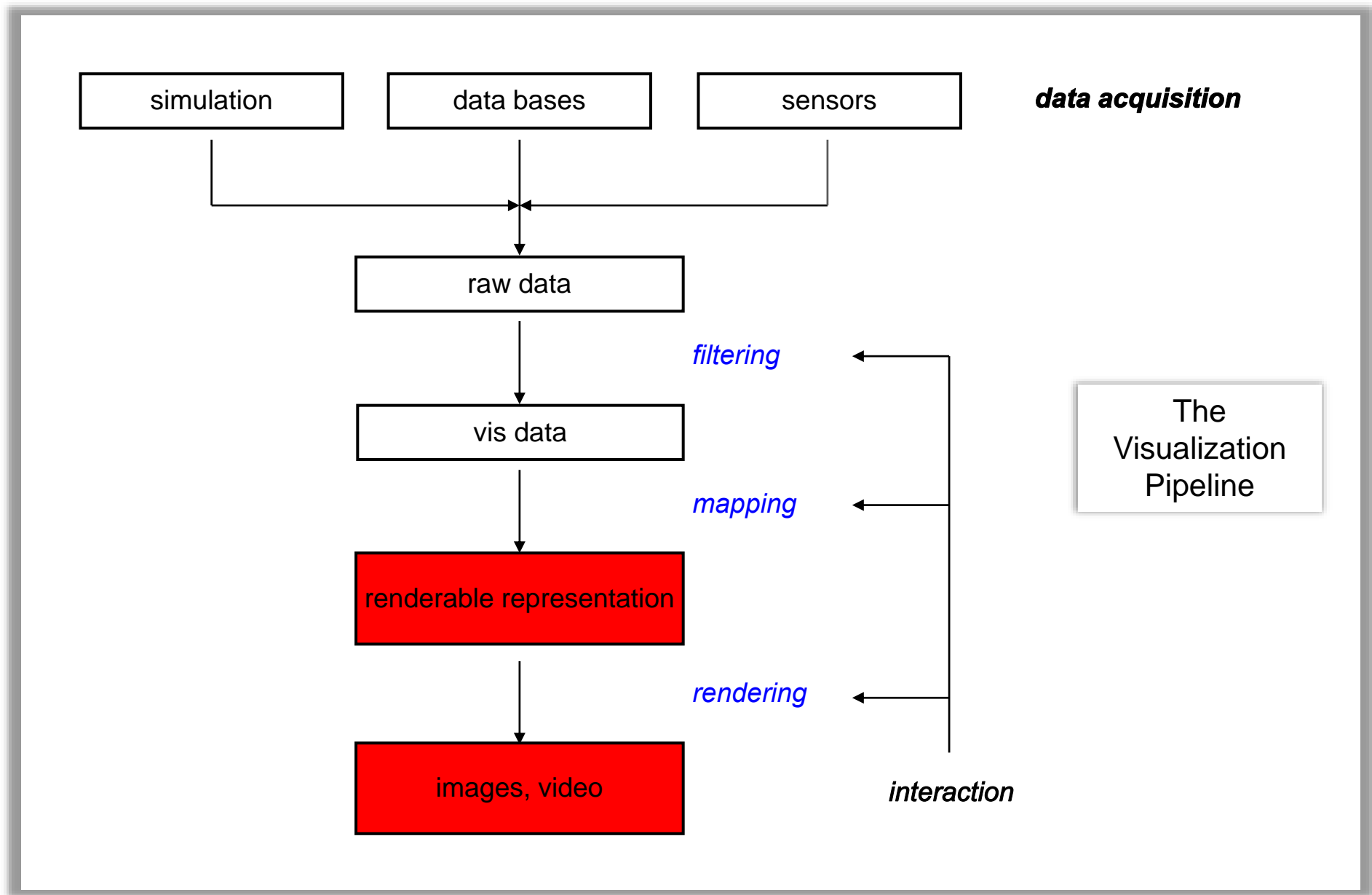




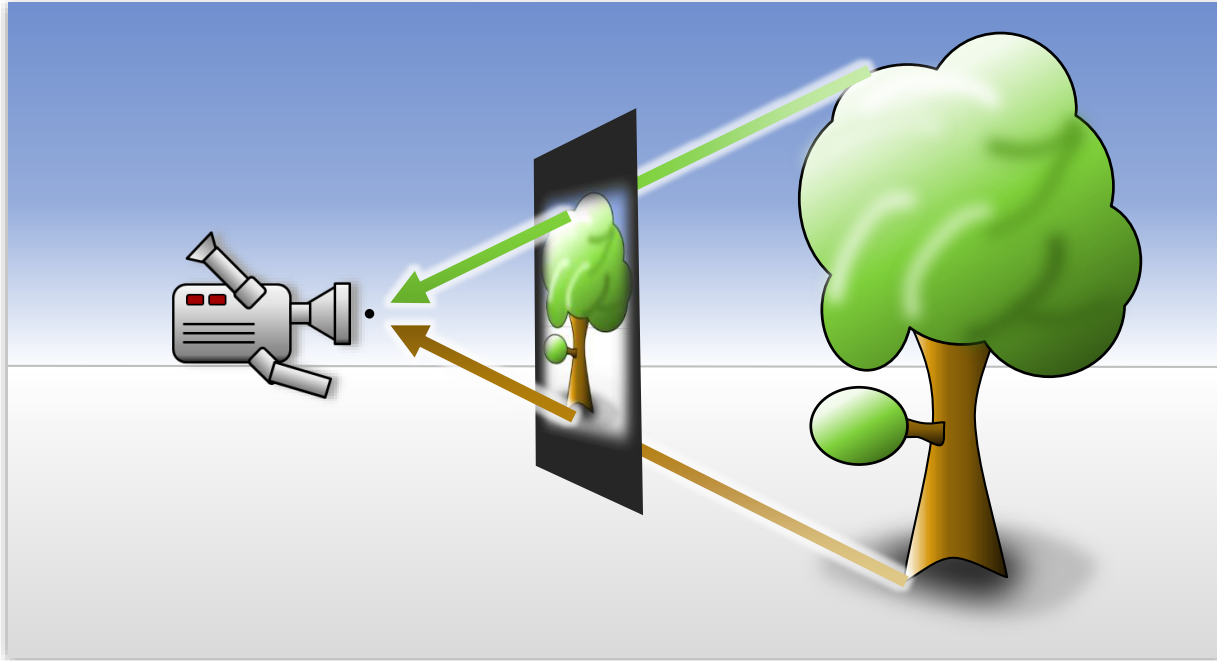
Visualization, DD2257
Prof. Dr. Tino Weinkauff

