Overview

This assignment covered several topics related to geometry processing and computer graphics. Specifically, I was asked to implement De Casteljau's algorithm, which is used to evaluate points on a Bezier curve and surface, as well as to implement area-weighted vertex normals to calculate the orientation of the surface at a given point.

I was also asked to implement the edge flip operation, which is a geometric transformation used to improve the quality of a triangular mesh by swapping two adjacent edges. Finally, I provided a brief implementation of loop subdivision, which is a technique used to refine the quality of a mesh by iteratively smoothing and subdividing its faces.

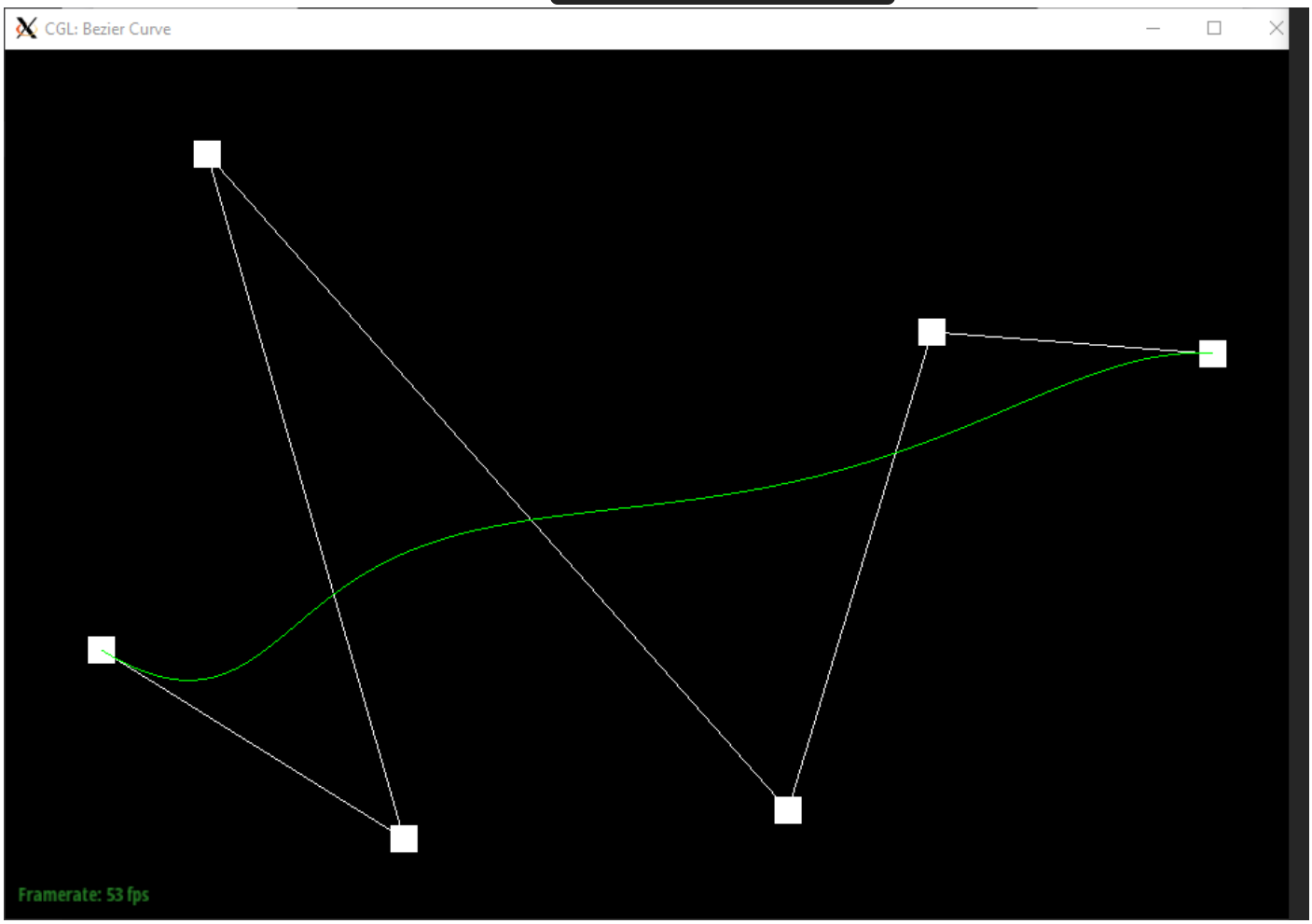
Overall, these questions demonstrated a broad range of concepts and techniques that are used in computer graphics and geometry processing, ranging from specific algorithms and operations to more general topics related to surface orientation and mesh refinement.

Task 1

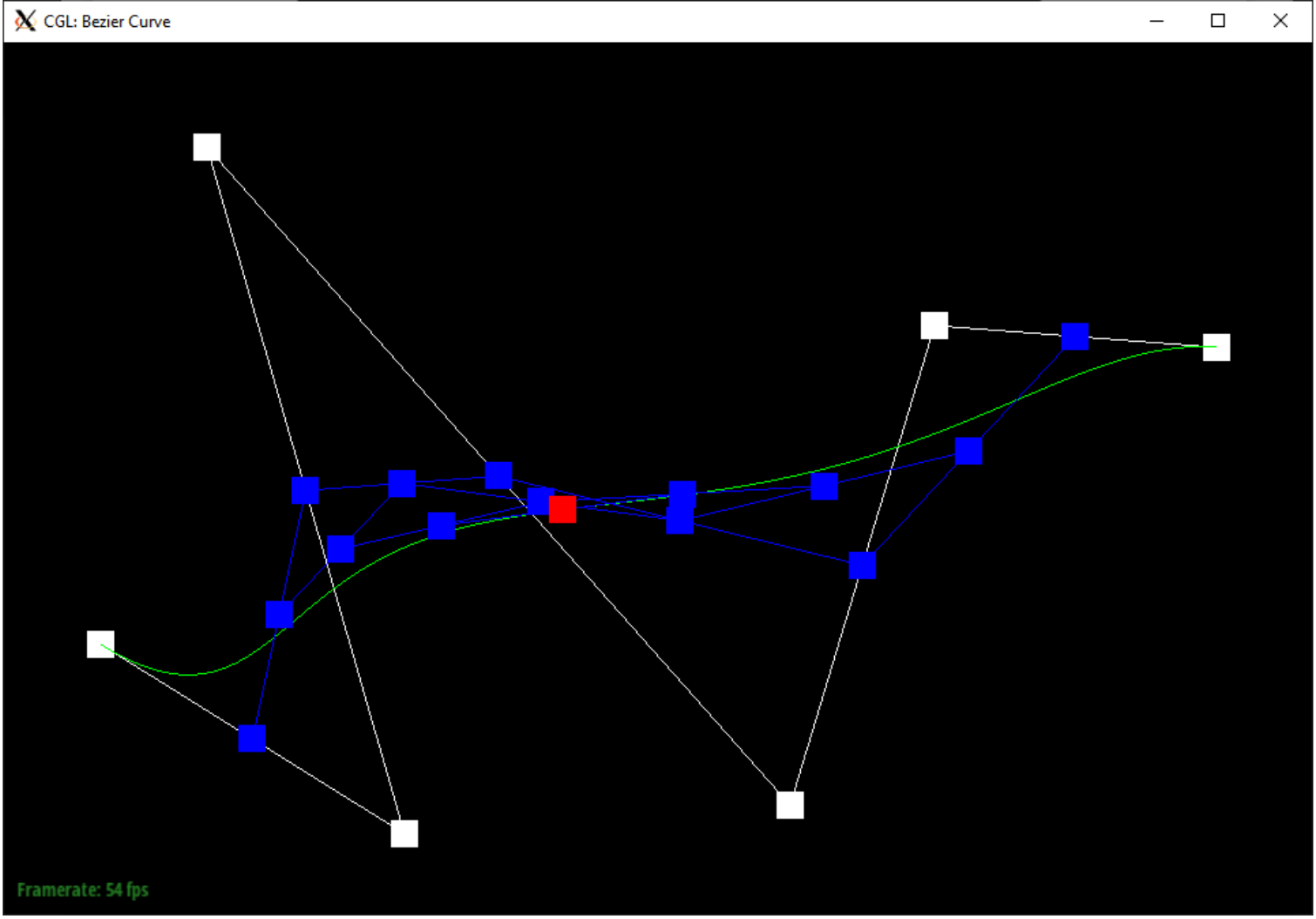
•Briefly explain de Casteljau’s algorithm and how you implemented it in order to evaluate Bezier curves.

