Exam Computer Graphics Class

Date: June 27, 2008 Time: 14:00–17:00

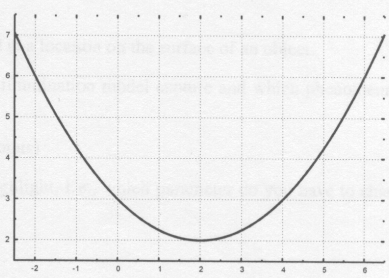
Instructions, read carefully: Fill in your **name and student number** on each of the answer sheets that you hand in. You have 3 hours to answer the questions. Please answer in English if at all possible, write clearly. When in doubt, use a small sketch/illustration to make your point. When deriving an equation, **show all the steps you took** to get to your result **in detail**, otherwise points cannot be awarded.

This exam has a total number of **11 questions** on **3 pages**. The total number of points (100%) is 100. As announced, the final grade for the class will be derived from both this final exam and the tutorials.

Question 1: Bresenham Midpoint Algorithm (25 points)

One important problem in computer graphics is to scan-convert a curve such as a straight line, a circle, a parabola, or a general function, i. e., to compute the pixels to set on a raster display that are to represent this curve. Given shall be the function of your teacher's currently favorite parabola (also shown on the right)

$$f(x) = \left(\frac{x}{2} - 1\right)^2 + 2.$$



Bresenham's midpoint algorithm can be used to scan-convert this function precisely and efficiently. For this purpose, the parabola is first split in half at the symmetry axis ($x = 2$), and each of the sides again into 2 segments which meet where the slope of the curve is equal to 1 or -1.

a) Looking at the positive (right) half of the curve ($x \geq 2$), between which pixels (relative to the pixel previously set, ***use the notation with N, NE, E, SE, S, SW, W, and NW for naming these directions***) is the decision made for each of the above mentioned two segments? (2 points)

b) Derive the decision variable d and the two increments of the Bresenham midpoint algorithm for the first segment ($0 < \text{slope} < 1$). (15 points)

c) Derive the second order differences. I. e., how do the two increments change depending on which decision was made in the previous step? (8 points)

Question 2: Homogeneous Coordinates (4 points)

a) What are homogeneous coordinates and why are they necessary? (3 points)

b) If you would visualize the regular 2D space in the homogeneous 2D space, what would this look like? (1 point)

Question 3: Transformation Order for Rotation around Arbitrary Axis in 3D (3 points)

In order to rotate points around an arbitrary axis given by a point and a vector in 3D, what transformations have to be done in which order? Explain briefly what each of the transformations does, give the order of execution, and name the way the final transformation matrix is computed (in the form $P' = A \cdot B \cdot \cdots \cdot N \cdot P$).

Question 4: Computer Graphics Camera Model (10 points)

In order to be able to produce images in computer graphics, we need to specify what a computer graphics camera looks like.

a) Describe the typical/basic camera model used in computer graphics, include its parameters, and illustrate these parameters using a small sketch. (5 points)

b) The camera model used in computer graphics differs from that of the typical camera that is used in photography. Name these differences and describe briefly what implications these differences have with respect to the resulting images. (5 points)

Question 5: View Frustum (2 points)

What is a view frustum and what does it look like in computer graphics?

Question 6: Backface Culling (10 points)

a) What is backface culling? (2 points)

b) How is it done? (4 points)

c) Why is it used? (2 points)

d) Is it sufficient for general hidden surface removal and why/why not? (2 points)

Question 7: Phong Illumination Model (10 points)

Rendering a scene requires determining how light gets reflected at a location on the surface of an object.

a) Which three aspects of light reflection does the Phong illumination model capture and which phenomena of real physical reflection do these represent? (6 points)

b) Give the formula of the Phong illumination model. (3 points)

c) How do you achieve a smaller but more pronounced highlight, i. e., which parameter do you have to change and how? (1 point)

Question 8: Two-pass Texture Mapping (6 points)

For complex shapes, a two-pass technique for texture mapping is used.

a) Explain the general approach briefly. (2 points)

b) Name the four techniques introduced in the lecture and draw sketches to explain their principle. (4 points)

Question 9: Color and Color Models (10 points)

In computer graphics, color is being represented using several different color models.

a) Name two different hardware-oriented color models as well as which type of color mixing is used for them. (4 points)

b) Name two different perceptual color models, name the properties (the letters in the abbreviation) they use for representing color. Sketch one of the perceptual color models, pointing out the "axes" of captures properties. (4 points)

c) Why are these perceptual color models necessary in addition to the hardware-oriented color models? (2 points)

Question 10: Liang-Barsky Clipping (10 points)

Describe the prerequisites and steps of the Liang-Barsky algorithm for determining intersections of line segments with axis-aligned clipping lines in 2D. Use a sketch to illustrate your explanation, also derive the equation to compute the intersection point.

Question 11: Radiosity (10 points)

a) What distinguishes radiosity fundamentally from the regular rendering that is typically used for 3D applications? (3 points)

b) Describe the approach of radiosity in general terms, i. e., name the steps that are performed. (4 points)

c) Which aspects of physical light behavior does radiosity capture particularly well, which does it not capture well? (3 points)

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