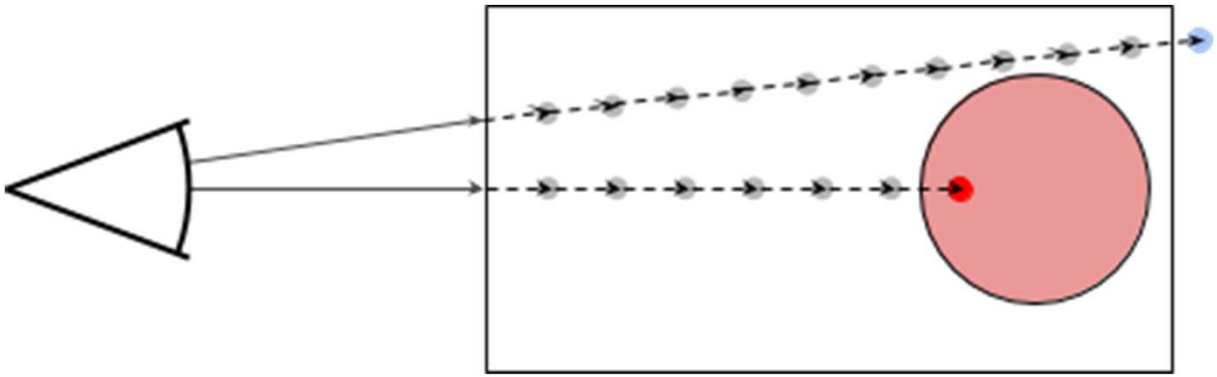
Raymarching

Raymarching

- Step along a ray until hit or max distance



Height Field

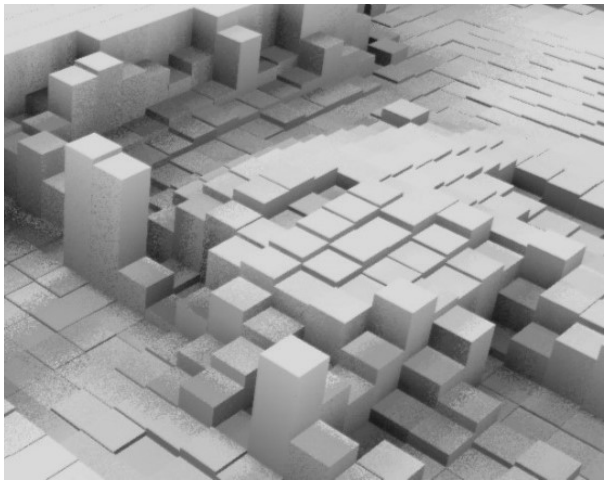
- Surfaces that can be described by a function $y = f(x, z)$
- Examples: terrain, measurements sampled on a plane, 2D scalar field

