

csc418/2504 Computer Graphics

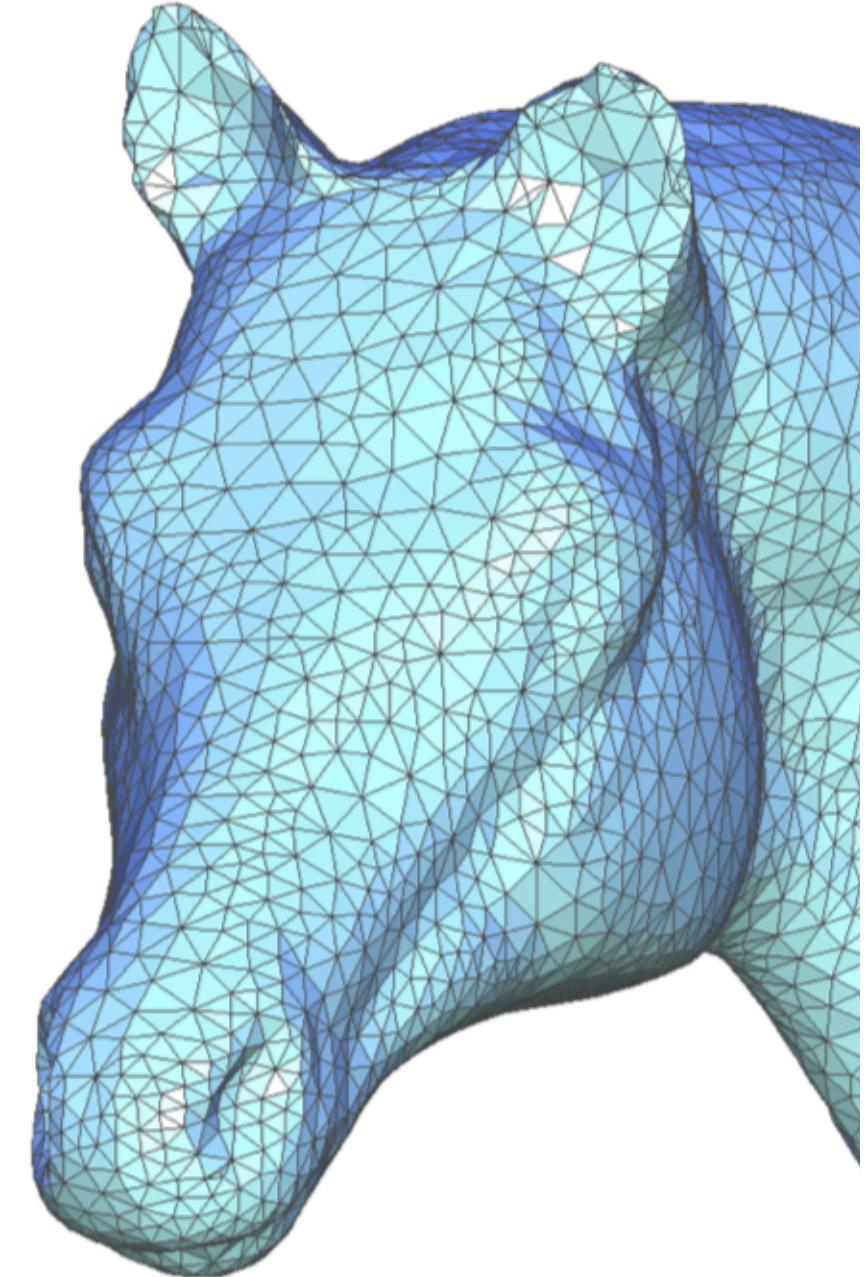
Rob Katz

Some Slides/Images adapted from Marschner and Shirley

Meshes



Ottawa Convention Center



Meshes

Types of Surfaces

Triangles

Data Structures for Triangle Meshes

Normals for Meshes

Texture Mapping

Subdivision Surfaces

Announcements

Assignment 4 due Friday

Point – Triangle squared distance is a bonus

Assignment 5 out soon

TA Office Hours: Thursday 2:30pm – 3:30pm, BA5256

TA Email Address: ***csc418tas@cs.toronto.edu***

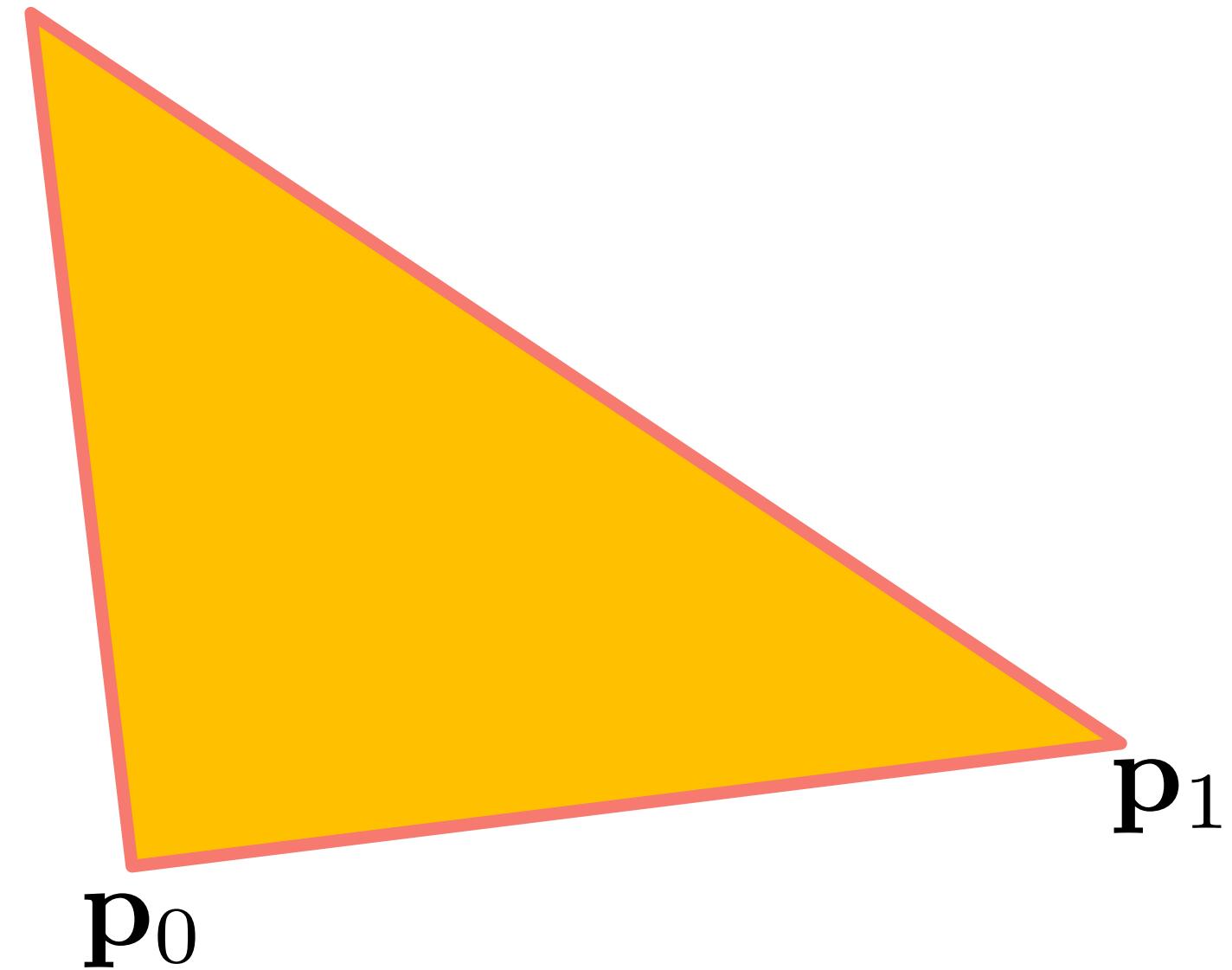
Any Questions ?

Surface Representations in Graphics

What are the two main types of surface representations ?