Rendering

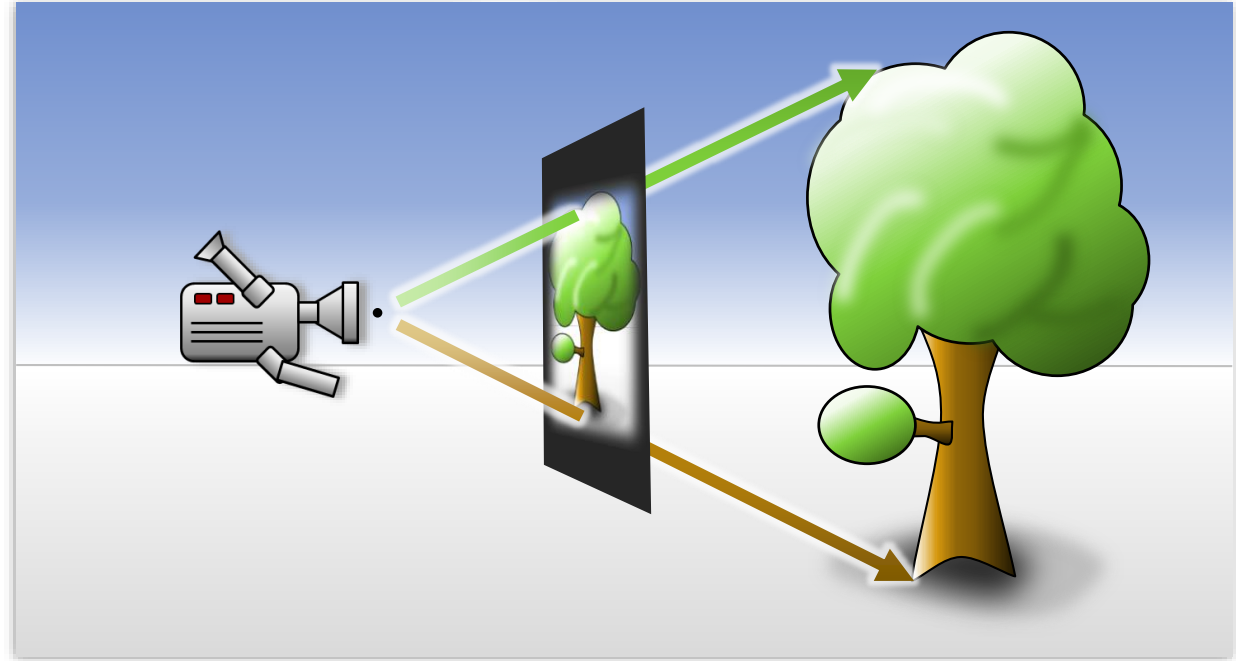


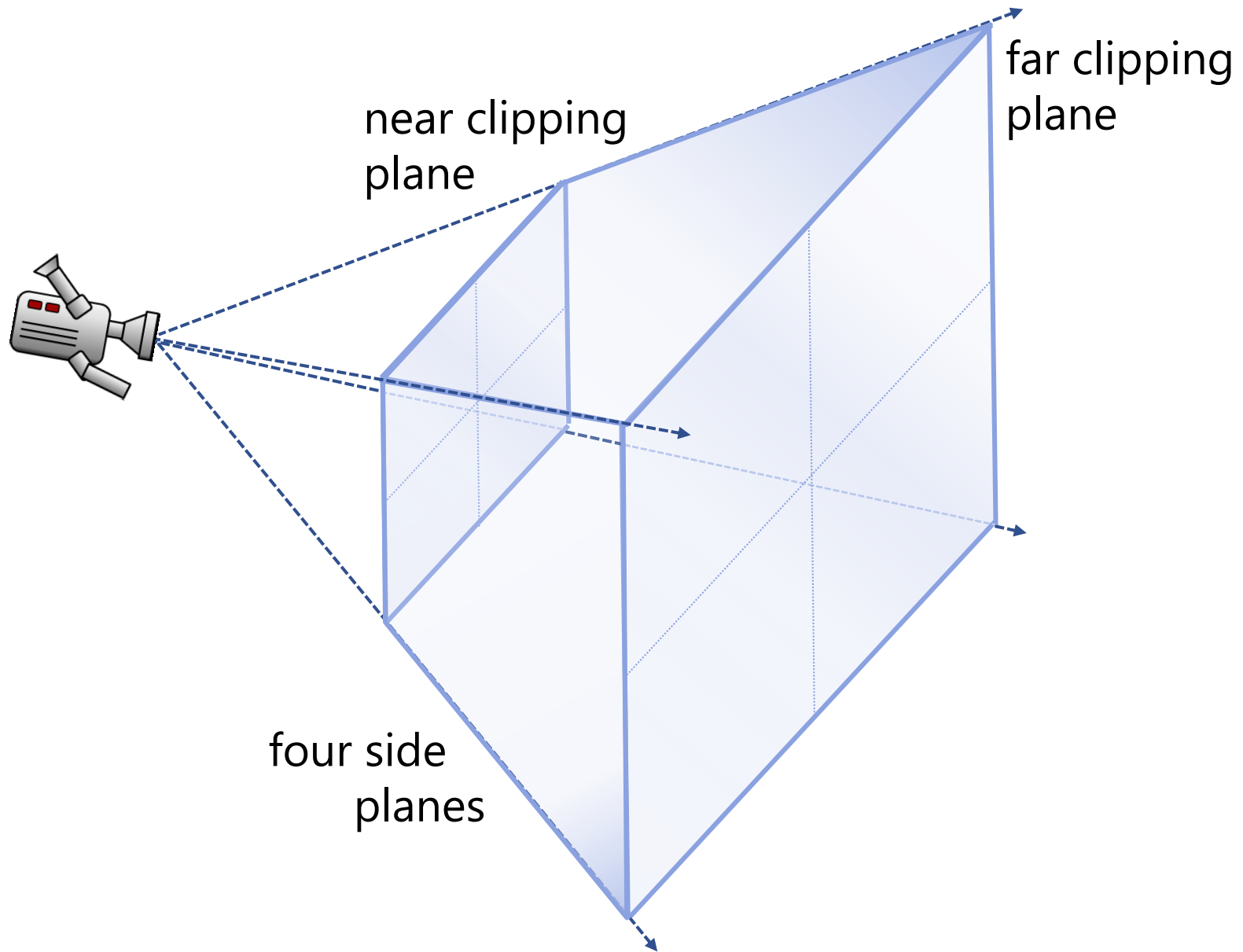


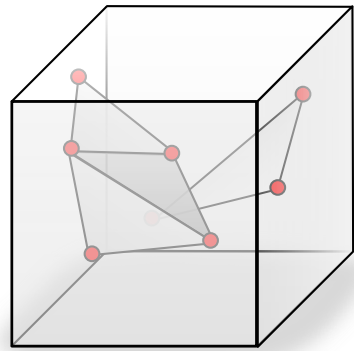
Rasterization



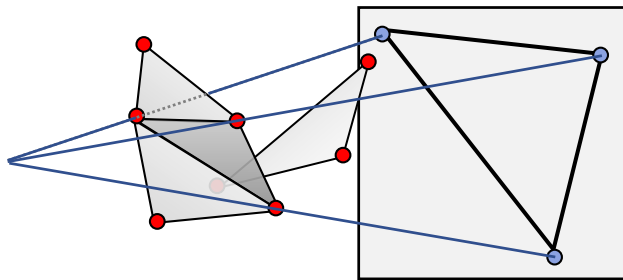
Raytracing