De Casteljau's algorithm is a approach that evaluates points on a Bezier curve. The algorithm operates by taking a collection of control points that define the curve and iteratively calculating the weighted average of adjacent control points.

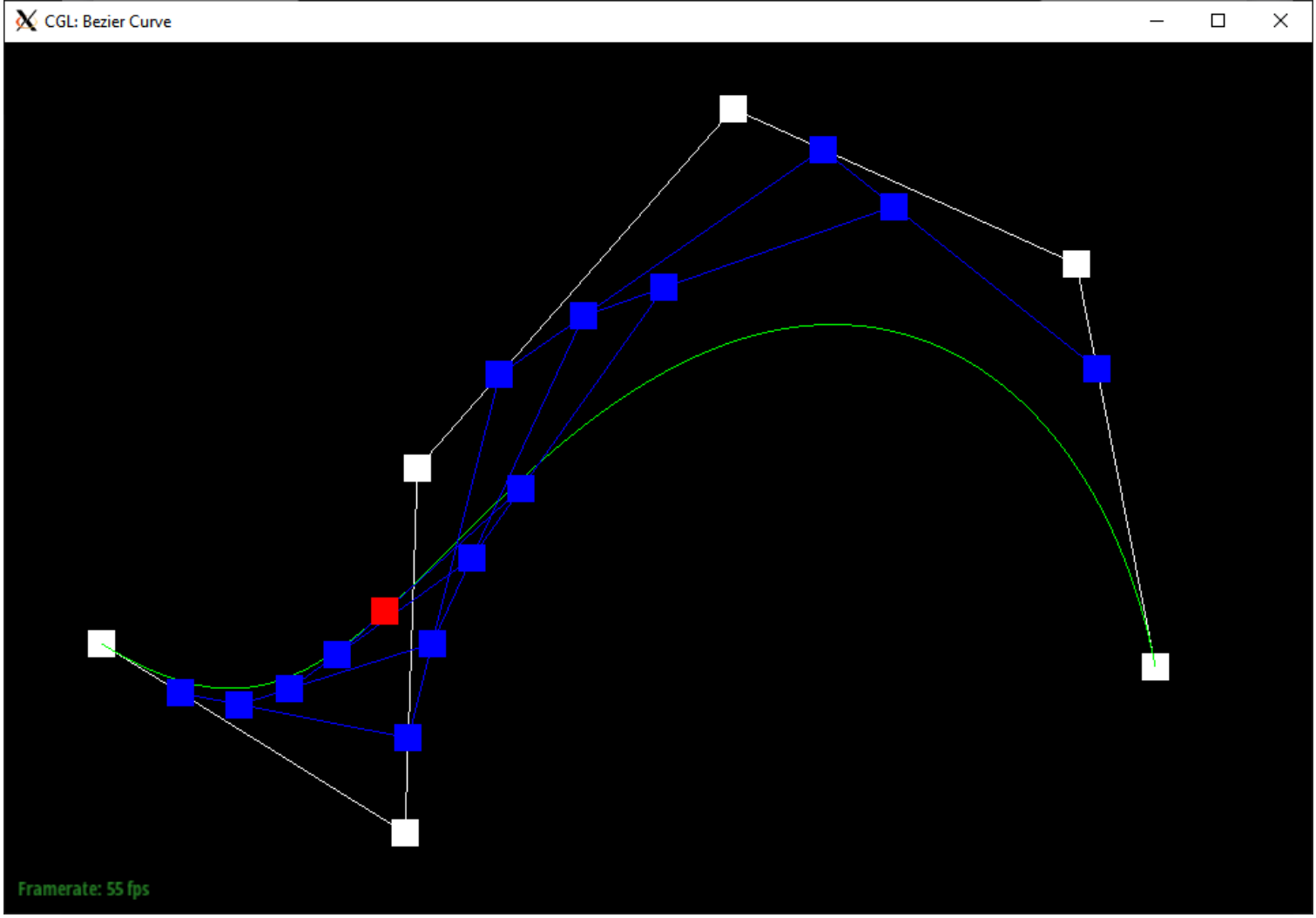
- Result of created curve `bzc/curve3.bzc`



