

Evaluation of Siemens SOMATOM CT-Simulator Reconstruction Space And Correlation Of Physical And Clinical Image Quality

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Purpose

The Siemens SOMATOM Definition Edge CT-Simulator, like many other simulators, comes with a variety of scan reconstruction capabilities. Some of these settings are proprietary algorithms that handle raw scan data in undisclosed manners or of minimal vendor description.

The purpose of this project was to evaluate the impact of CT-simulator reconstruction settings on image quality, focusing on spatial resolution, contrast, noise and contrast to noise ratio. Reconstruction settings that were varied included Reconstruction kernel, slice thickness, and strength of the Sinogram Affirmed Iterative Reconstruction (SAFIRE) setting.

A secondary objective was to determine if the results of reconstruction settings would translate from a phantom image set onto patient image sets.

Methods

A CatPhan 504 phantom was scanned on a Siemens SOMATOM Definition Edge CT. The raw image data was reconstructed with each unique combination of Slice Thickness [0.5, 1, 1.5, 2 mm], SAFIRE Strength [0, 1, 3, 5], and Reconstruction Kernel [Br38, Bv66, Hr38, Hv49, Qr40, Qv43] (96 in total).

Image sets were evaluated with DoseLab Pro v6.80 for:

I. Spatial Resolution

$$M_{lb} = \frac{S_l^{i\%} - S_b^{j\%}}{S_l^{i\%} + S_b^{j\%}} \quad i \gg j$$

$S_l^{i\%}$ = line bar ROI i^{th} percentile value

II. ROI Contrast

$$C [\%] = 100 \left(\frac{S_2 - S_1}{S_2 + S_1} \right)$$

III. ROI Noise

$$N [\%] = 100 \left(\frac{\sqrt{\sigma_1^2 + \sigma_2^2}}{\sqrt{S_1^2 + S_2^2}} \right)$$