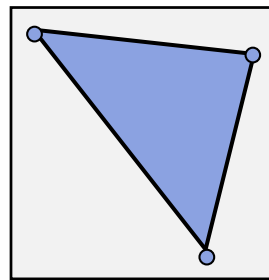




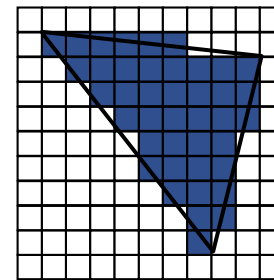
3D Scene



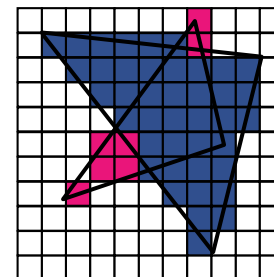
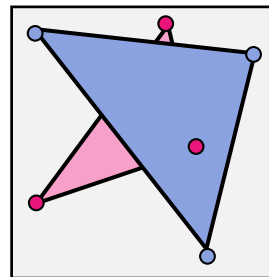
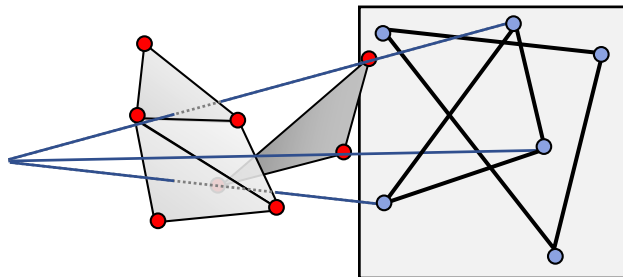
Projection

