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CS 445 - Project 4: Image Based Lighting

Complete the claimed points and sections below.

Total Points Claimed	**[120] / 210**
Core	
1. Recovering HDR maps	
a. Data collection	[20] / 20
b. Naive HDR merging	[10] / 10
c. Weighted HDR merging	[15] / 15
d. Calibrated HDR merging	[15] / 15
e. Additional HDR questions	[10] / 10
2. Panoramic transformations	[10] / 10
3. Rendering synthetic objects	[30] / 30
4. Quality of results / report	[10] / 10
B&W	
5. Additional results	[0] / 20
6. Other transformations	[0] / 20
7. Photographer & Tripod removal	[0] / 25
8. Local tone-mapping operator	[0] / 25

1. Recovering HDR maps
Include

- (a) Your LDR images (if you took your own)
- (b) Figure of rescaled log irradiance images from naive method
- (c) Figure of rescaled log irradiance images from calibration method
- (d) Plots of g vs intensity and intensity vs g
- (b-d) Figure comparing the three HDR methods
- (b-d) Text output comparing the dynamic range and RMS error consistency of the three methods
- (e) Answers to the questions below

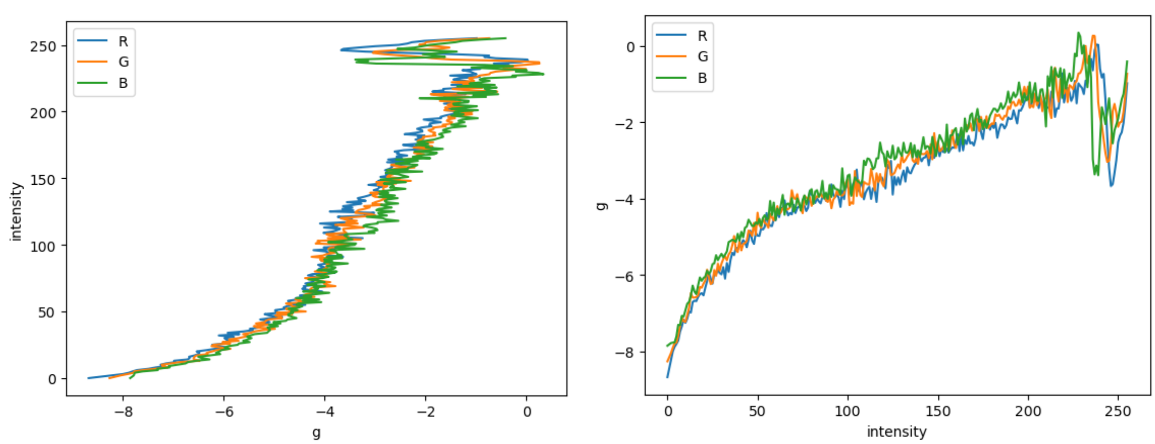
Note if you claim credit for data collection, you must use your own images for parts 1-3

(a) LDR images

(b) log irradiance images from naive method

(c) log irradiance images from calibration method

(d) Plots of g vs intensity and intensity vs g



(b-d) Figure comparing the three HDR methods

- Naive: log range = 9.125, avg RMS error = 0.76
- Weighted: log range = 8.324, avg RMS error = 0.764
- Calibrated: log range = 10.923, avg RMS error = 0.549

(**Note:** I have tried the provided images for the comparison and the result for log range is **naive < weighted < calibrated** and for avg RMS error is **naive > weighted > calibrated**. However, when I used my own images, the result for log range is **weighted < naive < calibrated** and for avg RMS error is **weighted > naive > calibrated**. I think the reason for such differences is that the collected data does not have very strong contrast between the dark and bright parts and thus the results of the weighted method do not have big differences from the naive method compared with the provided images.)

