COS 426 : Precept 4
Half-Edge

Agenda

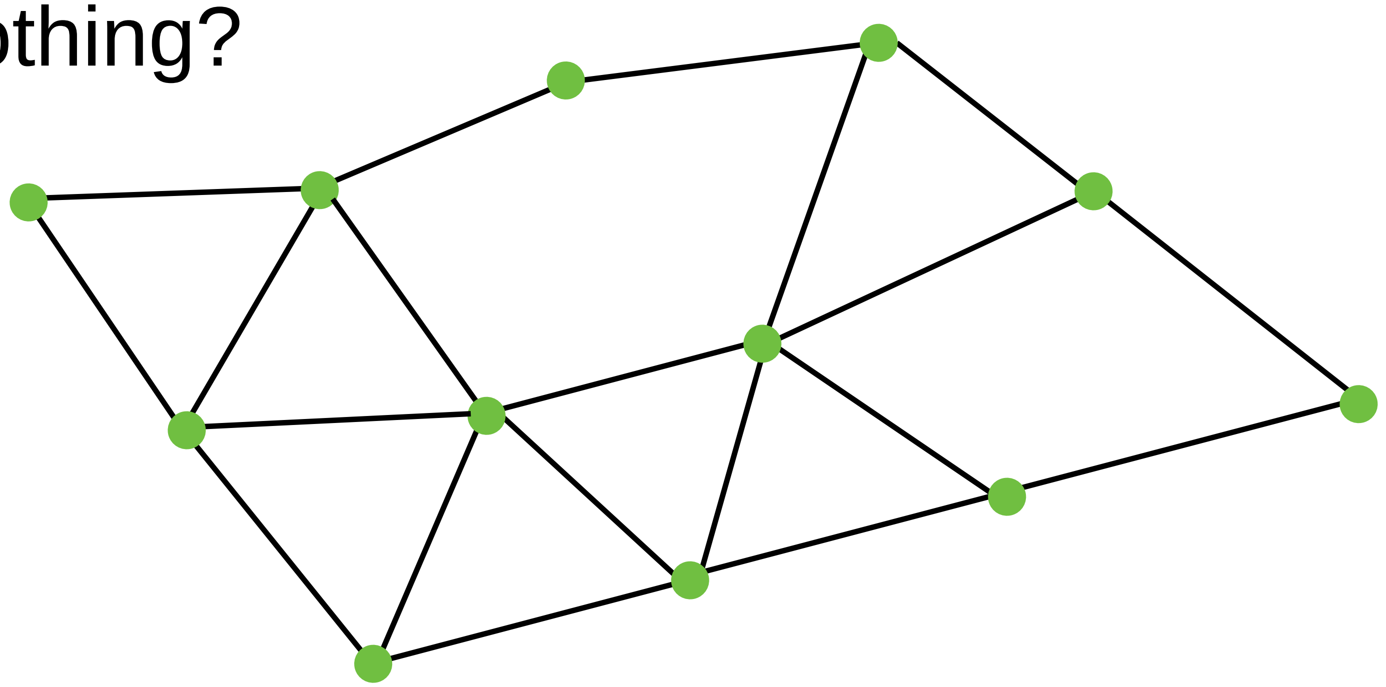
- Assignment 2 description
- Half-edge data structure
  - Traversal
  - Modification

Assignment 2

- Part 1 - Analysis
  - Implement traversal operations
  - Calculate mesh properties
    - Vertex normal, avg. edge length, etc.
- Part 2 - Filters
  - Filters and Warps similar to assignment 1
  - Topological modifiers

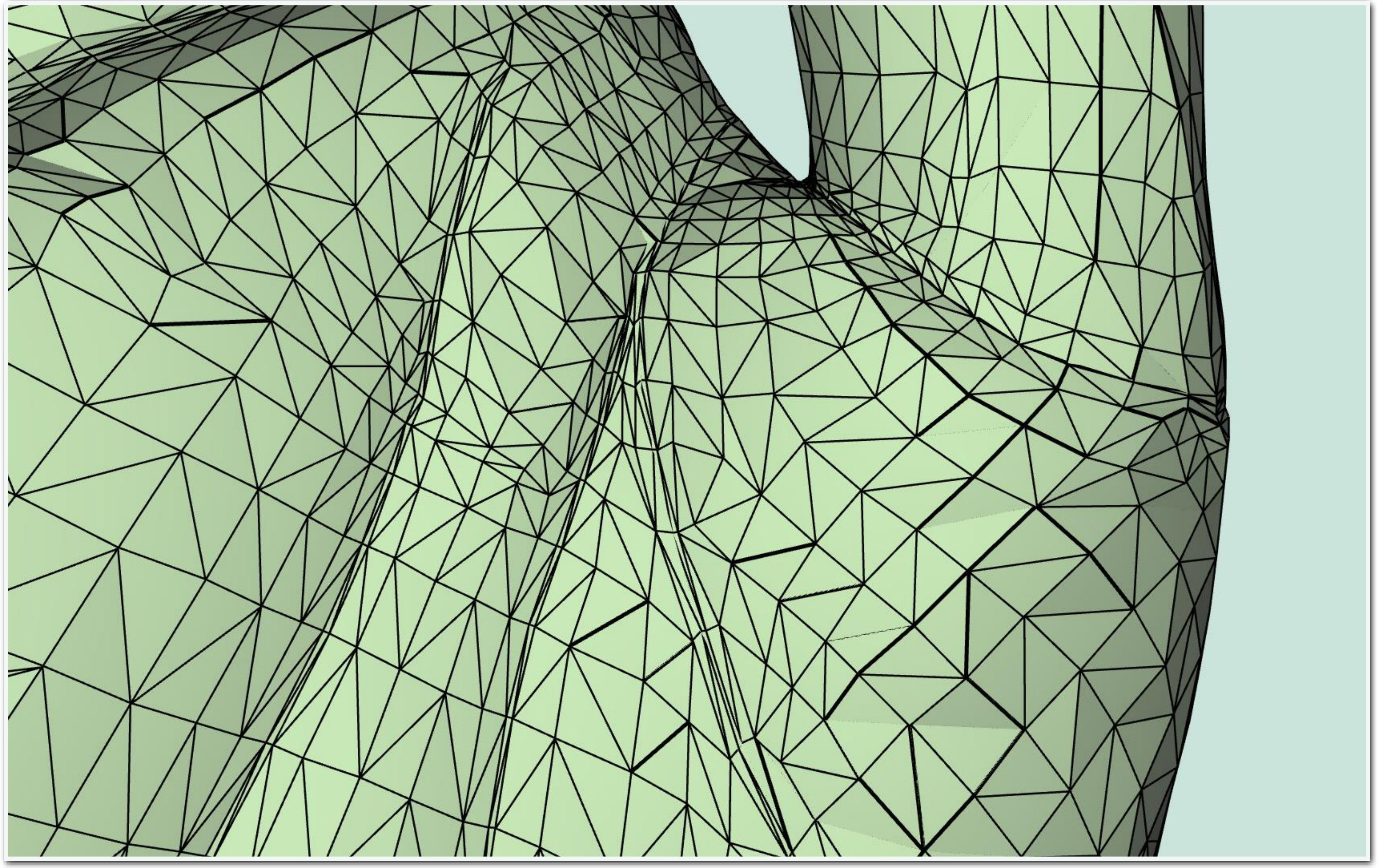
Meshes

- Images had implicit adjacency information
  - Grid around a pixel
  - Easy to express operations
- What about meshes?
  - How to apply smoothing?