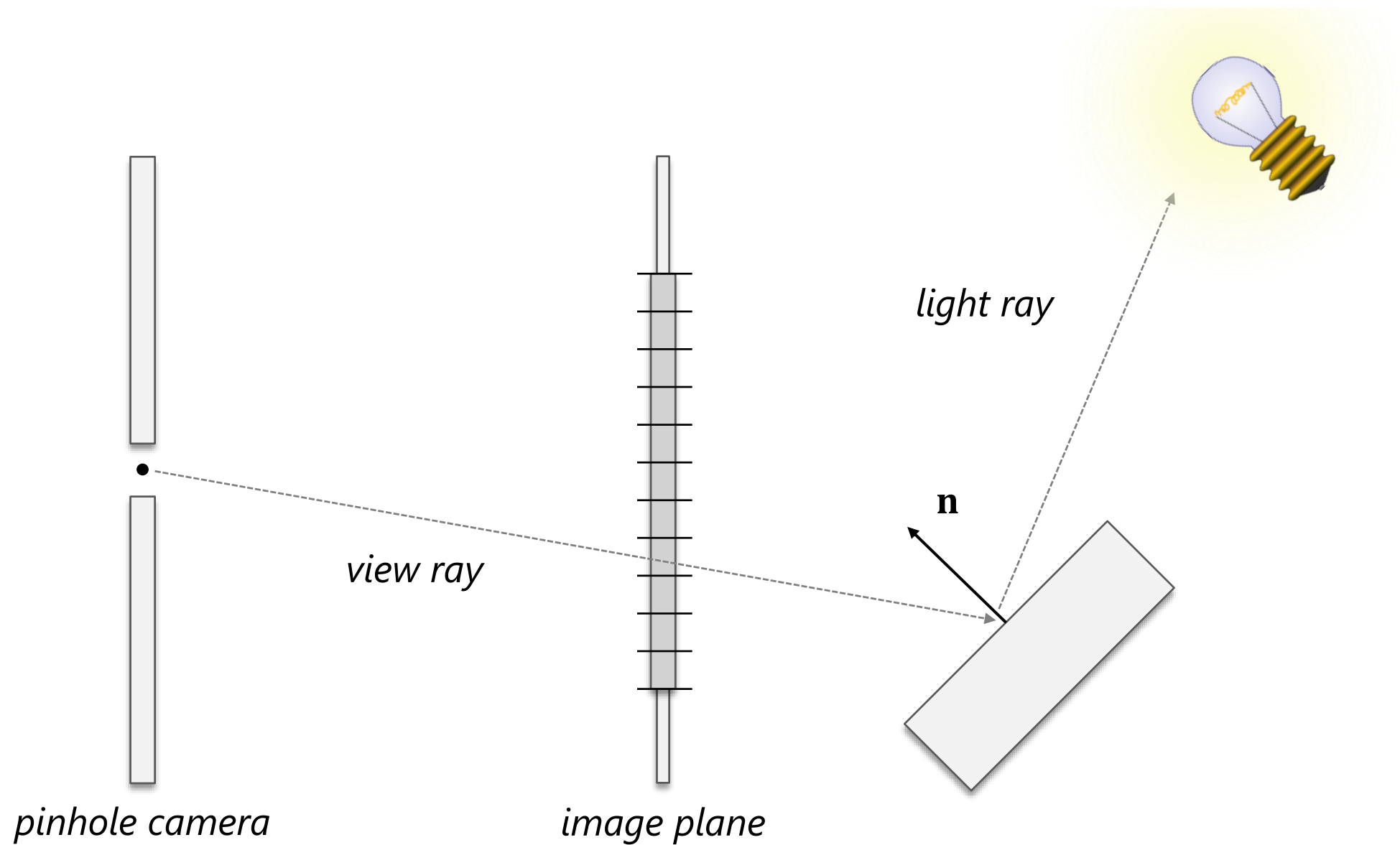


Visibility

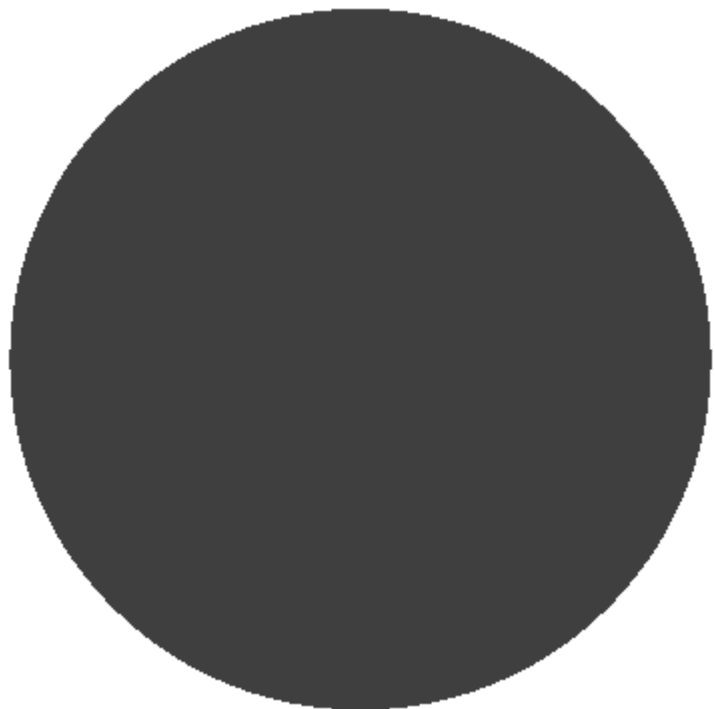


Rasterization

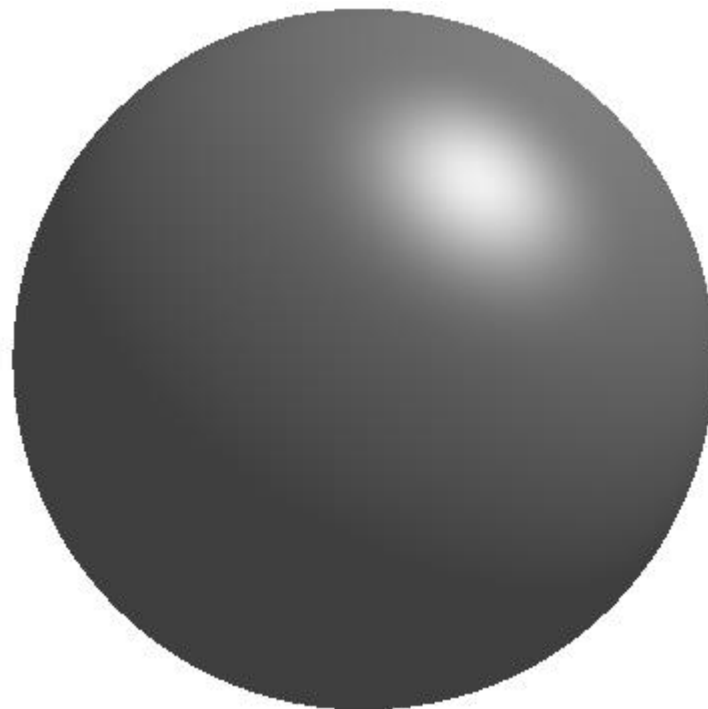




no lighting



Phong illumination





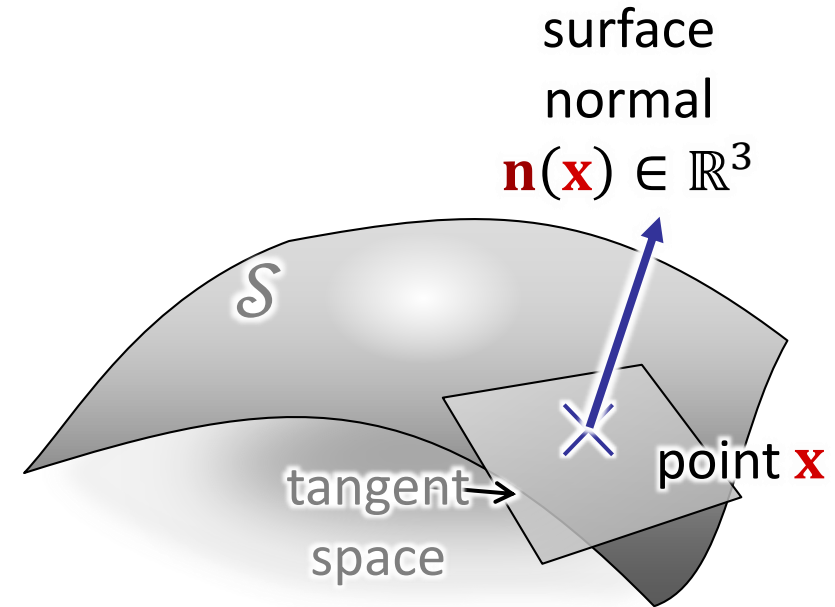
face normals
