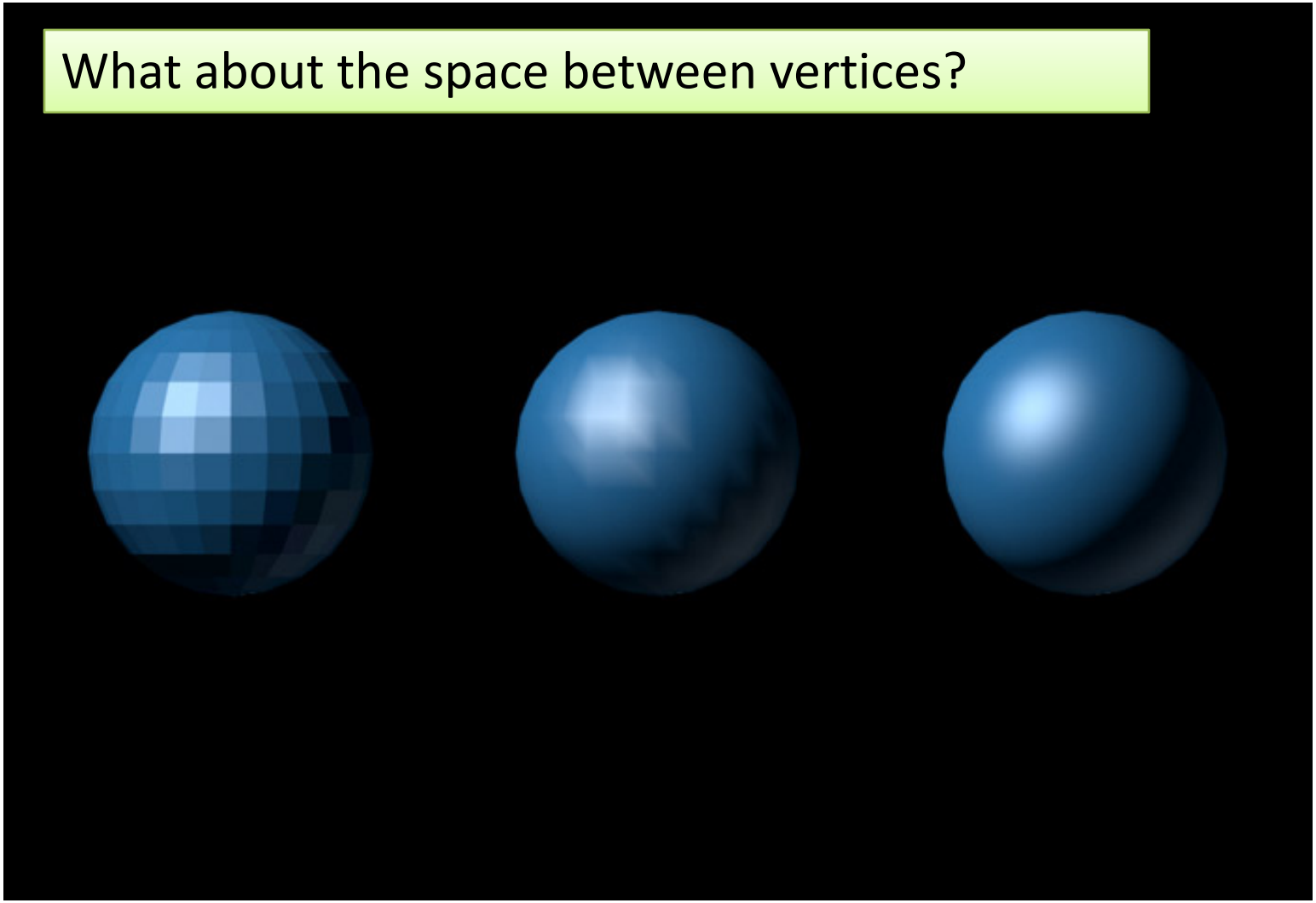
Lecture 18:
Rendering with Shading

October 31, 2019

Three Shading Options



http://www.ntsc-uk.com/features/tec/BeautyPixelDeep/GouraudPhong.jpg

Flat Shading

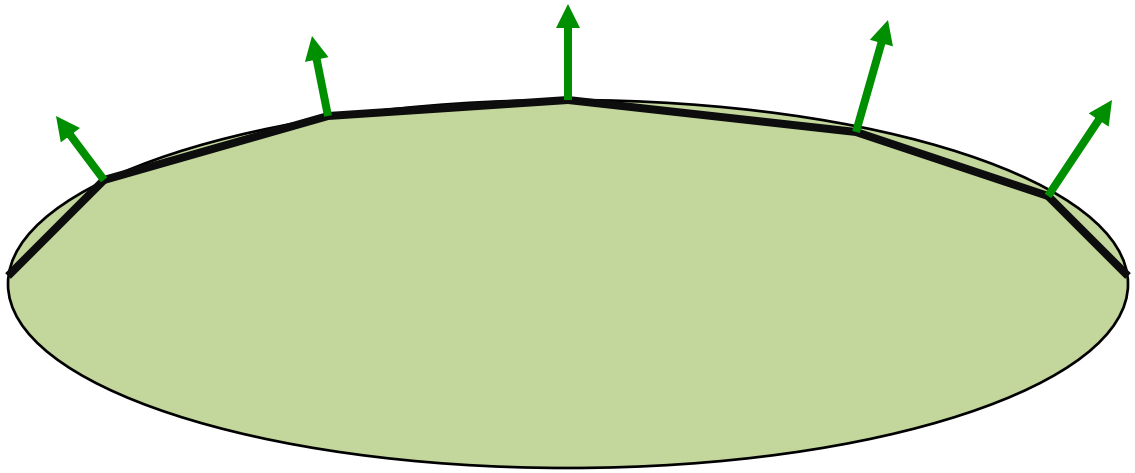
- Illumination is computed at every vertex
- The average illumination is the average of the illumination at the vertices
- Polygon filling then paints this color
- Downside:
  - 3D structure (from angle changes) is lost
  - Boundaries between surfaces become artifacts

Illumination at a vertex?

- Wait a minute
  - ***Illumination depends on the surface normal***
  - What's the surface normal at a vertex?
  - It's ambiguous – vertex shared by surfaces!
- Solution #1:
  - User-set vertex normals
  - OpenGL uses this solutions
- Solution #2:
  - Average adjoining surface normals

How users set normals

- How do you pick a normal?
- Case #1: polygonal approximation to a smooth surface