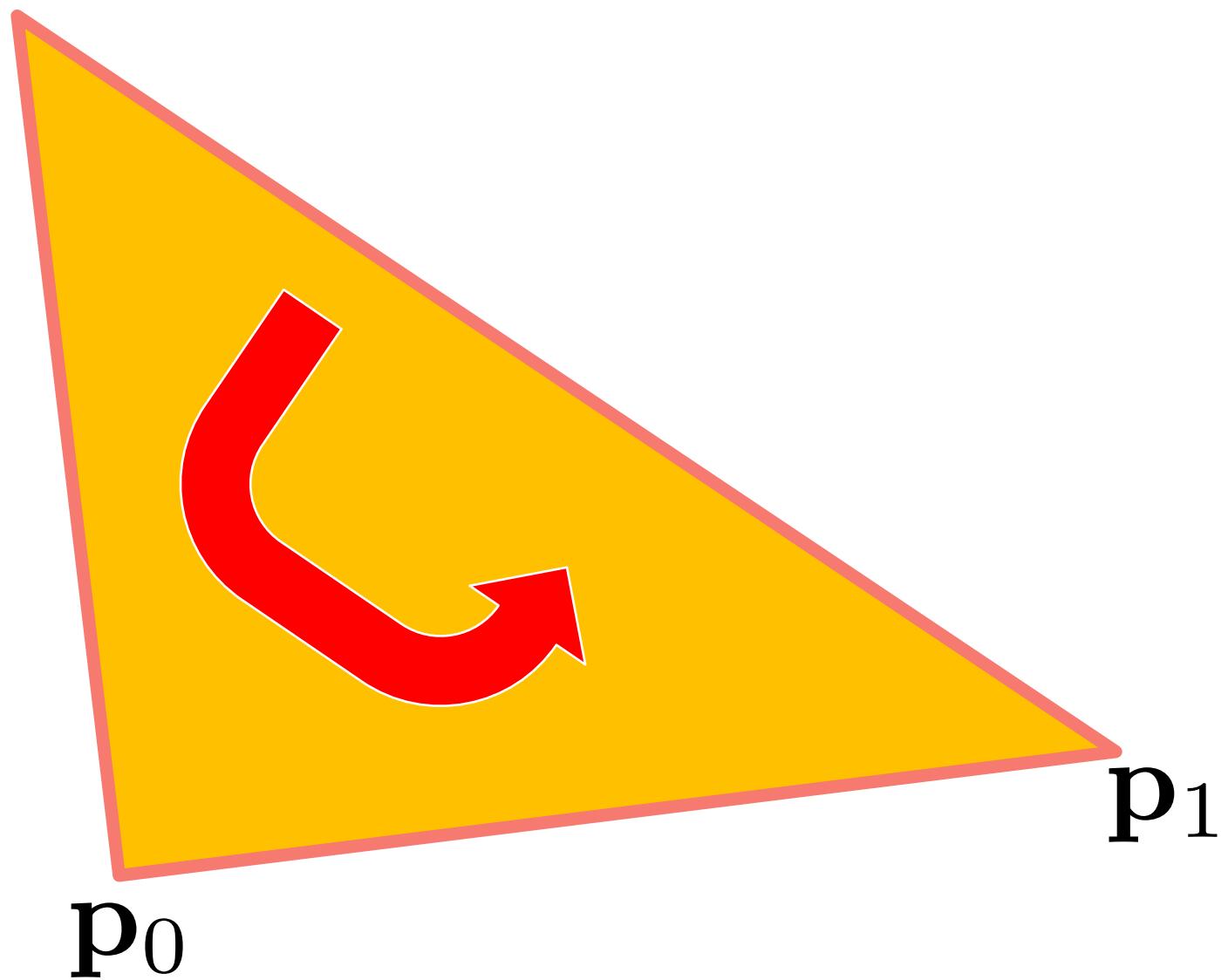
Triangles

p_2

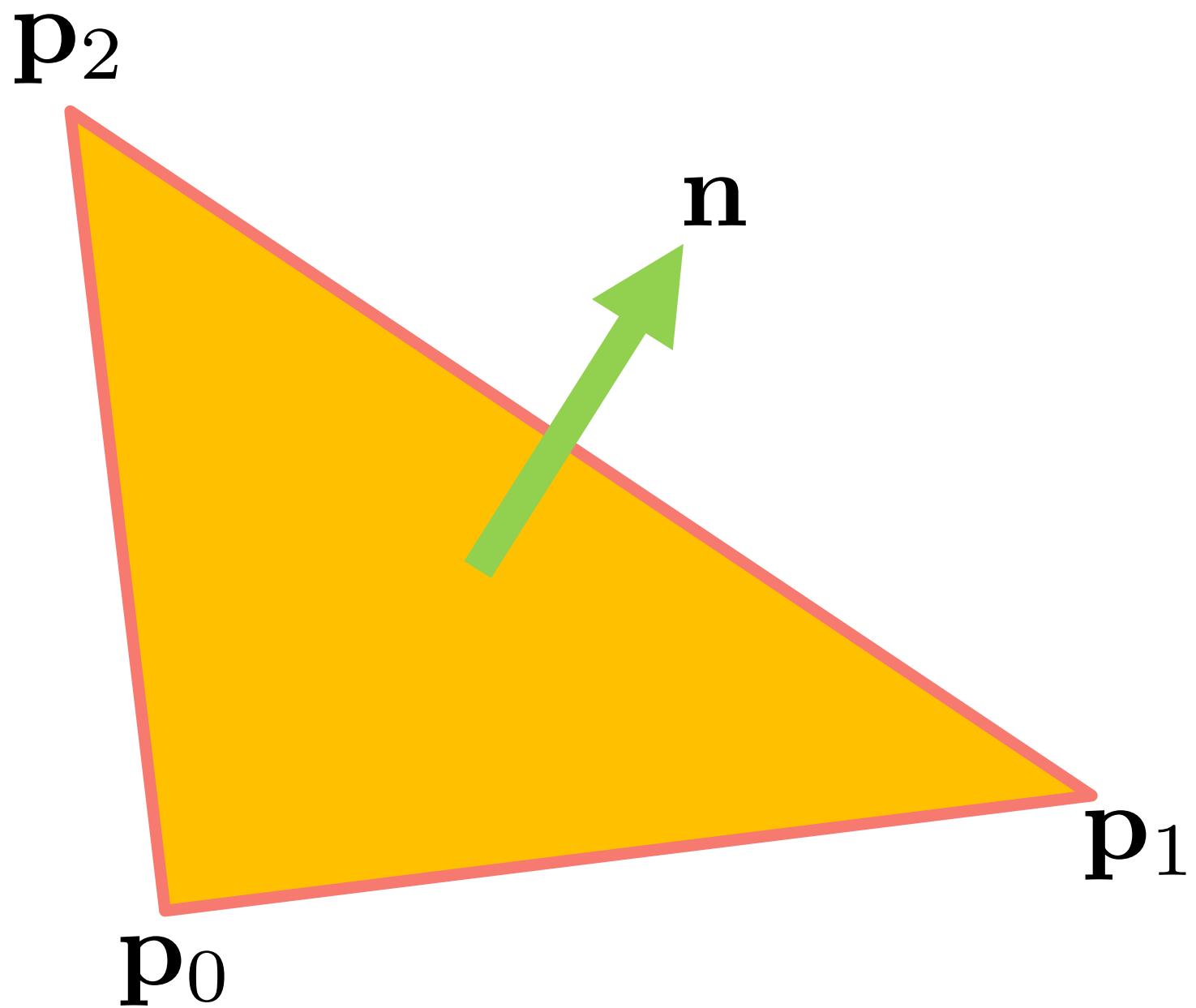


Triangles

p_2

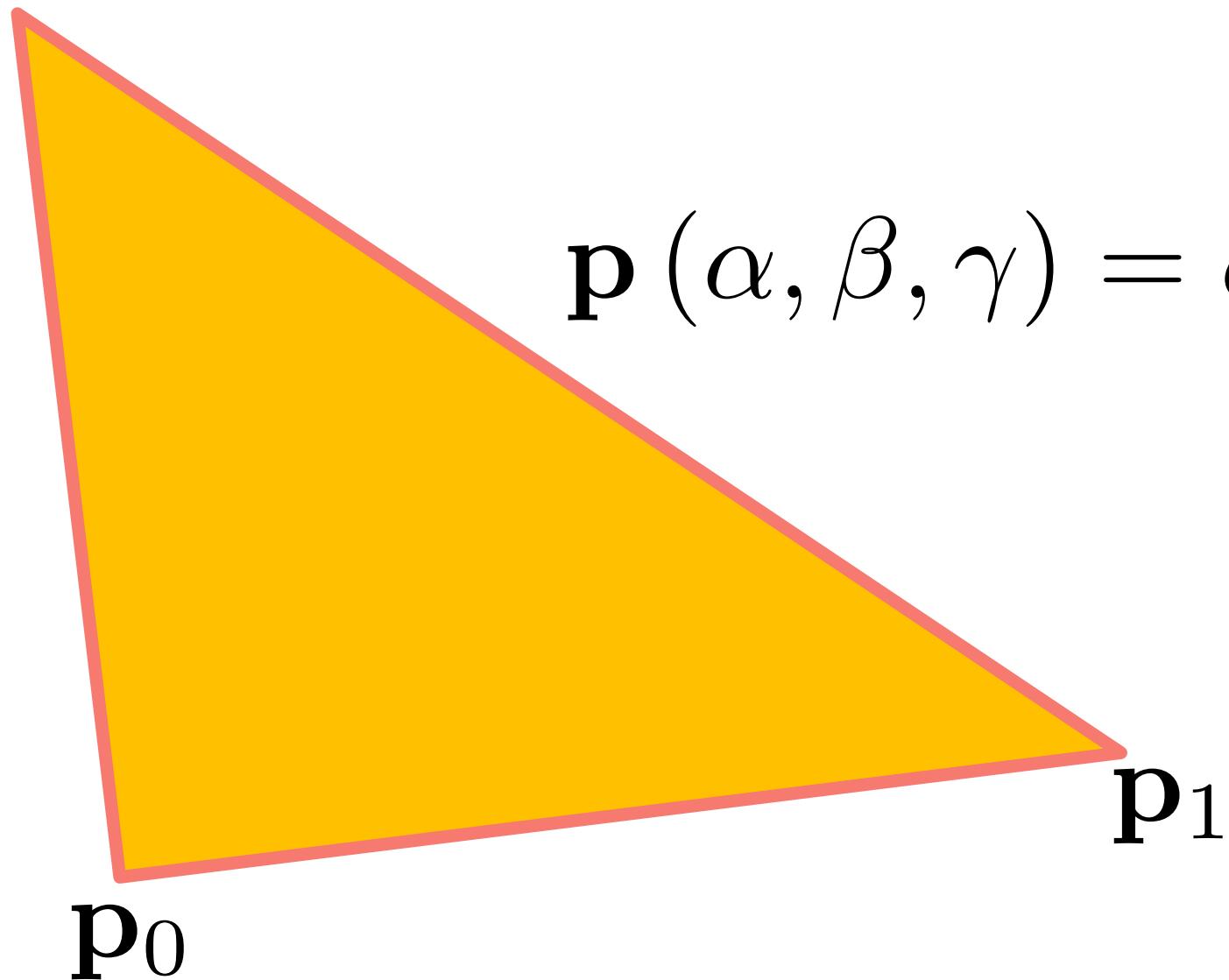


Triangles



Barycentric Coordinates

\mathbf{p}_2



$$\mathbf{p}(\alpha, \beta, \gamma) = \alpha\mathbf{p}_1 + \beta\mathbf{p}_2 + \gamma\mathbf{p}_0$$