1	2	1	2	2	1
2	1	2	1	10	1
3	1	2	6	9	0
4	1	2	5	0	0
5	1	2	3	0	0
6	1	2	2	1	0

Height Field

- Grid that stores a height at each position

1	2	1	2	2	1
2	1	2	1	10	1
3	1	2	6	9	0
4	1	2	5	0	0
5	1	2	3	0	0
6	1	2	2	1	0

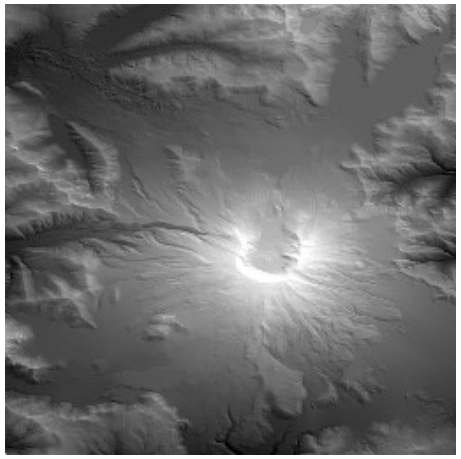


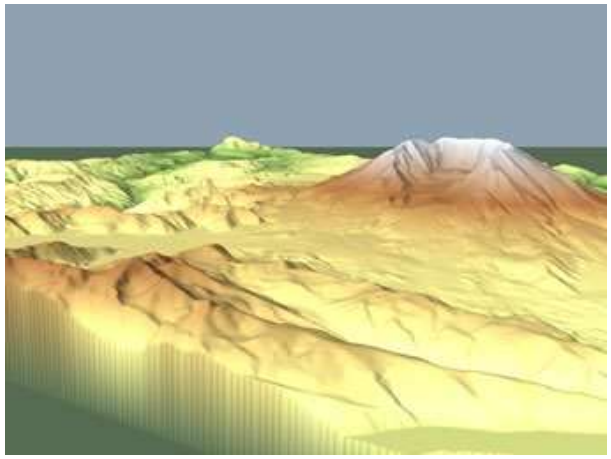
Height Field