  - Each step



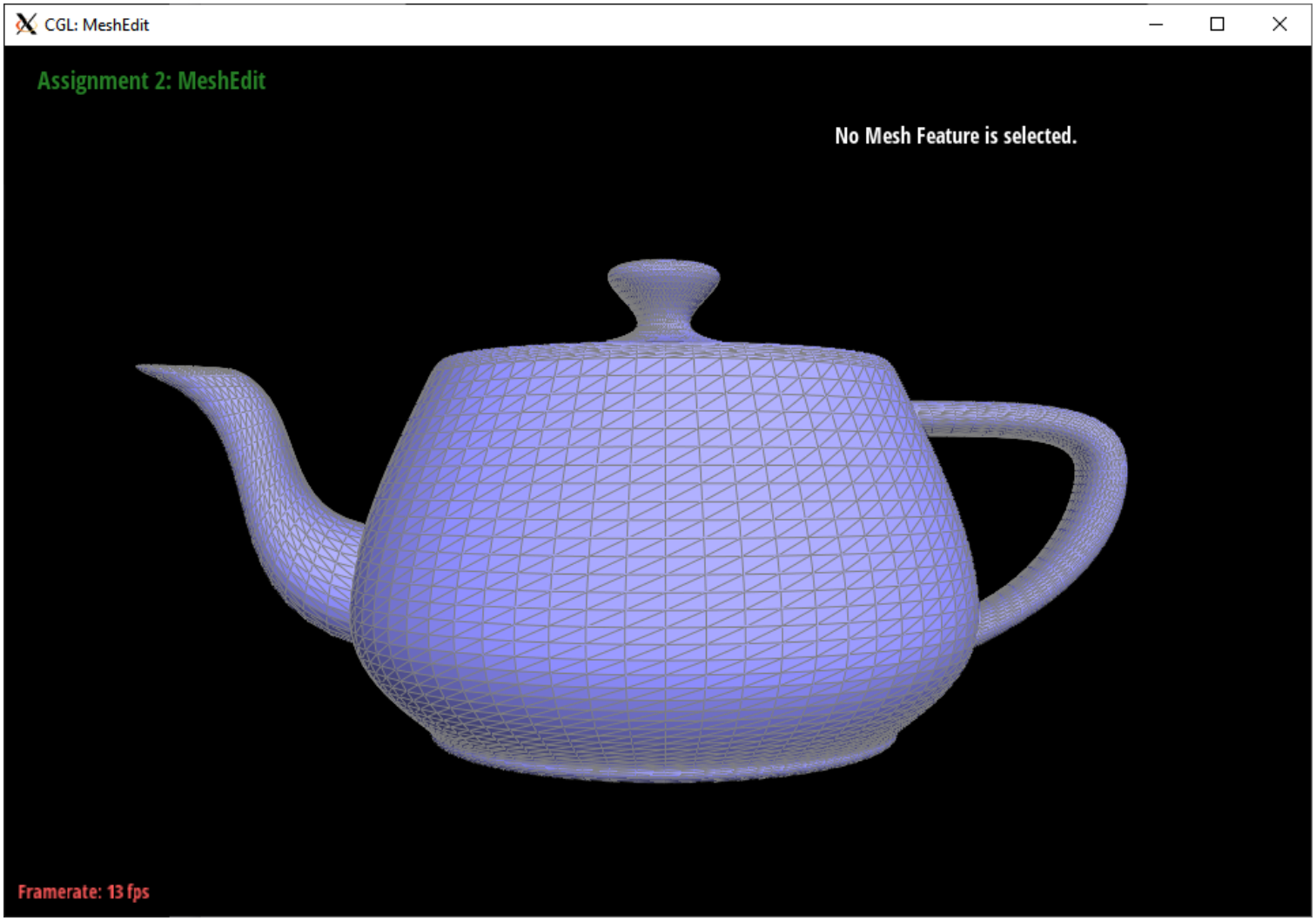
- Different curve



Task 2

By extending the De Casteljau algorithm, points on a two-dimensional Bezier surface can be evaluated. Similar to Bezier curves, Bezier surfaces are defined by a set of control points on a two-dimensional grid. The De Casteljau algorithm computes points on the surface at a given pair of parameters u and v. The algorithm operates through two levels of recursion: first in the u direction and then in the v direction. Beginning with the original grid of control points, the algorithm generates a new grid of points by interpolating between adjacent control points in the u direction using the

parameter u. Subsequently, the algorithm interpolates between the resulting points in the v direction using the parameter v. The process continues until a single point is left, which corresponds to a point on the Bezier surface.



Task 3

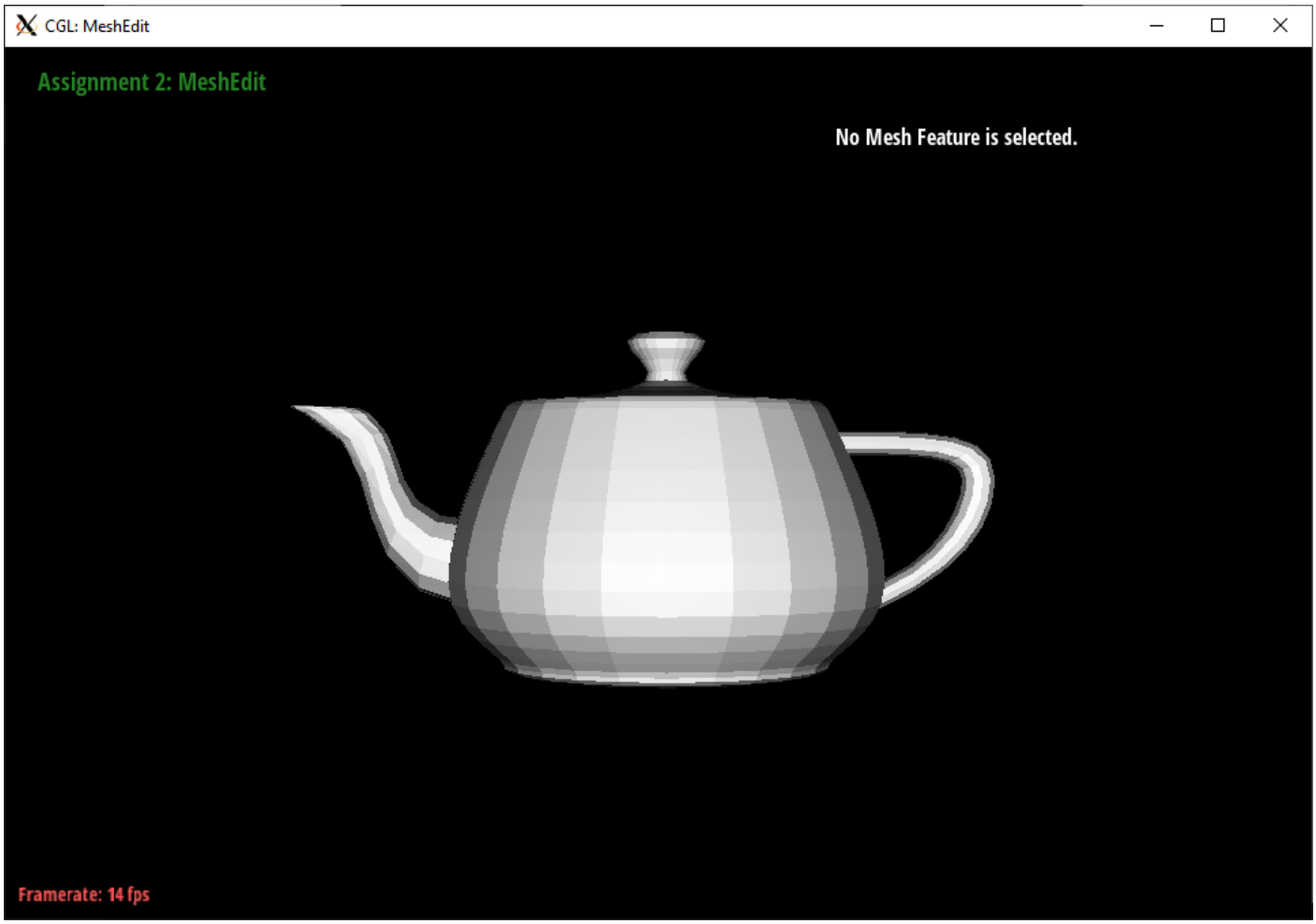
Briefly explain how you implemented the area-weighted vertex normals.

