CS 184: Computer Graphics and Imaging, Spring 2020

Project 2: Mesh Editor

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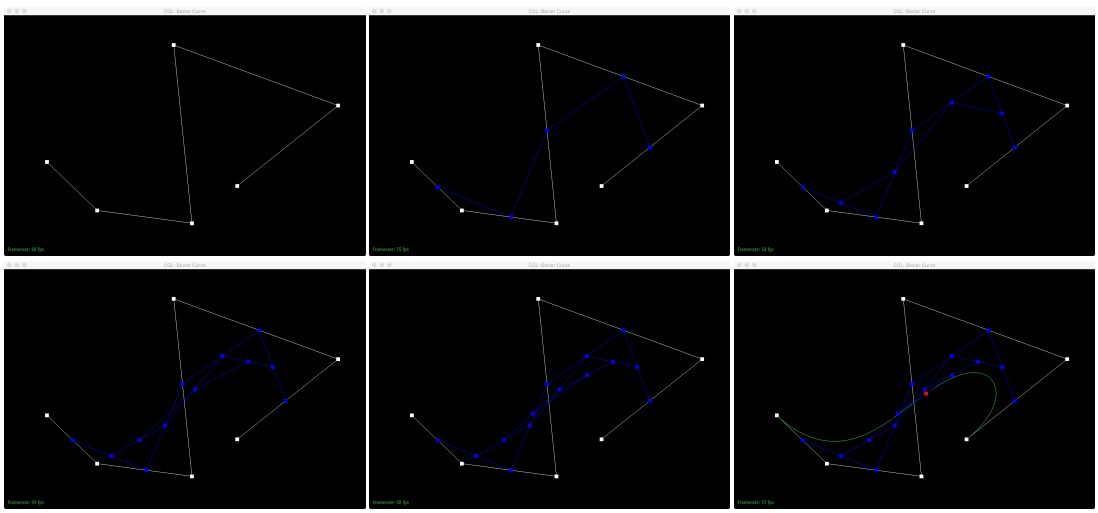
Overview

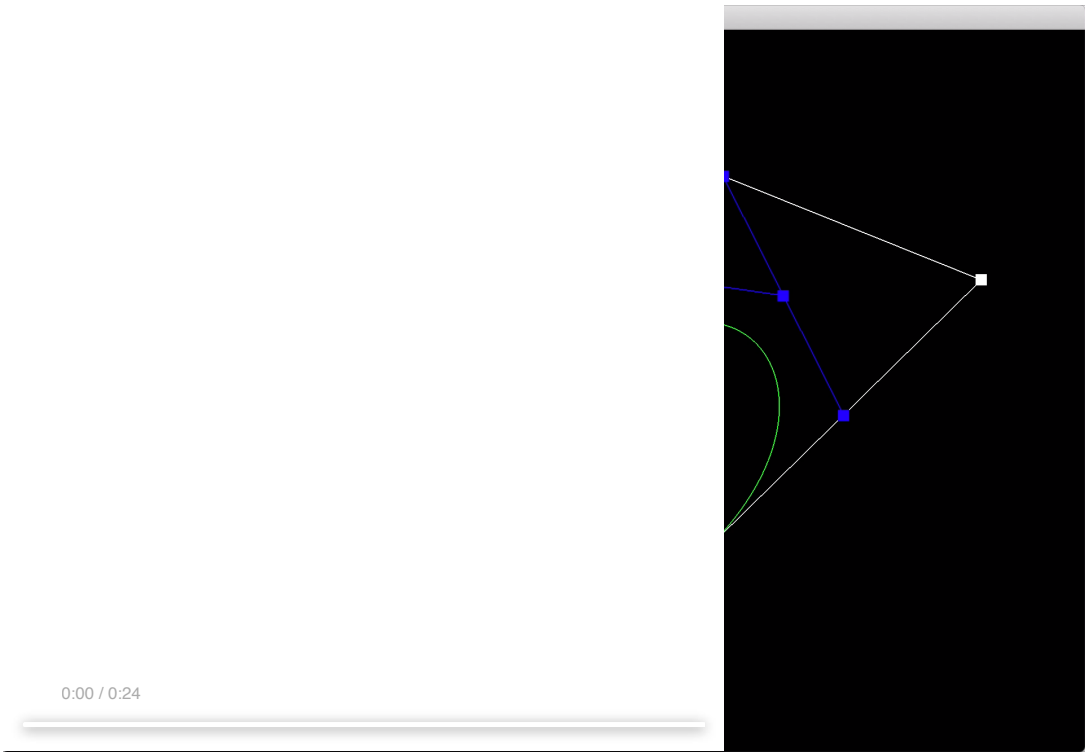
The project I implemented aim to linear interpolate Bezier Curves and Bezier Surface by control points. Also, I learn how to flip and split edges in order to upsampling meshes and make the meshes smoother and render better with shadows. The project gives me a more deep understanding of the engineering logic behind graphis.

