15-663 HW2

Sajal Maheshwari
sajalm@andrew.cmu.edu

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Collaborations I collaborted with my flatmate Shamit Lal (shamitl) for the capture of the HDR image exposure stack and the noise calibration. Specifically, we used the same scene to capture the exposure stacks and the same ramp pattern to capture the ramp images and dark images for the noise calibration from our respective cameras.

1 HDR Imaging

1.1 Develop RAW images

The command used to develop the RAW images was :

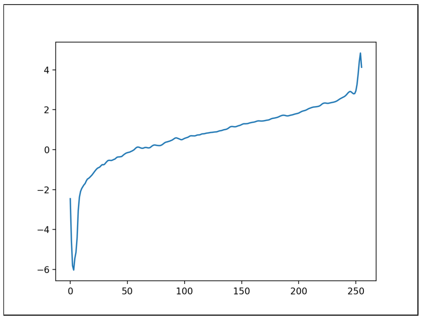
```
dcraw -w -o 1  -q 3 -4 -T *.nef
```

The various flags refer to the following operations :

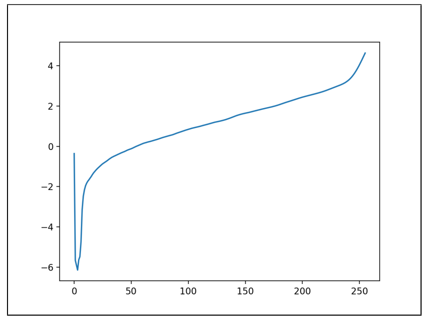
- w : Use the camera's white balance settings
- o 1 : The output is the sRGB output space
- q 3 : The interpolation during demosaicing using adaptive method.
- 4 : Produce linearized 16 bit output
- T : Save the output in TIFF format

1.2 Linearize Rendered Images

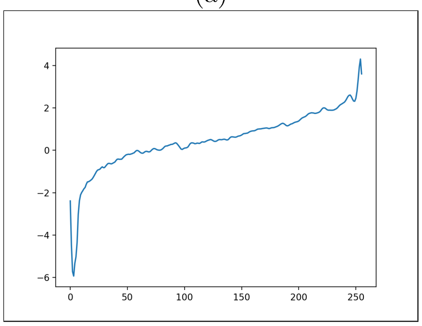
The function $g(\cdot)$ is a function that is recovered in this section. It is important that we retrieve the correct function in order to linearize the rendered images for HDR generation in later parts. The g retrieved depends on the weighting scheme as well as the smoothness factor. The various g functions retrieved for different weighting schemes are shown in Figure 1. All the results in this figure use the smoothness factor(λ) as 10.



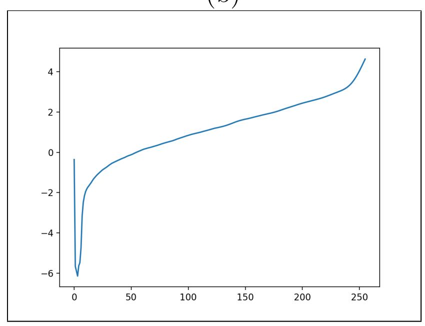
(a)



(b)



(c)



(d)

