Lighting and Shadows in Computer Graphics

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Previously...

What is lighting?

Point

Directional

Spotlight

Ambient

Diffuse

Ambient

Specular

What is lighting?

Point - lightbulb

Directional - sun

Spotlight - flashlight

Ambient - ?

Diffuse

Ambient

Specular

Flat Shading

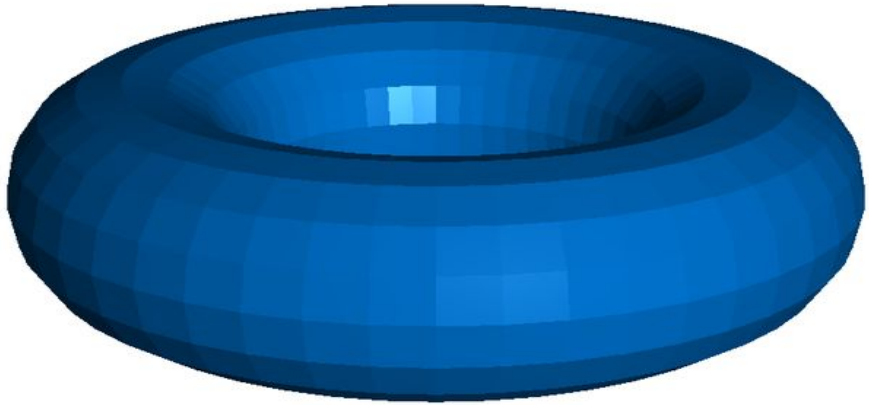
Flat Shading

Polygons drawn the same colour.

Lighting equation used once per polygon.

One normal for the entire polygon.

Cost-effective.



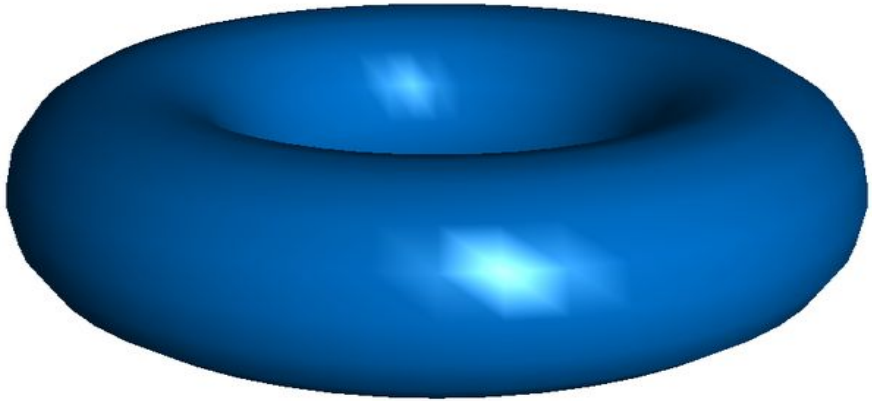
Gouraud Shading

Gouraud Shading

Colours are interpolated across the polygon.

Lighting equation used at each vertex.

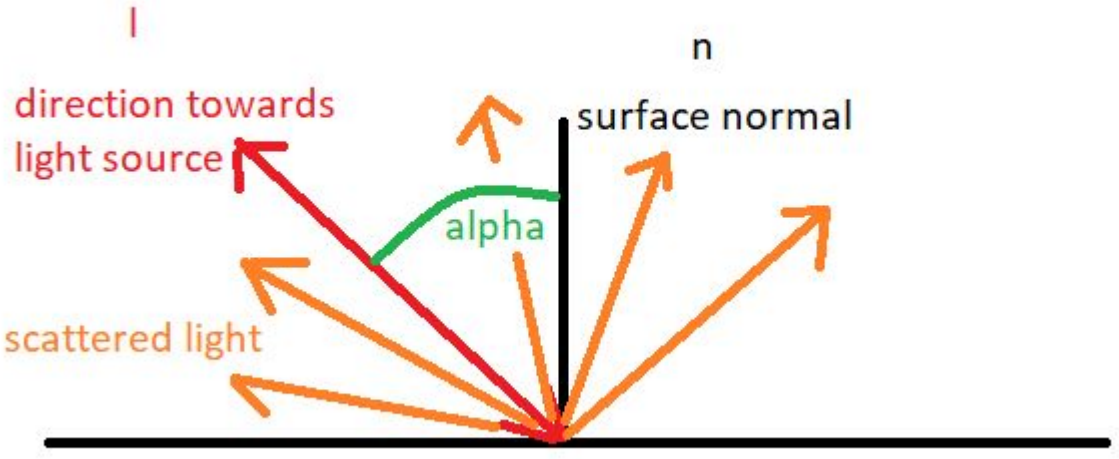
Normal different for each vertex.