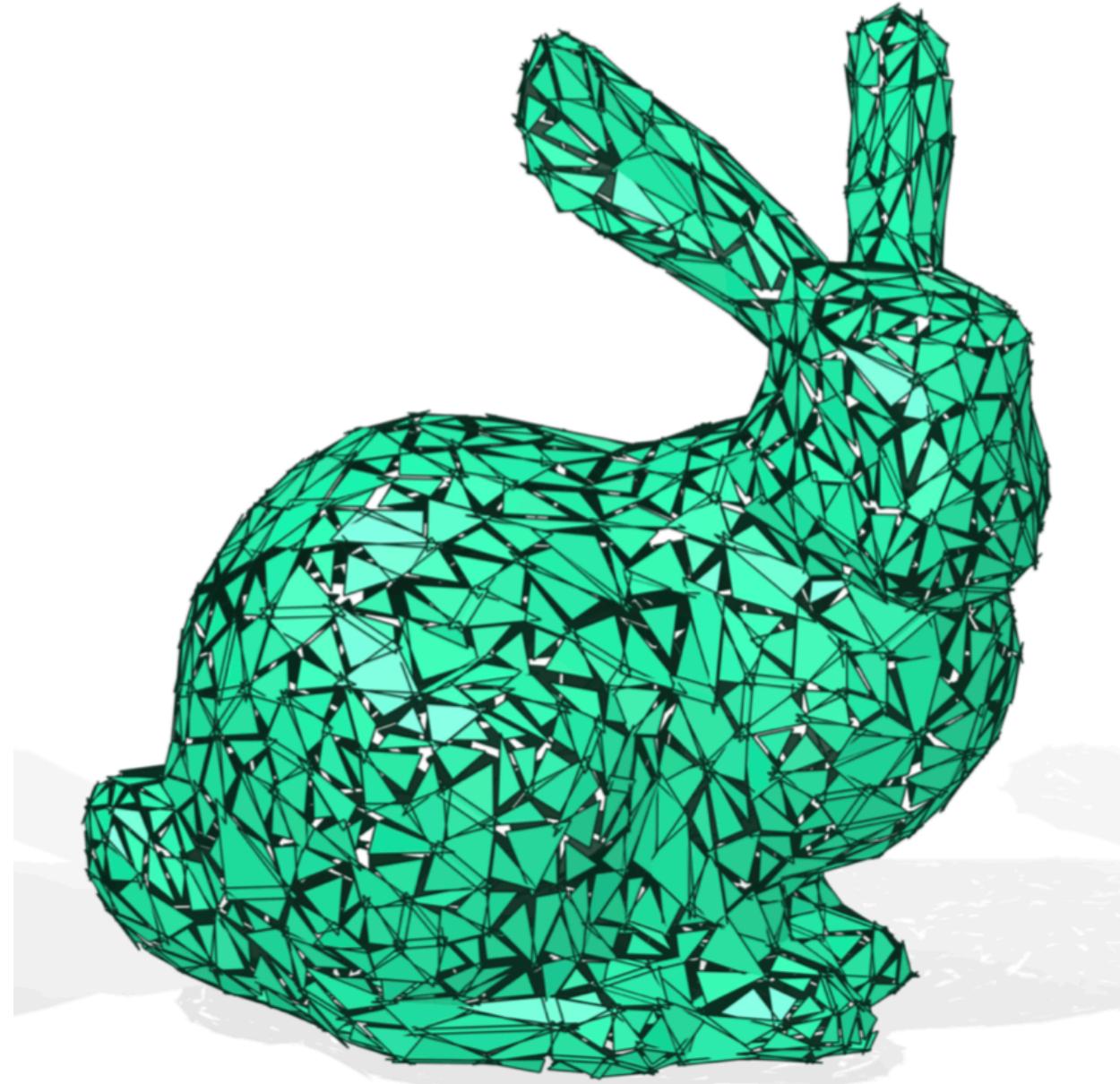
$$\alpha \geqslant 0$$

$$\beta \geqslant 0$$

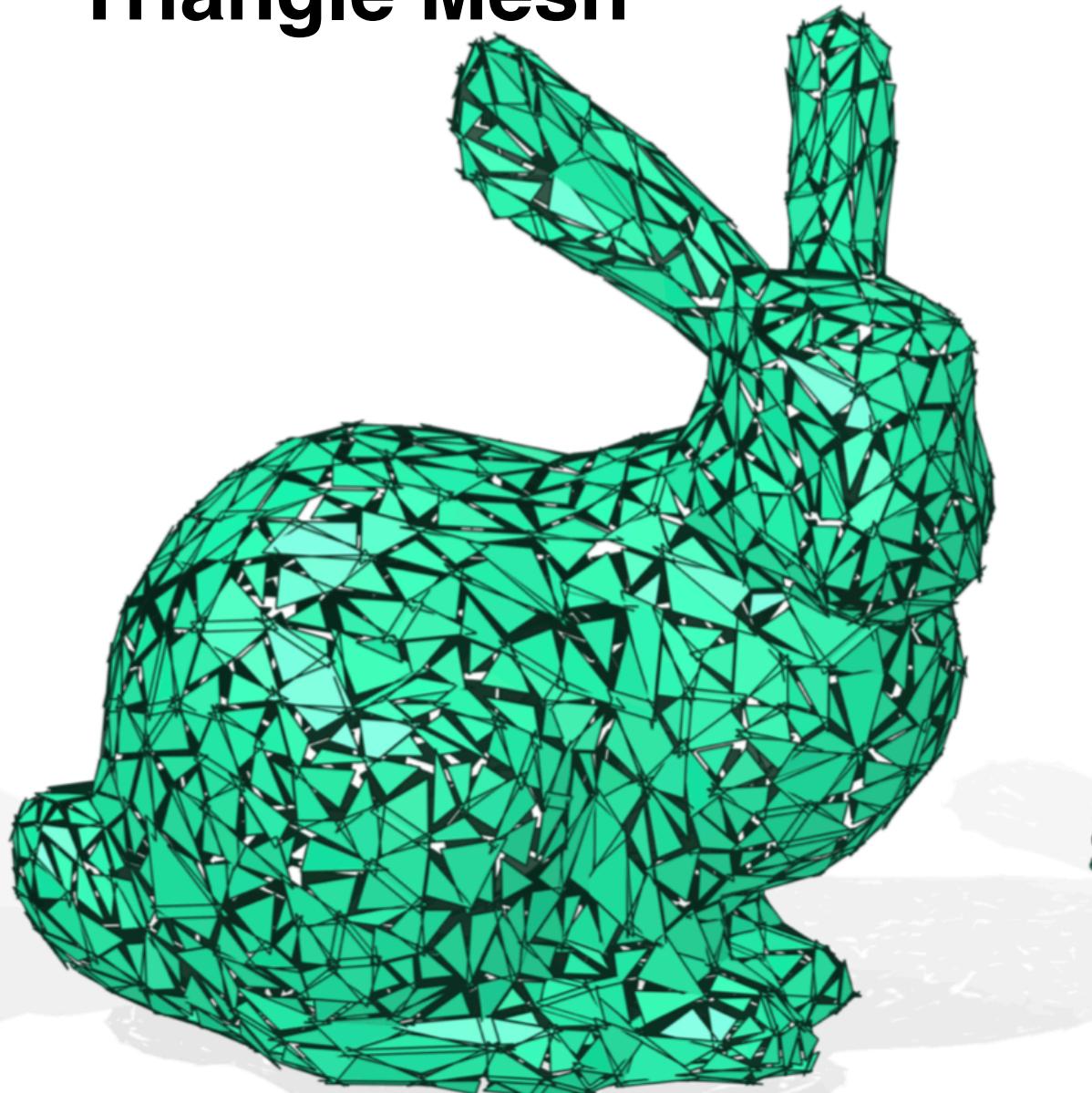
$$\alpha + \beta \leqslant 1$$

$$\gamma = 1 - \alpha - \beta$$

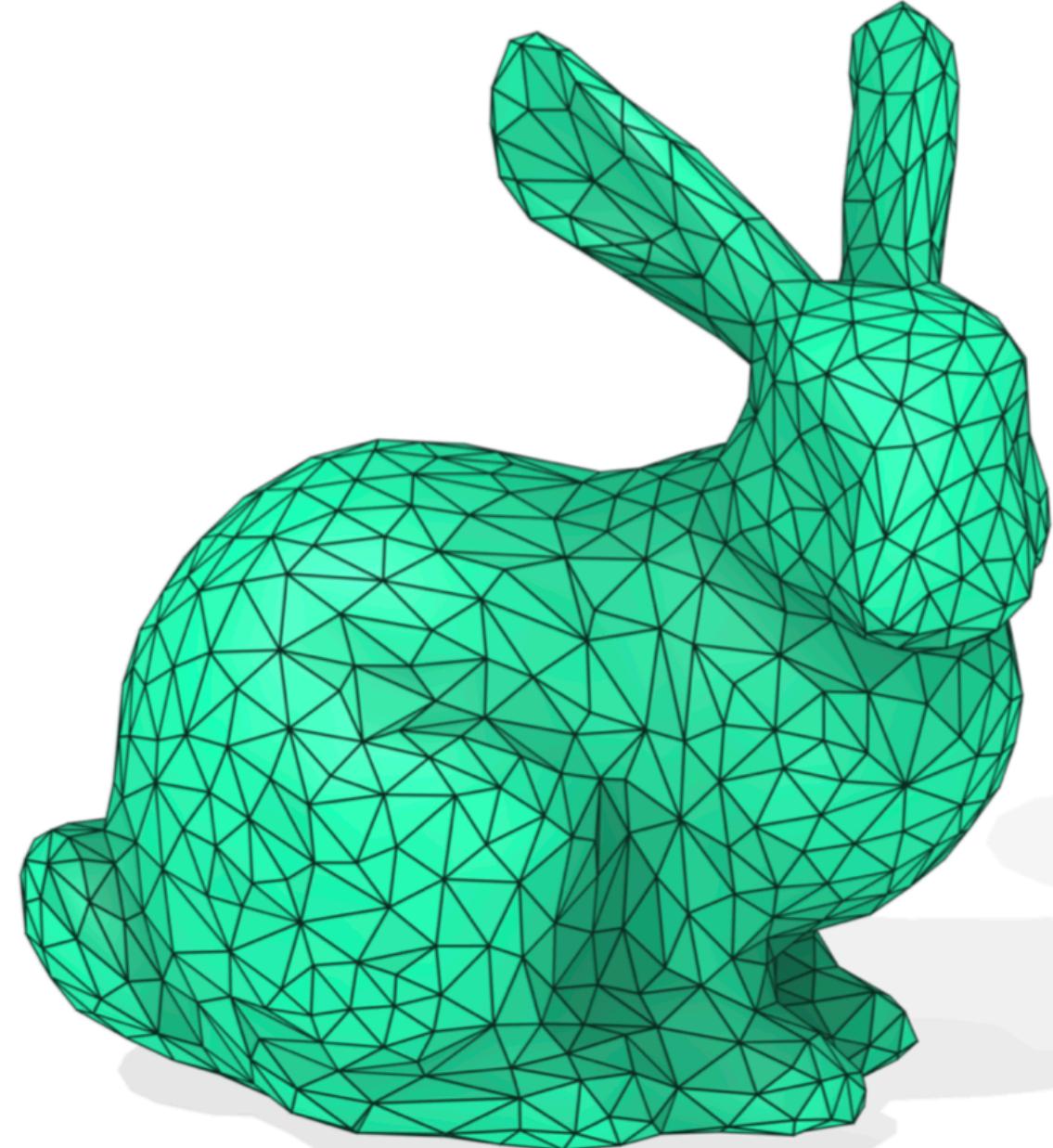
Triangle Soup



Triangle Mesh



Soup



Mesh

Topology

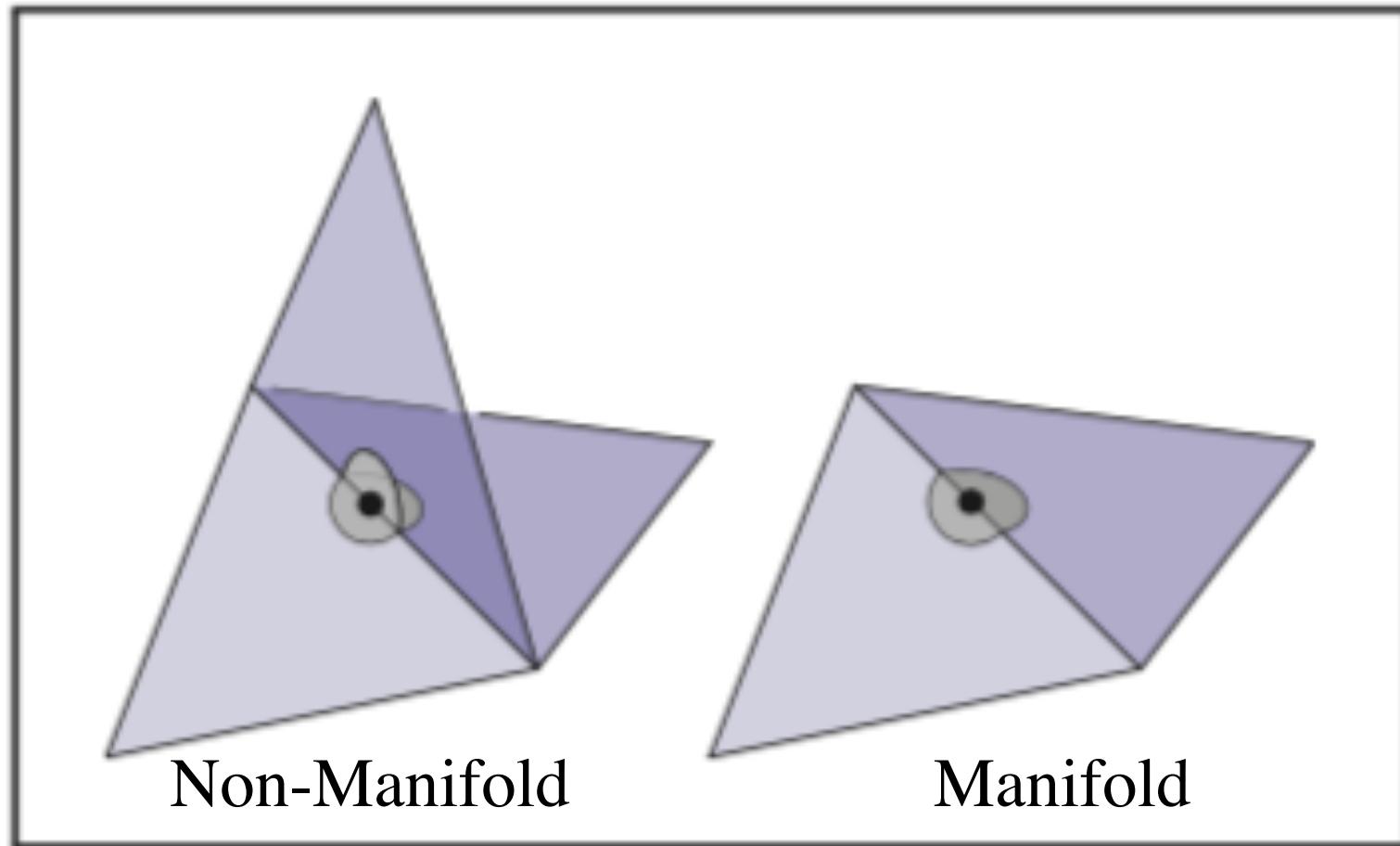
Topology is concerned with the connectivity of a mesh

Many algorithms are easier to implement or more efficient when connectivity data is available (we'll see an example of this later on).

We are going to assume that our meshes are *2-manifolds*

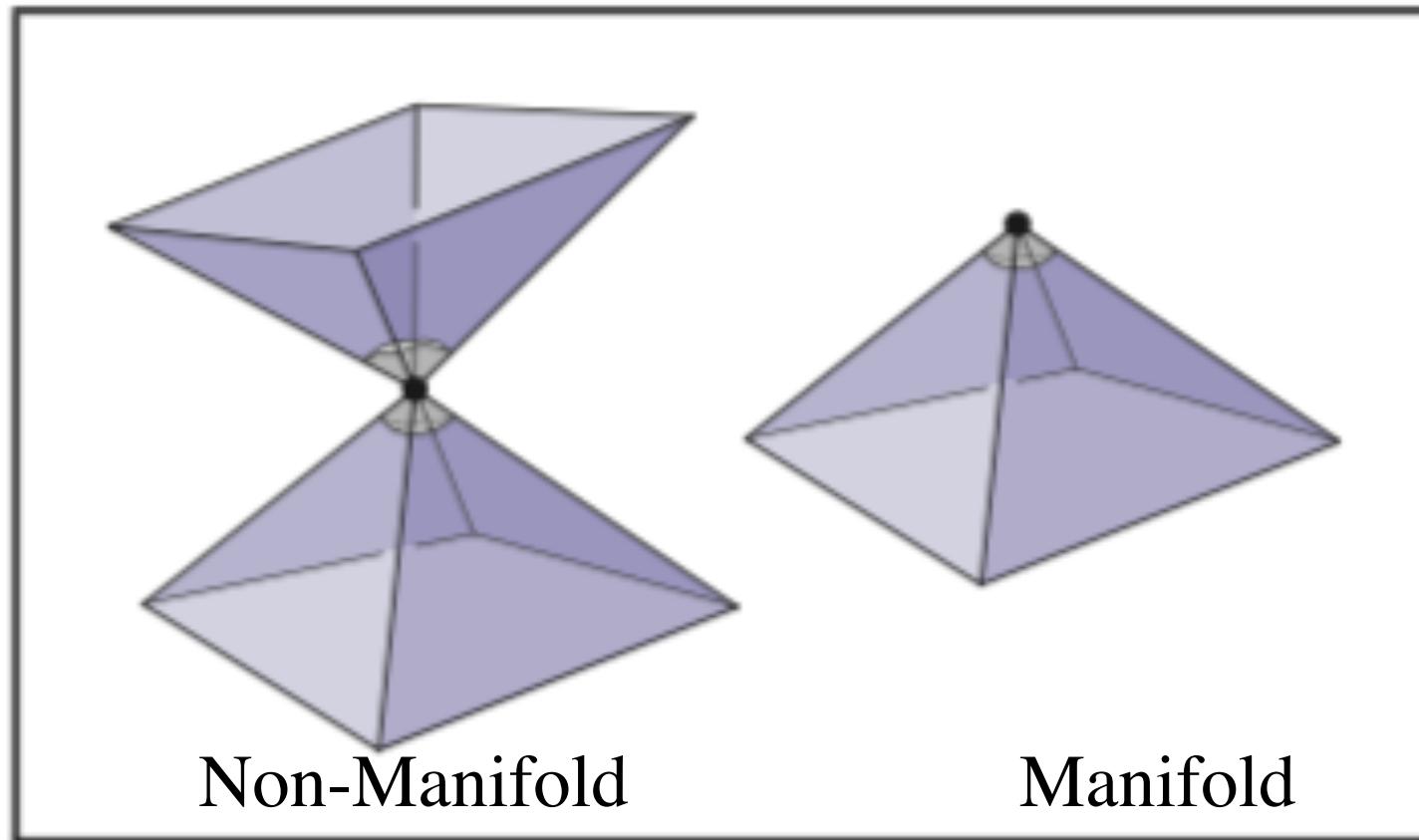
Manifold

A *2-manifold* is a surface for which the neighbourhood around any point can be flattened onto the plane



