Answer 1

Develop RAW images

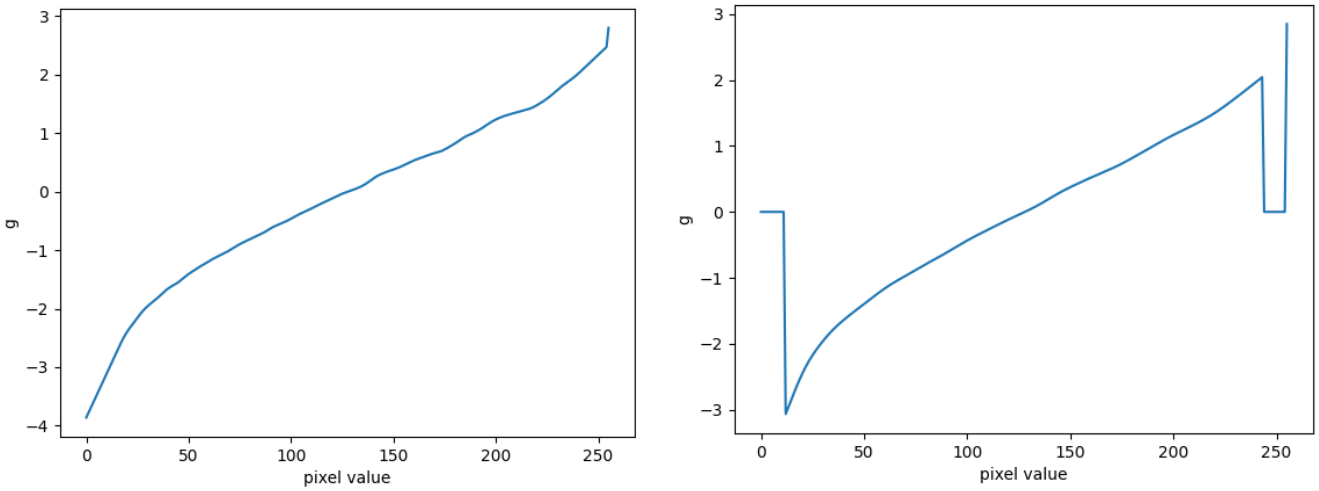
The following dcraw command was run to convert the .NEF files to .TIFF

```
C/C++
./dcraw -w -o 1 -T -q 3 -4 ./data/*/*.nef
```

Interpolation was done using `Adaptive Homogeneity-Directed (AHD) interpolation`

Linearize rendered images

On solving for *g* by minimizing Equation (2) in the write-up, the following curve for *g* was obtained. This curve corresponds using the photon weighting scheme and the uniform weighting scheme (with **λ**=100)



Curve for *g* with photon weighting scheme (left); Curve for *g* with uniform weighting scheme and **λ**=100 (right)

Weighting schemes

For all the experiments Z_{min} was set at 0.05 and Z_{max} was set at 0.95 - These roughly correspond to pixel values of 13 and 242 respectively.

Make your pick

For a fair comparison, the tone-mapped images from the JPEG and TIFF .hdr stacks were compared before applying color correction. After comparing all the 16 images, the best image from the TIFF stack andthe JPEG stack (in my opinion) are shown below:

RGB tone-mapped image of the TIFF stack(left) and the JPEG stack(right)

The best result from TIFF stack was obtained with linear merging and photon weighting scheme, and the best result from the JPEG stack was obtained with logarithmic merging and photon weighting scheme. The JPEG image has a very strong orange hue in the dark parts of the scene by default. The result obtained from the TIFF stack has more natural colors, however the JPEG has more observable details in the dark part of the scene (especially in the texts visible on the book). So we will proceed with both the images to the next section. **Currently, the result I prefer more is the one from the JPEG stack**

Images in data/Answer_1 :

