Low-Dose CT: Reducing Tube Current, Number of Projections, or Both?

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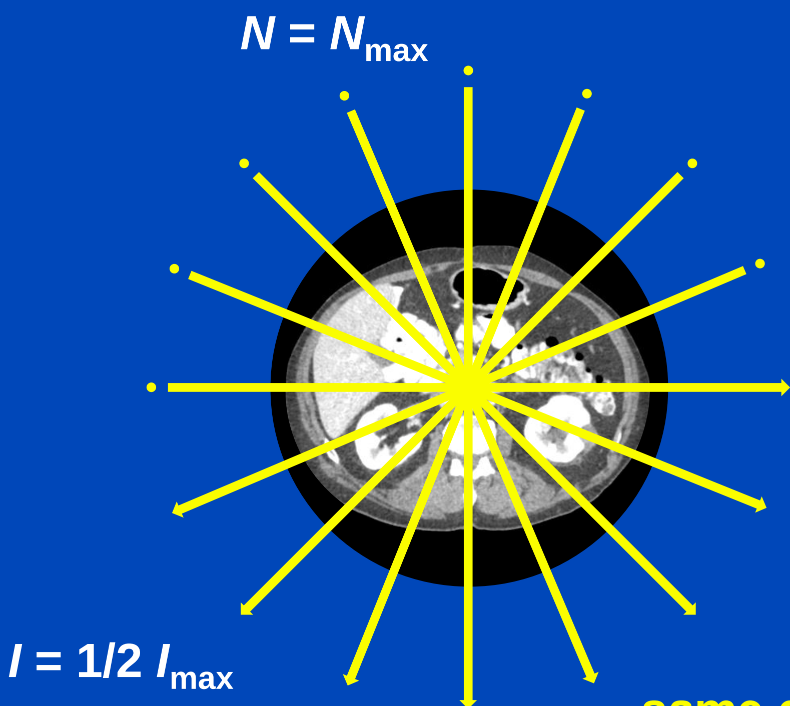
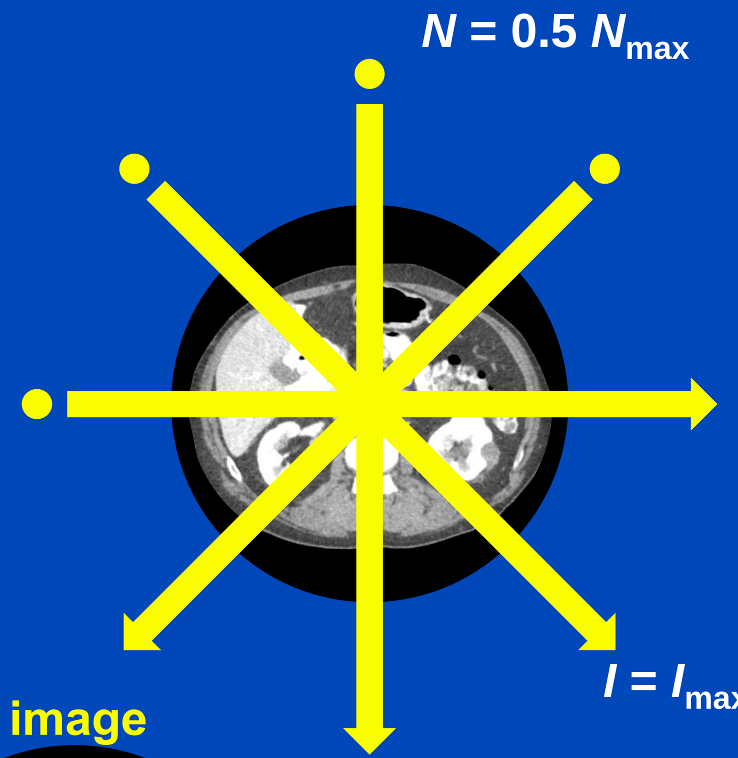
Aim

- Dose reduction is primary aim of CT research
  - How to reduce dose without decreasing image quality?
- Two dose reduction methods are lowering the tube current or decreasing the number of projections
- A lot of research available on how to correct either low-mAs or sparse-view CT, e.g. with neural networks
- What is the best realization of low-dose CT in combination with CNN denoising?