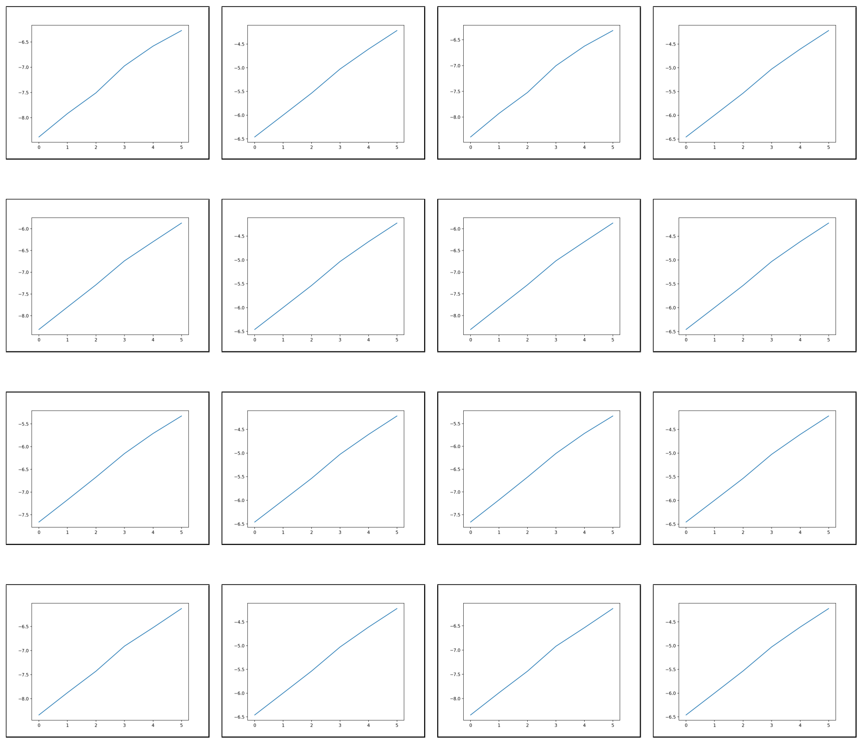
Figure 1: The figure shows the different plots for the function $g(\cdot)$ with the domain as the range of the pixels values with their corresponding weights on the ordinate. (a) shows the plot of g with uniform weighting. (b) shows the plot of g with tent weights.(a) shows the plot of g with gaussian weighting.(a) shows the plot of g with photon weighting.

1.3 Merge exposure stack into HDR image

We can use the various combinations of weights, image type (linear v/s rendered) and merging strategy (logarithmic/non-logarithmic). Each of these choices have a slight effect on the final HDR image. The graph showing the average log luminance for the 6 patches corresponding to increasing order of brightness in the Color Checker Chart are shown in Figure 2. The corresponding errors can also be seen in Table 1. It can be seen that images generated using TIFF images are generally more accurate in terms of error. Additionally, merging in the log-domain does not seem to affect the results by a significant margin.

1.4 Evaluate HDR

The average luminance can be seen in Figure 2. The minimum error corresponds to the HDR image generated in the log domain for TIFF images with tent-



(a) (b) (c) (d)

Figure 2: The figure shows the average luminance plots for the bright patches in the color checker chart. The first row corresponds to the Gaussian weighting scheme. The second row corresponds to the tent weighting scheme.The third row corresponds to the photon-based weighting scheme.The first row corresponds to the uniform weighting scheme. The first column (a) corresponds to the merging using rendered images without log domain.The second column (b) corresponds to the merging using linear images without log domain. The third column (c) corresponds to the merging using rendered images in log domain. The fourth column (d) corresponds to the merging using linear images in log domain.

based weighting, since this image is the one that gives the minimum average illumination error for the Color Checker chart.

2 Color correction and white balancing

In order to verify the color correction and white balancing, we look at the color checker charts before and after applying the transforms and compare it with the ground truth color checker. This can be seen in Figure 3. We can clearly

	N-JPG	N-TIFF	log-JPG	log-TIFF
Gaussian	0.0160	0.0055	0.0160	0.0054
Tent	0.0084	0.0054	0.0084	**0.0053**
Photon	0.0090	0.0055	0.0094	0.0054
Uniform	0.0072	0.0055	0.0068	0.0054

Table 1: Comparison of different approaches on the light-field focal stacks.

see here that the color checker values are much more closer to the ground truth after applying the transformation. On comparing the two HDR images, we find that the color corrected image looks much more realistic with accurate colors (visible in both the high and the low light parts of the image). The entire image for comparison regarding the effect of the color correction and white balance can be seen after the images have been tonemapped. This can be seen in Figure 5.

3 Photographic toneampping

The tone-mapping depends on three factors :

- The value of Key (K) : The value K can be associated with the brightness of the image. The observation is that as K increases, the brightness of the image increases and vice-versa.
- The value of Burn (B) : The value of Burn increases the contrast between the contrast of the image. The image therefore, becomes, darker in the non-saturated region and vice-versa in the saturated region.
- The color space used for tone-mapping. The tone-mapping tries to replicate the color temperature of the original input image. However, for tone-mapping in the RGB domain the color temperature of the output tone-mapped image might also change.

