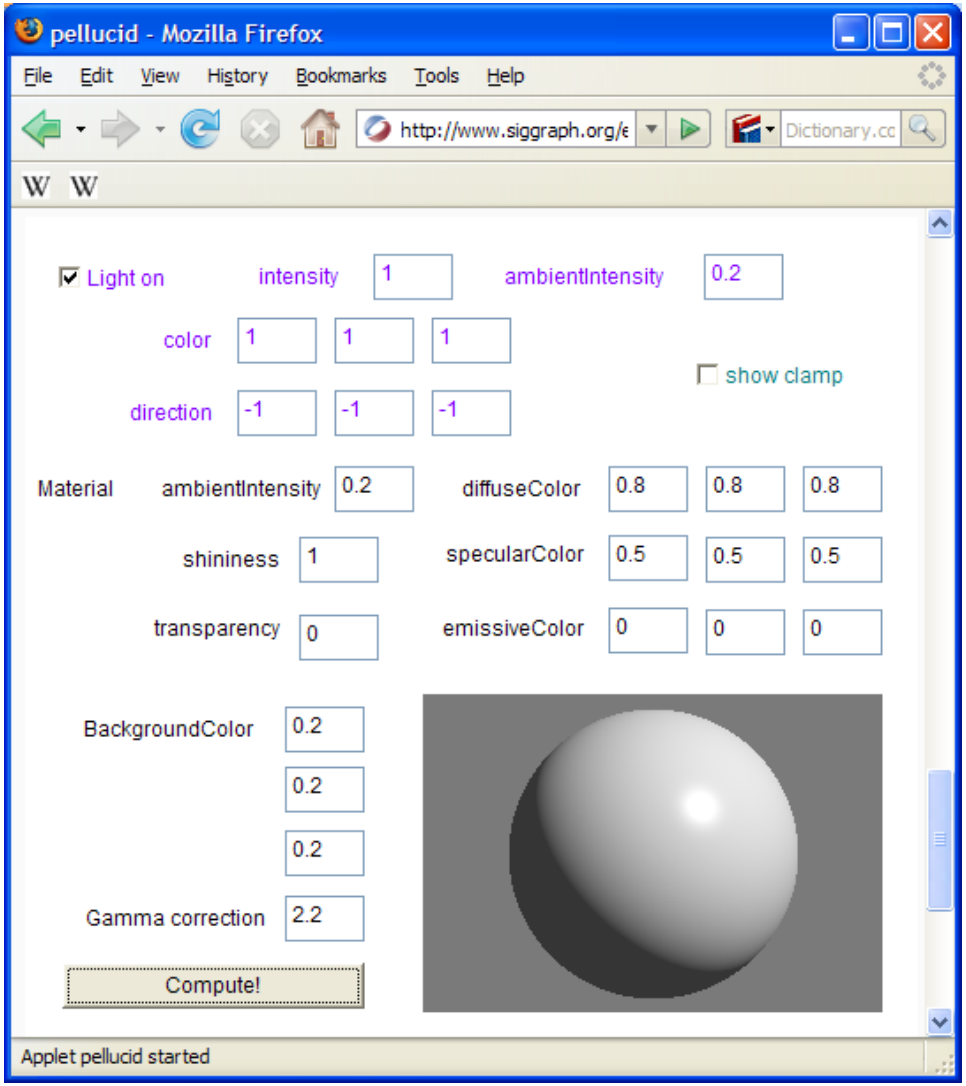
Interesting Illumination Demo



There's a very nice Java illumination model demo which may help you understand the effects of different kinds of reflections available at: http://www.siggraph.org/education/materials/HyperGraph/illumin/vrml/pellucid.html

Try playing with the various parameters and see if you can predict what the sphere will look like

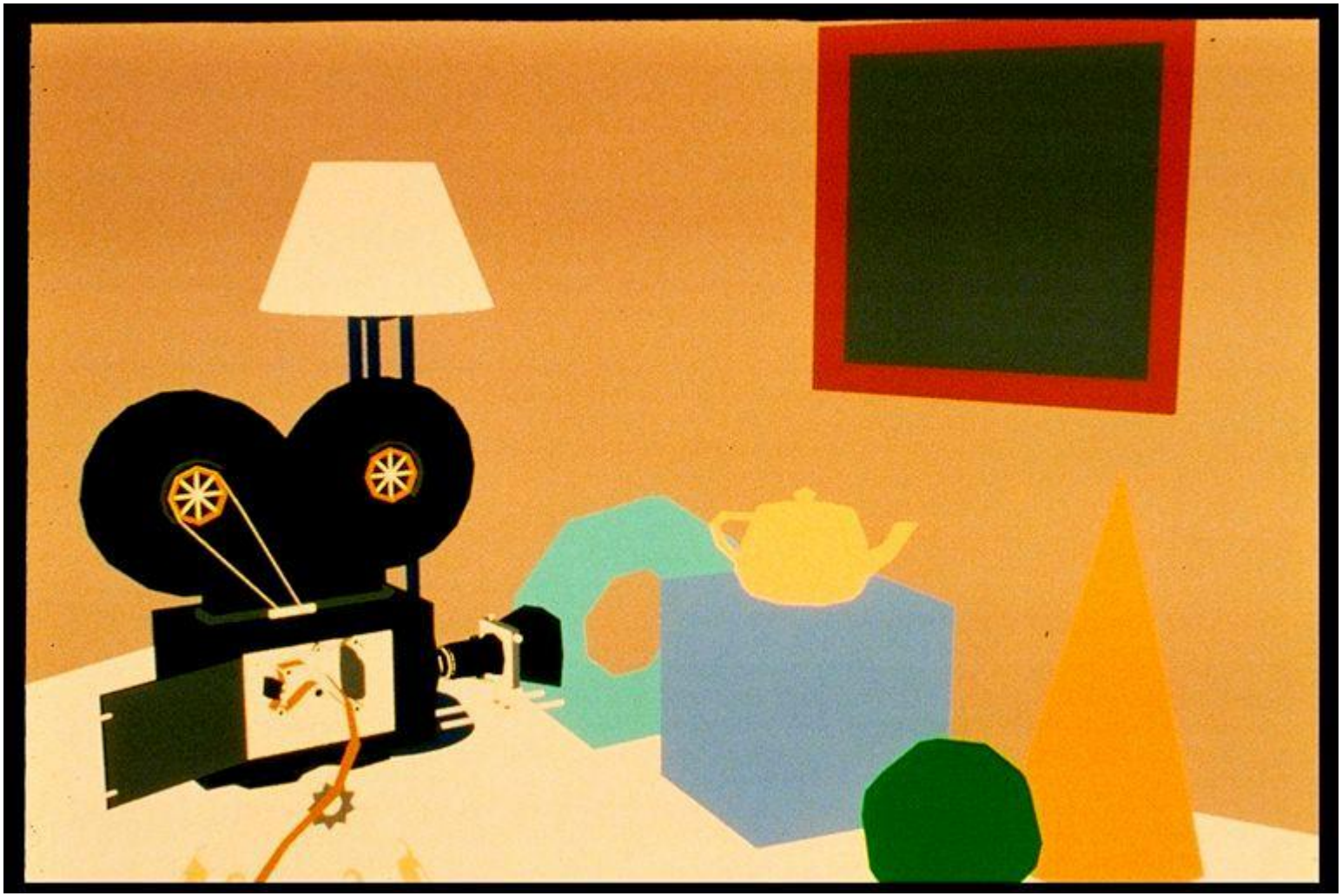
Computer Graphics 16: Polygon Rendering Methods

