Project 1b

Points: 55 (+20 BONUS)

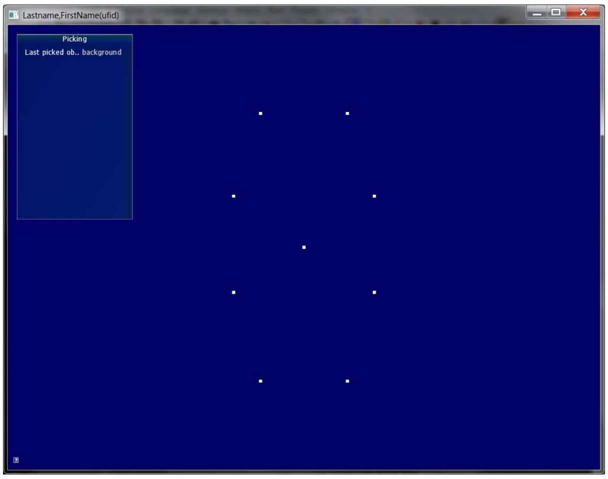
Purpose

Interact with smooth curves in OpenGL.

Set Up

Points: 5

Place $N = 10$ control points to form a "figure 8" (see image; why are there only 9 points visible?).



Title the window "yourFirstname yourLastname (ufid)"

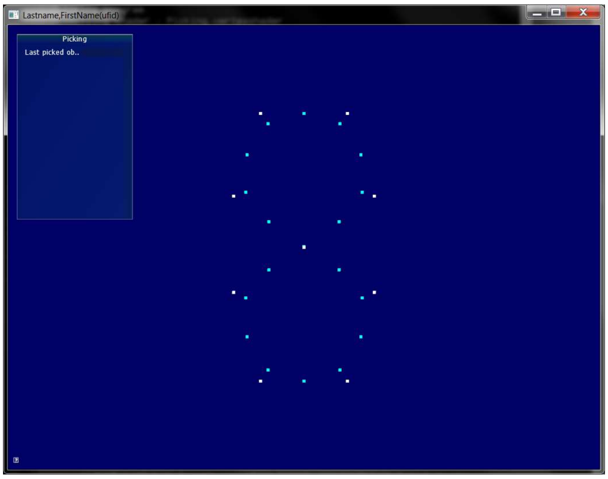
For each Task below show the control points and the curve (sequence of line segments).
For Tasks 2 and 3 also the BB-polygon of coefficients connected in red in the figure next to Task 3.
The points P_i are the same for all three Tasks.
The coefficients $c_{i,j}$ in Task 2 are in general different from those in Task 3.
In Task 2, determine $c_{i,0}$ and $c_{i,3}$.
In Task 3, determine $c_{i,1}$ and $c_{i,2}$.

Task 1: (B-spline) Subdivision

Points: 15

Initialize $P_i^0 = P_i$ (white points).
Use these formulas to create a refined set of control points (cyan)

$$P_{2i}^k := \frac{4P_{i-1}^{k-1} + 4P_i^{k-1}}{8}$$



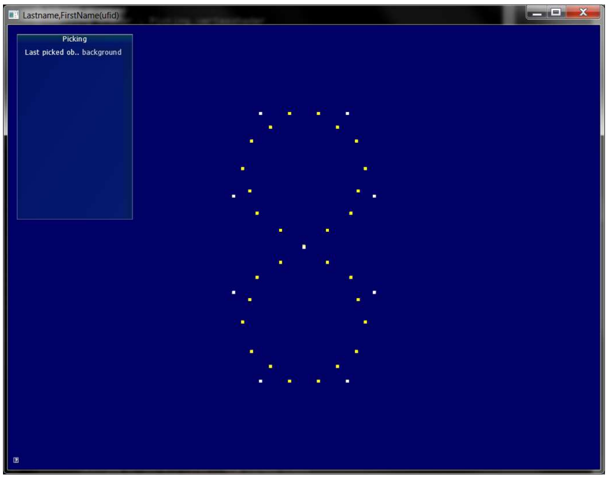
$$P^{k}_{2i+1} := \frac{P^{k-1}_{i-1} + 6P^{k-1}_{i} + P^{k-1}_{i+1}}{8}$$

where k is the level of subdivison and
i is the index of points is in range $0 \ldots (N \times 2^k - 1)$
.