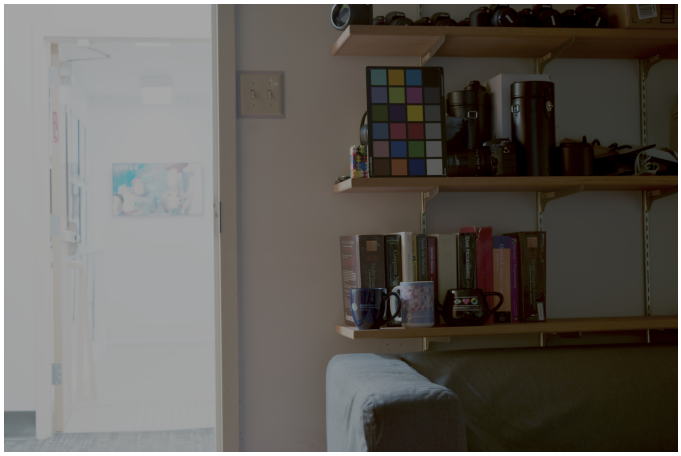
1. `jpg_log_photon.hdr - JPG stack -> photon weighting, log merging`
2. `jpg_log_photon_tm_gamma_0_75.png -> RGB tonemap of 1`
3. `tiff_linear_photon.hdr - RAW stack -> photon weighting, linear merging`
4. `Tiff_linear_photon_tm_gamma_0_75 -> RGB tonemap of 3`

Answer 2

Color correction and white balancing

The RGB tonemapped JPEG stacks before and after color correction and white balancing are shown below:

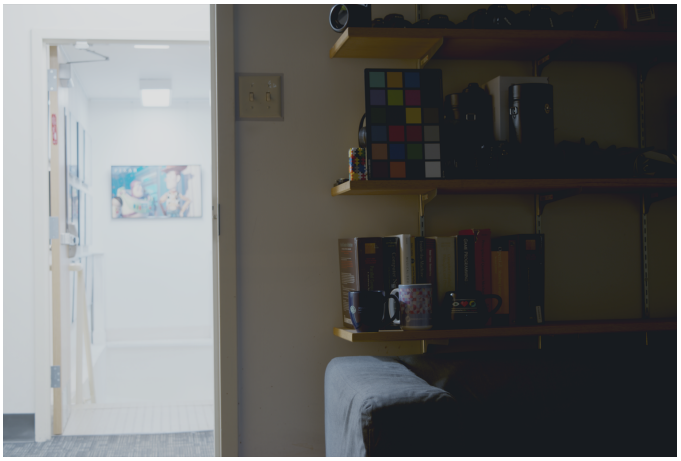
Before color correction and white balancing



After color correction and white balancing

The RGB tonemapped TIFF stacks before and after color correction and white balancing are shown below:

Before color correction and white balancing



After color correction and white balancing

Between the images before and after color correction and white balancing, I definitely prefer the ones after color correction and white balancing. Also, we can see that the difference between the JPG and TIFF-derived images become more pronounced on inspecting the brighter parts of the scene. It is to be noted that these differences are being observed by tonemapping in the RGB space for quick comparison. We will see, if we can improve the blown highlights of the JPEG image by varying the key and burn values in the next answer.

However, my personal preference gravitates towards the image developed from the TIFF stack, with just color correction and not the additional white balancing step, as it represents the lighting in the scene better:

Images in data/Answer_2:

1. `jpg_log_photon_color.hdr - color corrected JPG stack`
2. `jpg_log_photon_color_wb.hdr - color corrected + white balanced JPG stack`
3. `tiff_linear_photon_color_wb.hdr - color corrected + white balanced RAW stack`

Answer 3

Photographic tonemapping

The following are some of the best results obtained for photographic tonemapping in the xyY space for TIFF-based .hdr files

K = 0.08 ; B = 0.8

K = 0.08 ; B = 0.7

K = 0.15 ; B = 0.9

The image with K = 0.08 and B = 0.8 looked the best to me among the TIFF-derived images.