To implement area-weighted vertex normals, we need to calculate the area of faces neighboring to one vertex as

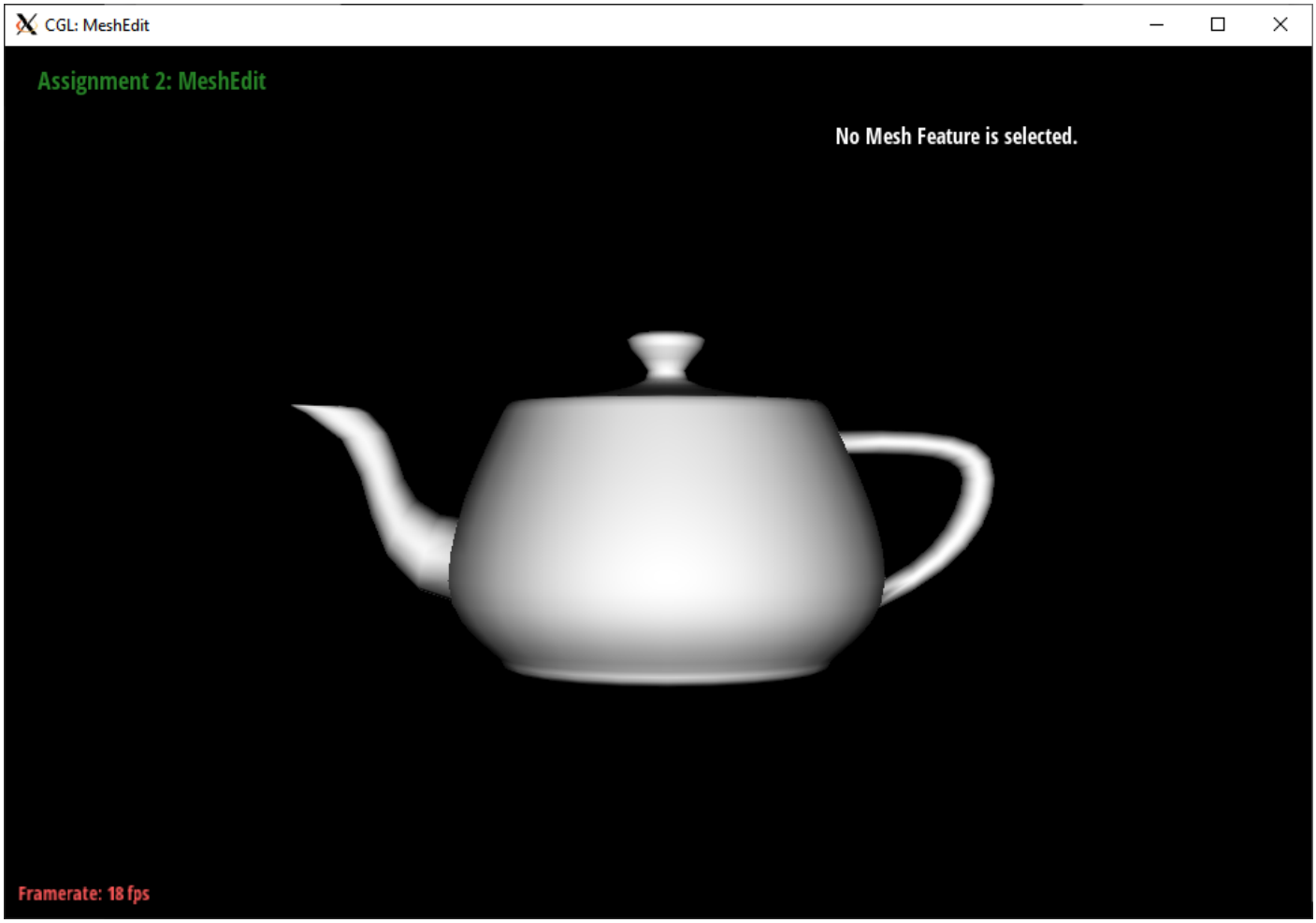
weights of normals. Then sum the neighboring normals together by area weights to be the normal of one vertex.

In practice, we can simply use cross product of two edge to be the weight of one triangle face.