Phong Shading

Phong shading

- Light intensity per pixel = $\cos(\alpha) = l \cdot n$



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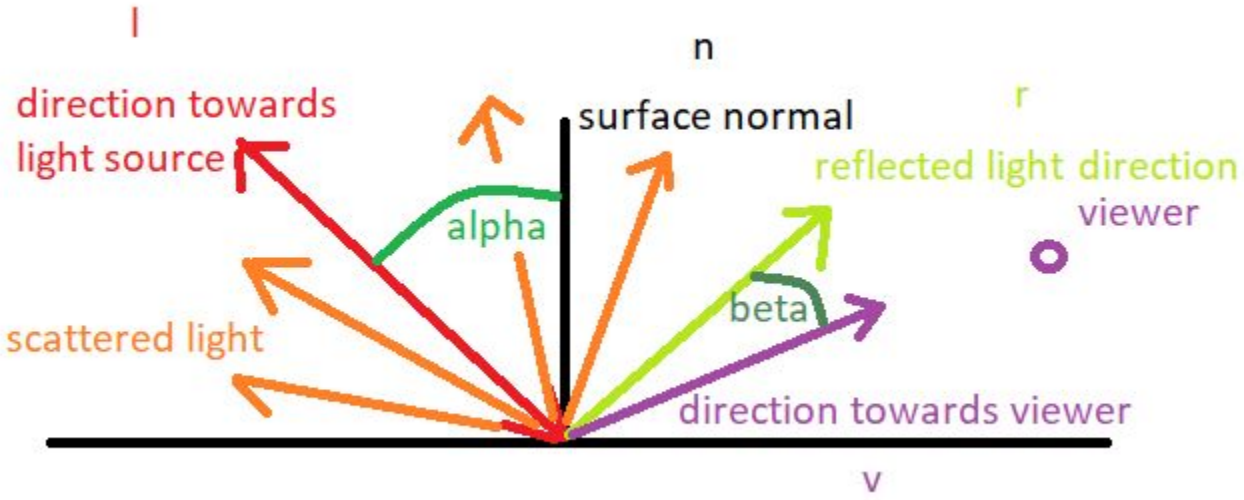
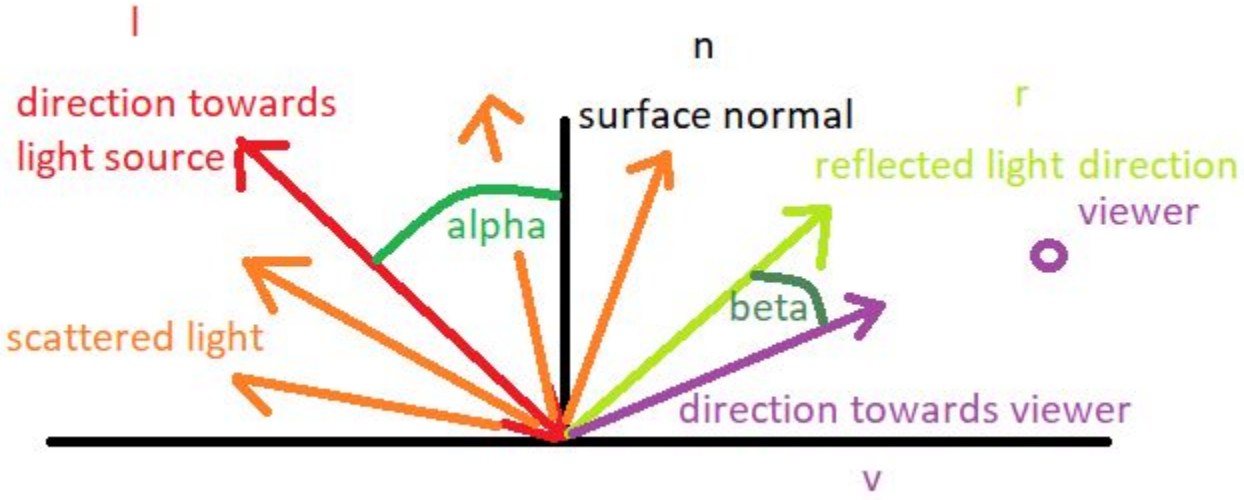


Phong Lighting Model

- $L_{Acv} \cdot M_{Acv} + n^T \cdot l \cdot L_{Dcv} \cdot M_{Dcv} + (r^T \cdot v)^c \cdot L_{Scv} \cdot M_{Scv}$



cv = colour value (red, green, blue)

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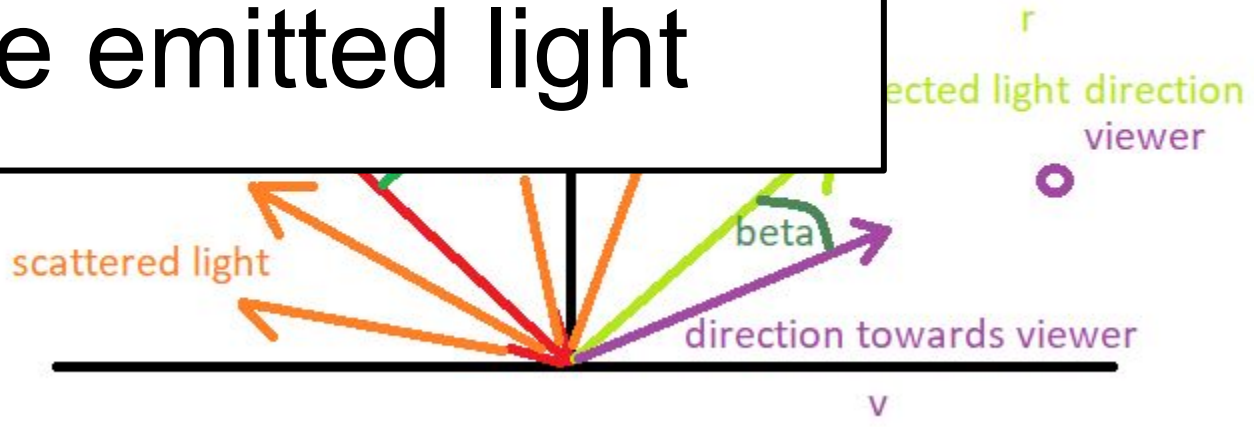
Source emitted light