Section I: Bezier Curves and Surfaces

Part 1: Bezier curves with 1D de Casteljau subdivision

De Casteljau's algorithm is a recursive method to evaluate linear interpolations in Bezier Curve. Bezier curve is defined by **N+1** control points. There is a single parameter **t**, ranging between 0 and 1. Finding **N** intermediate control points in **N** segments using linear interpolations based on **t**, and then I find **N-1** intermediate control points in **N-1** segments in the next level. I repeat the steps recursively until only 1 intermediate control point can be found. One smooth curve is generated by these control points of different levels.



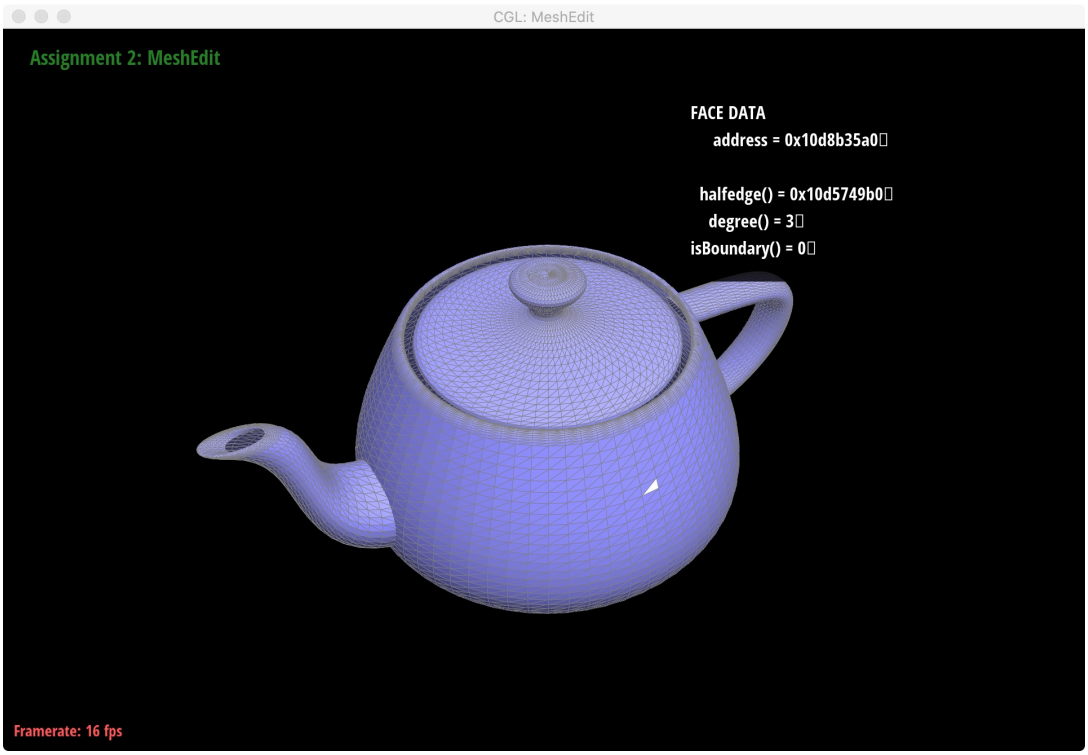


The video shows how Bezier Curve changes when changing the control points and t values

Part 2: Bezier surfaces with separable 1D de Casteljau subdivision

In order to evaluate the points lies on the Bezier Surface, I evaluate the Bezier Surface with **De Casteljau's algorithm** firstly which is similar to what I did in part1.

