Assignment 2: Computational Photography

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September 30, 2023

1 HDR Imaging

1.1 Develop Raw Images

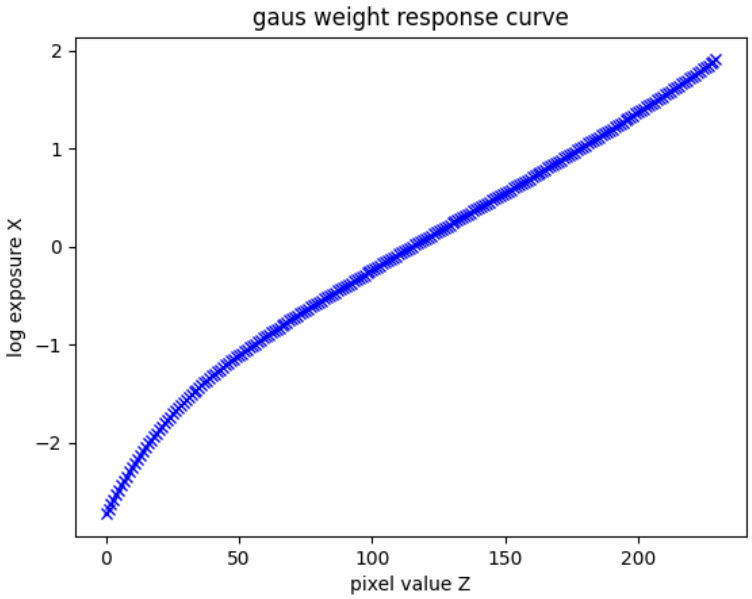
Command used to develop raw images:

```
dcraw -r 2.39 1 1.2239 1 -o 1 -q 1 -T -4 custom_tether/*.nef
```

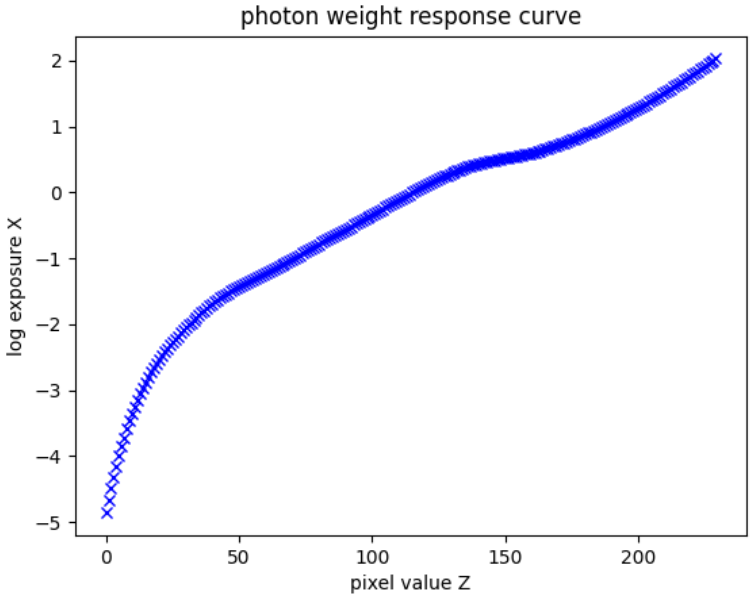
- -r v1 v2 v3 : RGB scaling factors for white balance
- -o 1 : sRGB color space
- -T : Write .tiff image
- -4 : Generate 16-bit linear image

