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Detector Noise

5. Summary of tasks of the experimental work

5.2 Noise evaluation

Please provide a table with the different means and standard deviations including parameters for each image and each color, for blue, green and red. (4 dark noise, 2 nearly saturated).

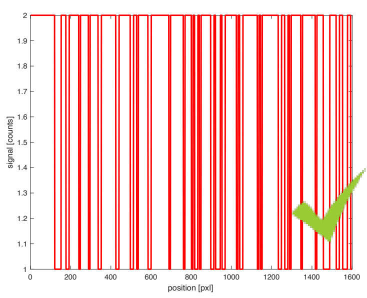
		RED		GREEN		BLUE	
		Mean	STD	Mean	STD	Mean	STD
Dark	Lowest Gain – Short exposure	2.0927	2.9486	2.2311	3.0048	2.1290	2.9617
	Highest Gain – Short exposure	1.9780	3.2520	2.5854	3.3526	2.6776	3.7869
	Lowest Gain – Long exposure	2.0429	2.9816	2.2100	3.0489	2.0970	2.9923
	Highest Gain – Long exposure	2.3792	3.6070	2.7959	3.6205	3.4420	4.4118
Bright	Lowest Gain – adapted	152.9819	5.0115	151.9057	4.1585	137.1808	3.72[illegible]2
	Highest Gain – adapted	194.8416	6.2765	187.8320	5.8831	178.5137	5.8316

Give example line plots with a width of one line taken in the middle of the image for the measurement. (select one channel – red, green or blue, **six plots** (4 dark noise, 2 nearly saturated, select one channel – red, green or blue).

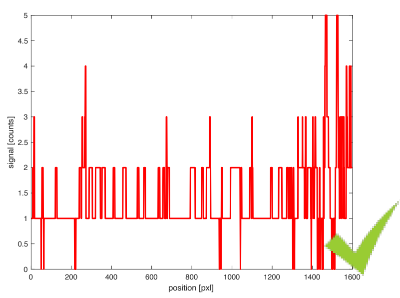
Channel color: RED

Dark noise plots

Picture 1 - Lowest Gain – Short exposure



Picture 2 - Highest Gain – Short exposure



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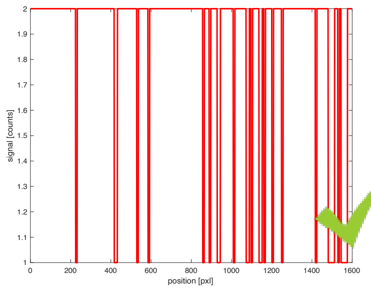
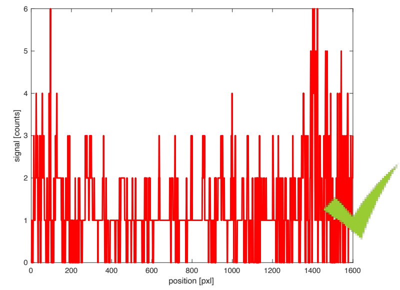
Picture 3 - Lowest Gain – Long exposure

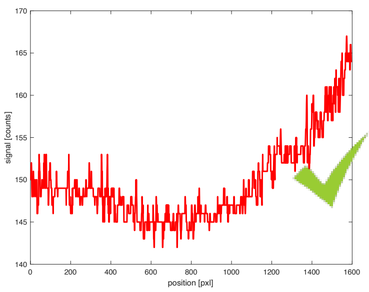


Picture 4 - Highest Gain – Long exposure

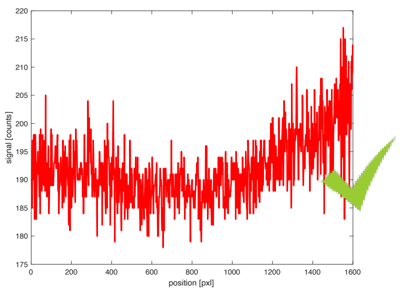


Bright images

Picture 1 - Lowest Gain – adapted exposure



Picture 1 - Highest Gain – adapted exposure



Comments: We observe that the signal to noise ratio (between Mean and STD) is much better when more light reaches the detector. The shot noise is more significant in the dark images because the relative change of photons is more important. Even in the absence of light, we still observe dark/thermal noise which is due to dark currents flowing in the detector. We also observe electronic noise when increasing the gain.