The control points of Bezier Surface is a **M x N** grid, each row of the control points in the grid generates a Bezier Surface based on the parameter **u**. After that, I select the point on each Bezier Surface at the same **v** coordinate by **BezierPatch::evaluate1D()** function which calls **BezierPatch::evaluateStep()** recursively and get the final single control point. I use **De Casteljau's algorithm** to evaluate point **v** on the moving curve generated by these points.



Bezier Surface of Teapot.

Section II: Sampling

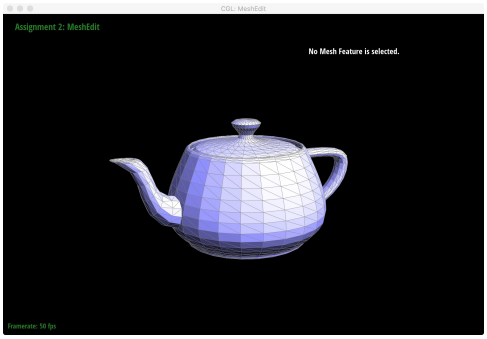
Part 3: Average normals for half-edge meshes

In this part, I compute the vertex normal vectors of the mesh in order to provides better shading for the surface smooth.

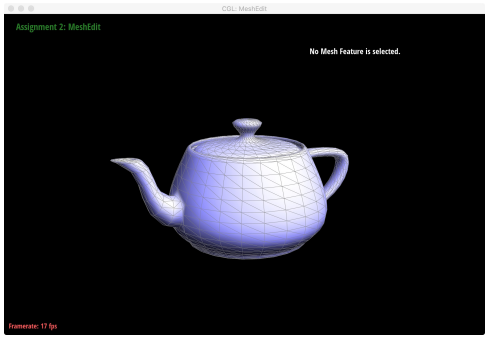
Firstly, I initialize a vector for storing the sum of normal.

Secondly, I select a half-edge connected with the vertex and traverse to the twin edge of this half-edge by using the **twin()** pointer. I compute the area-weighted normal vector of the face connected with the twin edge and add it to the initialized vector. By looping this process, I am able to iterate all the normal vectors of the faces and add them together.

Finally, I normalize the result.



Bezier Surface of Teapot.



Smoother surface of Teapot.

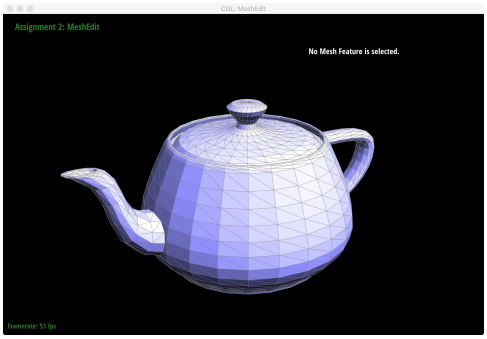
Part 4: Half-edge flip

Firstly, I list all the existing pointers of **half-edges**, **vertices**, **edges** and **faces** of the meshes.

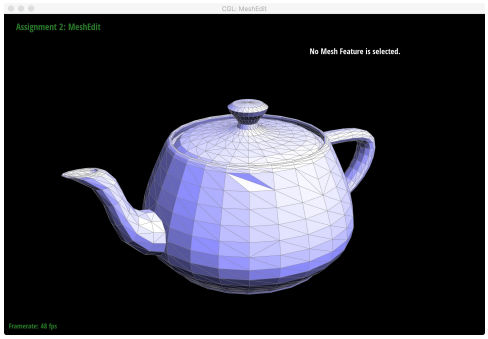
Secondly, I check whether the half-edges are on the boundary, if yes, I return these edges immediately.

Thirdly, I reset all the half-edge pointers to the updated edges, vertices and faces after remeshing with **Halfedge::setNeighbors()** function and also update the half-edges of vertices, edges and faces if they are changed.

I finish part4 very successfully without debugging.



Bezier Surface of Teapot.