- Before area weighted normal



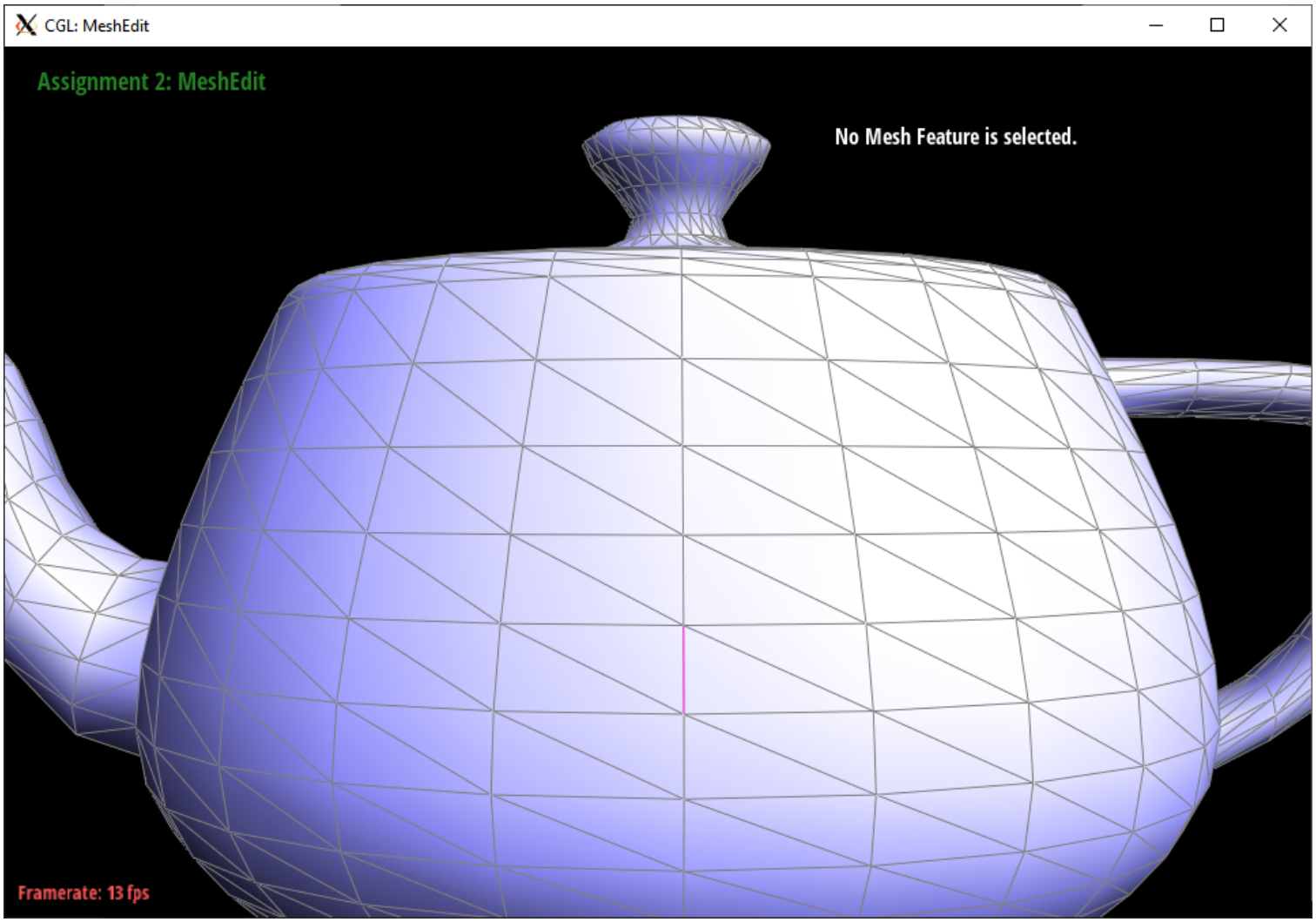
- After area weighted normal

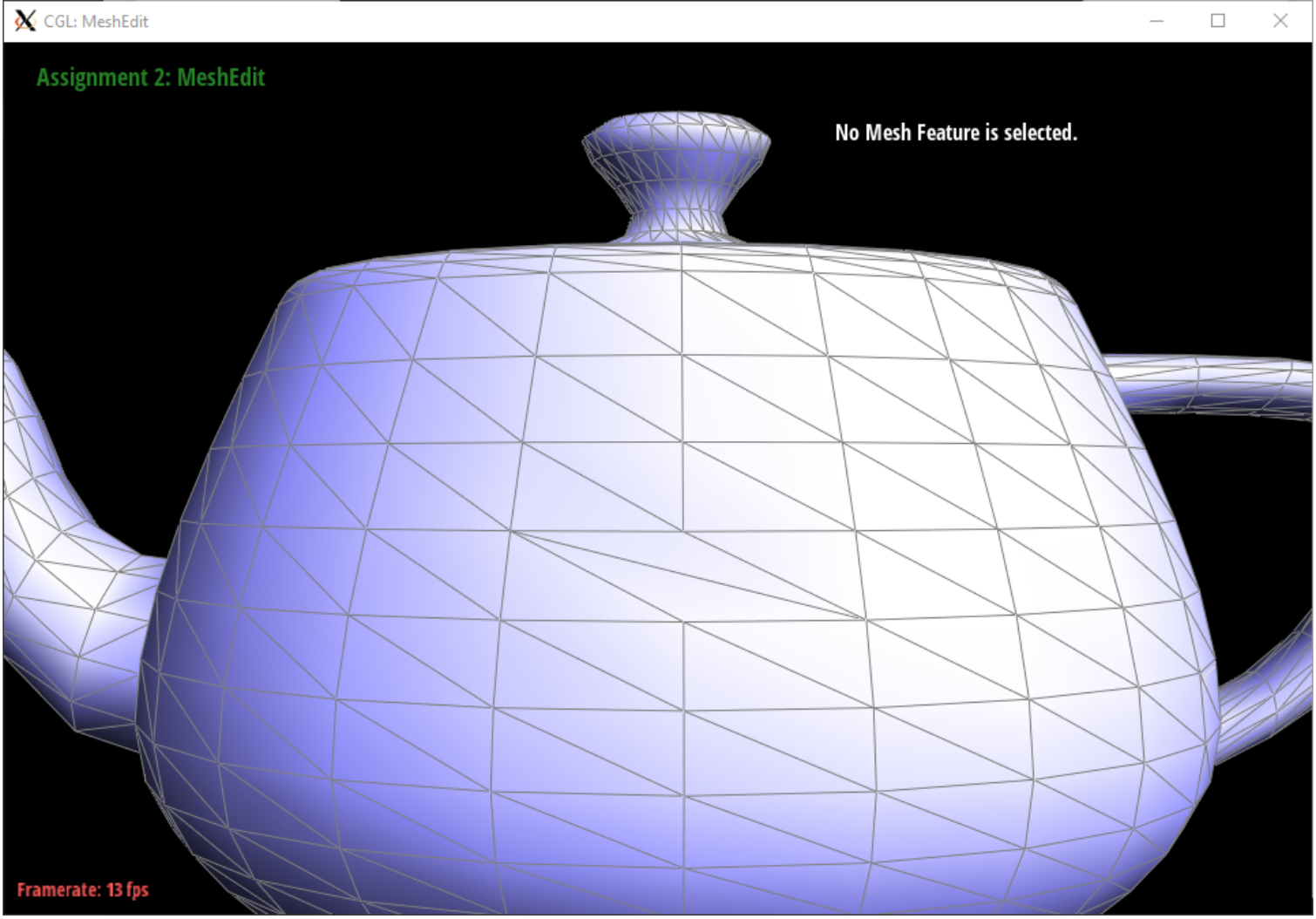


Task 4

An edge flip operation is a geometric transformation performed on a triangular mesh to improve its quality. It involves flipping an edge shared by two adjacent triangles, replacing the old edge with a new one connecting the two opposite vertices.
To do edge flip, we need to change only the edge-vertex relationship of related four vertices.

- Screenshots of a mesh before and after a edge flip.