5.3 Noise reduction by averaging (45 min)

Show one set of example images example images like in Figure 14 for the high gain! (one channel – red, **four plots**). Make a table with the value for single line for low and high gain.

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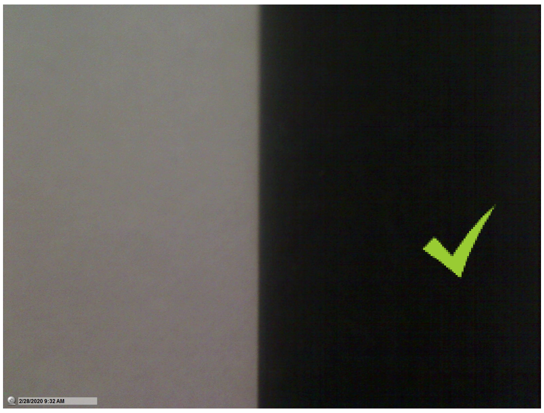
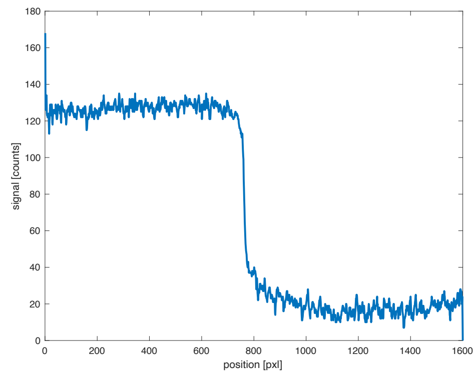
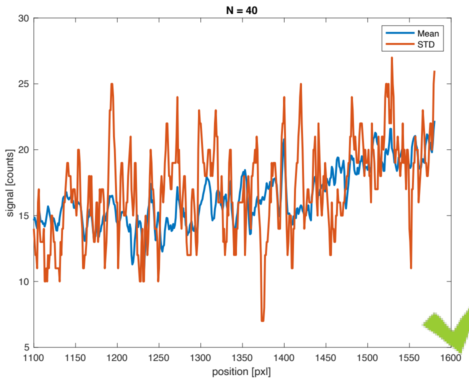
Picture 1 – Step image



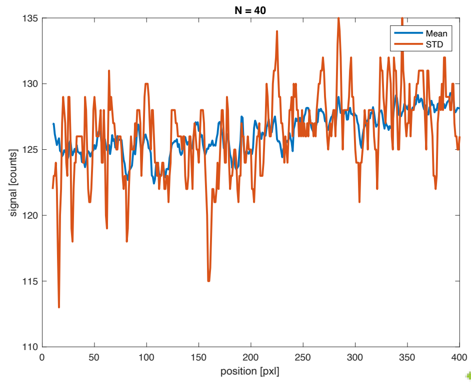
Picture 2 – Line plot



Picture 3 – cropped line plot low signal



Picture 4 – cropped line high signal



Find out how many lines from the high gain image have to be averaged to compensate the noise added by the gain!

	Low gain N=1	High gain N=1	High Gain N= 40
MEAN_red_left	113.1095	126.2353	126.2483
STD_red_left	1.2583	1.7072	2.7379
MEAN_red_right	13.1536	17.1538	16.4094
STD_red_right	1.6895	3.2665	2.1871

Comments: We first observe that by increasing the gain (signal amplification) we inevitably increase the electronic noise.

We know that we can decrease the electronic noise by averaging but for our picture it worked only for the low gain signal. We already had a very good signal to noise ratio for the higher gain image in the first place, so it was hard to observe the additional benefits of averaging.

In our case we determine that N = 40 number of lines is a local minimum for decreasing the electronic noise.