- Can use mathematical function to create grid values

Height Field

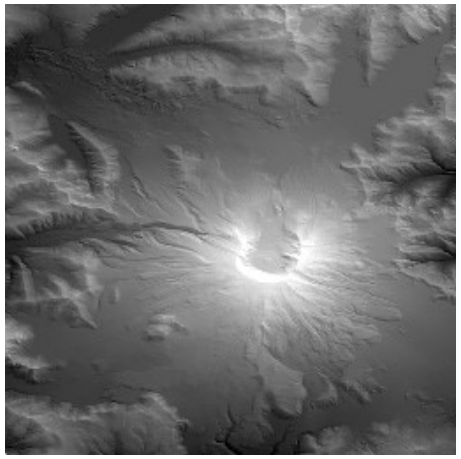
- Can use texture to store grid





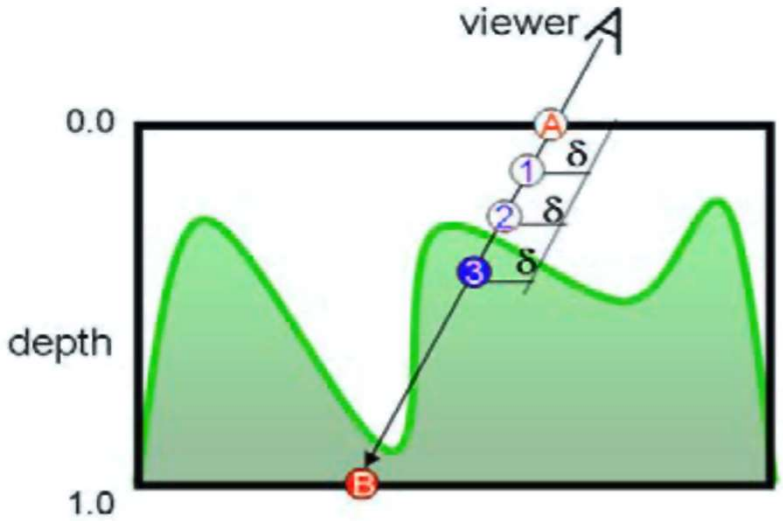
Height Field

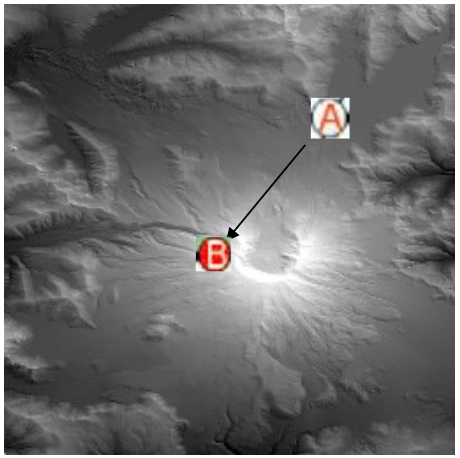
- Can render with different methods