The following are the best results obtained for photographic tonemapping in the xyY space for JPEG-based .hdr files
Both the images were obtained with K = 0.06 and B = 0.9

This tonemapped image was derived from the JPEG stack that was both color corrected and white balanced. However, just like in the case of the TIFF images, I prefer the color of the image after color correction and before white balancing, which is shown below:

Now comparing the best results obtained from the JPEG and TIFF stacks after all the steps (excluding the intermediate white-balancing step that I don't prefer), I **prefer the image on the left below which comes from the JPEG stack.**


Tonemapped image from JPEG stack (left) has better details in the darker parts of the scene compared to the tonemapped image from the TIFF stack (right)

Now coming to the RGB tonemapping, best results from the JPEG and TIFF stack are shown side by side below:

Tonemapped image from JPEG stack (left) has blown highlights even after adjusting the key value compared to the tonemapped image from the TIFF stack (right)

Among, the above two images I prefer the one on the right.

However after comparing all the images, the one that looks aesthetically the best is the one obtained from the JPEG stack using luminance method for photographic tonemapping:

Answer 4

Representative examples from the captured stack - The highlights of the sky and the bulb are contrasted against the shadows on the balcony.

On experimenting with all the merging and weighting schemes, the photon weighting scheme with linear merging gave the best results with the TIFF stack.

Luminance based tonemapped HDR image with K = 0.15 and B = 0.90 - This image brightens up the shadows quite well, but looks a bit washed out

Luminance based tonemapped HDR image with K = 0.1 and B = 0.90 - **Overall, this is the image I prefer as it shows the clouds properly and has good contrast**

RGB based tonemapped HDR image with K = 0.1 and B = 0.90 - Though all the elements in the image are well exposed, the blue color in the sky is completely lost

Now coming to the JPG stack, the image below shows the result with luminance based tonemapping after photon weighting and linear merging

This image also has good contrast, but has slightly lesser details compared to TIFF based image

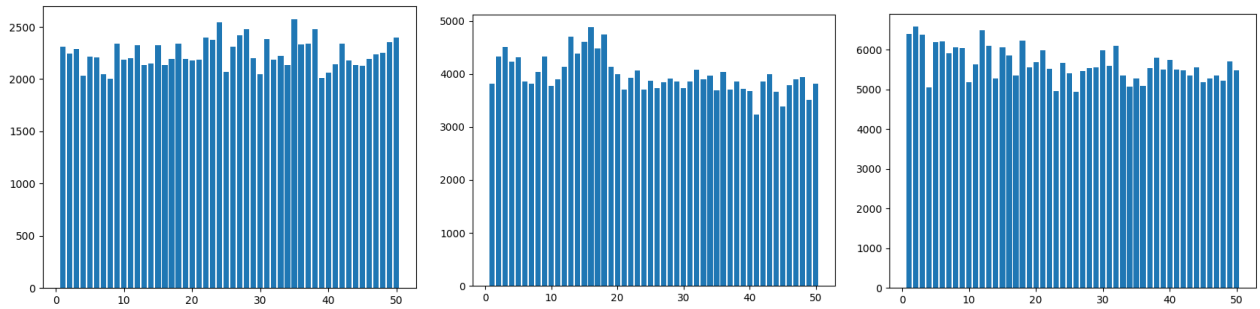
On the other hand, with RGB based tonemapping on the same JPG based HDR image, the result was a bit washed out as shown below:

Images in data/Answer_4

1. my_photon_linear.hdr - Captured RAW stack merged
2. myjpg_photon_linear - Captured JPG stack merged
3. my_photon_linear_tmxyz_gamma_brt_075 - tonemapped png of 1
4. Myjpg_photon_linear_tmxyz_gamma_brt_075 - tonemapped png of 2
5. Exposure4.nef and exposure4.jpg - Example captured photos