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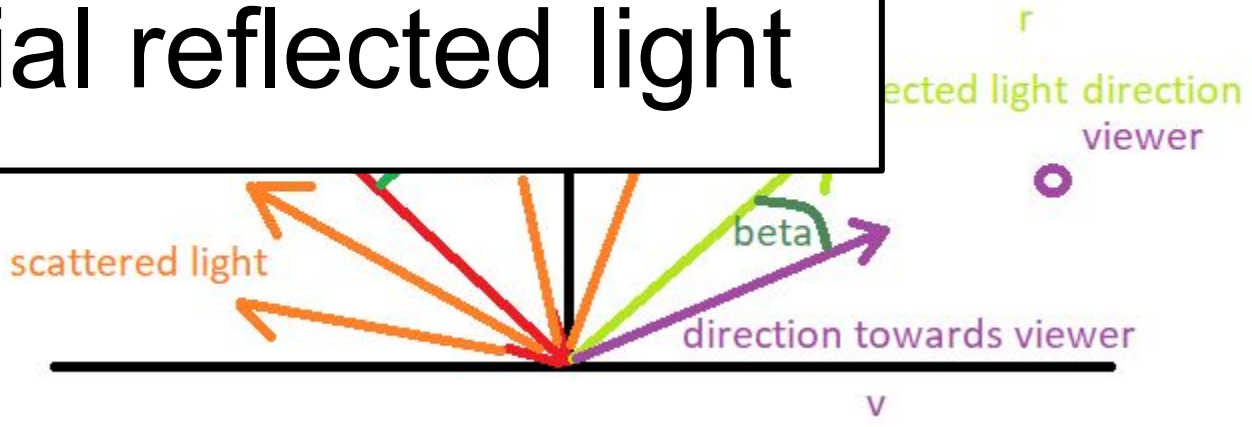
Material reflected light



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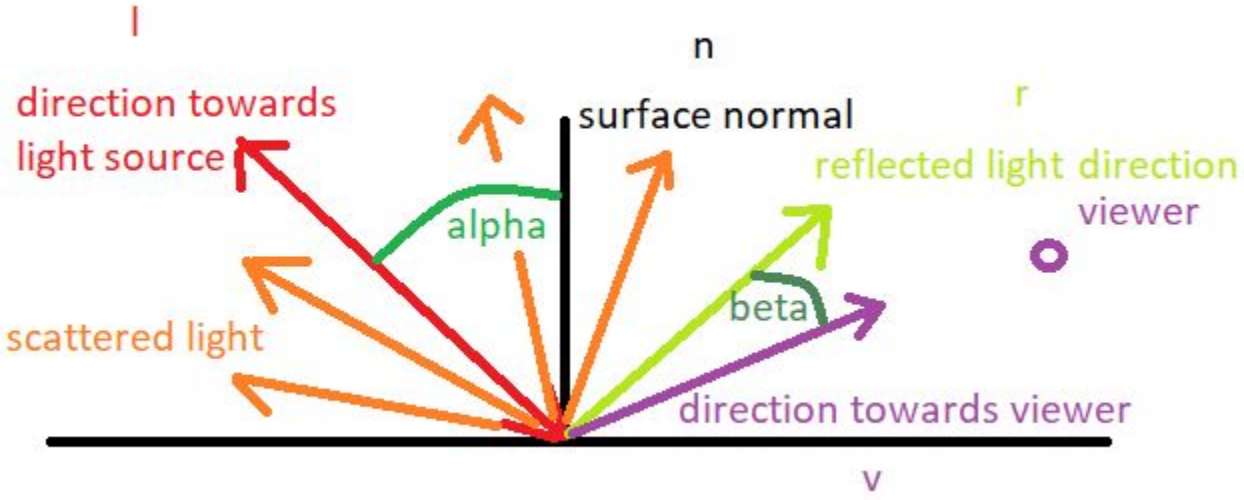

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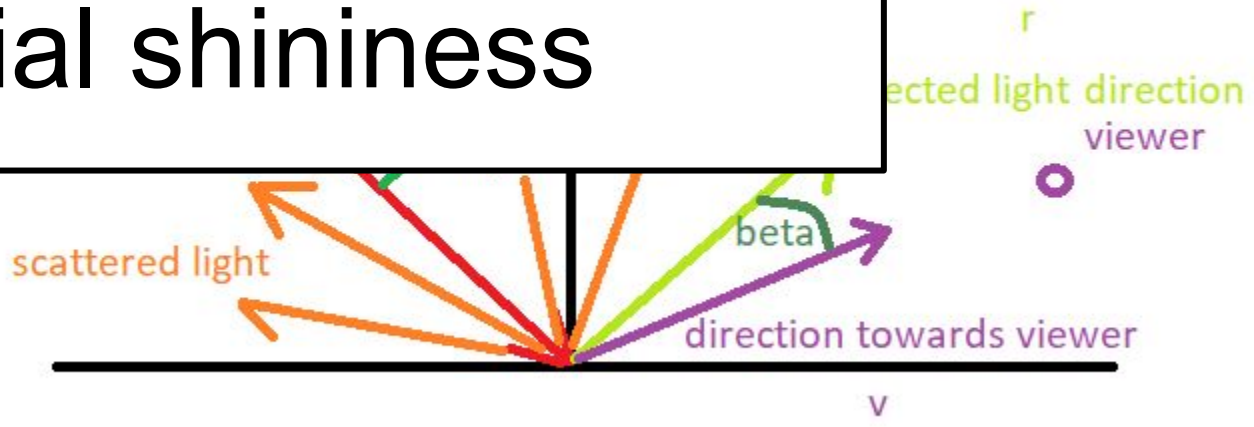
Material shininess



