Interactive Computer Graphics Ph.D. Written Exam March 2007

1. (15%) \( A \) and \( B \) are \( 3 \times 3 \) rotation matrices. Let \( C \) be a matrix created by a convex linear combination of them \( (C = \alpha A + (1 - \alpha)B) \). Under what circumstances will \( C \) be a rotation matrix?

2. (20%) The Phong illumination model can be summarized by the following equation:

\[
I = k_e + k_a I_a + \sum_i I_i \left( k_d (N \cdot L_i)_+ + k_r (V \cdot R_i)_+ \right) \min \left( 1, \frac{1}{a_0 + a_1 d_i + a_2 d_i^2} \right)
\]

Draw a diagram to explain the main variables in the above formulation. What effects do the terms of the above formulation intend to model?

3. (10%) For the above formulation, Blinn and Newell have suggested that, when \( V \) and \( L \) are assumed to be constants, the computation of \( V \cdot R \) can be simplified by associating with each light source a fictitious light source that will generate specular reflections. The second light source is located in the halfway direction \( H \) between \( L \) and \( V \). The term \( V \cdot R \) is then replaced by \( N \cdot H \). Under what circumstances might \( L \) and \( V \) be assumed to be constant and how does the new equation using \( H \) simplify shading equations?

4. (15%) (a) Describe Flat shading, Gouraud shading and Phong shading. (b) Discuss their visual differences.

5. (10%) Give 2 or 3 advantages that BSP trees have over a Z-buffer.

6. (10%) Please describe a method of generating shadows for point light sources in local shading.

7. (10%) Please describe a method to speed up the ray-scene intersection finding for ray tracing.

8. (10%) Despite its weaker graphics capability than PS3 and Xbox 360, Wii has gained more popularity than its competitors. Please give your explanations on this fact.