02, Assignment Rectangles and Sampling

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Part 2.1

2.1.1

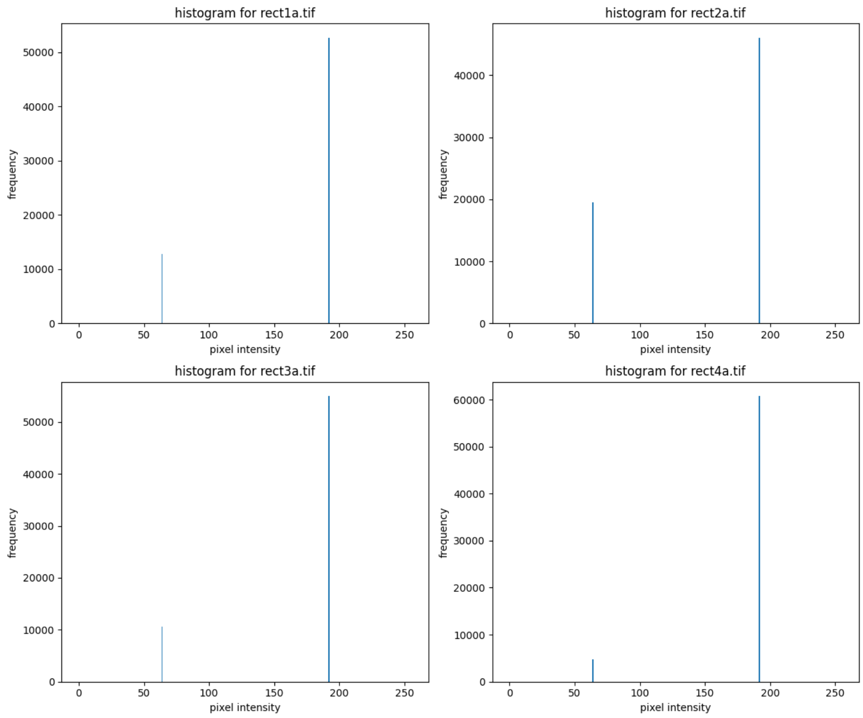


Figure 1: Histograms for series A images.

2.1.2 & 2.1.3

Image	**Area**	**Perimeter**
Image 1	12848.00 ± 0.00	457.50 ± 0.00
Image 2	3247.50 ± 28.8	233.81 ± 1.86
Image 3	1324.12 ± 19.55	147.58 ± 1.80
Image 4	483.00 ± 10.80	92.82 ± 1.26

Table 1: Mean areas and perimeters of objects in the noise-free images. Values are represented as $\mu \pm \sigma$ where μ is the mean and σ is the standard deviation.

Part 2.2

The tables for 2.2.4 & 2.2.5 are shown in figure 1.

2.2.4

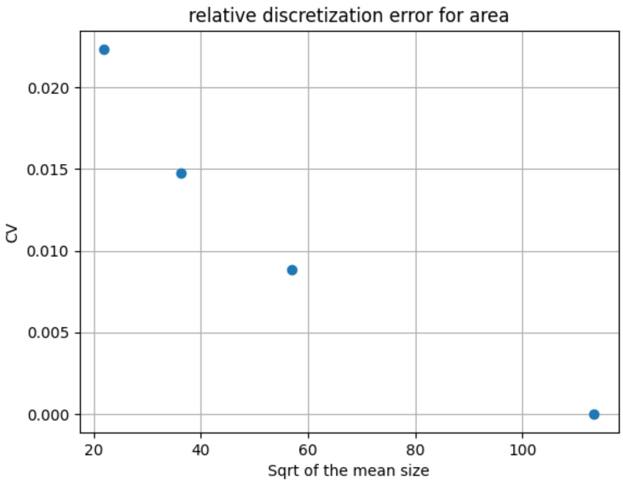


Figure 2: Relative discretization for area.

2.2.5

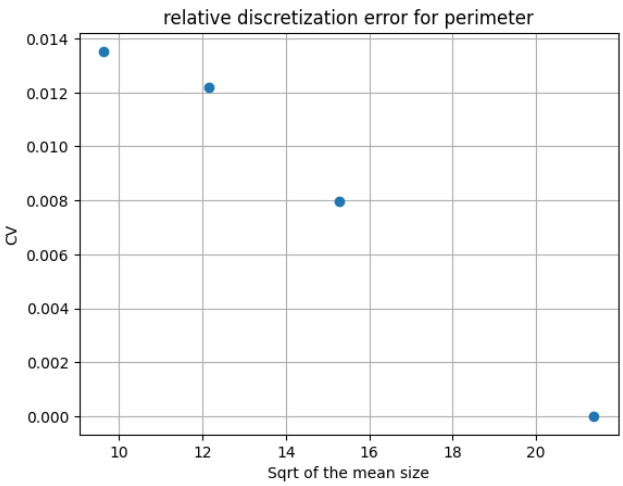


Figure 3: Relative discretization for perimeter.