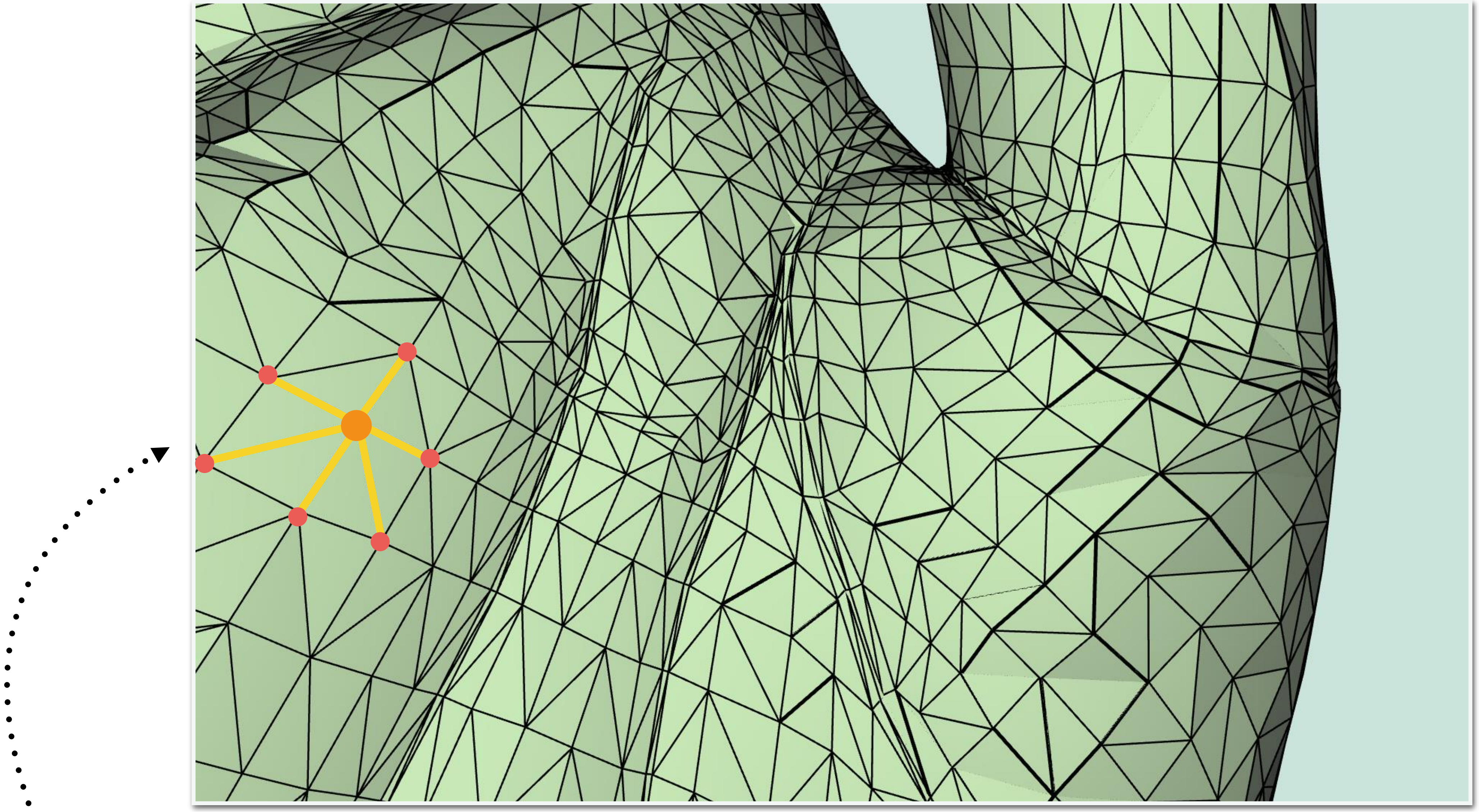
Meshes

- Meshes can be quite dense



Meshes

- How to access adjacency information quickly?



One - Ring Neighborhood

Half-Edge Data Structure

Half Edge	Vertex	Face
Vertex	Position	Half-Edge
Opposite Half-Edge	Outgoing Half-Edge	…
Face	…	
Next Half-Edge		

