CS 248: Introduction to Computer Graphics

FINAL Examination
Monday, March 16, 1998

NAME:

Note: This is exam is *closed-book.* No written materials or notes are to be used while taking this exam.

The exam consists of 5 questions. Each question is worth 20 points. Please answer all the questions in the space provided, overflowing on to the back of the page if necessary. We estimate that this exam should take 1 hour, but you will have 2 hours to complete the exam.

1. [Total: 20 points] Texture mapping techniques.

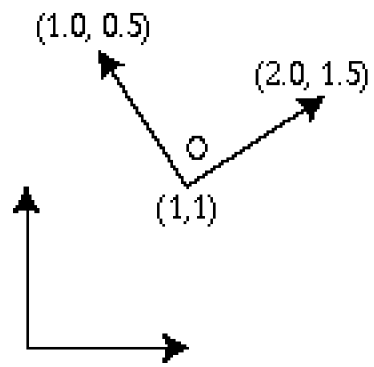
1A. (5 points) What is the difference between displacement mapping and bump mapping?

1B (15 points) In class and in assignment 4, we discussed the use of a “gazing” ball to acquire an environment map. Recall that a gazing ball is a large perfectly reflective sphere, and a reflection map may be acquired by photographing the environment as seen in the gazing ball.

Derive an expression or outline a procedure to calculate the reflected direction vector R for different positions (x,y) in the photograph of the gazing ball. To simplify the calculation, assume that the camera is very far away so that all the rays from the gazing ball to the camera are parallel.

2. [Total: 20 points] Transformations.

2A. (15 points) Drawn below are two 2D coordinate systems shown as a set of axes. The coordinates of the origin and the tips of the x and y axes of the coordinate system O (the object coordinate system) are given. These coordinates are with respect to the world coordinate system.

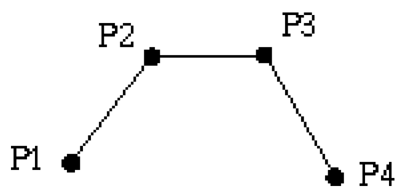


Derive a transformation matrix that transforms from the object coordinate system to the world coordinate system. You may write this matrix as a product of other matrices if you wish. You must fill in the entries for each matrix that you give (i.e. it is not enough to just give a answer that says rotate by 10 degrees); however, each entry may be a number or a mathematical expression.

2B. (5 points) Derive the transformation from the world coordinate system to the object coordinate system O.

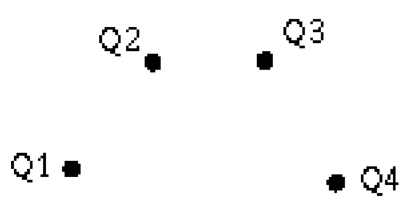
3. [Total: 20 points] Bezier curves.

3A. [10 points Drawn below are four points P1, P2, P3, and P4 that can be used to define a cubic Bezier curve P(t). Describe an algorithm to evaluate point P(t) given t.



3B. (10 points) Drawn below are four points Q1, Q2, Q3, and Q4. Suppose you want to define a curve from these 4 points that goes through the points Q2 and Q3. You also want the tangent of the curve at Q2 to be parallel to a line connecting Q1 to Q3, and similarly you want the tangent at Q3 to be parallel to a line connecting Q2 to Q4. Such a curve is called a Catmull-Rom spline.

One way to create a Catmull-Rom spline is to construct a set of Bezier control points (P1 P2 P3 P4) from the Catmull-Rom control points (Q1 Q2 Q3 Q4) so that the resulting Bezier curve has the desired properties. Derive this construction. Give equations relating the Bezier control points to the Catmull-Rom control points. Also, state why the Bezier curve you construct creates a curve with the properties of a Catmull-Rom spline.



4. [Total: 20 points] Reflection models.

4A. (5 points) What is a bidirectional reflection distribution function (BRDF)? What role does it play in computer graphics?

4B. (5 points) What does it mean to say that light reflection from a surface is linear?

4C. (5 points) Lambert's Law is often used to characterize diffuse reflection. What is Lambert's Law? What is the BRDF when a surface is Lambertian?

4D. (5 points) Specular or glossy surfaces can be modelled using a microfacet distribution function. What is a microfacet distribution function? And why does it cause highlights?

5. [Total: 20 points] Hidden Surface Algorithms.

5A. (5 points) Describe briefly the z-buffer algorithm for hidden surface removal.

5B. (5 points) List two advantages and two disadvantages of the z-buffer algorithm.

5C. (5 points) Recall, that the depth complexity d is the average number of objects that cover each pixel. How is the depth complexity related to the number of polygons P, the average area of a polygon a, and the resolution or number of pixels in an image I?

5D. (5 people) Graphics hardware architects often optimize their hardware for polygons of a certain average size. Typically these days they use 25 pixels per polygon in their designs. In 10 years, do you think they will use the same number? Explain your reasoning.

SCORES:

1. Texture mapping techniques (20)

2. Transformations (20)

3. Bezier curves (20)

4. Reflection models (20)

5. Hidden surface algorithms (20)

TOTAL SCORE :