Characterization of CT Reconstruction Kernels

Eric McKenzie and Dr. David Gauntt

A Comparison of Noise Power Spectrum Analysis

1. Abstract

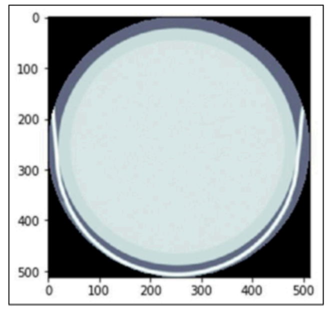
- Continuation of previous work accomplished by Dr.'s Eshan Samei (Duke University), Justin B. Solomon and Olav Christianson. the difference in approach are listed in the methods section
- The key of this experiment is to match noise power spectra amongst multiple CT scanner models and reconstruction kernels.
- Noise power is an inherent attribute to every CT filter type and can be used to characterize image reconstruction

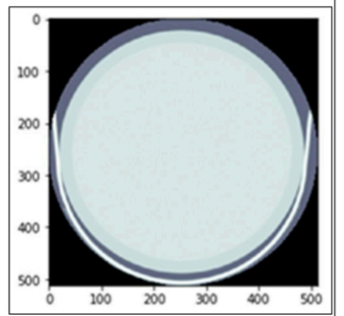
2. Methodology

- Create and compare noise power from two of the same images from the same reconstruction kernel across a multitude of different scanners.
- Differences between this study and Dukes are shown in the table at the end of the "Methods" section.

1.) Acquire and subtract pixel values from two DICOM images taken from the same location with a Gammex Phantom by a particular scanner and reconstruction kernel. The average of 64 pairs of images are used for calculating the NPS of a single filter.

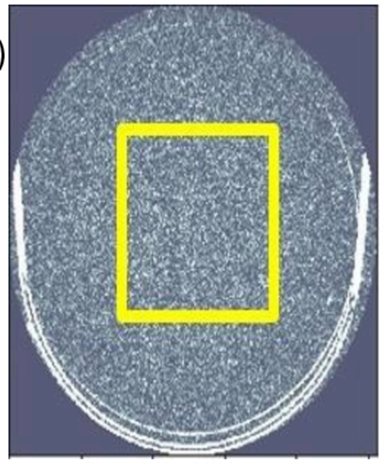
1.)





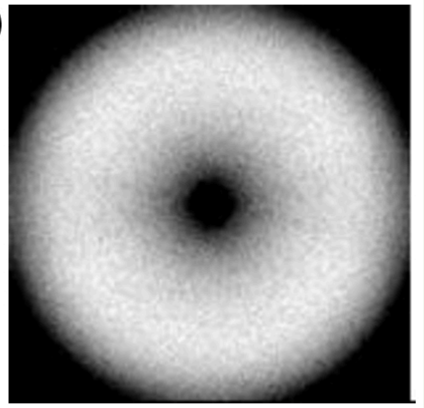
2.) Images were cropped to a smaller square in the center to acquire a uniform region free of edges or other external influences.

2.)



3.) Perform Fourier Transform on difference image, leaving two components of a 2D array, and take the sum of the squares of each component in order to calculate the noise power value for each pixel location.

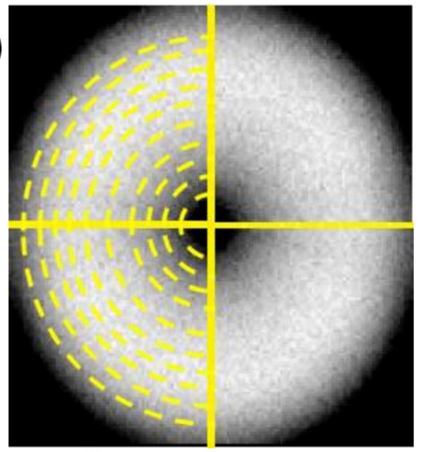
3.)



