Noise-Augmented Deep Denoising of CT Images

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Abstract

Denoising low dose CT images can have great advantages for the aim of minimizing patient risk, as it can help lower the effective dose to the patient, while providing constant image quality. In this work additional noise realizations were generated, reconstructed, and used as additional input into a denoising network to guide the denoising process. The network was compared to a similar network, without additional noise augmentation. It was shown, that the noise-augmented deep denoising network (NADD) outperformed the conventional denoising network.

Method

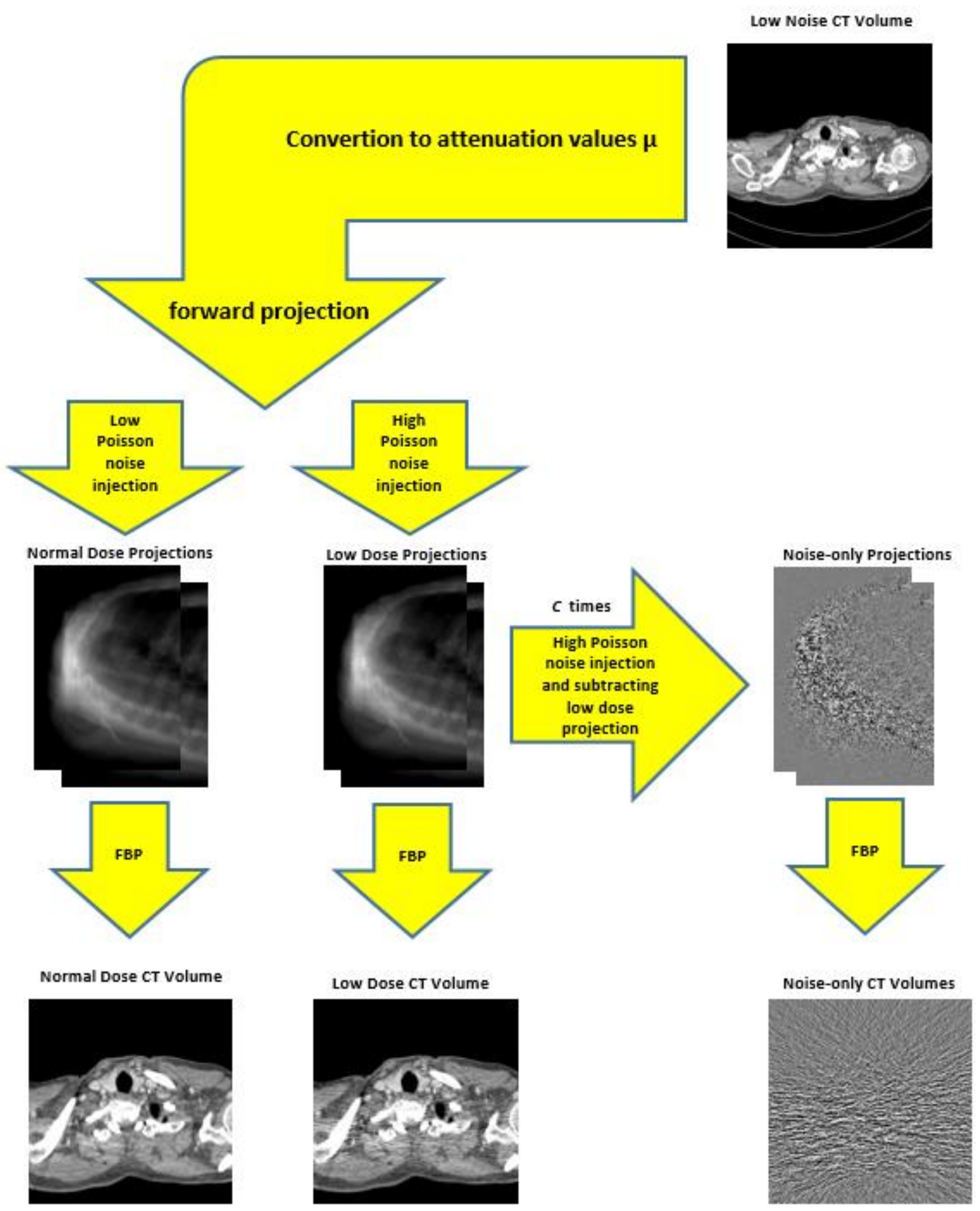

Figure 1: Flow chart illustrating the data set creation.