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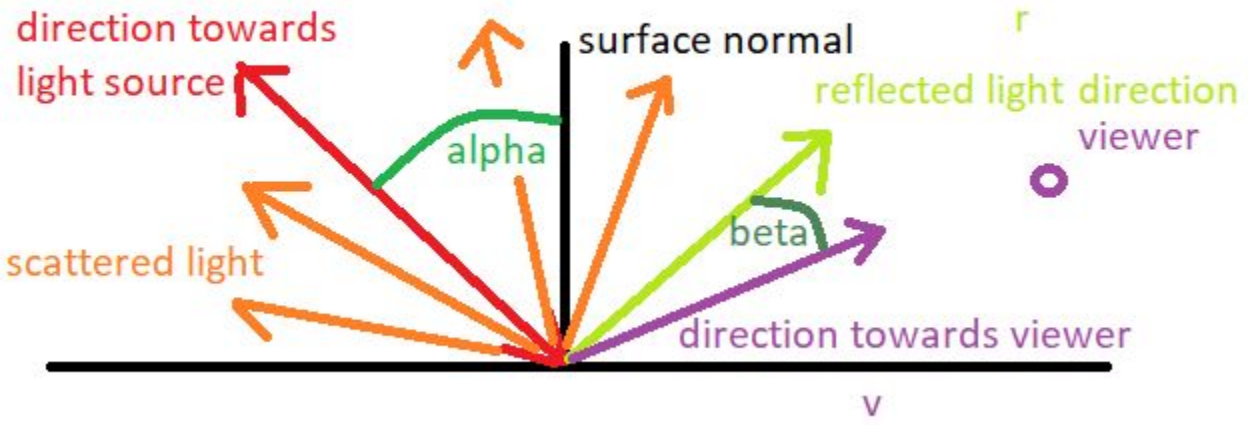
Phong Lighting Model

- $L_{Acv} \cdot M_{Acv} + n^T \cdot l \cdot L_{Dcv} \cdot M_{Dcv} + (r^T \cdot v)^c \cdot L_{Scv} \cdot$

Ambient light	Diffuse reflectance	Specular reflectance term



cv = colour value (red, green, blue)

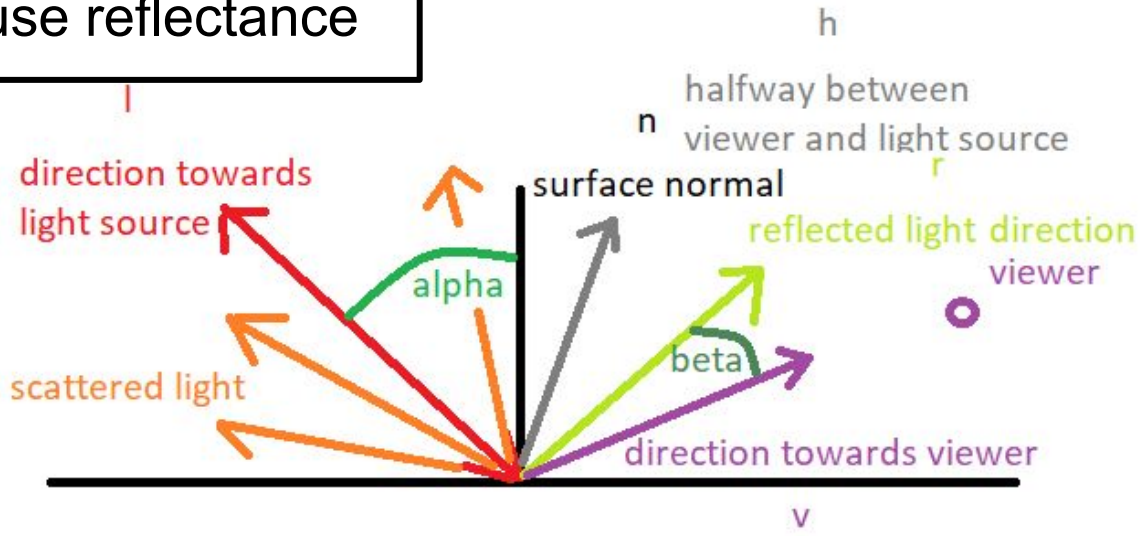
Blinn-Phong Lighting Model

Specular reflectance term

- $L_{Acv} \cdot M_{Acv} + n^T \cdot l \cdot L_{Dcv} \cdot M_{Dcv} + (n \cdot h)^c \cdot L_{Scv} \cdot$

Ambient light

Diffuse reflectance



cv = colour value

(red, green, blue)

Why?