  - Set normals to underlying “true” normal

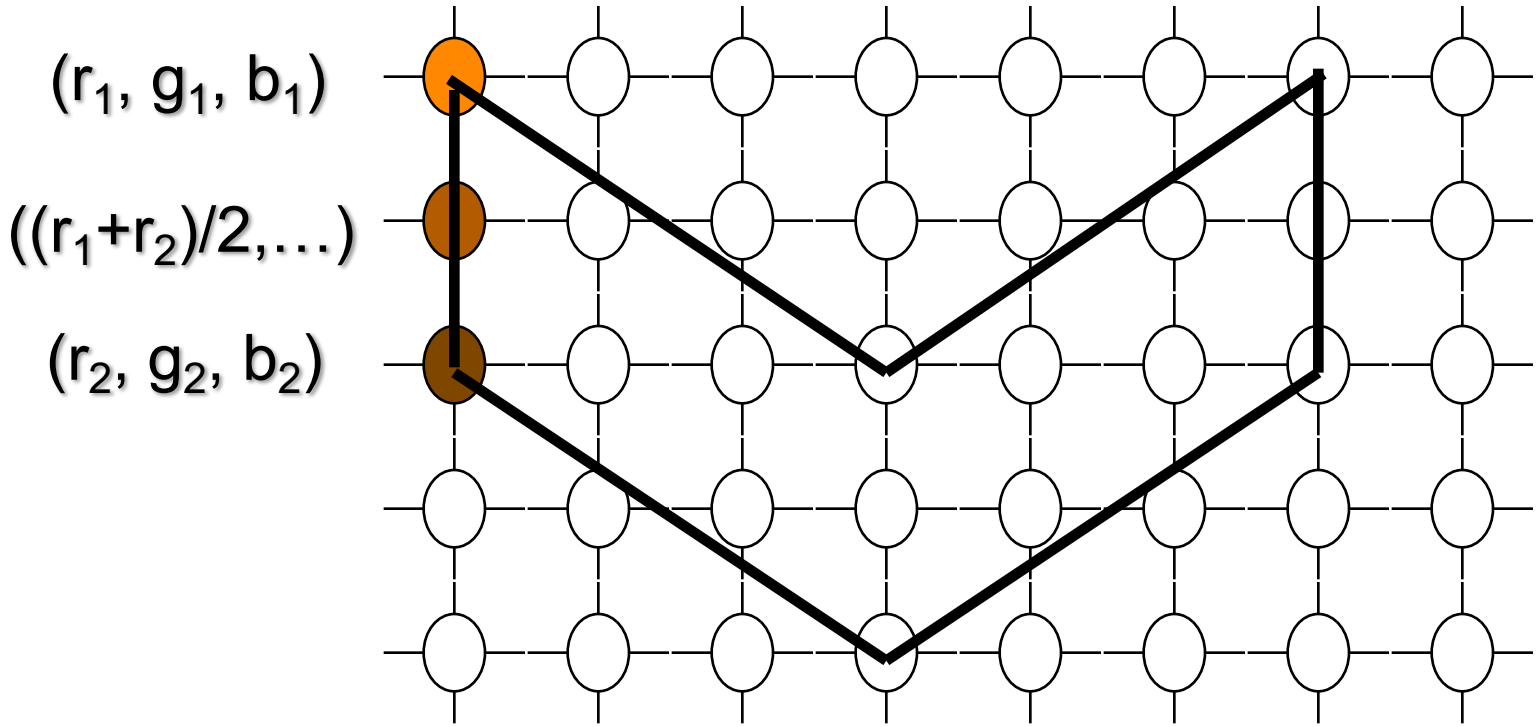
Rule(s) to set normals (II)

- Case #2: Truly polygonal object
  - Double up : create multiple vertices at one position, one for each adjacent surface.
  - Each vertex now has normal of associated surface.

Smooth (Gouraud) Shading

- Compute the illumination at every vertex
- Interpolate colors along edges
  - Between vertices
- When filling the polygon, interpolate colors between scan-line intersections

Smooth Shading Example



Phong Shading

- Calculate normals at vertices
- Interpolate **normals** along edges
- When polygon filling:
  - Interpolate normals between scan-line intersections
  - **Calculate color using interpolated normals**