Raymarching Height Field

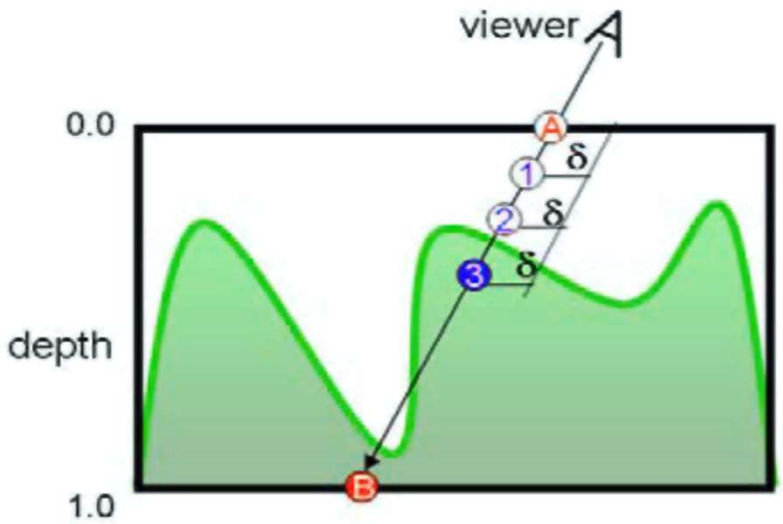
- Step with small increments along ray



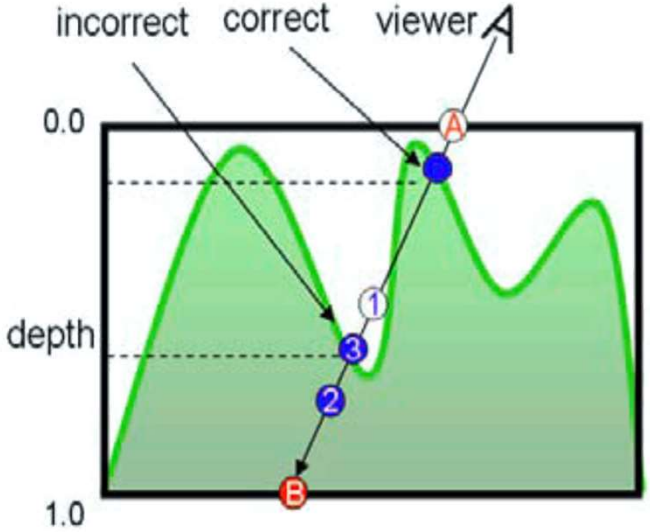


Raymarching Height Field

- Step with small increments along ray

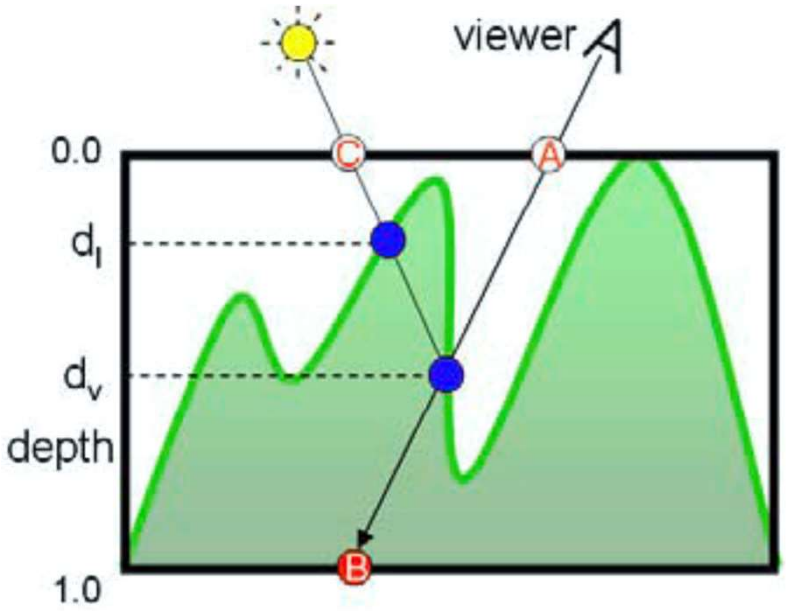


- Interval bisection



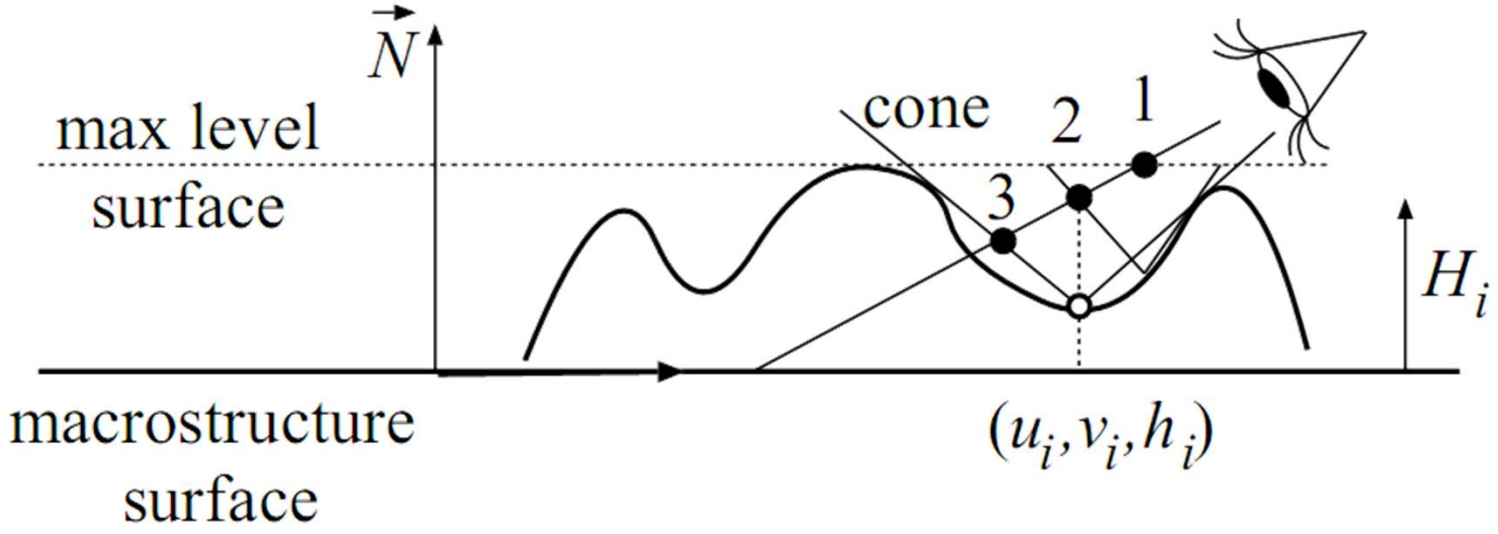