Contents

Today we will start to look at rendering methods used in computer graphics

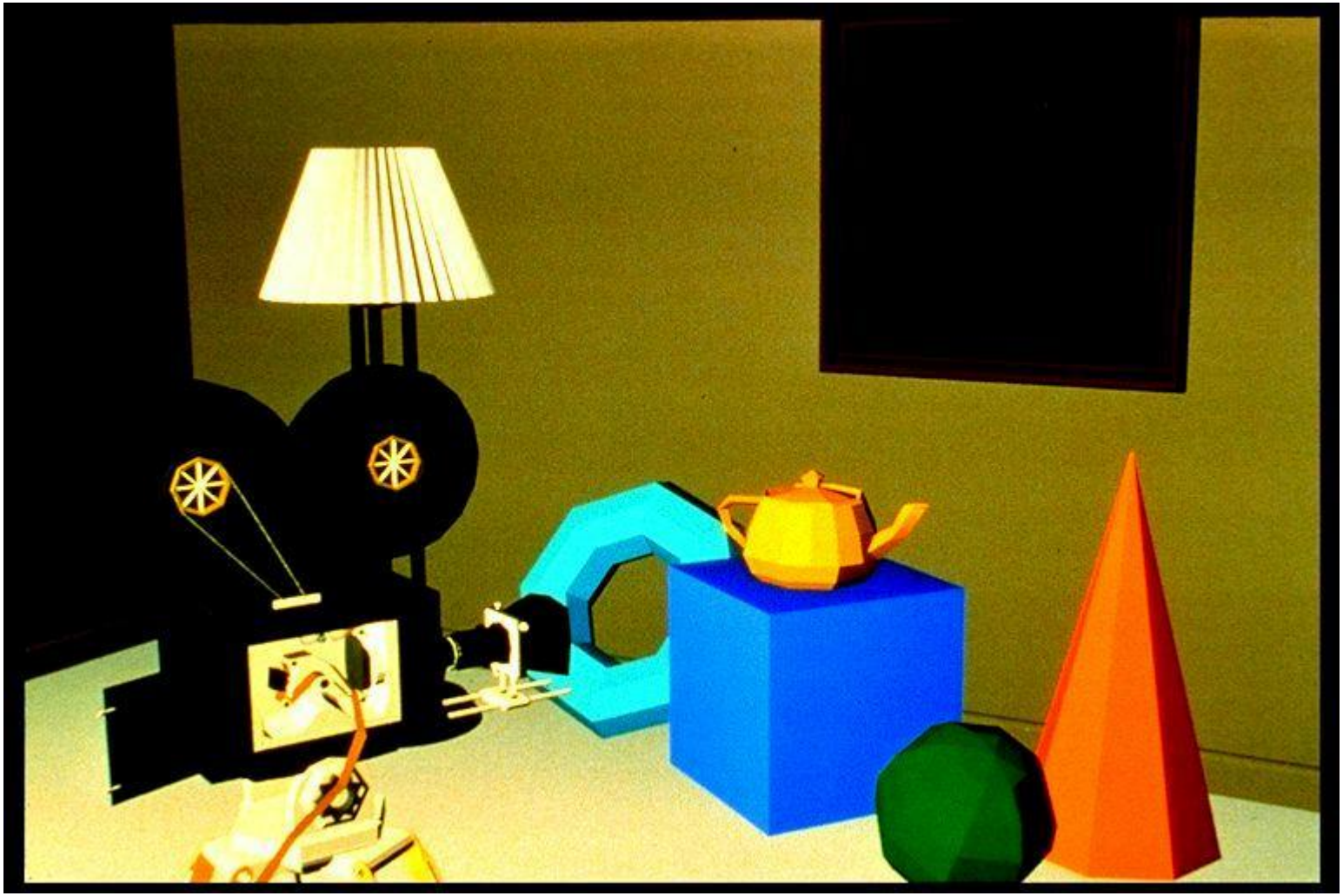
- Flat surface rendering
- Gouraud surface rendering
- Phong surface rendering

No Surface Rendering



Images come from:
www.siggraph.org/education/materials/HyperGraph/scanline/shade_models/shading.htm

Flat Surface Rendering



Images come from:
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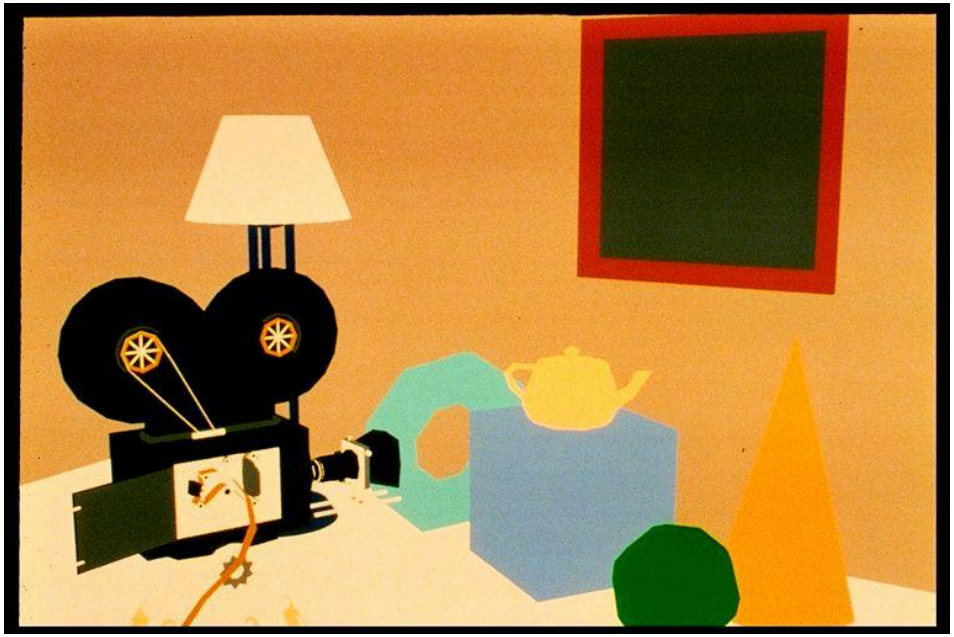
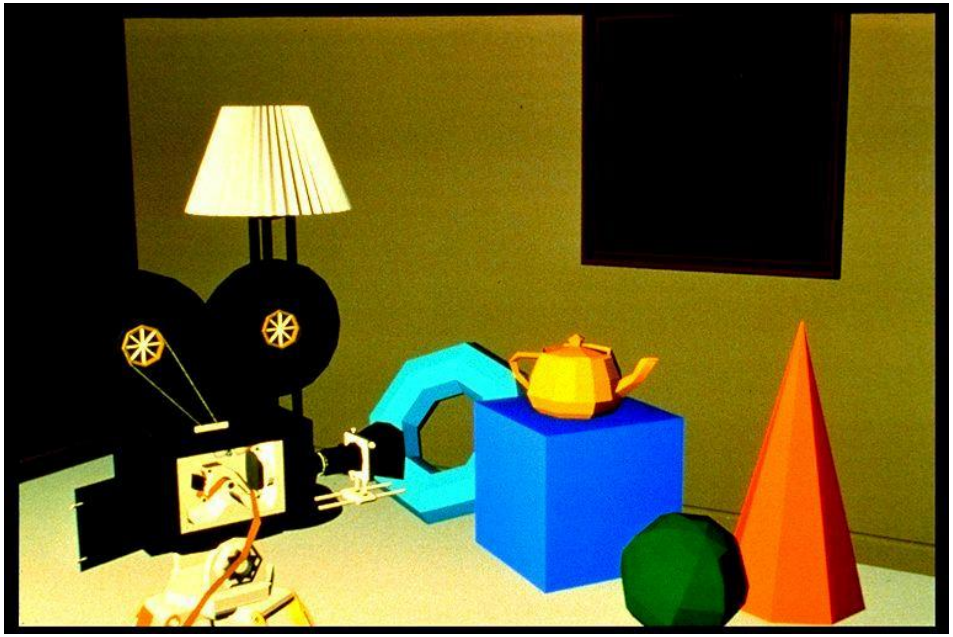
No Surface Rendering Vs Flat Surface Rendering