Warning: do not confuse *Phong Shading* with *Phong Reflectance*

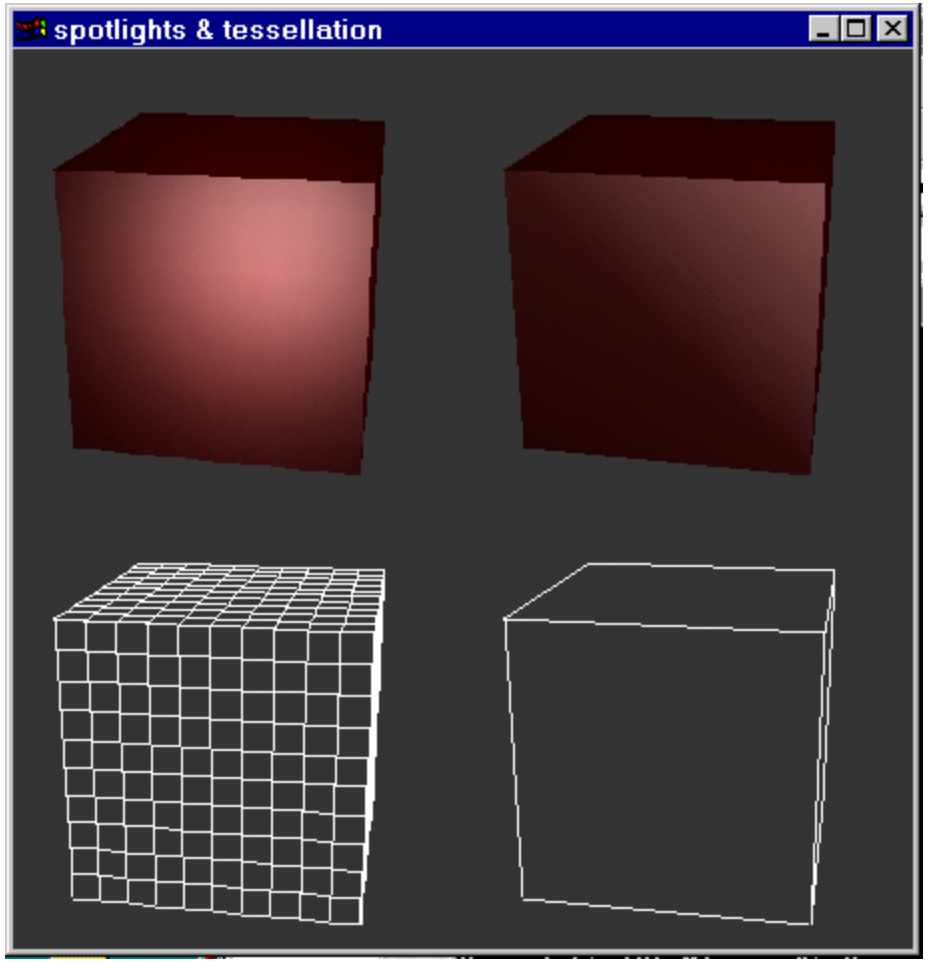
Selecting a Shading Model

- Case 1: Object is curved
  - Phong shading (most realistic)
  - Smooth shading (slightly faster)
- Case 2: Large flat surface, divided into multiple polygons
  - Same as above
- Case 3: Flat surface, true boundaries
  - Flat shading
  - Replicate vertices (for normals)

Not so subtle distinction

- Smooth shading discards 3-D normals
  - Operates solely with R,G,B values.
  - Direction to lights within surfaces fixed.
- Phong shading adjust 3-D normals.
  - Illumination better within surfaces.
  - What about direction to lights?