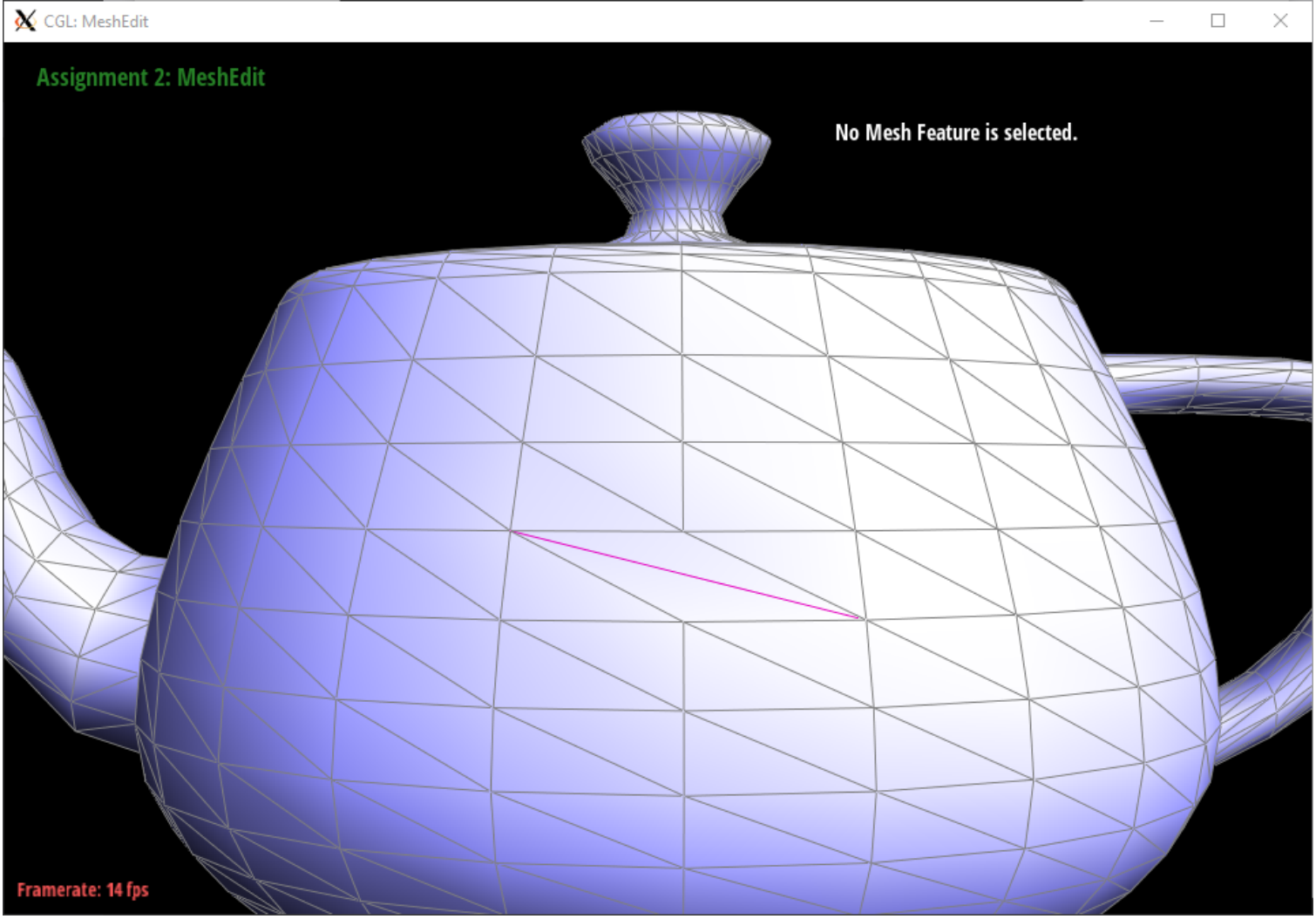




Task 5

Edge split involves creating an entire new vertex and add six new half-edges, two new edges, and two faces. And we also need to update all related edges, faces, half-edges and vertices.

•Screenshots of a mesh before and after a combination of both edge split and edge flip.


CGL: MeshEdit
Assignment 2: MeshEdit
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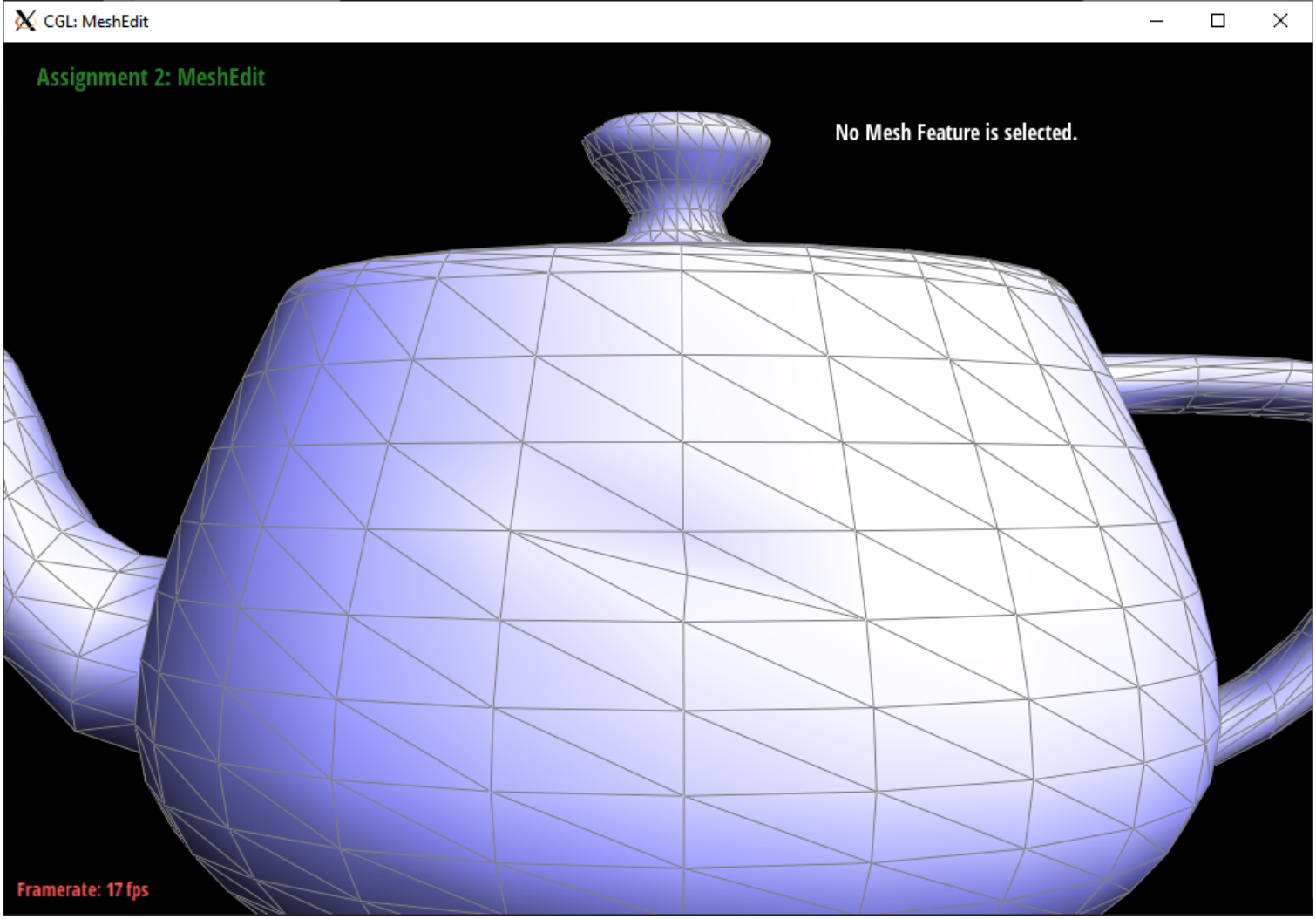
Framerate: 14 fps