5.4 High dynamic range imaging (45 min)

Show the images with the ROI (**two plots**).

Picture 1 – High Gain exposure setting

Picture 2 – Low Gain exposure setting

Indicate the **measurement zone** in the images!! Find the values as below

Image **highest gain**: **MEAN_ROI = 104.6968**

STD_ROI = 2.0990

Image **lowest gain**: **MEAN_ROI = 35.3342**

STD_ROI = 0.9374

Evaluate the dynamic range increase obtained by the changing of the gain from low to high and **c**alculate the dynamic range factor G with its error! (use the standard deviations as errors for the input values)

The dynamic range factor G is

$$\boldsymbol{G_0} = \frac{Mean\ signal\ value\ for\ high\ gain}{Mean\ signal\ value\ for\ low\ gain} = \frac{MEAN\_ROI_{high\ gain}}{MEAN\_ROI_{low\ gain}} = \frac{104.6968}{35.3342} = 2.96$$

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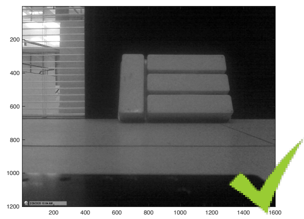
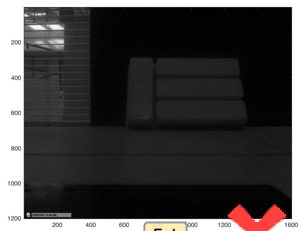
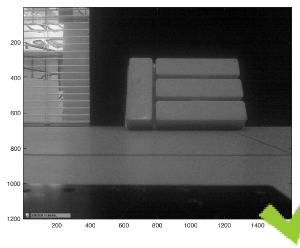
Error calculation

$$\frac{\Delta G}{G_0} = \left|\frac{(STD\_ROI_{high\ gain})}{MEAN\_ROI_{high\ gain}}\right| + \left|\frac{(STD\_ROI_{low\ gain})}{MEAN\_ROI_{low\ gain}}\right| = \frac{2.0990}{104.6968} + \frac{0.9374}{35.3342} = \mathbf{0.046}$$

Give the final result

$$G = G_0 + \Delta G = 2.96 + 0.046 * 2.96 = 3.096$$

Show an example of high dynamic range imaging and provide the **three images** as shown in the example. Indicate in the image in which area one can gather supplementary information.

Picture 1 - bright	Picture 2 - dark	Picture 3 – HDR combined
		

Describe below what are your observations.

Comments:
Taking an image with high gain increase the electronic noise.
The HDR technology is based on taking many pictures (here two) at different gains (low and high) and combining them in the hope of increasing the overall quality. In our case we took one image bright (high gain) and one image dark (low gain) and combined them using the provided matlab code. In our images, we clearly see the quality improvement in the top left corner of Picture 3 because we get a bright image with the details behind the blinds, visible in Picture 2 and not in Picture 1.

5.5. Web example for HDR

Find a HDR example image on the web and cite correctly!

Picture 1 – example image

Source : https://youtu.be/bTib3ENbu1E?t=120

What is your opinion about such images?

Comments: HDR can be great because it becomes easy to take pictures combining light intensity variation and details: it’s good for high contrast picture. It’s also useful for night pictures but, as written in the article linked below, it’s no recommended for low contrast pictures or shooting shadows, people, or animals which might be deformed in the process or get a “creepy/unnatural touch”. It’s definitely a great tool for beautiful landscape pictures.

https://www.digitalphotomentor.com/to-hdr-or-not-when-and-if-you-should-use-hdr/

Personal feedback:

Was the amount of work adequate? Yes.

What is difficult to understand? No.

What did you like about it? We really like to work on the HDR technology because we now clearly understand how it works and in which situations we should use it. It was helpful to work on it because camera sellers never talk about the technical aspects what they sell and it's good to know what we're buying.

How can we do better? This TP was great. We even had time at the end to discuss about other stuff with the TAs and put our smartphone cameras to the test.

Index of comments

5.1 -1, Hard to see the underexposed area