1.2 Linearize Rendered Image

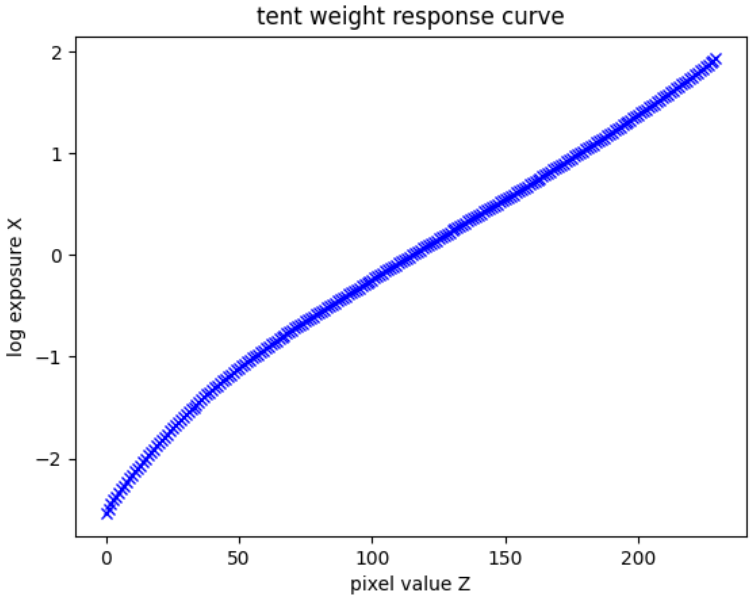
Following are the plots for the response curves using different weighing functions.



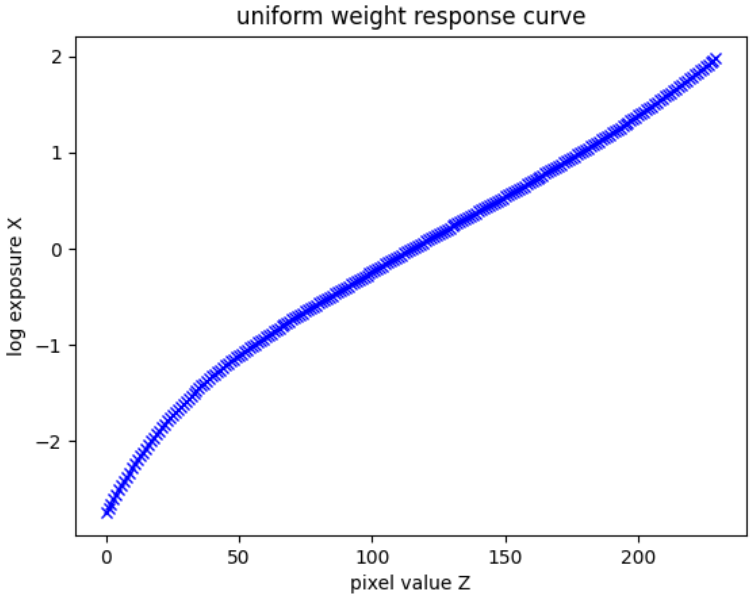
Response Curve for Guassian weight function



Response Curve for Photon weight function



Response Curve for Tent weight function



Response Curve for Uniform weight function

1.3 Merge exposure stack into HDR image

Out of the 16 iterations of HDR images, the following configuration worked best for me:

- **Image type**: RAW
- **Merging Scheme**: Linear
- **Weighing Scheme**: Tent
- **Z-Min** : 0.05
- **Z-Max** : 0.95

Figure 1: HDR Merged Image - RAW + Linear merging + Tent weighing scheme

I found this to be the most aesthetic image of the 16 HDR images as it preserved information on both highly exposed pixels as well as the low exposed pixels. Even though the low exposed pixels (right side of the image) are considerably dark, the relevant features of the shelves, the objects on the shelves and the couch are still visible. These features are restored to a large extent after color correction.