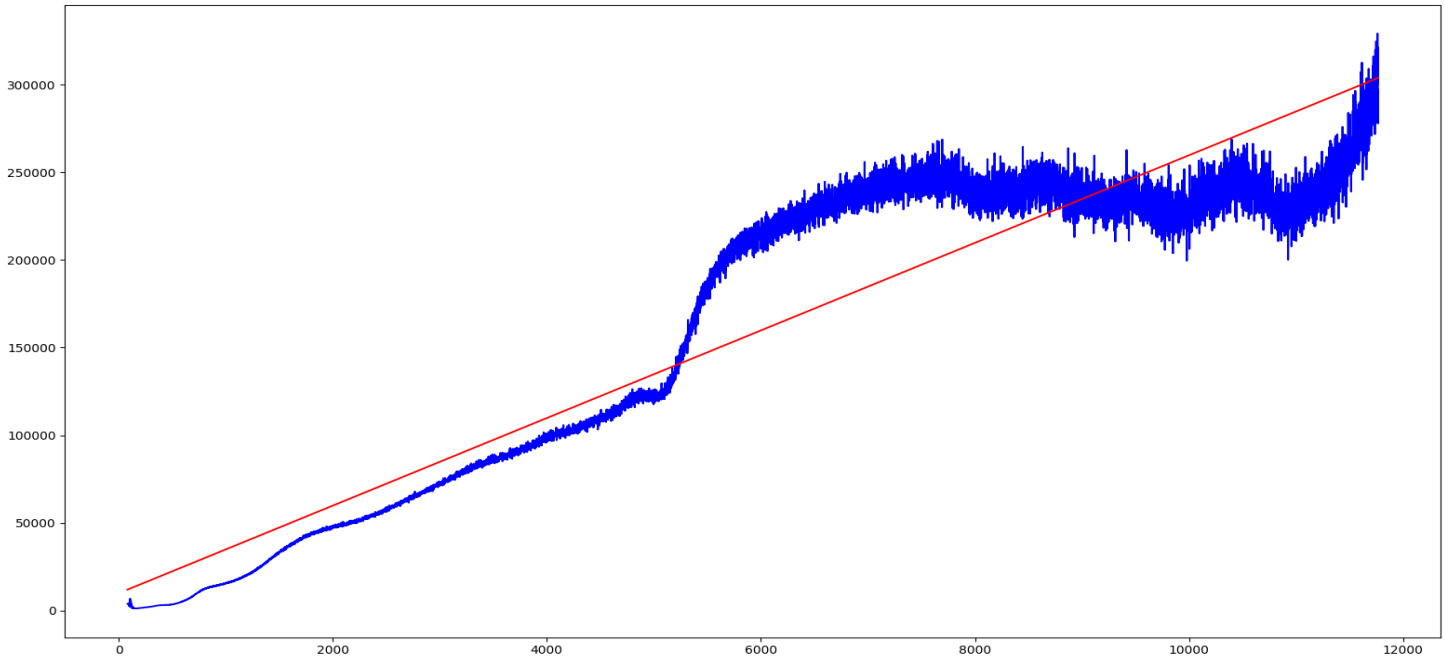
Answer 5

Noise calibration



Histograms of the intensity of three random pixels plotted across 50 dark images : The intensity doesn't seem to follow any pattern in particular, except in the middle histogram where there is a peak in the left side similar to a Poisson distribution

Variance vs Mean Plot for estimating gain and additive noise is shown below



The blue curve is the variance(on y axis) vs mean (on x axis) plot. The red line, is the line after linear regression fitted to the data. The slope is `24.98` and the intercept is `9852.45`

This gives the additive noise ($\sigma^2_{additive}$) to be 9852.45 and the gain(g) to be 24.98

Plugging in these values for the optimal weighting scheme gave the following image after tonemapping

This image has slightly better details in darker parts of the image (especially on the roof of the balcony) compared to the best photo from Answer 4 , which is shown below. However overall, I still prefer the image from answer 4