IV. Contrast-Noise Ratio

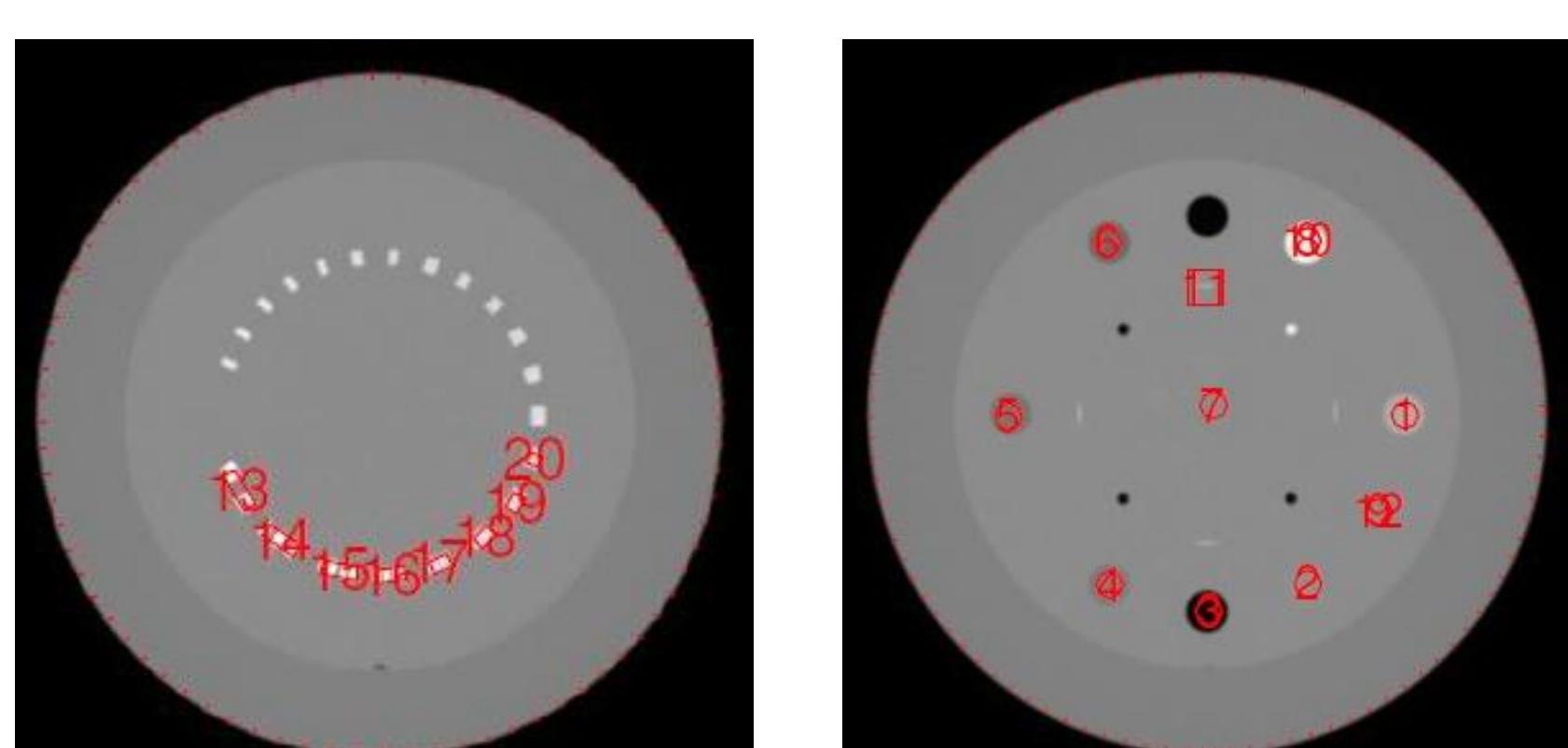


Figure 1. [Left] CTP528 module for DoseLab spatial resolution evaluation [Right] CTP404 module for DoseLab contrast and noise evaluation

The top three reconstruction combinations were then chosen to evaluate their impact on two anonymized clinical CTs, a pelvis and head/neck scan. Regions of interest (ROIs) were assessed in organs to quantify noise reduction and HU value changes relative to the current clinical protocol. That is, compare three reconstructions of the best kernel to the currently-utilized Br38, under matching SAFIRE strength and slice thickness settings.

Results

Kernel 1 – Br38 (Body Regular, Sharpness Level 38)					Kernel 5 – Qr40 (Quantitative Regular, Sharpness Level 40)				
	Slice Thickness [mm]	SAFIRE 0	SAFIRE 1	SAFIRE 3	SAFIRE 5	SAFIRE 0	SAFIRE 1	SAFIRE 3	SAFIRE 5
Spatial Resolution [lp/mm]	0.5**	0.37	0.37	0.37	0.37	0.42	0.42	0.43	0.43
	1	0.37	0.37	0.37	0.37	0.42	0.42	0.43	0.43
	1.5	0.37	0.36	0.36	0.36	0.42	0.42	0.42	0.41
	2	0.37	0.36	0.37	0.37	0.42	0.42	0.42	0.43
CNR	0.5**	15	16.4	19.6	24.2	17.3	14.3	23	35
	1	22.9	24.3	30.9	34.9	26.8	30.4	39.8	57.4
	1.5	24.5	25.7	35.9	40.2	30.5	34.5	44.3	64.5
	2	25.8	26.7	35.6	38.5	35.7	40.8	47.1	66.6
Contrast [%]	0.5**	27.6	27.6	27.5	27.5	26.9	26.7	27	27
	1	27.7	27.7	27.6	27.6	26.7	26.8	26.9	26.9
	1.5	27.7	27.6	27.6	27.6	26.8	26.8	26.9	26.9
	2	27.7	27.7	27.6	27.6	26.8	26.8	26.9	26.9
Noise [%]	0.5**	1.840	1.683	1.403	1.136	1.555	1.867	1.174	0.771
	1	1.210	1.140	0.893	0.791	0.996	0.882	0.676	0.469
	1.5	1.131	1.074	0.769	0.687	0.879	0.777	0.607	0.417
	2	1.074	1.037	0.775	0.717	0.751	0.657	0.571	0.404

*For SAFIRE 0, Thinnest Slice Thickness Is Actually 0.6mm

Table 1. CatPhan 504 reconstruction image quality statistics for kernels Br38 (Left; Clinical Default) and Qr40 (Right; Best-Performing)