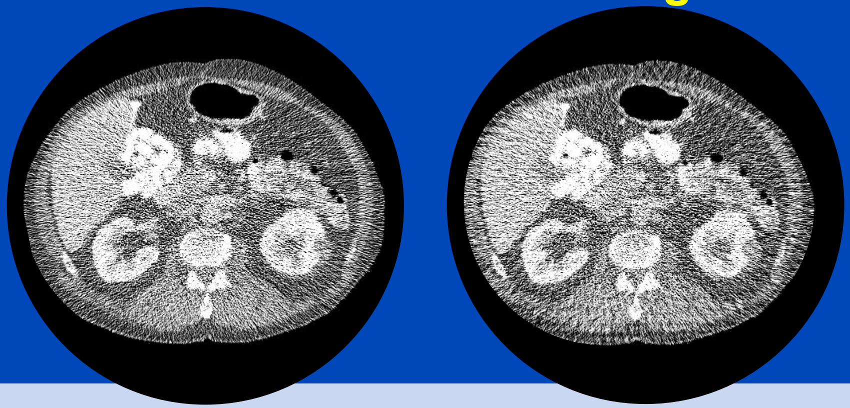
Low-mAs vs. Sparse-View





same dose ≠ same image

Statistical
loss of information



Deterministic
loss of information

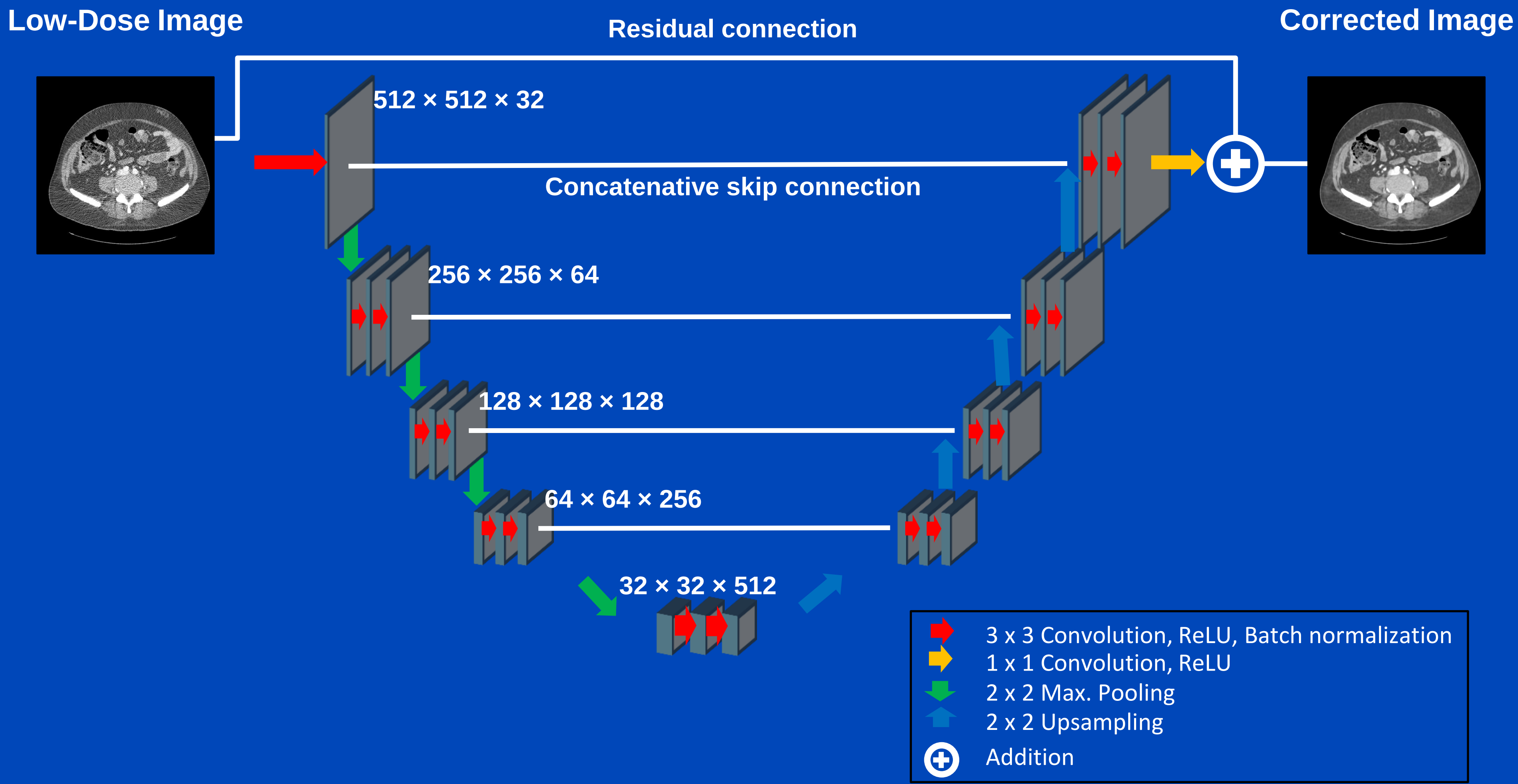
CT Simulations

- CT images are generated by monochromatically forward-projecting diagnostic CT scans in parallel beam geometry, and reconstructing with FBP.
- CT scans were acquired with a SOMATOM Force at 70 kV.
- Slices were filtered in z with a Gaussian with $\sigma = 1.5$ px.
- To simulate high-dose CT scans, Poisson noise was added to the projections ($N = 512$) with a photon number of 1.5×10^6.
- Low-dose scans are simulated with a dose reduction of 5:

1. $I_0 = 0.20\, I_{max}$, $N = 512$
2. $I_0 = 0.29\, I_{max}$, $N = 342$
3. $I_0 = 0.45\, I_{max}$, $N = 229$
4. $I_0 = 0.67\, I_{max}$, $N = 153$
5. $I_0 = 1.00\, I_{max}$, $N = 102$

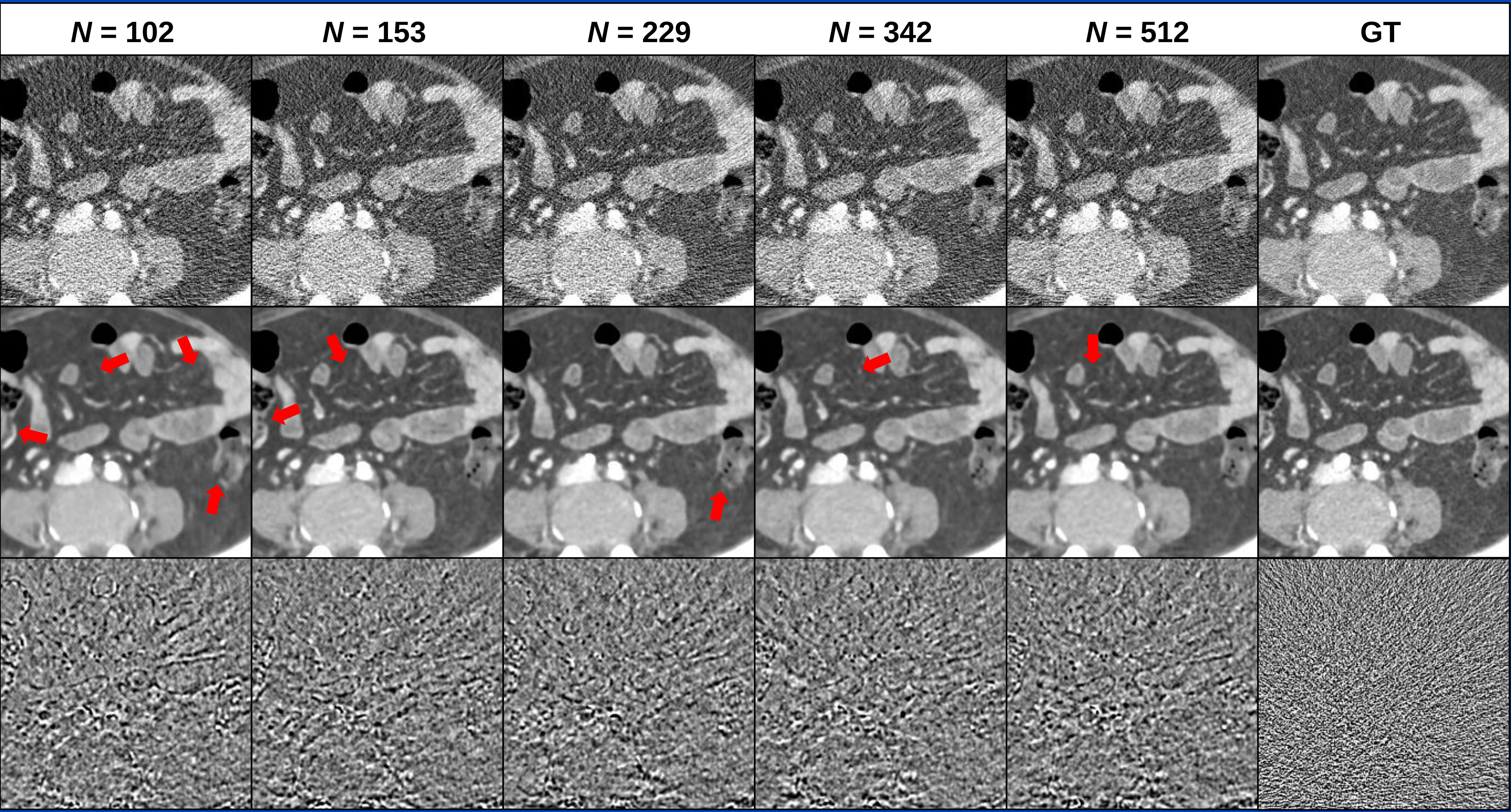
- same mAs product
- same network architecture
- separately trained networks