Shadowing

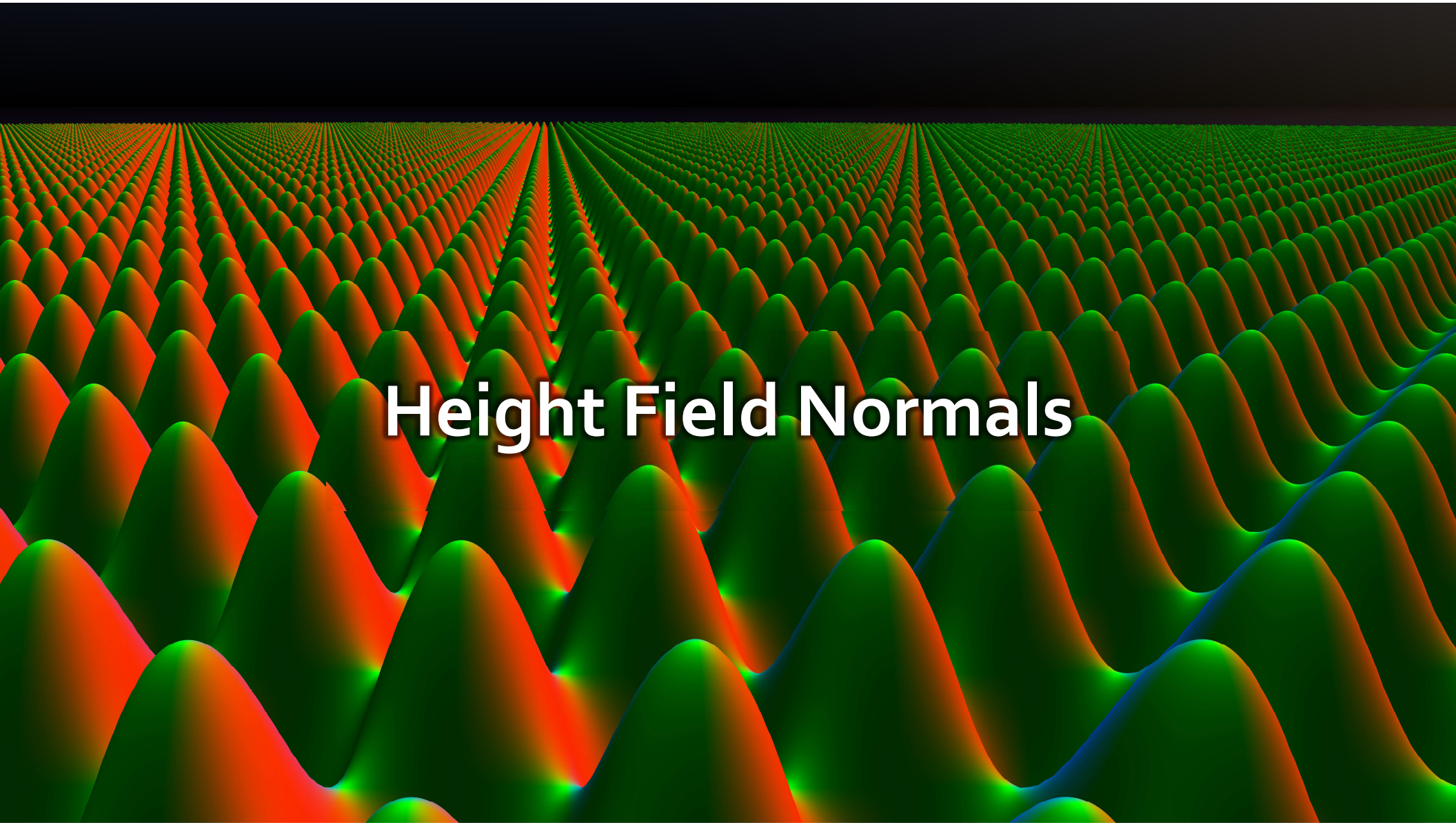
- Send shadow feeler ray



Accelerating Height Field Rendering

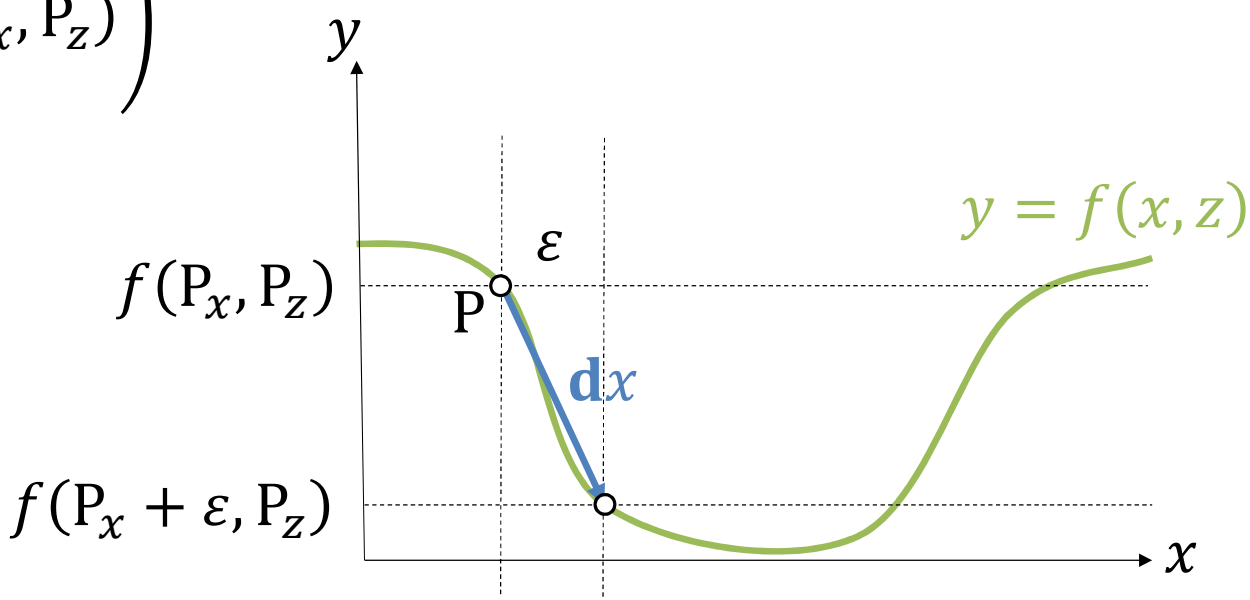
- Help texture
  - Each texel stores cone of empty space above
  - Only store opening angle (1 additional value per texel)