Answer these questions:

1. **For a very bright scene point, will the naive method tend to over-estimate the true brightness, or under-estimate? Why?**

The naive method tends to **underestimate** the true brightness for a very bright scene point. One cause for this is clipping, where the actual brightness of the scene captured by the LDR image will be lost since it exceeds the maximum brightness that the image format can store. The pixel for the very bright scene point is recorded as the brightest possible value, usually pure white, in the LDR image. Thus, by simply merging the LDR images to a HDR image, the true brightness that has been clipped can not be recovered, leading to an underestimate of the intensity of bright light sources. Also, the display of the HDR image usually involves the tonemapping method, which compresses the range of brightness levels into the narrower range that an LDR image can display.

2. **Why does the weighting method result in a higher dynamic range than the naive method?**

The naive method does not differentiate between well-exposed and poorly-exposed (under- or over-exposed) pixels, leading to clipping in bright areas and noise in dark areas being directly averaged into the final image. Instead, the weighting method assigns lower weights to the poorly-exposed pixels and thus eliminates the negative effect from them, resulting in a better HDR image whose bright and dark areas are represented more by pixels from exposures where they were well-exposed.

3. **Why does the calibration method result in a higher dynamic range than the weighting method?**

The weighting method assumes that intensity is a linear function of exposure for simplicity while it should be a nonlinear function due to the Camera Response Function (CRF), which for most cameras compress very dark and very bright exposure readings into a smaller range of intensity values. Calibration method can accurately determine the CRF and thus allows for a more accurate reconstruction of the wide range of luminance present in real-world scenes. Also, calibrated method can more effectively handle extremes in brightness, reducing the clipping issue and thus extending the usable dynamic range in the final HDR image.

4. **Why does the calibration method result in higher consistency, compared to the weighting method?**

Calibration method with standard reference tools provides consistent objective measurement of light intensity, minimizing variability and subjective interpretation. Besides, the calibration process involves a more structured and repeatable workflow, improving for higher consistency compared to the weighting method.

2. Panoramic transformations

Include:

- The images of normal vectors and reflectance vectors
- The equirectangular image from your calibration HDR result