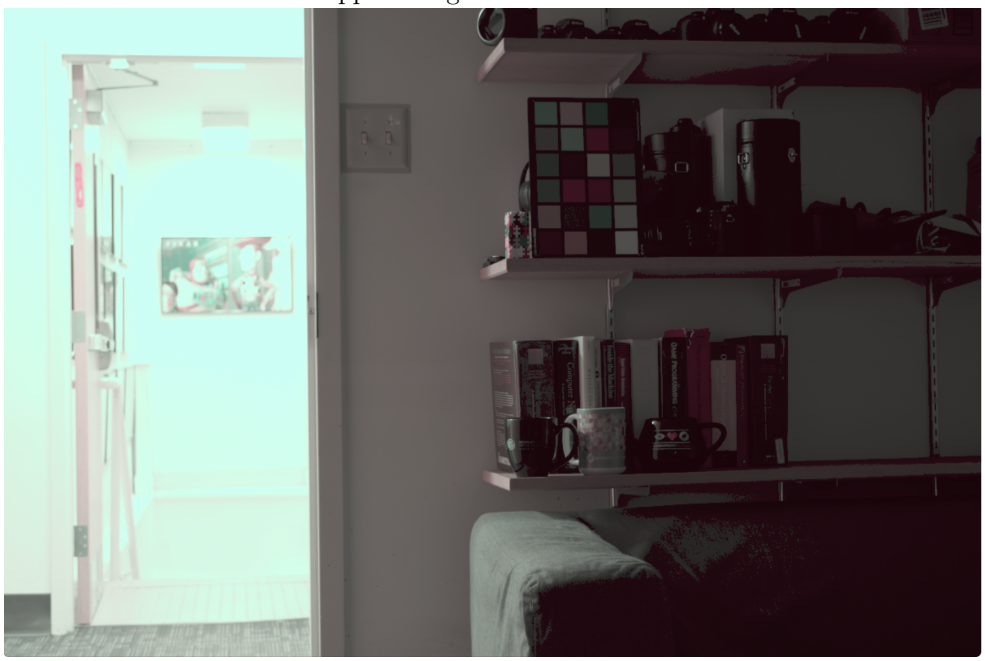
2 Color correction and white balancing

Figure 2: Color corrected image

The color corrected image is better as compared to the original image (Figure 1). The color corrected image better represents the colors in the image. A litmus test here could be looking at the color checker. The color checker on the original image does not reciprocate the ground truth values of the actual color checker. For eg., it is hard to makeout which one is the green and the blue patches in the color checker. The colors in the color corrected color checker are exactly the same as that of the ground truth and all colors can be distinguished easily.

3 Photographic Tonemapping

Tonemapped image with the RGB method



Tonemapped image with the luminance method

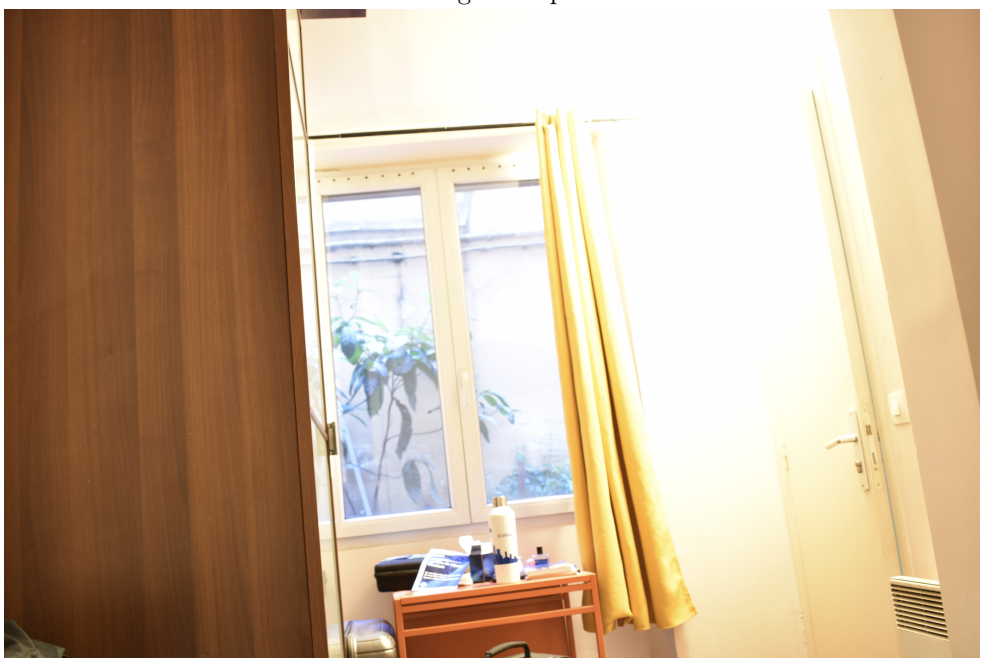
According to me the RGB tonemapped image is better than the luminance tonemapped image as it preserves the higher exposed pixels as well. For eg, the toy story painting on the distant wall and the details around the light bulb are better captured in the RGB tone mapped image.

4 Create and tonemap your own HDR photo

Images of the scene for the smallest and the largest exposure:

Rendered Images

JPEG image at exposure 1



JPEG image at exposure 16

Raw Images

Raw image at exposure 1

Raw image at exposure 16

Output HDR Images

The best possible parameters for merging the HDR images were found to be as follows:

Here are some outputs with varying the Image Type and Key as I found these two parameters hardest to tune.