Example of Case #2

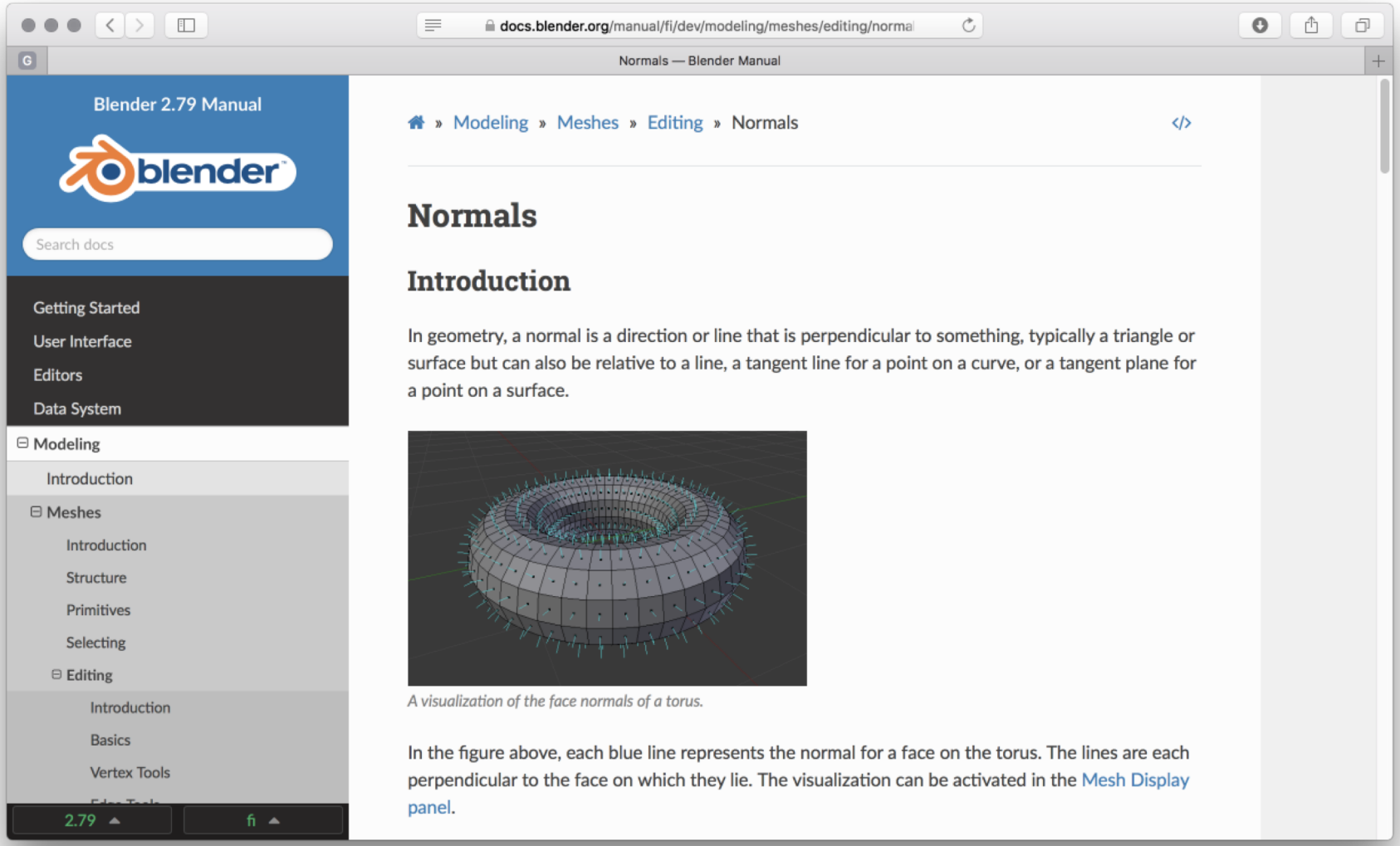


Impact of polygon size on appearance

Source: www.opengl.com

In this example, is illumination being recomputed internal to surface faces?

