Triangle meshes (contd.)

CS 4620 Lecture 3

© 2015 Kavita Bala •
(with previous instructor Marschner)

Announcements

- A1 is out
  - Part written: do ALONE
  - Programming: do in pairs, can do alone but fully responsible
- KB: Traveling starting tomorrow (No office hours)
- Wed: Blender lecture by Nic
- Friday: History of graphics (video), flows into 4621 class
- Monday
  - Labor Day!

- See you next Wednesday

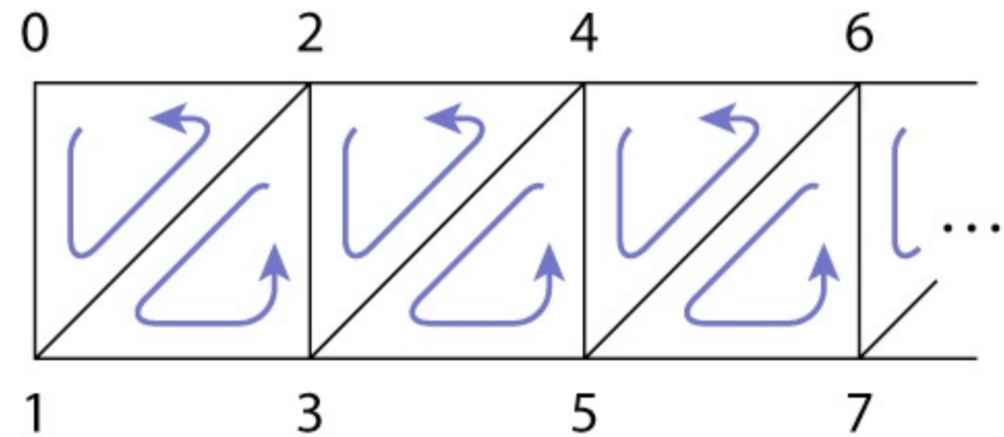
© 2015 Kavita Bala •
(with previous instructor Marschner)

Indexed triangle set

- array of vertex positions
  - float[n_V][3]: 12 bytes per vertex
    - (3 coordinates x 4 bytes) per vertex
- array of triples of indices (per triangle)
  - int[n_T][3]: about 24 bytes per vertex
    - 2 triangles per vertex (on average)
    - (3 indices x 4 bytes) per triangle
- total storage: 36 bytes per vertex (factor of 2 savings)
- represents topology and geometry separately
- finding neighbors is at least well defined

© 2015 Kavita Bala •
(with previous instructor Marschner)

Triangle strips



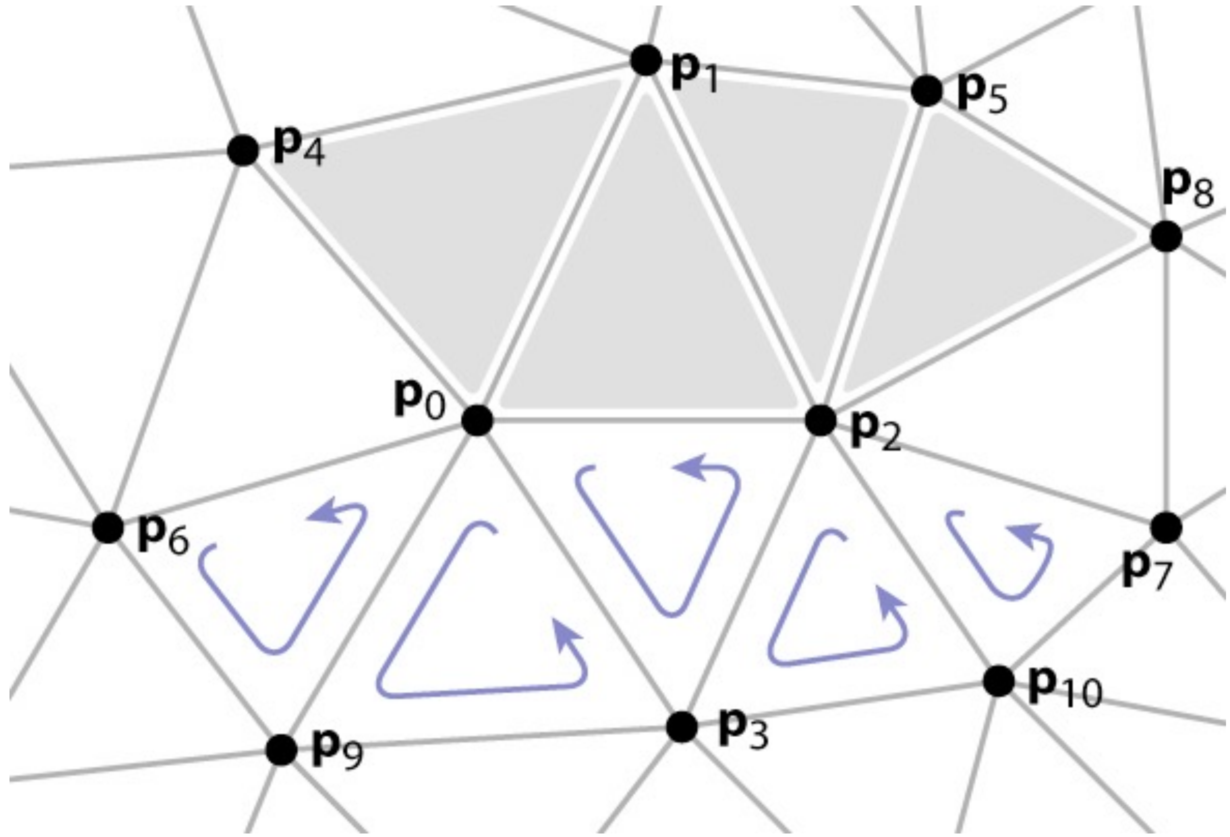
- Take advantage of the mesh property
  - each triangle is usually adjacent to the previous
  - let every vertex create a triangle by reusing the second and third vertices of the previous triangle
  - every sequence of three vertices produces a triangle (but not in the same order)
  - e. g., 0, 1, 2, 3, 4, 5, 6, 7, … leads to
    (0 1 2), (2 1 3), (2 3 4), (4 3 5), (4 5 6), (6 5 7), …
  - for long strips, this requires about one index per triangle

