Report

Group 6

1. The relationship between camera parameters and pixels

1.1 Exposure

From the experiment, we've found out that the longer is the exposure time, the brighter will be the picture (i.e. the RGB gets larger)

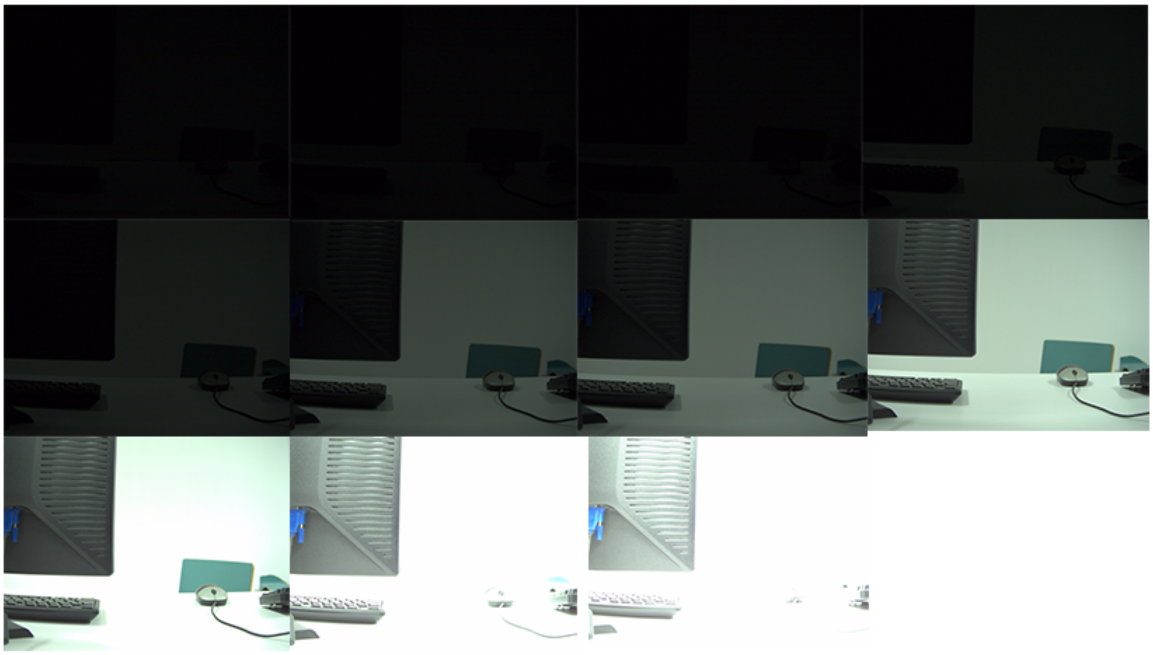


Figure 1: Experiment photos of different exposure time

The exposure time in our experiment ranges from `10` to `1000000`, we took `11` pictures at regular intervals. By comparing the RGB values of some pixels when the exposure time increases, we concluded that the pixel value increases with exposure time.

- The RGB of pixel (100,100) changes with exposure time

Exposure	G	B	R
10	0	3	1
50	5	0	2
100	7	0	9
500	6	0	2
1000	6	0	1
5000	6	11	9
10000	12	17	15
50000	46	45	41
100000	65	65	59
500000	140	146	127
1000000	187	202	175

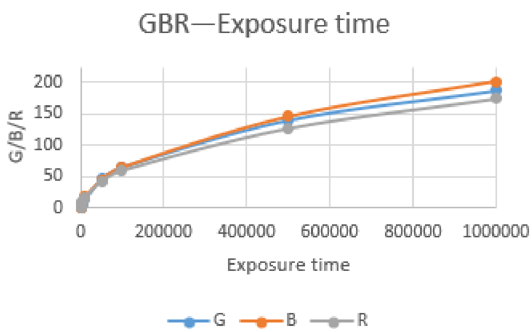


Figure 2: The RGB variation of pixel(100,100) with different exposure time

- The RGB of pixel (400,400) changes with exposure time

Exposure	G	B	R
10	4	0	8
50	3	2	4
100	4	2	2
500	4	2	1
1000	10	2	2
5000	19	12	15
10000	23	30	25
50000	65	69	58
100000	88	95	80
500000	187	205	188
1000000	255	247	255