No Surface Rendering



Flat Surface Rendering

Images come from:
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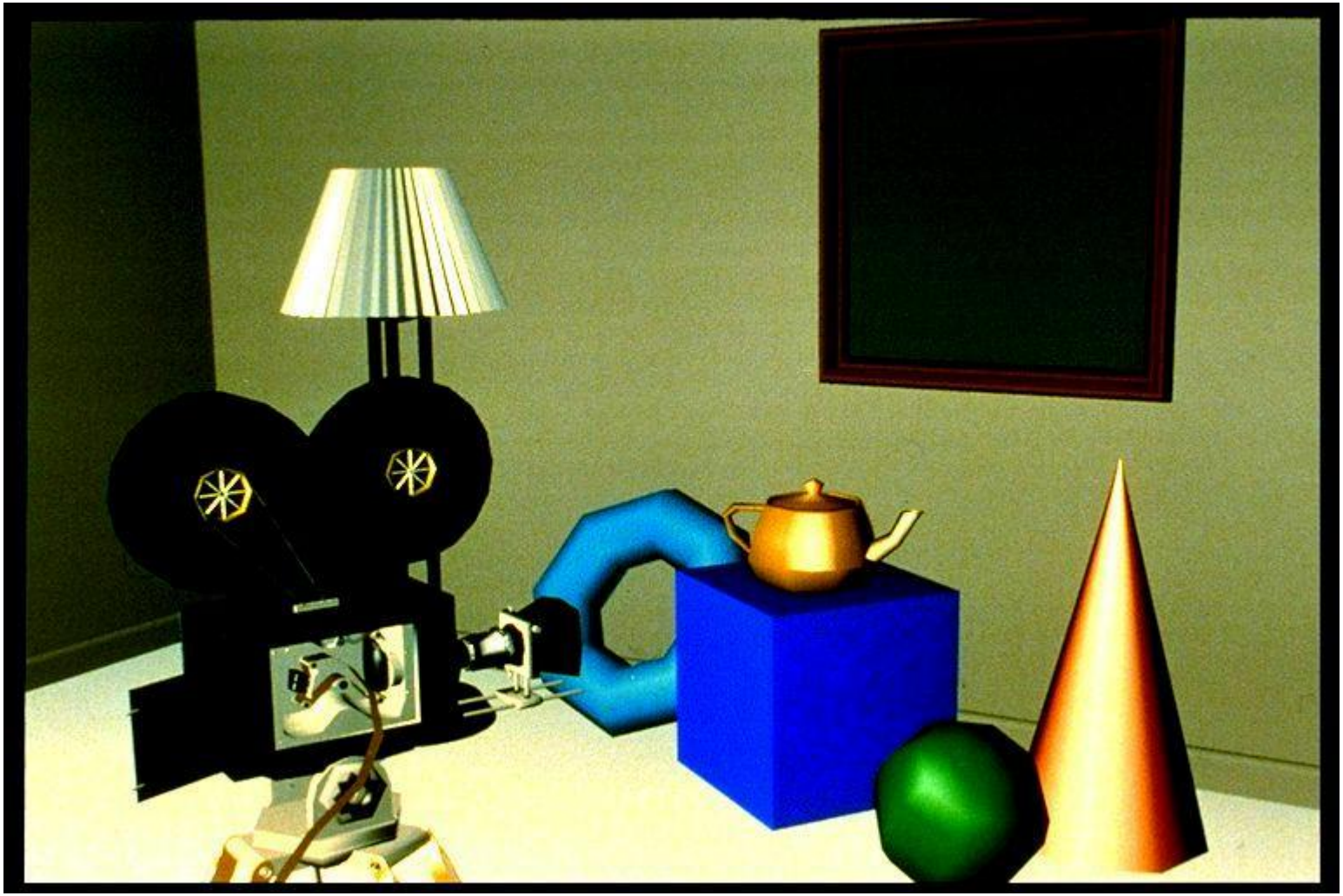
Gouraud Surface Rendering



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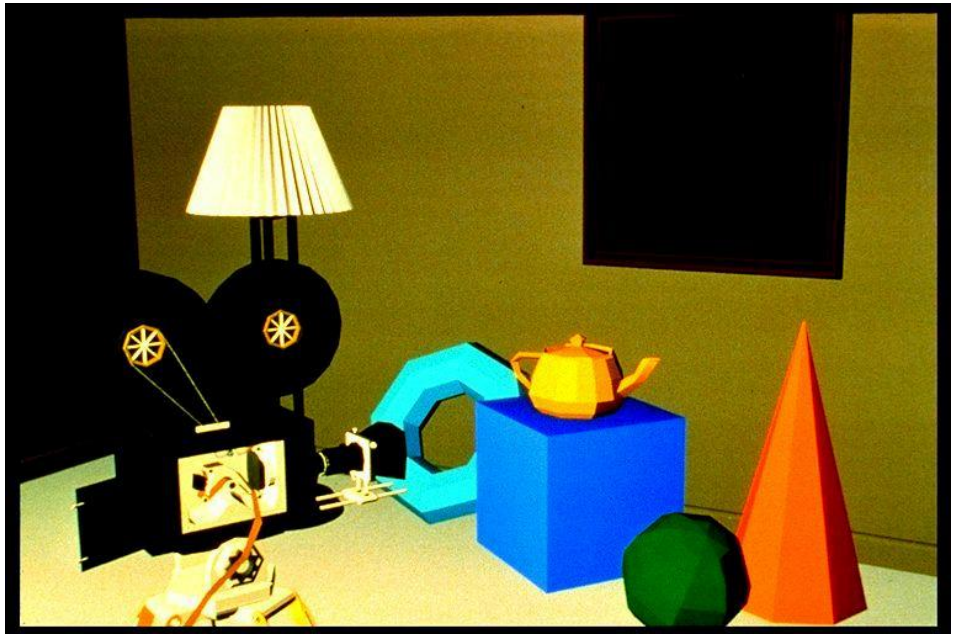
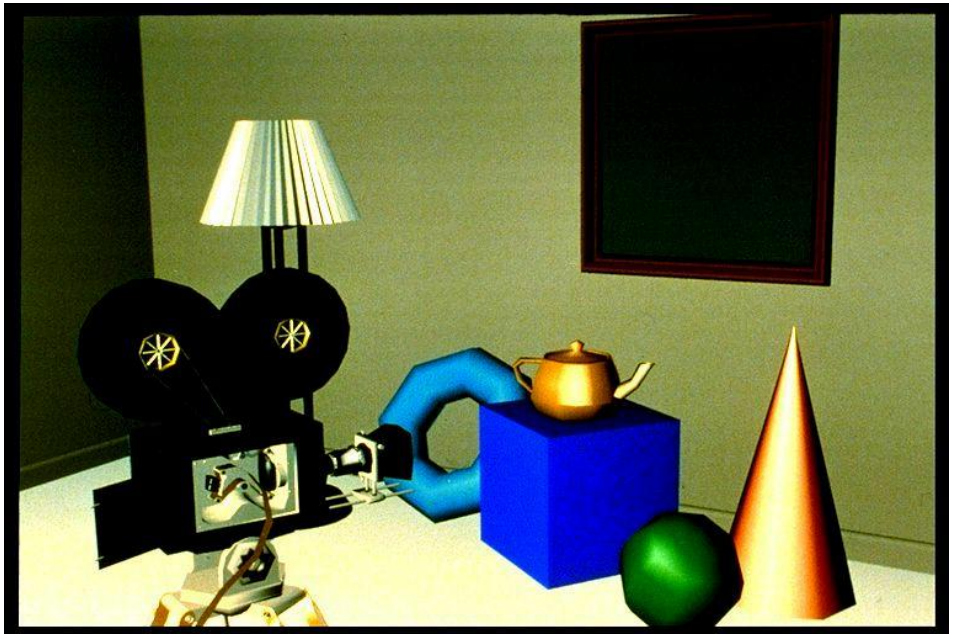
No Surface Rendering Vs Flat Surface Rendering



