Note on Digital Image Synthesis Project 3

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1 Part 1

We will provide you measured brdfs [1], you are asked to write a material plugin of pbrt which uses tabulated method to answer brdf values.

Remember what the teacher said in class, material does NOT return brdf values, it just pass a brdf object(or instance, in Java sense) whenever needed. To this end, you may need write your own brdf class which use tabulated method to answer brdf values.

For reading measured brdfs, we provide BRDFRead.h and a skeleton code of tabulated.cpp. See read_brdf() and lookup_brdf_val() for more information.

2 Part 2

You're asked to factorize brdf table(matrix) to save the storage. This is an extension of Part 1 and the basis of Part 3.

A tabulated brdf can be queried by assign incoming direction and outgoing direction. Every direction can be parameterized by θ and ϕ. So a brdf is a four dimensional function and a tabulated brdf can be thought as a four dimensional matrix.

Mathematically, the factorizing process is to write brdf as below

$$brdf(\omega_i, \omega_o) = g(\omega_i) f(\omega_o)$$

Where ω_i is the incoming direction and ω_o is the outgoing direction. If we can rewrite brdf into the product of g and f. The dimensionality of both functions are only 2. The great storage is saved. Unfortunately, most brdf cannot be rewrite as product of two fucntions and each of which is only function of one direction.

So we only approximate brdf by a series of product of functions.

$$brdf(\omega_i, \omega_o) \approx g_1(\omega_i) f_1(\omega_o) + \ldots + g_j(\omega_i) f_j(\omega_o)$$

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[1] The table of measured brdfs is provided by Mitsubishi Electric Reaseach Laboratories.