© 2015 Kavita Bala • (with previous instructor Marschner)

Triangle strips

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
	⋮

tStrip[0]	4, 0, 1, 2, 5, 8
tStrip[1]	6, 9, 0, 3, 2, 10, 7
	⋮



© 2015 Kavita Bala •
(with previous instructor Marschner)

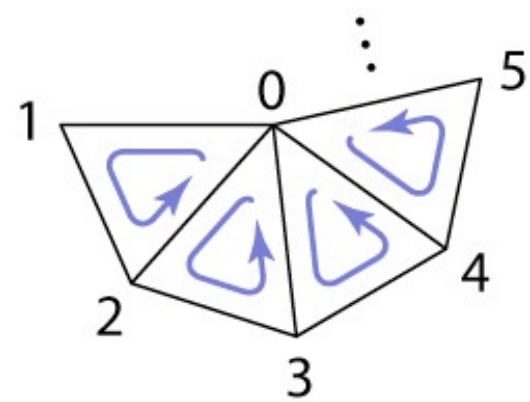
Triangle strips

- array of vertex positions
  - float[n_V][3]: 12 bytes per vertex
    - (3 coordinates x 4 bytes) per vertex
- array of index lists
  - int[n_S][*variable*]: 2 + *n* indices per strip
  - on average, (1 + ε) indices per triangle (assuming long strips)
    - 2 triangles per vertex (on average)
    - about 4 bytes per triangle (on average)
- total is 20 bytes per vertex (limiting best case)
  - factor of 3.6 over separate triangles; 1.8 over indexed mesh

© 2015 Kavita Bala •
(with previous instructor Marschner)

Triangle fans

- Same idea as triangle strips, but keep oldest rather than newest
  - every sequence of three vertices produces a triangle
  - e. g., 0, 1, 2, 3, 4, 5, … leads to
    (0 1 2), (0 2 3), (0 3 4), (0 4 5), …
  - for long fans, this requires about one index per triangle
- Memory considerations exactly the same as triangle strip



© 2015 Kavita Bala •
(with previous instructor Marschner)

