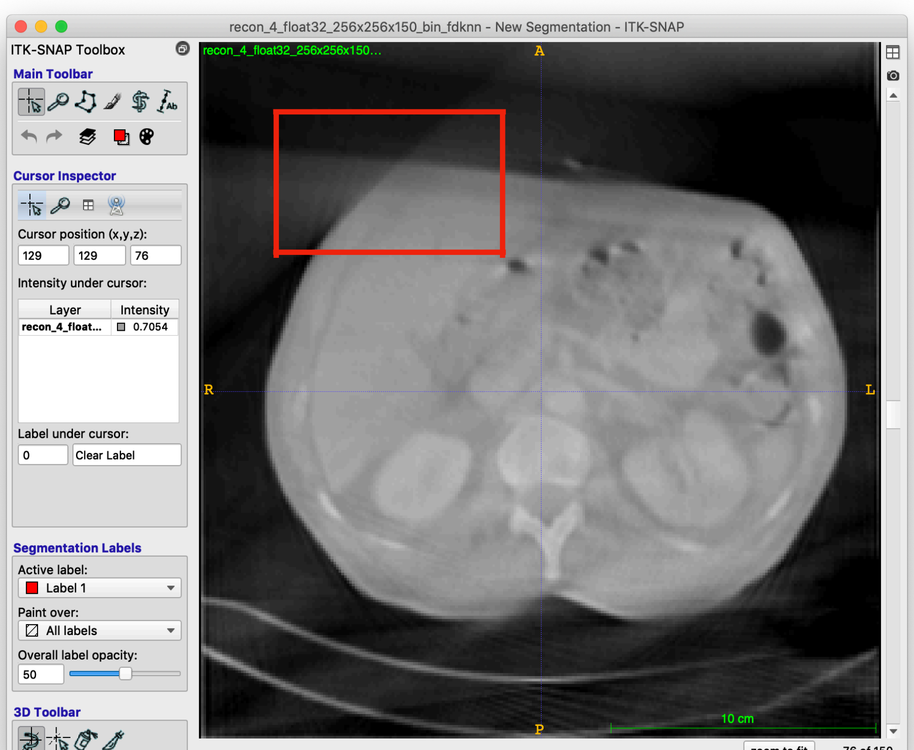
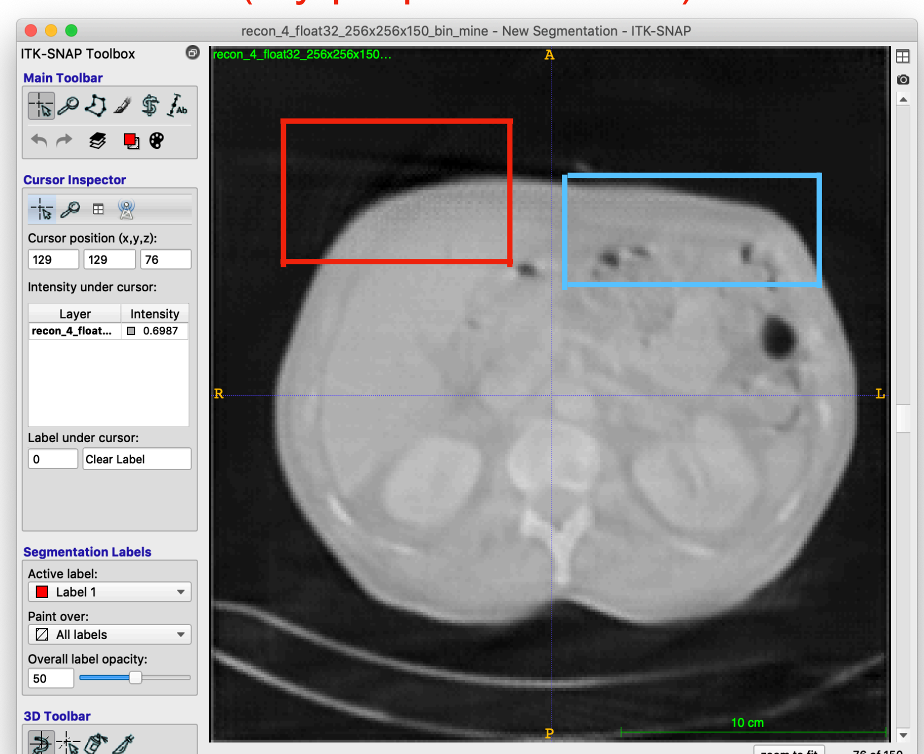


Figure 7. Filtered-backprojection neural network with U-Net
(My proposed model)



Results (Based on limited angle of 145)

My approach achieved a much low mean square error, high structural similarity and high peak signal-to-noise ratio.

	Mean Square Error	Structural Similarity	Peak Signal-to-Noise Ratio
Conventional Filtered-Backprojection Algorithm	0.0253	0.7658	16.0472
Filtered-Backprojection Neural Network	0.0066	0.8006	21.9392
Filtered-Backprojection Neural Network with U-Net	0.0022	0.8620	26.7212

Table 1. Numerical results of different algorithms for limited-angle CT reconstruction

Conclusion & Future Directions

- Deep learning algorithms can reduce artifacts and recover missing features in limited-angle CT reconstruction problem
- However, some features are still missing which would be a concern for use in clinical applications such as misdiagnosis due to missing lesion.
- Moreover, most popular neural networks, in particular the U-Net, are sensitive to noise generated during scanning[1]
- Using Generative Adversarial Networks which are resistant to noise may increase robustness

[1] Huang et al., 2018

Reference

- Gu, J. and Ye, J.C., 2017. Multi-scale wavelet domain residual learning for limited-angle CT reconstruction. arXiv preprint arXiv:1703.01382.
- Huang, Y., Würfl, T., Breininger, K., Liu, L., Lauritsch, G. and Maier, A., 2018, September. Some investigations on robustness of deep learning in limited angle tomography. In International Conference on Medical Image Computing and Computer-Assisted Intervention (pp. 145-153). Springer, Cham.
- Würfl, T., Hoffmann, M., Christlein, V., Breininger, K., Huang, Y., Unberath, M. and Maier, A.K., 2018. Deep learning computed tomography: Learning projection-domain weights from image domain in limited angle problems. IEEE transactions on medical imaging, 37(6), pp.1454-1463.