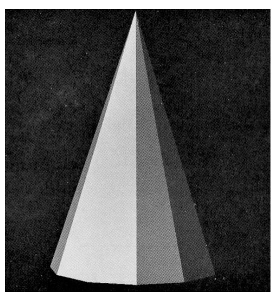
Classical Rendering Paper Summaries

Illumination for Computer Generated Pictures

Bui Tuong Phong
University of Utah
Communications of the ACM,
Vol. 18, No 6, 1975

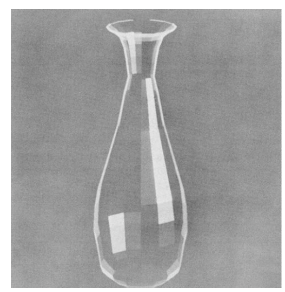
Warnock Shading

- Flat shading
- Decrease intensity with distance from light and object
- Highlights



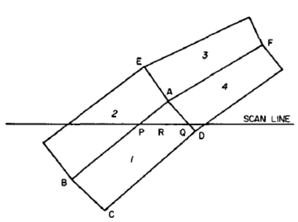
Newell, Newell, and Sancha

- Flat shading of polygons
- Transparency & highlights due to reflected light



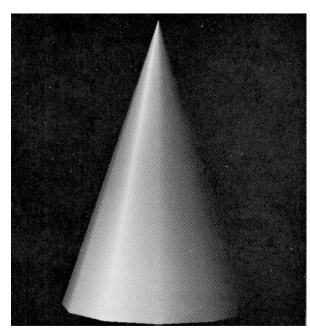
Gouraud Shading

- Interpolation
  - A to B
  - A to D
  - P to Q
- = Bilinear Interpolation



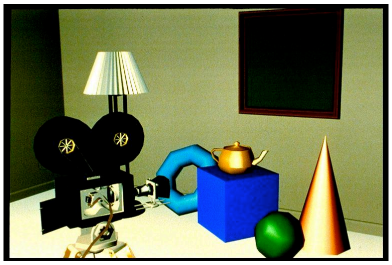
Gouraud Shading

- Compute shading at each vertex
- Interpolate shading



Problem with Gouraud Shading

- Highlights across polygons

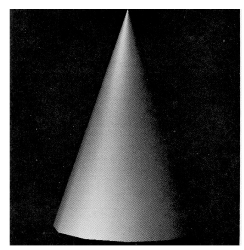


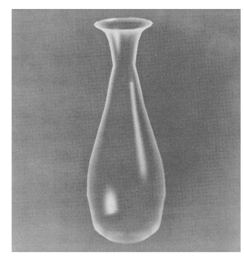
Phong Shading

Phong Shading

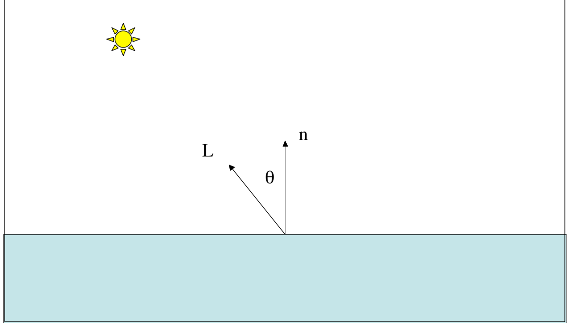
- Interpolate Normals
  - $N_t = tN_1 + (1 - t)N_0$
- Evaluate Shading for each pixel