Example: unit sphere

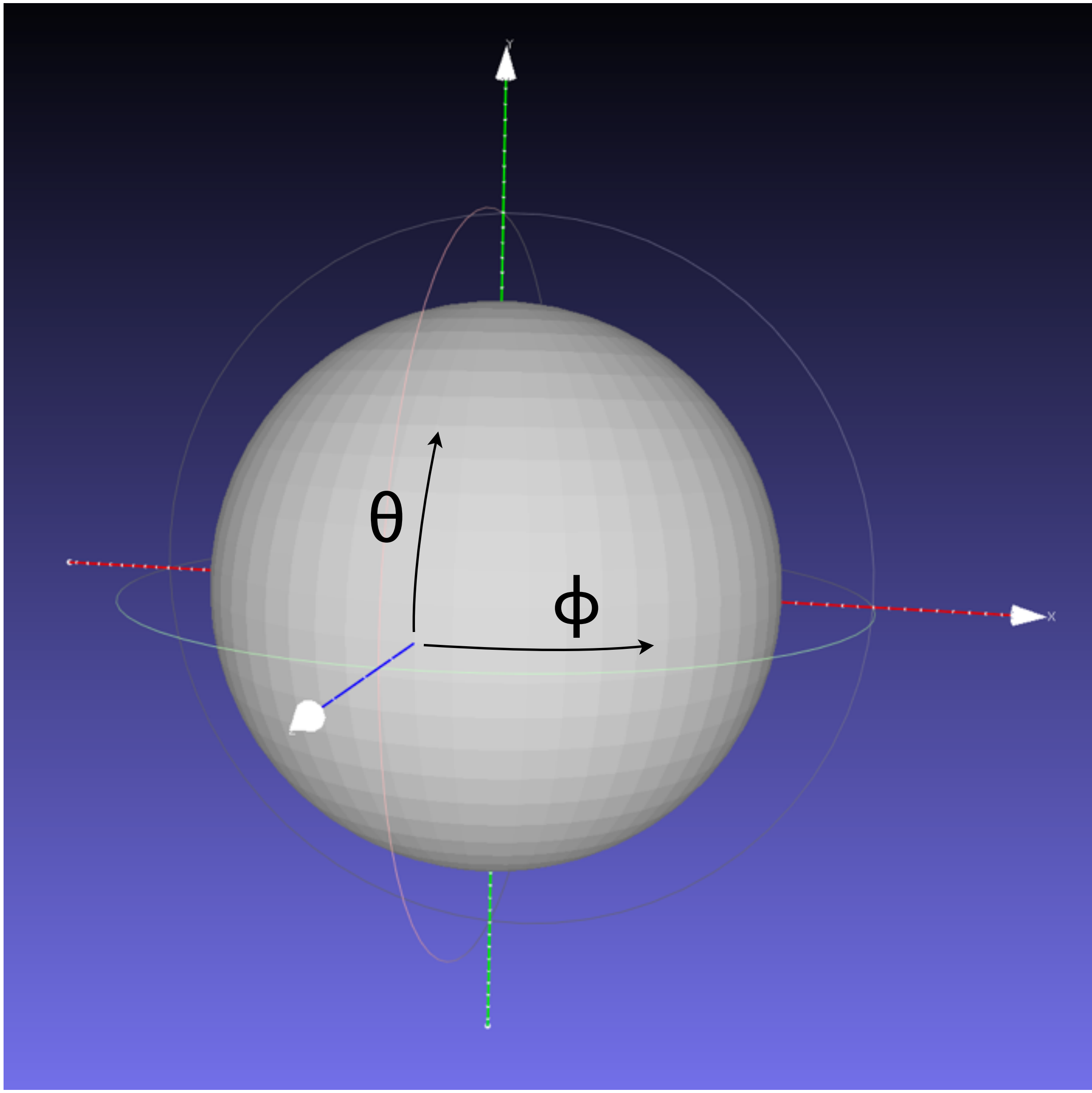
- position:

$$x = \cos\theta \sin\phi$$

$$y = \sin\theta$$

$$z = \cos\theta \cos\phi$$

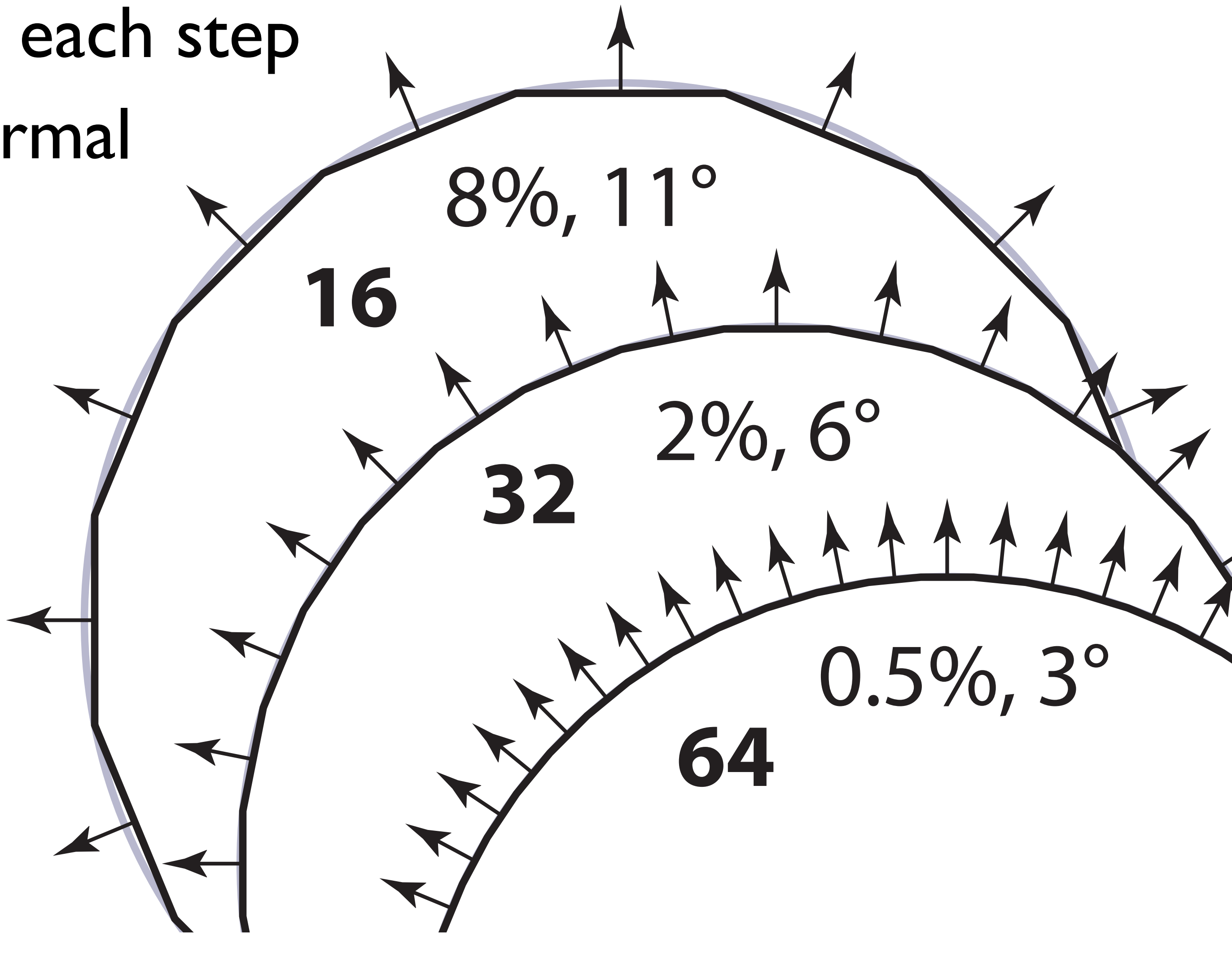
- normal is position (easy!)



© 2015 Kavita Bala • (with previous instructor Marschner)

Interpolated normals—2D example

- Approximating circle with increasingly many segments
- Max error in position error drops by factor of 4 at each step
- Max error in normal only drops by factor of 2



How to think about vertex normals

- Piecewise planar approximation converges pretty quickly to the smooth geometry as the number of triangles increases

- But the surface normals don't converge so well

- Better: store the "real" normal at each vertex, and *interpolate* to get normals that vary gradually across triangles

© 2015 Kavita Bala •
(with previous instructor Marschner)

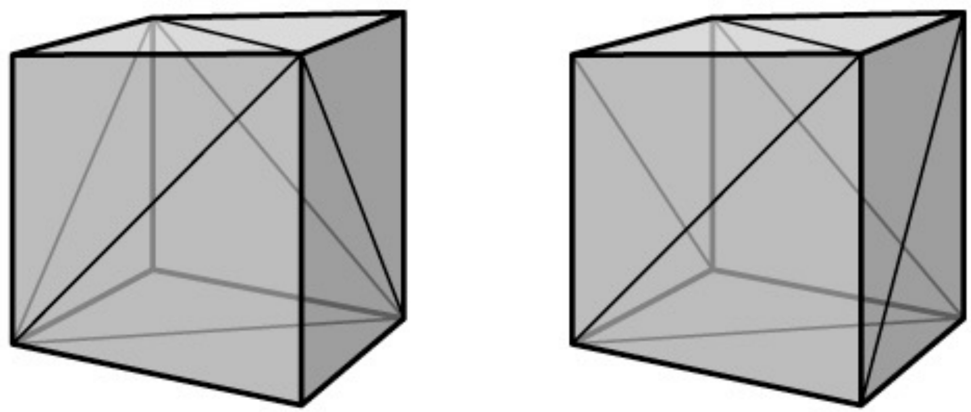
Topology vs. geometry

- two completely separate issues:
- **mesh topology**: how the triangles are connected (ignoring the positions entirely)
- **geometry**: where the triangles are in 3D space

