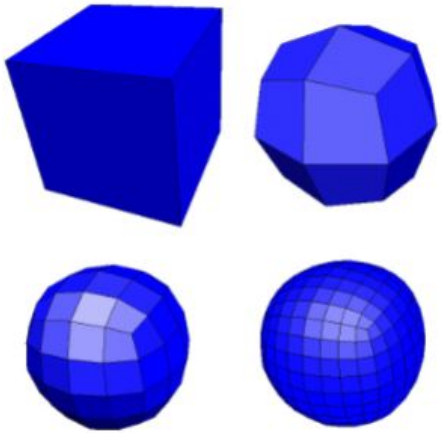
Project 2 Recitation

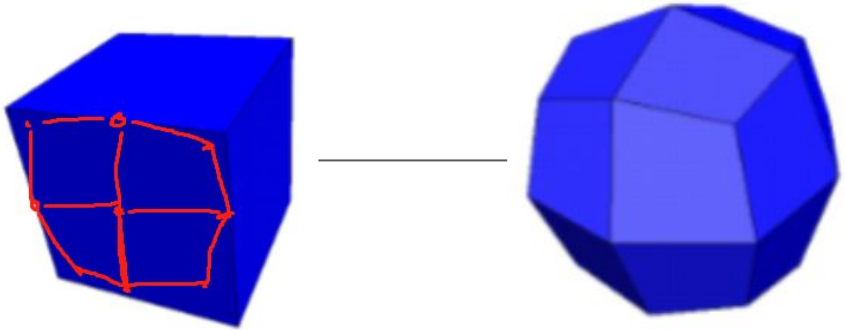
Subdivision Algorithm

Objective

Subdivision is a recursive algorithm, which takes the mesh objects(face and vertex) to subdivides it. From an intuitive perspective, this algorithm will generate more faces on the original surface, which also implies the need to generate more vertices(Face is also maintained by different vertices.)



Subdivision by new vertices, which generate new faces



Objective

Mesh Object data structure

```
# HalfedgeMesh
mesh = halfedge_mesh.HalfedgeMesh(data_path)
```

```
# print(mesh.vertices)
for vertex in mesh.vertices:
    print(vertex.get_vertex(), vertex.index)

# print(mesh.facets)
print('--------------------')
for face in mesh.facets:
    print(face.a, face.b, face.c, face.index)
```

([x,y,z], index)

```
([0.0, 0.0, 0.488037], 0)
([0.003906, 0.042188, 0.476326], 1)
([0.003906, -0.042188, 0.476326], 2)
([0.010742, 0.0, 0.575333], 3)
([0.0125, 0.056251, 0.450561], 4)
([0.0125, -0.056251, 0.450561], 5)
([0.019531, 0.0, 0.413654], 6)
([0.021094, 0.042188, 0.424797], 7)
([0.021094, -0.042188, 0.424797], 8)
([0.025, 0.0, 0.413086], 9)
([0.03875, 0.19625, 0.488037], 10)
([0.03875, -0.19625, 0.488037], 11)
([0.039063, 0.0, 0.66803], 12)
([0.04866, 0.192034, 0.575333], 13)
([0.04866, -0.192034, 0.575333], 14)
([0.056768, 0.188584, 0.413654], 15)
([0.056768, -0.188584, 0.413654], 16)
([0.0625, 0.0, 0.358795], 17)
([0.074785, 0.180918, 0.66803], 18)
([0.074785, -0.180918, 0.66803], 19)
([0.079102, 0.0, 0.764481], 20)
([0.096406, 0.171719, 0.358795], 21)
([0.096406, -0.171719, 0.358795], 22)
([0.1, 0.0, 0.769043], 23)
([0.103906, 0.042188, 0.777779], 24)
...
```