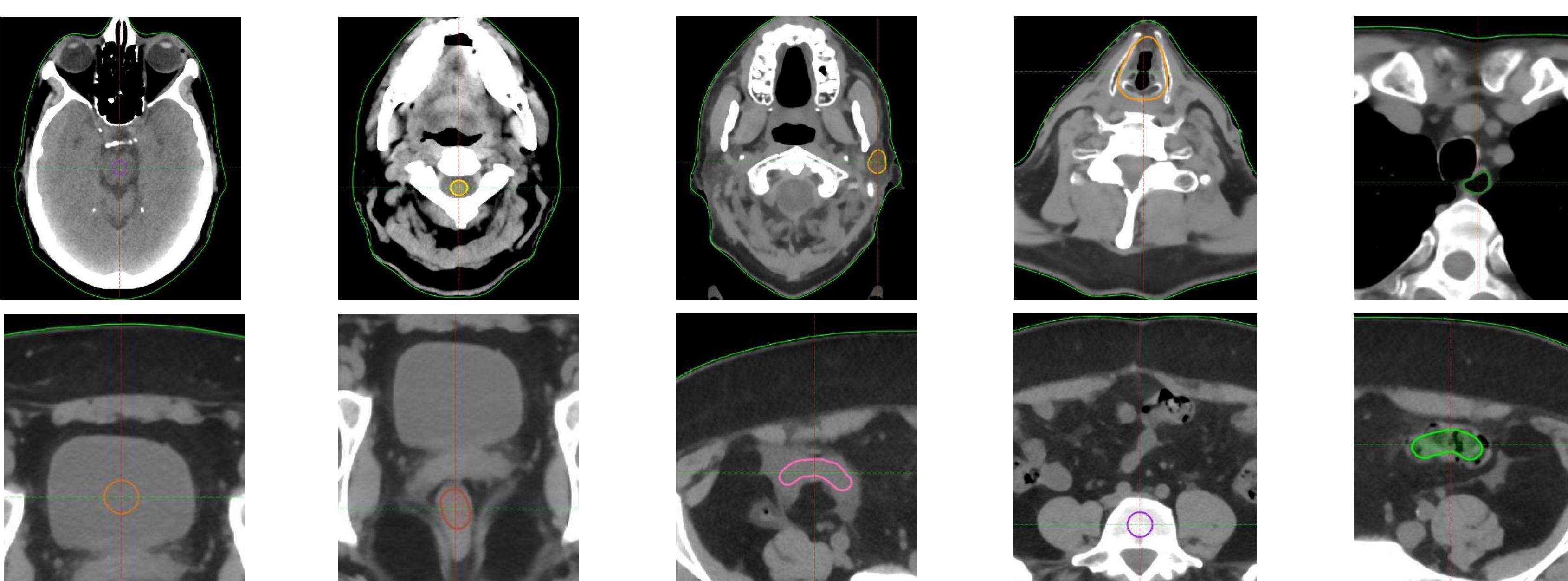


Figure 2. [Top] Anatomical ROIs for head & neck anonymized CT reconstructions (Brain Stem, Spinal Cord, L Parotid, Larynx, Esophagus) [Bottom] Anatomical ROIs for female pelvis anonymized CT reconstructions (Bladder, Rectum, Small Bowel, Spinal Body, Sigmoid)

Organ	Kernel, SAFIRE Strength	Slice Thickness [mm]	ROI Mean (HU)	ROI St.Dev (Noise)	Organ	Kernel, SAFIRE Strength	Slice Thickness [mm]	ROI Mean (HU)	ROI St.Dev (Noise)
Brain Stem	Br38, SAFIRE 5	0.5	30.0	7.5	Bladder	Br38, SAFIRE 5	0.5	22.3	7.6
		1.0	30.4	4.7			1.0	22.2	4.9
		2.0	31.1	3.3			2.0	22.3	3.8
	Qr40, SAFIRE 5	0.5	29.7	6.9		Qr40, SAFIRE 5	0.5	22.3	7.0
		1.0	30.0	4.5			1.0	22.2	4.4
		2.0	30.8	3.0			2.0	22.3	3.5
Spinal Cord	Br38, SAFIRE 5	0.5	38.1	10.6	Rectum	Br38, SAFIRE 5	0.5	41.4	9.0
		1.0	38.3	7.2			1.0	41.8	6.6
		2.0	38.0	6.5			2.0	41.6	5.8
	Qr40, SAFIRE 5	0.5	41.8	9.2		Qr40, SAFIRE 5	0.5	38.5	8.6
		1.0	42.1	5.9			1.0	38.6	6.6
		2.0	41.7	5.2			2.0	37.9	5.9
Parotid (L)	Br38, SAFIRE 5	0.5	-34.5	12.3	Small Bowel	Br38, SAFIRE 5	0.5	23.9	10.2
		1.0	-34.4	10.4			1.0	24.2	6.7
		2.0	-33.3	10.1			2.0	24.5	5.4
	Qr40, SAFIRE 5	0.5	-34.7	11.5		Qr40, SAFIRE 5	0.5	22.6	9.4
		1.0	-33.7	9.6			1.0	22.8	6.1
		2.0	-32.4	8.3			2.0	23.1	4.9
Larynx	Br38, SAFIRE 5	0.5	-102.0	343.8	Spinal Body	Br38, SAFIRE 5	0.5	210.6	31.1
		1.0	-105.2	338.9			1.0	212.5	30.4
		2.0	-102.7	337.2			2.0	218.5	30.4
	Qr40, SAFIRE 5	0.5	-100.5	322.8		Qr40, SAFIRE 5	0.5	212.1	26.5
		1.0	-100.6	320.3			1.0	214.5	25.8
		2.0	-101.7	318.4			2.0	221.3	26.2
Esophagus	Br38, SAFIRE 5	0.5	-411.2**	407.0**	Sigmoid	Br38, SAFIRE 5	0.5	-26.8	78.0
		1.0	-426.7**	397.8**			1.0	-25.1	73.9
		2.0	-414.8**	388.8**			2.0	-23.4	69.0
	Qr40, SAFIRE 5	0.5	-410.6**	362.9**		Qr40, SAFIRE 5	0.5	-31.2	64.0
		1.0	-422.8**	356.2**			1.0	-29.7	60.6
		2.0	-454.6**	355.4**			2.0	-28.0	56.0
Max Δ 			4.6	21.0	Max Δ 		4.6	14.0	

Table 2. Reconstruction mean HU and noise values for anatomical ROIs. Red indicates max absolute difference in each between kernels.

**Values skewed due to ROI volume changes between reconstructions; Omitted from max |Δ| and 'Results' consideration