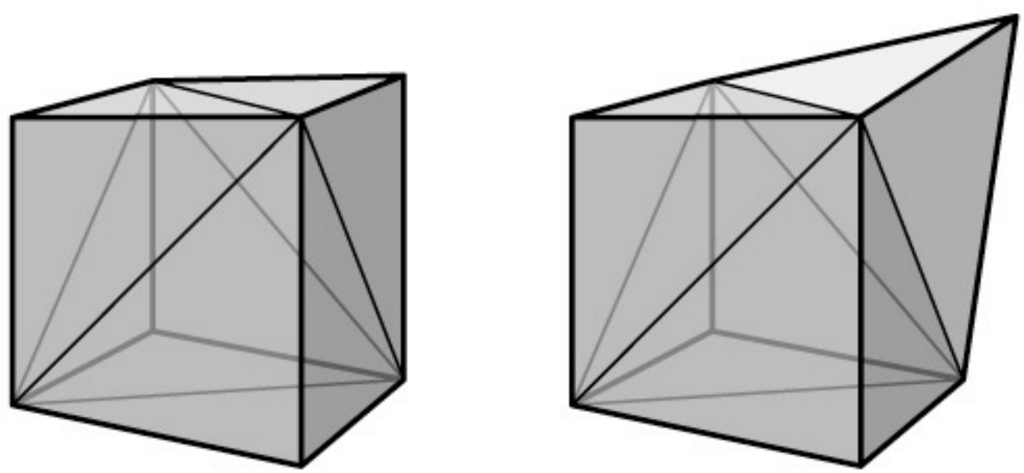
© 2015 Kavita Bala • (with previous instructor Marschner)

Topology/geometry examples

- same geometry, different mesh topology:



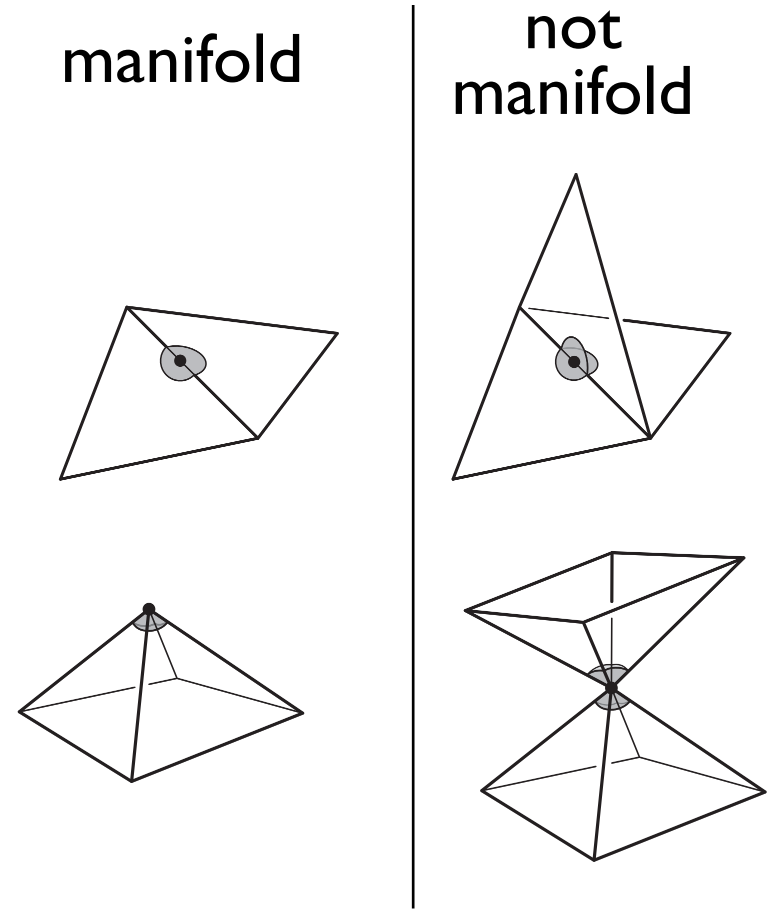
- same mesh topology, different geometry:



© 2015 Kavita Bala •
(with previous instructor Marschner)