These observations can be visualized in Figure 4. We use the image (d) as the final tonemapped output. This value for K = 0.08 and B = 0.80 and the tonemapping is done in the RGB domain. Additionally, we also show the tonemapped output for the non-color corrected image in contrast with the color corrected one for the best settings mentioned above (K = 0.08 and B = 0.80) in Figure 5.

4 Create and tonemap your own HDR photo

In this section, we create the tonemapped images for the exposure stack captured in indoor setting. The weighting scheme used here was tent weighting scheme as the tent weighting scheme. The tonemapped images were created for the HDR image created using both logarithmic merging and otherwise. Additionally,

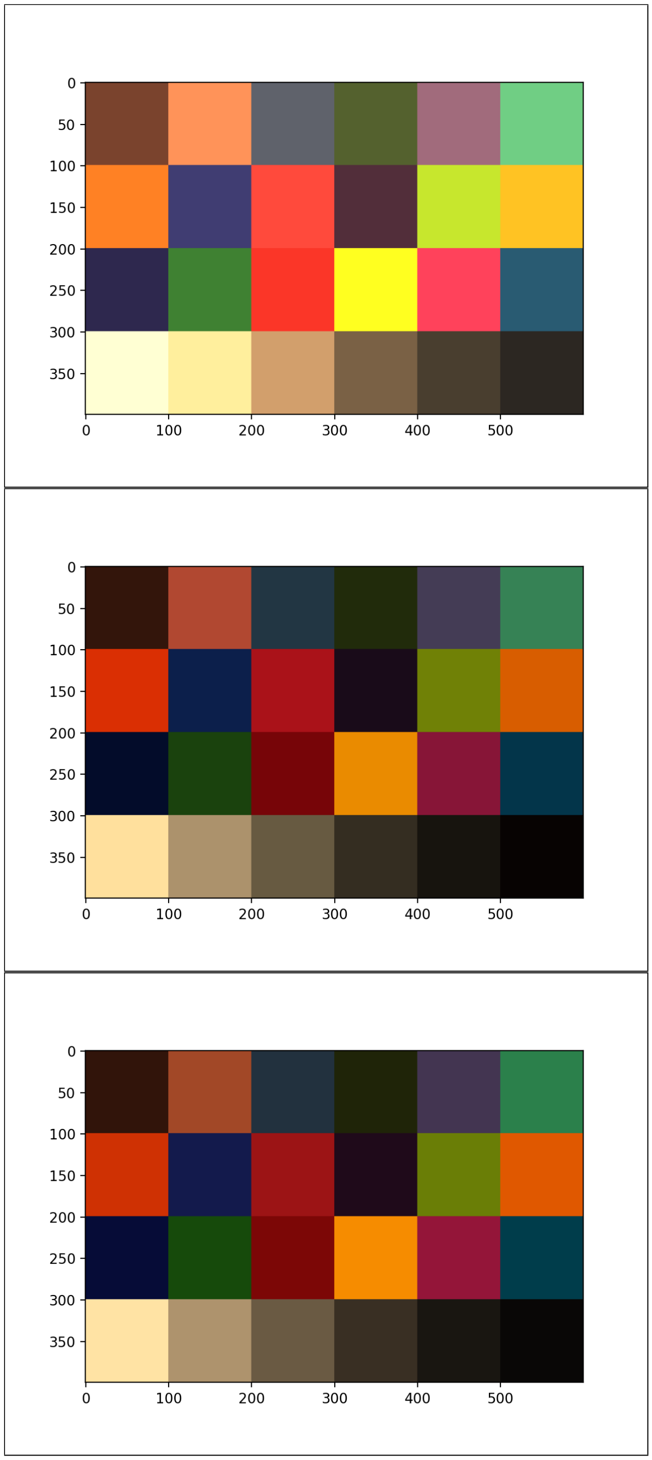
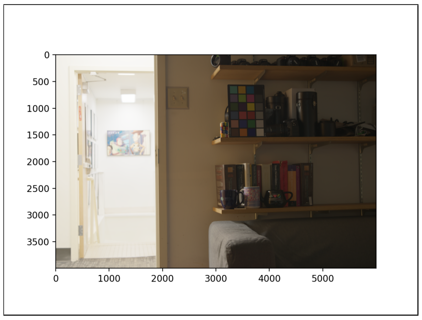
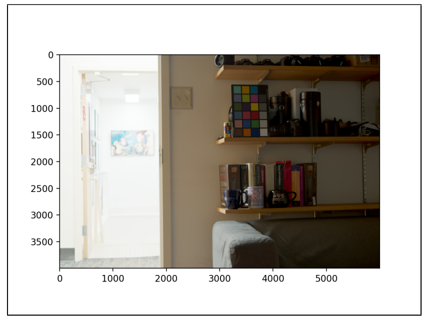
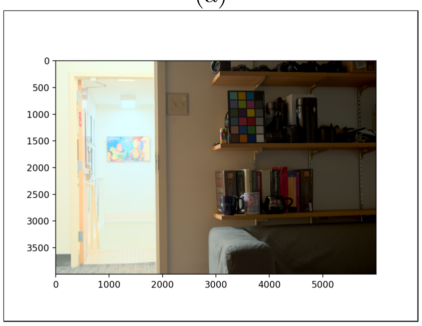