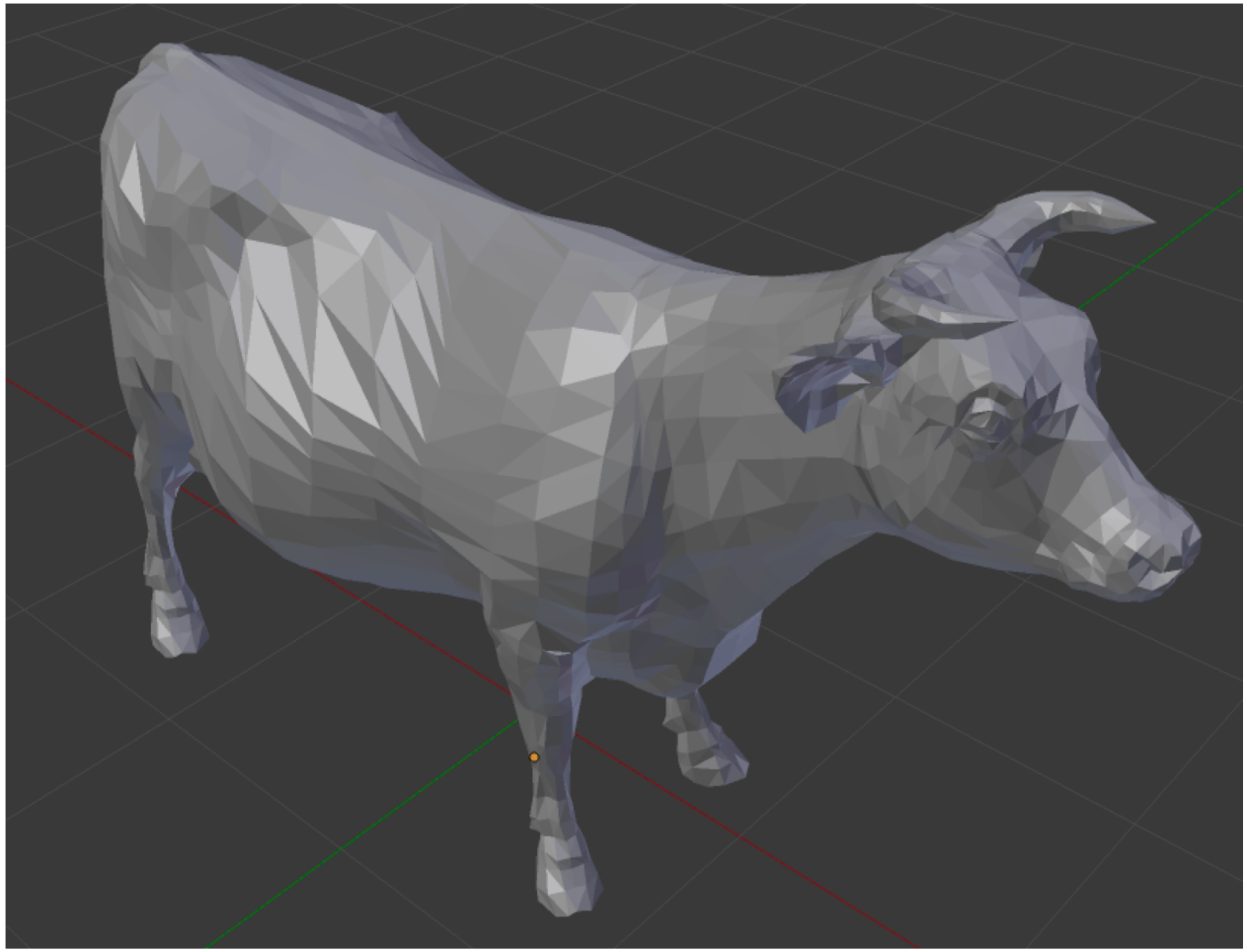
More on Normals - Blender



Part of P4 – A Smoother Cow

Your P3 ray tracer essentially creates this illumination of the cow object.

Put essentially the Phong model into your ray tracer.



P4 - Smoothing Approach

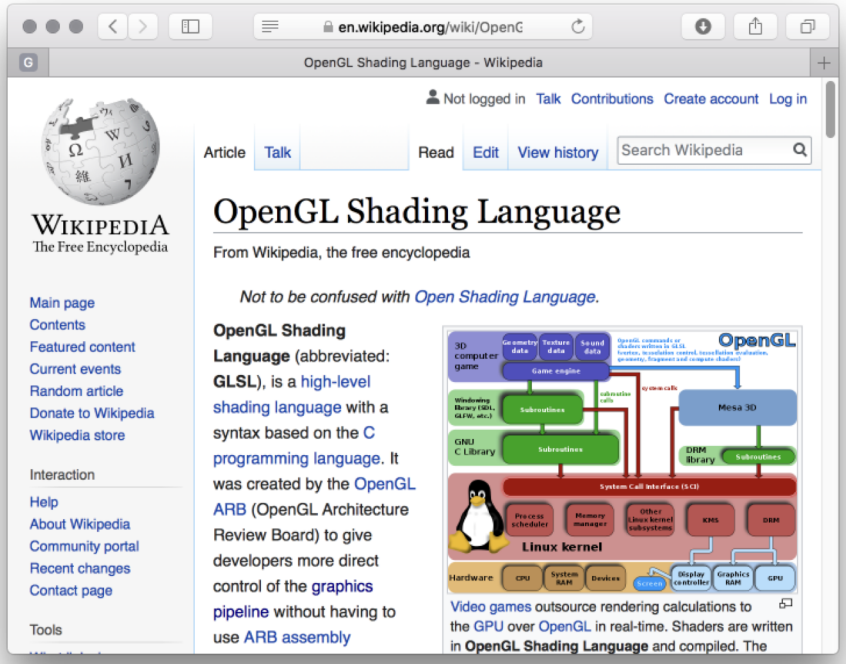
- Identify shared vertices
  - Lookup vertex numbers for a given triangle
- Compute true normal for every surface
  - Here assume A then B then C traversal
  - Compute the average normal at a vertex
    - Exclude adjacent faces too far off in orientation
- Use beta and gamma to interpolate normals