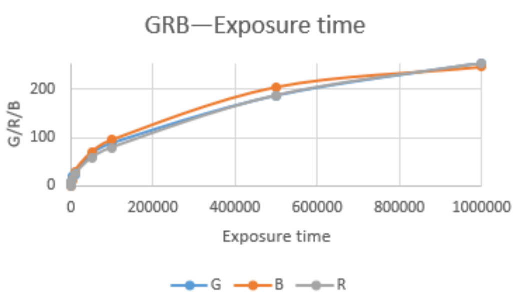


Figure 3: The RGB variation of pixel(400,400) with different exposure time

- The RGB of pixel (800,800) changes with exposure time

Exposure	G	B	R
10	0	2	2
50	2	0	0
100	2	1	3
500	7	0	0
1000	3	2	6
5000	9	11	5
10000	14	18	13
50000	49	46	41
100000	79	66	61
500000	147	148	139
1000000	201	200	186

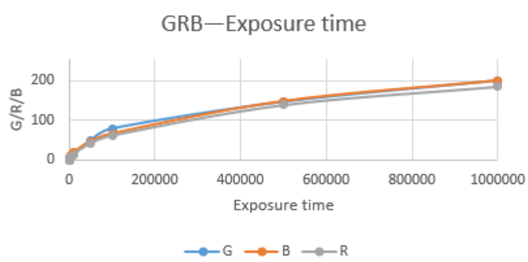


Figure 4: The RGB variation of pixel(800,800) with different exposure time

We also attempt to use logarithmic coordinates, but it seems that there's no obvious pattern.

1.2 Gain

Similarly, when the gain increase, the RGB of one pixel increases as well.

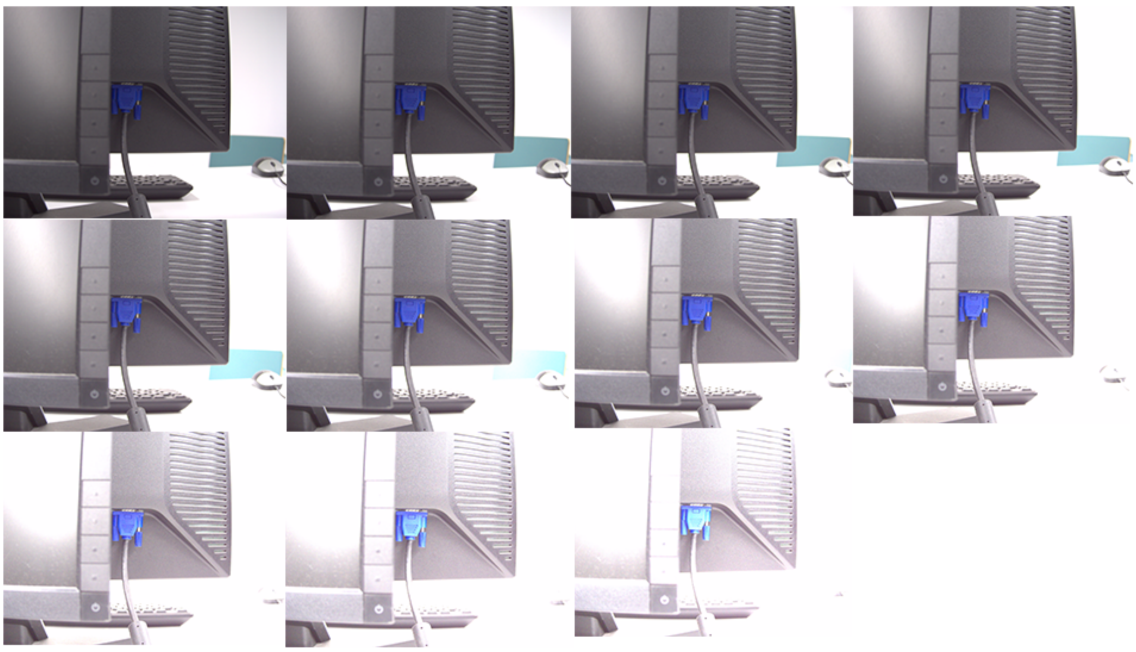


Figure 5: Experiment photos of different gain

In our experiment, the gain ranged from `0` to `24`, so we took a picture every `2.4` gain. The result shows that the RGB of a pixel increases with the gain. When the gain gets large enough, the RGB of a pixel will remain roughly unchanged.

