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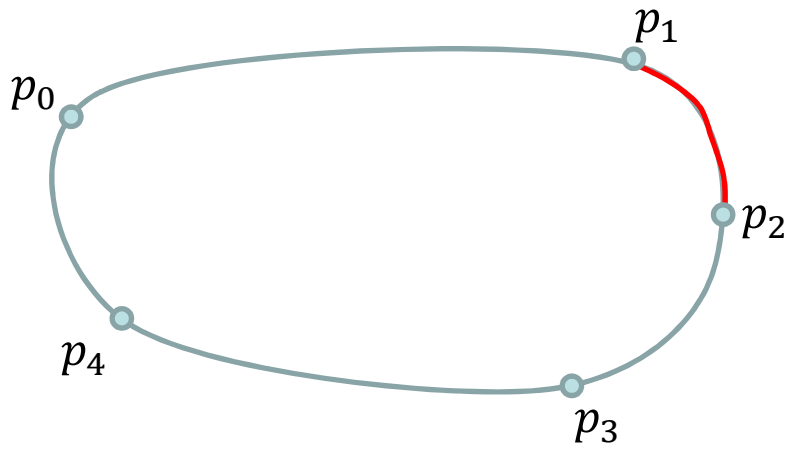
Animation with Catmull-Rom Curves

Cubic Curves – Catmull-Rom

- Matrix formulation
- $$P(t) = [t^3 \quad t^2 \quad t \quad 1] \begin{bmatrix} -0.5 & 1.5 & -1.5 & 0.5 \\ 1 & -2.5 & 2 & -0.5 \\ -0.5 & 0 & 0.5 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} P_o \\ P_1 \\ P_2 \\ P_3 \end{bmatrix}$$



Cubic Curves – Catmull-Rom

- P(t) provides the position of an object "walking" along the curve
- P'(t) provides a vector tangent to the curve.
- Assuming an initial specification of an $\overrightarrow{up}$ vector, to place and align the object with the curve, we need to build a transformation matrix for the object:

$$\vec{X} = P'(t)$$
$$\vec{Z} = X \times \overrightarrow{up}$$
$$\overrightarrow{up} = \vec{Z} \times \vec{X}$$

$$M = \begin{bmatrix} X_x & up_x & Z_x & p_x \\ X_y & up_y & Z_y & p_y \\ X_z & up_z & Z_z & p_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

`glMultMatrix(float *m)`

- Current 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 *res, 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}};

      // reset res and deriv
      res[0] = 0.0; res[1] = 0.0; res[2] = 0.0;
      deriv[0] = 0.0; deriv[1] = 0.0; deriv[2] = 0.0;
      // Compute A = M * P
      // Compute point res = T *A
      // compute deriv = T' * A
      // ...
}
```

Assignment

- Write the function

```
void renderCatmullRomCurve() {

// draw the curve using line segments - GL_LINE_LOOP
}
```

To get the points for the full curve call

```
void getGlobalCatmullRomPoint(float gt, float *res, float *deriv)
```

with `gt` in [0,1[.

- Apply the required transformations to have the teapot travelling along the curve oriented accordingly to the derivative.