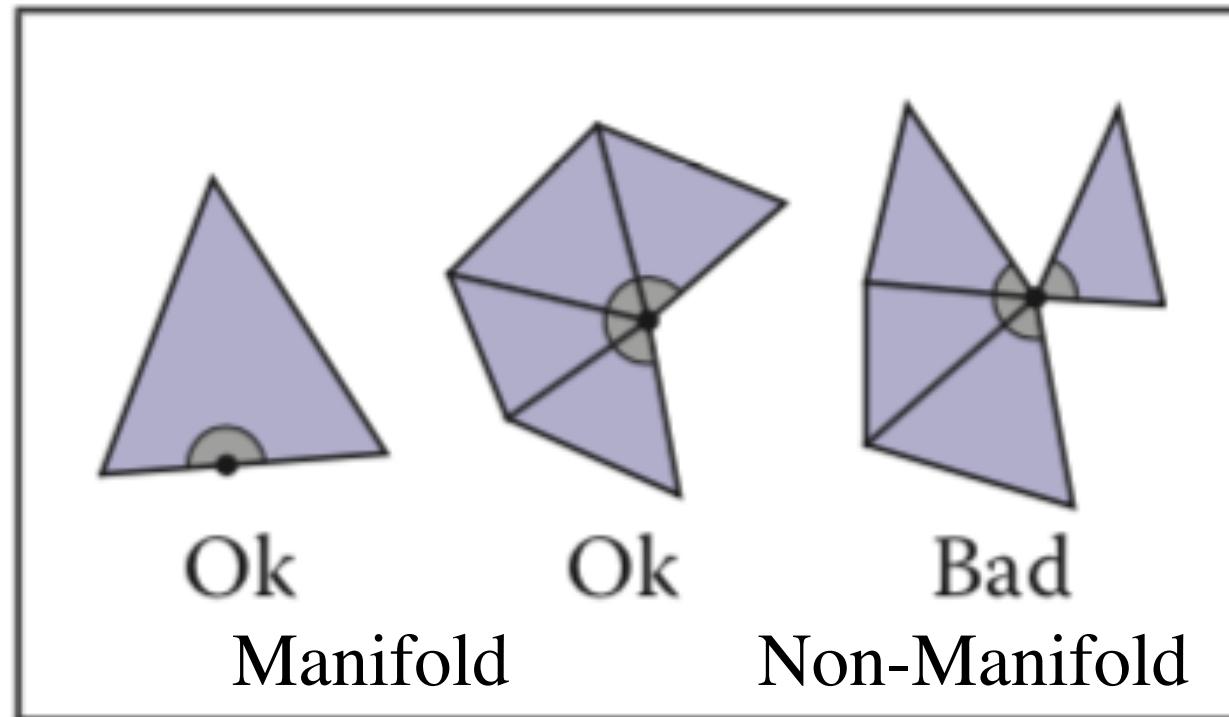
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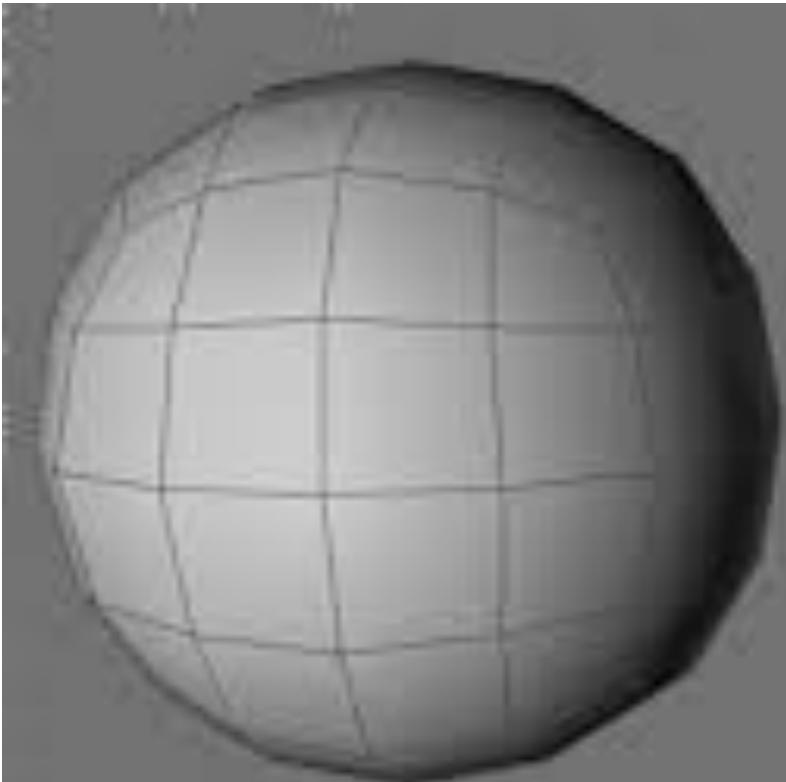
Manifold

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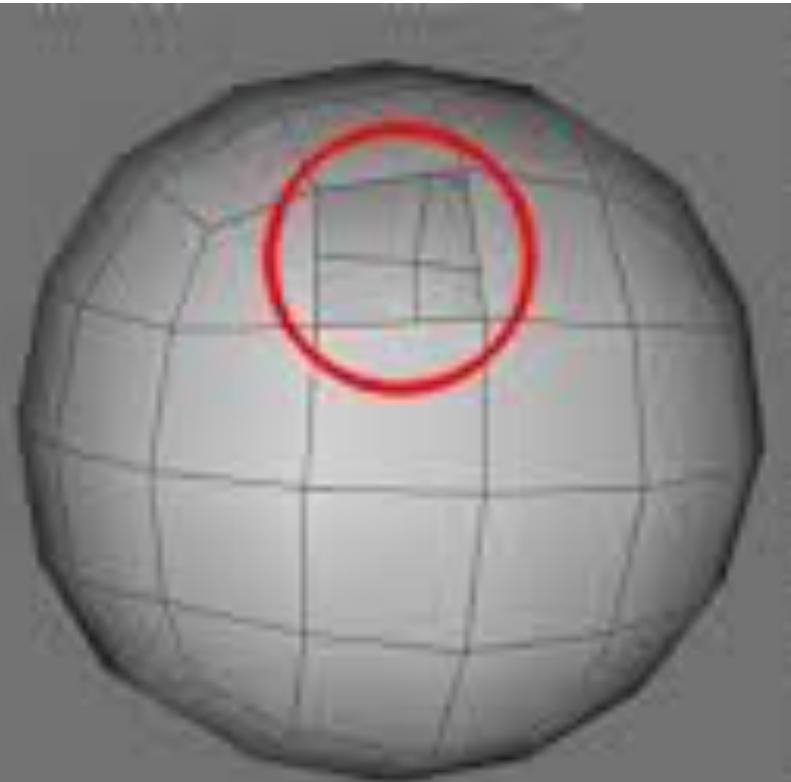


Watertight

Watertight meshes have no holes



Watertight Mesh

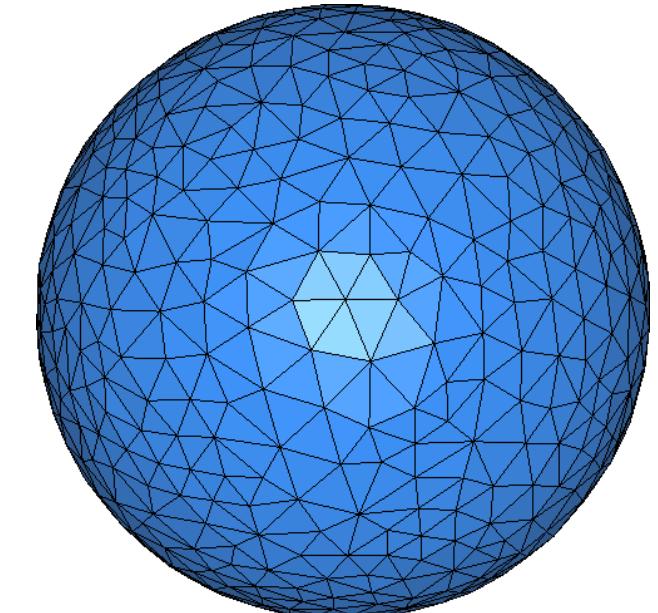


Not Watertight

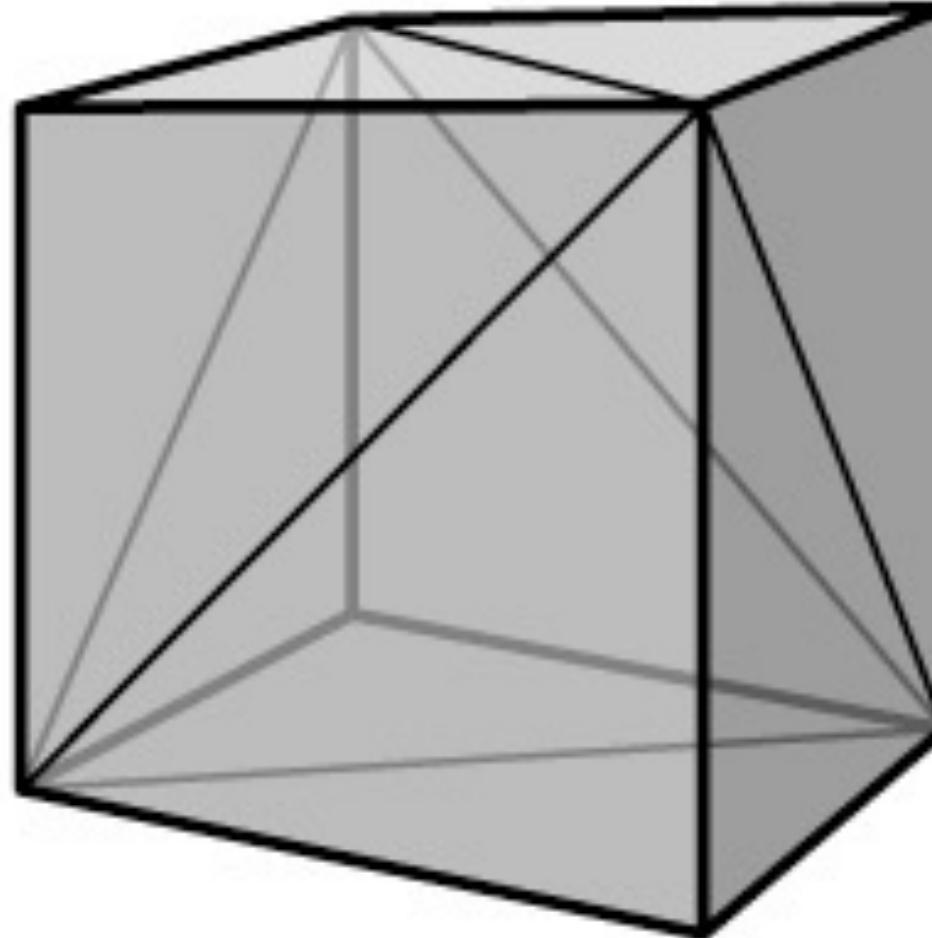
Geometry

Geometrically, a mesh is a piecewise planar surface
almost everywhere, it is planar
exceptions are at the edges where triangles join

Often, it's a piecewise planar approximation of a smooth surface



Examples of Meshes



12 triangles, 8 vertices

Examples of Meshes



10 million triangles from a high-resolution 3D scan

Traditional Thai sculpture—scan by XYZRGB, inc.,
image by MeshLab project



About a trillion triangles from automatically processed satellite and aerial photography.

Google earth

42°26'48.26" N 76°29'15.80" W elev 720 ft eye alt 1438 ft

Storing Triangle Meshes

What do we care about ?