$$N_i = (1 - \beta - \gamma)\, N_A + \beta N_B + \gamma N_C$$

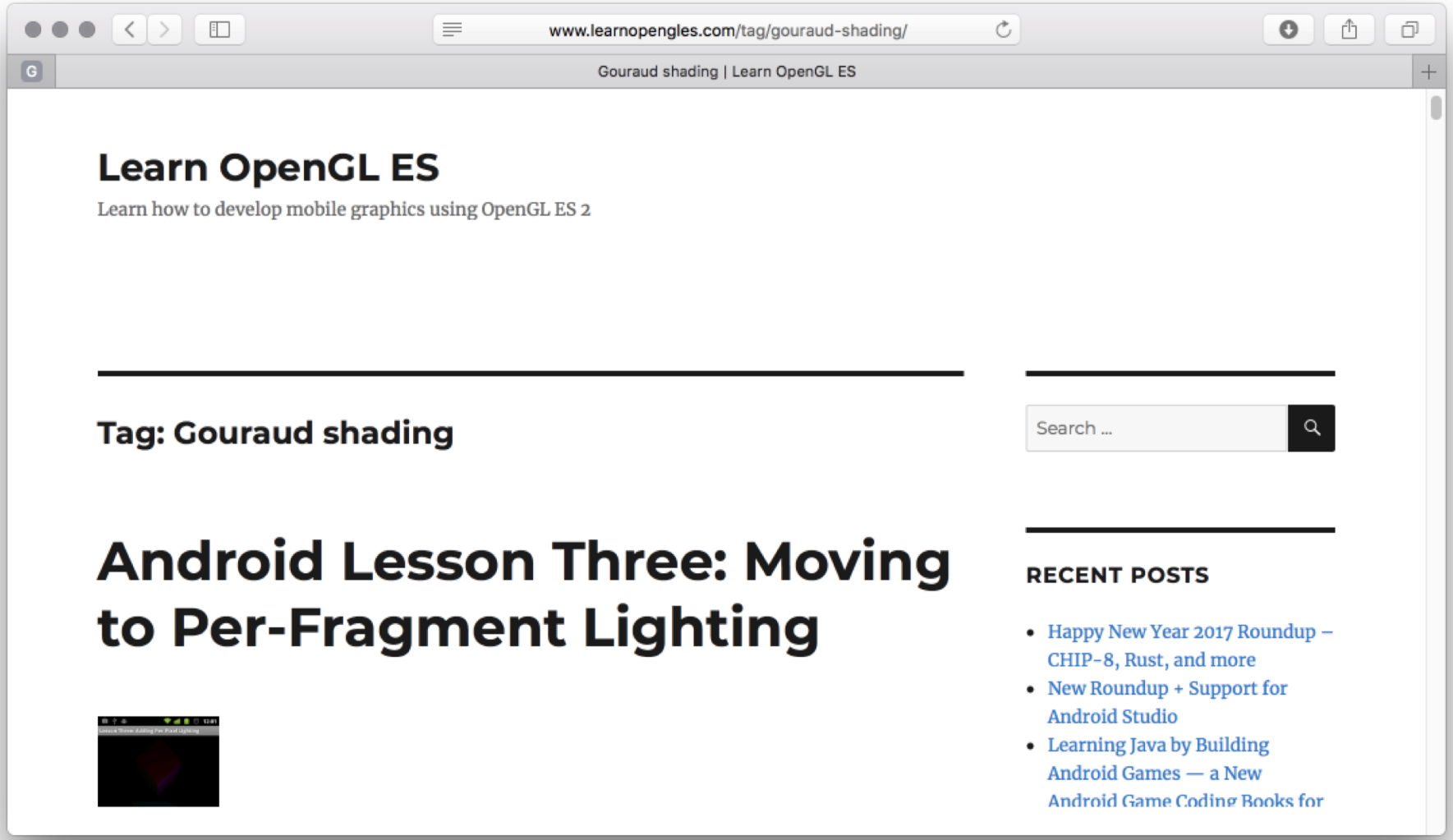
A Glimpse at Shaders

- Original OpenGL and the Fixed Pipeline
  - Example: Gouraud Shading
- Modern OpenGL means writing shaders
  - Vertices
  - Fragments

In CS410, know the role shaders play.
Do not expect to know how to write shaders.



One More Glimpse



https://www.learnopengles.com/tag/gouraud-shading/