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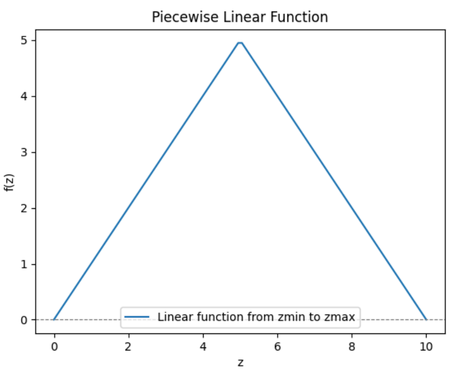
Assignment 3: High-Dynamic-Range Imaging

HDR imaging

Linearize images

Here we can see the weight function for the sensor range. It assigns less weight to the errors on the extremes of the sensor, because they may have a much bigger variance due to how camera sensors work. In short, it is a function to reduce the weight of spurious values on the extremes on the sensor range.

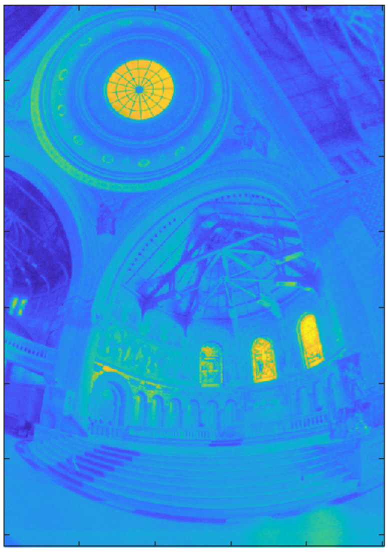


By using these weights the convergence is much better. The range is better assigned to the less bright parts, and pixels too bright (which probably have bigger variance) just burn to a very high value.

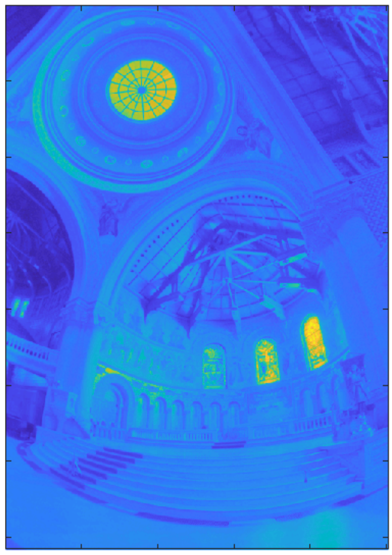
When using weights, very bright pixels have a smaller influence, and the final result has a higher detail and range on the mid-radiance values. This is especially noticeable on the windows, which are less burned. You can see in Figure 1 the response function.

Obtain the radiance map

Once the images have been linearized, the next step is to reconstruct the scene radiance. For each pixel, the radiance is estimated by combining the weighted contributions from the multiple exposures. This process averages the radiance values while mitigating the effects of sensor noise. The radiance map obtained using the weighting scheme shows a better allocation of dynamic range, particularly in less bright areas, compared to a map computed without weighting. The improvement is evident when comparing results across different processing pipelines.



Without weighting scheme



With weighting scheme

Global tone mapping

After constructing the HDR radiance map, it must be compressed into an 8-bit range suitable for display. Global tone mapping operators—such as the one proposed by Reinhard et al.—apply a uniform transformation to all pixels. This operator compresses the luminance range while attempting to maintain the overall appearance of the scene.

In our experiments, we applied the global operator with various parameter settings. For instance, a simple tone-mapped result is illustrated in Figure 2. Further adjustments to the burn parameter are shown in Figure 5, where values of 0.1, 0.5, and 1.0 demonstrate how over-bright areas are progressively suppressed. Similarly, Figure 3 displays the effect of tuning the key parameter (with values 0.1, 0.07, and 0.02), which controls the overall brightness and contrast.

Local tone mapping

Global operators, while effective, may not always preserve local contrast or fine details. To address this, local tone mapping techniques apply adaptive adjustments based on the content surrounding each pixel. In the approach, the image is decomposed into a base layer and a detail layer using a bilateral filter. The base layer, which captures large-scale luminance variations, is then contrast-reduced using a scaling operator, and the detail layer is reintroduced to recover fine textures.

Figure 4 shows the base and detail decomposition, highlighting how the image structure is separated. The final result after local tone mapping, which better preserves local contrast and detail, is presented in Figure 5. Compared to the global method, local tone mapping offers improved reproduction of subtle variations in texture and illumination.