Starting from low noise clinical CT patient data sets, the attenuation values are forward projected. Normal and low dose CT volumes are created by injecting low and high Poisson noise respectively followed by filtered back-projection (FBP). The normal dose volume serves as the ground truth (GT) while the low dose volume serves as the actual measurement and is the one to be denoised. For NADD we need additional noise-only realizations, based on the low dose projections. To obtain these, we once more inject Poisson noise into the low dose projections and therefrom we subtract the low dose projections and perform FBP.
For this study we chose C = 10 additional noise realizations.

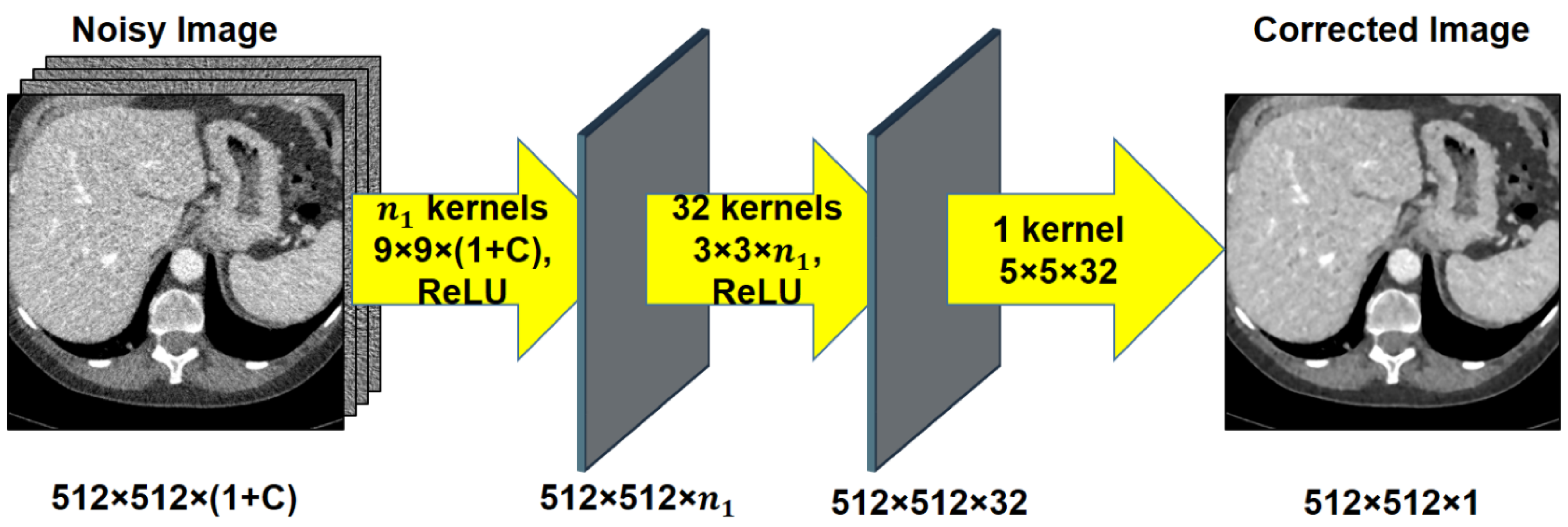

Figure 2: Network architecture used in this work [1].

The baseline architecture, here called NADD_0, was originally proposed by Chen et al. [1]. The network architecture can be seen in figure 2. The original network uses C=0 and n_1=205. We use C=10 and n_1=64 such that the proposed NADD_{10} has slightly less trainable parameters than the original architecture.