Data Structures for Triangle Meshes

Separate Triangles

Indexed Triangle Set

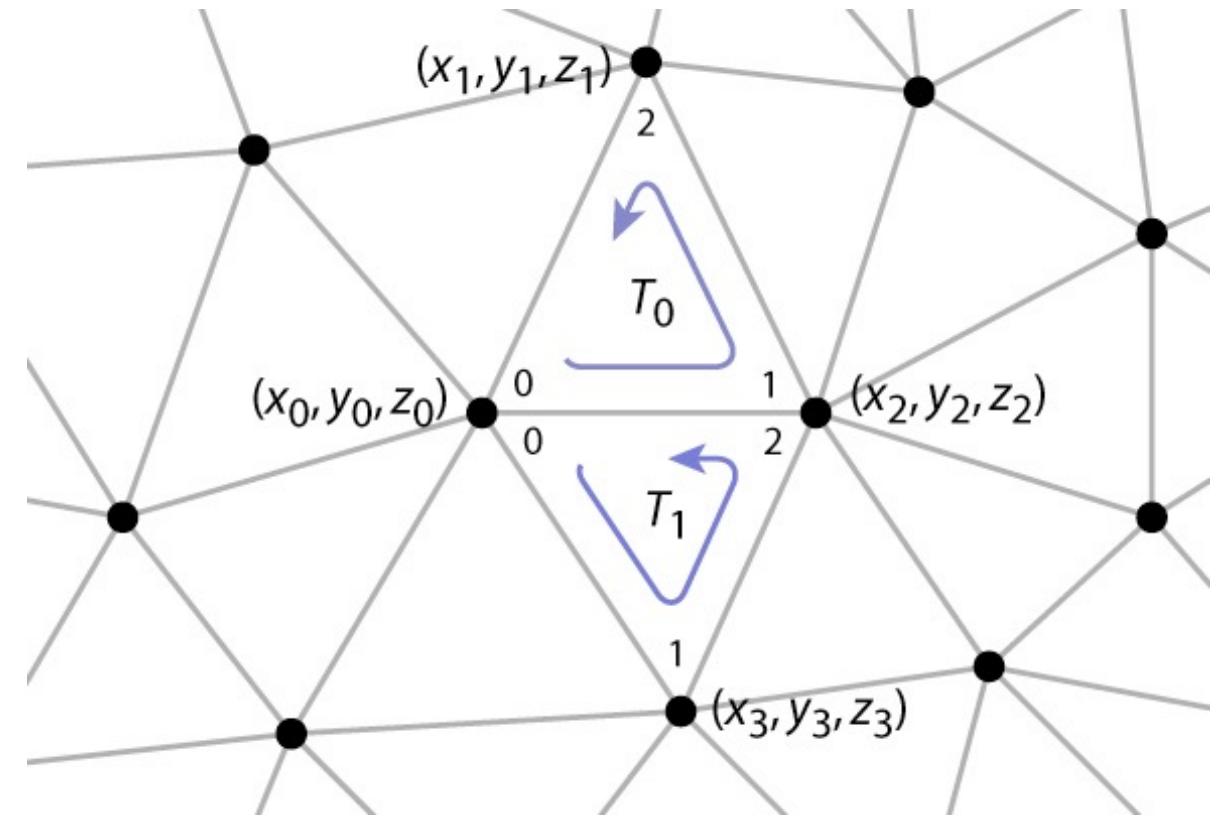
Triangle-Neighbour Data Structure

Winged-Edge Data Structure

Half-Edge Data Structure

Separate triangles

	[0]	[1]	[2]
tris[0]	x_0, y_0, z_0	x_2, y_2, z_2	x_1, y_1, z_1
tris[1]	x_0, y_0, z_0	x_3, y_3, z_3	x_2, y_2, z_2
:	:	:	:



Indexed triangle set

verts[0]

x_0, y_0, z_0

verts[1]

x_1, y_1, z_1

x_2, y_2, z_2

x_3, y_3, z_3

\vdots

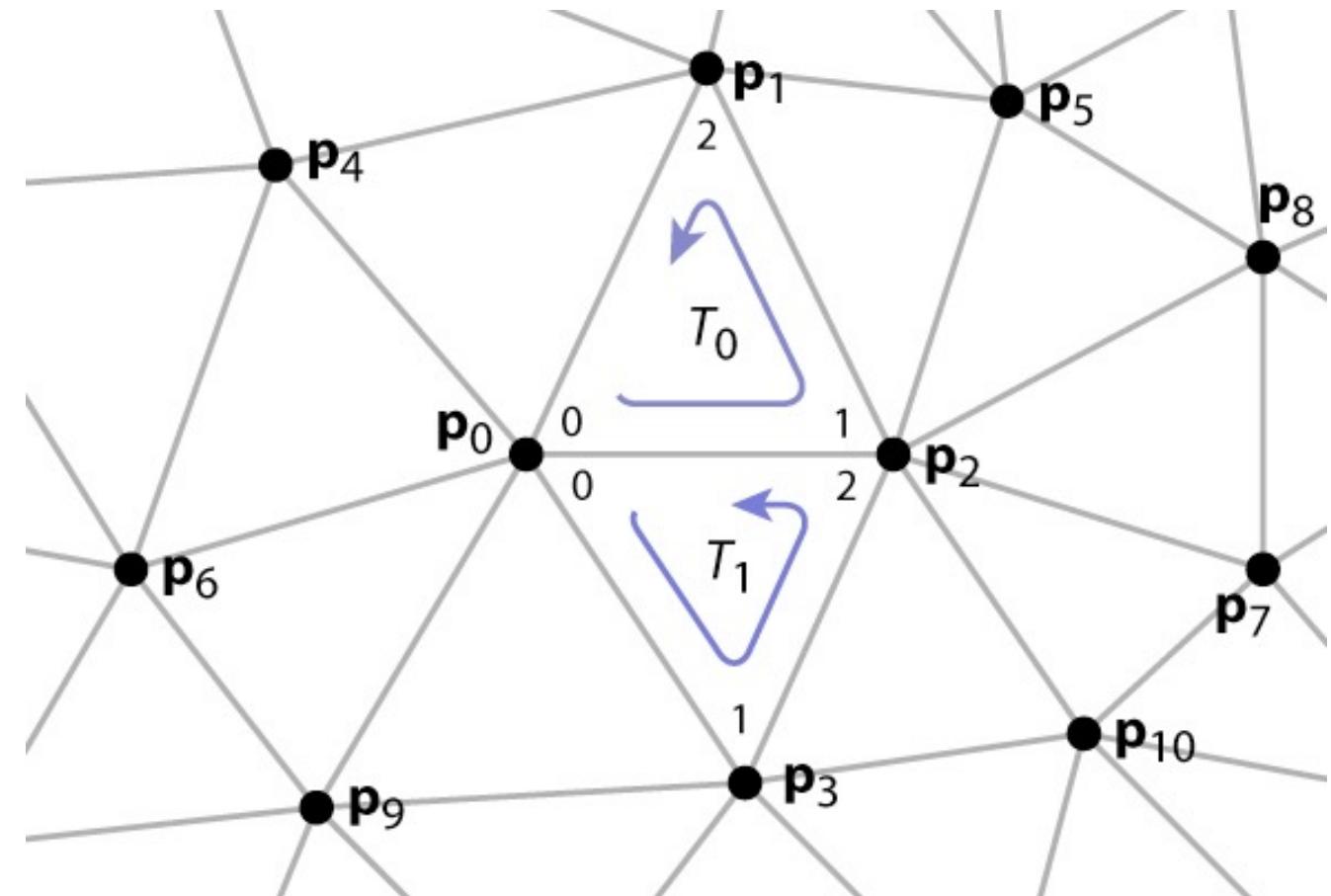
tInd[0]

0, 2, 1

tInd[1]

0, 3, 2

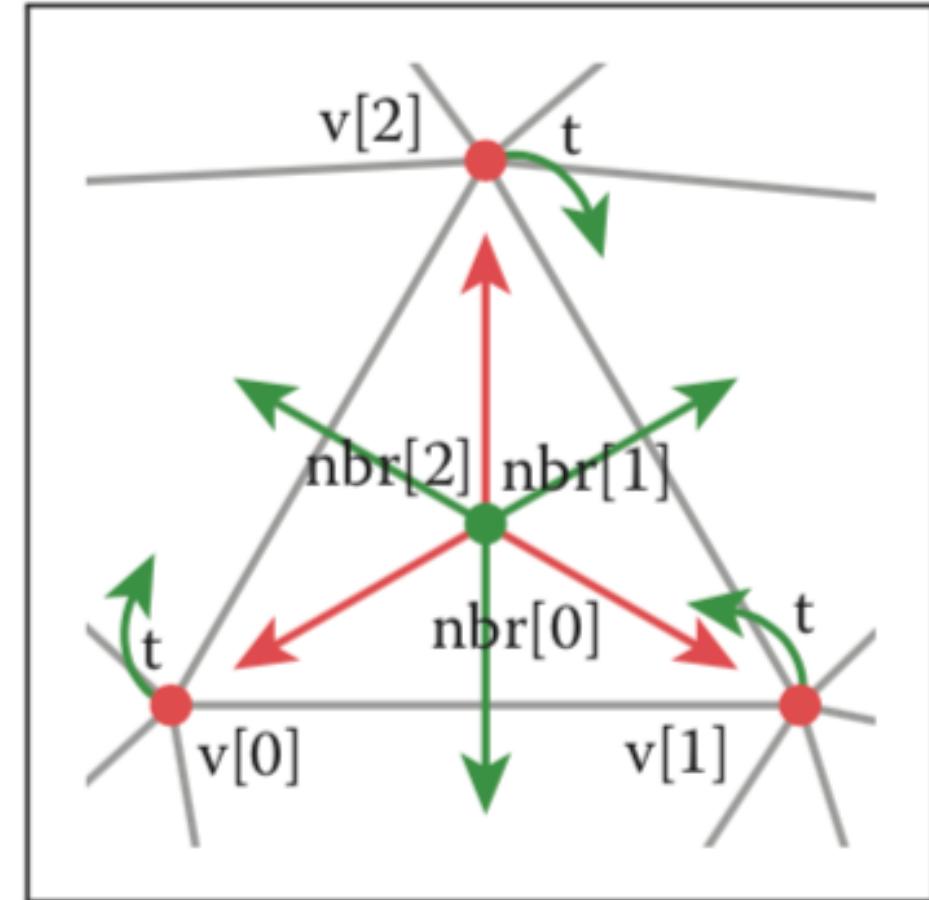
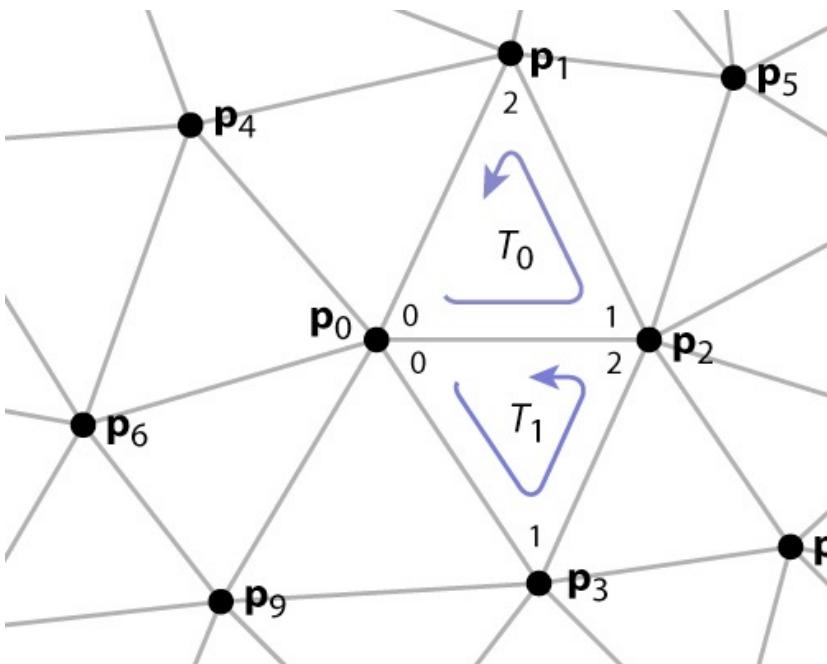
\vdots



