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In 2005/2006, the course INFODDM was given by Twan Maintz.

3D Modeling (INFODDM)
May 22, 2006

Curves and surfaces

1. a) Draw $\mathbf{Q}(t) = \left(\sin(t), \left(\frac{t}{\pi}\right)^2\right)$ for $t \in [-\pi, \pi]$.

   b) For what t is the tangent vector to $\mathbf{Q}$ horizontal?

2. Compute $\mathbf{Q}_{uv}$ for $u = v = 1$ for a cubic Bézier patch if $\mathbf{P}$ is a control point matrix,

$$\mathbf{Q}(u,v) = \begin{bmatrix} u^3 & u^2 & u & 1 \end{bmatrix} \mathbf{B}_z \mathbf{P} \mathbf{B}_z^T \begin{bmatrix} v^3 \\ v^2 \\ v \\ 1 \end{bmatrix}$$

   and

$$\mathbf{B}_z = \begin{bmatrix} -1 & 3 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 3 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}.$$

3. Many curves $\mathbf{Q}$ are formulated as weighted combinations of a control points set, i.e.,

$$\mathbf{Q}(u) = \sum_i \mathbf{P}_i B_i(u),$$

   with control points $\mathbf{P}_i$, curve parameter u and weight functions B_i.

   a) Give a formula for the rational variant of this $\mathbf{Q}$.

   b) Explain why the rational form is more flexible, i.e., can represent more curve shape variation than the non-rational form.

4. Give a patch surface $\mathbf{Q}(u,v)$, give a general formula to compute the surface normal at (u,v).

Animation

5. In the context of computer animation techniques, we treated both *object models* and *motion models*.

   a) Name the two examples of each model type (i.e., give **four** names).

   b) Carefully explain the difference between the two model types.

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

$$\begin{aligned} q = (s, \mathbf{v}) &= (2, (1,1,1)) \\ q' = (s', \mathbf{v}') &= (0, (2,0,2)) \end{aligned}$$

7. Explain why the *slerp* function is necessary to interpolate quaternions in an animated sequence.

Acquisition

8. Describe how *structured light* is used to acquire a point cloud representing a 3D object. Specifically, explain how the coordinates of a point in the point cloud are obtained.

9. Name three other types of optical acquisition methods.

Reconstruction

10. In the paper *Surface Reconstruction from Unorganized points* by Hoppe et al., two different Euclidean Minimum Spanning Trees are used. What is the goal of these trees, and how are they used to achieve those goals?

11. Consider the following set of points in 2D:

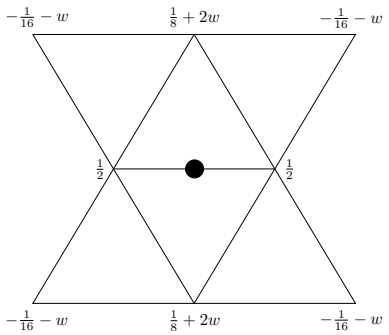
    $(0,0), (0,2), (2,0), (2,2)$ and $(1,1)$.

    Make two drawings that illustrate the results of using alpha shapes to do surface reconstruction applied to this point set, both for $\alpha = 0$ and $\alpha = \infty$. Explain both drawings.

Subdivision surfaces

4. In the Catmull-Clark subdivision scheme, several types of new vertices/points are distinguished in a refinement step. Describe algorithmically for each of the types of new points how they are created. (You may ignore extraordinary points.)

5. The figure below shows the mask for the Butterfly subdivision scheme. What is the role of the parameter w, i.e., what is the effect of varying the value of w?



6. When is a subdivision scheme called *interpolating*? Is the Catmull-Clark scheme interpolating? And the Butterfly scheme?