SPRING 2006
COMPUTER SCIENCES DEPARTMENT
UNIVERSITY OF WISCONSIN-MADISON
PH. D. QUALIFYING EXAMINATION
Computer Graphics
Monday, January 30, 2006
3:00-7:00 PM

GENERAL INSTRUCTIONS:

1. Answer each question in a separate book.

2. Indicate on the cover of *each* book the area of the exam, your code number, and the question answered in that book. On one of your books list the numbers of all the questions answered. *Do not write your name on any answer book.*

3. Return all answer books in the folder provided. Additional answer books are available if needed.

SPECIFIC INSTRUCTIONS:

• Answer **ALL** four questions in separate blue books. Each question has multiple parts - be sure to answer each one. The questions are weighted equally.

• For full credit, an answer must be both correct *and* well-presented (clear and concise).

• If you feel a question is ambiguous, state any assumptions that you need to make. Hint: more often than not, this is a sign that you either do not understand the question, or are missing some important insight or piece of knowledge.

• Several of the questions are "essay" questions (specifically 1C and 2). For these essay questions, there are many correct answers. It is more important that you provide a good argument for the answers you give than that you give the "most correct possible" answer.

POLICY ON MISPRINTS AND AMBIGUITIES:

The Exam Committee tries to proofread the exam as carefully as possible. Nevertheless, the exam sometimes contains misprints and ambiguities. If you are convinced a problem has been stated incorrectly, mention this to the proctor. If necessary, the proctor can contact a representative of the area to resolve problems during the *first hour* of the exam. In any case, you should indicate your interpretation of the problem in your written answer. Your interpretation should be such that the problem is nontrivial.

Graphics Qualifying Exam
Spring, 2006

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Question 1: Texture Synthesis

Example-based texture synthesis methods can create a large texture based on a smaller example piece. When the methods work well, the larger patches preserve the properties and structure of the example yet avoid pure repetition.

On the reading list, a paper by Efros and Freeman introduced a method called "Quilting" as well as described some other possible methods.

1A. 1B. Describe **two** methods for example-based texture synthesis (creating a large texture from a small sample). Describe the types of textures that they work well on, as well as the types of texture on which they fail. At least one of your methods should come from a SIGGRAPH or ICCV paper.

Hint: one of your methods may be something really simple if you don't remember more than one sophisticated method from the papers. However, if you pick a simple method, be sure to give examples of when it works and when it doesn't.

1C. *essay question...* One could imagine using texture synthesis to create a large amount of complex patterned geometry (a large mesh) from a small example (a small mesh). This would (effectively) require running one of the above methods on meshes rather than images. Discuss some of the issues you foresee in making this extension.

Question 2: The Fall Forest

Imagine a Wisconsin forest in the Autumn at the height of the "fall colors." The leaves have changed to the wonderful bright colors of the season. The sunlight filters through the leaves (not only are leaves not completely opaque, but light bounces around in the trees) giving a very special quality to the light in the forest. When the leaves blow, and the leaves move, the light is "animated" and can be particularly beautiful.

In this question, we consider trying to recreate the wonderful light of the Autumn forest.

essay question...

What rendering techniques would you suggest for simulating the lighting in the forest? Choose two or three approaches and discuss their pros and cons. If you were to try a research project to do this simulation, what would you choose?

You may assume that there are methods that allow you to generate the geometry of the trees. (good methods exist, although they are not on the qual reading list). You may assume that the generator provides you with the detailed shapes and positions of the leaves and branches.

Question 3: Subdivision Surfaces

Subdivision surfaces are rapidly becoming the preferred representation for smooth surfaces in computer graphics.

3A: In most cases, approximating surfaces schemes (such as Catmull-Clark or Loop) are preferred over interpolating schemes, despite the fact that they do not interpolate their control points. What advantages do approximating surfaces provide that make up for the loss of interpolation?

3B: For most schemes, special rules are used at the edges of surfaces to make the surfaces interpolate edge points. What are the advantages of having these special rules?

3C: Are there situations where NURBS surfaces may still be preferable to Catmull-Clark surfaces? Either describe situations where this may be the case, or explain why such situations do not exist.

Question 4: Animation

Answer these two questions about the use of blending in character animation.

4A: The most common method for skinning connects each vertex to multiple bones (coordinate systems) and blends the results according to weights. This method goes by a number of names including "linear blend skinning," "skeletal-subspace deformation," and "smooth skinning." Because of the simple nature of the method, its results aren't so great.

In some cases, the quality of results obtained using linear blend skinning can be improved by inserting "helper" bones between the existing bones. These helper bones have orientations that are halfway between the bones that they are in between.

Describe situations where these helper bones do indeed help, and explain why they are helpful.

4B: A common tool for creating new motions from existing ones is to blend the original ones together, interpolating corresponding poses. Unfortunately, blending requires enough similarity in the poses so that the interpolation makes sense. A common way to address this is to modify the motions so that the poses are more similar before blending. While there are many different variants of this, the Registration Curves technique on the qual reader makes several different types of "alignments," each effectively modifying the motions so that they are more similar and more likely to blend.

Describe two (there are three in the Registration Curve paper) ways that motions may be "misaligned" so that blending does not work. For each, describe how an alignment process can make the motions more similar so that blending will work. Give a specific example for each.