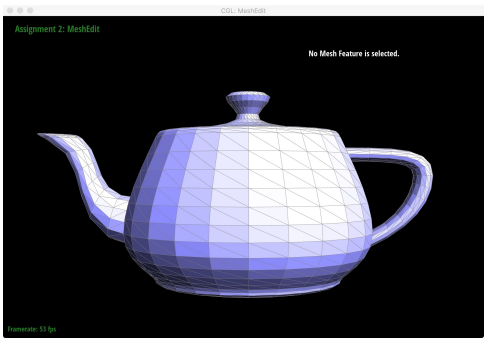
Bezier Surface of Teapot after Flipping.

Part 5: Half-edge split

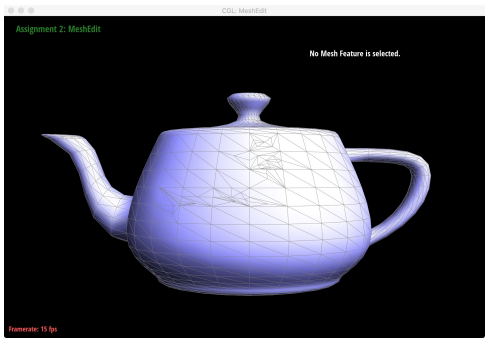
Firstly, similar to what I did in Part 4, I list all the existing pointers and check whether half-edges are on the boundary.

Secondly, since after splitting the meshes, there are new half-edges, edges, vertices and faces and they are initialized.

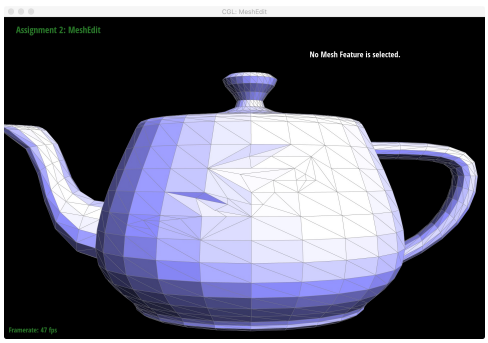
Thirdly, I reset the pointers with **Halfedge::setNeighbors()** function as I did in the part 4.



Bezier Surface of Teapot.

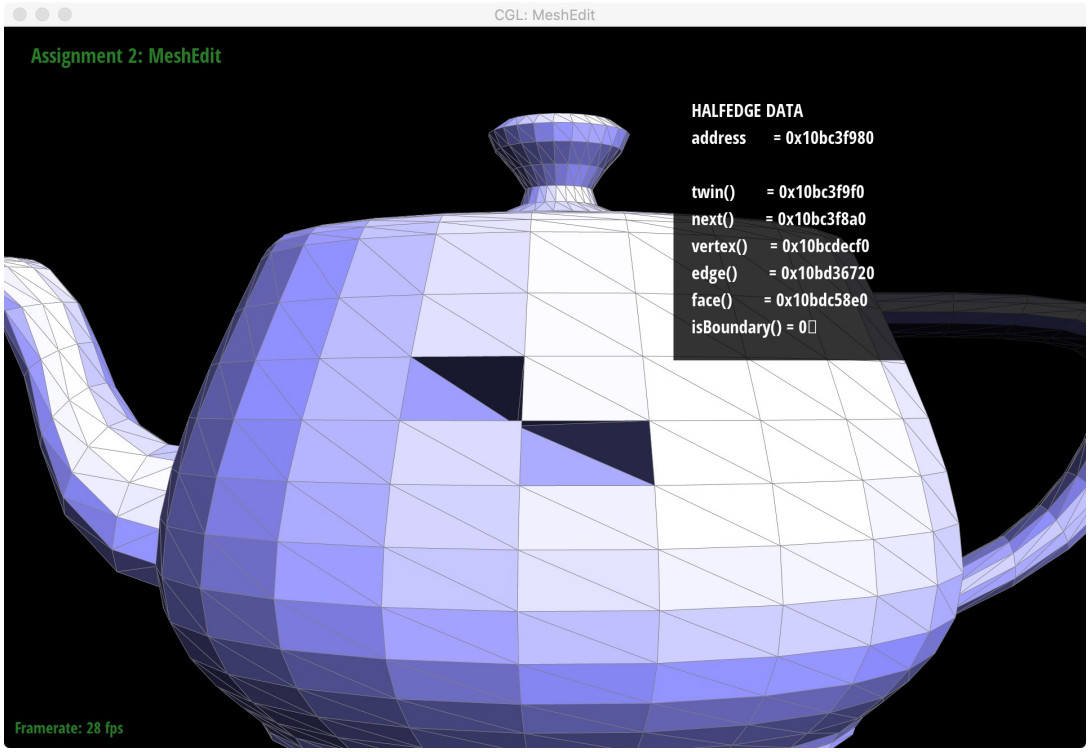


Bezier Surface of Teapot after Splitting.