Phong

round highlight

often used

Blinn-Phong

thin elongated highlight

more efficient approaching infinity

Lighting effects

Opaque

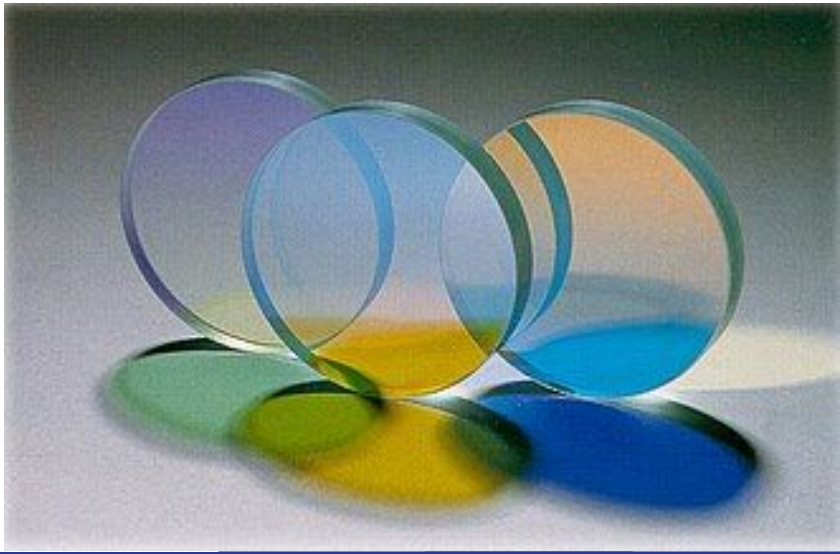
impenetrability to electromagnetic ect radiation

Translucent

Allows some light to pass through

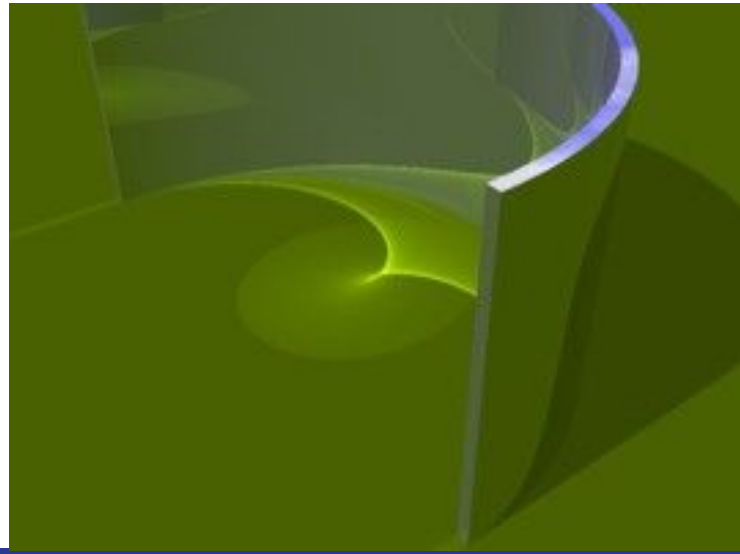
Transparent

Allows light to pass through



Caustics

Reflections through mediums



Particle effects

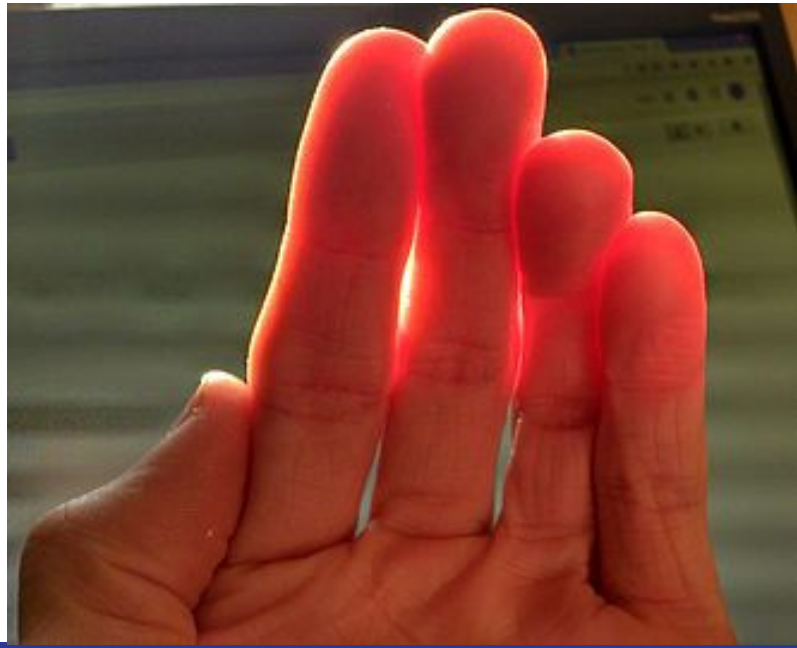
Emitter

Simulation

Render

Subsurface scattering

Light interacting with a translucent object



Global Illumination

Global Illumination

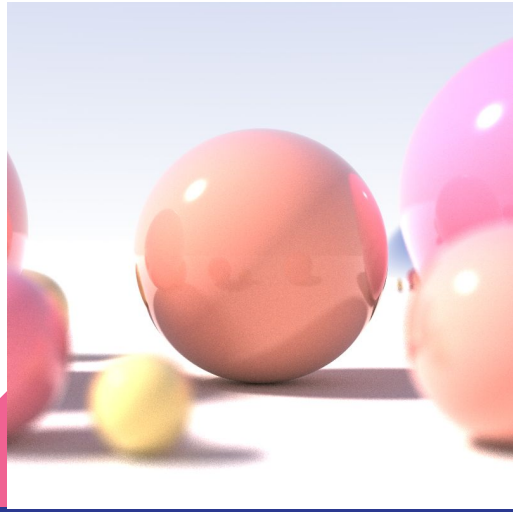
More accurate to reality, but expensive and slower.