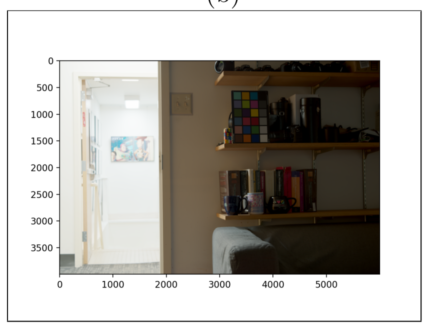
Figure 3: The color checker charts validating the effect of the color transformation and white balancing. The top5image shows the color checker pattern without any color corerction. The middle image shows the color pattern after the affine transform for the color correction has been applied. The image at the bottom shows the ground truth colors for the color correction chart. As we can see here, the colors are quite off and not close to the ground truth before the affine transformation corresponding to color correction while they are quite close after the transformation has been applied. This validates the correctness of the color correction transformation matrix.



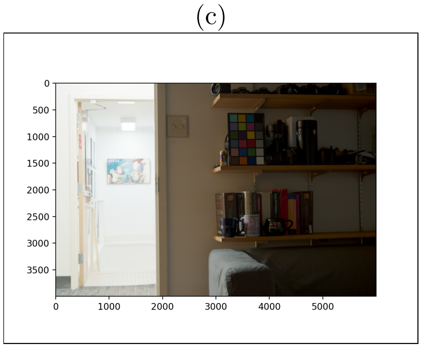


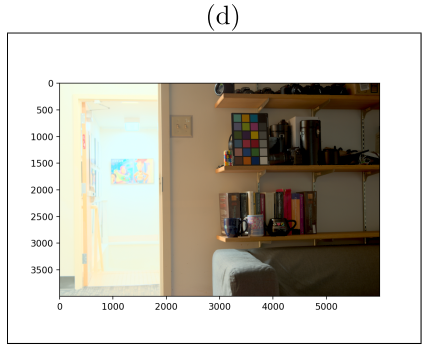
(a) (b)





(c) (d)





(e) (f)

Figure 4: The figure shows the various tonemapped images. The image (a) shows the input RGB image that is fed to the tonemapping module without the color correction.The figure shows the various tonemapped images. The image (b) shows the input RGB image that is fed to the tonemapping module with the color correction module. The image (c) shows the tonemapped output for K = 0.15 and B = 0.95 for the XYZ domain. The image (d) shows the tonemapped output for K = 0.08 and B = 0.9 for the RGB domain. The image (e) shows the tonemapped output for K = 0.30 and B = 0.80 for the RGB domain. The image (f) shows the tonemapped output for K = 0.30 and B = 0.95 for the XYZ domain.