The figure illustrates one step of subdivision.
Your implementation should allow repeated refinement (at least 5 times).
Upon pressing key 1, one additional refinement should be triggered.
Initially when ($k = 0$), the control polygon should be drawn without subdivision.
Whenever key 1 is pressed the subdivided control polygon should be redrawn.
Every sixth refinement resets to level $k = 0$.

Task 2: C^2 Bézier curves

Points: 15



Let $\mathbf{P} = \{P_1, \ldots, P_N\}$ be the the set of input points.
You will construct N Bézier curves of degree 3: one curve segment for each input point.

The coefficients of the **i***th* curve are $\mathbf{c}_i = \{c_{i,0}, c_{i,1}, c_{i,2}, c_{i,3}\}$.
The interior Bézier points (yellow) are:

$$c_{i,1} := \frac{2P_i + P_{i+1}}{3}$$

$$c_{i,2} := \frac{P_i + 2P_{i+1}}{3}$$

.

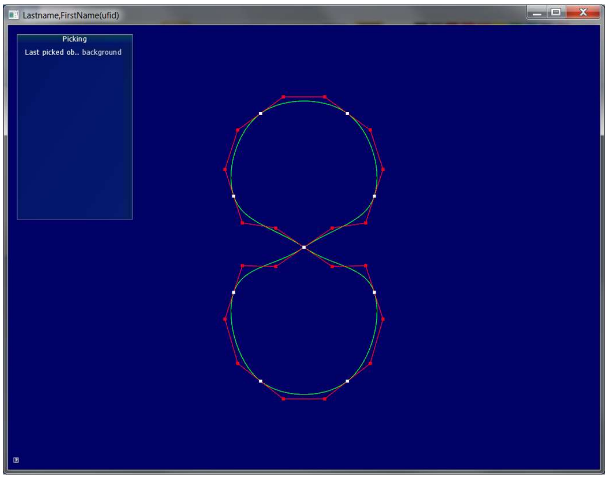
Determine $c_{i,0}$ and $c_{i,3} = c_{i+1,0}$ so that the polynomial pieces join C^1.
Write down the formulas for $c_{i,0}$ and $c_{i,3}$ and place them into your **ReadMe.txt** file.

This method should be activated when key 2 is pressed on the keyboard

Task 3: C^1 Catmull-Rom curves

Points: 20

Let



$\mathbf{P} = \{P_1, \ldots, P_N\}$ be the the set of input points.
Construct a Catmull-Rom curve that interpolates the N points P_i as follows.
There are N Bézier curve segments of degree 3.
The coefficients of each segment i are $\mathbf{c}_i = \{c_{i,0}, c_{i,1}, c_{i,2}, c_{i,3}\}$ where $c_{i,0} = P_i$ and $c_{i,3} = P_{i+1}$.
The tangent at $c_{i,0}$ is a multiple of $P_{i+1} - P_{i-1}$.

Once all of the Bézier points (red) are determined use **deCasteljau's Algorithm** to evaluate the curve at 17 points per segment.
Connecting the points yields the Catmull-Rom curve (green).

This method should be activated when key 3 is pressed on the keyboard

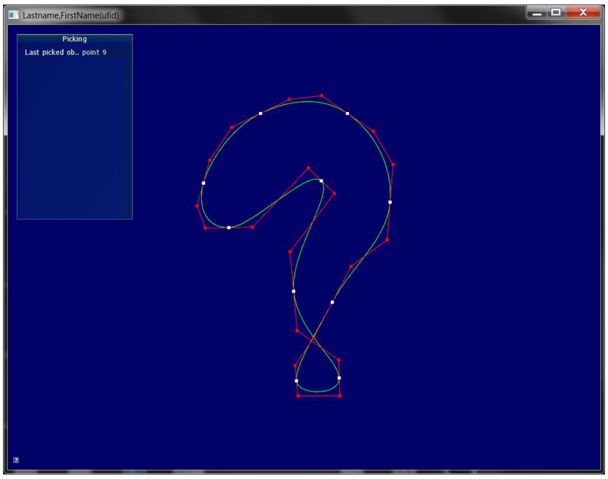
BONUS

Points: 20

Implement **Task 3** using the **OpenGL 4.x**'s tessellation engine.

REMARK

Make sure **picking still works** on the original N vertices, and your curves adapt to their movement.



WHAT TO SUBMIT

- A .zip archive containing
  - all **modified source** files (.cpp's and-or .js, shaders, etc)
  - A **link** to a screen capture of your running program showcasing the implementation of all of the tasks using recordit (Mac, Win) or similar software.