Neurophotonics HW2

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1. Calculate for each recording (make a table)

a. Temporal Noise – Column 2
b. Global Spatial Noise (after averaging in time) - Column 3
c. Local Spatial Noise with window size of 7 (after averaging in time) - Column 4
d. Local Spatial Noise with window size of 7 per frame – then average over all frames. - Column 5
e. Total Noise [totalNoise = √TemporalNoise2 + LocalSpatialNoise2] - Column 6
f. Temporal Noise Contribution = temporalNoise2 /Mean – Column 7
g. Theoretical Noise = $\frac{2^{nBits}[DU]}{\text{maxcapacity[e]}} \cdot 10^{gain[dB]/20}$ - Column 8

```
temporalNoise(recordIndex)=mean2(std(rec,0,3));
% b. Global Spatial Noise (after averaging in time)
globalSpatialNoise(recordIndex)=std2(mean(rec,3));
%c. Local Spatial Noise with window size of 7 (after averaging in time)
localSpatialNoise_avg_time(recordIndex)=mean2(stdfilt(mean(rec,3),ones(window_size)));
% d. Local Spatial Noise with window size of 7 per frame – then average over all frames.
for frameIndex=1:size(rec,3)
    localSpatialNoise_temp(frameIndex)=mean2(stdfilt(rec(:,:,frameIndex),ones(window_size)));
end
localSpatialNoise_per_frame_Thenavg_frames(recordIndex)=mean2(localSpatialNoise_temp);

% d. Is it equal to the total Noise [ totalNoise = √TemporalNoise2 + LocalSpatialNoise2 ]
totalNoise(recordIndex)=sqrt(temporalNoise(recordIndex).^2+localSpatialNoise_avg_time(recordIndex).^2);

% Noise of question number 5 - temporal noise in power 2 divided by the
% average of the pixels
noiseNumber5(recordIndex)=temporalNoise(recordIndex).^2./mean2(mean(rec,3));

% Calculate temporalNoise^2 / Mean and compare with the given formula
gain_dB = info.name.Gain;  % Assuming Gain is in RecordInfo
theoreticalNoise(recordIndex) = ((2^nBits) / max_capacity) * 10^(gain_dB / 20);
```

Figure 1. My code segment for the calculation

RecordName	TemporalNoise	GlobalSpatialNoise	LocalSpatialNoiseAvgTime	LocalSpatialNoisePerFrames	TotalNoise	TemporalNoiseContribution	TheorticalNoise
WhitePaper_Gain24dB_expT0.5ms_BlackLevel0DU	78.8383	19.1743	10.6451	79.0892	79.5538	5.8782	6.1826
WithCover_Gain0dB_expT0.021ms_BlackLevel30DU	0.8722	0.1902	0.1873	0.8919	0.8920	0.0263	0.3901
WithCover_Gain24dB_expT0.021ms_BlackLevel30DU	7.3346	2.7758	2.7322	7.9198	7.8270	1.7866	6.1826
WithCover_Gain24dB_expT10ms_BlackLevel30DU	7.5175	2.8027	2.7546	8.0309	8.0063	1.9135	6.1826

Figure 2. Table calculation

Answers to question (The index is in respect to the homework assignment):

d. The Total noise is relatively close to the Local Spatial noise per frame.

5. The Temporal Noise Contribution is relatively close to the Theoretical Noise only when the camera is open with an exposure time larger than 0.021ms as shown in Figure 2 first row.

2. Which noise is recorded when the exposure time is 21μs (given this is the minimum exposure time for that camera) and the camera is closed with a cover?

It's the Quantum efficiency.

3. Which noises are recorded when the exposure time is >>21µs and the camera is closed with a cover?

It's the Dark current which is measured without illumination (camera closed with a cover) and it's dependent on the exposure time. The record with cover and higher exposure time is characterized by a higher total noise value compared to the minimum exposure time, as seen in Figure 2.

