Abstract: Trainable Joint Bilateral Filters for Enhanced Prediction Stability in Low-dose CT

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Low-dose computed tomography (CT) denoising algorithms aim to enable reduced patient dose in routine CT acquisitions while maintaining high image quality. Recently, deep learning (DL)-based methods were introduced, outperforming conventional denoising algorithms on this task due to their high model capacity. However, for the transition of DL-based denoising to clinical practice, these data-driven approaches must generalize robustly beyond the seen training data. We, therefore, propose a hybrid denoising approach consisting of a set of trainable joint bilateral filters (JBFs) combined with a convolutional DL-based denoising network to predict the guidance image. Our proposed denoising pipeline combines the high model capacity enabled by DL-based feature extraction with the reliability of the conventional JBF. The pipeline's ability to generalize is demonstrated by training on abdomen CT scans without metal implants and testing on abdomen scans with metal implants as well as on head CT data. When embedding RED-CNN/QAE, two well-established DL-based denoisers in our pipeline, the denoising performance is improved by 10 %/82 % (RMSE) and 3 %/81 % (PSNR) in regions containing metal and by 6 %/78 % (RMSE) and 2 %/4 % (PSNR) on head CT data, compared to the respective vanilla model. Concluding, the proposed trainable JBFs limit the error bound of deep neural networks to facilitate the applicability of DL-based denoisers in low-dose CT pipelines. We made our trainable bilateral filter layer package (PyTorch, GPU accelerated) publicly available [1, 2].

References

1. Wagner F, Thies M, Denzinger F, Gu M, Patwari M, Ploner S et al. Trainable joint bilateral filters for enhanced prediction stability in low-dose CT. Sci Rep. 2022;12(1):1–9.
2. Wagner F, Thies M, Denzinger F, Gu M, Patwari M, Ploner S et al. Trainable joint bilateral filter layer (PyTorch). https://github.com/faebstn96/trainable-joint-bilateral-filter-source. Accessed: 9 Dec 2022.

T. M. Deserno et al. (Hrsg.), *Bildverarbeitung für die Medizin 2023*,
Informatik aktuell, https://doi.org/10.1007/978-3-658-41657-7_16