2.2.6

Differences: RDE is an indication of how accurate the measure is, compared to its actual size. If a rectangle is smaller, its more difficult to be very accurate. So as perimeter is only the outside of the object, a single inaccuracy can have a bigger impact than the entire size. This is why the RDE gets lower more for perimeter slowly than for area.

Part 2.3

2.3.7

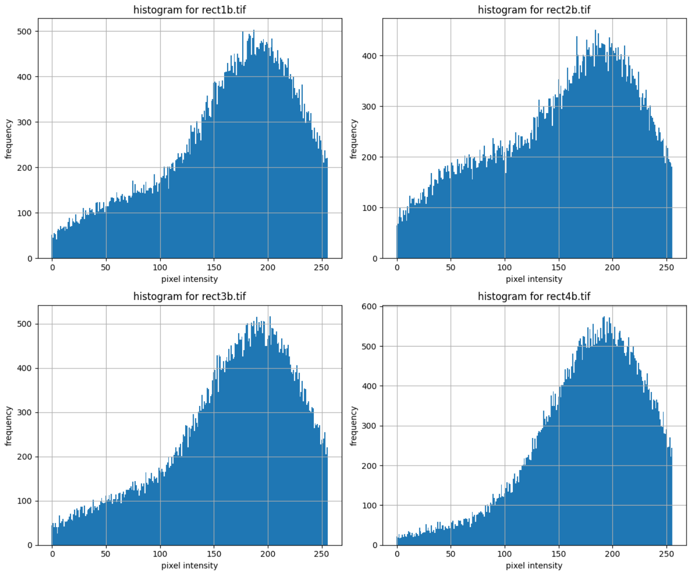


Figure 4: Histograms for Series B.