Half-Edge Data Structure

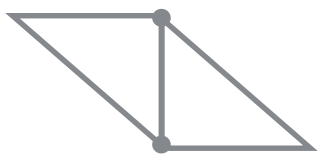
Half-Edge

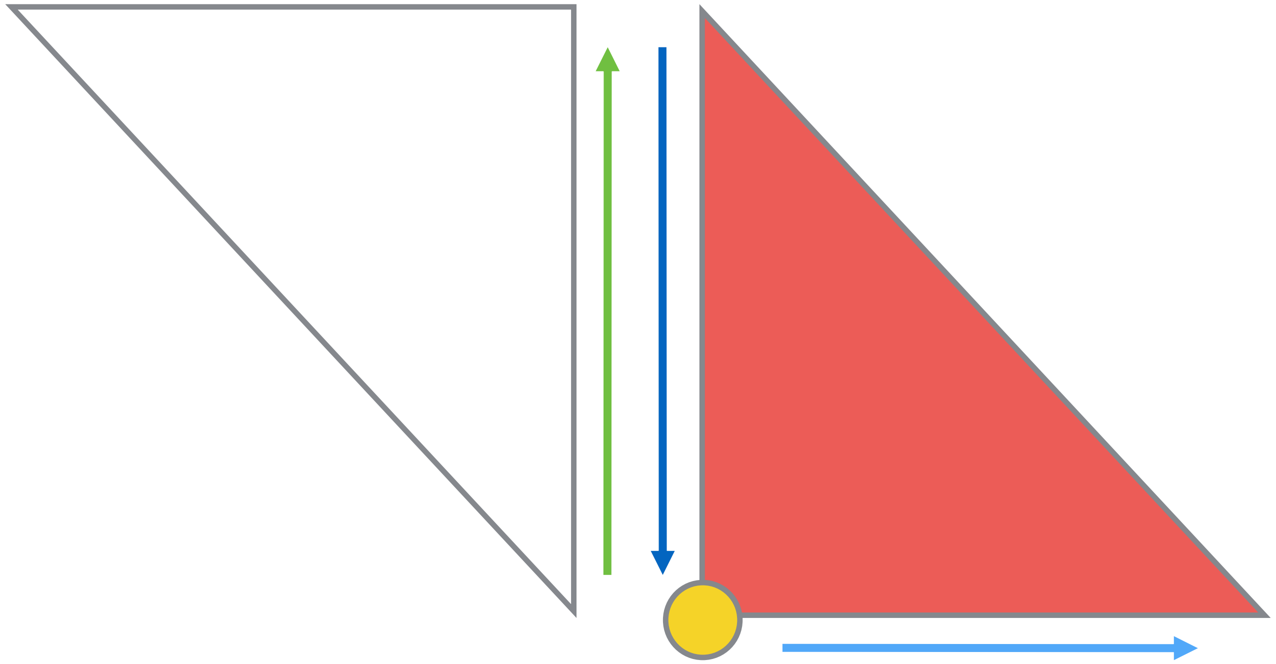
Vertex

Opposite
Half-Edge

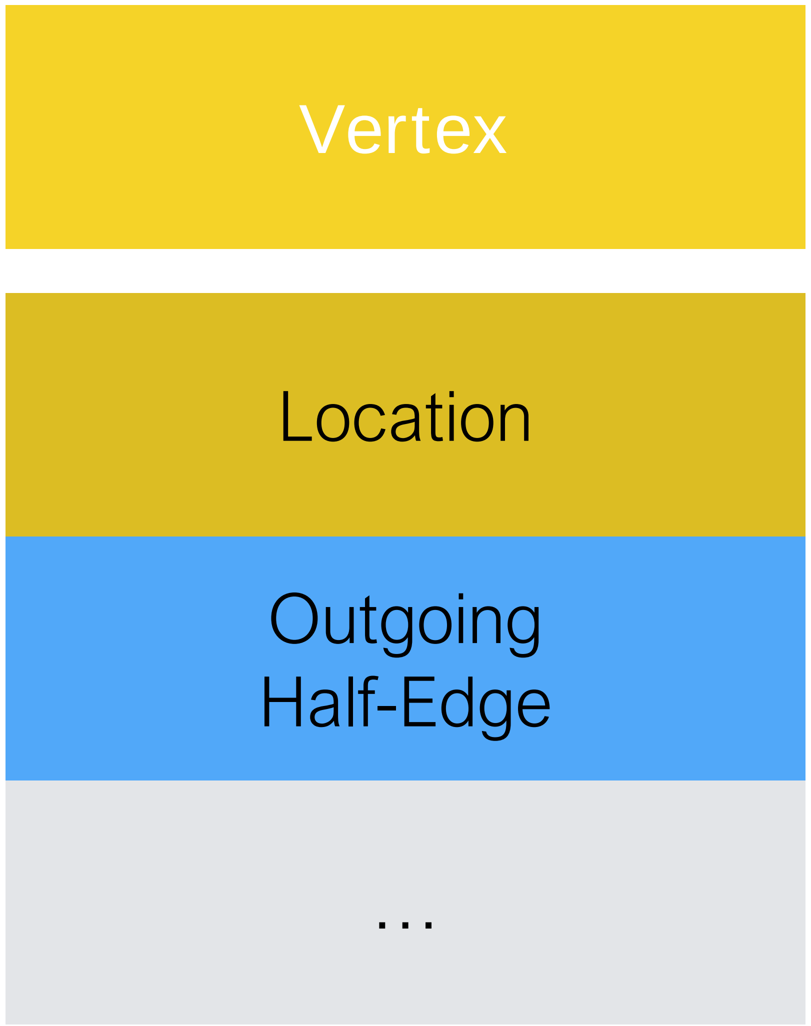
Face

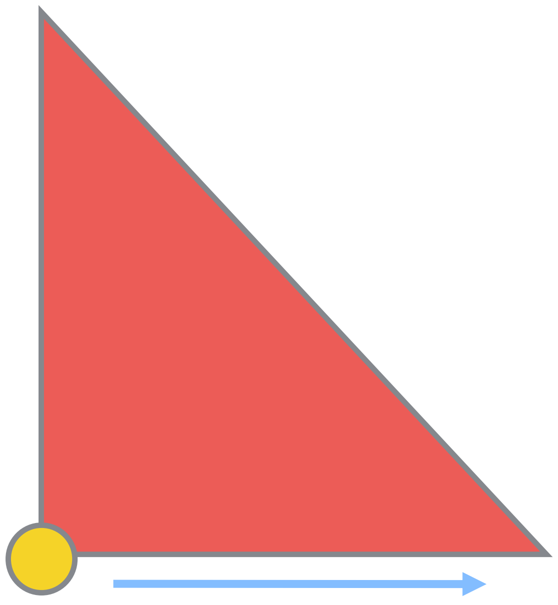
Next
Half-Edge





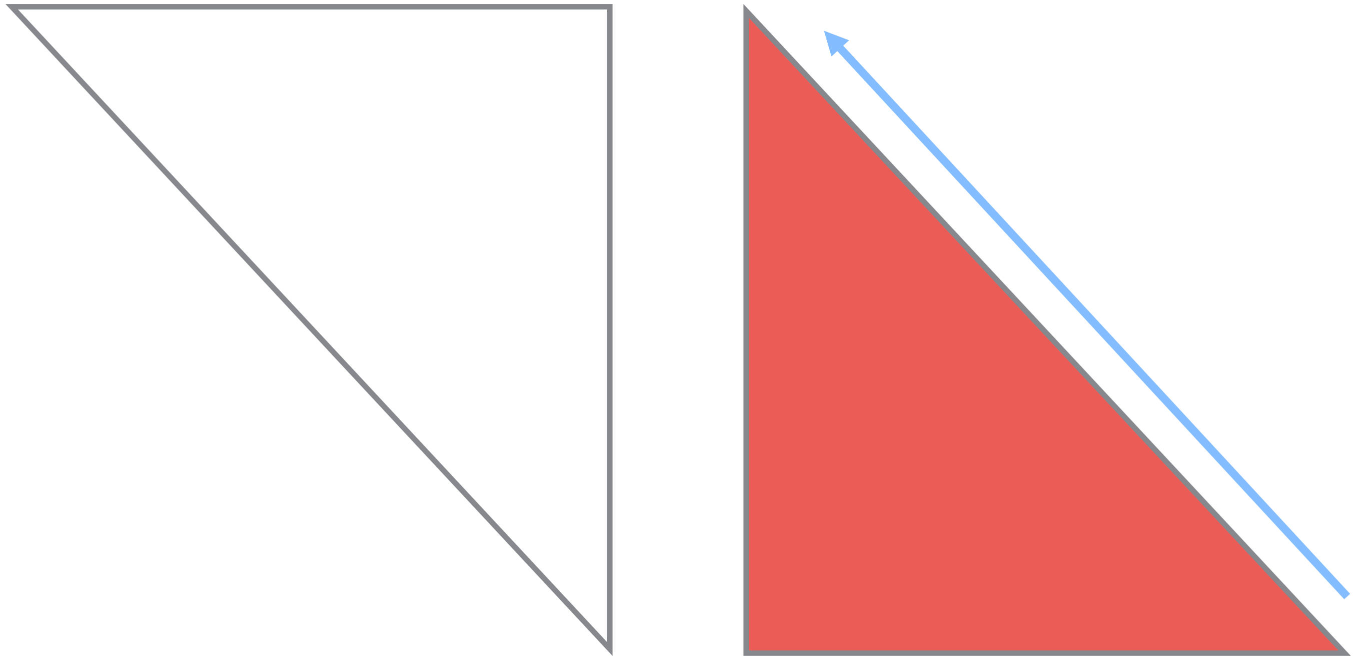
Half-Edge Data Structure



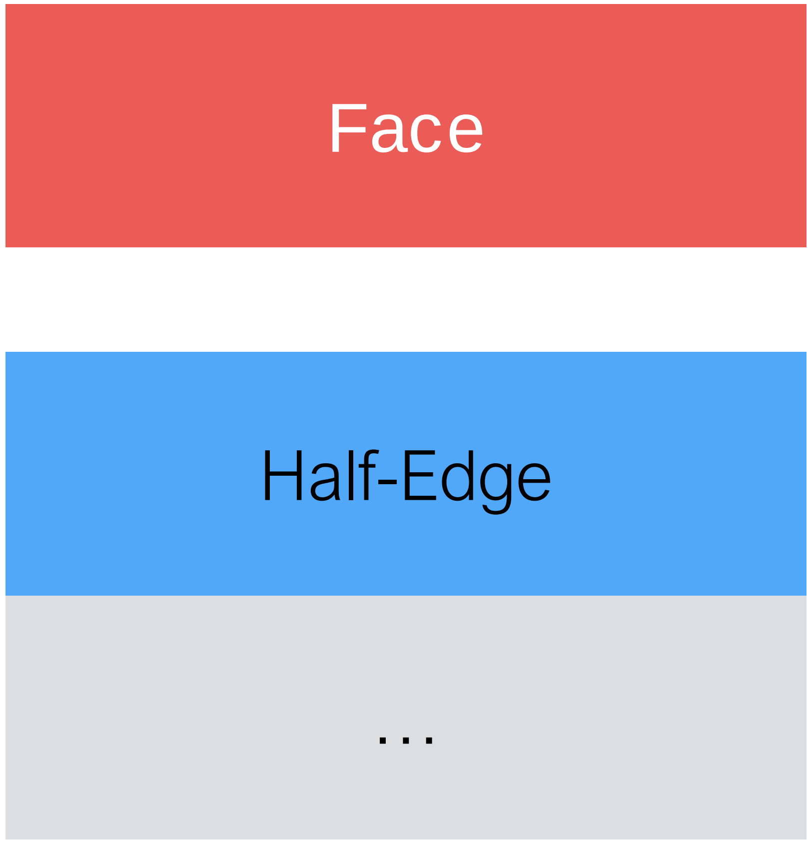


One of the two outgoing edges will be used

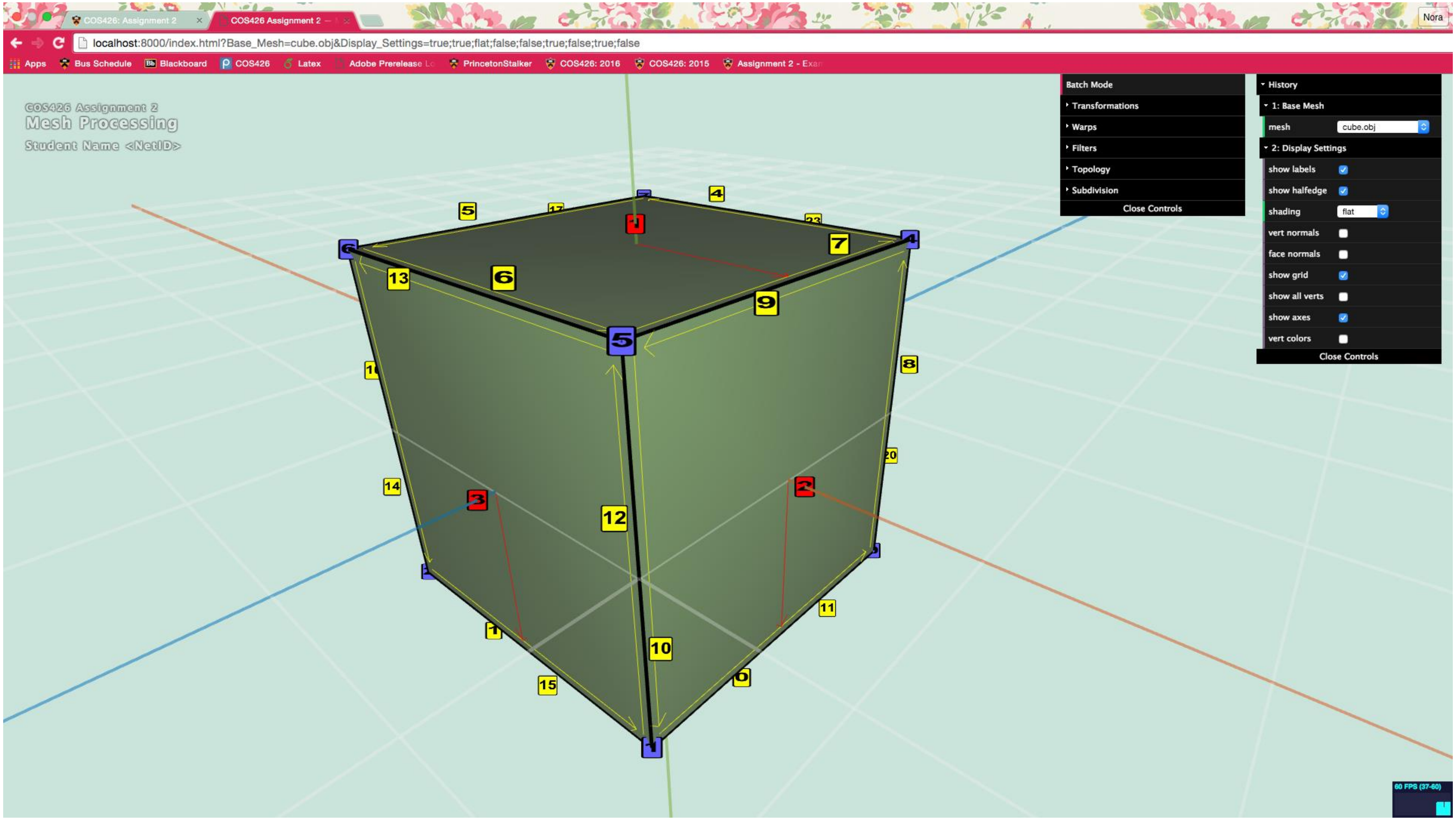