(vertex index1,index2,index3, face index4)

```
(298, 290, 333, 130)
(333, 290, 319, 131)
(257, 290, 262, 132)
(262, 290, 298, 133)
(176, 257, 178, 134)
(178, 257, 262, 135)
(347, 333, 354, 136)
(354, 333, 338, 137)
(311, 298, 347, 138)
(347, 298, 333, 139)
(262, 298, 266, 140)
(266, 298, 311, 141)
(178, 262, 180, 142)
(180, 262, 266, 143)
(352, 347, 358, 144)
(358, 347, 354, 145)
(322, 311, 352, 146)
(352, 311, 347, 147)
(266, 311, 272, 148)
(272, 311, 322, 149)
(180, 266, 182, 150)
(182, 266, 272, 151)
(355, 352, 359, 152)
(359, 352, 358, 153)
(326, 322, 355, 154)
...
```

Loop Subdivision Algorithm

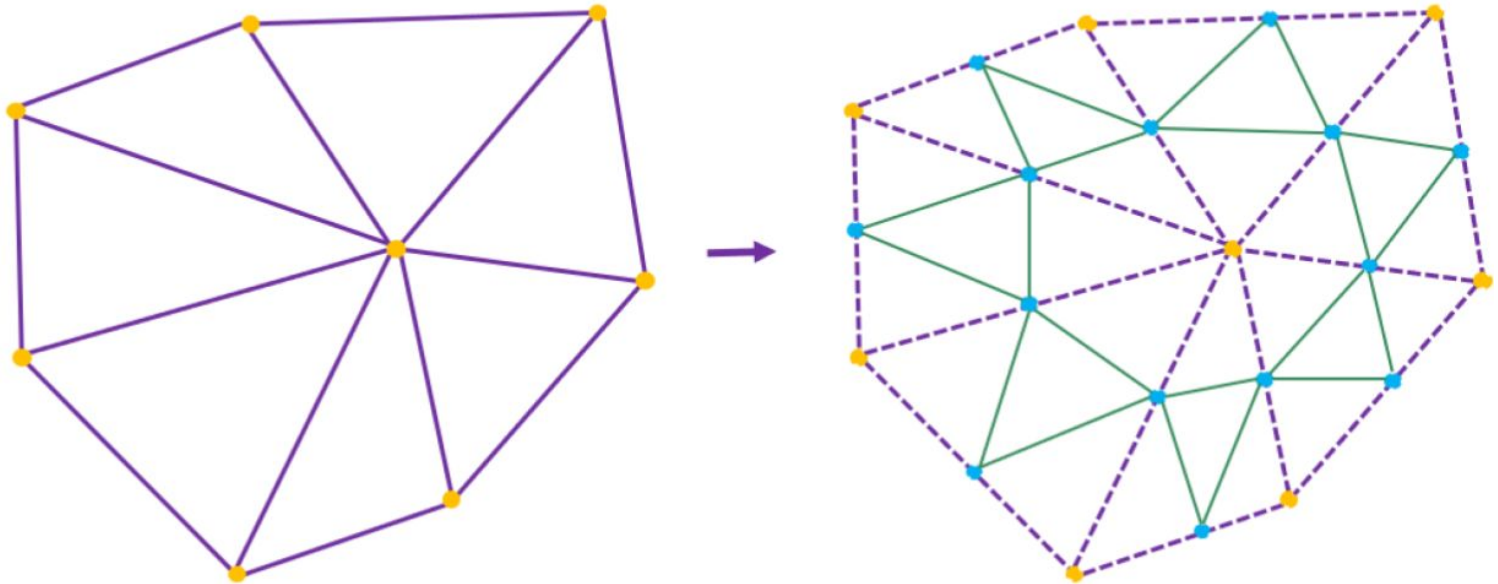
Loop, Charles. "Smooth subdivision surfaces based on triangles." (1987).