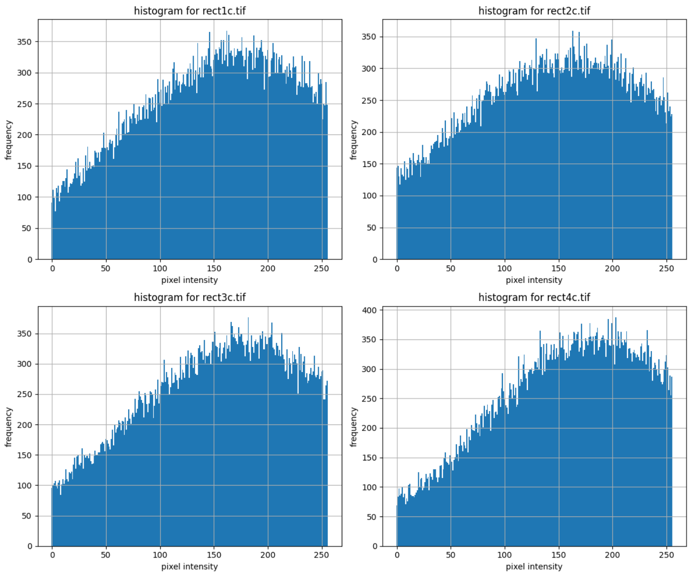
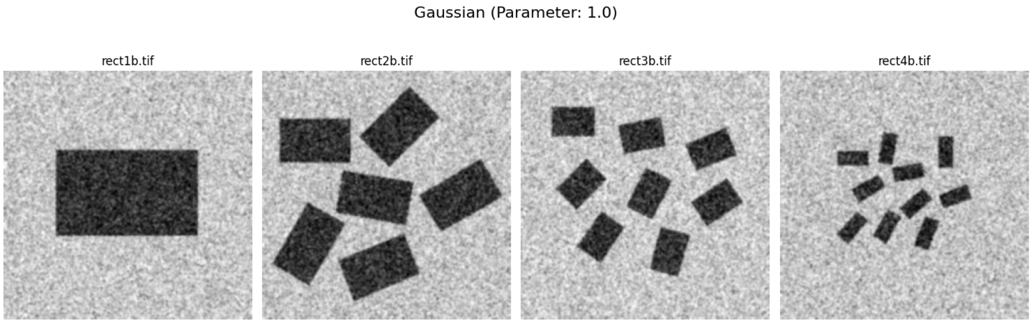
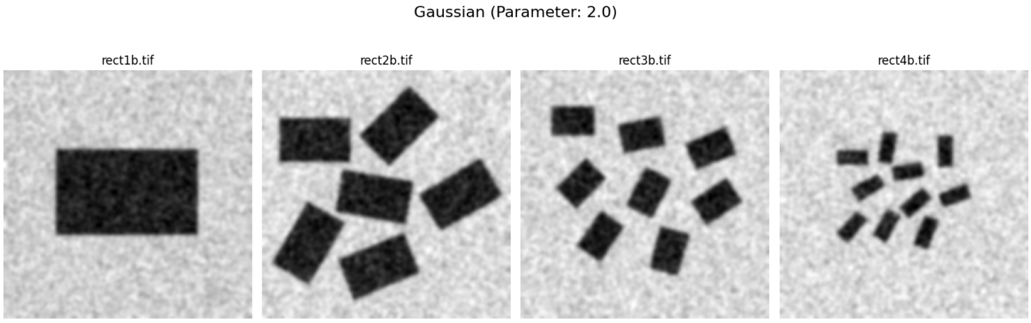
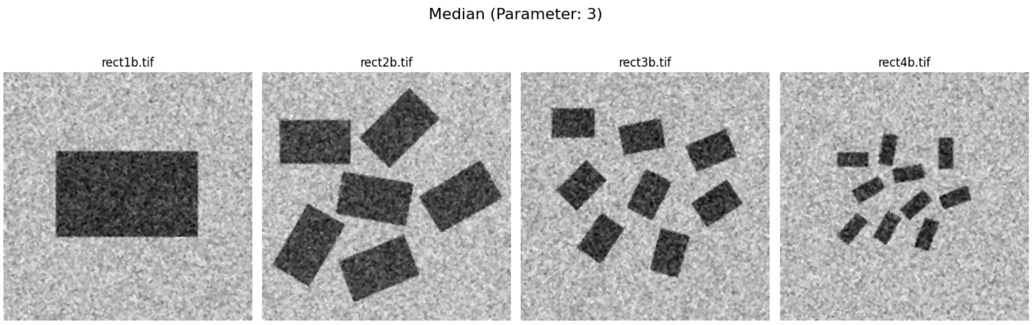


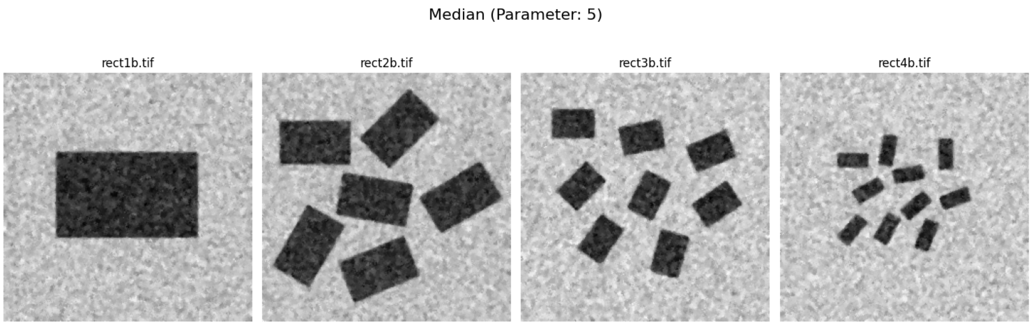
Figure 5: Histograms for Series C.