Half-Edge Data Structure



One of the three edges
will be used

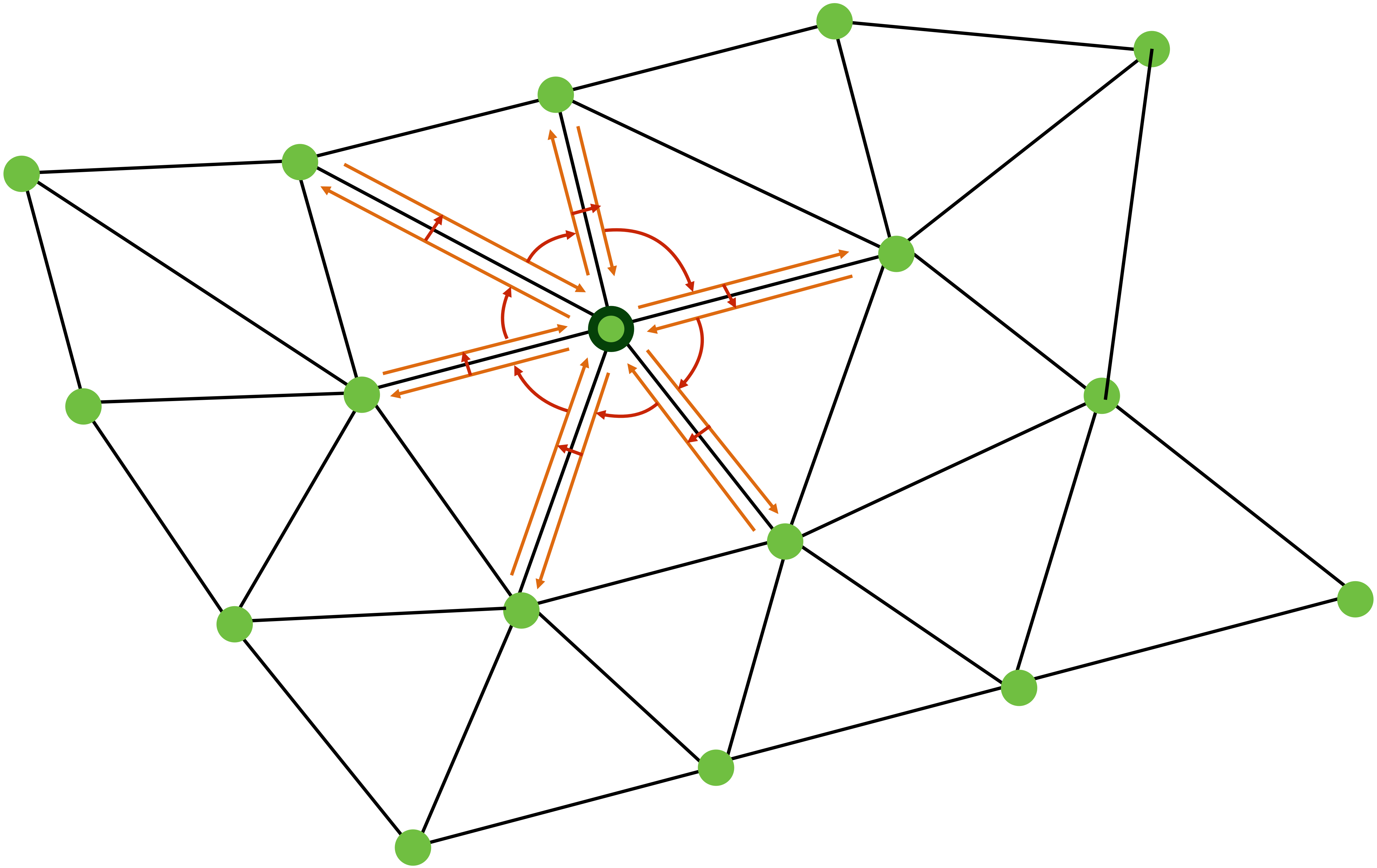


Half-Edge Visualization



Traversal

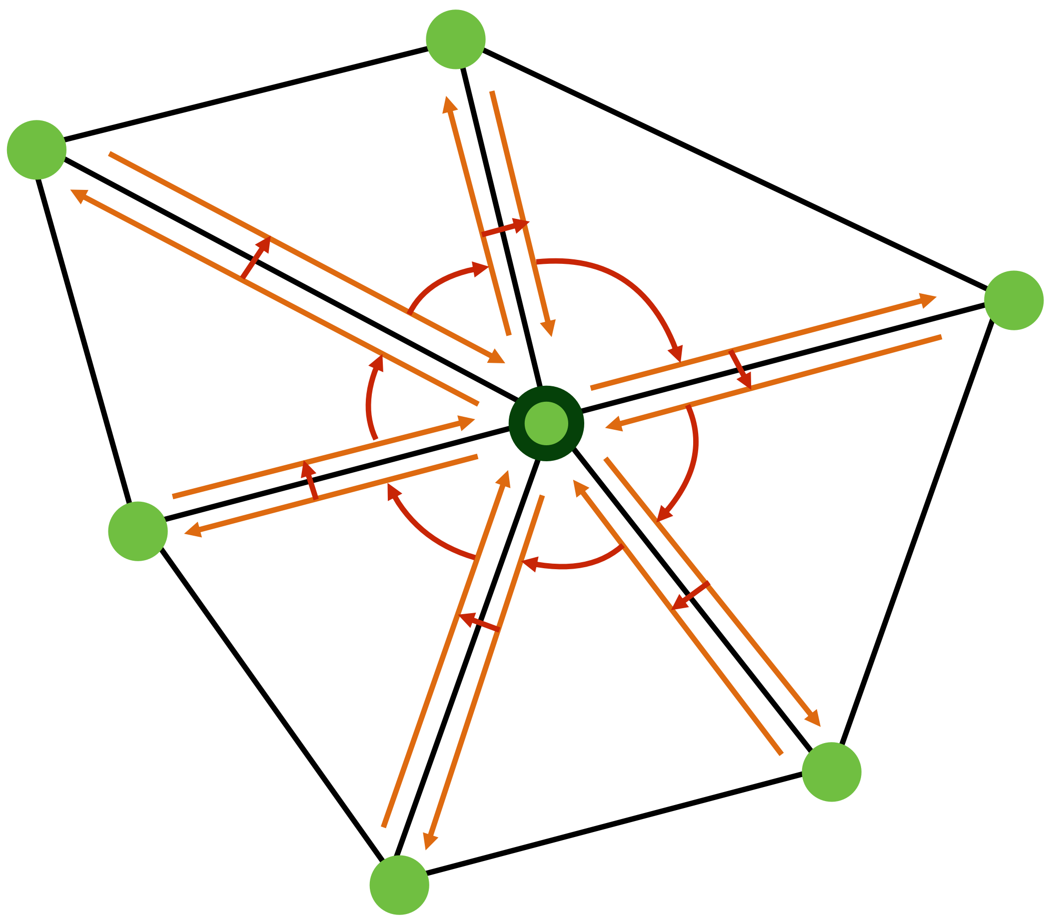
- How to get one-ring neighbors?



Traversal

- How to get one-ring neighbors?

```
original_he = vertex.he;
he = original_he;
do {
  // do something with data
  he = he.opposite.next;
} while ( he != original_he)
```



- Assignment will ask you for other kind of adjacency queries