no ambient or specular light



vertex normal
all light components

What is a surface normal?

- Tangent space:
 - Plane approximation at a point $\mathbf{x} \in \mathcal{S}$
- Normal vector:
 - Perpendicular to that plane
- Oriented surfaces:
 - Pointing outwards (by convention)
 - Orientation defined only for closed solids



Single Triangle

- Parametric equation

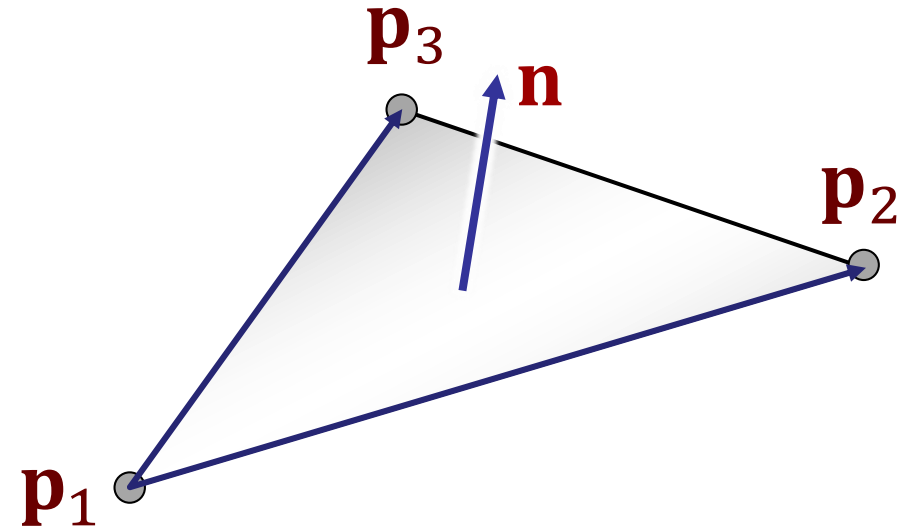
$$\{\mathbf{p}_1 + \lambda(\mathbf{p}_2 - \mathbf{p}_1) + \mu(\mathbf{p}_3 - \mathbf{p}_1) \mid \lambda, \mu \in \mathbb{R}\}$$