U-Net Architecture



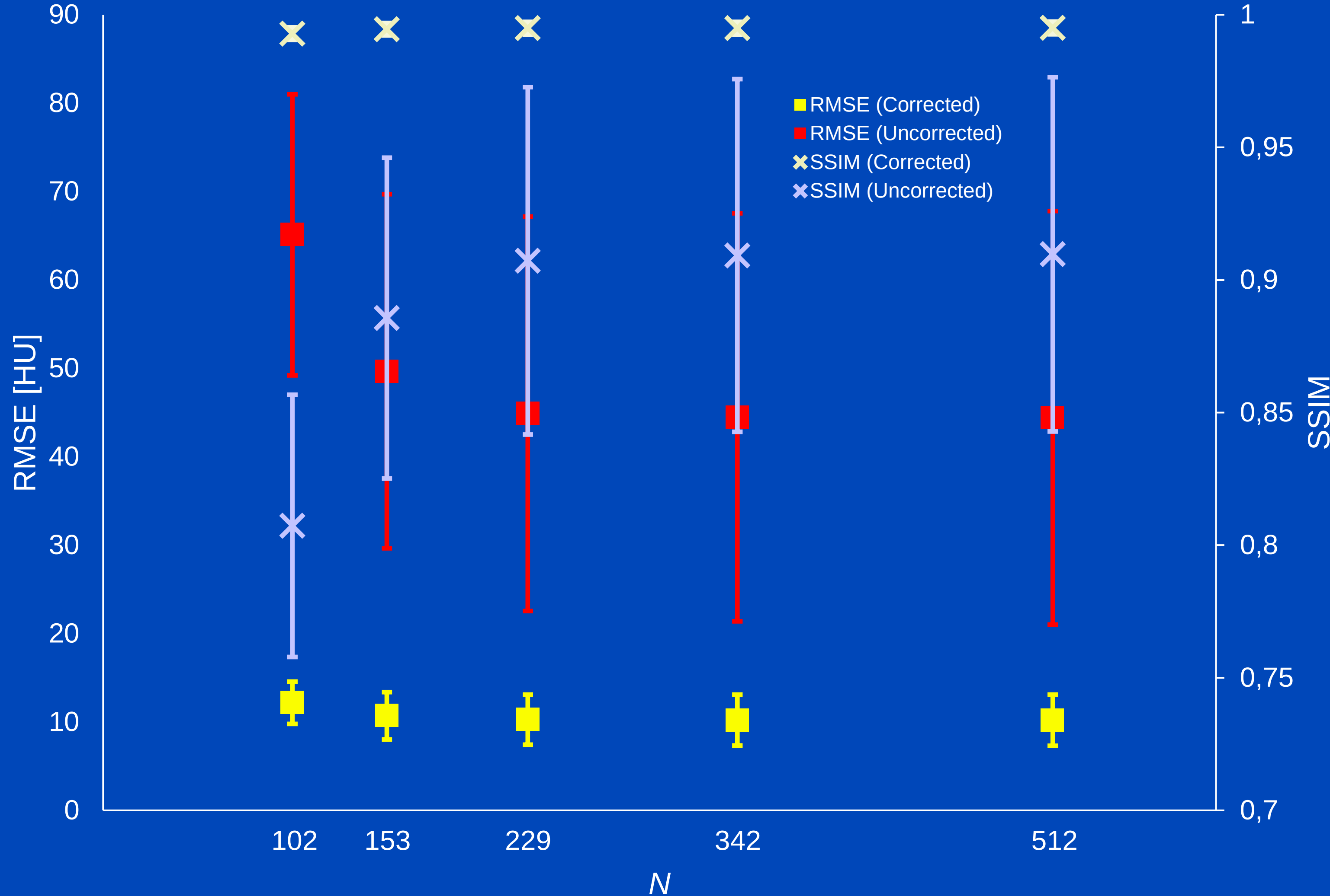
Network is trained separately for each scenario

Results



C = 0 HU, *W* = 500 HU, difference images: *C* = 0 HU, *W* = 100 HU

Quantitative Results



Paired t-test: corrected > uncorrected

***N*: 512 = 342 > 229 > 153 > 102**

Conclusions

- CNN was able to correct all forms of low-dose CT
  - Some structures better preserved in low-mAs image
- Higher numbers of projections lead to statistically significantly better image metrics
  - Physical difference is relatively small
- Need to evaluate image quality based on specific task, e.g. lesion detection
- Perform architecture search to further optimize network per noise implementation

Thank You!

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