  - Vertices around Face, Faces around Vertex etc.

Traversal

- Vertex Normals are defined as weighted average of adjacent faces (weighted by face area)

- How would you compute vertex normals given per face normal and area?

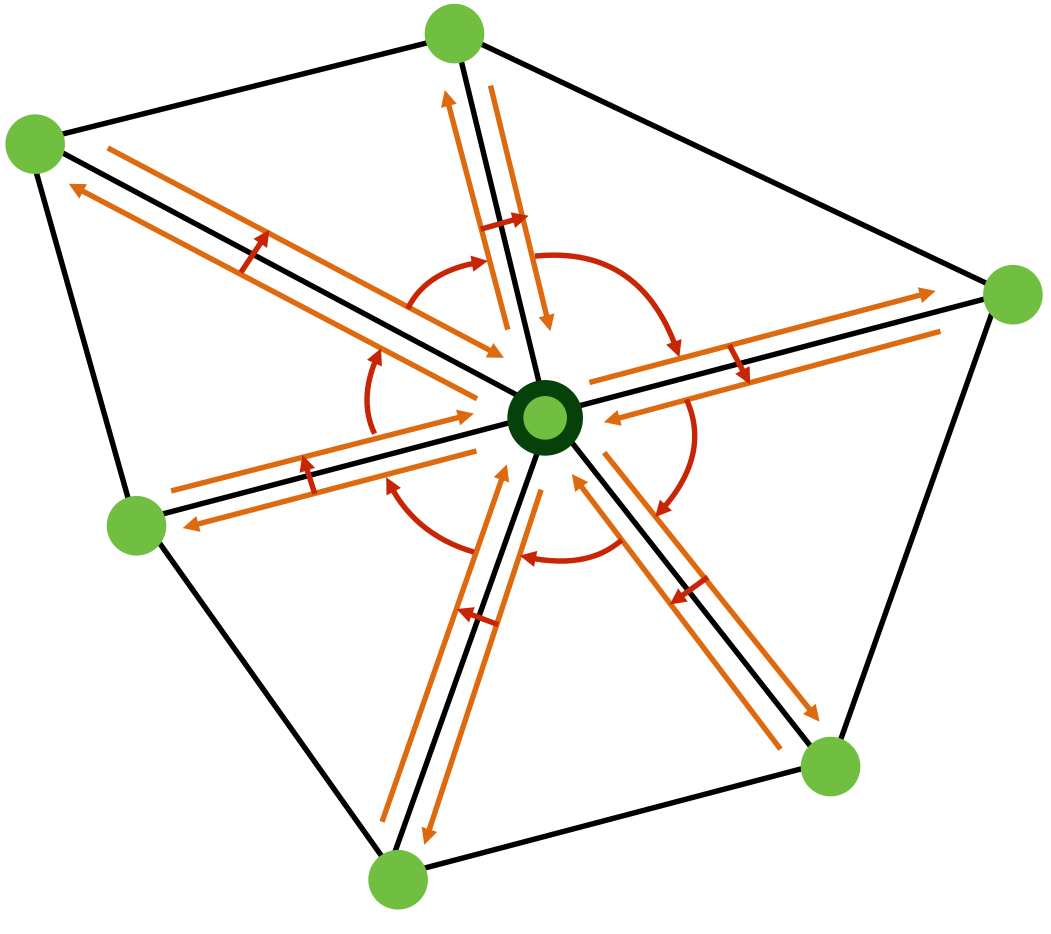
Half-Edge

Vertex

Opposite Half-Edge

Face

Next Half-Edge



Traversal

- Vertex Normals are defined as weighted average of adjacent faces (weighted by face area)