Image of normal vectors

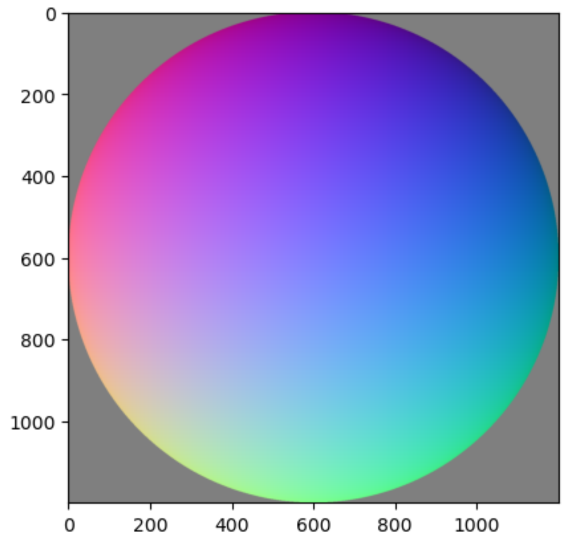
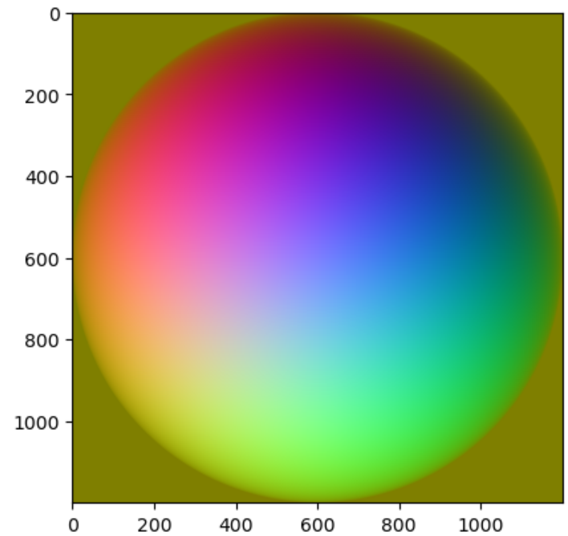
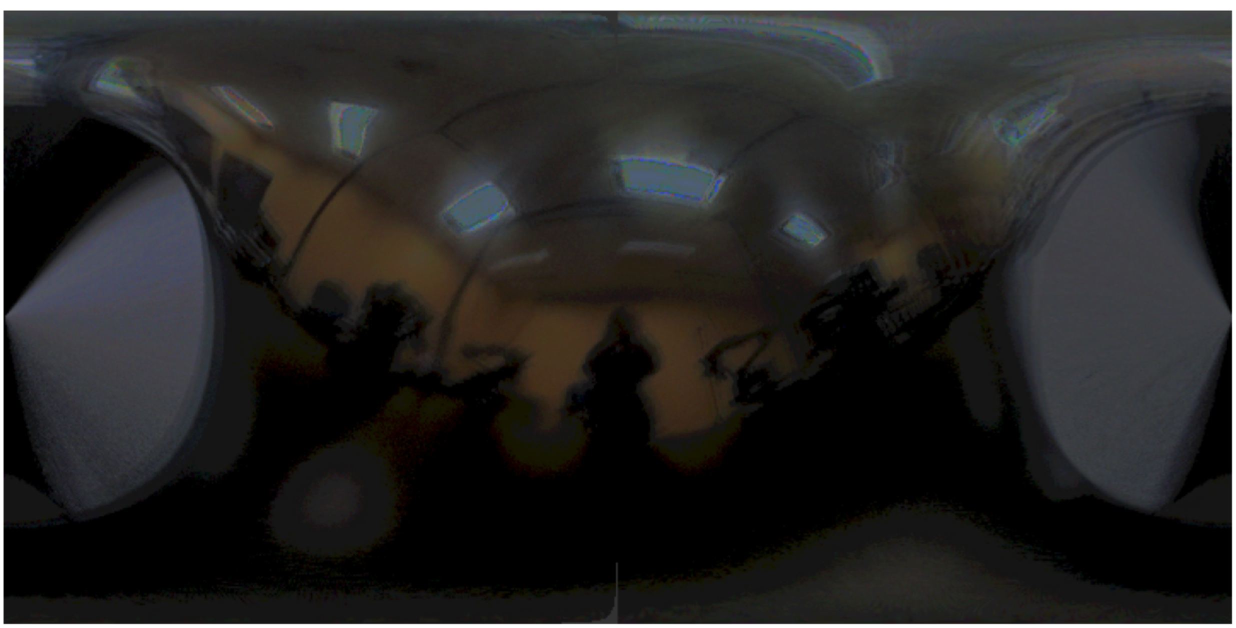