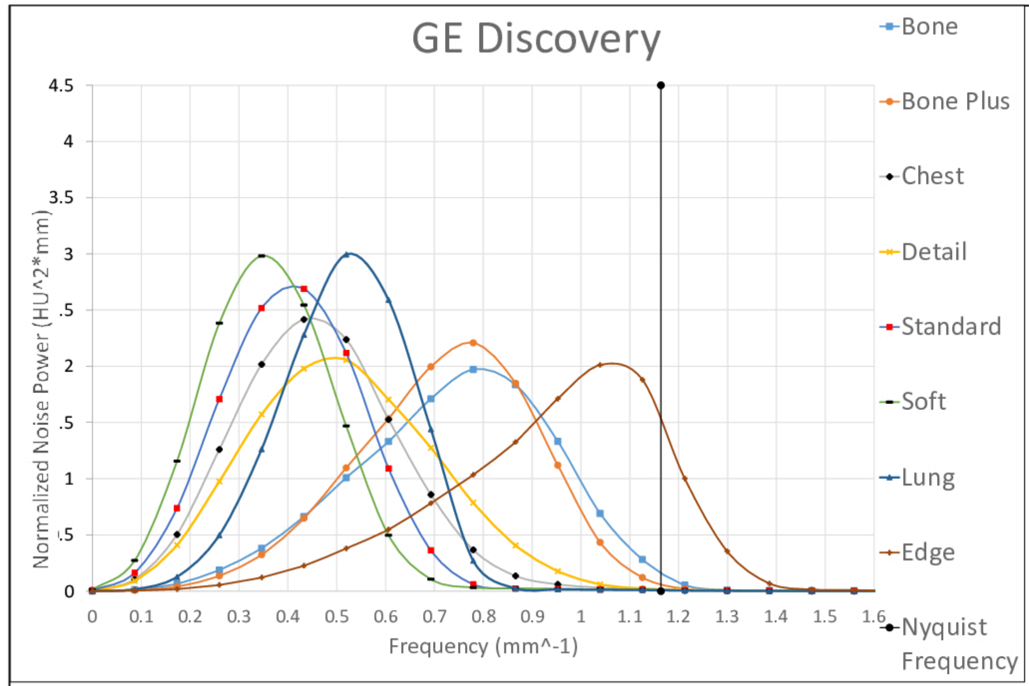
4.) The resulting output is a spectrum of spatial frequencies (x and y location of pixel) and the associated noise for that spatial frequency (magnitude of pixel).

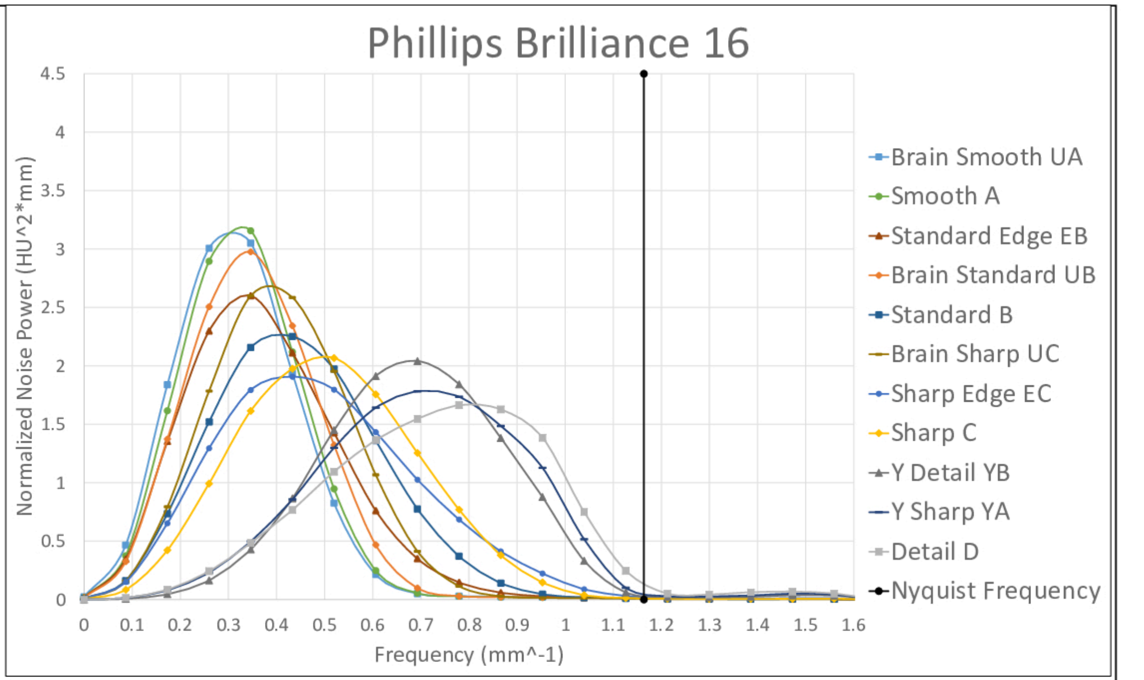
5.)
e) Divide k-space into 20 ring-shaped frequency bins
f) Calculate the total power in each bin
g) Multiply by a visual response function
h) Normalize to unit area, 1 HU^2
i) Calculate RMS difference between normalized curves