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original_he = vertex.he;
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do {
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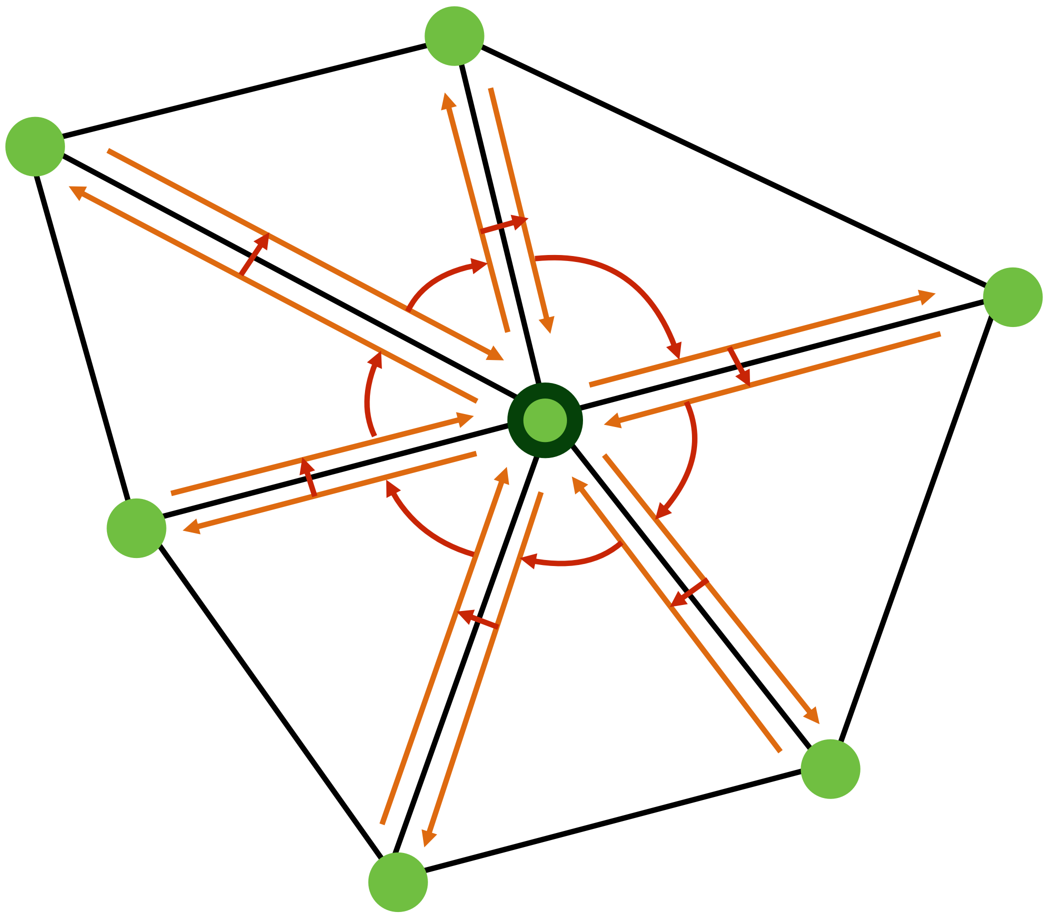
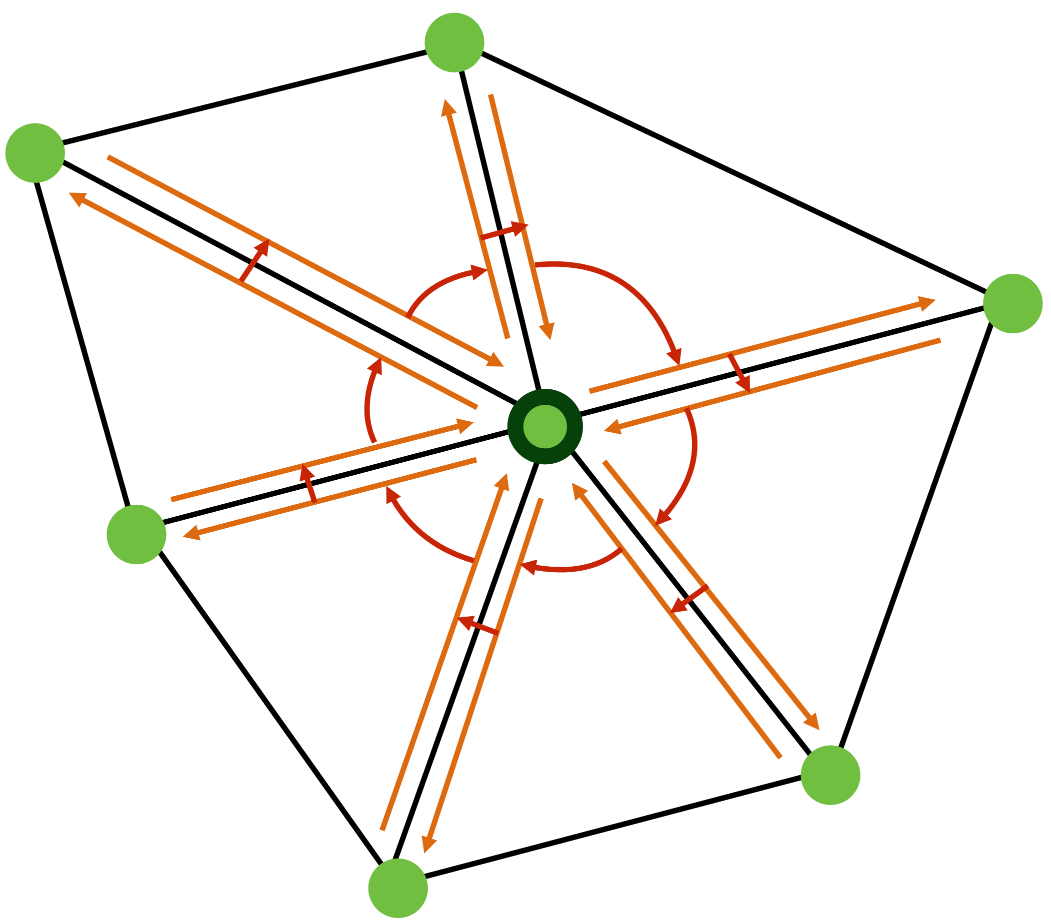
```



Traversal

- Vertex Normals are defined as weighted average of adjacent faces (weighted by face area)
- (Can also be done by using facesOnVertex)

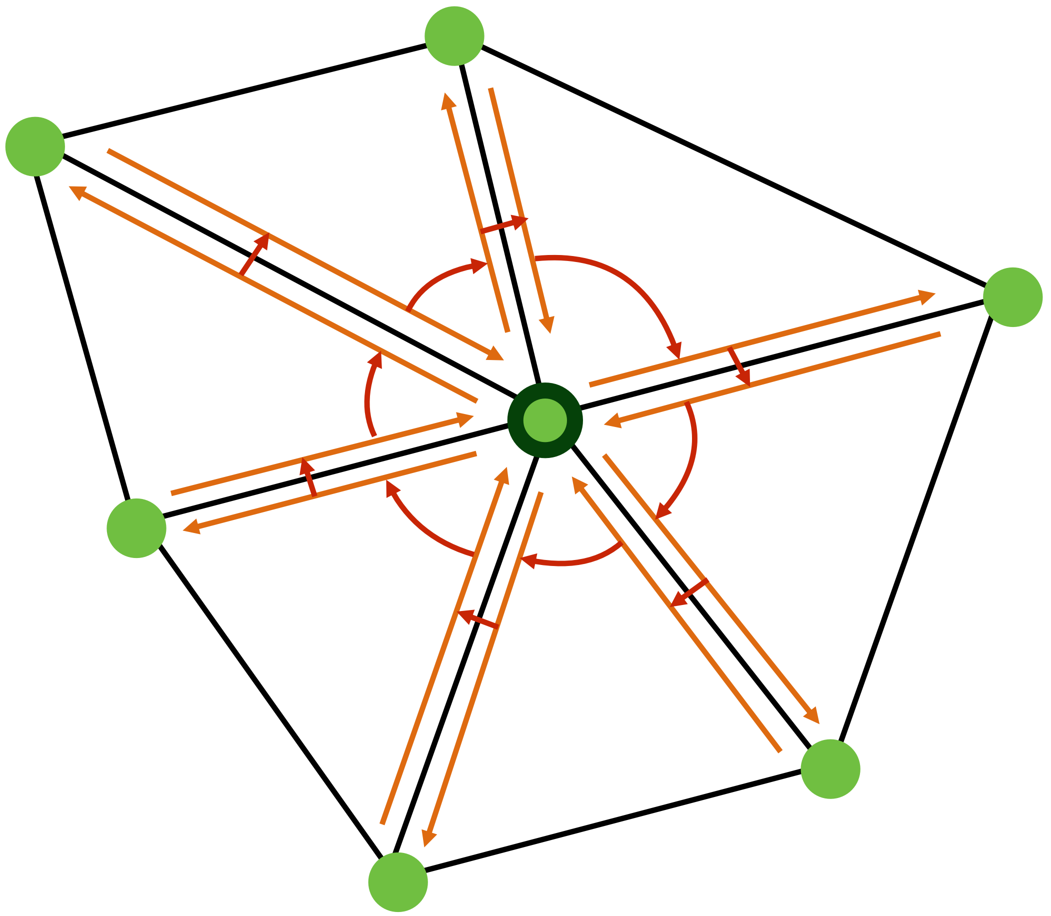
```
original_he = vertex.he;
he = original_he;
v_normal.set( 0, 0, 0 );
do {
  f_normal = he.face.normal;
  area = he.face.normal.area;
  v_normal.add(f_normal*area);
  he = he.opposite.next;
} while ( he != original_he)
v_normal.normalize();
```



Traversal

- Similarly, in uniform Laplacian smoothing each vertex is moved towards the average of it and its neighbors.

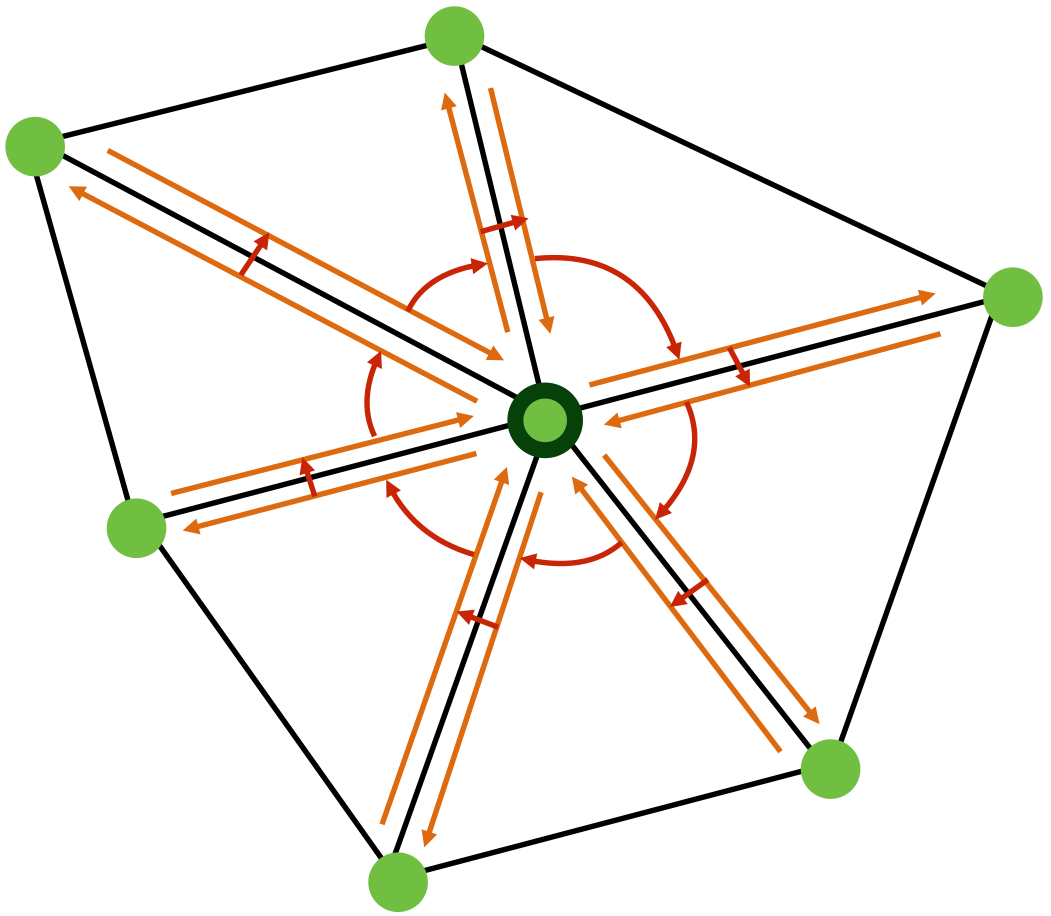
```
original_he = vertex.he;
he = original_he;
do {
  // do something with data
  he = he.opposite.next;
} while ( he != original_he)
```



Traversal

- Similarly, in uniform Laplacian smoothing each vertex is moved towards the average of it and its neighbors.