- The RGB of pixel (100,100) changes with gain

Gain	G	B	R
0	155	152	154
2.4	177	176	180
4.8	198	190	197
7.2	217	222	225
9.6	248	248	254
12	255	254	255
14.4	255	254	255
16.6	255	254	255
19.2	255	254	255
21.6	255	254	255
24	255	254	255

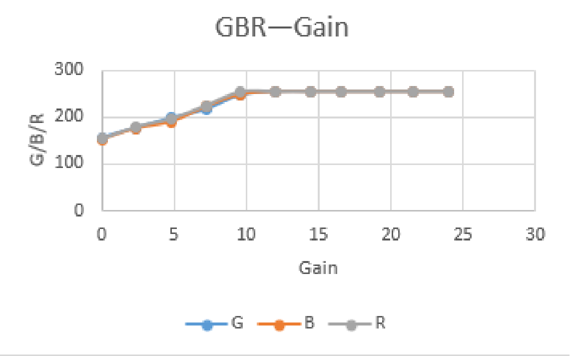


Figure 6: The RGB variation of pixel(100,100) with different gain

- The RGB of pixel (400,400) changes with gain

Gain	G	B	R
0	148	149	153
2.4	178	173	182
4.8	189	190	200
7.2	214	207	220
9.6	242	240	246
12	255	254	255
14.4	255	254	255
16.6	255	254	255
19.2	255	254	255
21.6	255	254	255
24	255	254	255

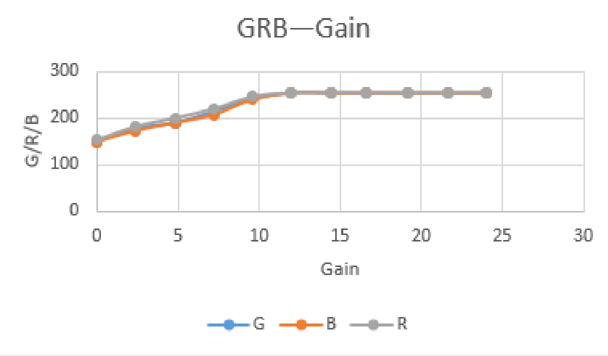


Figure 7: The RGB variation of pixel(400,400) with different gain

- The RGB of pixel (800,800) changes with gain

Gain	G	B	R
0	94	87	90
2.4	112	107	106
4.8	122	115	122
7.2	134	130	135
9.6	152	148	159
12	175	169	174
14.4	193	185	196
16.6	221	204	213
19.2	251	233	240
21.6	255	254	255
24	255	254	255

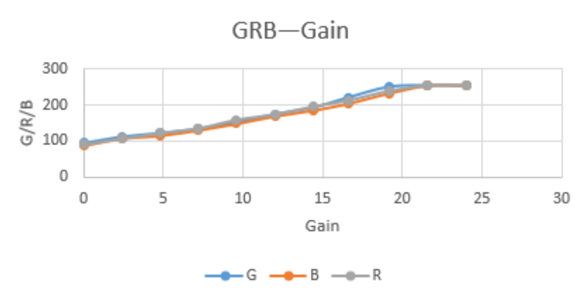


Figure 8: The RGB variation of pixel(800,800) with different gain

2. The quantitative noise model for captured pixels

2.1 Related parameters

- Exposure time (`S`)
- Gain (`G`)

2.2 Equation of the noise

We assume that increasing the exposure time or decreasing the gain will reduce the noise.

Our group take the image whose gain is `2.76` and exposure time is `100000` as the standard picture(i.e. the noise can be seen as `0`). And using the following formula to compute the `PSNR` with the standard picture as an evaluation of the noise.

$$MSE = \frac{1}{mn}\sum_{i=0}^{n-1}\sum_{j=0}^{m-1} \| K(i,j) - I(i,j)\|^2$$

For RGB images, we can compute the `MSE` for each color and then compute the mean `MSE` as result.

