

Computer Graphics Ph.D. Qualifying Exam, March 2017

1. (20%) (a) Give the 4×4 matrix \mathbf{T} for translation by a vector (t_x, t_y, t_z) in homogeneous coordinates. (10%) (b) What is the 4×4 matrix \mathbf{R} for 3D rotation about the z axis by θ in homogeneous coordinates? (10%)
2. (20%) (a) The Phong illumination model can be summarized by the following equation:

$$I = k_e + k_a I_a + \sum_i \left[I_{l_i} (k_d (\mathbf{N} \cdot \mathbf{L}_i)_+ + k_s (\mathbf{V} \cdot \mathbf{R}_i)_+^{n_s}) \min \left(1, \frac{1}{a_0 + a_1 d_i + a_2 d_i^2} \right) \right]$$

Draw a diagram to explain the main variables in the above formulation. What effects do the terms of the above formulation intend to model? (b) Describe how to shade a triangle using flat shading, Gouraud shading and Phong shading. Discuss their visual differences.

3. (20%) Rasterization and ray casting are two methods for rendering an image. Explain how they work.
4. (20%) Consider the following equation and diagram in Figure 1(a):

$$L(x, x') = \delta(x, x') \left[E(x, x') + \int_S \rho_{x'}(x, x'') L(x', x'') \frac{\cos(\theta') \cos(\theta'')}{\|x' - x''\|^2} dx'' \right]$$

Explain what the terms $\delta(x, x')$, $E(x, x')$, S , $\rho_{x'}(x, x'')$, $\cos(\theta')$ and $\|x' - x''\|^2$ account for. What is the equation for?

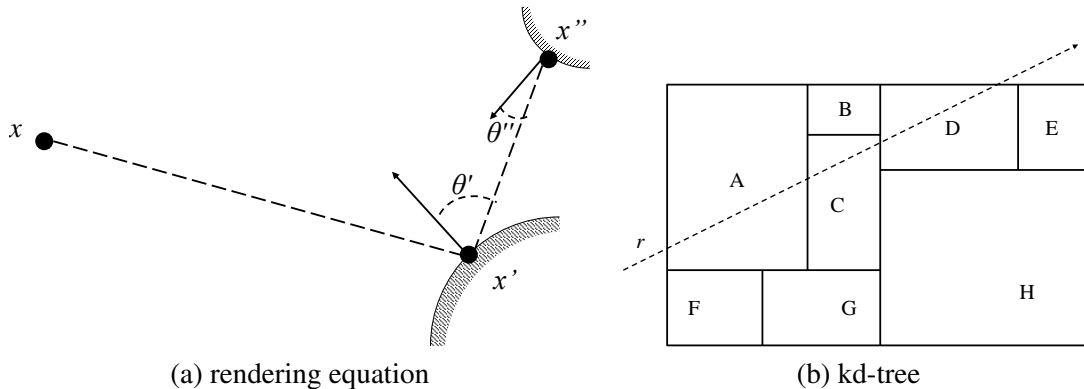


Figure 1: The rendering equation for question 4 and the kd-tree for question 5.

5. (20%) K-D tree is a method for accelerating ray-scene intersection computation. Assume that a 2D KD-tree partitions the scene in the way illustrated in Figure 1(b). Draw the corresponding tree structure. Please name your interior nodes. Given a ray r in Figure 1(b), list the node that r visits in order (including both interior and leaf nodes). We say that a ray visits a node if the ray hits the bounding box of the node.