```
original_he = vertex.he;
he = original_he;
avg_pos.set( 0, 0, 0 );
do {
  avg_pos.add(he.vertex);
  he = he.opposite.next;
} while ( he != original_he)
avg_pos.add(-vertex*num_neigh);
new_pos = vertex + avg_pos*delta;
```



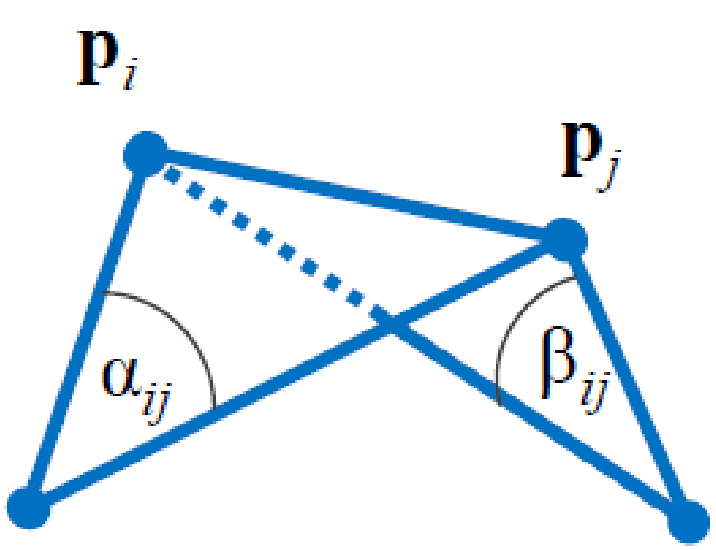
Traversal

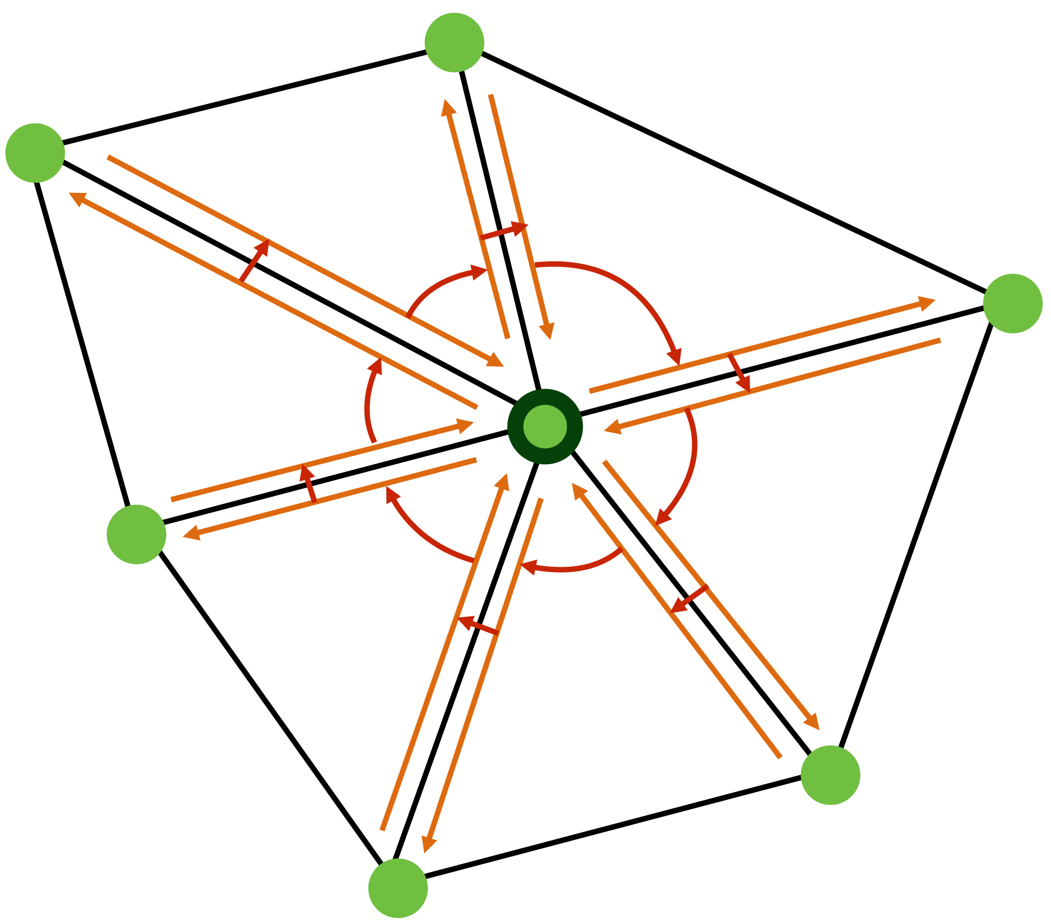
- Cotan Laplacian smoothing

avg_pos.add(he.vertex); ⟶ avg_pos.add(w*he.vertex);

num_neigh ⟶ total_w

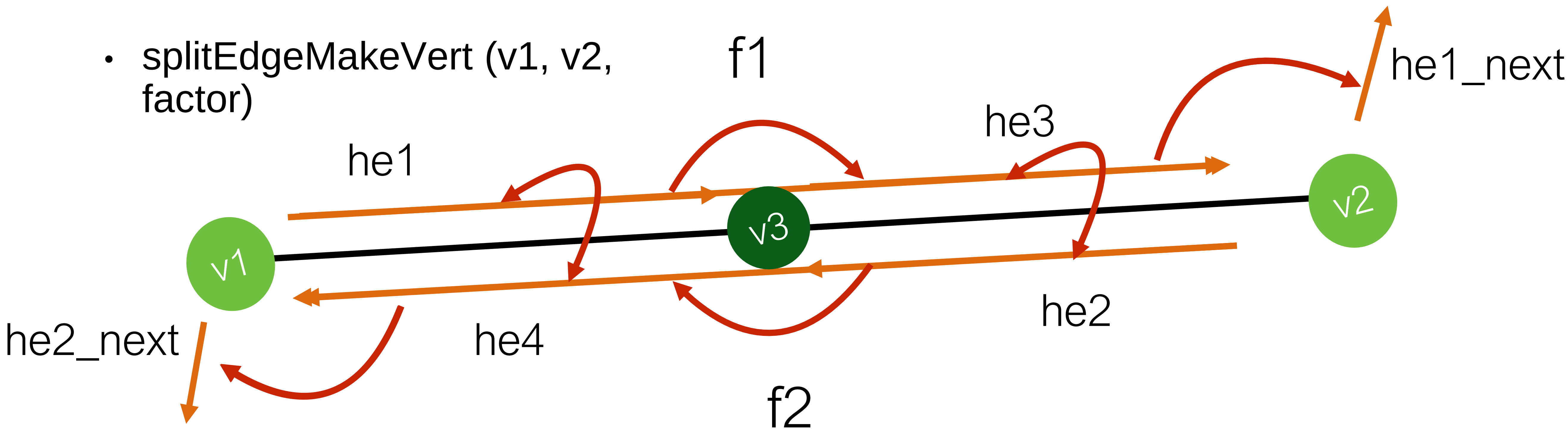
$$w = \frac{\cot(\alpha_{ij}) + \cot(\beta_{ij})}{2}$$





Data Structure Modification

- splitEdgeMakeVert (v1, v2, factor)




