Advanced Topics in Computer Graphics I

Universität Bonn
Institut für Informatik II
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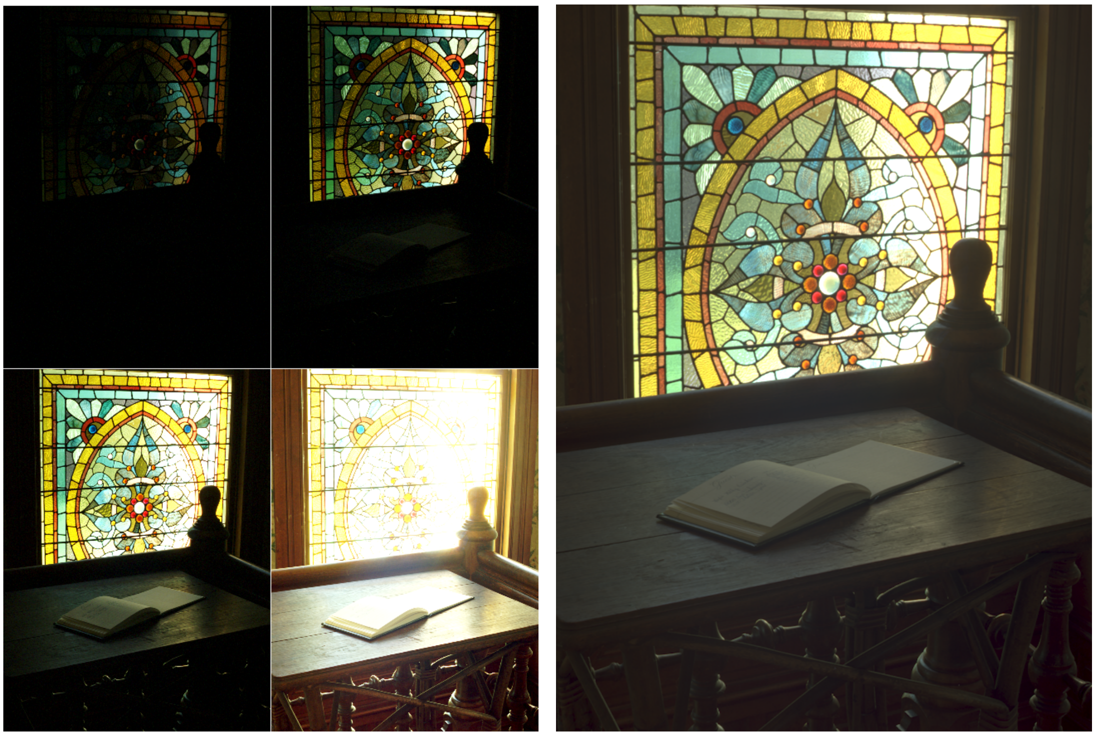
Sheet R01 - High Dynamic Range imaging, Radiometry and Tonemapping

Hand in your solutions via eCampus by Tue, 22.04.2025, **12:00 p.m.**. Compile your solution to the theoretical part into a single printable PDF file. For the practical part, hand in a single ZIP file containing only the exercise* folder within the src/ directory. Please refrain from sending the entire framework.

Assignment 1) HDR imaging *(3Pts)*



(a) Several LDR images with different exposure times.

(b) Tonemapped HDR image.

Figure 1: Input and result for the HDR task.

In the lecture the response curve and HDR image recovery from Robertson et al. [1] was explained. In this exercise you get to implement that algorithm. Here is a short outline of the algorithm:

a) Initialize the I_m with a linear curve and the weights w_{ij} as described below.
b) Pre-compute E_m according to equation (11).
c) Estimate $\hat{x}_j$ using $y_{i,j}$, t_i and I for every j, see equation (8).
d) Estimate the I_m from t_i and $\hat{x}_j$ for all m.
e) Re-scale the curve so that $I_{128} = 1$.

f) Continue with step c).

Implement the missing steps c) to e) in `Robertson.cpp`.

The framework for this exercise includes input data that can be used for the algorithm in `data/exercise01_HDR/book`. You can specify the data directory manually by running `./bin/exercise01_HDR -d data/exercise01_HDR/book` from the framework root directory, for example.