Image of reflectance vectors



The equirectangular image

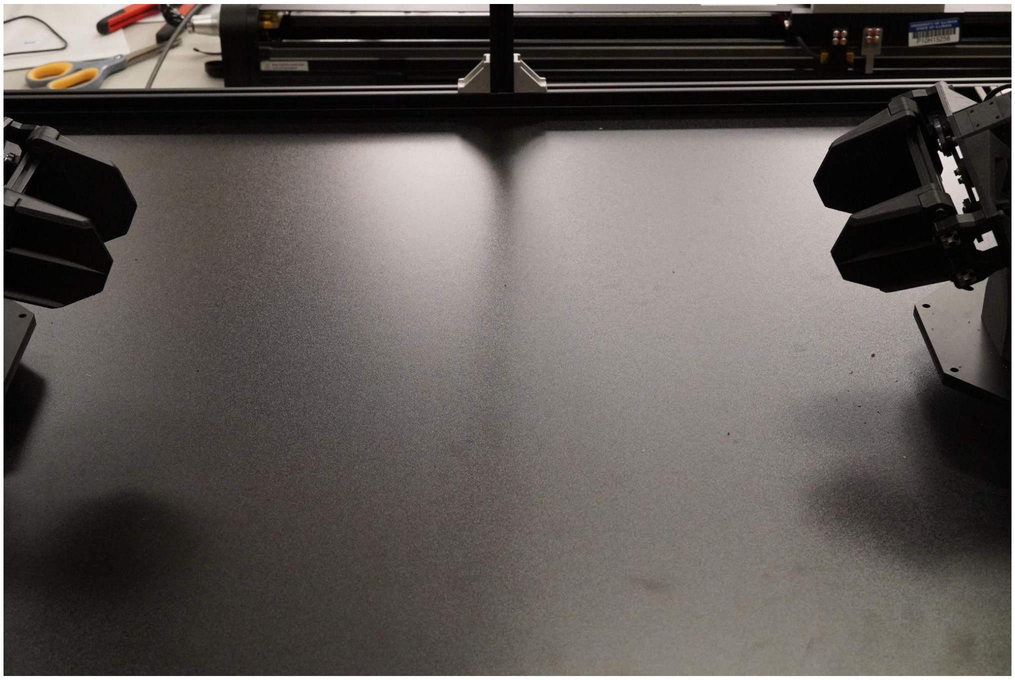


3. Rendering synthetic objects

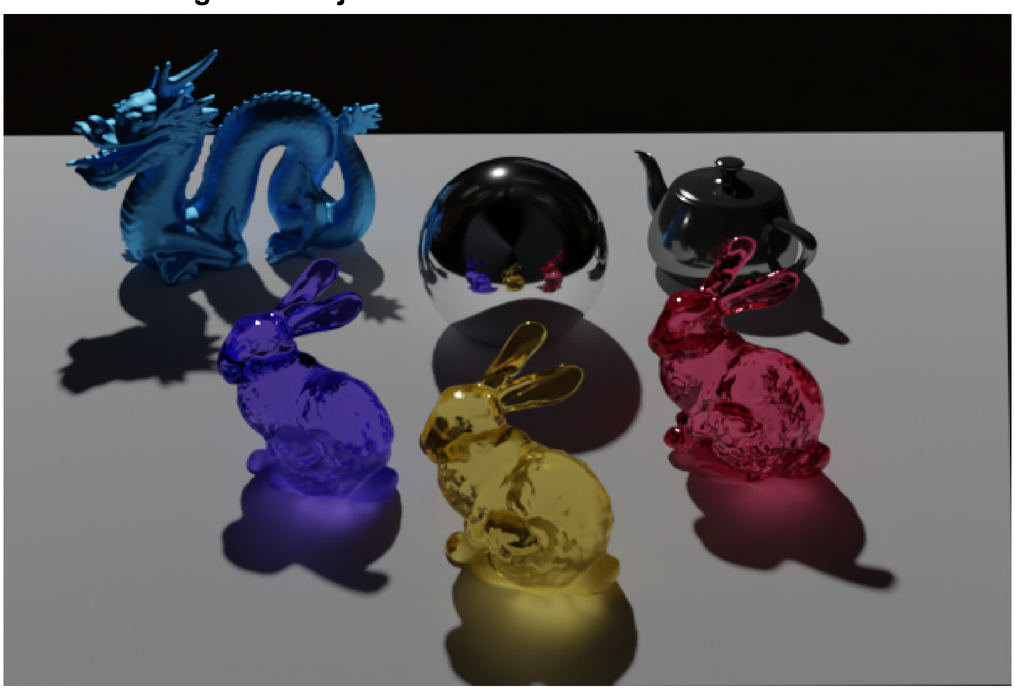
Include:

- Component images: (1) Background image; (2) Rendered image with objects; (3) Rendered image with local geometry (e.g. support plane); (4) Rendered mask image
- Final composited result