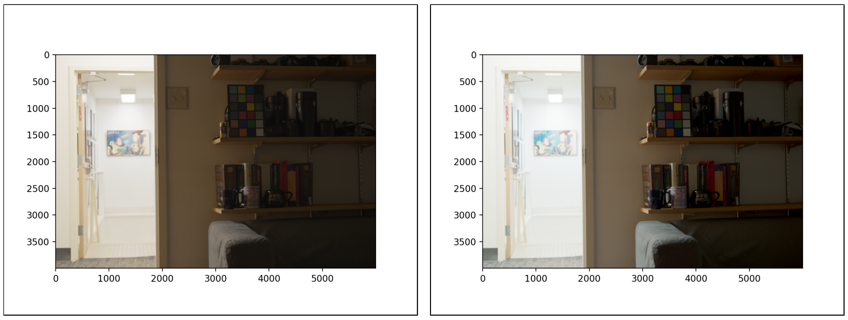


Figure 5: The figure shows a comparison between the tonemapped images for the HDR images before and after the color correction step. The image on the ledt shows the tonemapped image corresponding to the merged HDR without color correction while the image on the right shows the color corrected image. We can see that after the color correction the orange-ish color cast is removed.

various settings of K and B along with the tonemapping in RGB and XYZ domain were experimented with. These results can be visualized in Figure 6 and Figure 7.

The best image we get here is the one with K = 0.08 and B = 0.95 in the RGB domain with merging in the log domain for merging using linear images. This image is shown separately in Figure 8.

5 Noise calibration and optimal weights

5.1 Noise calibration

In this section, we show that the dark current behaves like a Gaussian function. The histogram of a few plots for the pixels which are covered and have a response only due to the dark current are shown in Figure 9. Additionally, we also plot the mean-variance plot for the ramp images. This plot can be seen in Figure 10. The mean and the variance we get for the value of the gain and the additive noise are 2.28 and 62.7 respectively.

5.2 Mixing with optimal weights

The values for the gain and the additive noise are used to create the noise optimal weights which can be used to merge the exposure stack into an HDR image. We apply this procedure on the RAW images as they are linear. The resulting HDR image can be seen in Figure 11 along with the best HDR image generated previously for the captured exposure stack. It can be seen here that the regions which correspond to the dark regions in the tone-mapped image.

Figure 6: The figure shows the various tonemapped images generated for the exposure stack captured for images merged from rendered images. The first row shows the tonemapped for K = 0.08. The first row shows the tonemapped for K = 0.15. The first row shows the tonemapped for K = 0.30. The B parameters are equal to 0.9 in the first and second columns and 0.99 in the third and fourth columns. The 2nd and 4th columns show the tonemapped images in the XYZ domain and the 1st and 3rd columns show the tonemapped images in the RGB domain. The images are all merged in the log domain. The results for the merging otherwise are similar.

Figure 7: The figure shows the various tonemapped images generated for the exposure stack captured for images merged from rendered images. The first row shows the tonemapped for K = 0.08. The first row shows the tonemapped for K = 0.15. The first row shows the tonemapped for K = 0.30. The B parameters are equal to 0.9 in the first and second columns and 0.99 in the third and fourth columns. The 2nd and 4th columns show the tonemapped images in the XYZ domain and the 1st and 3rd columns show the tonemapped images in the RGB domain. The images are all merged in the log domain. The results for the merging otherwise are similar.