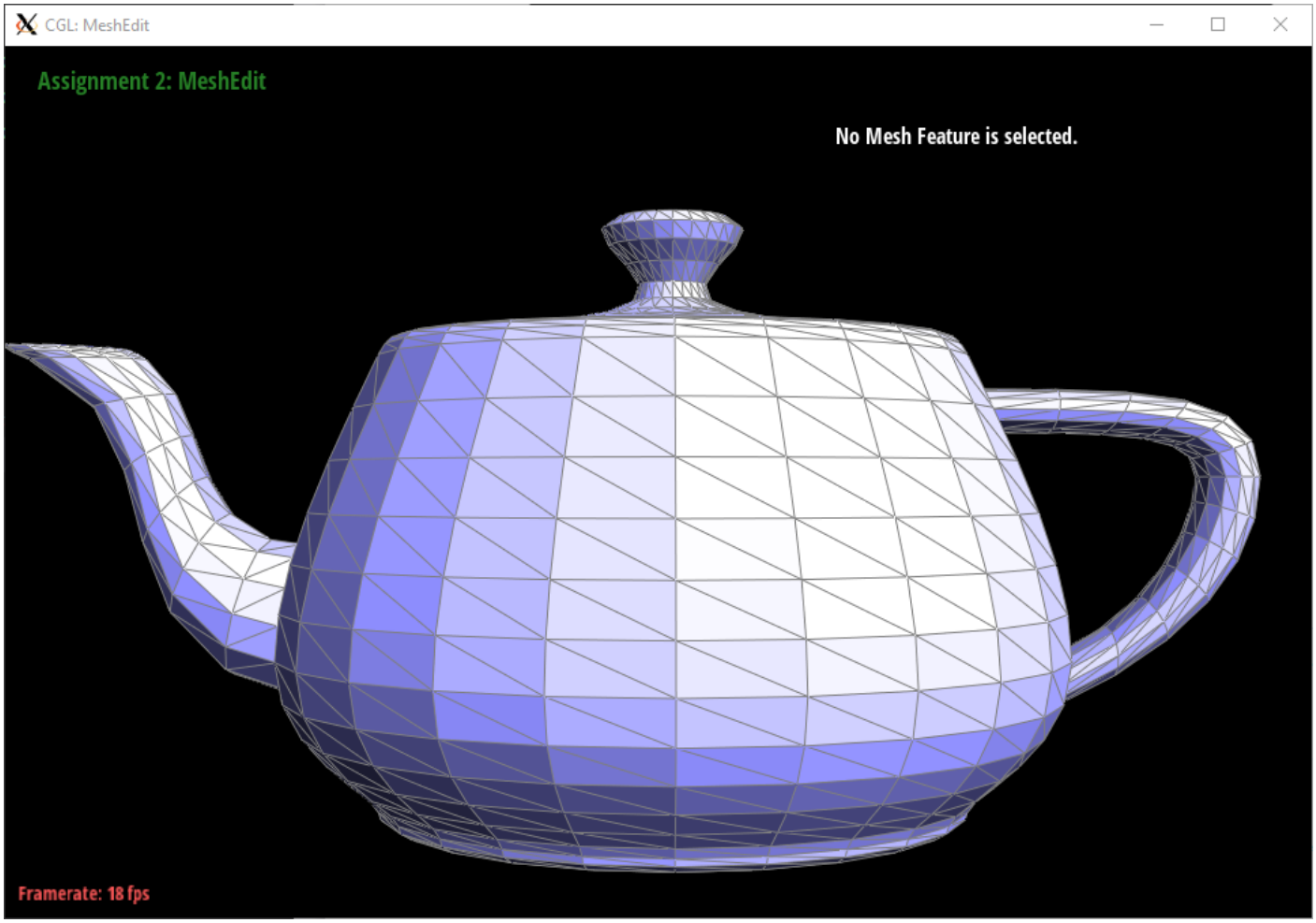


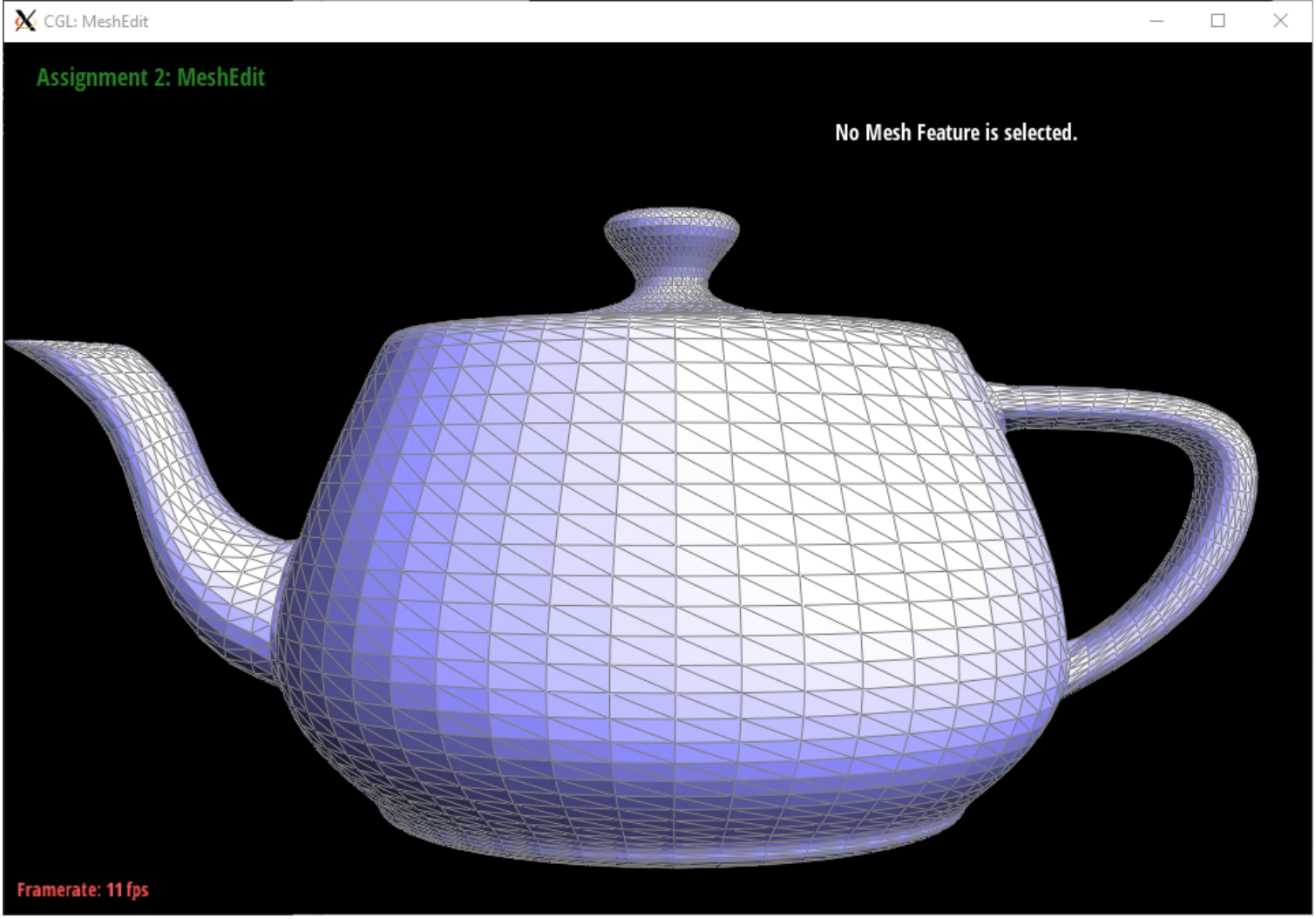
Task 6

Loop subdivision is a technique used to improve the quality of a mesh by smoothing and subdividing its faces in an iterative manner. To begin, we compute the new positions of the vertices by averaging their positions with those of their neighboring vertices. Next, we calculate the positions of the new vertices located along the edges of the mesh by averaging the positions of their neighboring vertices and the midpoint of the edge. Finally, we connect the newly created vertices along each edge to form new faces. This process repeats for a predetermined number of iterations or until the

desired level of refinement is achieved. Overall, loop subdivision combines smoothing and subdivision operations to enhance the overall quality and smoothness of a mesh.