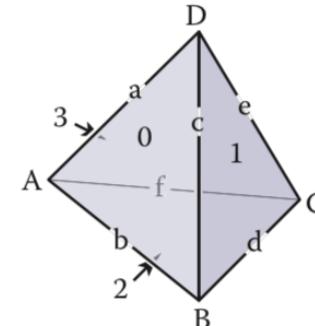
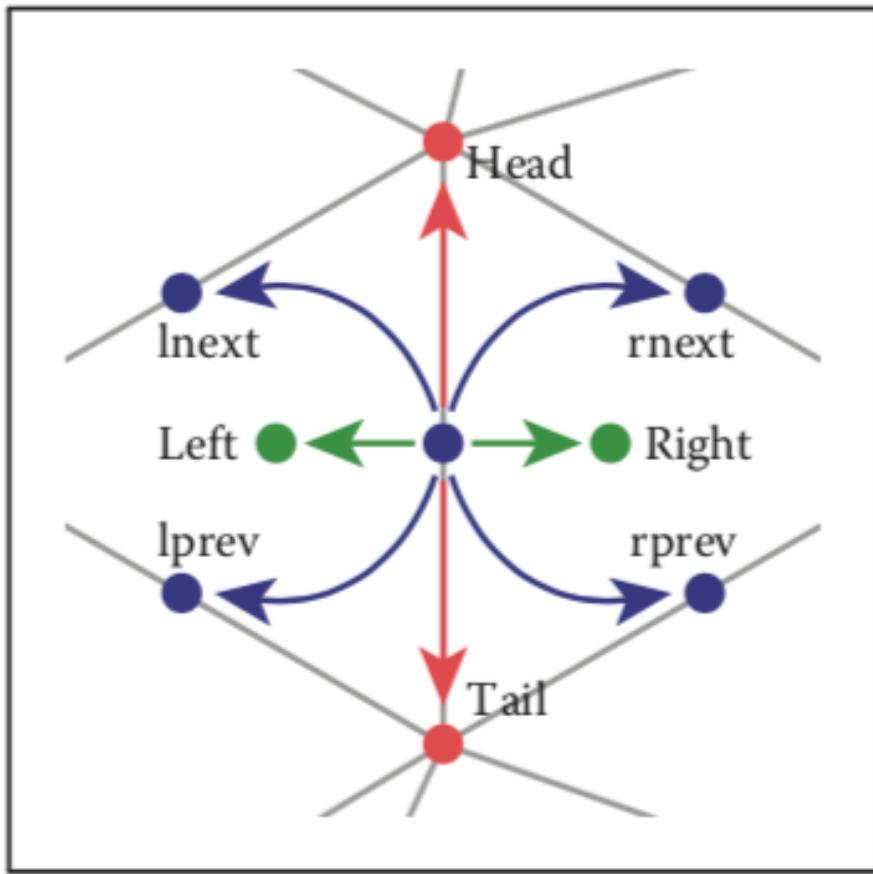
Triangle-Neighbour Data Structure

verts[0]	x_0, y_0, z_0
verts[1]	x_1, y_1, z_1
	x_2, y_2, z_2
	x_3, y_3, z_3
:	

tInd[0]	0, 2, 1
tInd[1]	0, 3, 2
:	



Winged-Edge Data Structure

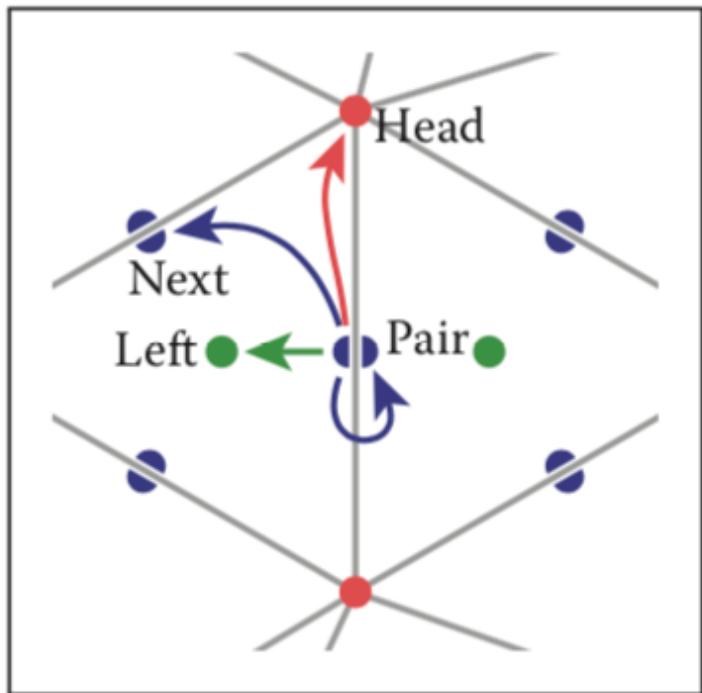


Edge	Vertex 1	Vertex 2	Face left	Face right	Pred left	Succ left	Pred right	Succ right
a	A	D	3	0	f	e	c	b
b	A	B	0	2	a	c	d	f
c	B	D	0	1	b	a	e	d
d	B	C	1	2	c	e	f	b
e	C	D	1	3	d	c	a	f
f	C	A	3	2	e	e	b	d

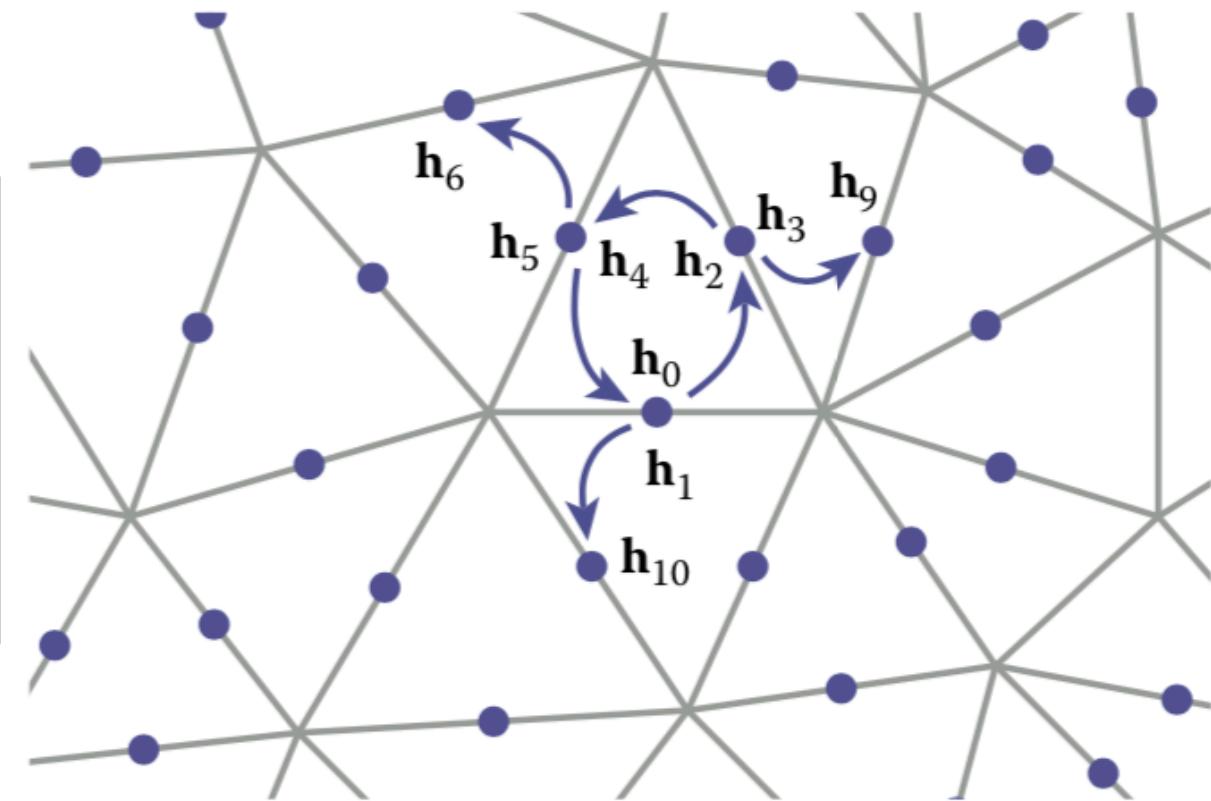
Vertex	Edge
A	a
B	d
C	d
D	e

Face	Edge
0	a
1	c
2	d
3	a

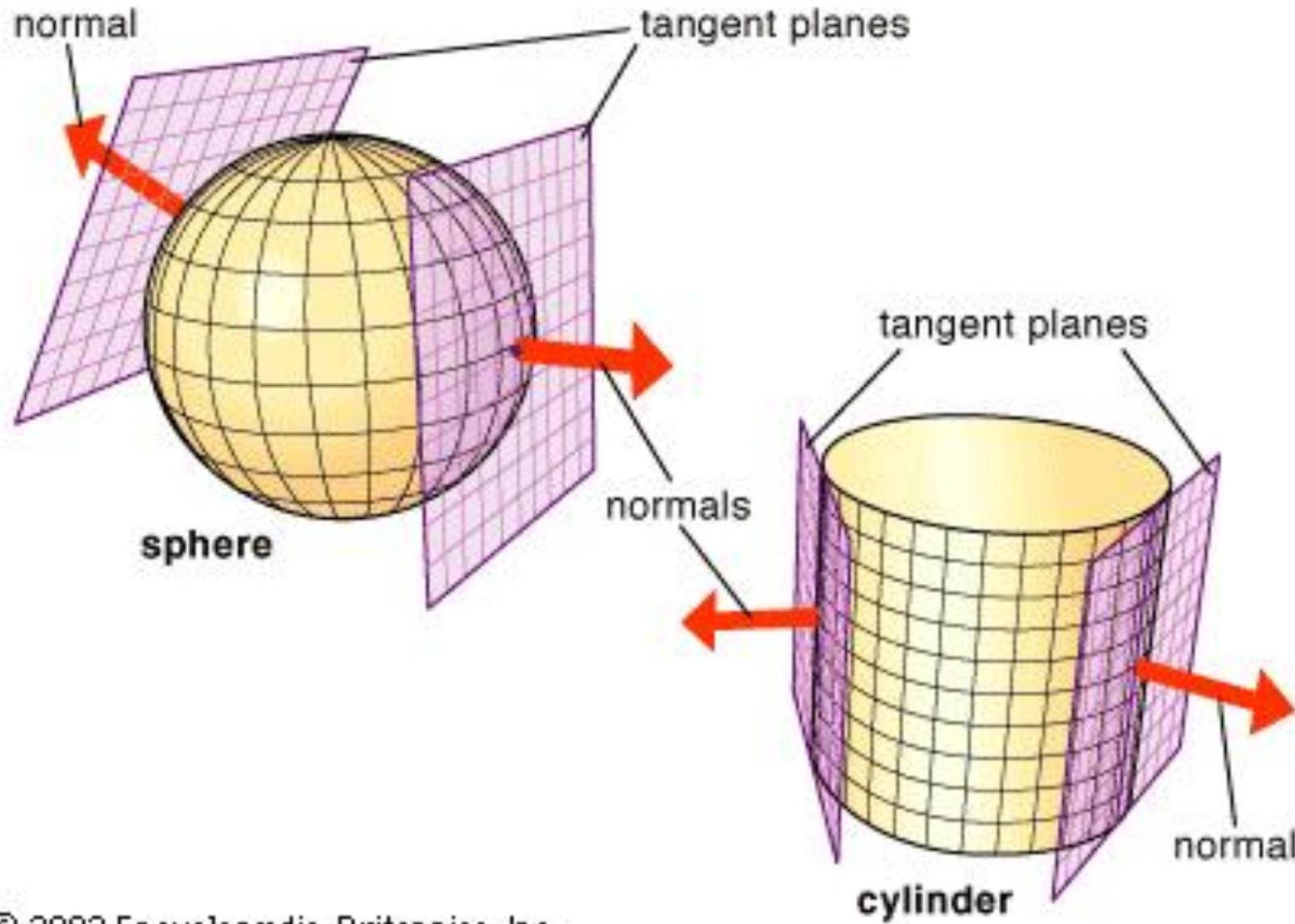
Half-Edge Data Structure



	Pair	Next
hedge[0]	1 2	
hedge[1]	0 10	
hedge[2]	3 4	
hedge[3]	2 9	
hedge[4]	5 0	
hedge[5]	4 6	
	:	

