Graphics Qualifying Exam

Sept 23, 2002

- 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:

A boundary representation (B-Rep) solid modeler describes solids through a collection of surfaces that form its boundary. A key challenge in creating such a representation is insuring that the pieces fit together exactly, so that the surface formed by the union of the pieces remains a solid under all editing operations. Creating a B-Rep modeler is particularly difficult if the surfaces pieces are allowed to be curved and the joins must be smooth.

Discuss why the use of a subdivision representation for the surface pieces might be superior to the use of a parametric representation in the design of a B-Rep solid modeler.

Question 2:

The image morphing method of Beier and Neely was significant in part because of the artistic success their company (PDI) had in using it. In fairness, a lot of this artistic success was due to the talented artists that used their system. However, certain features of the algorithm made this possible.

This key algorithm still is known as the Beier-Neely method, and has been the foundation of many other methods (including Seitz and Dyer's View Morphing).

a. Describe the important advances of the Beier-Neely method over the previously available techniques (such as those that used uniform grids). Discuss how these advances helped lead to the artistic successes.

b. Describe how Mipmapping would be used in an implementation of Beier-Neely morphing, or any warping method that employs "reverse mapping."

Question 3:

Algorithms for efficiently rendering complex models, such as visibility and level-of-detail schemes, must make a range of trade-offs related to quality, reduction of polygon counts, and graphics system performance. Discuss the assumptions and choices made for:

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

  b. Garland and Heckbert's Quadric Error Simplification.

  c. Hoppe's progressive meshes.

Question 4:

Compositing is a widely used tool in computer graphics. Other than the obvious use for combining layers in film special effects, describe several significantly different tasks or algorithms in which compositing plays a role, and why compositing is the preferred tool in each situation.

Question 5:

Image-based rendering can be broadly defined to mean any rendering technique that incorporates images as a core primitive or modeling aid. One of the primary ideas behind all of image based rendering is the plenoptic function, which describes what can be seen in any direction from any point. Images can be seen as samples of the plenoptic function.

Accurately sampling the plenoptic function for an arbitrary scene and a wide range of viewpoints is not feasible. Describe the choices made by three different image-based rendering systems in sampling the plenoptic function. What are the implications for these choices on the range of scenes and viewpoints that the systems can handle?

Question 6:

These questions concern the impact of seminal graphics systems. (There are 5 systems described in the two parts of the question. You need only answer for 4.)

a. While Sutherland's Sketchpad and Catmull's original 3D animation system are both over 30 years old, they still have relevance on the field of graphics. For each system, describe some of the ideas they introduced that are still seen in current systems. Also, describe any important concepts that do *not* appear in current mainstream tools.

b. An important consideration in the design of a graphics system is to provide for sufficient generality. Good systems devise abstractions that cleanly handle a range of objects, operations, appearances and so on. They also incorporate features that enable extensions to meet the changing needs of users.

   Menv, Inventor, and Reyes were all successful, in part, because they provided good extension mechanisms and abstractions that allowed them to be sufficiently general. Discuss the mechanisms and abstractions that enabled this generality in these three systems.