CS 481/681 Computer Graphics Rendering
Midterm Exam

Due Saturday, March 9th, 2019 9:00am

Please answer the questions to the best of your ability. It shouldn't take more than a few sentences per problem. Feel free to use the cited papers for reference.

The following questions refer to this figure.

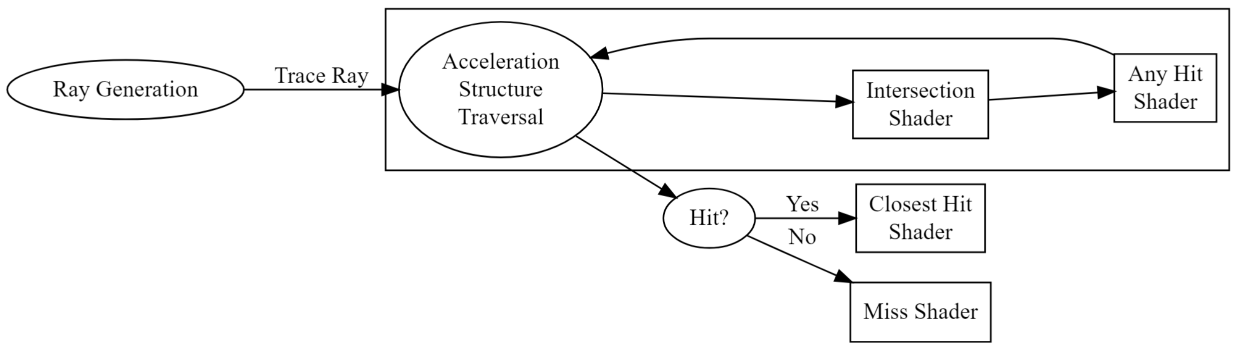

Figure 1: Ray Tracing Pipeline

1. (10 points) What is the difference between *forward*- and *backward*- ray tracing? How is the ray generation step used to accomplish this step?
2. (10 points) What is the intersection shader used for? How might sphere tracing [Har96] be useful in this context?
3. (10 points) What is the any hit shader used for? If we wanted to model participating media [JDZJ08] with this shader, we need to understand the difference between the terms homogeneous vs heterogeneous and isotropic vs anisotropic. What is the differences between these terms?
4. (10 points) After we have determined that we have found no hits while traversing out acceleration structure, we call a miss shader. How might we simulate a physically based sky model [HW12]? What factors do we need to consider when using a sky model?

The following questions refer to the rendering equation [Kaj86]

$$L_o(\mathbf{x} \to \omega_o) = L_e(\mathbf{x} \to \omega_o) + \int_\Omega f_r(\omega_i, \omega_o)\, L_i(\omega_i \to \mathbf{x})\langle \omega_i, \omega_o \rangle \, d\omega_i \,. \tag{1}$$

5. (10 points) The closest hit shader is often used to evaluate the rendering equation. What are the six parts of the rendering equation and what are they used for?
6. (10 points) For a *bidirectional reflectance distribution function* (BRDF) to be consider physically based [Hei14], it must obey several conditions. Name at least three of them.

7. (10 points) The specular BRDF introduced by Cook and Torrance [CT82] is

$$f_r(\omega_i, \omega_o) = \frac{f_r(\omega_i, \omega_o) D(\omega_i) G_2(\omega_i)}{4 \cos\theta_i \cos\theta_o} \tag{2}$$

What are the functions $f_r(\omega_i, \omega_o)$, $D(\omega)$, and $G_2(\omega_i, \omega_o)$ used for?

8. (10 points) Distributed ray tracing [CPC84] allows for a number of special effects. Name at least two and describe how they are used in a production context.

9. (10 points) Whitted ray tracing [Whi80] helped solve what three problems simultaneously in the synthesis of computer generated images?

10. (10 points) Paul Heckbert [Hec90] introduced a regular expression notation for light paths. What rendering method (______ illumination) is associated with $L\{D|S\}E$ light paths and what rendering method (______ illumination) is associated with $L\{D|S\}^+E$ light paths.

References

[CPC84] Robert L. Cook, Thomas Porter, and Loren Carpenter. Distributed ray tracing. *SIGGRAPH Comput. Graph.*, 18(3):137–145, January 1984.

[CT82] R. L. Cook and K. E. Torrance. A reflectance model for computer graphics. *ACM Trans. Graph.*, 1(1):7–24, January 1982.

[Har96] John C Hart. Sphere tracing: A geometric method for the antialiased ray tracing of implicit surfaces. *The Visual Computer*, 12(10):527–545, 1996.

[Hec90] Paul S. Heckbert. Adaptive radiosity textures for bidirectional ray tracing. *SIGGRAPH Comput. Graph.*, 24(4):145–154, September 1990.

[Hei14] Eric Heitz. Understanding the masking-shadowing function in microfacet-based brdfs. *Journal of Computer Graphics Techniques (JCGT)*, 3(2):48–107, June 2014.

[HW12] Lukas Hosek and Alexander Wilkie. An analytic model for full spectral sky-dome radiance. *ACM Trans. Graph.*, 31(4):95:1–95:9, July 2012.

[JDZJ08] Wojciech Jarosz, Craig Donner, Matthias Zwicker, and Henrik Wann Jensen. Radiance caching for participating media. *ACM Trans. Graph.*, 27(1):7:1–7:11, March 2008.

[Kaj86] James T. Kajiya. The rendering equation. *SIGGRAPH Comput. Graph.*, 20(4):143–150, August 1986.

[Whi80] Turner Whitted. An improved illumination model for shaded display. *Commun. ACM*, 23(6):343–349, June 1980.