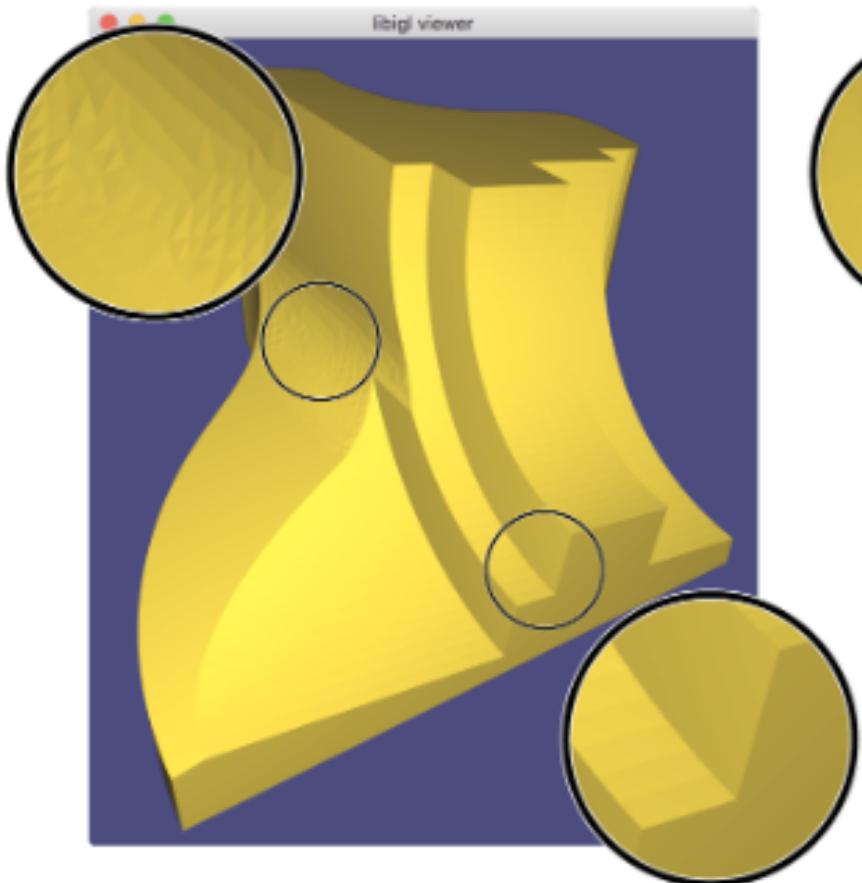


Normal Vectors

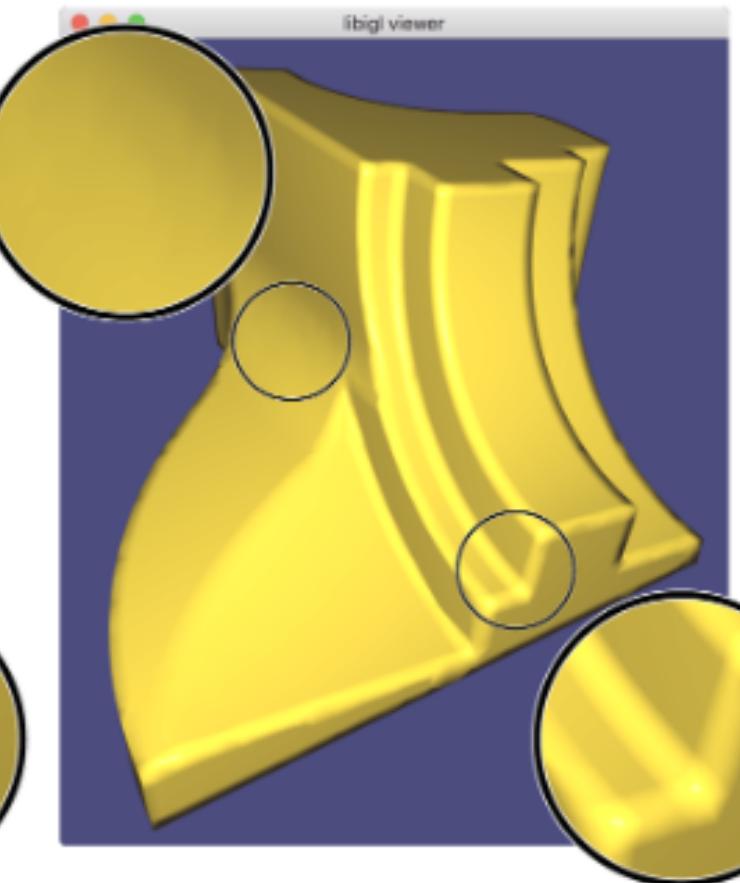


Computing a Per-vertex Normals

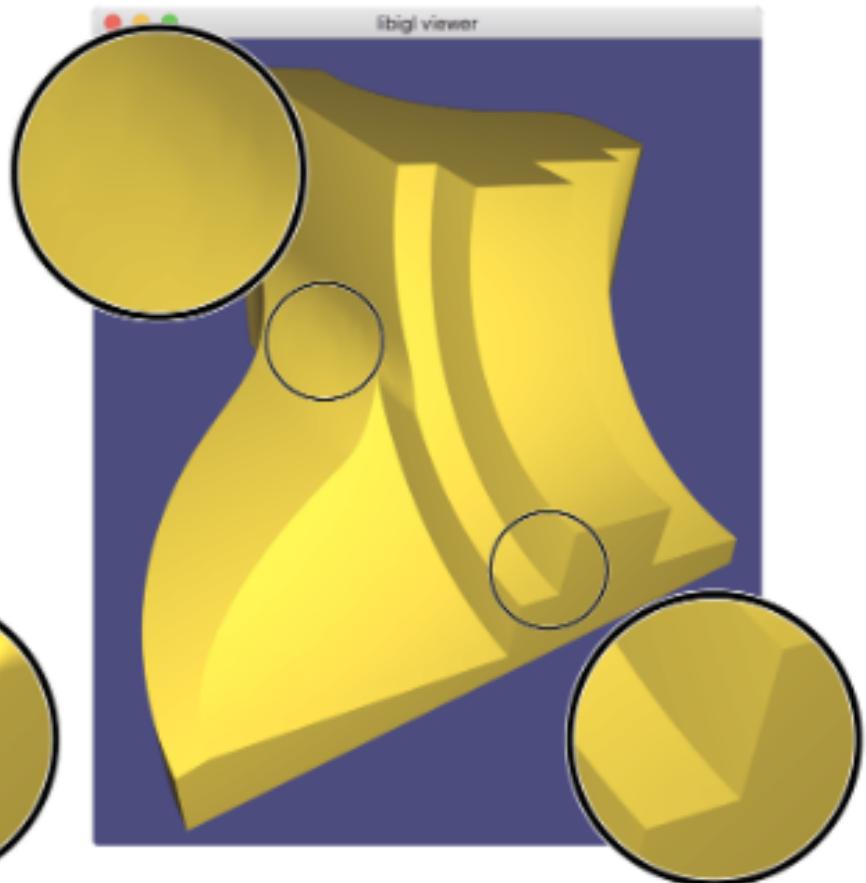
Per-Face Normals



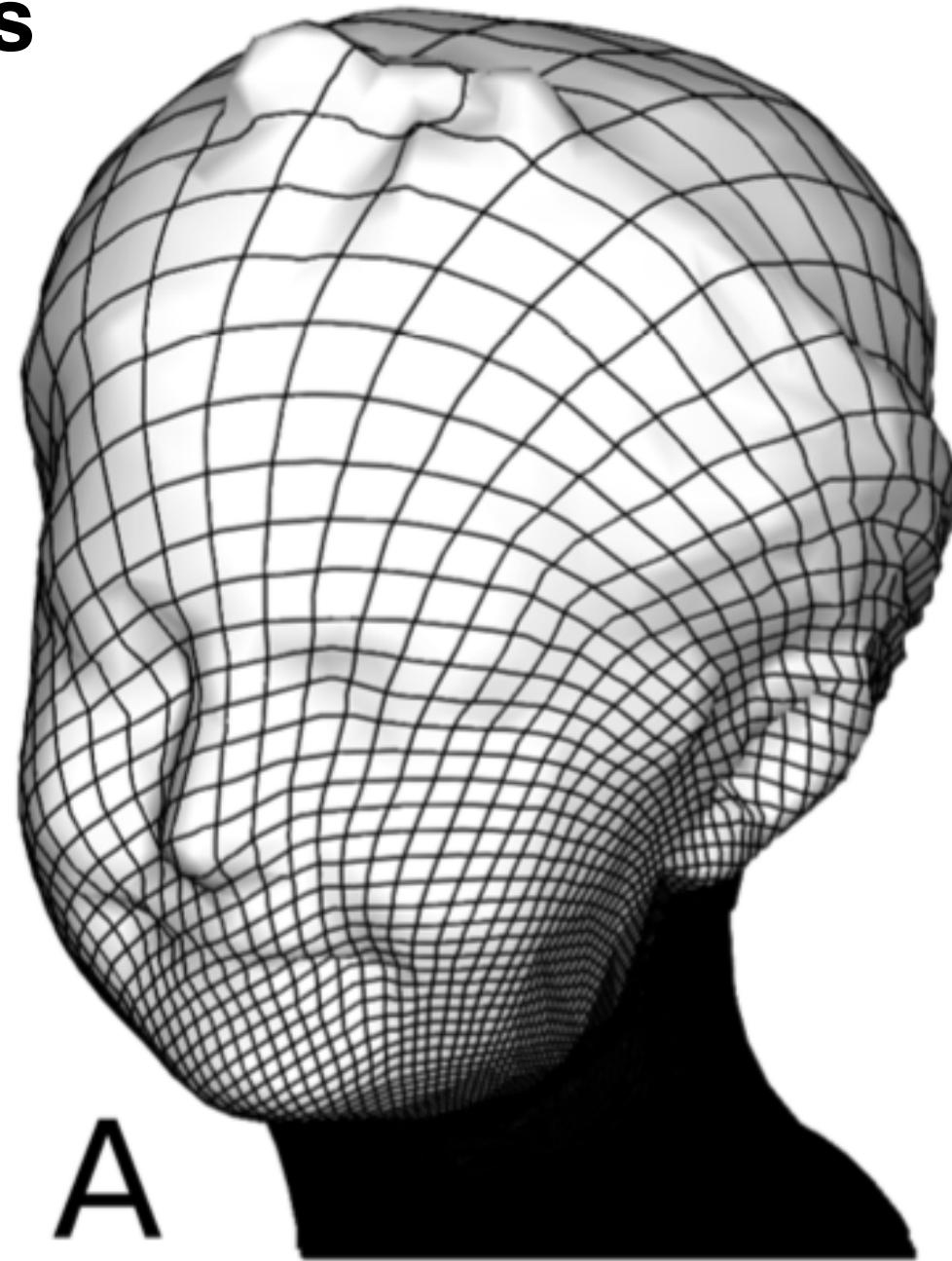
Per-Vertex Normals



Per-Corner Normals

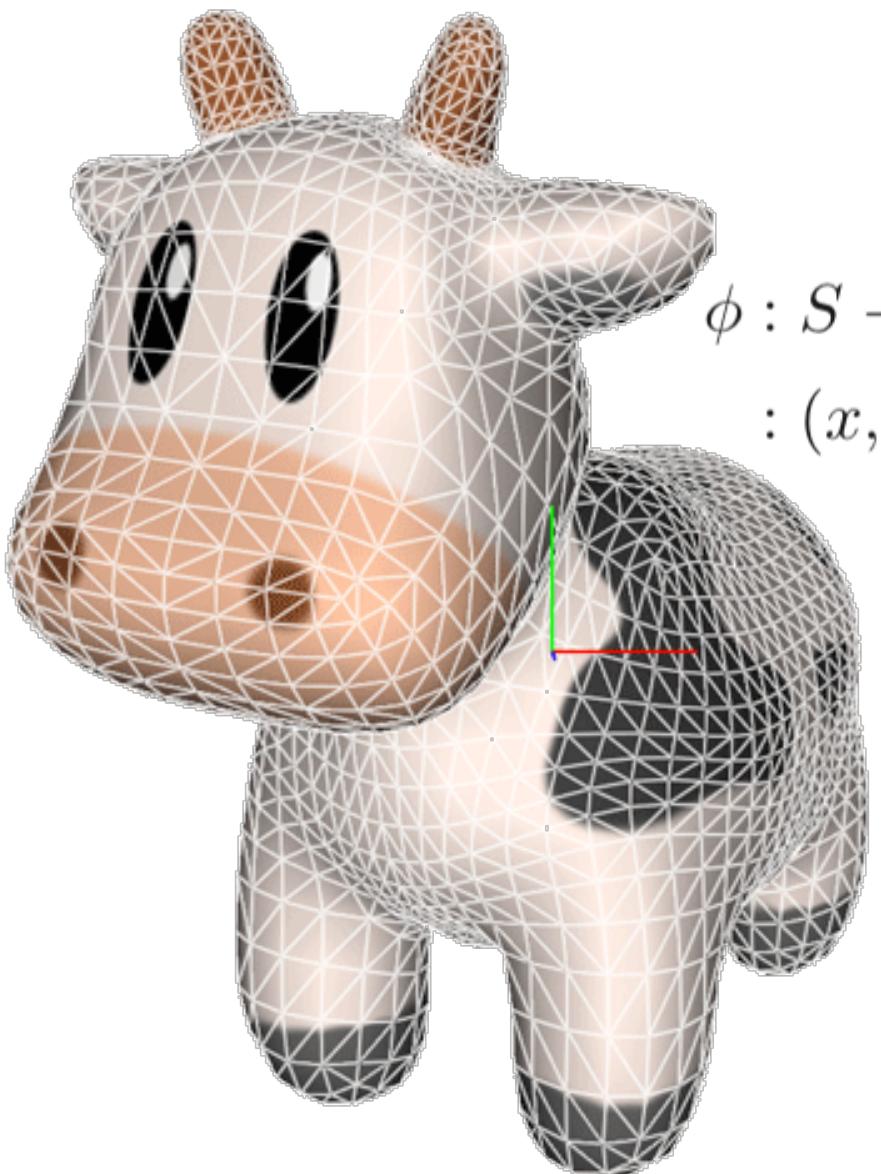


Quadrilateral (Quad) Meshes

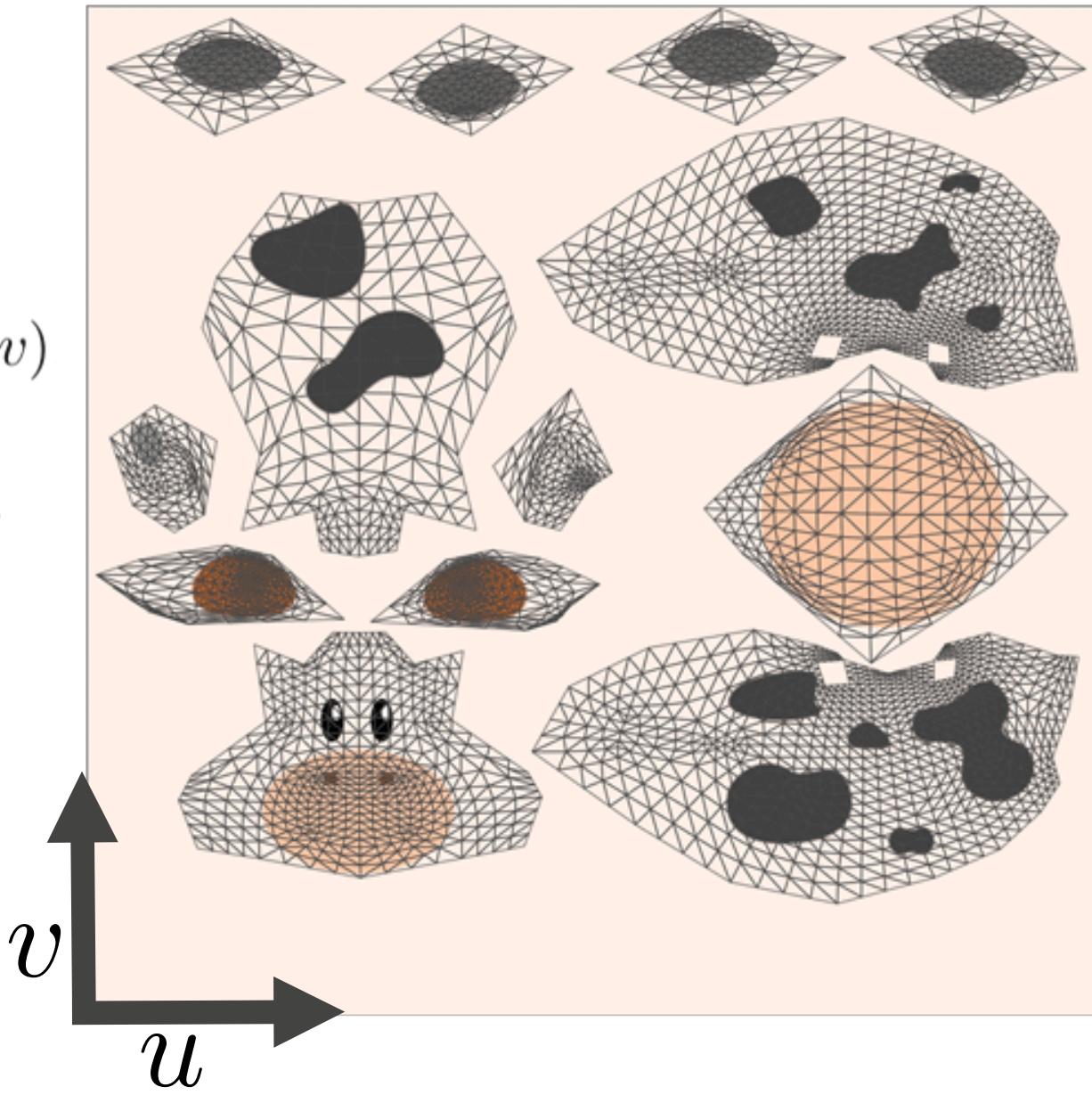


A

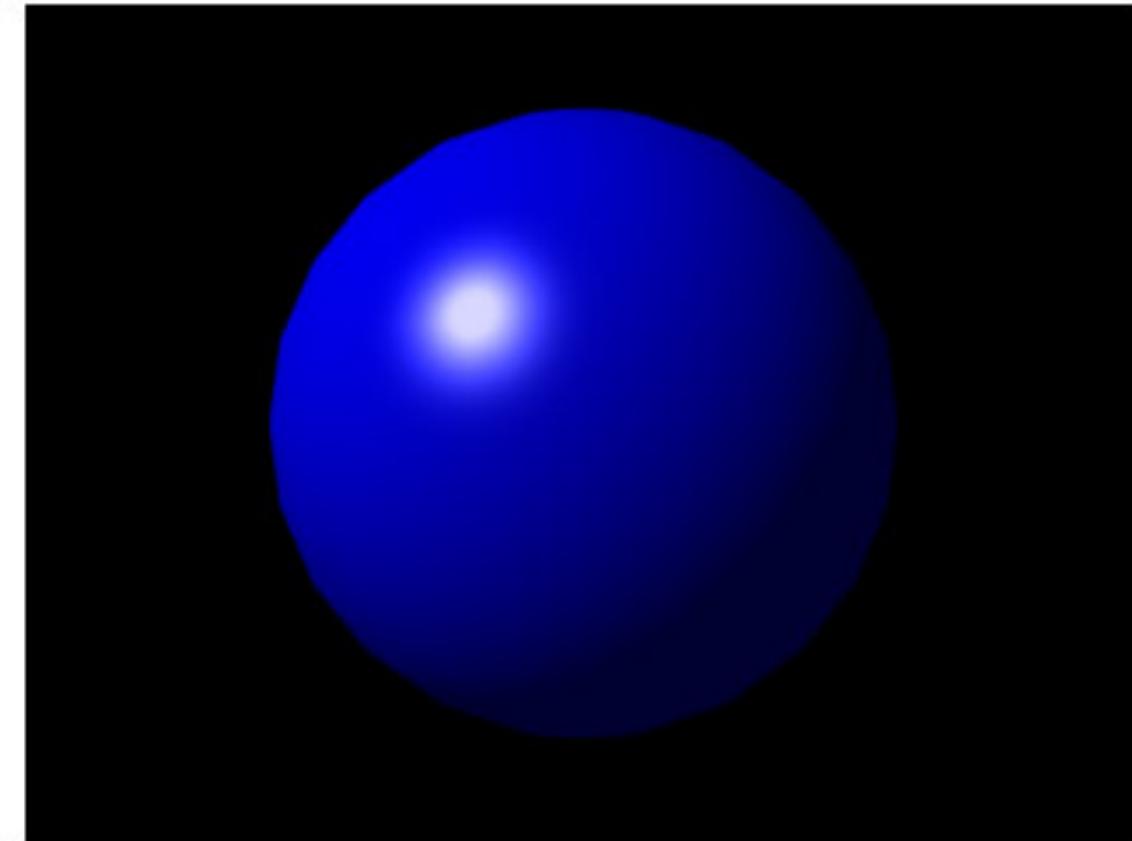
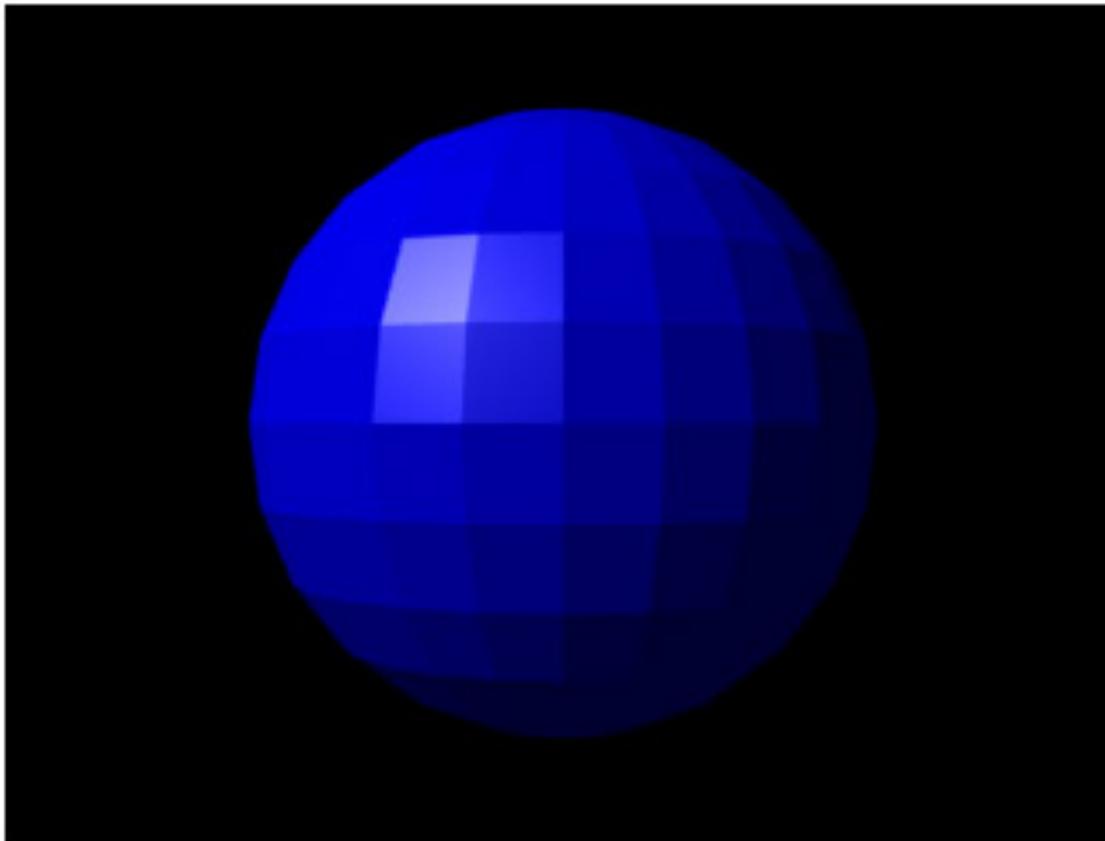
Texture coordinates