- Screenshots of teapots after several loop subdivisions




CGL: MeshEdit
Assignment 2: MeshEdit
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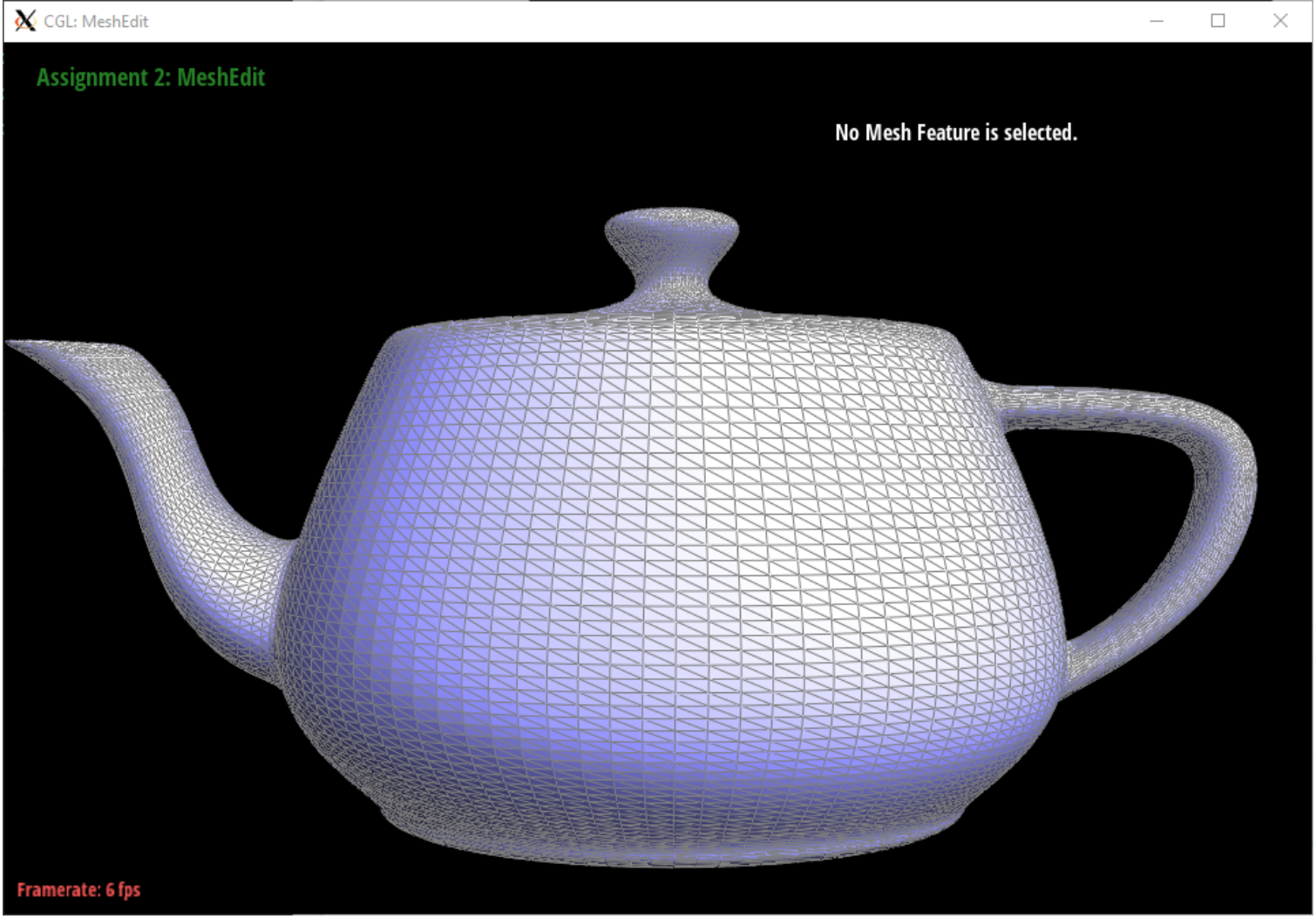
Framerate: 11 fps


CGL: MeshEdit
Assignment 2: MeshEdit
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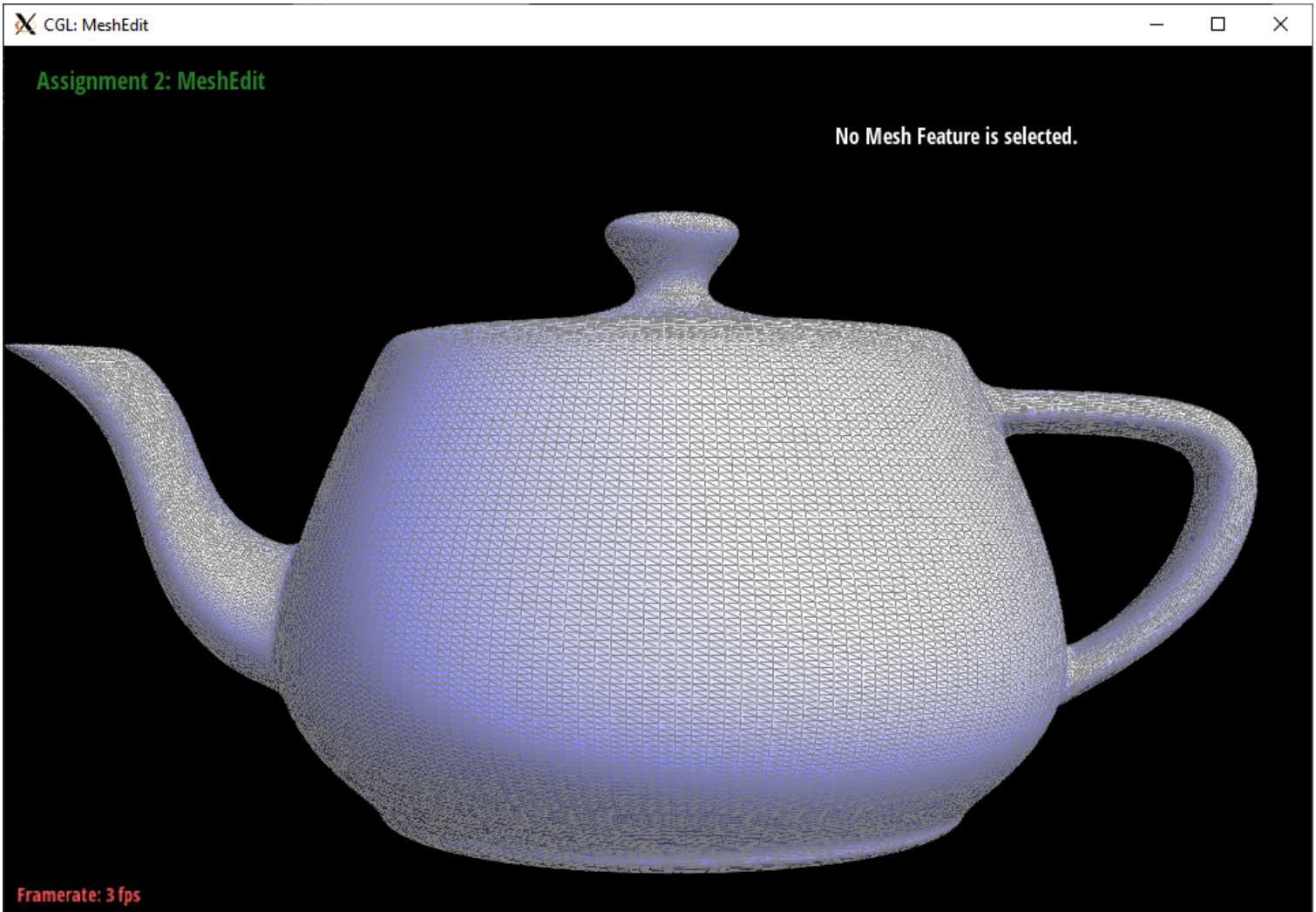
Framerate: 6 fps


CGL: MeshEdit
Assignment 2: MeshEdit
No Mesh Feature is selected.
Framerate: 3 fps