The University of Calgary

Department of Computer Science

ENEL/CPSC 555 Computer Graphics

Mid-Term Exam November 1997

Instructions: Attempt all questions. Open Book.

1 Question 1 (20%) Parametric Curves

Using the Hermite matrix and geometry vector, describe how four curve segments can be made to form a closed loop approximating a circle. What are the endpoints and tangent vectors of each of the four segments? Derive the parametric equations for at least one of the segments. The continuity between two Hermite curve segments is known as G^1. How could a piecewise cubic curve be made to have a higher level of continuity?

2 Question 2 (20%) Perspective Transformation

The perspective transformation matrix is given by:

$$\begin{pmatrix} 1/S_x & 0 & 0 & 0 \\ 0 & 1/S_y & 0 & 0 \\ 0 & 0 & \frac{1}{d(1-d/f)} & \frac{1}{d} \\ 0 & 0 & \frac{-1}{(1-d/f)} & 0 \end{pmatrix}$$

Two polygons (rectangles) are defined in the eye coordinate system as:

- $p0 : (-2, 2, 1), (-2, -2, 1), (2, -2, 2), (2, 2, 2)$
- $q0 : (-1, 1, 1.25), (-1, -1, 1.25), (1, -1, 1.75), (1, 1, 1.75)$

The viewing system is set up with the near plane at $D = 1$ and far plane at $F = 2$ and the screen has $s_x = s_y = 0.5$ Sketch a diagram of the scene as the viewer would see it along the Z_e axis and also sketch the scene looking down the Y_e axis. What are the coordinates of the two polygons in the screen system after the perspective projection and division by W?

A Z-buffer algorithm uses the screen system Z_s values at each vertex and linear interpolation to find the Z_s values at the start of each scanline and across the scanline at each pixel. Both the polygons pass through the centre point X_centre on scanline $Y_s = 0$, calculate this point. What are the interpolated Z_s values found at $X_centre, 0$ for each polygon, and what are the true Z_s values found directly from the perspective projection? Comment on the significance of these values and what it would mean if an animation was made where the viewpoint was rotated around the Y_e axis.

3 Question 3 (20%) Polygon Meshes

A triangular mesh is used to represent a 3D engineering surface model. Describe a suitable data structure that would enable a user to perform the following:

1. Obtain a fast wire frame view of the model.
2. Obtain a shaded view of the model.
3. Ensure that each edge is shared by at least two and not more than two triangles.
4. Ensure that each triangle has three edges and three vertices which are not degenerate. (i.e. avoid coincident vertices).
5. Adjust the position of a mesh vertex.

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4 Question 4 (20%) Colour Tables

A graphics system has a frame buffer using 3 bits per pixel. Each pixel holds the address of an entry in a colour table. The colour table is 6 bits wide and uses 2 bits per gun for each of red and blue. The frame buffer is loaded to display a triangle, a cross and a circle on bit planes 0,1 and 2 respectively. WIth the aid of a diagram show how the colour table would be loaded to display each of the following:

1. A red cross only.
2. A green triangle only.
3. A yellow circle only.
4. A red cross over a blue circle.
5. A green triangle over a blue circle over a red cross.

5 Question 5 (20%) Short Answer Questions.

Write brief answers to the following:

1. Describe briefly a circumstance when back face removal could create artifacts by throwing away a surface in a rendering algorithm.
2. In what order are polygons fed to a z-buffer algorithm?
3. What is the limit on the number of polygons a Z-Buffer program could handle?
4. Distinguish between parametric space and range space for parametric curves.
5. How can a B-spline curve be changed into a Bezier curve by adjusting the knot positions?
6. What happens to the continuity of the curve in the above case?
7. Why does a point of inflection in a curve cause a problem if a generalised cylinder is being built around the curve?