https://charlesloop.com/thesis.pdf

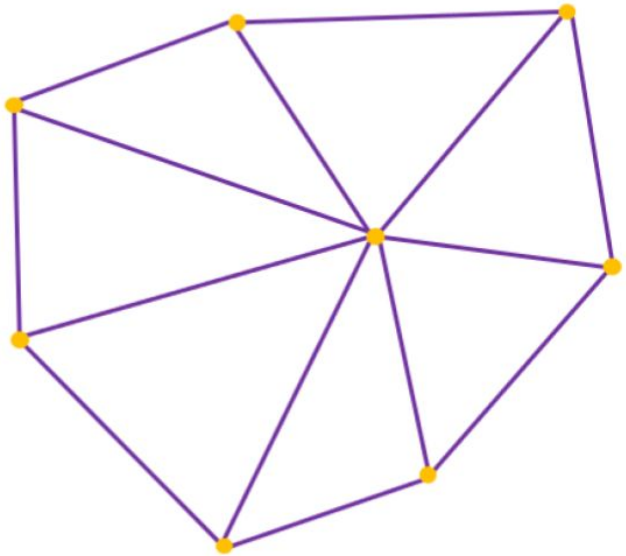
https://www.rorydriscoll.com/2008/08/01/catmull-clark-subdivision-the-basics/

Loop Subdivision Objective

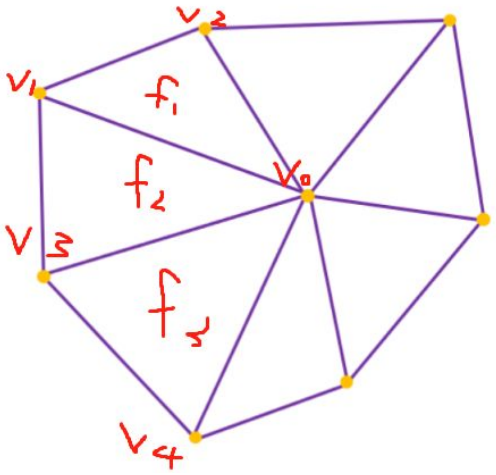
Loop Subdivision Surface is an approximating subdivision scheme for triangular meshes. The algorithm mainly divide into two part: Generate the new vertices, and Update the old vertices.



Loop Subdivision Objective

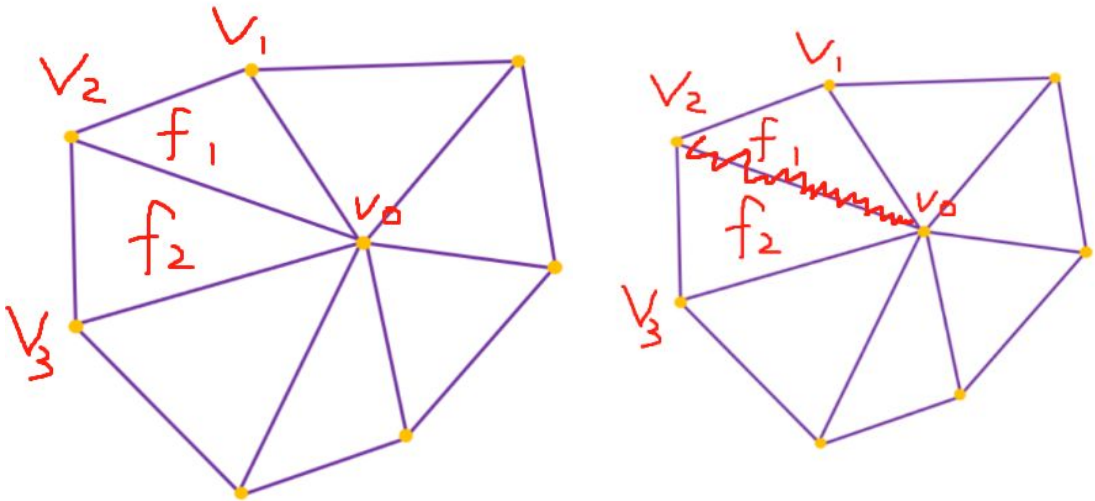


Iterate through each face object and obtain each edge.