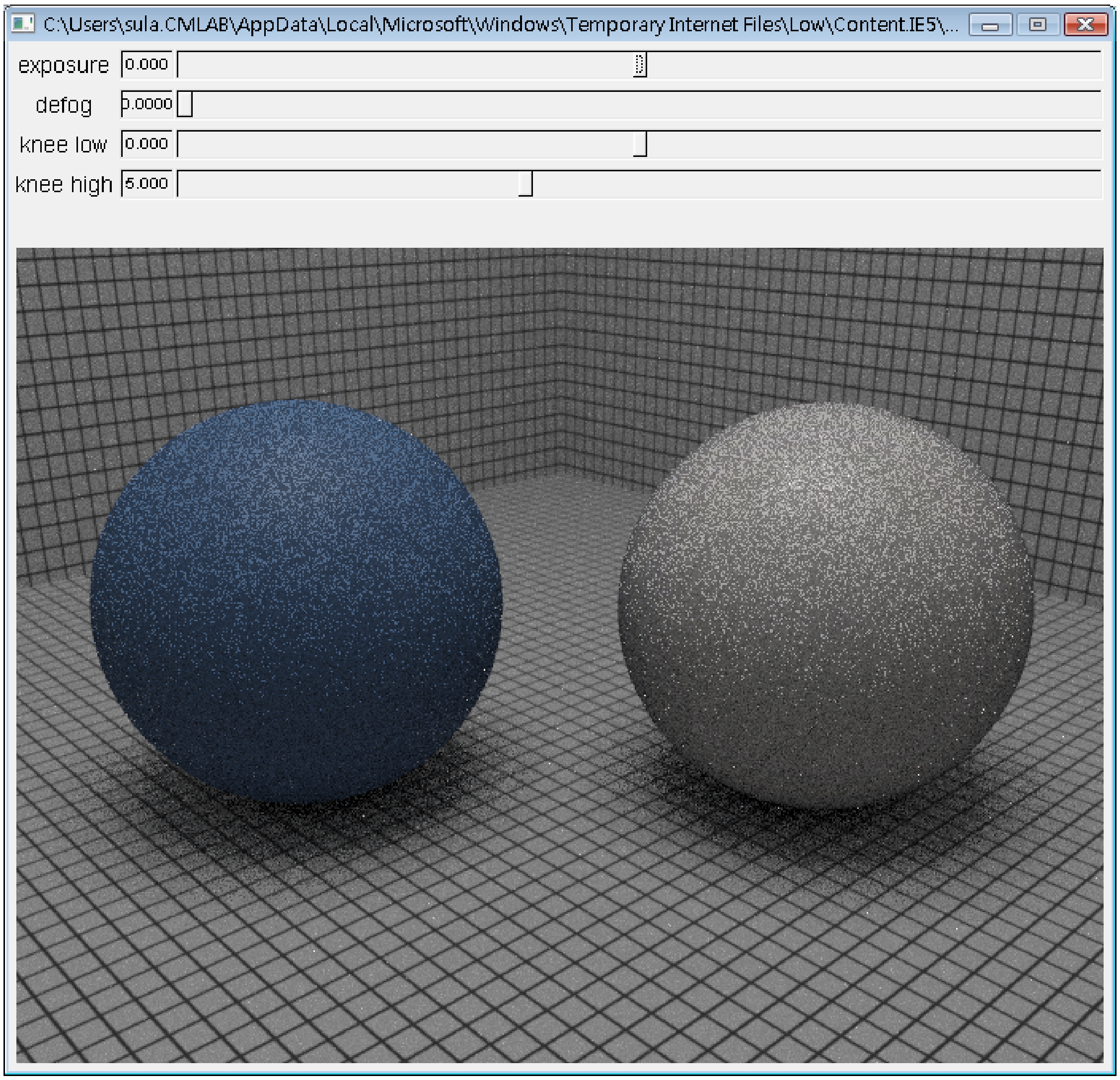

Figure 1: 4 samples per pixel

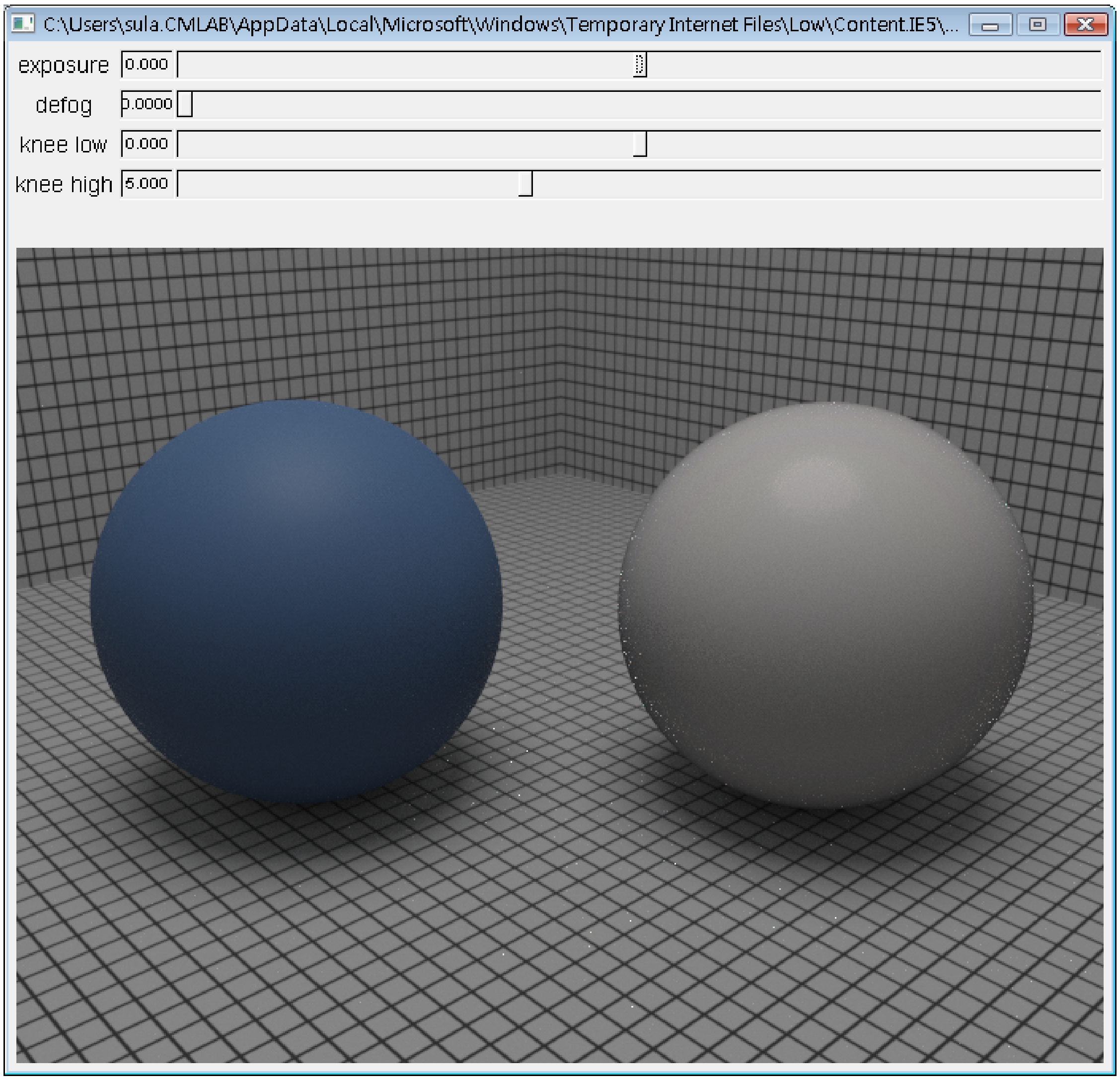

Figure 2: 256 samples per pixel

j is much smaller than resolution of ω.

For detailed description, see Efficient BRDF Importance Sampling Using a Factored Representation. [2]

However, the standard parameterization of brdf (using ω_i, ω_o) is not the only method to parameterize brdf. Furthermore, parameterization affect the quality of factorization. Figure 3 to 6 use different parameterizations.

We do not know which parameterization is better for some materials in advance, this is a cumbersome work to try all parameterization. Fortunately, a great guy tried different methods on the materials you need to factorize. You can follow his/her suggestion to factorize or use your own method. If you find out some better parameters for some material, please let me know.

We will also provide a factorized file for debugging. You can use the same file format as mine but this is not a requirement. You can use your own file format since the factorization work should be done by you.

The algorithm for factorizing brdf (nmf:Non-negative matrix factorization) is also provided by J. Lawrence (fortunately, not by me). You can download the program from his website[2].

3 Part 3(bonus)

As a bonus part, you should read Efficient BRDF Importance Sampling Using a Factored Representation [2] and its website [3].

References

[1] W. Matusik, H. Pfister, M. Brand L. McMillan. *A Data-Driven Reflectance Model*. ACM Transactions on Graphics.

[2] J. Lawrence, S. Rusinkiewicz, R. Ramamoorthi. *Efficient BRDF Importance Sampling Using a Factored Representation.* ACM Transaction on Graphics.