Bezier Surface of Teapot after Flipping and Also Splitting.

The main bug I have is that although I set the half-edge of the new vertex to the new half-edge, I don't set the position of it. Therefore, when I am going to split the edge, the face will disappear.



Bug: The Sample of the Mesh Disappear.

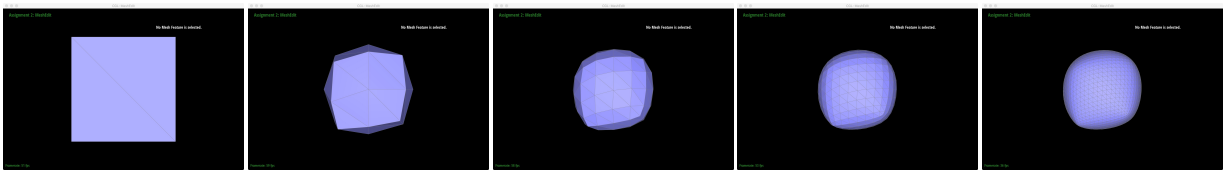
Part 6: Loop subdivision for mesh upsampling

Loop Subdivision provides a data structure to smooth the sharp meshes.

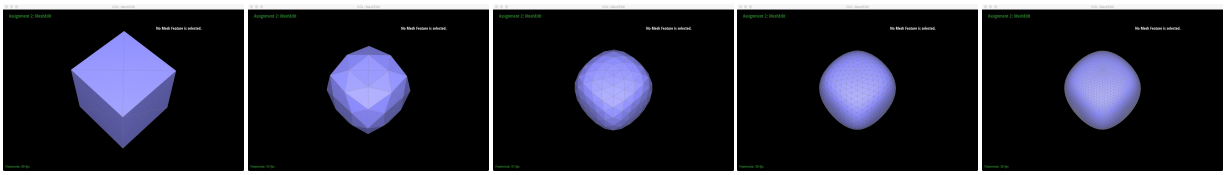
Firstly, I calculate the position of the new vertex following **3/8 * (A + B) + 1/8 * (C + D)** and update the position of the old vertex following **(1 - n * u) * original_position + u * original_neighbor_position_sum**. I set bool isNew of all existing edges and vertices to be **false**.

Secondly, I split all the old edges using **HalfedgeMesh::splitEdge()**. The way I determine whether the edges are old or the newly subdivided is whether two of their vertices both are old. Then, I set the **newPosition** to the new vertices after splitting and also set **bool isNew** of these vertices to be **true**.

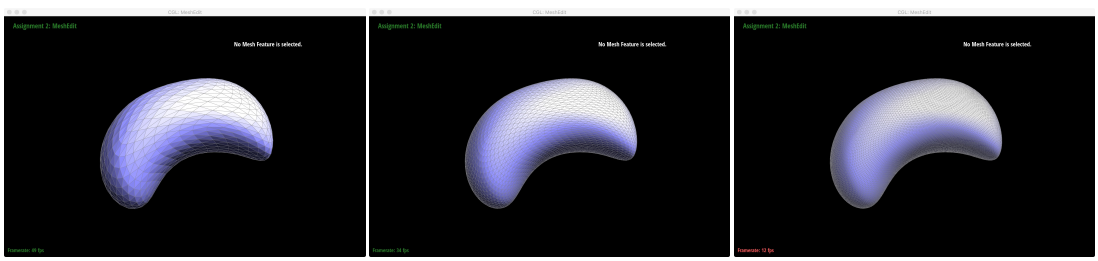
Thirdly, I flip the edges that are newly subdivided and one of their two connected vertices are new and one are old using **HalfedgeMesh::flipEdge()**. I also set **bool isNew** of these edges to be **false** in order for the next turn.



