CS 559 Final Exam

December 17, 2008

Please write your name on every page (we may unstaple the exams for grading)

Write numerical answers in fractional form or use radicals (square root symbols) – we would prefer to see $\frac{\sqrt{3}}{2}$ than .866. You should not need a calculator for this exam.

Unless otherwise noted, assume that everything is a right-handed coordinate system and that angles are measured counter clockwise. E.g. to find the direction of rotation, point your thumb along the axis and curl your fingers.

If you need extra space, use the back of a page, but clearly mark what everything is. We may look at your work to determine partial credit.

The exam has 100 points

You have the entire exam period to complete the exam.

Question 1: What did that word mean and why did we use it? (5pts each = 15)

For each part (A,B,C) there are two subparts. Please be clear where your answers are for each part. A sentence or two is sufficient for each.

1.A.1) The XYZ color system uses "**imaginary** colors" as its primaries. Why are these colors "**imaginary**"?

1.A.2) Why would you need a color system with **imaginary** primaries (rather than one with non-imaginary primaries)?

1.B.1) What are the three things referred to by the "tri" in **tri-linear** interpolation?

1.B.2) Where is **tri-linear** interpolation used, and why would you prefer it to "less than tri-" linear interpolation (like bi-linear or uni-linear)?

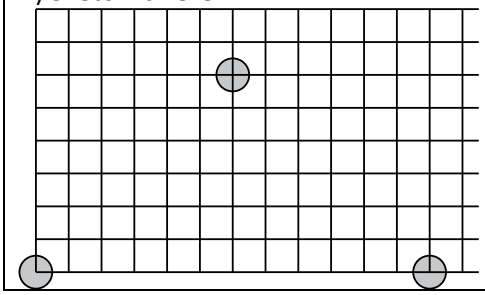
1.C.1) What are the two parts refered to in the "bi" in **bilateral** filtering?

1.C.2) What is **bilateral** filtering useful for that plain (uni-lateral) filtering is not?

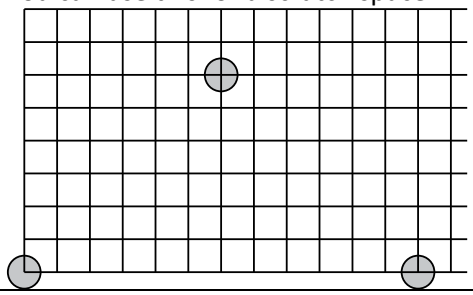
Question 2: Bézier Curves (2+4+5+2+3 = 16pts)

A quadratic Bézier Curve in 2D has its control points at (0,0), (6,6) and (12,0).

A) Sketch it here:



You can use this for a scratch space



B) Divide the curve in Part A in half – that is create a new that is the same as the first half of the given curve. Give the positions of the control points of the new curve.

C) A Cubic Bézier is the same curve as the curve in Part A (Hint: it is sufficient for the endpoints and the first derivatives at the endpoints to match). What are the positions of its control points?

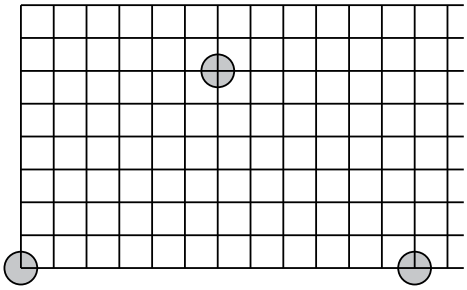
As part of figuring this out, you'll need to first figure out what the derivatives of the curve in Part A are. Write them here so we can give you partial credit if you get the answer wrong:

The Positions for the cubic control points are:

Question 2: Bézier Curves (continued)

D) You could compute the value of the curve that is your answer to part C for a particular U value by doing a number of linear interpolations. How many?

E) Compute the value of your curve in Part C at parameter (U) value .5 by doing the sequence of linear interpolations. Give the positions of all of the intermediate points. If Part C is correct, this answer should be related to Part A/B – but we're checking to see that you get the right answer for the numbers you have in part C.



You can use this grid for scratch space.

Question 3: Déjà vu (4pts + 4 pts = 8pts)

If these questions seem familiar, it's because they are very similar (but not exactly the same) as questions on the midterm.

A) For the town project, a student said they wrote a Phong shader (e.g. that implements lighting using the Phong lighting model and Phong shading) that is used for all objects in the world. We're not sure if they aren't just doing the standard OpenGL lighting (using Phong lighting and Gouraud shading).

Describe an object that we could add to the world that would make it easy to tell if the student really did Phong shading. Describe how it would look different if it were really Phong shading (versus just being Gouraud shading).

B) A vertex (point) is drawn at the origin. It is viewed through a camera that is positioned with the viewing matrix:

The object that the vertex is drawn with transformation matrix:

This simple projective transform matrix is used:

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & -1 & 0 \end{bmatrix}$$

Where does the point appear in screen coordinates? (give the x,y position)

Question 4: Subdivision (4pts + 9 pts = 13 pts)

The control mesh (the initial polygon for subdivision) in all of these examples is a tetrahedron.

A Tetrahedron is a 4-sided polyhedron where every side is a triangle.

Describe the polygons (number and number of sides) you would have if you did:

0) No subdivision (example)
   4 polygons, all with 3 sides
A) One round of Loop subdivision

B) One round of Catmull-Clark subdivision

C) One round of Butterfly (or modified Butterfly) subdivision

Describe the vertices (with the number of edges) that you would have if you did:

0) No subdivision (example)
   a. Four vertices, all with 3 edges connected to them

A) One round of Loop subdivision

B) One round of Catmull-Clark subdivision

C) Two rounds of Catmull-Clark subdivision

Question 5: Programmable Shading (5 pts each = 15)

While these questions use GLSL terminology (since we used it in class, and it was in the readings), the concepts are more general and apply to other current systems.

A) Explain what a varying variable is. Is this something you specify in your host (e.g. C++) program?

B) Can a vertex program pass a value directly to a fragment program? Explain why or why not. Your explanation should be about how the hardware works, not just the syntax of the language.

C) A type of "mapping" was done that used a texture to make a flat surface appear bumpy. The effect is very convincing: even the silhouette (e.g. when you look edge on) is correct. (so when you look at the flat surface from the side, you can see the bumps). Was this bump mapping? Could it have been done in the pixel shader? Explain how you know.

Question 6: Some Definitions (4 pts each = 20pts)

Explain the following terms in a sentence or two:

A) Limit Surface

B) Metamer

C) Caustic (in the way it was used in the rendering lecture)

D) Tone Mapping

E) Euler Angles

Question 7: Lighting (4+4+5= 13 points)

A) What term (or lighting type) in the standard OpenGL lighting model is used to fake global illumination. Explain how it approximates it.

B) Can global illumination be created easily with a (traditional from the eye) Ray-Tracer? Give a brief explanation why or why not.

C) Distribution Ray Tracing uses a number of rays (usually randomly distributed) where a traditional ray tracer might just send one ray. Describe 3 effects that are easy to create using distribution (that are hard without it). (Note: 2 points for the first one, 2 points for the second, 1 point for the third)

C1)

C2)

C3)