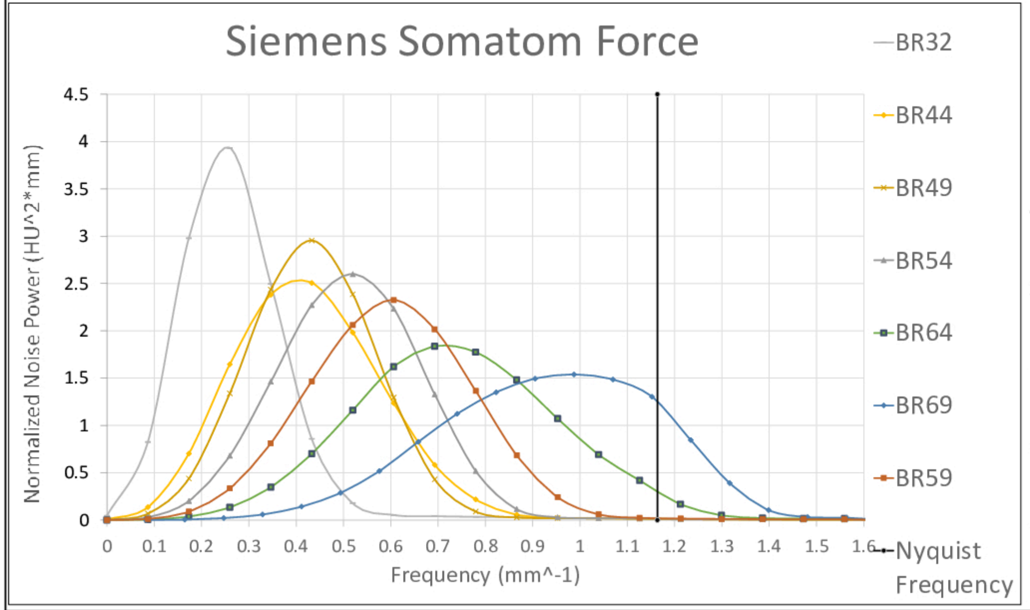
4.)