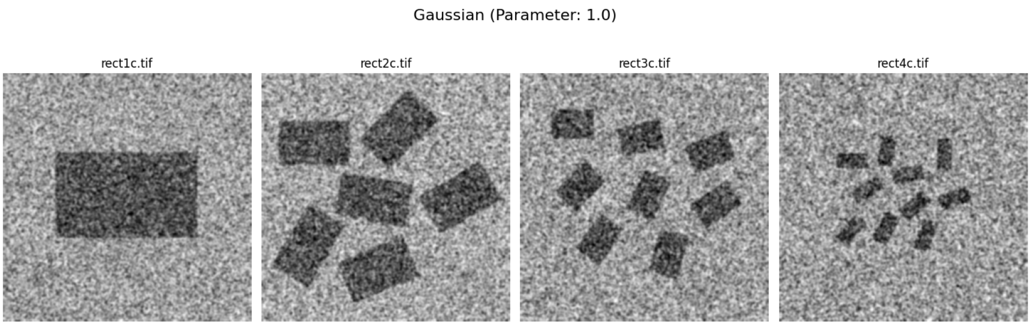
2.3.8

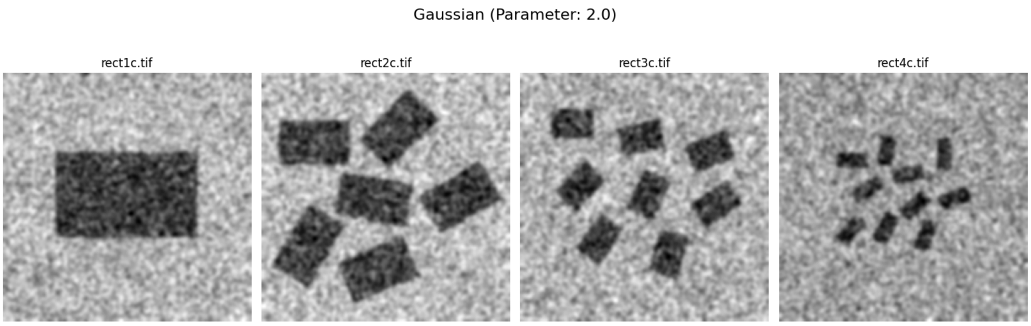

Gaussian (Parameter: 1.0)
rect1b.tif
rect2b.tif
rect3b.tif
rect4b.tif

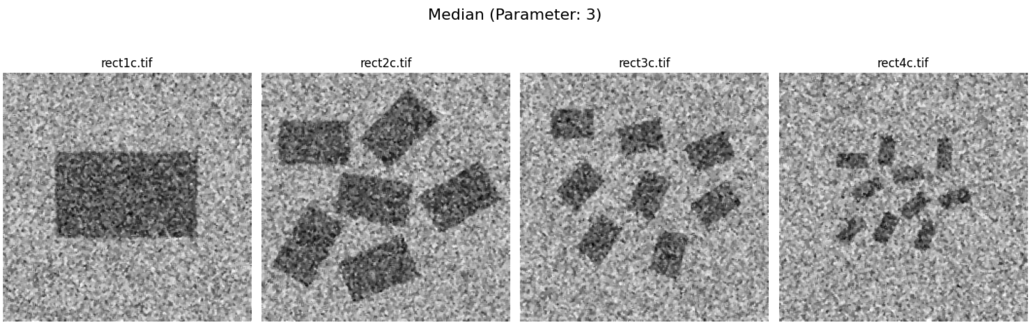

Gaussian (Parameter: 2.0)
rect1b.tif
rect2b.tif
rect3b.tif
rect4b.tif

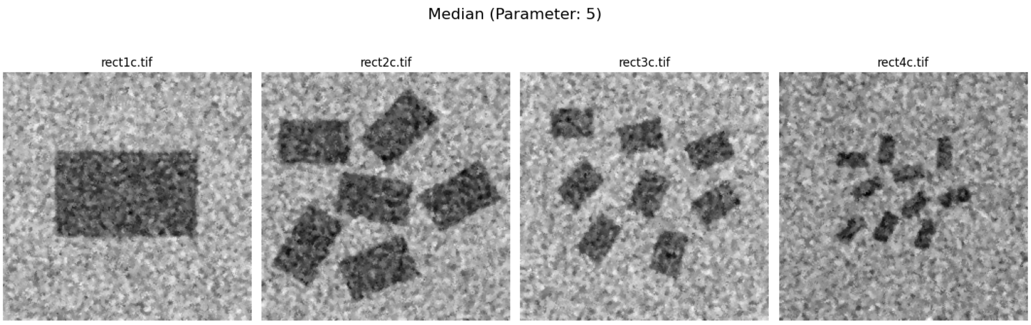

Median (Parameter: 3)
rect1b.tif
rect2b.tif
rect3b.tif
rect4b.tif


Median (Parameter: 5)
rect1b.tif
rect2b.tif
rect3b.tif
rect4b.tif


Gaussian (Parameter: 1.0)
rect1c.tif
rect2c.tif
rect3c.tif
rect4c.tif


Gaussian (Parameter: 2.0)
rect1c.tif
rect2c.tif
rect3c.tif
rect4c.tif


Median (Parameter: 3)
rect1c.tif
rect2c.tif
rect3c.tif
rect4c.tif


Median (Parameter: 5)
rect1c.tif
rect2c.tif
rect3c.tif
rect4c.tif

2.3.9

Image	Area	Perimeter
Image 1	2.35 ± 6.26	4.89 ± 6.28
Image 2	2.75 ± 7.86	5.38 ± 7.62
Image 3	2.10 ± 4.93	4.62 ± 5.24
Image 4	1.69 ± 3.12	4.11 ± 3.56