Generate the new vertices

1. Edges shared with other triangles



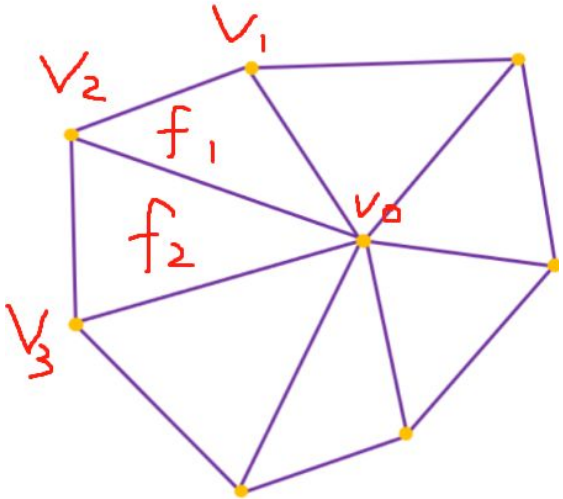
Edge (v0 - v1) shared by face f1 and f2

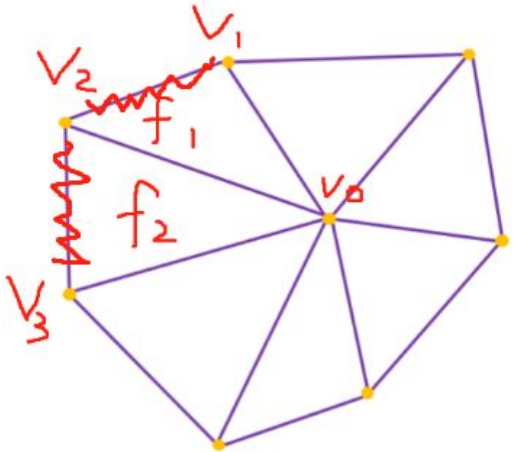
For these cases, we calculate the new vertex for this edge be formale by

V_new = ⅜(v0+v2) + ⅛(v3+v1)

Generate the new vertices

1. Edges Not shared with other triangles





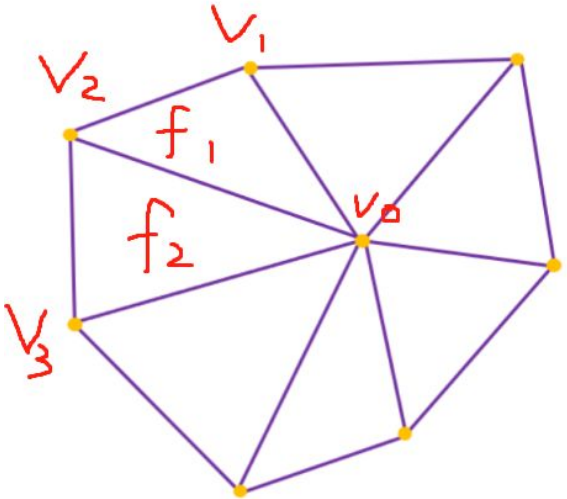
Edge (v2 - v3 and v1 - v2) Not shared by other triangles

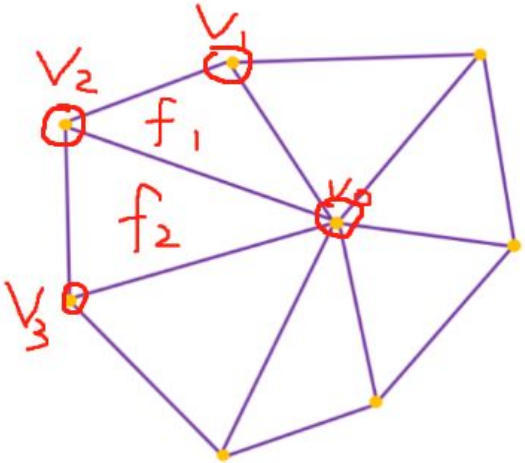
For those cases, we calculate the midpoint for this edge as the new vertex be formale by

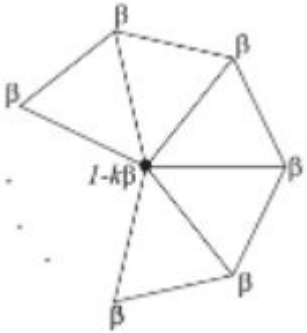
V_new = ½(v3+v2)
V_new = ½(v2+v1)

It is necessary to traverse each edge to ensure the generation of new vertices !

