Datorgrafik DT3025

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Tools No tools (books or calculators) are allowed.

There are three types of questions on this exam, targeted for the goals that correspond to a passing grade (3) and a pass with distinction (grades 4–5).

- To pass with grade 3 (G), you need 12 out of 16 points (75%) from the {3} questions *or* 20 points in total (from all questions).
- To pass with grade 4 (VG), you additionally need 75% from the {4} questions.
- To pass with grade 5, you additionally need 75% from the {5} questions.

You may answer in Swedish or English.
Good luck!

Question 1

4 points {3} Describe the following four terms: gamut, hue, saturation, refraction.

4 points {4} A common colour space is sRGB, where colours to be displayed are modelled as a weighted sum of three specific R, G, B components. It has a smaller nominal gamut than, e.g., the Adobe RGB colour space. Consider extending sRGB to a "sRGBC" colour space that also includes a cyan component. Would that affect the gamut? In what way, and why?

4 points {5} It is convenient to assume a single pin-hole camera model with zero exposure time when rendering computer graphics. List advantages and disadvantages of this model. Are the assumptions behind using this model valid? Explain why or why not.

Question 2

4 points {3} Describe the difference between Phong or Gouraud shading and the Phong reflectance model.

2 points {4} Figure 1a shows a white Lambertian sphere lit by a white point light source (located behind the camera in this scene). The BRDF of a Lambertian surface is a constant value. Why is it then that this surface does not appear flat white, but is darker towards the silhouette?

2 points Assume we want to model the moon as a smooth sphere. Suggest a lighting model that would be more suited than purely Lambertian scattering (to achieve a result closer to Figure 1b). Disregard the texture.

4 points {5} The rendering equation can be written in the following two, slightly different, forms.

$$L(P,\omega_o) = L^e(P,\omega_o) + \int\limits_{\omega_i \in S^2(P)} L(P,-\omega_i) f(P,\omega_i,\omega_o)(|\omega_i \cdot \mathbf{n}_P|)\, d\omega_i \quad (1)$$

$$L(P,\omega_o) = L^e(P,\omega_o) + \int\limits_{\omega_i \in S^2_+(P)} L(P,-\omega_i) f(P,\omega_i,\omega_o)(\omega_i \cdot \mathbf{n}_P)\, d\omega_i \quad (2)$$

What is the difference between Equation (1) and (2), in terms of which materials they can model? Describe the implications of the difference in the limits used in the integral and the use of an absolute value in the last factor.

Question 3

Figure 2 shows an indoor scene with two light sources, rendered with path tracing.

4 points {3} Describe the difference between ray tracing and path tracing in terms of rendering indirect illumination, and how the difference would affect the appearance of Figure 2.

4 points {4} Path tracing implementations typically make use of *Monte Carlo integration*. Use Monte Carlo integration, with one sample, to compute the integral $\int_0^1 x^2\, dx$ (using appropriate assumptions when needed).

4 points {5} Some rendering methods produce a *biased* value of each pixel and some rendering methods produce an unbiased value, but with a larger *variance*. Explain where such bias and variance come from, and how they affect the appearance of the rendered image.

Question 4

Figure 3 shows an example of a hard shadow rendered in real-time using shadow volumes.

4 points {3} Outline the steps of a naive *shadow volume* algorithm for rendering hard shadows cast by a polygon model onto a terrain object, given a point light source, such as the one in Figure 3.

4 points {4} Discuss performance issues of your algorithm and give details of how it can be amended to be more efficient. Still only on a pseudocode level. (Alternatively, give details of what measures you took in the previous algorithm.)

4 points {5} Shadow volumes are typically used for rendering hard shadows. Discuss how your shadow volume algorithm could be amended to render soft shadows (from an area light source), and discuss pros and cons relative to implementing soft shadows with shadow mapping instead.

(a) Lambertian sphere. *(b) Full moon.*

Figure 1: Comparing the light reflected off a Lambertian sphere and the moon.

Figure 2: Indoor scene rendered with bidirectional path tracing.

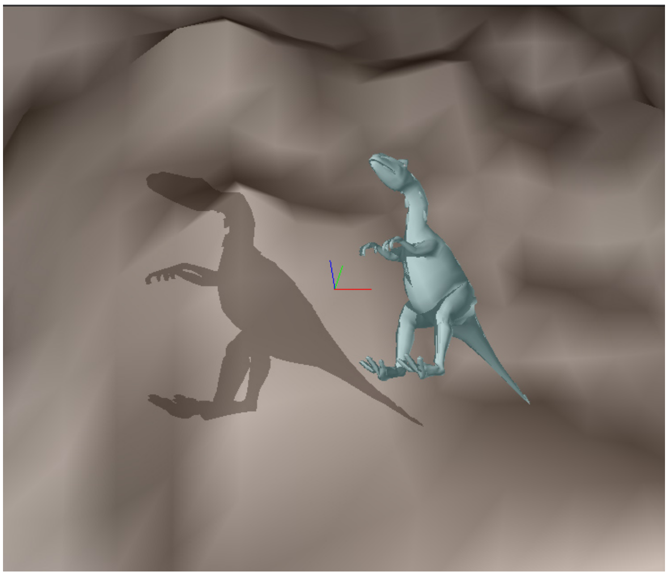

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Figure 3: Hard shadow rendered with shadow volume.