Indirect illumination.

Ray tracing

Simulates rays of light hitting virtual objects.

High (light) realism, not suited for real-time applications.

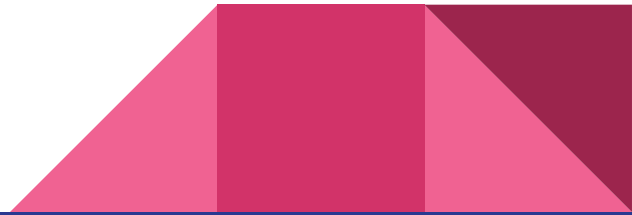


Path tracing

Using random directions, ray bounces calculate colour.

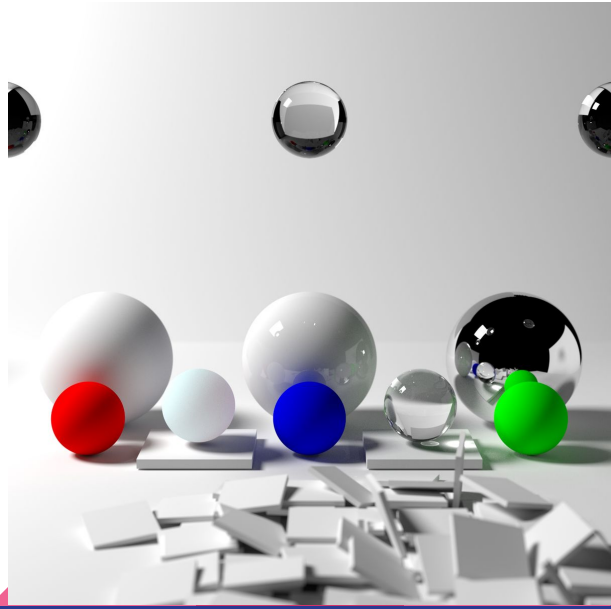
A lot of times per pixel.

soft shadows, depth of field, motion blur, caustics, ambient occlusion, indirect lighting