[2] http://www.cs.virginia.edu/ jdl/

[3] http://www.cs.princeton.edu/gfx/proj/brdf/fig10/

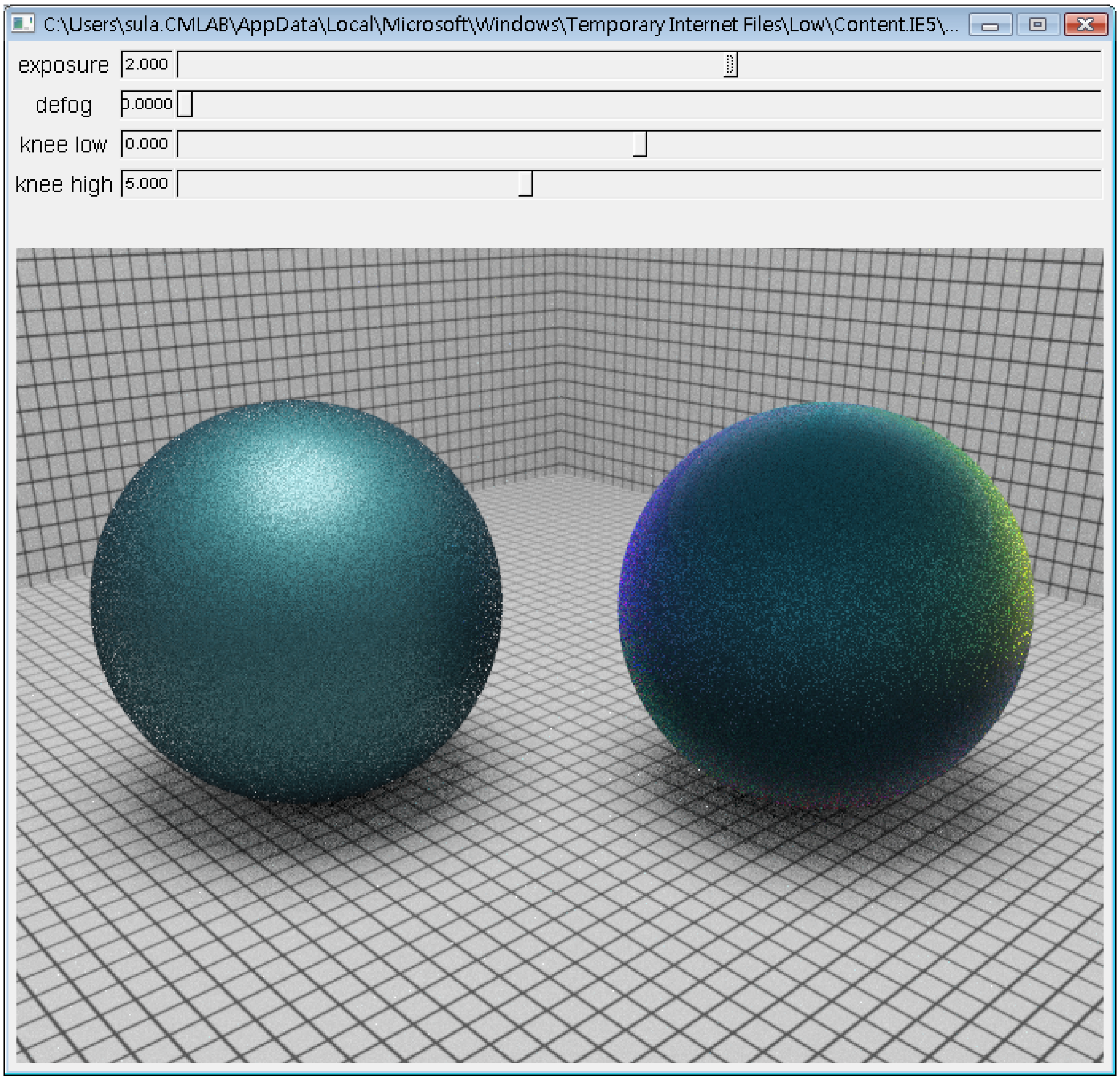

Figure 3: Left ball: tabulated, Right ball: factorized

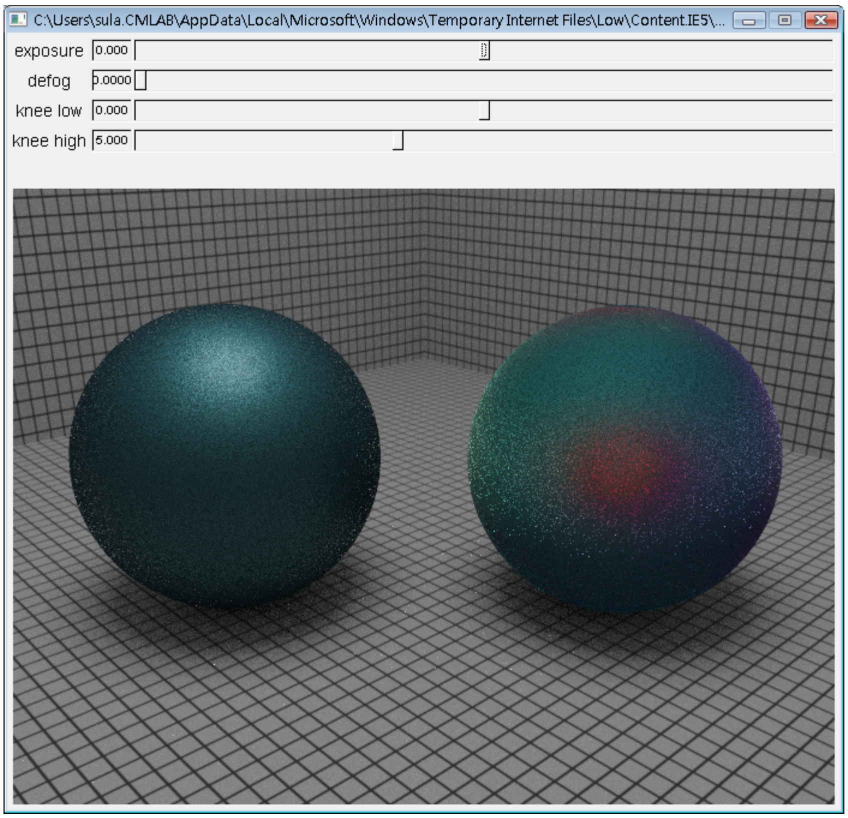