Table 2: Mean areas and perimeters of objects in the images, aggregated across series, e.g. Image 1 represents all images *rect1x.tif* where x is a series. Values are represented as $\mu \pm \sigma$ where μ is the mean and σ is the standard deviation.

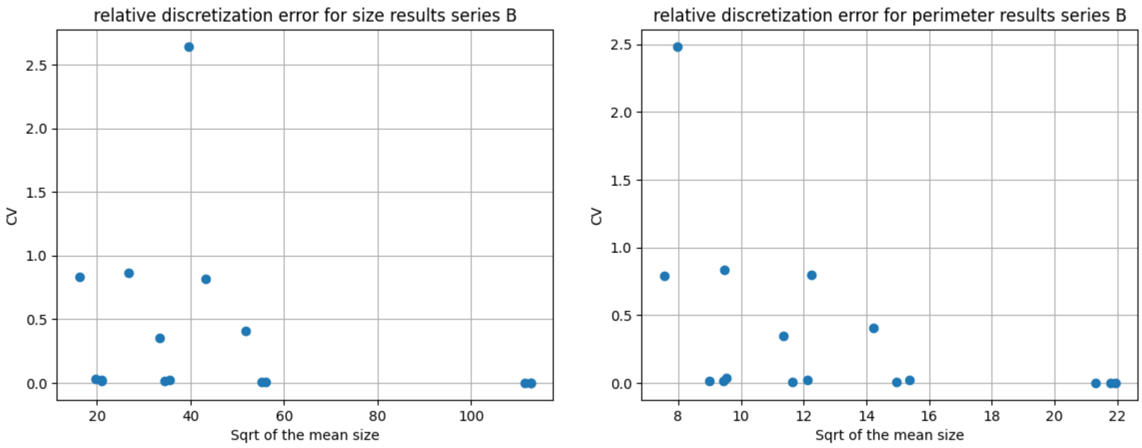


Figure 8: Relative discretization error for the perimeter and size for series B

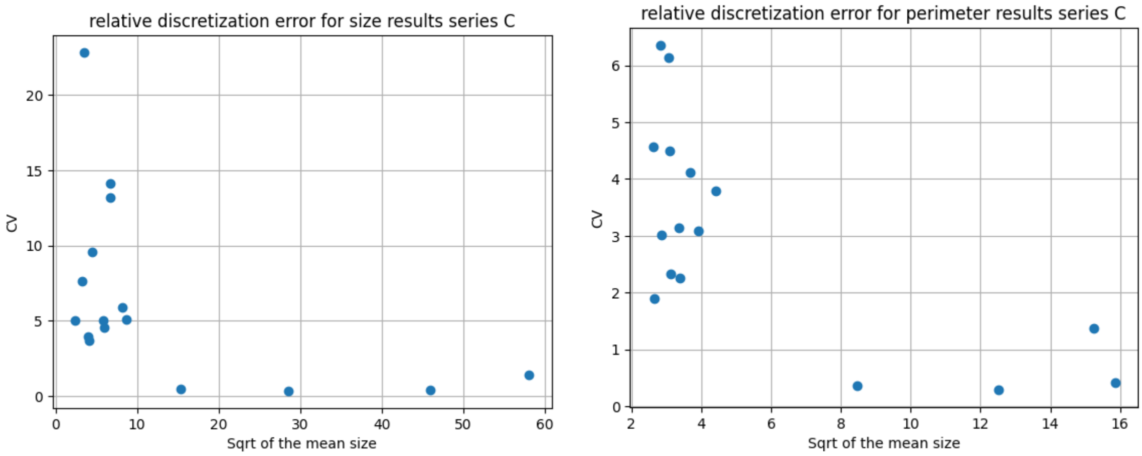


Figure 9: Relative discretization error for the perimeter and size for series C

2.3.10

The effect of noise on the deviation is that the errors are a lot more spread out than without noise. This means some of the objects are more influenced by the noise than others. The noise in this case

causes certain parts of the object to be left out due to the thresholding, resulting in less pixels in the area and perimeter.
We can also see the effect of noise on the absolute values of the B and C series. The size values for C are a lot smaller, and the error margins a lot higher. This means that in the C series, the noise causes a lot more pixels to be excluded in the thresholding, and the error to be higher.