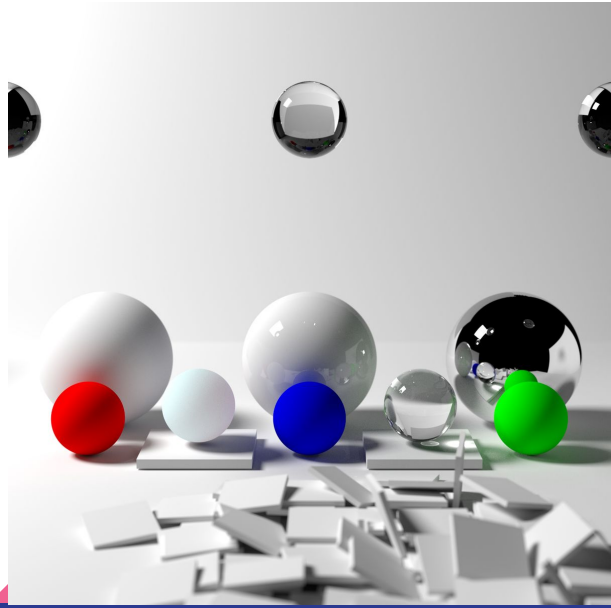
Path tracing

Shooting rays vs gathering rays



Path tracing

Energy redistribution

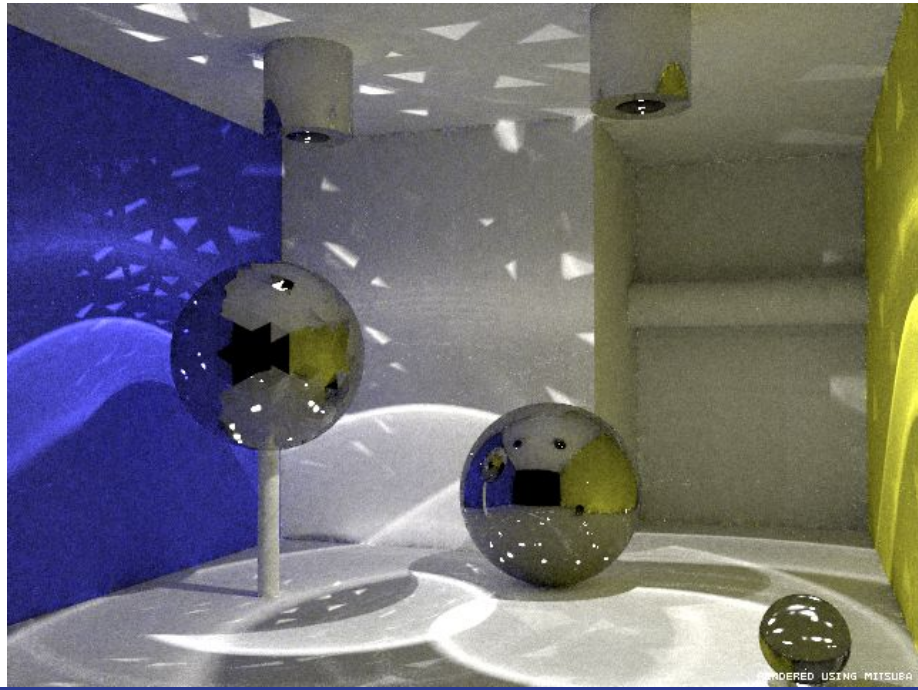


Metropolis light transport

Bidirectional path tracing

Distribution of brightness

Explore nearby paths



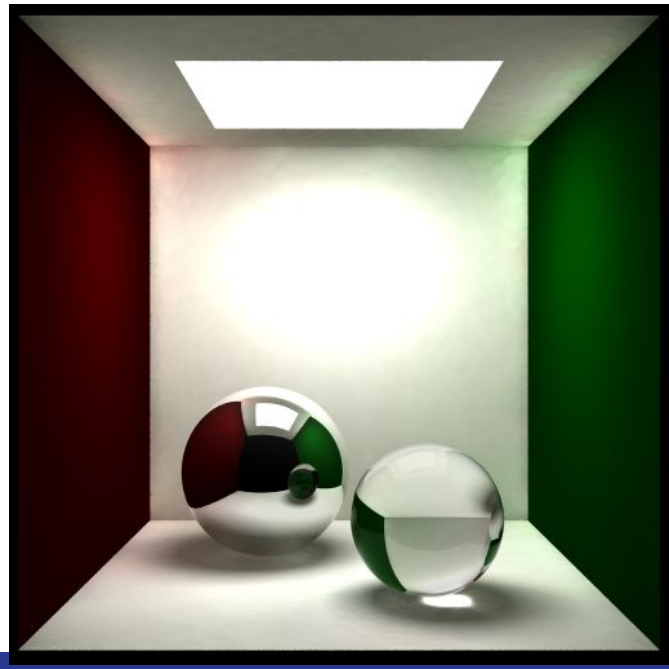
Photon mapping

Great for caustics, works with specular

Rays from the light source,
rays from the camera

Photon map

Ray tracing until intersection



Lightcut

Light source clusters

Error map

More lights, less noise

Point based global illumination

Point cloud of the directly illuminated geometry in the scene.