Topological validity

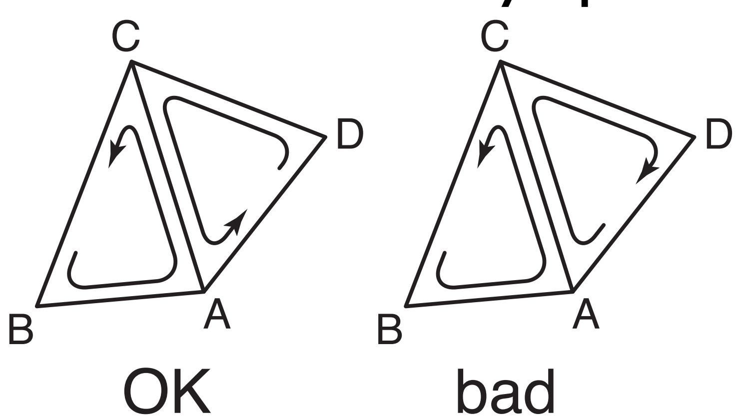
- strongest property: be a manifold
  - this means that no points should be "special"
  - edge points: each edge must have exactly 2 triangles
  - vertex points: each vertex must have one loop of triangles

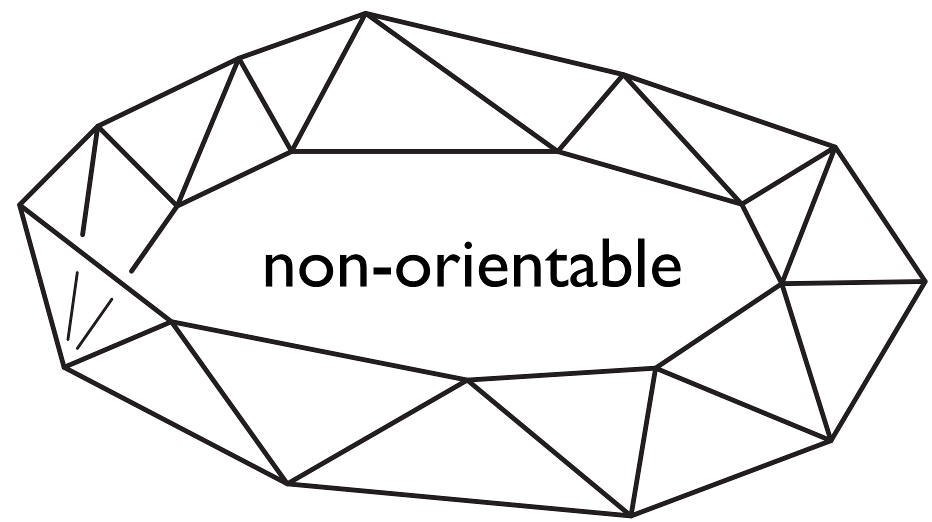


© 2015 Kavita Bala • (with previous instructor Marschner)

Topological validity

- Consistent orientation
  - Which side is the "front" or "outside" of the surface and which is the "back" or "inside?"
  - rule: you are on the outside when you see the vertices in counter-clockwise order
  - in mesh, neighboring triangles should agree about which side is the front!
  - caution: not always possible