Flat Surface Rendering



Gouraud Surface Rendering

Images come from:
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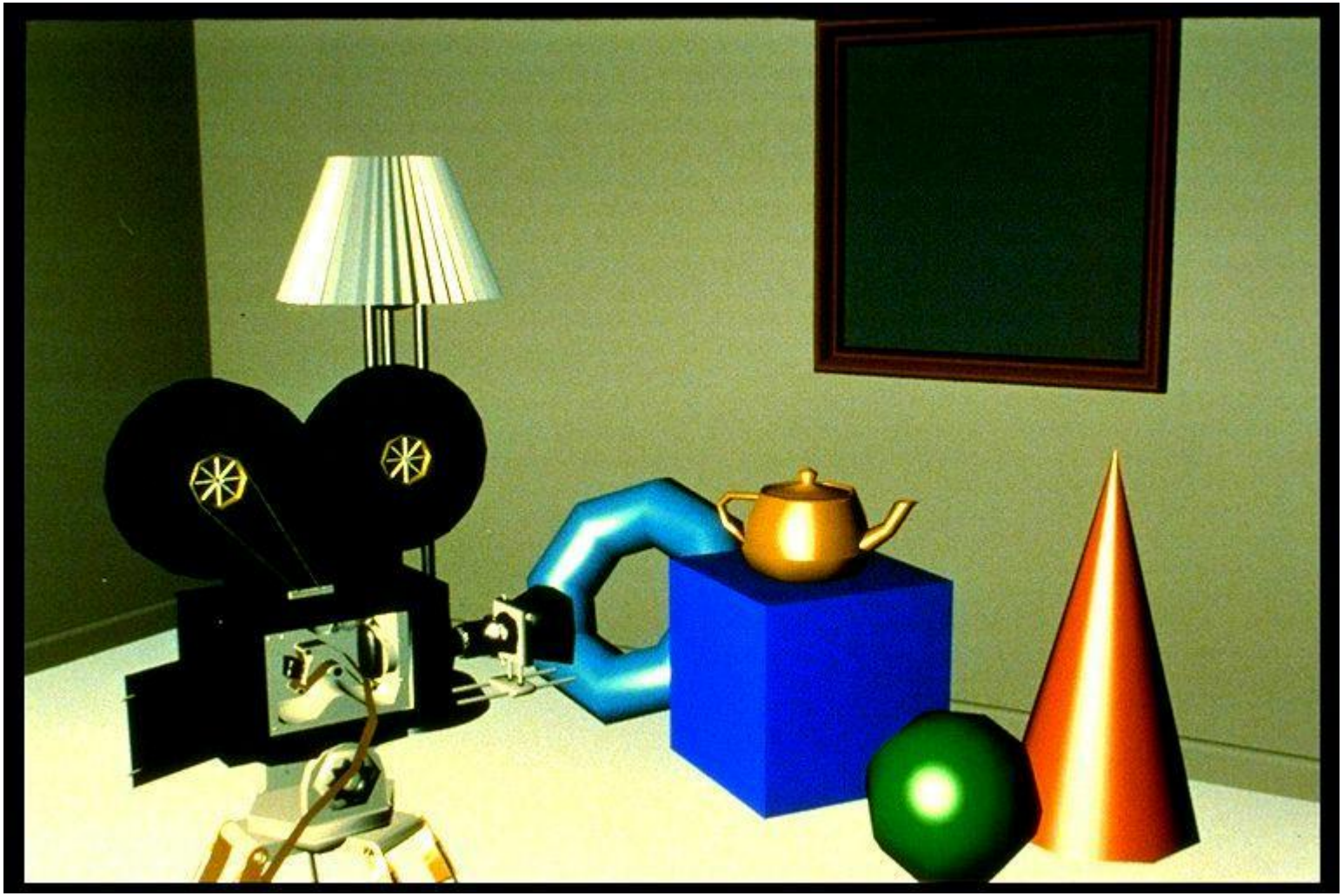
Phong Surface Rendering



Images come from:
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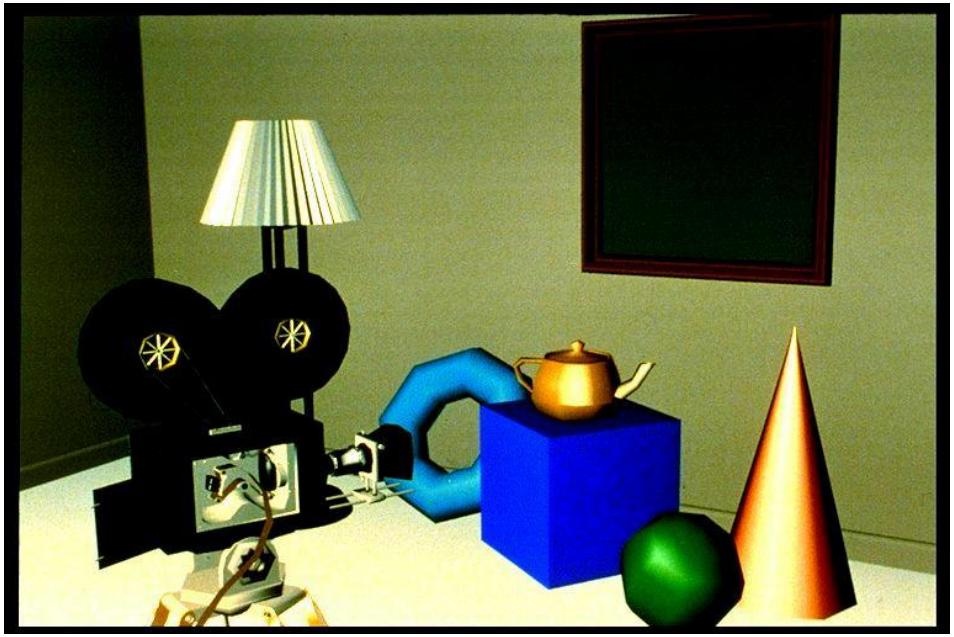
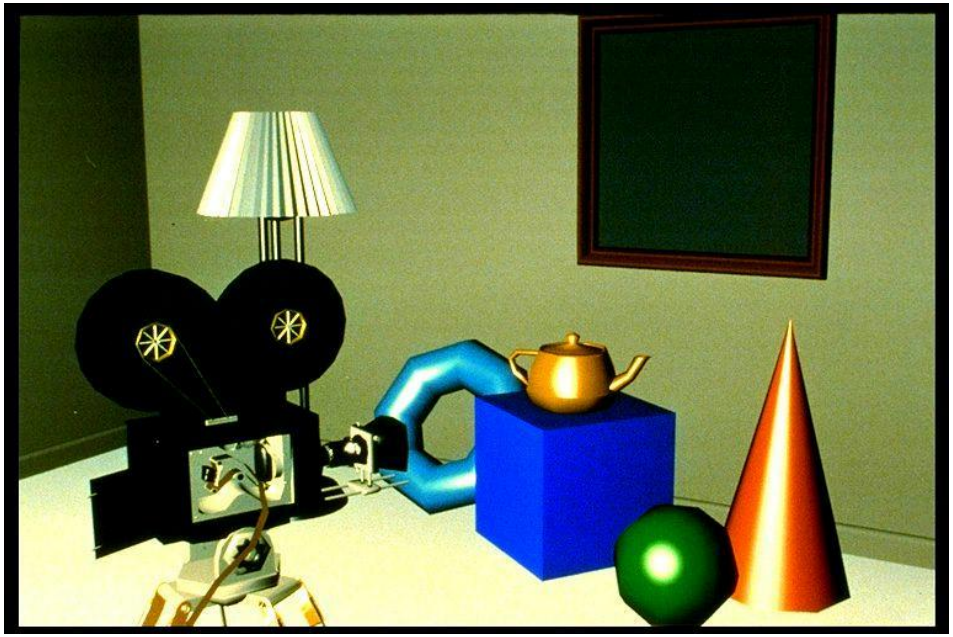
No Surface Rendering Vs Flat Surface Rendering



