3D scout scans using projection domain denoising

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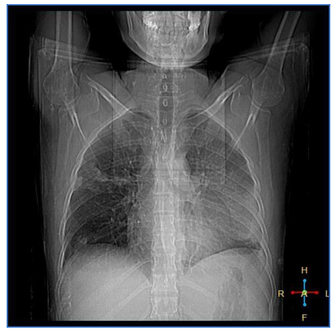
Introduction

- Scout scans are used for planning before the diagnostic CT
- 3D scout is a conventional CT captured with ultra low X-ray dose (≈1% of the full dose)
- Ultra low dose level leads to strong artifacts in projections and images

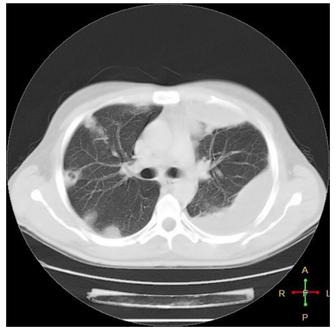
Motivation

- Planning in 3D provides more information about anatomy and it helps to reduce the dose during the further diagnostic scan

2D scout (topogram)



Conventional CT (3D)



Projections (sinograms)

Reconstruction

Reconstructed image

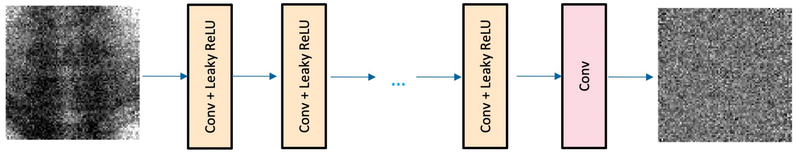
Method

- CNNs for denoising of the ultra-low dose CT in the projection domain
  - Denoiser working in line-integrals
  - Denoiser in raw photons
- Total Variation (TV) denoiser as a baseline for comparison
- Supervised dataset for training the CNNs

$$I_i \sim Poisson\{I_{i,0}e^{-p_i}\} = Poisson\{I_{i,0}e^{-\int_0^\infty \mu(\eta)d\eta}\}$$

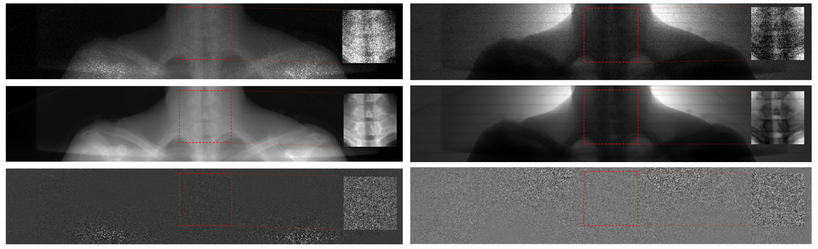
Photons

Line Integrals



Dataset

- Poisson noise model was used to create low dose CTs
- Overlapping patches of 64 × 64 from 160000 projections for training, and 20000 projections were set for validation.
- Two separate CT volumes were set as a holdout for testing



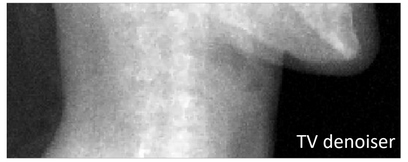
Line Integrals data

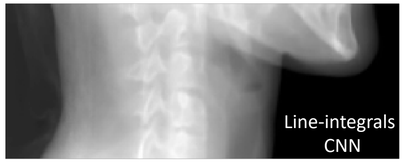
Raw photon counts

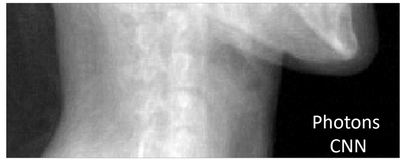
Results

Projections

Images (W/L = 500/50)







Denoiser	Projections (full scan)		Images (full volume)	
	SSIM	MSE	SSIM	MSE, HU^2
Low dose	0.435	0.120	0.275	38007
TV-denoiser	0.635	0.022	0.332	3646
Line-integrals CNN	**0.943**	**0.004**	**0.383**	**1733**
Photons CNN	0.803	0.014	0.338	2586

Conclusion

- Was demonstrated the potential to use CNN for projection based denoising in extremely low dose situation
- Both networks outperform TV denoiser
- Denoising of raw photon data results in images that are sharper but noisier at the same time
- Future work to achieve improved results may include the use of slightly less aggressive dose reduction as well as alternative loss functions and architectures