Noise2Quality: Non-Reference, Pixel-Wise Assessment of Low Dose CT Image Quality

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Overview

Problem

- Low Dose CT has high noise, Image Quality Assessment must be performed
- Localized IQA is clinically important, but often requires reference images

N2Q (Noise2Quality)

- Novel, reference-free DL method for predicting pixel-wise IQA maps
- Code: https://github.com/ayaanzhaque/Noise2Quality

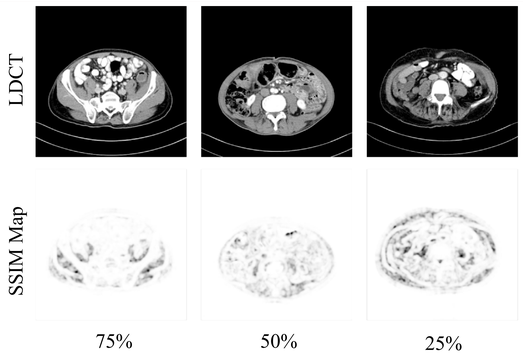
Noise2Quality

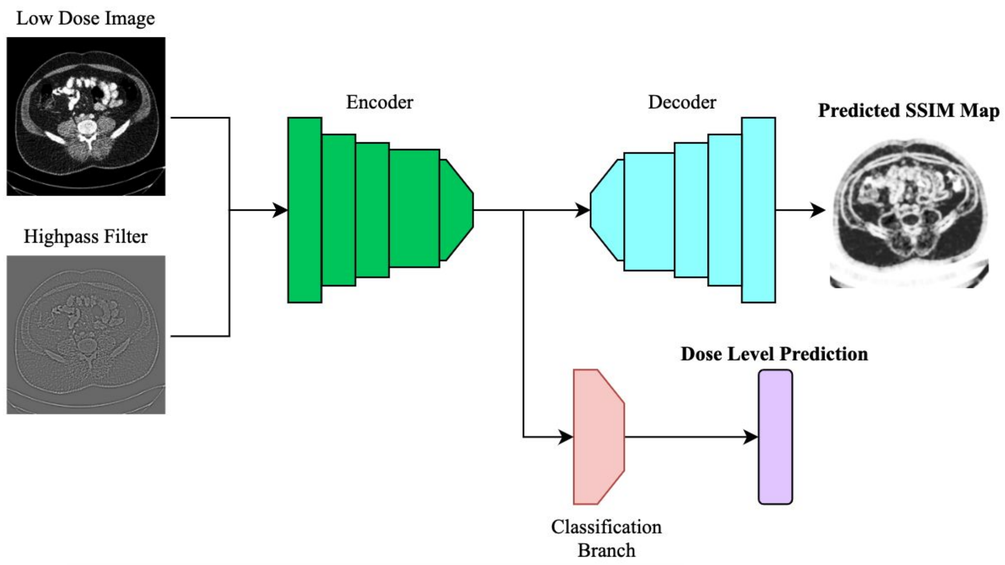
SSIM Maps

- SSIM score is calculated for each pixel
  - High pixel intensity → high quality

Training

- Objective: LDCT → SSIM Map
- U-Net backbone [1], MSE Loss between pred map and reference map





Schematic of the N2Q Model

- Classification branch from encoder is used to predict dose level of inputted LDCT
- Improves representation learning, Cross-Entropy loss for 5-class classification task

$$L(y, \hat{y}, c, \hat{c}) = L_{MSE}(\hat{y}, y) + \alpha \mathcal{L}_{CE}(\hat{c}, c)$$

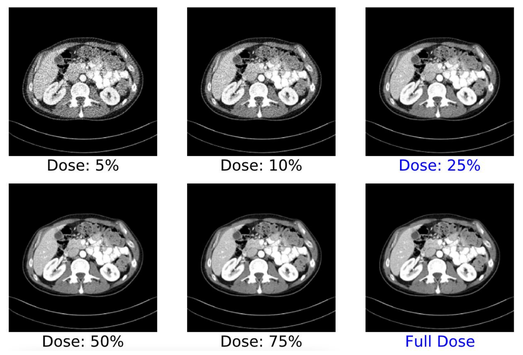
Dataset and Data Preparation

Details

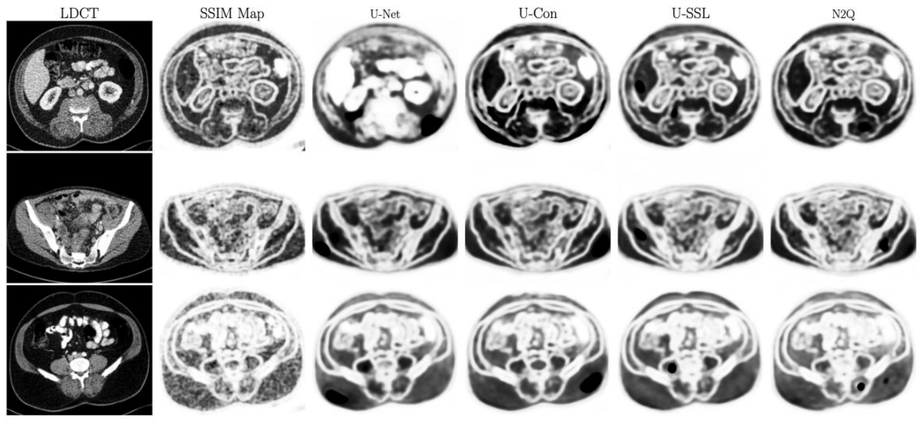
- Abdomen scans from Mayo CT dataset
- LDCT is originally 25%

Dose Simulation

- Scale zero-mean independent noise from 25% dose to produce 5 dose levels [2]
  - 5, 10, 25, 50, 75%
- Examples of various doses are shown



Qualitative Results



N2Q produces improved SSIM maps compared to baselines

Quantitative Results

Metrics	AE	RED-CNN	U-Net	U-HPF	U-Con	U-SSL	N2Q
SSIM	0.6761	0.7250	0.7448	0.7381	0.7484	0.7572	**0.7664**
MSE	0.1033	0.0594	0.0804	0.0979	0.0759	0.0669	**0.0686**
NRMSE	0.3226	0.2434	0.2830	0.3237	0.2794	0.2505	**0.2437**

N2Q outperforms other baseline architectures and training algorithms

Conclusion and References

- SSWL outperforms many SOTA methods, proving a task-relevant surrogate is important
- Future work includes an organ-specific IQA training algorithm for true localized IQA

[1] Ronneberger, O., Fischer, P., and Brox, T., "U-net: Convolutional networks for biomedical image segmentation," in [International Conference on Medical image computing and computer-assisted intervention], 234–241, Springer (2015).
[2] Imran, A.-A.-Z., Pal, D., Patel, B., and Wang, A., "SSIQA: Multi-task learning for non-reference CT image quality assessment with self-supervised noise level prediction," in [2021 IEEE 18th International Symposium on Biomedical Imaging (ISBI)], 1962–1965 (2021).