Height Field Normals

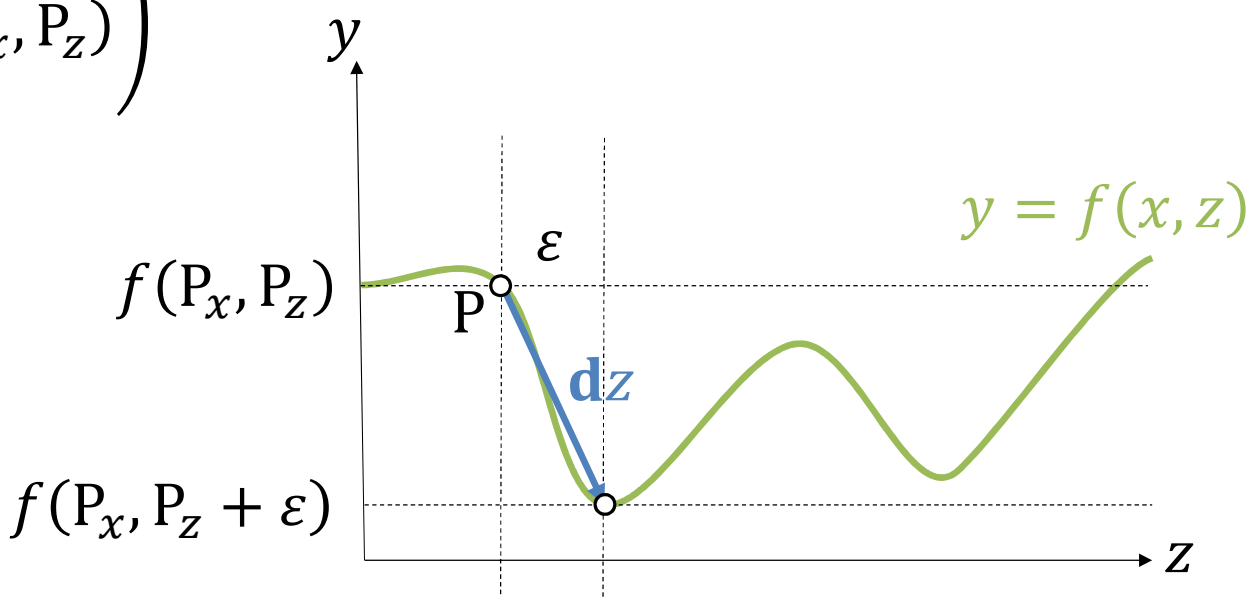
Calculating Height Field Normals

- $\mathbf{d}x = \begin{pmatrix} \varepsilon \\ f(\mathrm{P}_x + \varepsilon, \mathrm{P}_z) - f(\mathrm{P}_x, \mathrm{P}_z) \\ 0 \end{pmatrix}$



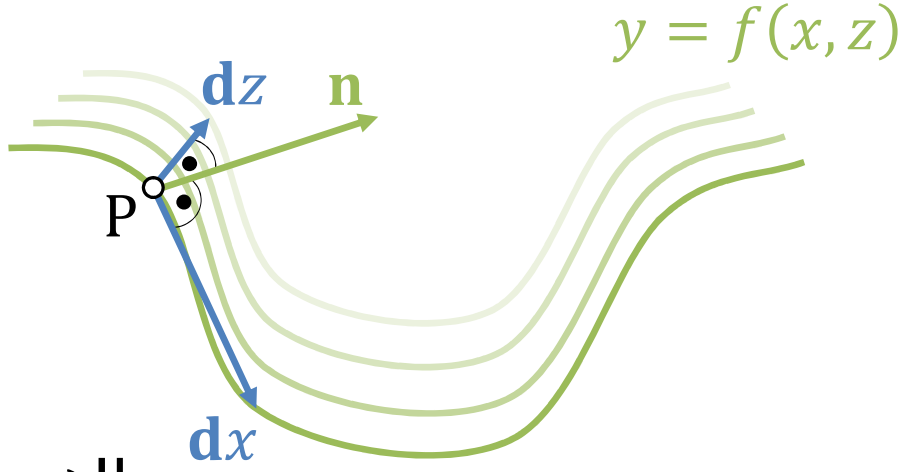
Calculating Height Field Normals

- $\mathbf{d}z = \begin{pmatrix} 0 \\ f(\mathrm{P}_x, \mathrm{P}_z + \varepsilon) - f(\mathrm{P}_x, \mathrm{P}_z) \\ \varepsilon \end{pmatrix}$



Calculating Height Field Normals

- $\mathbf{d}x = \begin{pmatrix} \varepsilon \\ f(\mathrm{P}_x + \varepsilon, \mathrm{P}_z) - f(\mathrm{P}_x, \mathrm{P}_z) \\ 0 \end{pmatrix}$
- $\mathbf{d}z = \begin{pmatrix} 0 \\ f(\mathrm{P}_x, \mathrm{P}_z + \varepsilon) - f(\mathrm{P}_x, \mathrm{P}_z) \\ \varepsilon \end{pmatrix}$