Try out with your own pictures

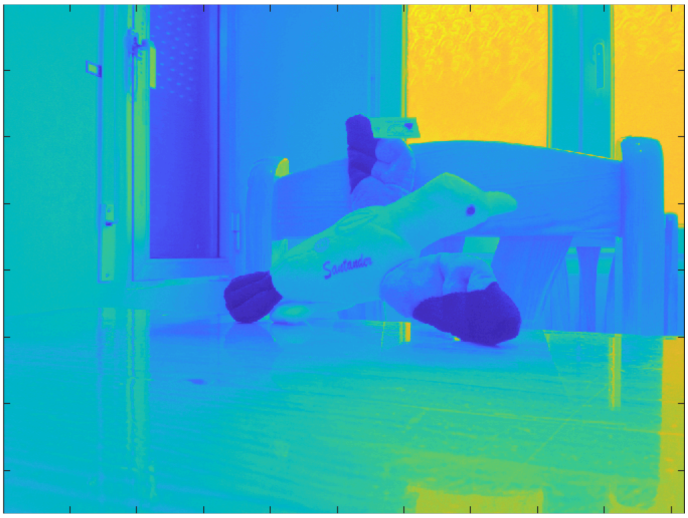
To validate the HDR imaging pipeline, a set of self-captured images was used:

1/2

1/250

1/4000

We selected this scene because different exposures are necessary to get all the details of the scene, including the brighter parts (open blinds window), and the darker details (closed blinds window):



Radiance map

Reinhard tonemapper key=0.02

Durand tonemapper dR=6

Figures

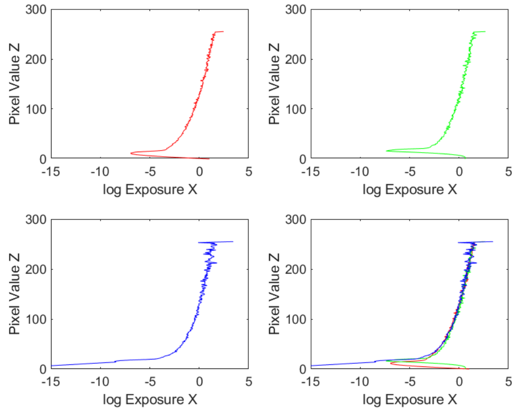


Figure 1: response function obtained with the full method, without the smoothness term (low λ), and without using the weighting scheme.

Figure 2: Simple HDR

burn=0.1 burn=0.5 burn=1.0

Figure 5: tonemapped_reinhard_burn

key=0.1 key=0.07 key=0.02

Figure 3: tonemapped_reinhard_key

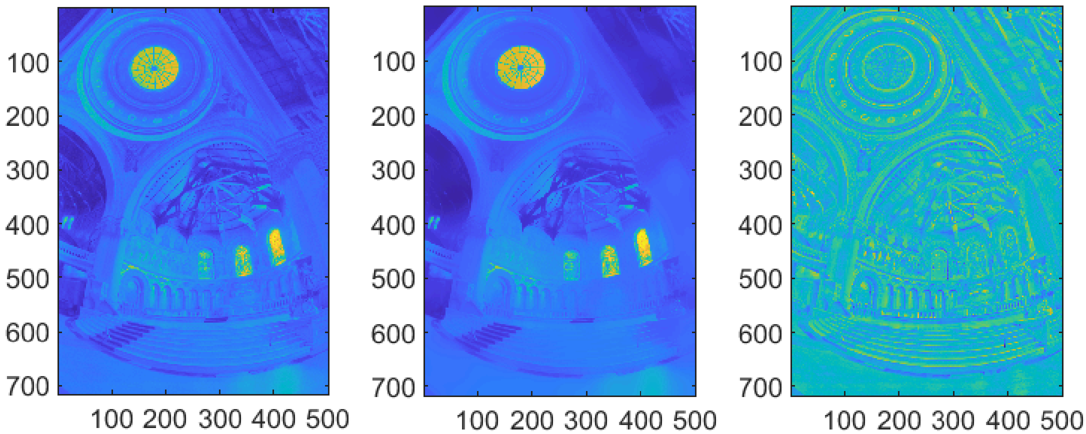


Figure 4: base_decomposition

dR=2 dR=4 dR=6

Figure 5: tonemapped_durand