Imperial College London

COURSEWORK

IMPERIAL COLLEGE LONDON

DEPARTMENT OF COMPUTING

417 Advanced Graphics

Author:
Jinwei Zhang, Yuan Zhu (CID: 01540854,01531935)

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1 Assemble an HDR Image and tonemap for display

In this section, we are given a indoor lighting environment in a set of LDR images (floating point format, range 0-1) photoed in different exposure. The aim of the program is to integral the picture set and generate corresponding assemble HDR picture.

The whole procedure including several steps:

1) Load all images into a sequence and create a buffer the same size as LDR image to process HDR later

2) Compute and store relative exposures of each image. Given all images have same f/stop and ISO, set the first exposure to be 1 and each following relative exposure is four times the previous one. The relative exposure set would be: $\delta t_i = [1, 4, 16, 64, 256, 1024, 4096]$

3) Implement a Gaussian function as weight function, considering that it fulfill the constraint of center weighted function(pixels closed to center are given higher weight). The mean of Gaussian distribution is set to be 0.5, and variance to be 0.2:

$$\boldsymbol{W}(I) = \tilde{N(\mu, \sigma)} = \exp\frac{-(I-\mu)^2}{2\sigma^2} \tag{1}$$

   Here, the function is applied to intensity, which is calculated by: $\boldsymbol{I} = 0.3R + 0.6G + 0.1B$, instead of apply to each color channel. The reason of intensity separation is to avoid color deformation.

4) After acquiring weight function, for each pixel of LDR image set, implement the weight function on the pixel and calculate the assembled log weighted average of that pixel. The assemble algorithm is as below:

$$\boldsymbol{F}(x, y) = \exp\frac{\sum_i(\log(\frac{1}{\delta t_i} * \boldsymbol{Z}_i(x, y)) * \boldsymbol{W}(\boldsymbol{Z}_i(x, y))}{\sum_i \boldsymbol{W}(\boldsymbol{Z}_i(x, y))} \tag{2}$$

   In processing, a pixel that greater than 0.92 or smaller than 0.005 is considered as bad input, given that those pixels have a potential to be more unstable or limited by upper bound of range, and therefore being ignored.

5) Calculate brightest and dimmest pixel of the HDR intensity, which is:

$$Radius = \frac{max}{min} = \frac{0.0868914}{0.00000213459} = 40706.2 \tag{3}$$

6) Firstly, apply linear scaling tone mapper:

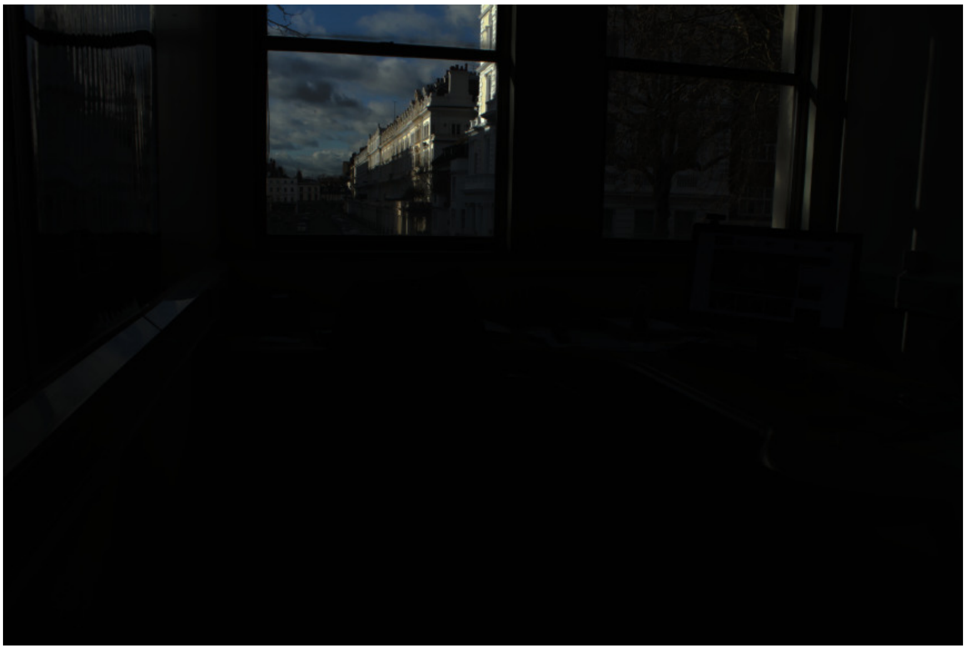


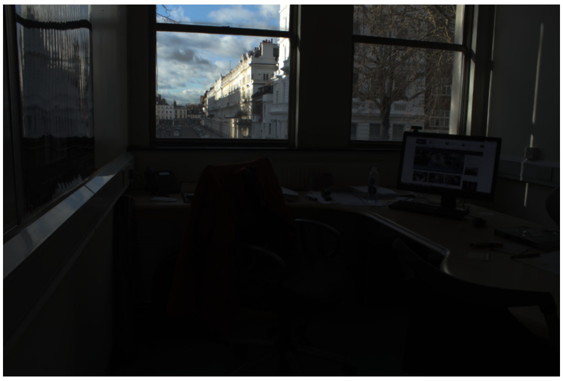
Figure 1: Assembled HDR image

7) Secondly, apply exponential scaling, here with exponent 2 and stop 0, 1 and 2

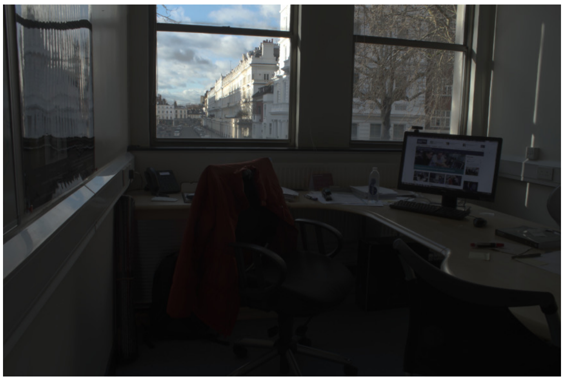
((a)) STOP=0 **((b))** STOP=1 **((c))** STOP=2

Figure 2: Exponential scaling with exponent 2 and stop 0, 1 and 2

8) Thirdly, apply Gamma function, here with Gamma value 1.5 and stop 1, 2, 3 and 4. 1 stop of Gamma function has a algorithm of $\Gamma = pixel^{\frac{1}{gamma}}$



((a)) STOP=1



((b)) STOP=2

((c)) STOP=3

((d)) STOP=4

Figure 3: Gamma function with Gamma value 1.5 and stop 1, 2, 3 and 4

9) Apply Gamma function, here with Gamma stop 2 and value 1.5, 1.8, 2.2 and 2.6

((a)) VALUE=1.5 ((b)) VALUE=1.8 ((c)) VALUE=2.2 ((d)) VALUE=2.6

Figure 4: Gamma function with Gamma stop 2 and value 1.5, 1.8, 2.2 and 2.6

Figure 5:
Best result with 1 stop exponential scaling with factor 2, 3 stop Gamma correction with Gamma value 1.5

2 Implement simple Image Based Lighting

In this section, we are given an outdoor (urban) lighting environment in lat-long format (.pfm) we need to create an image m of 511x511 resolution containing a mirror ball sphere lit by the lat-long map.