Parameter	Duke	UAB
ROIs/Image	4-128x128	1-128x128
Back. Subtr.	Quadratic fit	Subtract 2 images
Images/Filter	"All in series"	54 to 64
Scanner Models	GE Discovery Siemens Flash	GE Discovery Siemens Force Philips Brilliance

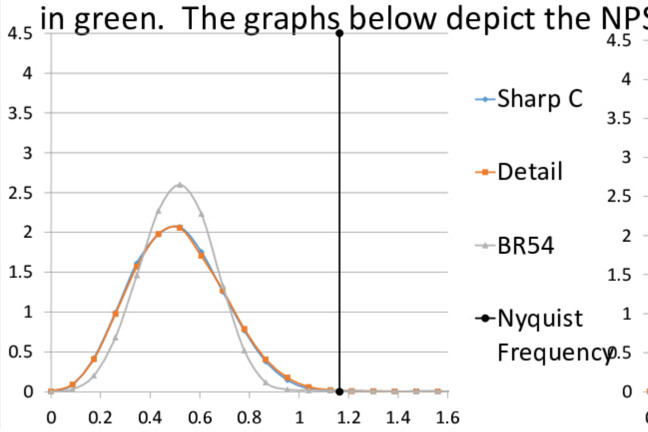


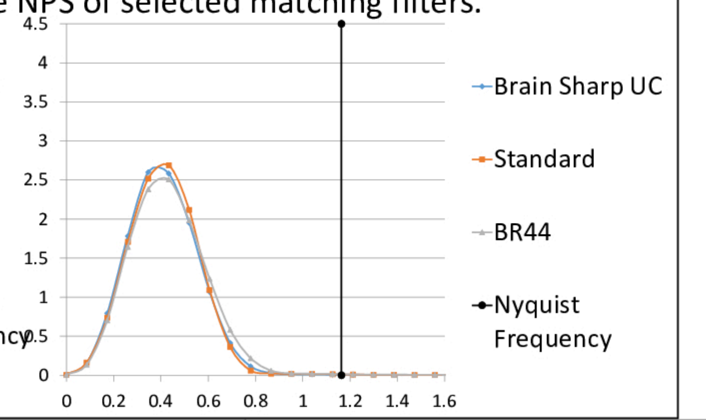




3. Results

Below are two graphs depicting similar filter types across three manufacturers. The table below lists the RMS difference in NPS between pairs of filter kernels; the GE kernel that most closely matches each Philips kernel is highlighted in red, and the Siemens kernel that most closely matches is highlighted in green. The graphs below depict the NPS of selected matching filters.





4. Conclusion

As stated previously, filter types were matched to RMSD in order to best match the shape of each curve across three different manufacturers. In an industry where techs and radiologists are expected to know the outcome of filter algorithms, matching the RMSD between normalized NPS curves gives the best characteristic to match across scanners and show an expected results relative to other filters one has seen.

	GE Discovery filters						Siemens Force filters			
	Soft	Stnd	Chest	Detail	BonePlus	Bone	Br32	Br44	Br54	Br64
BRAIN_SMOOTH_UA	0.3	0.58	0.75	0.87	1.37	1.33	0.47	0.59	1.03	1.31
SMOOTH_A	0.23	0.52	0.71	0.84	1.36	1.32	0.55	0.54	0.99	1.3
BRAIN_STANDAR_UB	0.08	0.36	0.56	0.71	1.29	1.25	0.68	0.39	0.85	1.22
STANDARD_EDGE_EB	0.17	0.3	0.45	0.58	1.17	1.13	0.7	0.3	0.73	1.1
STANDARD_B	0.42	0.2	0.12	0.28	0.98	0.96	1	0.11	0.4	0.9
BRAIN_SHARP_UC	0.26	0.06	0.26	0.46	1.14	1.11	0.95	0.09	0.55	1.06
SHARP_EDGE_EC	0.55	0.37	0.2	0.15	0.8	0.78	1.04	0.28	0.35	0.72
SHARP_C	0.67	0.45	0.22	0.02	0.77	0.76	1.18	0.36	0.22	0.69
Y_SHARP_YA	1.16	1.01	0.82	0.61	0.17	0.17	1.45	0.93	0.73	0.11
DETAIL_D	1.17	1.04	0.87	0.68	0.21	0.11	1.44	0.97	0.81	0.14
Y_DETAIL_YB	1.2	1.04	0.83	0.61	0.2	0.26	1.5	0.95	0.7	0.17