Phong Shading



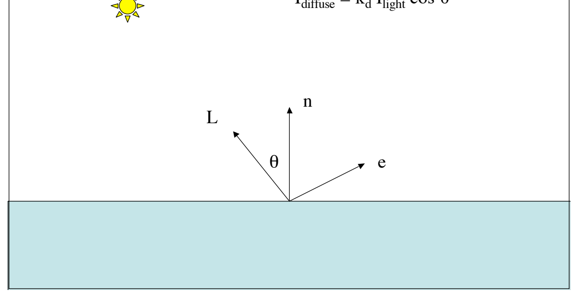


Lambert's law



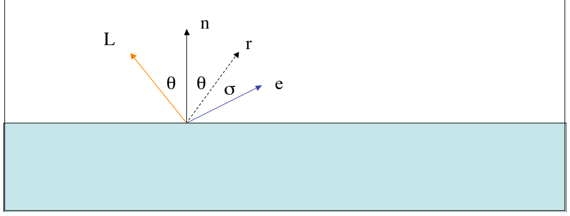
Diffuse Shading

$I_{diffuse} = k_d \, I_{light} \cos \theta$



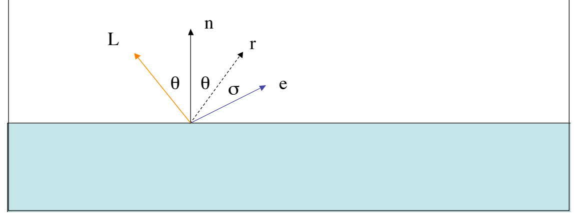
Specular Shading

Add specular by looking at reflection, **r**
Shiny surfaces, such as a mirror

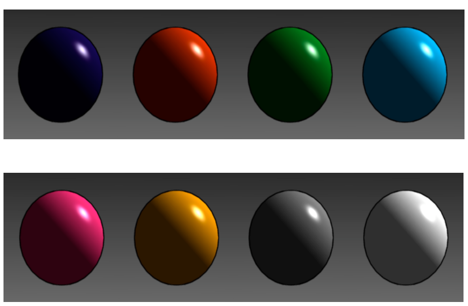


Phong Shading

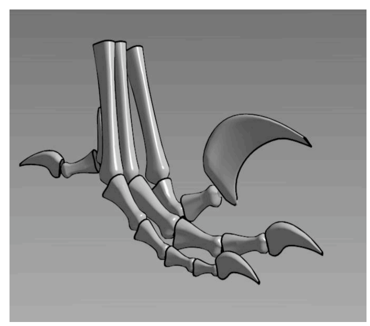
$$I_{total} = k_a I_{ambient} + \sum_{i=1}^{lights} I_i \left(k_d(N \cdot L) + k_s(V \cdot R)^{n_{shiney}}\right)$$



Phong Shaded Spheres



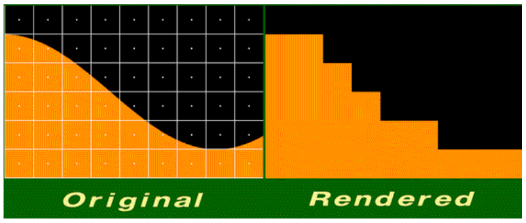
Hand-tuned Phong shading



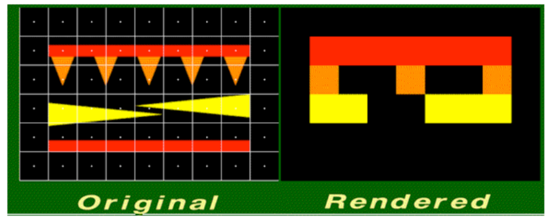
The Aliasing Problem in Computer Generated Shaded Images

Frank Crow
University of Texas at Austin
Communications of the ACM,
Vol. 20, No. 11, 1977

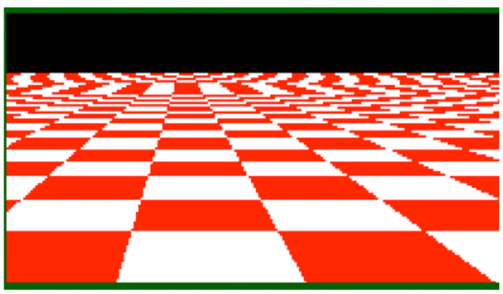
Problems with rendering pixels: **Jaggies**



Problems with rendering pixels: **Loss of Detail**



Problems with rendering pixels: **Disintegrating Texture**



Problems with just rendering pixels

- 1) along edge of silhouette of object or crease in a surface
  - Jaggies
- 2) very small objects
  - Can disappear between dots
- 3) areas of complex detail

