Interactive Computer Graphics Ph.D. Written Exam October 2007

1. (15%) (a) Describe Flat shading, Gouraud shading and Phong shading. (b) Discuss their visual differences.

2. (10%) Describe bump mapping and displacement mapping and describe a situation where you can see the difference between them.

3. (20%) The Phong illumination model can be summarized by the following equation:

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

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

4. (20%) Consider the case of an orthographic viewer and the viewer sees an opaque, texture-mapped plane oriented to face the viewer head-on. Assume a pixel p projects onto the plane to cover an area A_p and the texture-mapping hardware computes

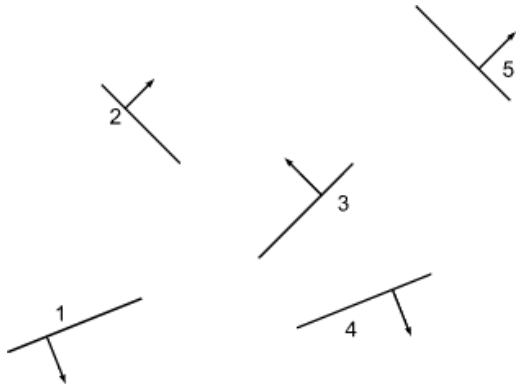
$$T_p = \frac{1}{A_p} \sum_{q \ in A} T(q),$$

   where $T(q)$ is the texture image which modifies a shading parameter such as the diffuse coefficient, and T_p is the result of filtering this image over a particular pixel area A_p. For anti-aliasing, we often use super-sampling, casting multiple rays per pixel and averaging the results together. Instead of performing several shading calculation for q's and averaging the results, a faster way is to only perform shading once using the pre-filtered value T_p as the shading parameter.

   Assume the Phong shading model as defined above. For each of the following cases, determine whether or not the use of pre-filtered textures introduces errors into the shading calculation.

   (a) The texture modulates k_e.
   (b) The texture modulates k_d.
   (c) The texture modulates k_s.
   (d) The texture modulates n_s.
   (e) The texture modulates $\mathbf{N}$ and the surface is diffuse.
   (f) The texture modulates $\mathbf{N}$ and the surface is diffuse and specular.
   (g) The texture modulates displacement d (that is, a displacement map texture) and the surface is diffuse.

5. (15%) (a) Painter's algorithm draws polygons from back to front. Give an example where painter's algorithm fails. (b) BSP tree is an algorithm to address the problem painter's algorithm faces. Construct the BSP tree for the following figure. Use face 3 as the root.



6. (10%) (a) Describe traditional graphics pipeline. (b) One of the most important advance of modern graphics hardware is its programmability. Explain what the programmability is.

7. (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.