2.3.11

The sampling theorem (Nyquist-Shannon theorem) states that a signal should be sampled at least twice the highest frequency present to accurately reconstruct it. And even though the points are more spread out than without noise, we clearly see that the larger the size of the objects, the smaller the CV. This supports the sampling theorem

Part 2.4

2.4.12

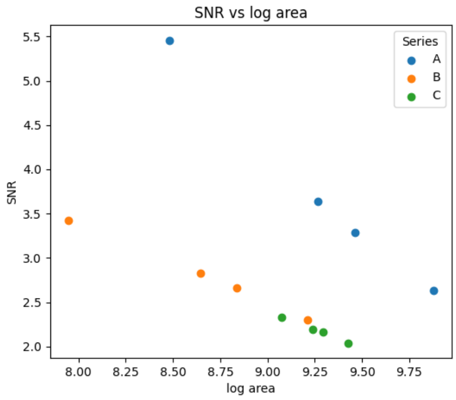
In table 3 we see the results of the SNR calculation before and after the filters. In all three series, Gaussian filters consistently result in improvements in SNR values. For each series, the SNR improvements are highest with a Gaussian filter parameter of 2.0 compared to 1.0. The largest improvements are observed in Series C, with noise reduction leading to significant gains. For instance, the SNR of rect4c.tif improved from 2.33 to 9.80 with Gaussian 2.0. Therefore, the Gaussian with parameter 2.0 performed best.

Image	**Before filter**	**Gaussian 1.0**	**Gaussian 2.0**	**Median 3**	**Median 5**
Series A					
rect1a.tif	3.28	3.33	3.37	3.29	3.29
rect2a.tif	2.63	2.71	2.79	2.63	2.63
rect3a.tif	3.64	3.78	3.93	3.64	3.65
rect4a.tif	5.46	5.80	6.19	5.48	5.50
Series B					
rect1b.tif	2.66	3.63	3.78	3.32	3.46
rect2b.tif	2.30	3.02	3.18	2.76	2.88
rect3b.tif	2.83	4.09	4.40	3.68	3.91
rect4b.tif	3.43	5.93	6.75	5.16	5.74
Series C					
rect1c.tif	2.16	5.22	6.37	3.79	4.54
rect2c.tif	2.04	4.58	5.48	3.37	3.93
rect3c.tif	2.20	5.54	7.11	3.95	4.83
rect4c.tif	2.33	6.76	9.80	4.59	6.04

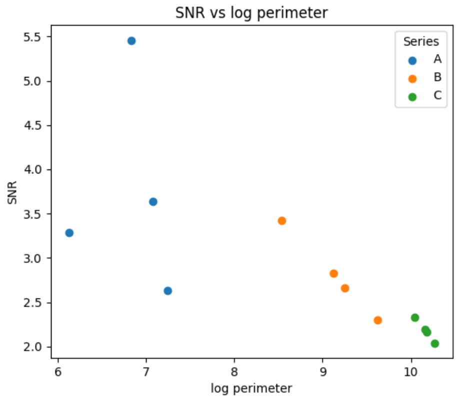
Table 3: SNR results for series A, B, and C

2.4.13

Figure 10 examines the relationship of the *Signal-to-Noise Ratio (SNR)* with the magnitude of different measurements for each of the images using area and perimeter as proxies. For each image, the measurements were aggregated via a sum. We can observe that for each series, SNR decreased with the increase of the total magnitude of measurement for both area and perimeter. Additionally, and predictably, SNR decreased with the increase of noise strength within images. The decrease of SNR with relation to the increase in measurement magnitude suggests that overall, the more objects there is within the photo and the larger they are, the less signal we can extract from them. It seems logical that the increase of the number of objects (reflected in high increases of the perimeter) would decrease SNR as effectively we increase the entropy of the image, getting closer to a truly noisy image.



(a) SNR vs log area



(b) SNR vs log perimeter

Figure 10: Influence of the magnitude of different measurements on the Signal-to-Noise Ratio (SNR). We can observe that in general, SNR tends to decrease with the increase of the magnitude of measurements.