Figure 4: Left ball: tabulated, Right ball: factorized

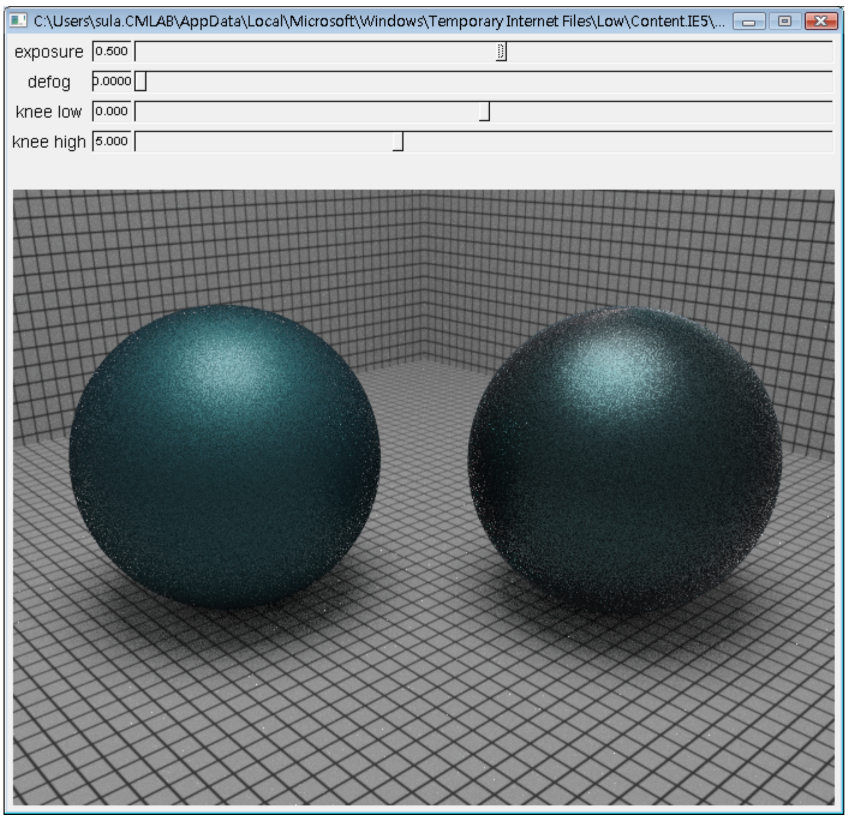

Figure 5: Left ball: tabulated, Right ball: factorized

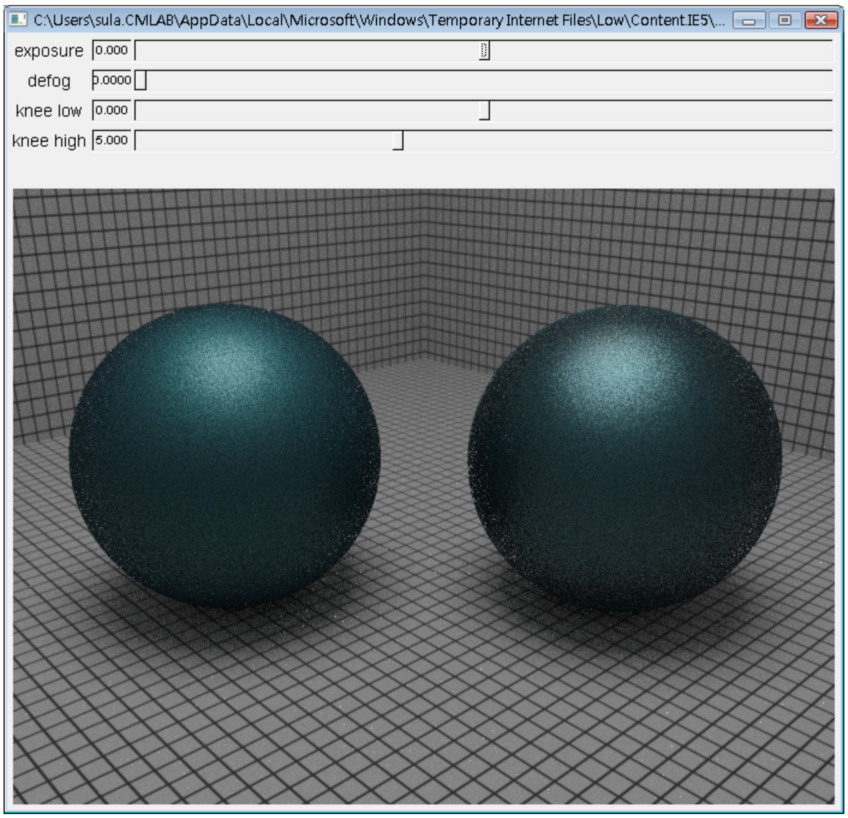

Figure 6: Left ball: tabulated, Right ball: factorized