

# Graphics Qualifying Exam

February 2, 2004

- 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 and triangular meshes are two methods for representing a surface. Each method has advantages and disadvantages when it comes to representing detail and editing the surface.

- a. Subdivision surfaces have an obvious advantage for smooth surfaces because they represent a smooth limit surface with a coarse base mesh. However, special techniques must be used to create sharp geometric features, such as creases. DeRose et. al. in their paper “Subdivision Surfaces in Character Animation” introduced one such technique. Explain their method for achieving sharp features in otherwise smooth subdivision surfaces, or (for partial credit) explain another technique.
- b. Triangular meshes have the disadvantage that they can be difficult to edit. To combat this, Guskov et. al., in the paper “Multi-Resolution Signal Processing for Meshes”, describe a hierarchical scheme where surface details are represented relative to a smoothed version of the surface. *Detail coefficients* were the key to this representation.

In order to be useful for editing, a hierarchical representation for meshes must deal with the challenging issues of scale and coordinate systems. Explain these issues for editing on hierarchically represented meshes, and how detail coefficients address them. (Partial credit for describing a different method that addresses these issues)

**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 *riplemap* set generates additional down-sampled textures by decoupling the down-sampling in each dimension. For instance, an initial  $4 \times 4$  texture will generate a ripmap set with sizes  $4 \times 2$ ,  $2 \times 2$ ,  $2 \times 4$ ,  $1 \times 4$ ,  $1 \times 2$ ,  $1 \times 1$ ,  $2 \times 1$  and  $4 \times 1$ .

- 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:**

Physical simulation is a good mechanism for creating some kinds of motion in computer graphics, and a terrible one for other settings.

- a. Describe a real-world physical phenomenon that existing techniques can accurately simulate in a real-time application, such as a computer game. Accurate means that a viewer cannot readily detect any flaws. What kind of objects are involved in the simulation, and what sort of forces are modeled?
- b. Describe a real-world effect that can be accurately simulated only off-line (given the current state-of-the-art).
- c. Give examples of at least two situations where simulation would be a poor tool for creating motion, and the reasons why.

**Question 4:**

Stylized (non-photorealistic) attempts to convey information about geometry of texture through abstract colors or strokes.

- a. Give at least two geometric or surface features that are communicated by the technical illustration style of Gooch and Gooch, and the way in which they are abstracted (that is, what is drawn to convey the information).
- b. Give at least two aspects of a scene conveyed by Winkenbach and Salesin's pen-and-ink illustration style and the techniques used to render them.

**Question 5:**

Image-based rendering can be broadly defined as any rendering technique that reconstructs one image based on information obtained from another set of images. A key aspect of image based systems is the intermediate representation used for image-derived data; input images are typically converted to this representation to enable efficient rendering.

Quicktime VR, Surface Light Fields, and Facade each use a very different representation for their image data. Describe the representation used by each, and discuss their benefits and limitations.

**Question 6:**

Historical systems become “seminal” when their key ideas influence and inspire future work. For each of the following pairs of systems, describe a key idea from the first system and how it influences the second systems.

- a. SGI Hardware graphics (for example, as described in the Akeley paper) and modern graphics hardware.
- b. The Reyes Renderer and modern graphics hardware.
- c. Menv and modern animation systems (like Maya).

Not all ideas from all seminal systems catch on. For each pair of systems, describe a key idea in the first system that did not catch on in the second.

- d. Sketchpad and modern drawing programs (like Illustrator).
- e. Sketch and modern 3D design systems (like Maya).