Update the old vertices







$$v = (1 - n\beta)v_0 + \beta \sum_{i=1}^{n} v_i$$

$$\beta = \frac{1}{n}\left[\frac{5}{8} - \left(\frac{3}{8} + \frac{1}{4}\cos\frac{2\pi}{n}\right)^2\right]$$

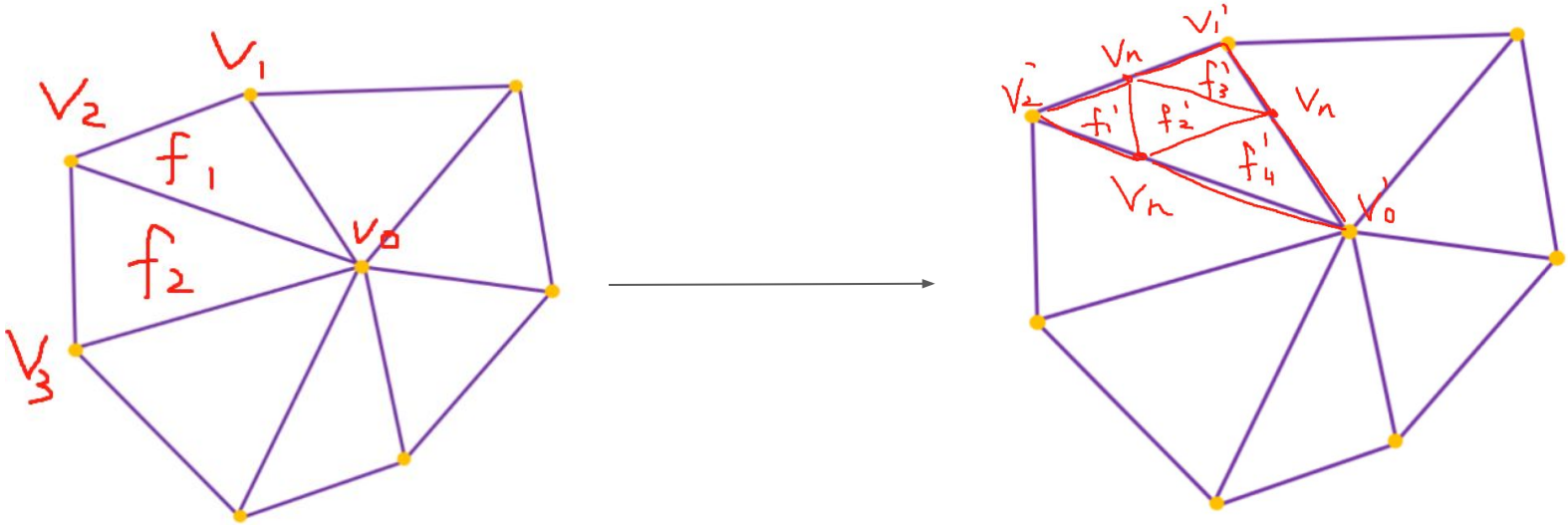
$$v^{i+1} = (1 - n\alpha)v^i + \alpha\Sigma_{j=1}^{n} vv_j^i$$

where

$$\alpha = \frac{1}{n}(\frac{5}{8} - (\frac{3}{8} + \frac{1}{4}\cos\frac{2\pi}{n})^2]$$

for $n > 3$ and $\alpha = \frac{3}{16}$, if $n = 3$.