5. Which noise dominates in the recording when the camera is not closed, and the exposure time is >>21µs ?

The dominant noise in these conditions is the temporal noise, or in other words the readout noise. As seen in Figure 3 the image received is not uniform some pixels registered higher intensities while other regions record fewer photons. Hence, the noise in different regions is different and this explains the difference between the noises.

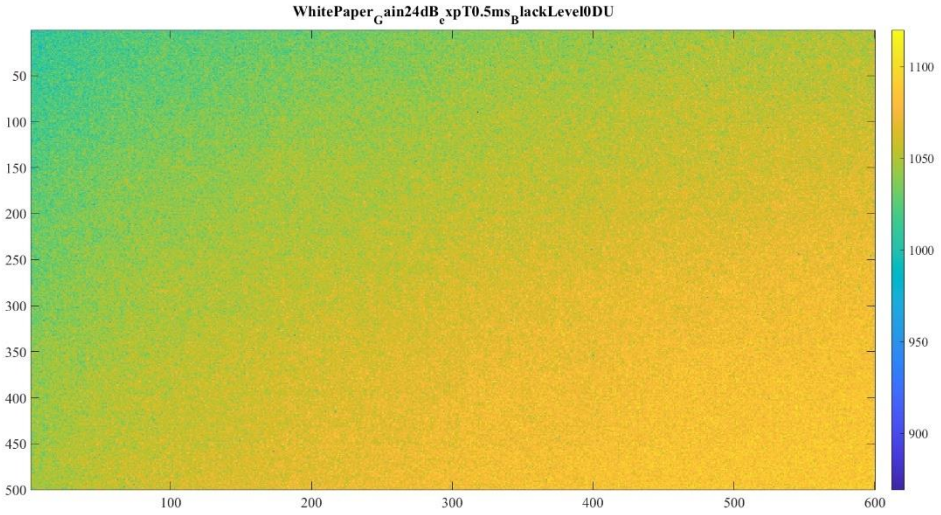

Figure 3. The image of the record with the open camera average over time

However, when observing the image of the speckle pattern in all of the other records where the camera is closed, we can see that the image is uniform. Furthermore, the global spatial noise and local spatial noise for those uniform images is similar, supporting my conclusion.

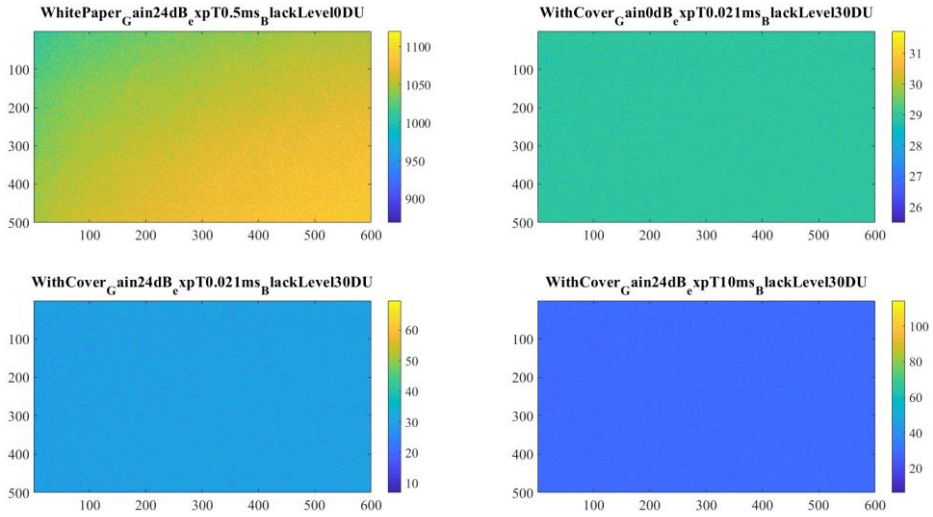

Figure 4. The image of the record average over time for each of the recording with the corresponding recording name