Gouraud Surface Rendering



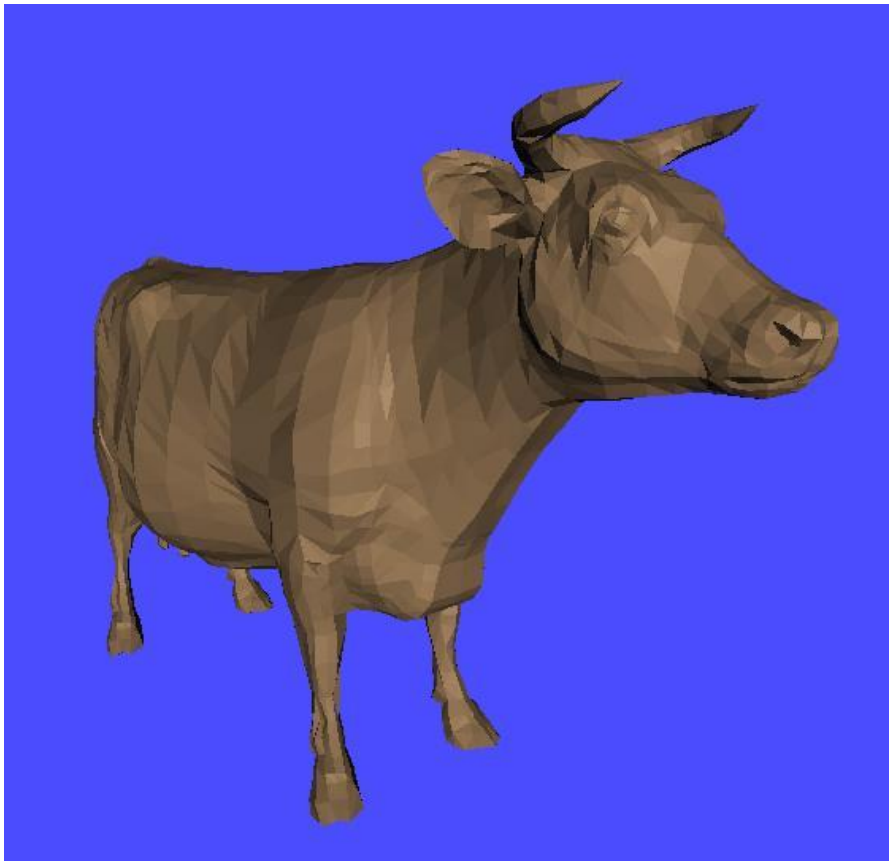
Phong Surface Rendering

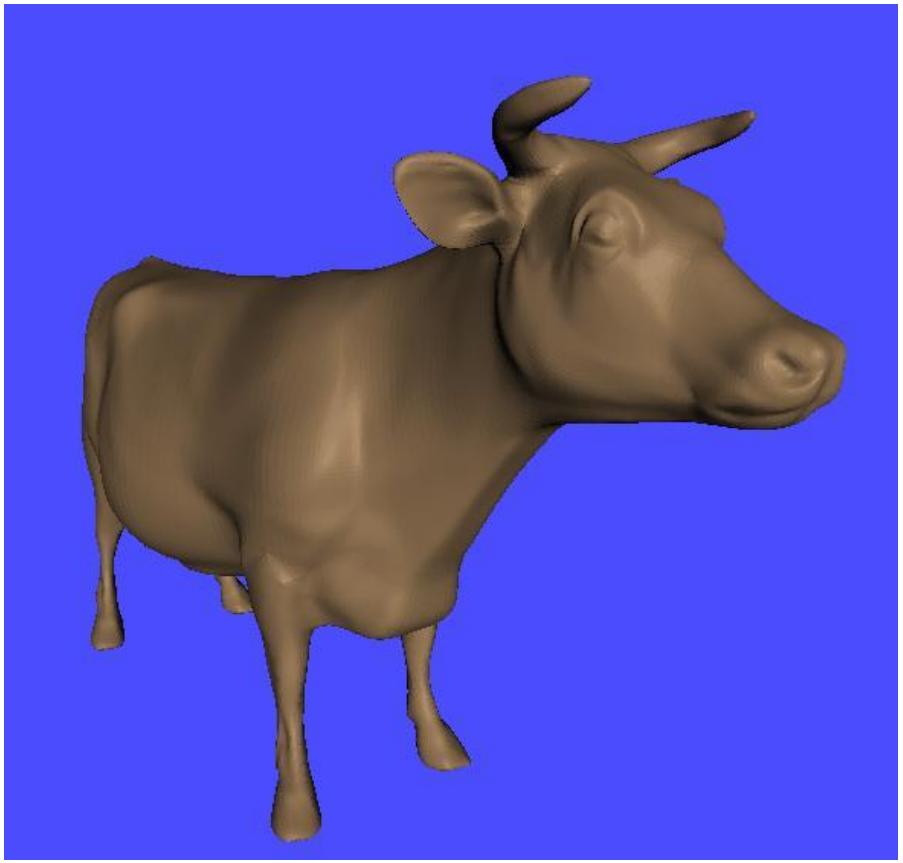
Images come from:
www.siggraph.org/education/materials/HyperGraph/scanline/shade_models/shading.htm

Flat Surface Rendering

- The simplest method for rendering a polygon surface
- The same colour is assigned to all surface positions
- The illumination at a single point on the surface is calculated and used for the entire surface
- Flat surface rendering is extremely fast, but can be unrealistic

Overcoming Flat Shading Limitations





Images come from: http://www-static.cc.gatech.edu/classes/AY2004/cs4451a_spring/shading_models/linint.html

Just add lots and lots of polygons – however, this is SLOW!

Gouraud Surface Rendering

Gouraud surface shading was developed in the 1970s by Henri Gouraud

Worked at the University of Utah along with Ivan Sutherland and David Evans

Often also called **intensity-interpolation surface rendering**

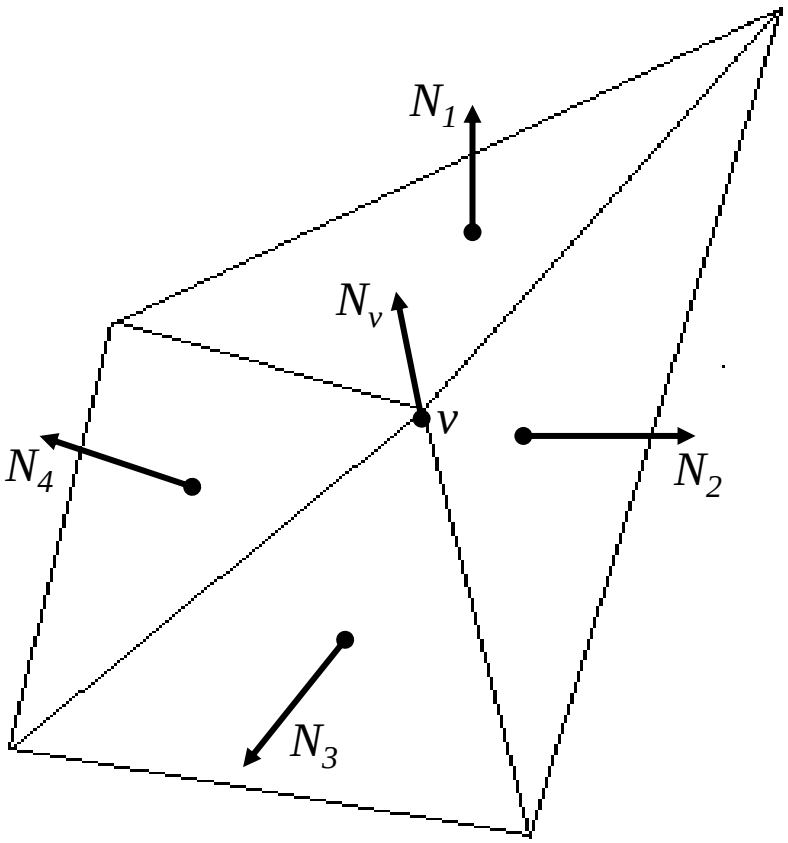
Intensity levels are calculated at each vertex and interpolated across the surface

Gouraud Surface Rendering (cont…)

To render a polygon, Gouraud surface rendering proceeds as follows:

1. Determine the average unit normal vector at each vertex of the polygon
2. Apply an illumination model at each polygon vertex to obtain the light intensity at that position
3. Linearly interpolate the vertex intensities over the projected area of the polygon

Gouraud Surface Rendering (cont…)



The average unit normal vector at v is given as:

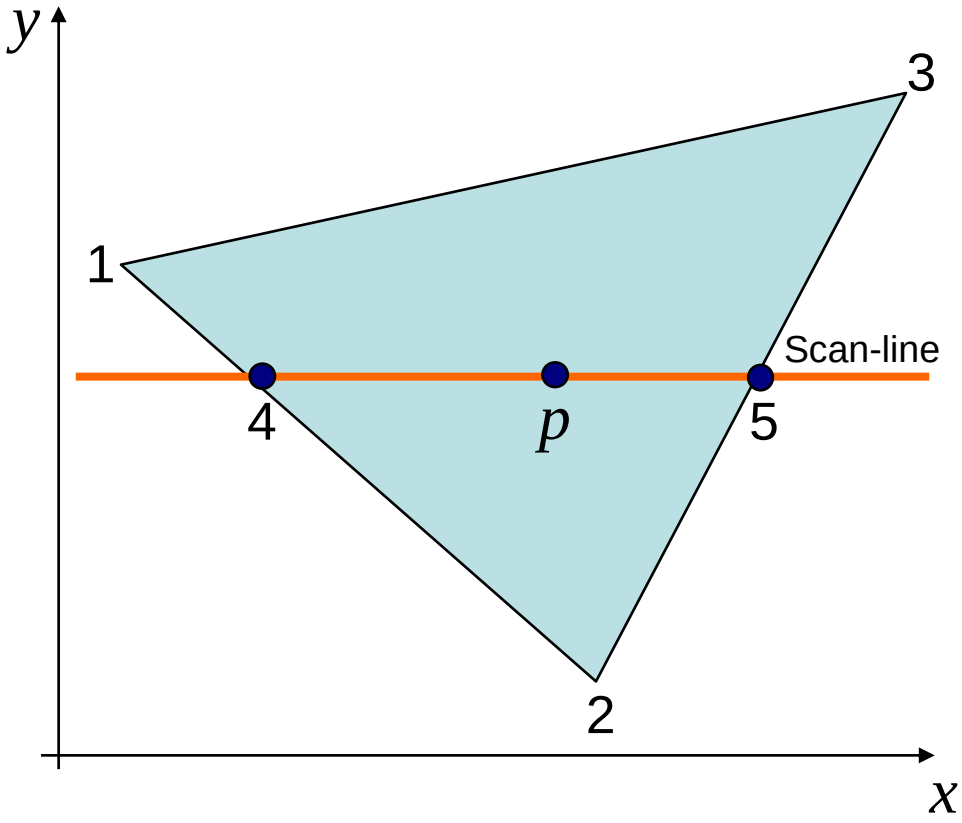
$$N_v = \frac{N_1 + N_2 + N_3 + N_4}{\left| N_1 + N_2 + N_3 + N_4 \right|}$$

or more generally:

$$N_v = \frac{\sum_{i=1}^{n} N_i}{\left| \sum_{i=1}^{n} N_i \right|}$$

Gouraud Surface Rendering (cont…)