The basic algorithm is shown as follow:

1) Creating a circle image of diameter 511, First create a square a square image of length and height 511 then set the pixel outside the circle to be black (RGB 0.0)

2) for the pixel inside the circle, calculate the normal vector $\boldsymbol{n}(x, y, z)$

3) After that calculate the reflection vector by using

$$\boldsymbol{r} = 2 * (\boldsymbol{n} * \boldsymbol{v}) * \boldsymbol{n} - \boldsymbol{v}. \tag{4}$$

4) Then, mapping the Cartesian coordinate system to Spherical coordinate system using the equation below:

$$\begin{aligned} R &= \sqrt{x^2 + y^2 + z^2} = 255.5(Radius) \\ \theta &= \arctan\left(\frac{\sqrt{x^2 + z^2}}{y}\right) = \arccos\left(\frac{y}{\sqrt{x^2 + y^2 + z^2}}\right) \\ \phi &= \arctan\left(\frac{x}{z}\right) = \arccos\left(\frac{z}{\sqrt{x^2 + z^2}}\right) = \arcsin\left(\frac{x}{\sqrt{x^2 + z^2}}\right) \end{aligned} \tag{5}$$

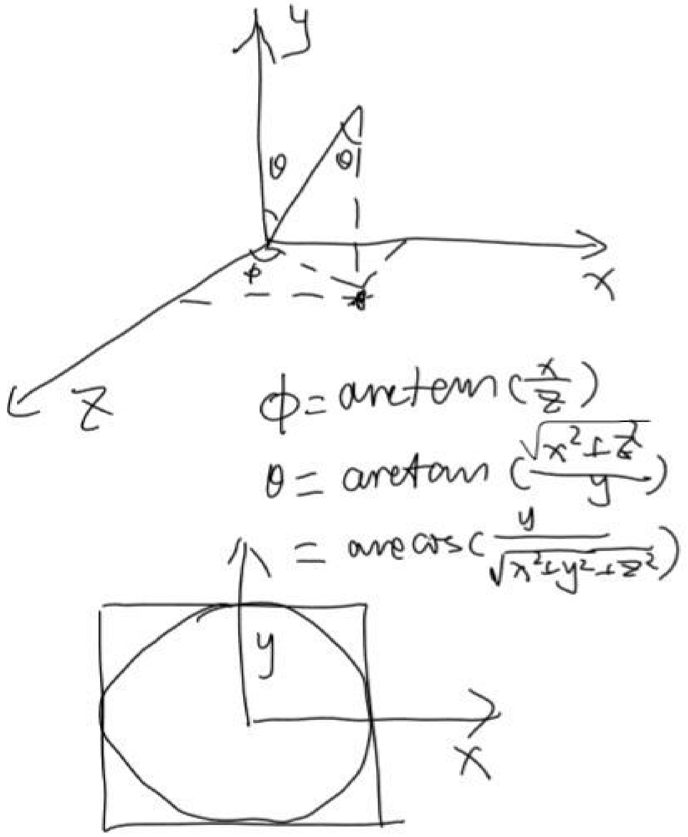


Figure 6: This is a draft.