Possible Solutions

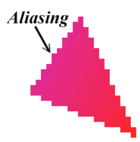
- Increase Resolution
  - Sometimes impractical
- Blurring
  - Removes detail
- Sample represents finite area, not infinitesimal spot

Solution

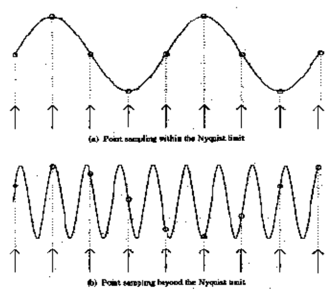
- Super-sampling (more samples than pixels)
- Low-pass prefiltering (averaging of super-samples)

Solution: Convolution Filter

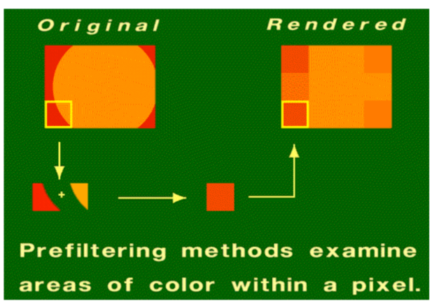
- Signal can be reproduced if the highest frequencey in the signal does not exceed one half the sampling frequency
  - called the Nyquist Limit
  - $N_{sample} >= 2^* N_{analog}$
- Failing to do so produces
  Aliasing