Ray tracing,
disk approximation
and clusters

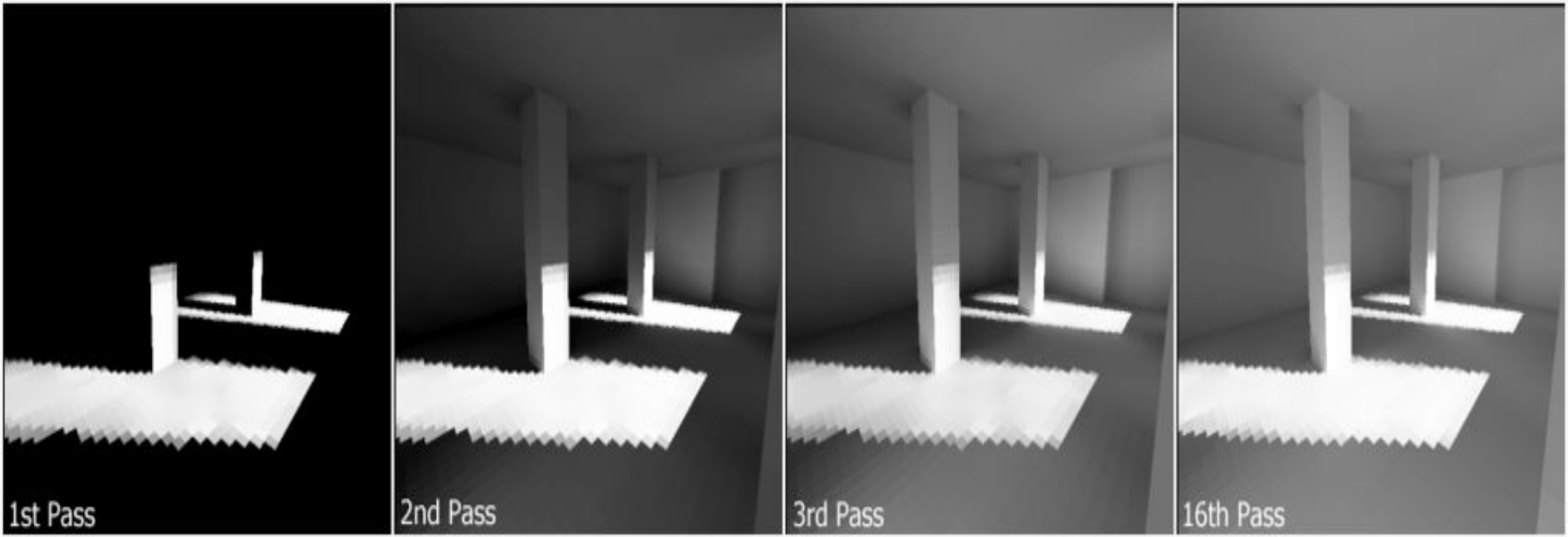
Radiosity

Patches

View factor

Light bounces

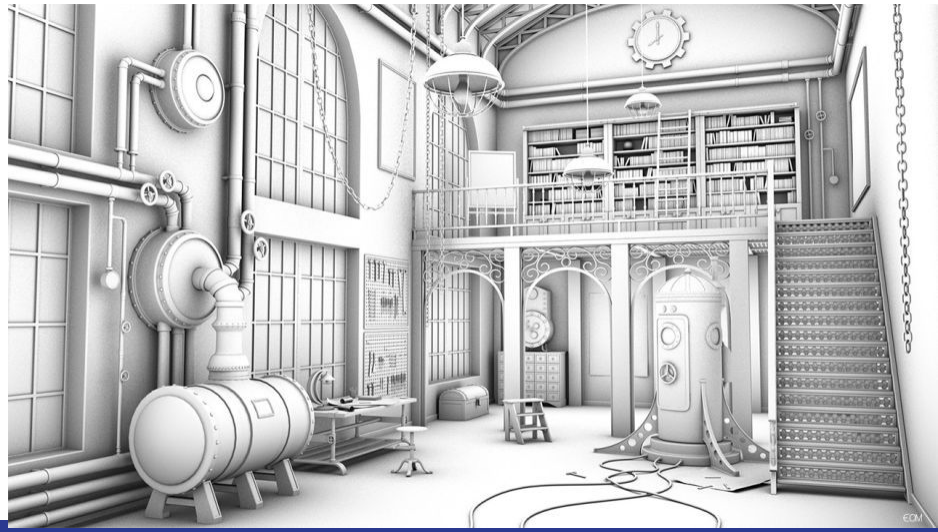
Radiosity



Ambient occlusion

Casts no clear shadows

Real-time applications



Voxel-based global illumination

opacity map, emittance map

3D clipmap

Diffuse, specular cones

Real-time applications

Shadows

What is it?

Light source blocked by an opaque object

Hard shadow

Soft shadow

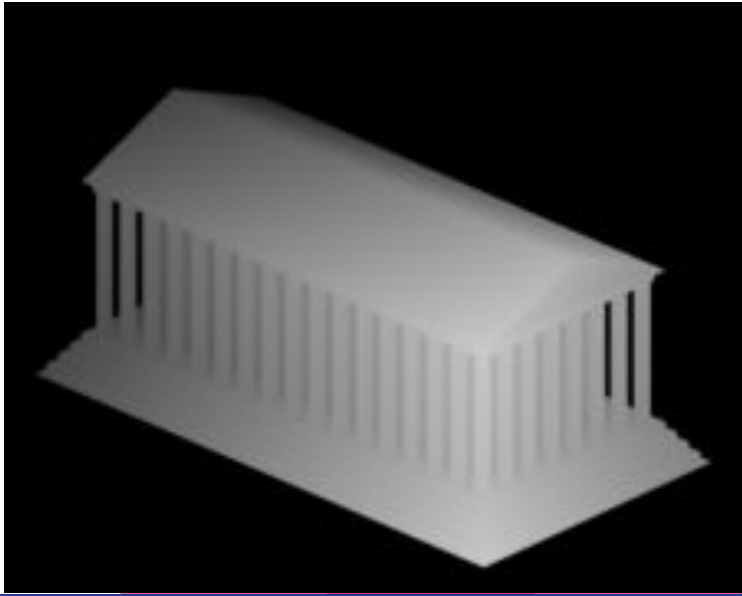
Shadow Map

Z-buffer

Multiple lights - multiple maps

Compare coordinates to test

Draw object

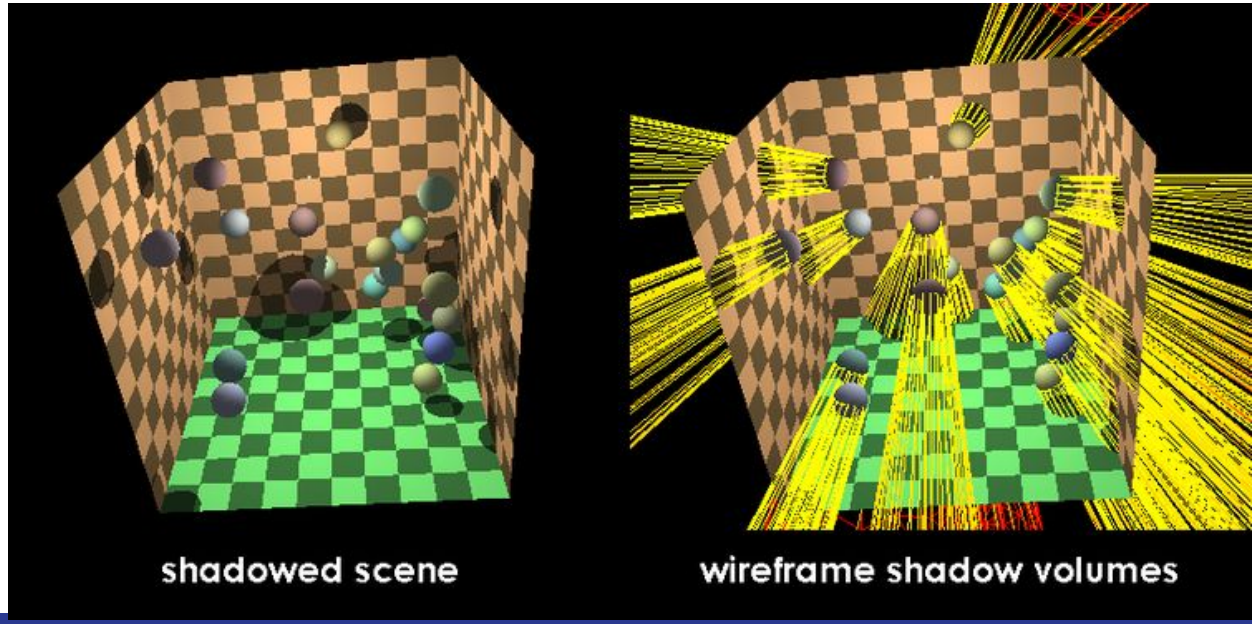


Shadow Volume

Shadow geometry

Silhouette edge

Closed volume



Thank you for listening!