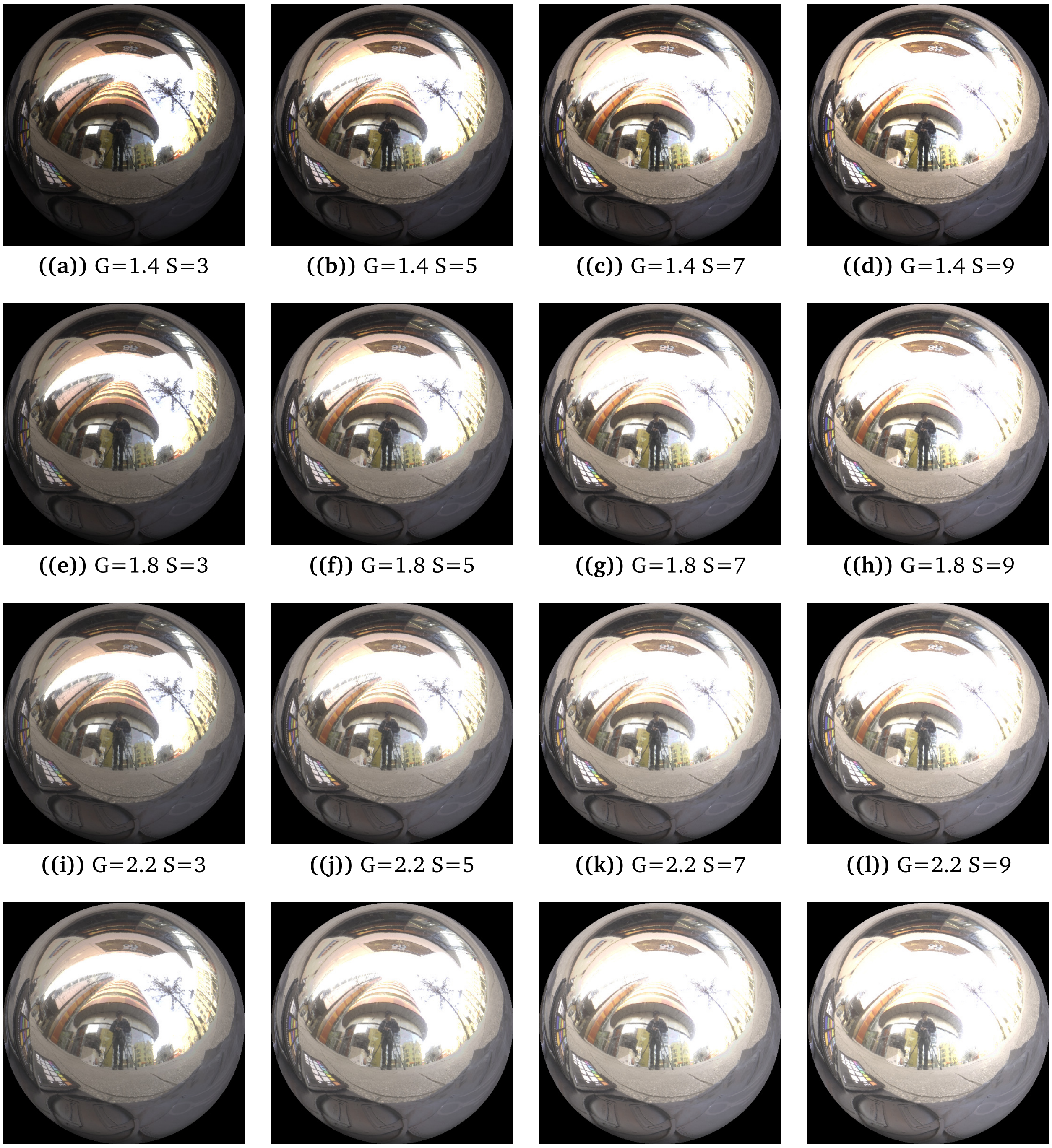
5) Coordinates Y is up, X is pointing right and Z is pointing out of the XY plane. For spherical coordinates of the lat-long map, Width varies along $\phi(0, 2\pi)$, and Height varies along $\theta(0, \pi)$.

6) Once we get the vector in spherical coordinates we can map the lat-long map onto the circle using the coordinate system above.

   the outcome is as below.

Figure 7: This is a figure.

7) the gamma correction function multiply the original image into a stop and power 1/gamma outcome is as follow, the best image is gamma = 1.8 and stop = 3:



((a)) G=1.4 S=3 ((b)) G=1.4 S=5 ((c)) G=1.4 S=7 ((d)) G=1.4 S=9

((e)) G=1.8 S=3 ((f)) G=1.8 S=5 ((g)) G=1.8 S=7 ((h)) G=1.8 S=9

((i)) G=2.2 S=3 ((j)) G=2.2 S=5 ((k)) G=2.2 S=7 ((l)) G=2.2 S=9

((m)) G=2.6 S=3 ((n)) G=2.6 S=5 ((o)) G=2.6 S=7 ((p)) G=2.6 S=9

Figure 8: 4 x 4