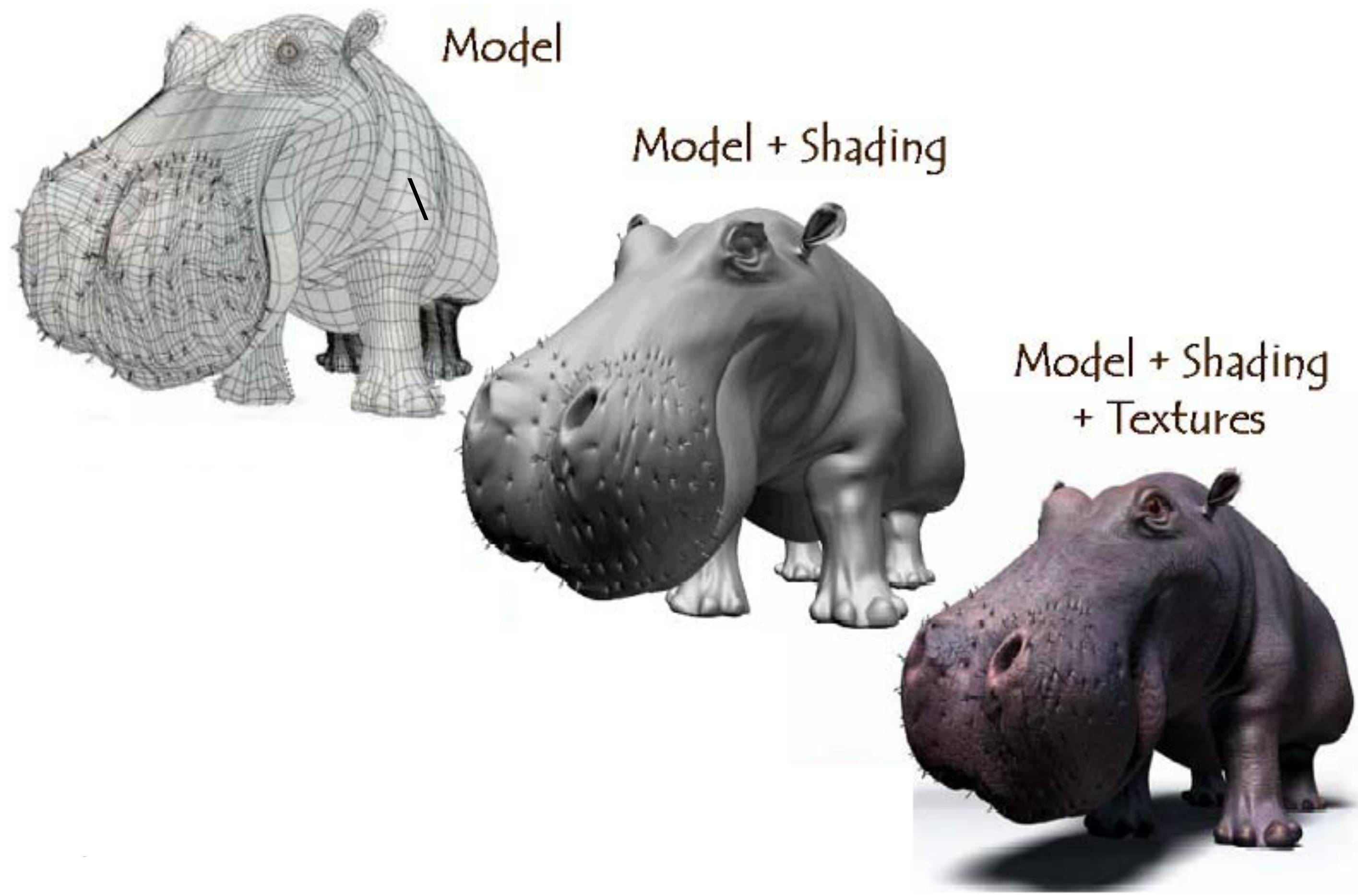




© 2015 Kavita Bala • (with previous instructor Marschner)

Texture Mapping

- Cannot model every single change using primitives
- Instead we make the shading parameters (and other properties) vary across the surface



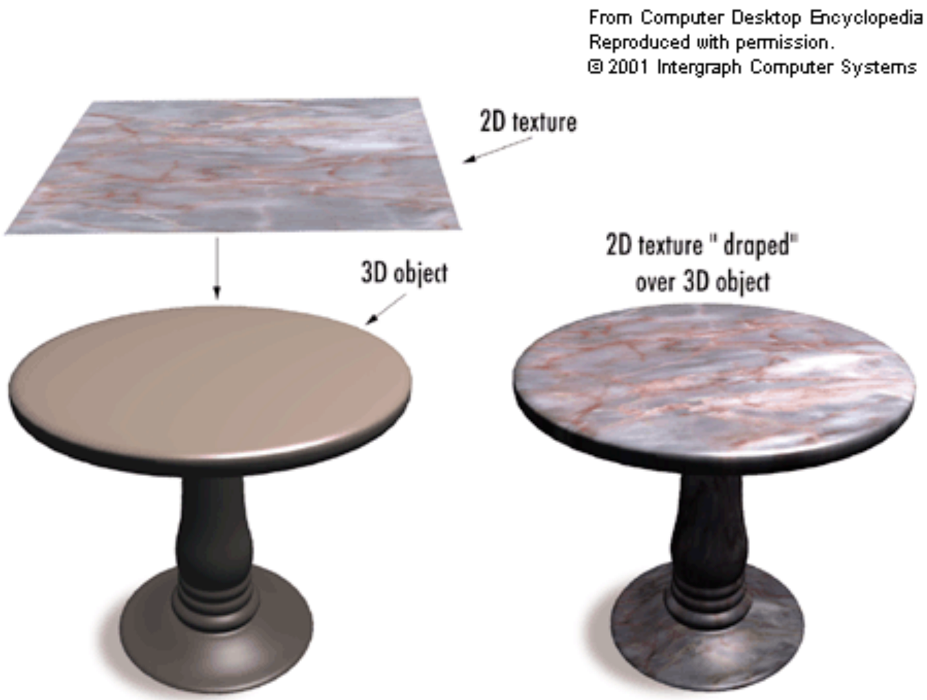
(with previous instructor Marschner)