Hints:

- Compare your result with the given inverse response curves (`crf_gt.txt`) and the reference image (`hdr_gt.exr`).
- Under- and overexposed pixels (for which `underexposed_buffer` is set to true) should not participate in the computation of the response curve.

Assignment 2) Tone mapping *(4Pts)*

In the previous task, we generated an HDR image from a stack of LDR images and exposure values. This task is about the other way around: the process of creating an LDR image from an HDR image (with pixels y_{ij}) while preserving as much detail as possible. Please implement the following algorithms in *Tonemapping.h*, *Tonemapping.cpp*, and *Tonemapping.cu* and apply them to the HDR data from the previous task:

- **Linear scaling:** Apply a linear scaling $y_{if} \mapsto \lambda \cdot y_{if}$ to the image. Try to use the maximum color value $\lambda = y_{ij}^{max}$ as well as a fixed hand picked scaling factor.
- **Gamma correction:** Apply a gamma correction $y_{ij} \mapsto y_{ij}^{\gamma}$ to the image.
- **Histogram adjustment:** Apply the histogram adjustment method by Larson 97. Only consider the naïve method discussed on slides 47 to 50 of the lecture and assume $\log(L_{d\min}) = 0$ and $\log(L_{d\max}) = 1$.

Theoretical assignment

Assignment 3) Radiance and Irradiance *(3Pts)*

Consider the simple scene in Figure 2. Given the radiance of the sun $L_s = 20.045 \frac{MW}{m^2 sr}$ and the direction v having an angle of 45° to the table, calculate the irradiance at the table and the total radiant power incident on the table plate. For this, assume that the radiance is constant over the whole surface of the sun. Note: you may have to look up some physical dimensions.

References

[1] Mark A Robertson, Sean Borman, and Robert L Stevenson. Dynamic range improvement through multiple exposures. In *Proceedings 1999 international conference on image processing (Cat. 99CH36348)*, volume 3, pages 159–163. IEEE, 1999. URL: `https://citeseerx.ist.psu.edu/document?doi=876a681bfd80aead17fe7003a06a56c17fba95d8`.

Good luck!

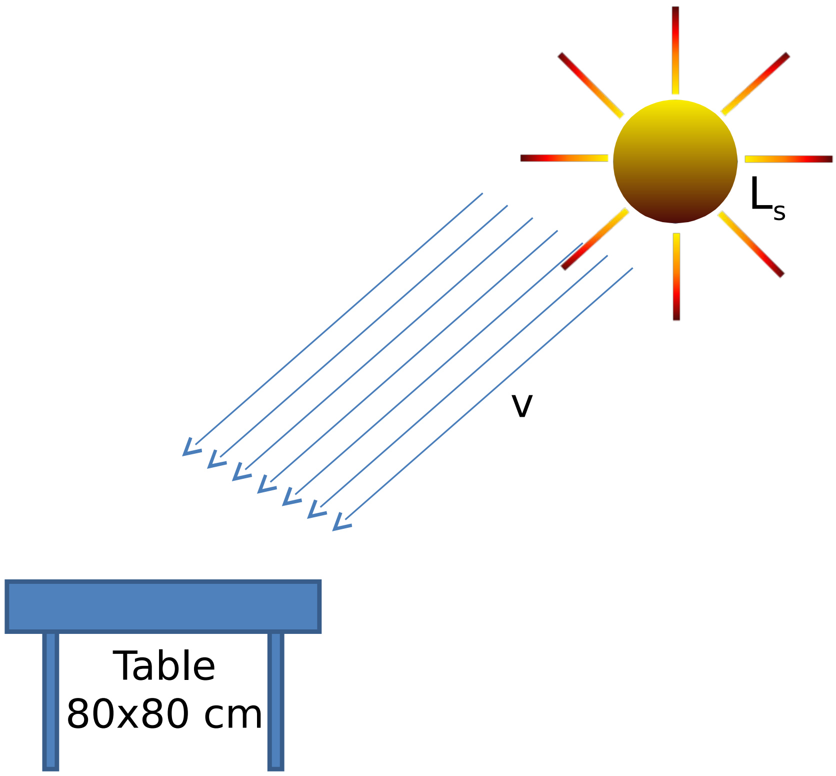


Figure 2: Toy example for radiometric quantities