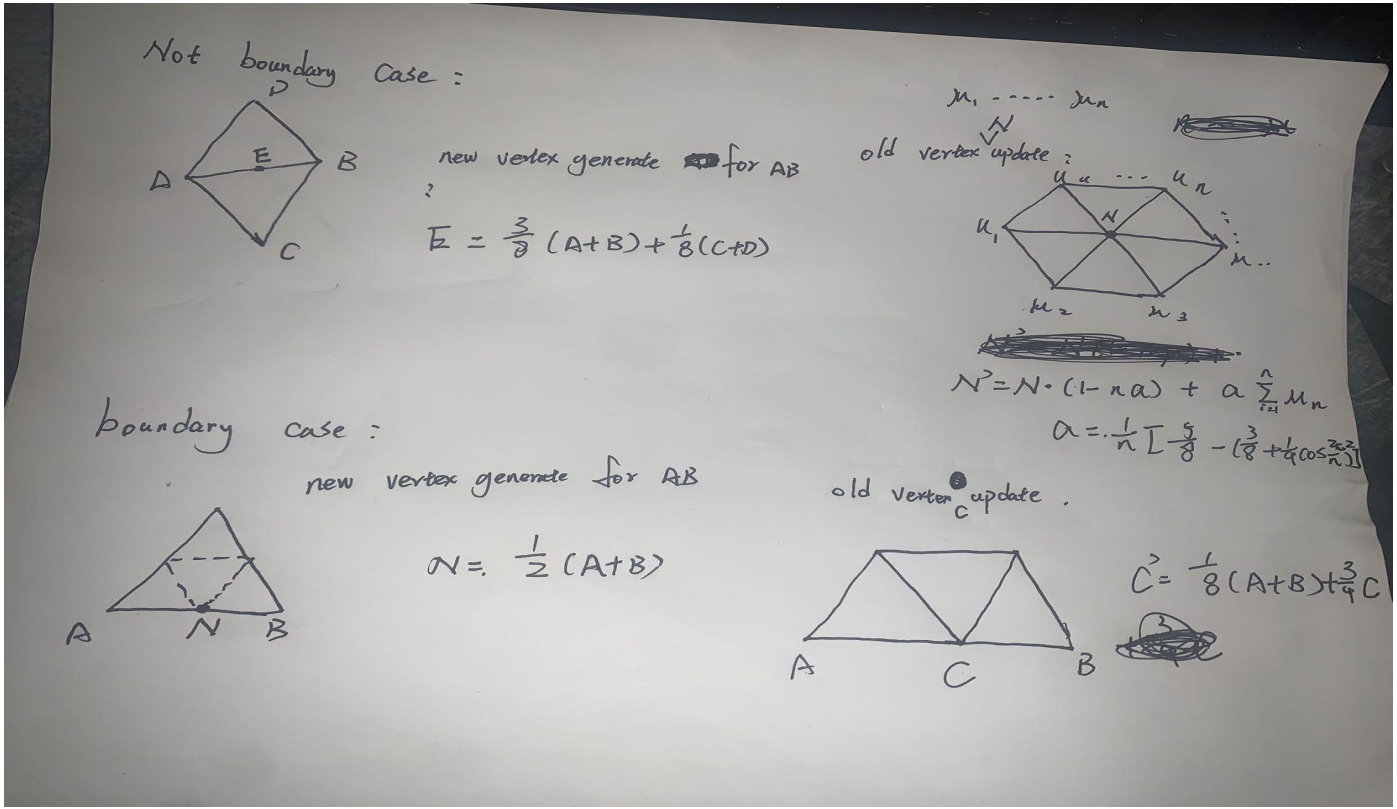
New Mesh Object



The old face object f1 update to new faces (f'1,f'2,f'3,f'4).
f'1 -> (v2',vn,vn) etc.

we iterate through each old face and combine it with three new vertices and three updated old vertices (eg. (v1,v2,v3) to generate new face).

Generation and Updating Details



Checking the subdivision performance

Download the https://www.meshlab.net/

Final Review

Loop Subdivision Algorithm

1.Generate new vertex for each edge.(whether an edge is shared by other triangles)

2.Update the old vertices.

3. Update the mesh object by each face, all old face will divide into 4 new faces, which comprise by new vertices (3) and updated old vertices (3).

Half-edge structure: https://jerryyin.info/geometry-processing-algorithms/half-edge/