Illumination values are linearly interpolated across each scan-line

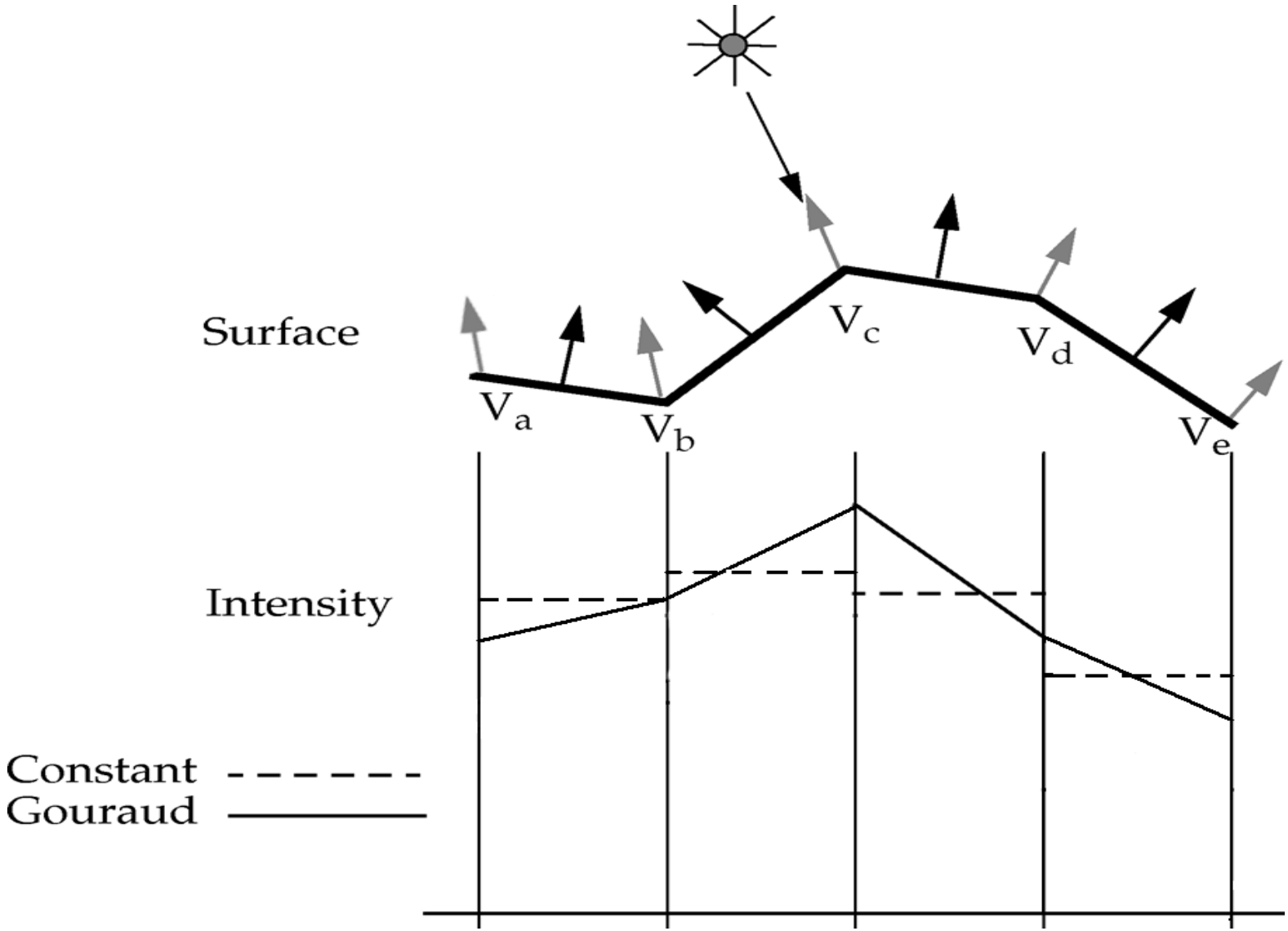


$$I_4 = \frac{y_4 - y_2}{y_1 - y_2} I_1 + \frac{y_1 - y_4}{y_1 - y_2} I_2$$

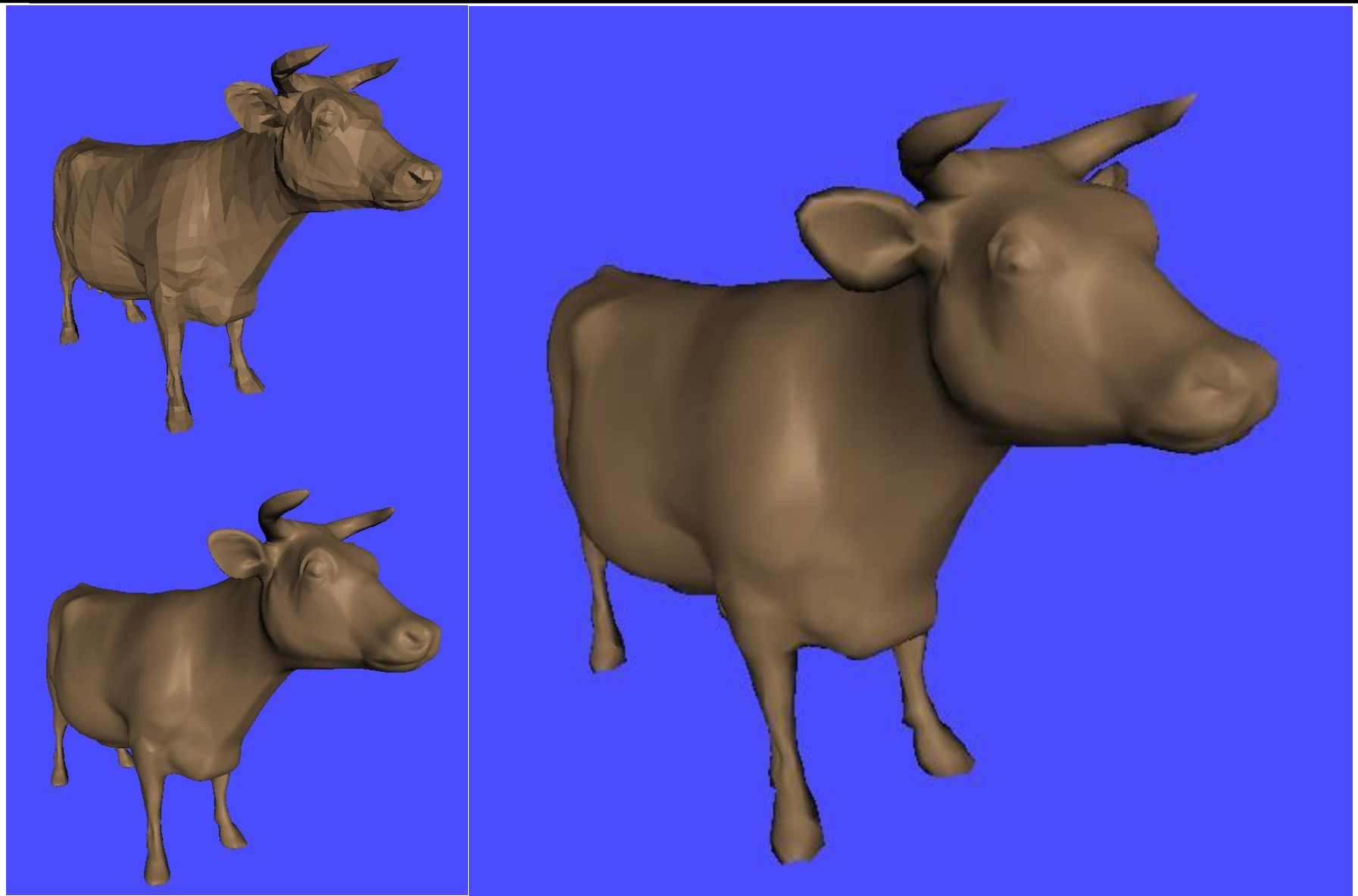
$$I_5 = \frac{y_5 - y_2}{y_3 - y_2} I_3 + \frac{y_3 - y_5}{y_3 - y_2} I_2$$

$$I_p = \frac{x_5 - x_p}{x_5 - x_4} I_4 + \frac{x_p - x_4}{x_5 - x_4} I_5$$

Advantages of Gouraud Surface Rendering



Gouraud Surface Rendering Example



Images come from: http://www-static.cc.gatech.edu/classes/AY2004/cs4451a_spring/shading_models/linint.html

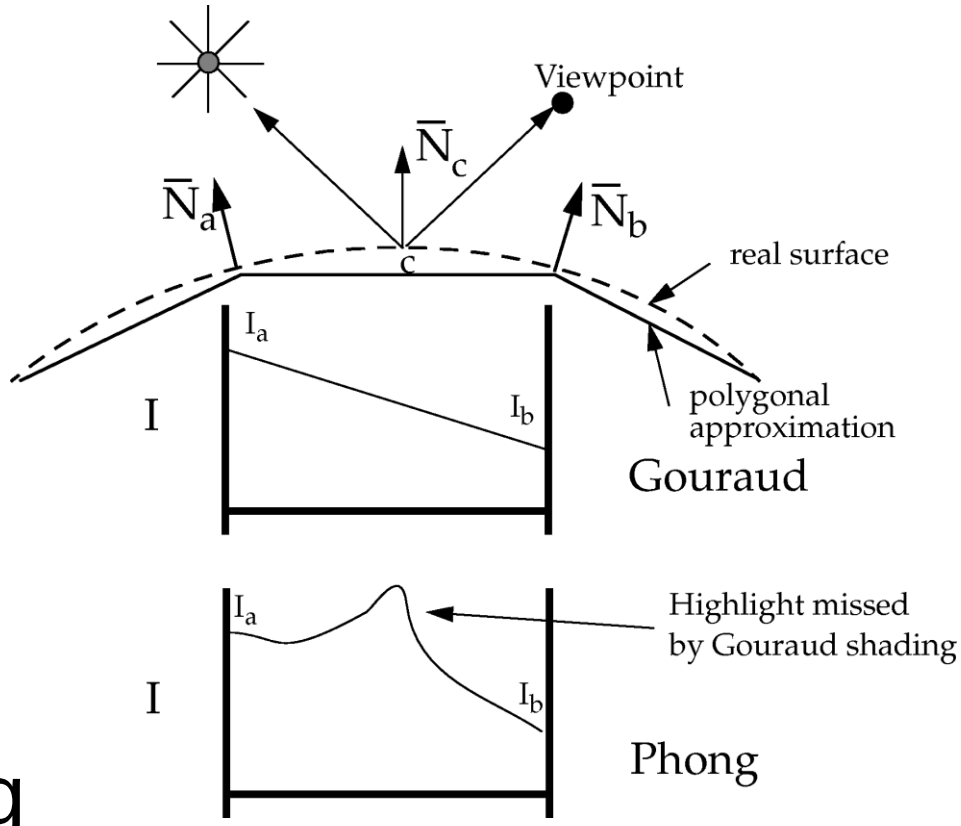
Gouraud Surface Rendering Implementation

Gouraud surfacing rendering can be implemented relatively efficiently using an iterative approach

Typically Grouaud shading is implemented as part of a visible surface detection technique

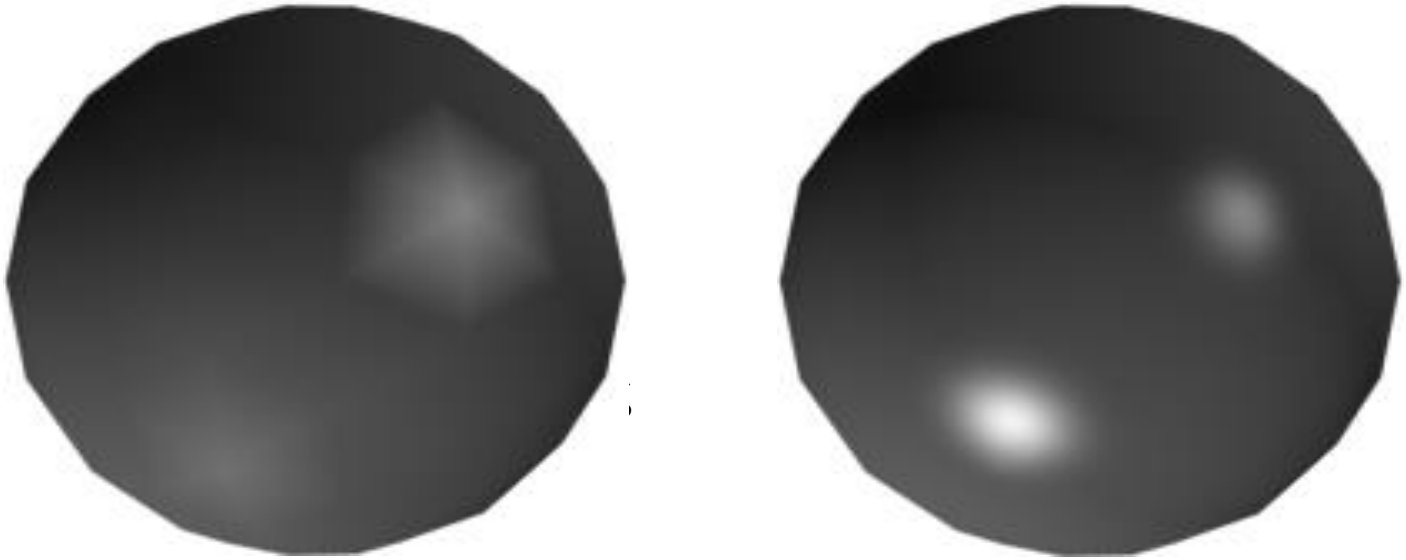
Problems With Gouraud Shading

Gouraud shading tends to miss certain highlighting
In particular Gouraud shading has a problem with specular reflections