$$\begin{aligned}\phi : S &\rightarrow T \\ : (x, y, z) &\mapsto (u, v)\end{aligned}$$



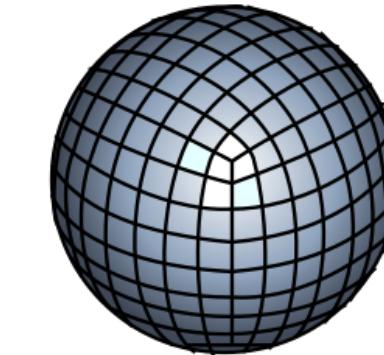
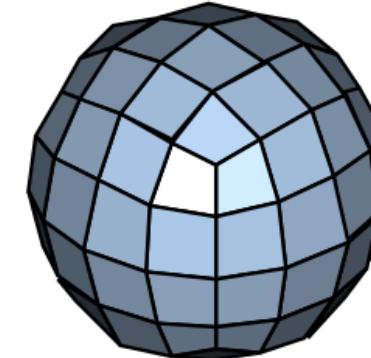
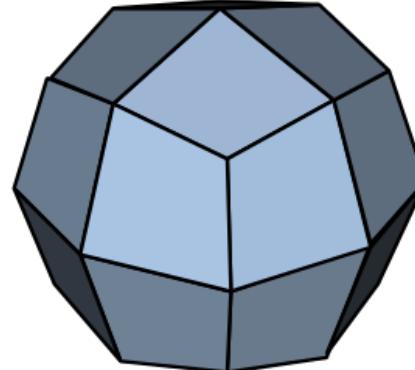
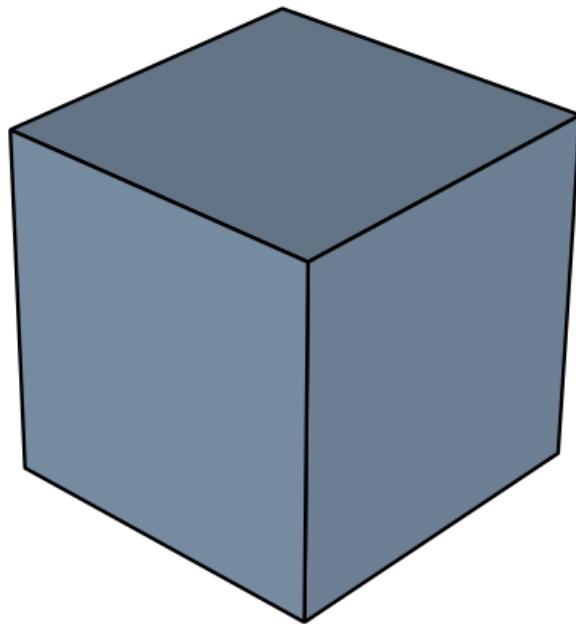
Smooth Surfaces in Computer Graphics



Subdivision Surfaces

Recursive refinement of polygonal mesh

Results in a smooth “limit surface”



Refinement

Done

Assignment 4 due on Friday

Assignment 5 out soon

Office hours now BA5268