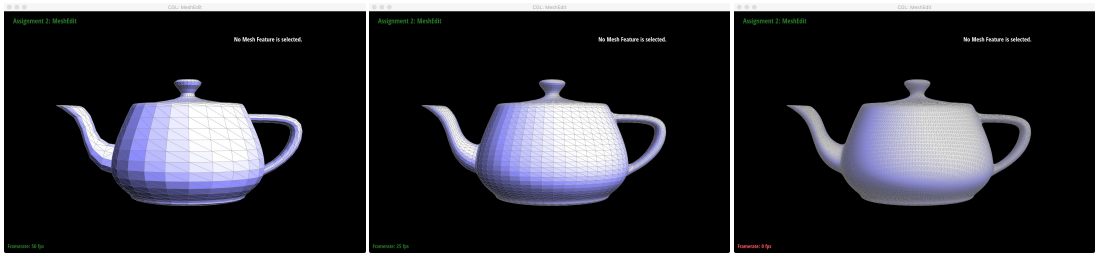
Cube with pre-splitting is smoother and reduce the sharp corners and edges at some degree.



Bean after mesh upsampling.



Teapot after mesh upsampling.

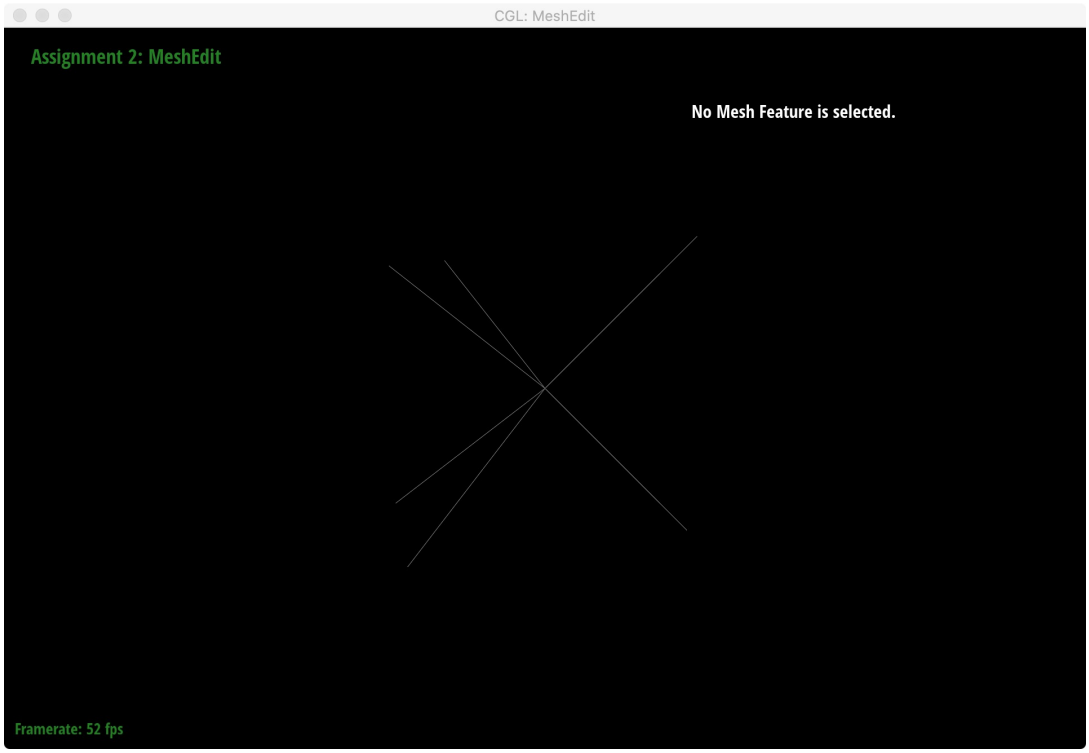


I have main three bugs when I am implementing the function:

1. I didn't determine whether the edges were old or newly subdivided before I split the edges, causing it runs infinitely.

2. I didn't set all the variables to double or float.

3. I didn't set bool isNew of newly subdivided edges to be true, thus, although when I was going to flip the edges, there weren't any new edge and nothing was input into HalfedgeMesh::flipEdge(). Therefore, when I run the program, only lines were shown.



Bug: Mesh Disappear.