- Tangent space: the plane itself

- Normal vector

$$(\mathbf{p}_2 - \mathbf{p}_1) \times (\mathbf{p}_3 - \mathbf{p}_1)$$

- Orientation convention:
 $\mathbf{p}_1, \mathbf{p}_2, \mathbf{p}_3$ oriented counter-clockwise
 - Length: Any positive multiple works
(often $\|\mathbf{n}\| = 1$)



Smooth Triangle Meshes

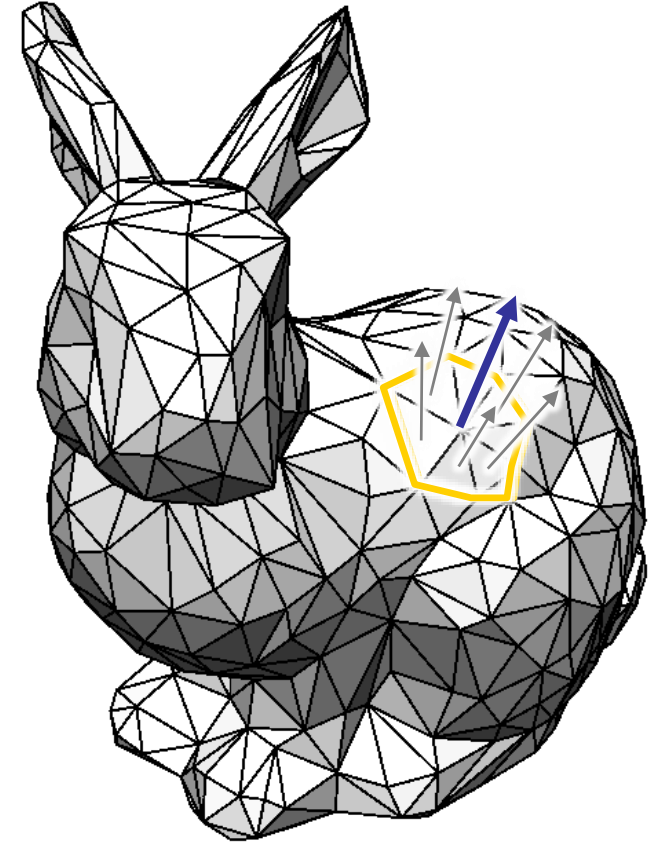
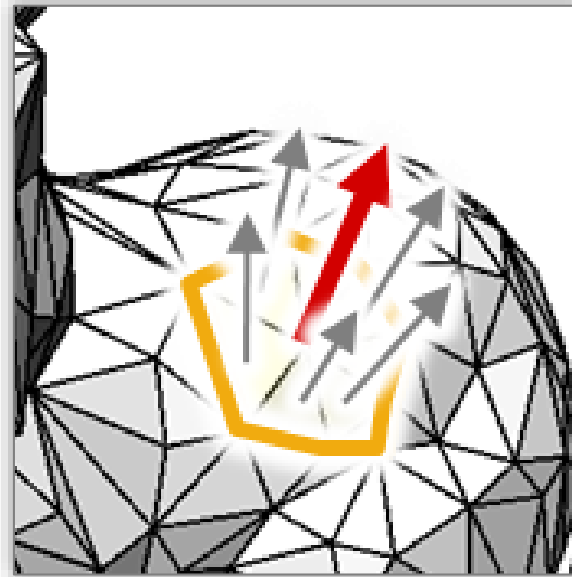
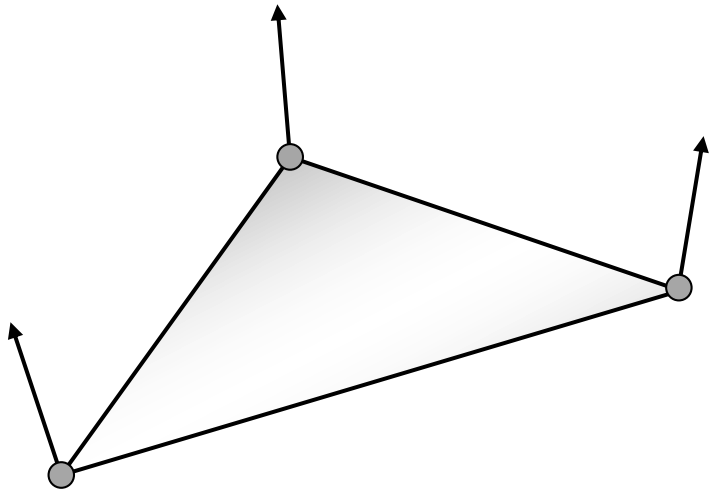
Store three different “vertex normals”