```
v3 = addVertex( weightedAvgPos(v1, v2, factor) );

he1.vertex = v3;
he2.vertex = v3;

he3 = addHalfEdge( v3, v2, f1 );
he4 = addHalfEdge( v3, v1, f2 );

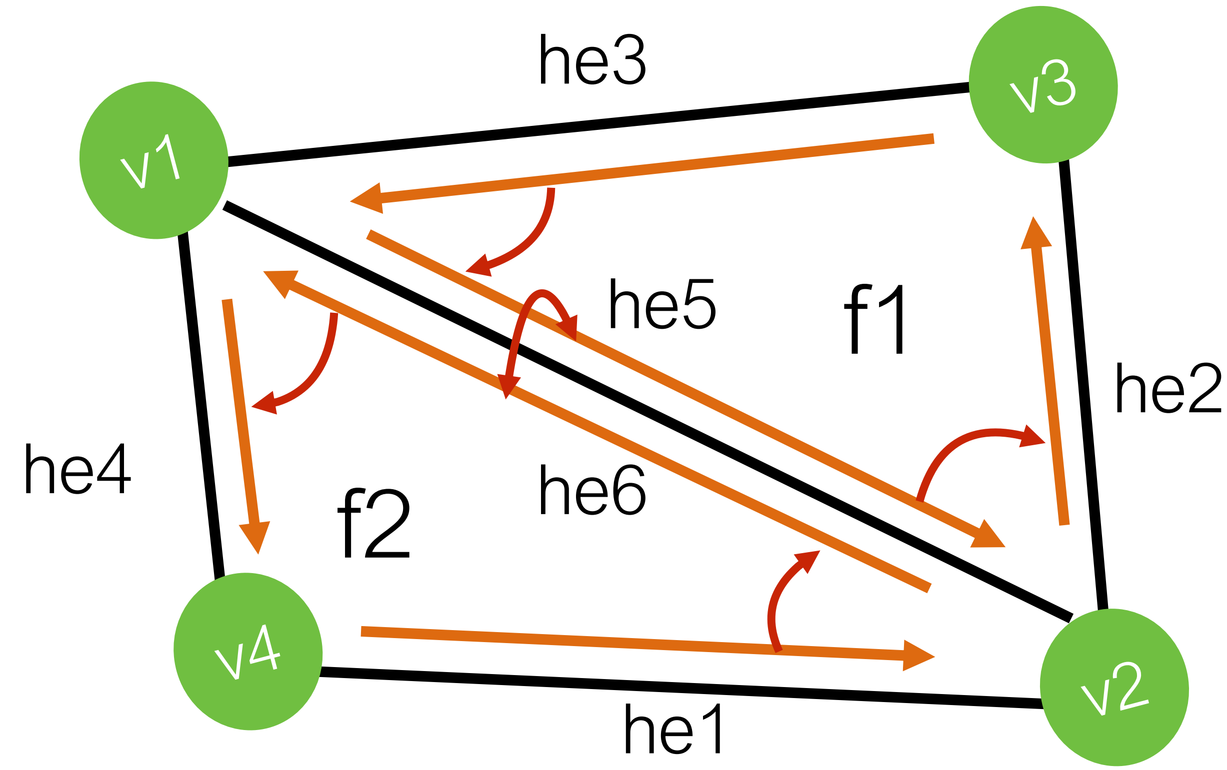
he1.next = he3;
he2.next = he4;

he3.next = he1_next;
he4.next = he2_next;

he1.opposite = he4;
he4.opposite = he1;
he2.opposite = he3;
he3.opposite = he2;
```

Data Structure Modification

- splitFaceMakeEdge (f, v1, v2, vertOnF, switchFaces)




```
f2 = addFace();

he5 = addHalfEdge( v1, v2, f1 );
he6 = addHalfEdge( v2, v1, f2 );
he5.opposite = he6;
he6.opposite = he5;
```

```
he5.next = he2;
he3.next = he5;
he1.next = he6;
he6.next = he4;

f1.halfedge = he5;
f2.halfedge = he6;
```

Remember to re-link he4 and he1 to point to f2

Data Structure Modification

- How would you go about subdividing a quad face?
  - You’re given split edge and split face
  - Just use those - guaranteed validity of dataset after use!
- Part of the assignment
  - Think about it for next week!