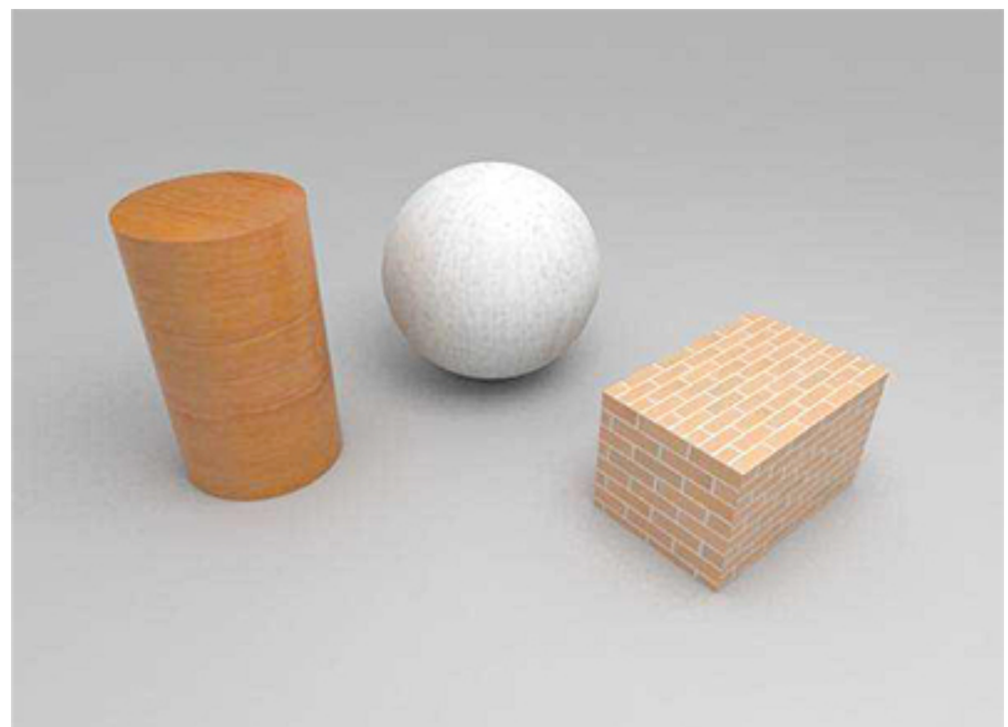
Texture Mapping: applications

- Surprisingly simple idea but with big results

© 2015 Kavita Bala •
(with previous instructor Marschner)

Examples



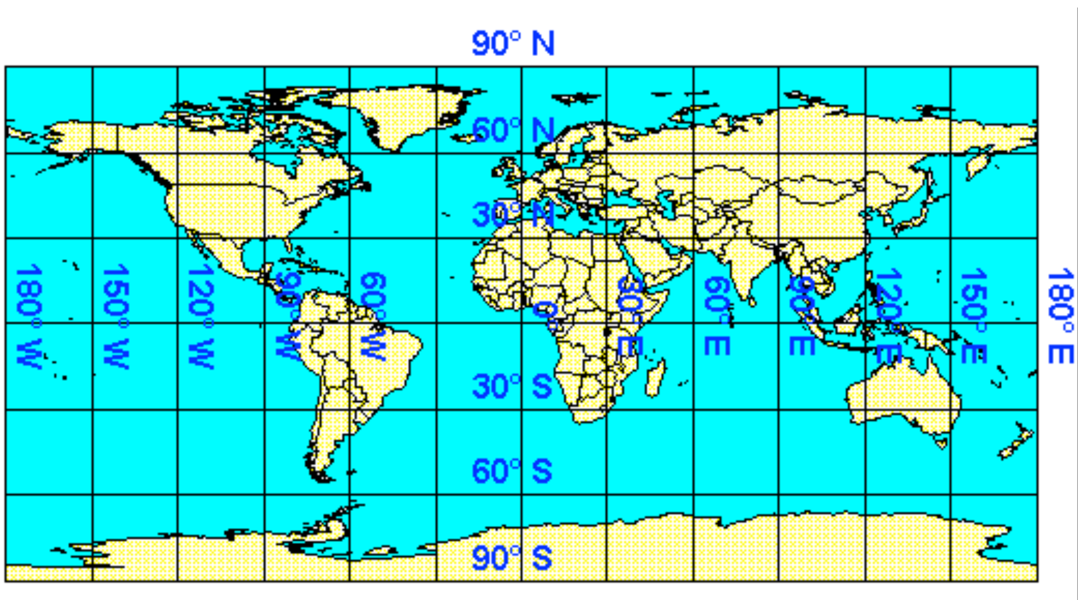


© 2015 Kavita Bala •
(with previous instructor Marschner)

Examples of projector functions

- For a sphere: latitude-longitude coordinates
  - maps point to its latitude and longitude

[map: Peter H. Dana]



© 2015 Kavita Bala •
(with previous instructor Marschner)

Cylinder