e.g., from original surface (if known)

or from visualization algorithm

Heuristic:

Average neighboring triangle normals



Phong Model:

- Ambient part:

$$\mathbf{c} = \mathbf{c}_r \circ \mathbf{c}_a$$

- Diffuse part:

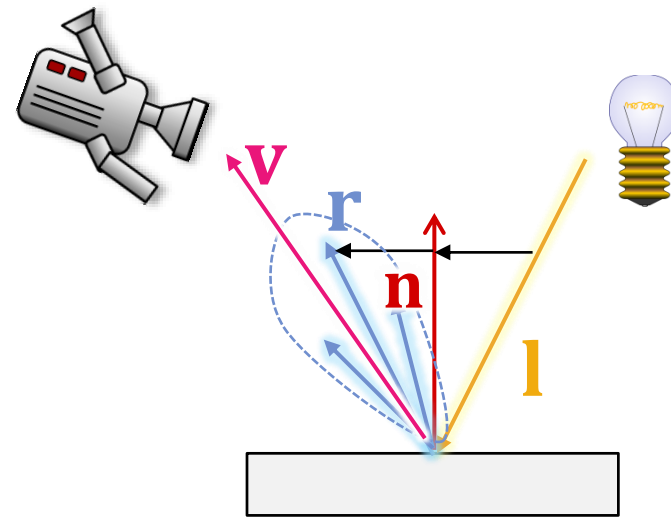
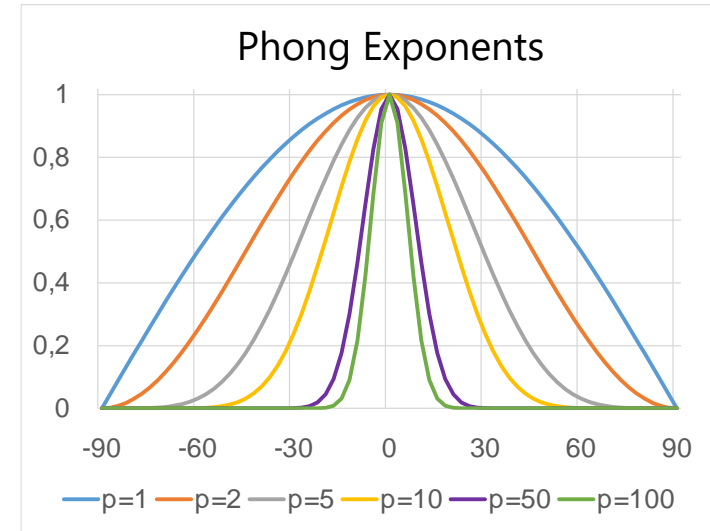
$$\mathbf{c} = \mathbf{c}_r \circ \mathbf{c}_l \cdot \langle \mathbf{n}, \mathbf{l} \rangle$$

- "Specular" (glossy) part:

$$\mathbf{c} = \mathbf{c}_p \circ \mathbf{c}_l \cdot \underbrace{\left\langle \frac{\mathbf{r}}{\|\mathbf{r}\|}, \frac{\mathbf{v}}{\|\mathbf{v}\|} \right\rangle}_{\cos \angle \mathbf{r}, \mathbf{v}}^p$$

(high-) light color \uparrow

- Add all terms together



Summary

- Rendering as a part of the visualization pipeline
 - fast rendering means more time for interaction
- Two main approaches for rendering
 - Rasterization
 - Raytracing
- Convey depth in 3D scenes
- Normals
 - triangle, triangle meshes
- Lighting