Results

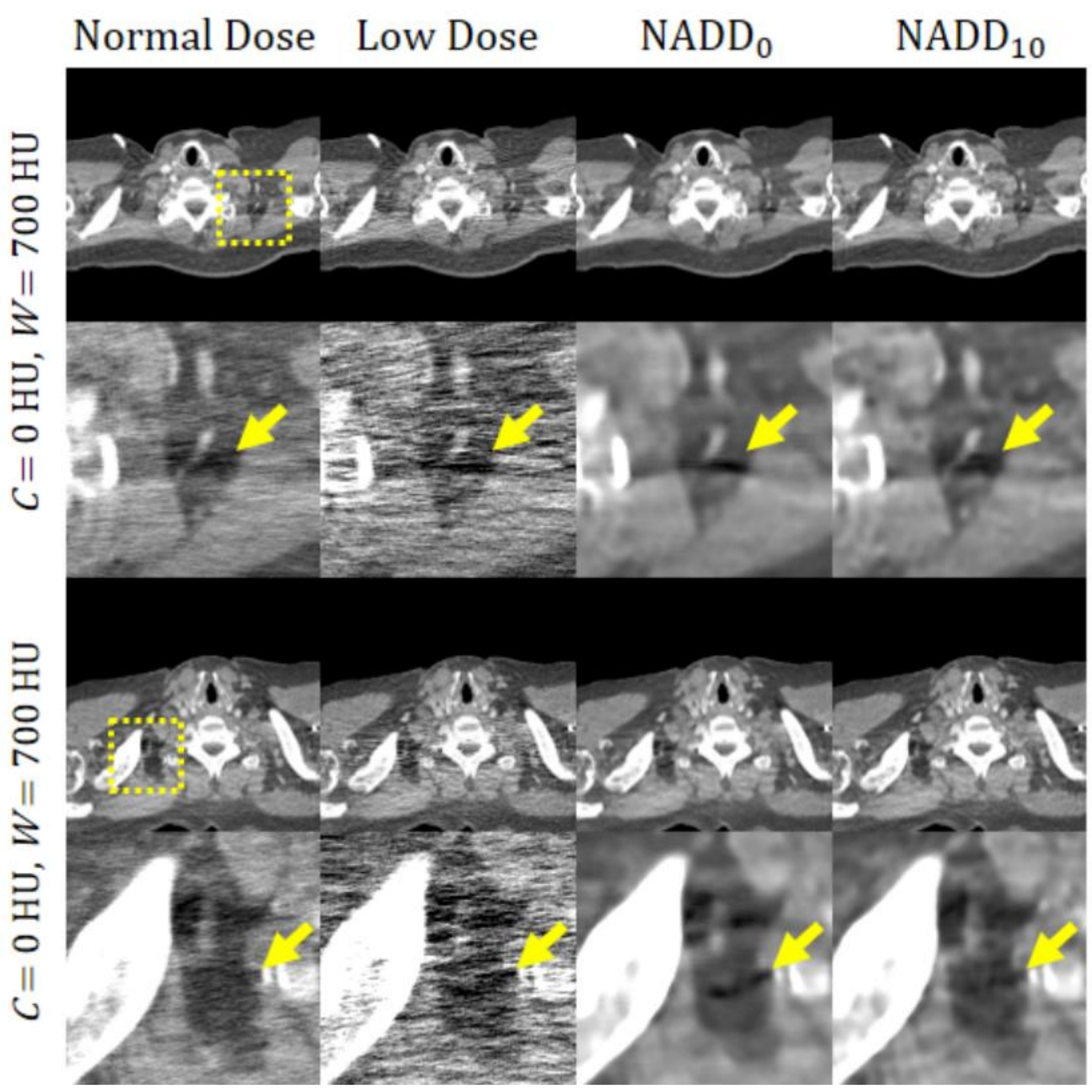

Figure 3: Ground truth, input and predictions for the different networks.

Conclusions and Outlook

Noise-augmented denoising has the potential to outperform other denoising techniques due to the added knowledge of the noise correlations and texture. A disadvantage is that C additional reconstructions are required.

The implementation of this method for a different network architecture can be done in a straightfoward manner. A study concerning the number of additional input channels C and the comparison with other more state-of-the-art architectures is at hand.

[1]*H. Chen, Y. Zhang, W. Zhang, P. Liao, K. Li, J. Zhou, and G. Wang, "Low-dose CT denoising with convolutional neural network," in 2017 IEEE 14th International Symposium on Biomedical Imaging (ISBI 2017), 2017, pp. 143–146.*

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