Graphics Qualifying Exam

Sept 15, 2003

- This exam contains six questions.
- **Answer 4 of the first 5 questions, and question 6.**
- All questions are of equal point value.
- Answer each question in a separate blue book.

Question 1:

Subdivision surfaces for modeling 3D objects were first introduced in 1978, in a pair of papers by Catmull and Clark, and Doo and Sabin. It was not until Geri's Game, in 1997, that subdivision surfaces saw major use in film. Since that time, subdivision surfaces are becoming increasingly popular as a mechanism for representing shapes in modeling and animation.

Suggest two technical issues in using subdivision surfaces that made them impractical for widespread use prior to the mid- to late- 1990s. For each challenge:

a. Discuss the issue thoroughly, and explain its relevance to production systems.

b. Describe the technical advances or trends that address the issue, helping to make subdivision surfaces practical in real applications.

Question 2:

Mipmapping is an important part of texture-mapping. A set of mipmaps is typically generated by down-sampling a base texture by powers of two in both directions. A *ripmap* set generates additional down-sampled textures by decoupling the down-sampling in each dimension. For instance, an initial 4×4 texture will generate a ripmap set with sizes 4×2, 2×2, 2×4, 1×4, 1×2, 1×1, 2×1 and 4×1.

a. Roughly how much memory does a standard mipmap set use compared to the initial image alone? How much would a ripmap set use? Hint: It helps to draw a diagram of the maps.

b. Give a polygon/viewer configuration for which ripmaps would be better than mipmaps. Use a sketch to explain why.

c. The Beier-Neely image morphing algorithm can take advantage of mipmaps to improve efficiency. Why would ripmaps be an improvement? Use sketches to help explain your answer.

Question 3:

Algorithms for efficiently rendering complex models, such as visibility and level-of-detail schemes, are designed to overcome limitations in overall rendering system performance. These limitations can be summarized as assumptions about the relative costs of rendering, main CPU operations, bus transfers, network transfers, and available memory. The methods also make assumptions about the types of models to be rendered.

For each of the following LOD or visibility techniques, discuss the major assumptions underlying the algorithm.

a. Funkhouser, Sequin and Teller's Walkthrough system.

b. Garland and Heckbert's Quadric Error Simplification.

c. Hoppe's progressive meshes.

Question 4:

Stylized (non-photorealistic) rendering poses two major problems when animated. The first is the "shower door" effect that causes objects to appear as though they are moving behind a textured piece of glass. The second is jittering of painterly strokes of features.

a. Explain the underlying causes of these affects.

b. Describe two ways in which researchers have attempted to overcome the shower door effect.

Question 5:

The Quicktime VR system, the Light-Field and Lumigraph systems, and Debevec's Facade system represent three different approaches to image-based modeling and rendering.

For each system describe a scenario to which it is particularly well suited, and explain why. For each scenario, also discuss the suitability of the other two systems.

Question 6:

Choose 3 of the following 4 pairs. For each system in each chosen pair, explain why it is considered seminal.

- Menv and Inventor
- Sketchpad and Sketch
- Brook's Walkthrough and Quicktime VR
- The Reyes Renderer and SGI Hardware Graphics.