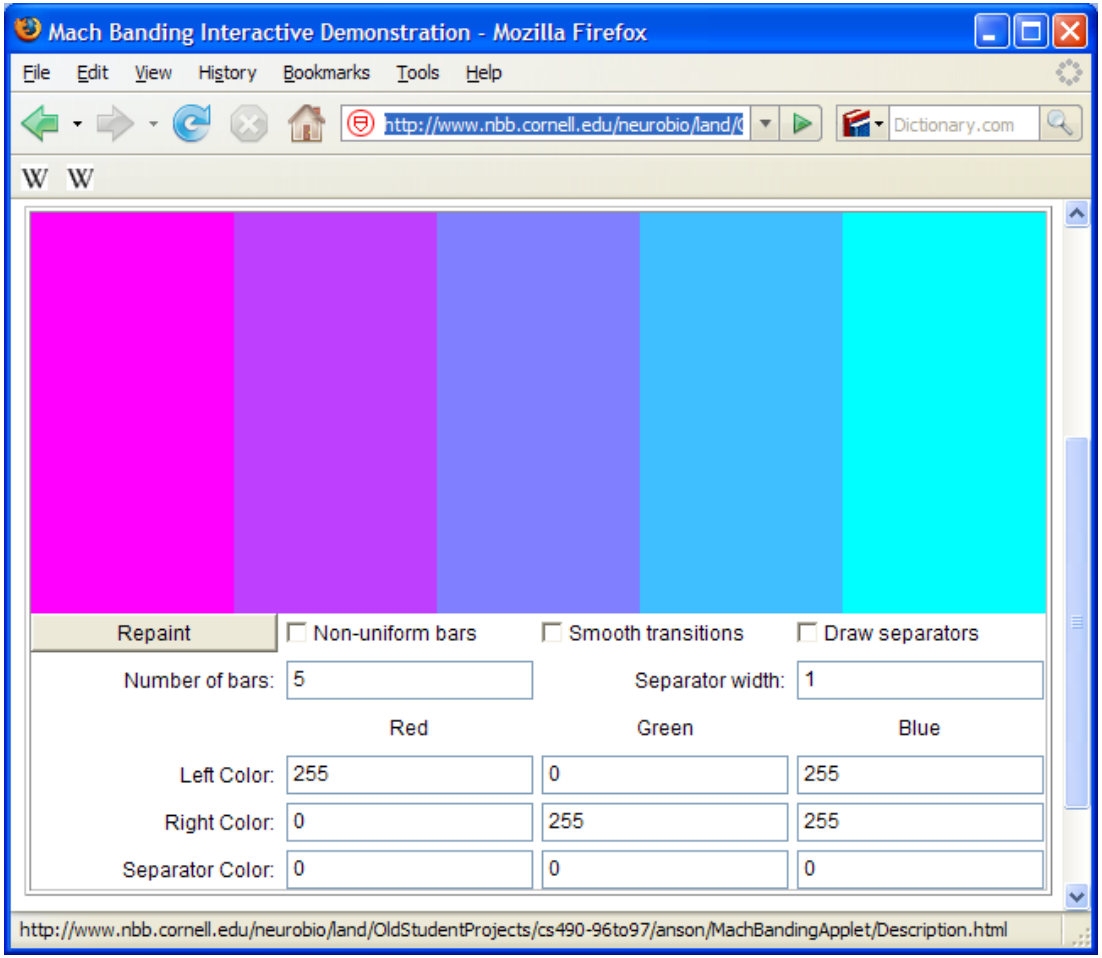
Also, Gouraud shading can introduce anomalies known as **Mach bands**

Problems With Gouraud Shading (cont…)



The major problem with Gouraud shading is in handling specular reflections

Mach Bands



A psychological phenomenon whereby we see bright bands where two blocks of solid colour meet

A good demo is available to experiment with this at:

http://www.nbb.cornell.edu/neurobio/land/OldStudentProjects/cs490-96to97/anson/MachBandingApplet/

Try playing with the various parameters and see if you can predict what the sphere will look like

Phong Surface Rendering

A more accurate interpolation based approach for rendering a polygon was developed by Phong Bui Tuong

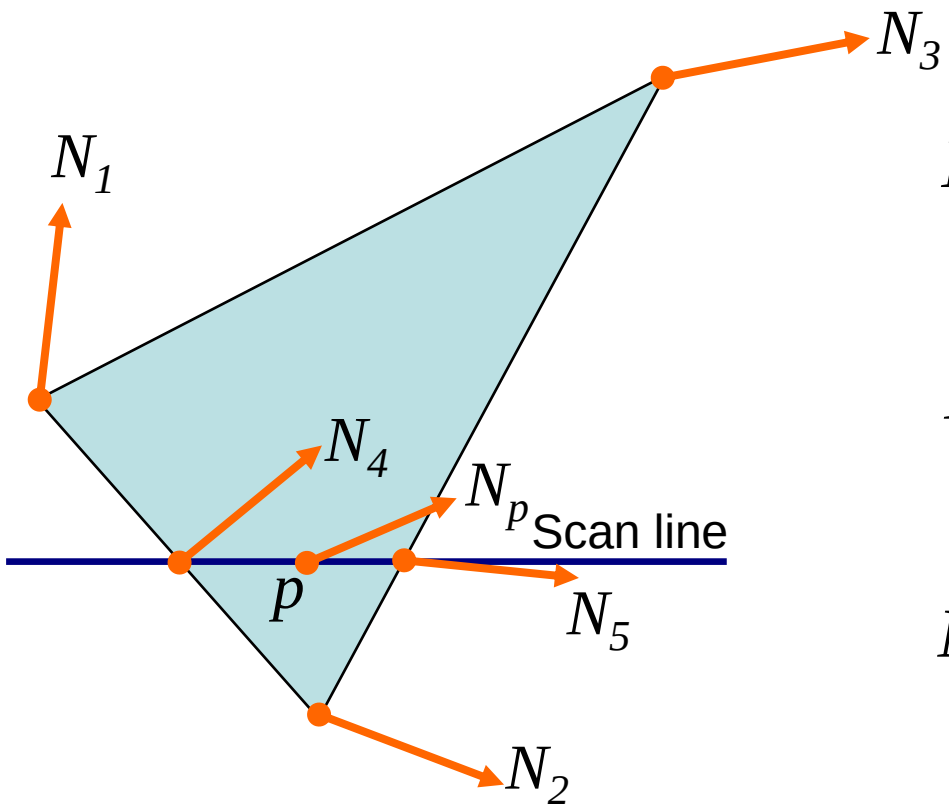
Basically the Phong surface rendering model (or **normal-vector interpolation rendering**) interpolates normal vectors instead of intensity values

Phong Surface Rendering (cont…)

To render a polygon, Phong surface rendering proceeds as follows:

1. Determine the average unit normal vector at each vertex of the polygon
2. Linearly interpolate the vertex normals over the projected area of the polygon
3. Apply an illumination model at positions along scan lines to calculate pixel intensities using the interpolated normal vectors

Phong Surface Rendering (cont…)



$$N_4 = \frac{y_4 - y_2}{y_1 - y_2} N_1 + \frac{y_1 - y_4}{y_1 - y_2} N_2$$

$$N_5 = \frac{y_5 - y_2}{y_3 - y_2} N_3 + \frac{y_3 - y_5}{y_3 - y_2} N_2$$

$$N_p = \frac{y_p - y_5}{y_4 - y_5} N_4 + \frac{y_4 - y_p}{y_4 - y_5} N_5$$

Phong Surface Rendering Implementation

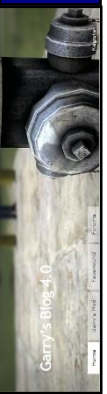
Phong shading is much slower than Gouraud shading as the lighting model is re-evaluated so many times

However, there are fast Phong surface rendering approaches that can be implemented iteratively

Typically Phong shading is implemented as part of a visible surface detection technique

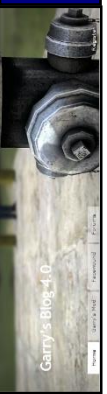
Phong Shading Examples

Images come from Garry's Mod:
http://www.garry.tv/



Phong Shading Examples

Images come from Garry's Mod:
http://www.garry.tv/



Summary

For realistic rendering of polygons we need interpolation methods to determine lighting positions

Flat shading is fast, but unrealistic

Gouraud shading is better, but does not handle specular reflections very well

Phong shading is better still, but can be slow