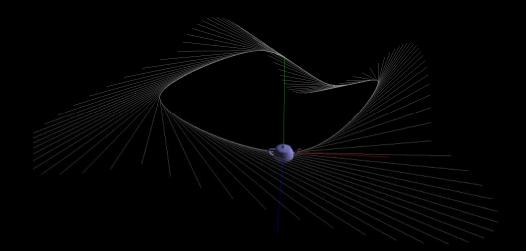


COMPUTAÇÃO GRÁFICA



Animation with Catmull-Rom Curves



ANTÓNIO RAMIRES FERNANDES — COMPUTAÇÃO GRÁFICA 20/21

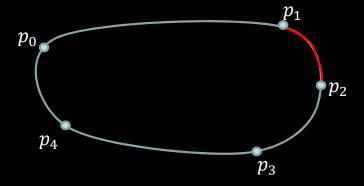


Cubic Curves – Catmull-Rom

• Matrix formulation

$$\bullet \qquad P(t) = \begin{bmatrix} t^3 & t^2 & t & 1 \end{bmatrix} \begin{bmatrix} -0.5 & 1.5 & -1.5 & 0.5 \\ 1 & -2.5 & 2 & -0.5 \\ -0.5 & 0 & 0.5 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} P_0 \\ P_1 \\ P_2 \\ P_3 \end{bmatrix}$$

$$\bullet \quad P'(t) = \begin{bmatrix} 3t^2 & 2t & 1 & 0 \end{bmatrix} \begin{bmatrix} -0.5 & 1.5 & -1.5 & 0.5 \\ 1 & -2.5 & 2 & -0.5 \\ -0.5 & 0 & 0.5 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} P_0 \\ P_1 \\ P_2 \\ P_3 \end{bmatrix}$$

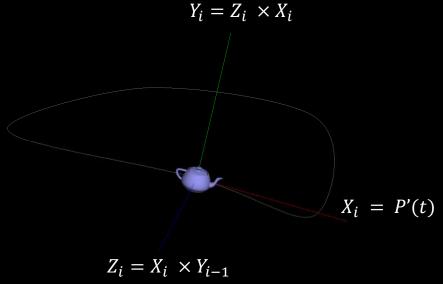




Cubic Curves – Catmull-Rom

• Axis for Rotation Matrix

- Available data at instant *t*
 - P(t) position of an object "walking" along the curve
 - P'(t) vector tangent to the curve
- Transform for teapot
 - Translation to place teapot
 - Rotation to align with curve
 - $Y_0 = (0,1,0)$





Cubic Curves – Catmull-Rom

• Assuming an initial specification of an $\overrightarrow{Y_0}$ vector, to align the object with the curve, we need to build a rotation matrix for the object:

$$\overrightarrow{Z_i} = Y'(t)
\overrightarrow{Z_i} = X_i \times \overrightarrow{Y_{i-1}}
\overrightarrow{Y_i} = \overrightarrow{Z_i} \times \overrightarrow{X_i}$$

$$M = \begin{bmatrix} X_x & Y_x & Z_x & 0 \\ X_y & Y_y & Z_y & 0 \\ X_z & Y_z & Z_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Note: All vectors need to be normalized

glMultMatrixf(float *m)

Current OpenGL MODEL_VIEW matrix gets multiplied by m

Note: OpenGL matrices are column major => compute the transpose instead



Assignment

Complete the function

```
void getCatmullRomPoint(float t,
                           float *p0, float *p1, float *p2, float *p3,
                           float *pos, float *deriv) {
      // catmull-rom matrix
      float m[4][4] = {
                          {-0.5f, 1.5f, -1.5f, 0.5f},
                           { 1.0f, -2.5f, 2.0f, -0.5f},
                           {-0.5f, 0.0f, 0.5f, 0.0f},
                           { 0.0f, 1.0f, 0.0f, 0.0f}};
     // For each component i: // x, y, z
             Compute vector A = M * P // use function multMatrixVector
      //
                in component i P is the vector (p0[i], p1[i], p2[i],p3[i]
      //
            Compute pos[i] = T * A
      //
     //
            compute deriv[i] = T' * A
}
```



Assignment – cont.

Write the function

```
void renderCatmullRomCurve() {

// draw the curve using line segments - GL_LINE_LOOP (see slides near the end)
}

- To get the points for the full curve call

    void getGlobalCatmullRomPoint(float gt, float *pos, float *deriv)

with gt in [0,1[.
```

- To draw the curve select a tessellation level, for instance 0.01. This will get a curve with 100 line segments.



Assignment – cont.

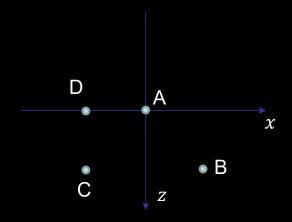
- In function renderScene, apply the required transformations to have the teapot travelling along the curve oriented accordingly to the derivative.
 - Get the position and derivative in the curve for current t value getGlobalCatmullRomPoint(t,pos, deriv)
 - Use glTranslate to position the teapot along the curve
 - Build the rotation matrix to align the teapot with the curve
 - Compute the axis
 - functions, cross and normalize, are provided in the code.
 - Use buildRotMatrix provided in the source code
 - Apply the matrix using glMultMatrix



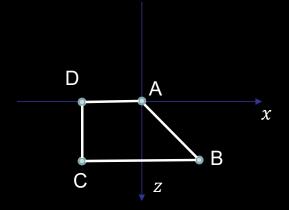
Drawing with line loops

Consider the following points:

-
$$A = (0,0,0), B = (1,0,1), C = (-1,0,1), D = (-1,0,0)$$



A line loop receives all the points and draws a line between each two points and connects the last to the first point:





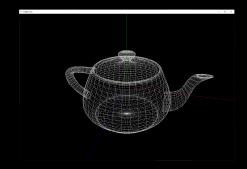
Drawing with line loops

• Line loops in OpenGL



Questions

- Replace the teapot with the cone from GLUT.
 - What happens?
 - How to fix it?





- What would be required to use Bezier or Hermite curves?
 - What parts of the code would require change?