Background image



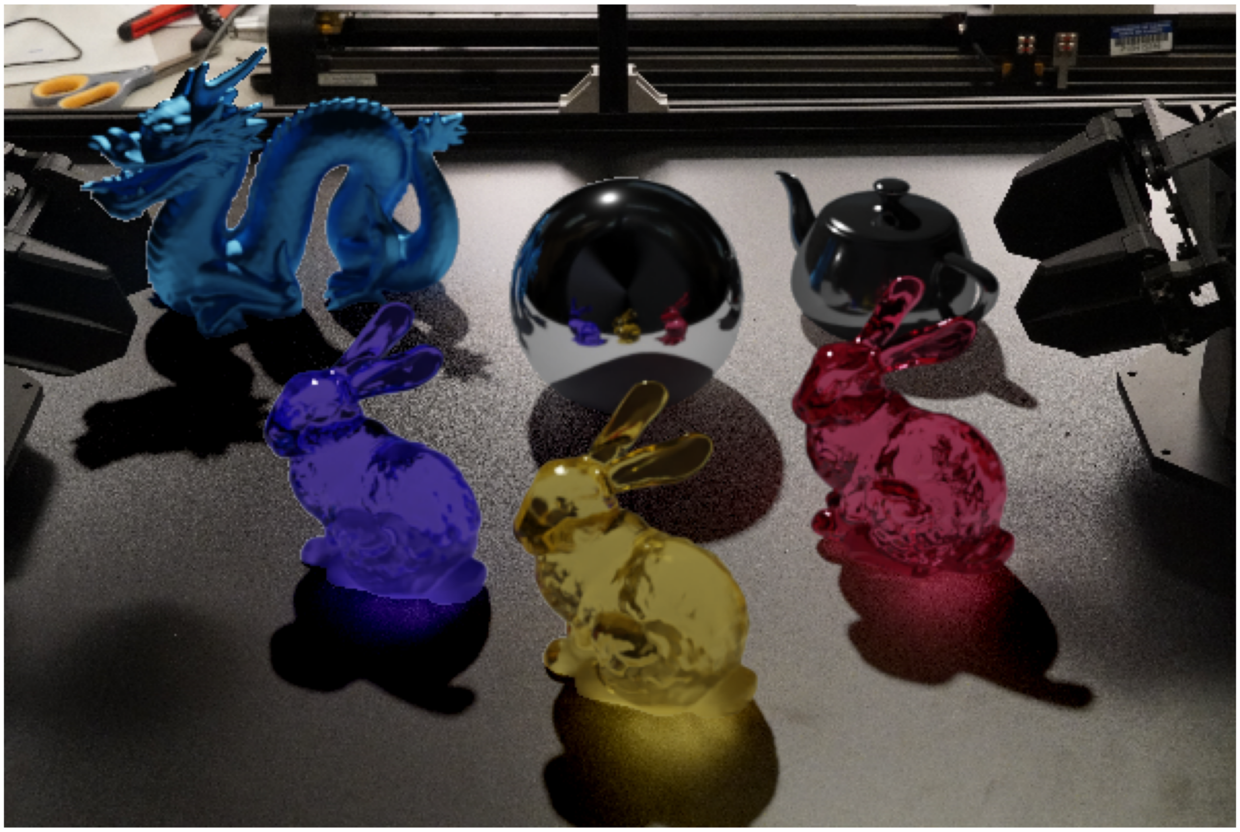
Rendered image with objects



Rendered image with local geometry

Rendered mask image

Final composited result



4. Quality of results / report

Nothing extra to include (scoring: 0=poor 5=average 10=great).

5. Additional results (B&W)

Include background image and final composited result image for: (10 pts each)

- New objects, same environment map
- New environment map, same objects

6. Other transformations (B&W)

Include (10 pts each)

- Angular environment map
- Vertical cross environment map

7. Photographer and tripod removal (B&W)

Include:

- Original LDR images
- Equirectangular image created from your own photos without photographer
- Explain your method

8. Local tone-mapping operator (B&W)

Include:

- Displayed HDR image, computed as linearly rescaled log of HDR image
- Your HDR image display improved by tone mapping
- Explain your method

Acknowledgments / Attribution

List any sources for code or images from outside sources

- OpenCV HDR tutorial:
  - https://docs.opencv.org/3.4/d2/df0/tutorial_py_hdr.html
  - https://docs.opencv.org/3.4/d3/db7/tutorial_hdr_imaging.html