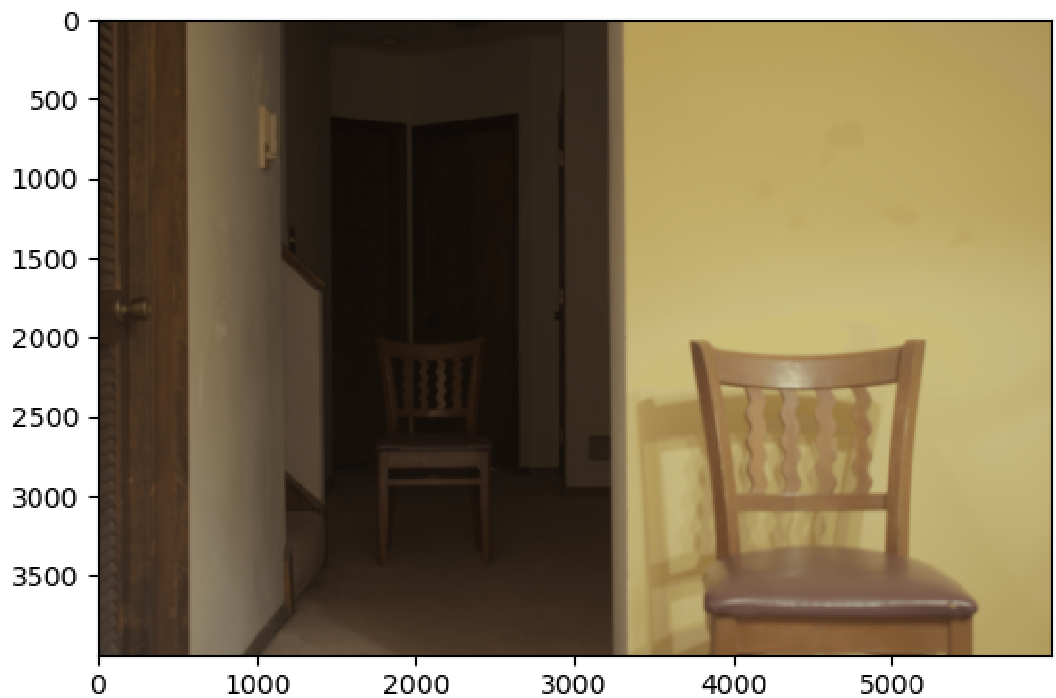
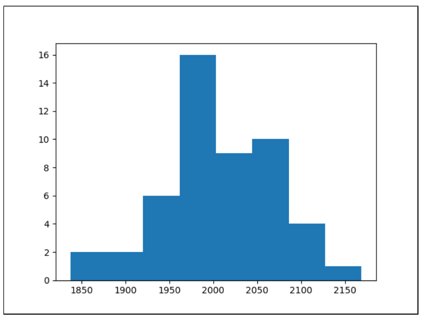
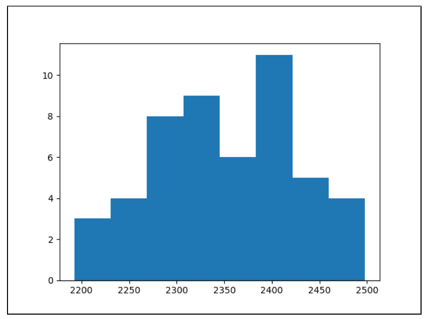


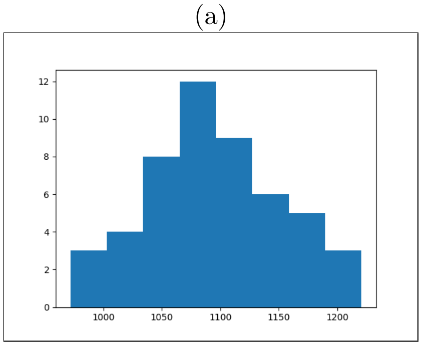
Figure 8: The best HDR image generates using the merging of the exposure stack and the subsequent tonemapping operations.



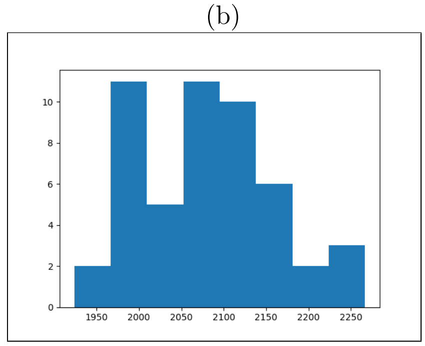
(a)



(b)



(c)



(d)

Figure 9: The figure shows the histogram plots for the various pixels across 50 images.