Varying the Image Type

RAW HDR merge

JPEG HDR merge

Varying the Key for JPEG Tonemaps

K = 0.05

K = 0.15

Varying the Key for RAW Tonemaps

K = 0.05

K = 0.15

After carrying out multiple iterations, the most aesthetic image according to me was formed using the following parameters:

- **Image Type**: JPEG
- **Weighing scheme**: Photon
- **Merging Scheme**: Linear
- **Key (K)** : 0.05
- **Burn (B)** : 0.95

Figure 3: Custom HDR Merged Tonemap

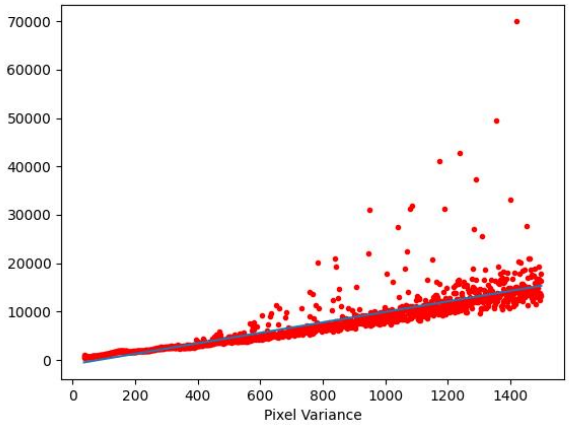
5 Noise calibration and optimal weights

5.0.1 Noise Calibration

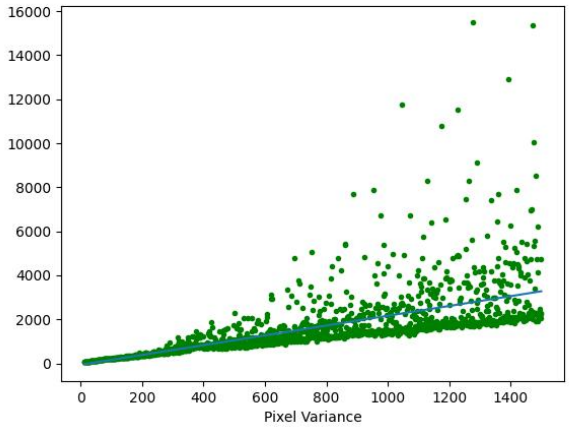
Estimated gain and additive variance for different color channels are as follows:

- Channel R : Gain g = 10.8245, Additive Noise Variance σ_{add} = -871.71
- Channel G : Gain g = 2.2269 , Additive Noise Variance σ_{add} = -60.25
- Channel B : Gain g = 4.5565 , Additive Noise Variance σ_{add} = -17.17

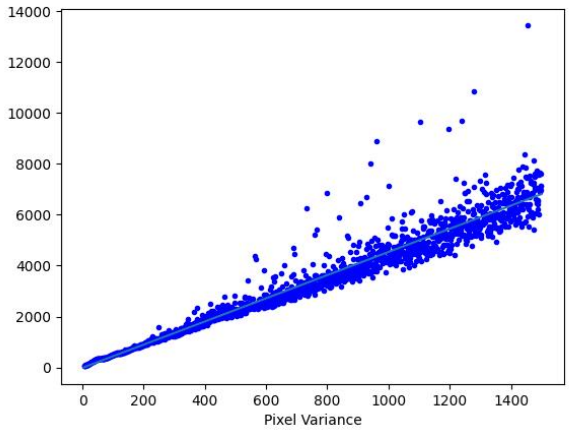
Following is the graph for variance vs mean for the different color channels (R, G, B).



Red Channel Variance vs Mean



Green Channel Variance vs Mean



Blue Channel Variance vs Mean

5.1 Merging with optimal weights

Following is the HDR image formed by merging with the optimal weights obtained above.

Figure 4: Tonemaped HDR for optimal weighing scheme

Adding the noise calibration made the biggest difference to the high exposure regions. The overall lighting of the scene has improved and is more closer to the actual physical lighting of the scene. However, the highly exposed regions have been illuminated a lot.