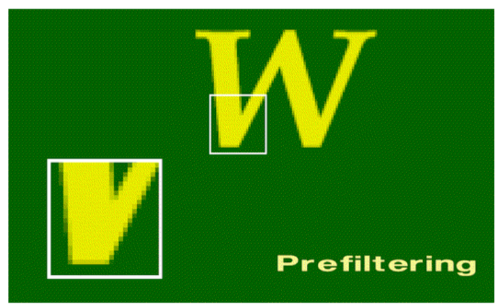
Nyquist Limit



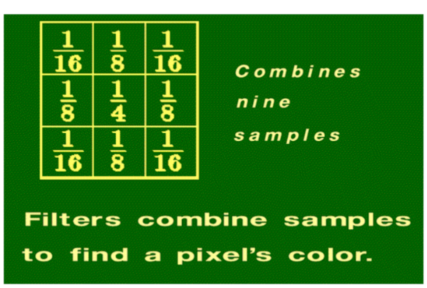
Prefiltering

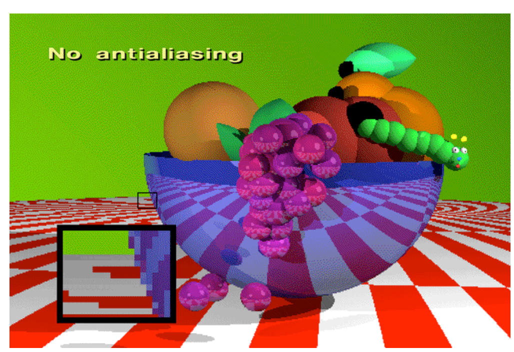


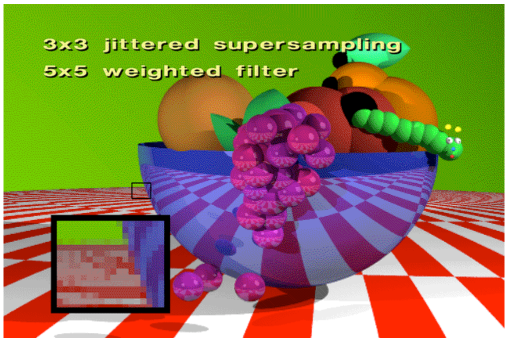
Prefiltering

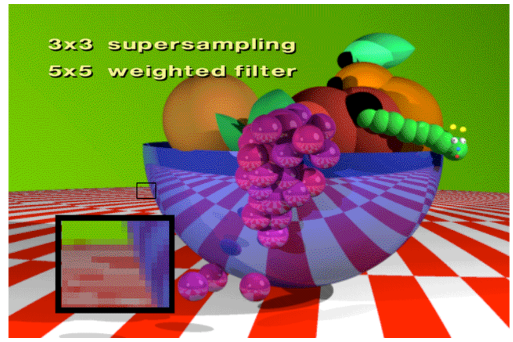


Filtering









Pyramidal Parametrics

Lance Williams

NYIT

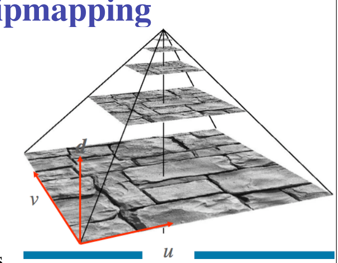
SIGGRAPH 1983

Mip-Mapping

- MIP from Latin phrase
  - Multum in parvo
  - “many things in a small place”

Mipmapping

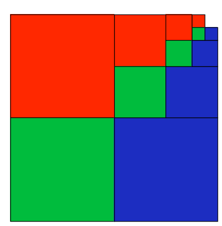
- Image pyramid
- Half height and width



- Compute d
  - Gives 2 images
- Bilinear Interpolate in each image

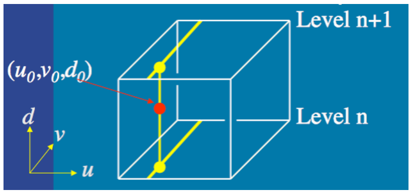
From Tomas Akenine-Moller

MipMapping Memory Requirements



Mipmapping

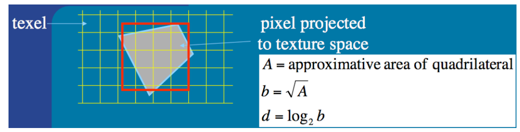
- Interpolate between those bilinear values
  - Trilinear interpolation



From Tomas Akenine-Moller

Mipmapping

- Compute d



- Over blur, approximating quad with square

From Tomas Akenine-Moller

Results:

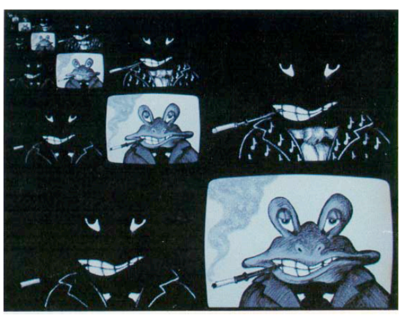


Figure (2)
Mip map of the flexible NYIT Test Frog.

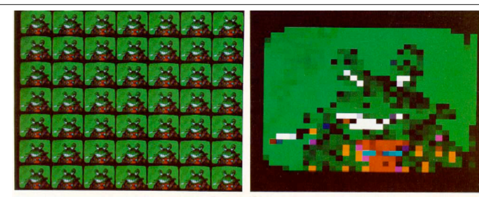


Figure (5)
Downsampling the frog: compression by point sampling (detail, right).

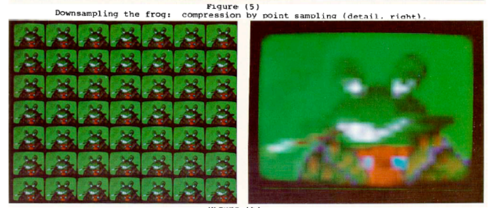


Figure (6)
Downsampling: compression by pyramidal interpolation (detail, right).

The Rendering Equation

James T. Kajiya
CalTech
SIGGRAPH 1986

Ray Tracing Jell-O Brand Gelatin

Paul S. Heckbert
Pixar
SIGGRAPH 1987

Credits

- http://escience.anu.edu.au/lecture/cg/Revisal/AntiAliasing/alias2b.en.html#39
- Pixar shutterbug images:
  http://www.siggraph.org/education/materials/HyperGraph/shutbug.htm