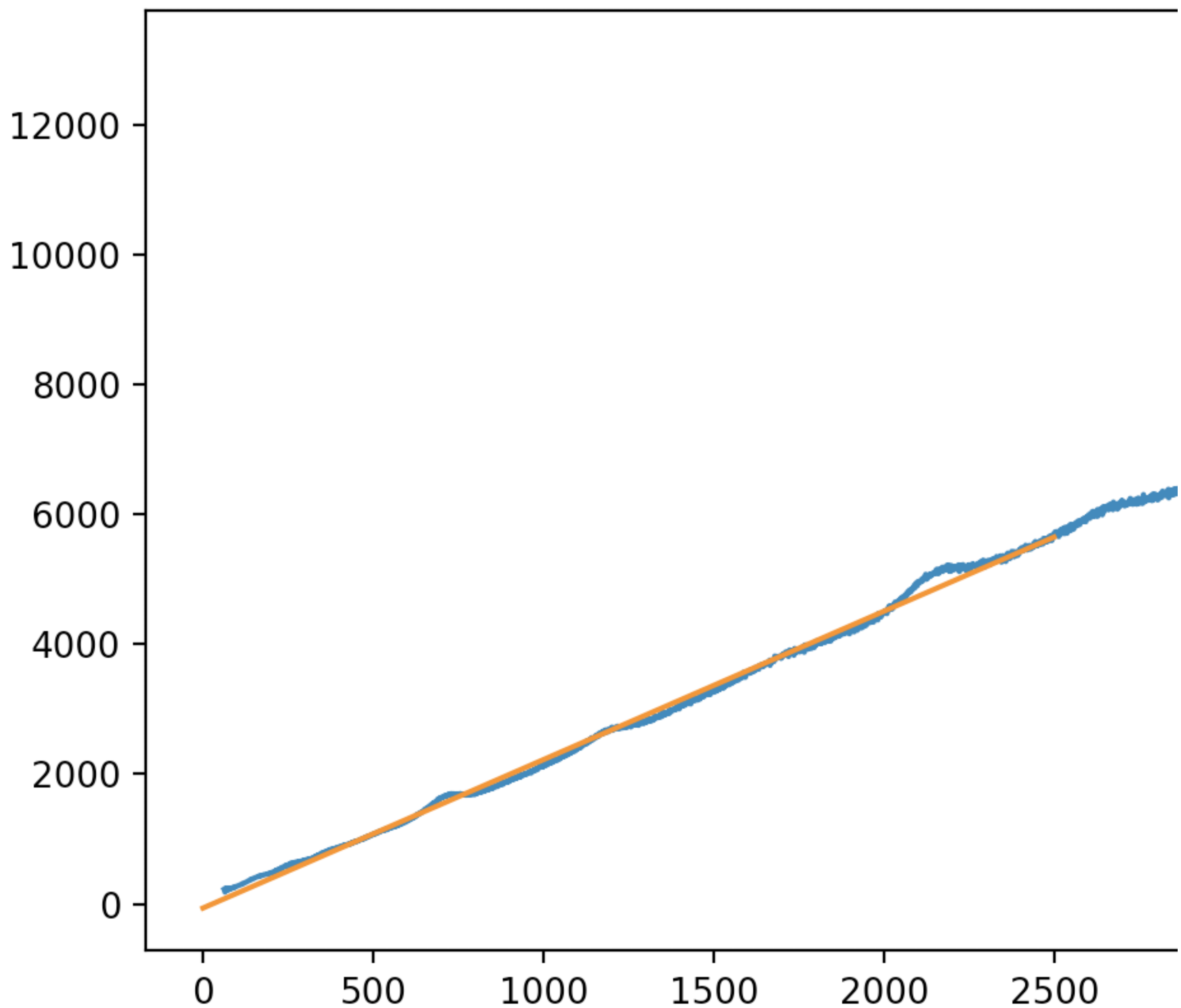


Figure 10: The mean-variance plot along with the points for the ramp image.

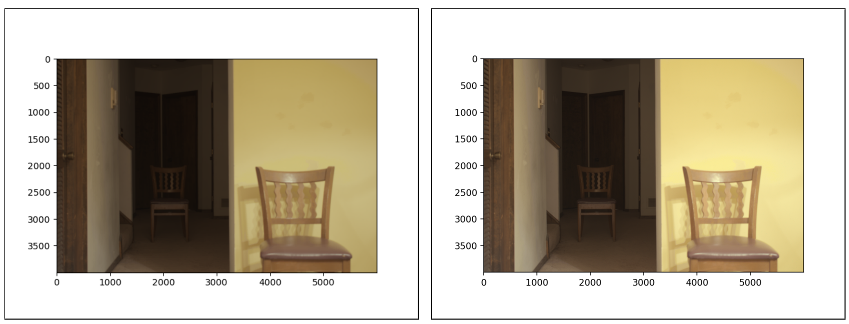


Figure 11: The figure shows a comparison of the best HDR image obtained previously(left) and the HDR image obtained using noise optimal weighting(right).