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In 2004/2005, the course INFODDM was given by Twan Maintz.

3D Modelling (INFODDM)
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A simple explanation must be part of every answer! Simple answers such as "yes" or "4" will not be given any credit.

Basics

Question 1

Given the plane equation $3x + 2y + 4z - 12 = 0$,

a) draw a sketch of the plane in the positive octant ($x \geq 0, y \geq 0, z \geq 0$)

b) give the length 1 normal for the plane

c) what is the distance between the point $p = (5, 5, 5)$ and this plane?

Curves & surfaces

Question 2

Give an advantage and a disadvantage of using patches (such as Bézier, B-splines, NURBS) over polygon meshes.

Question 3

a) Draw $Q(t) = (\sin(\pi - t), \sin(t))$ for $t \in [0, 2\pi]$.

b) Give a formula for the tangent vector of $Q(t)$. Give a compact form without using "π" in the formula.

Question 4

Show that a cubic Bézier curve is tangent to its control polygon at the start and end point.

$$\begin{aligned} \vec{Q}(u) &= \sum_{i=0}^{3} \vec{P}_i B_i(u) \\ B_0(u) &= (1-u)^3 \\ B_1(u) &= 3u(1-u)^2 \\ B_2(u) &= 3u^2(1-u) \\ B_3(u) &= u^3 \end{aligned} \qquad u \in [0, 1].$$

Question 5

A rational curve — when compared to its non-rational counterpart — adds a new set of parameters. What is the function of this set of parameters and what is the visible effect on the curve?

Acquisition, reconstruction & simplification

Question 6

Give three reasons why you would want to store an object at multiple levels of detail.

Question 7

In Hoppe's surface reconstruction method (from the paper "Surface Reconstruction from Unorganized Points"),

a) what is used as the initial surface approximation?

b) why not just use these as the final surface approximation?

Question 8

In Garland and Heckbert's surface simplification method (from the paper "Surface Simplification using Quadric Error Metrics"),

a) what error measure does the Q matrix of a vertex store?

b) what is the approximate error of the contraction target? what is this an approximation of? why not just compute the actual error?

Mesh representations

Question 9

Consider a triangular mesh representing a mug with a handle.

a) name three advantages of using the triangle as the building block of a surface representation (instead of more complex structures)

b) what is the difference between the mesh topology and the object topology.

c) when is a triangular mesh a 2-manifold?

Question 10

Consider the following variation of the Koch snowflake:

- **F**: move forward 1 unit.
- $+$: turn counter-clockwise by 90 degrees
- $-$: turn clockwise by 90 degrees
- production rule: $\mathbf{F} \rightarrow \mathbf{F} + \mathbf{F} - \mathbf{F} - \mathbf{F} + \mathbf{F}$.

Generation 0 is the string **F**.

a) apply the production rule once, and draw the resulting curve.

b) apply the production rule again, and draw the resulting curve.

c) is the fractal dimension of this curve higher or lower than that of the original Koch snowflake? Why?

d) compute the fractal dimension of this curve.

Question 11

a) is it possible to use an arbitrary mesh as the input to a subdivision method?

b) is the Catmull-Clark subdivision method interpolating or approximating? Explain.

c) in a subdivision method, what are "extraordinary vertices"?

Animation

Question 12

In the list *fundamental principles of traditional animation*, what is meant by *anticipation*? How, according to Disney, should this be used in animation?

Question 13

Which object model would you use for (and say why):

1. Smoke
2. A shaking cube of gelatin
3. A goat
4. A school of fish
5. A long human hair

Question 14

Show by explicit multiplication that the formula for quaternion multiplication $qq' = (ss' - \vec{v} \cdot \vec{v}', \vec{v} \times \vec{v}' + s\vec{v}' + s'\vec{v})$ is correct for

$$q = (s, \vec{v}) = (1, (1, 1, 1))$$
$$q' = (s', \vec{v}') = (0, (2, 0, 2))$$

Question 15

Name a strength and two weaknesses of mocap.

Question 16

What, from an animator's point of view, is an advantage of using space-time constraints over initial-value dynamic simulation.