$$PSNR = 10log_{10}(\frac{MAX^2}{MSE})$$

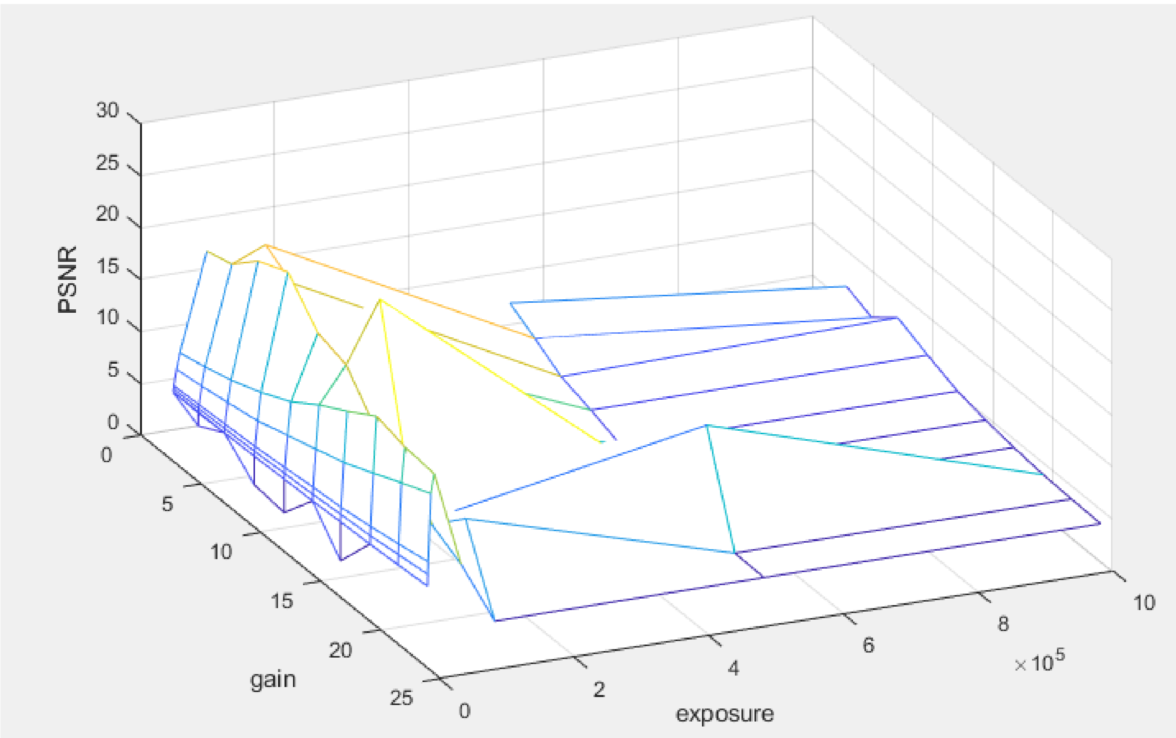
where `MAX` is the maximum value of pixel, that is 255 for RGB iamges.

Since the `PSNR` indicates the similarity of two image, the bigger the `PSNR`, the more similar is the image to the standard picture, the less noise does the image have.

The data is as follows.

	2.76	4.86	7.04	9.54	12.04	14.4	16.74	19.2	21.56	24.01
10	6.72902	5.46374	6.84312	4.17994	3.84385	7.18682	3.61614	7.52749	7.74065	8.01285
50	6.7744	6.80117	6.84414	6.93202	7.0718	7.191	7.36228	7.52765	7.74441	7.985
100	6.77414	6.69498	6.84965	6.92784	7.06872	7.19404	7.35933	7.52698	7.7567	7.98704
500	7.0473	7.13111	7.23682	7.39411	7.62118	7.82181	8.08249	8.33653	8.73006	9.11905
1000	7.35846	7.47775	7.66921	7.86081	8.17346	8.50225	8.74945	9.22291	9.73545	10.3346
5000	8.8902	9.24425	9.7114	10.2769	11.2424	12.1305	13.0337	14.3143	15.595	16.8588
10000	10.4261	11.026	11.8073	12.9725	14.4257	16.3284	17.9157	19.7406	18.9996	18.717
50000	19.7893	20.5028	22.8624	24.1363	20.6264	19.763	16.1465	13.7879	11.0919	9.57395
100000	std	21.8593	20.2148	16.7874	13.8679	25.5546	10.7824	9.12369	11.1522	3.58317
500000	10.1096	8.66271	7.04123	6.16942	5.12112	4.52904	4.08569	13.771	3.67129	3.61334
1000000	6.49241	5.48584	7.50702	6.23831	5.12168	4.54524	4.11063	3.80115	3.6618	3.58344

And we use matlab to obtain a 3D picture. You can have a better view in *A1_bonus.fig* via matlab.



The data roughly indicates that when the gain gets small, or the exposure time gets large within some range, the `PSNR` gets large.