- $\mathbf{n} = \|\mathbf{d}z \times \mathbf{d}x\| = \left\| \begin{matrix} f(\mathrm{P}_x, \mathrm{P}_z) - f(\mathrm{P}_x + \varepsilon, \mathrm{P}_z) \\ \varepsilon \\ f(\mathrm{P}_x, \mathrm{P}_z) - f(\mathrm{P}_x, \mathrm{P}_z + \varepsilon) \end{matrix} \right\|$

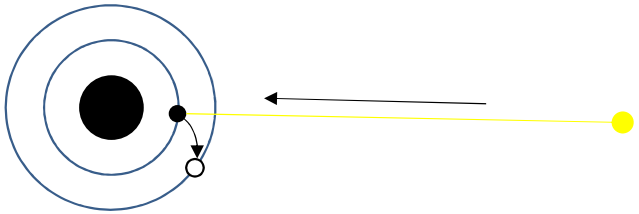
Links

- www.iquilezles.org/www/articles/terrainmarching/terrainmarching.htm

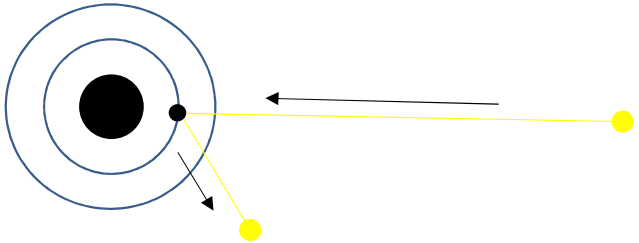

Volume Rendering
Horizon: Zero Dawn, Guerrilla Games

What's Happening to Light Hitting a Particle ?

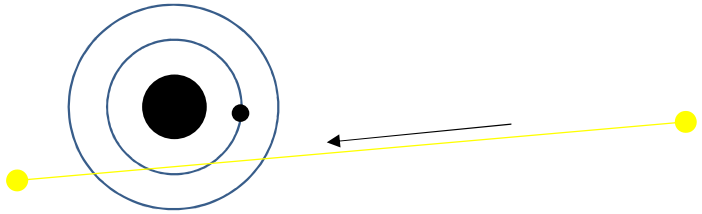
- Absorption



- Scattering into a random direction



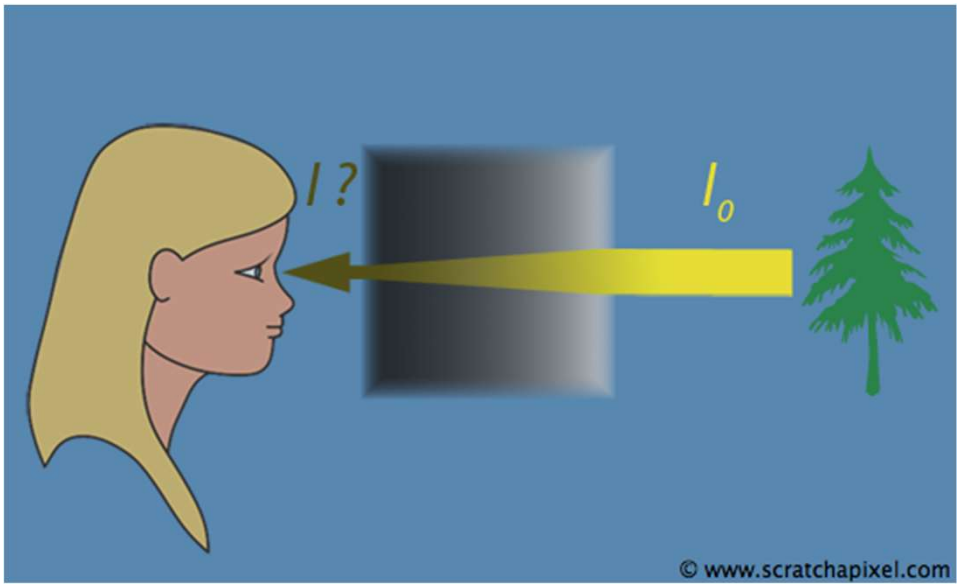
- Passing through



Volume Rendering – Transmittance

- Light is attenuated as it travels through a medium
- **Transmittance** is the ratio between light received and the incident light

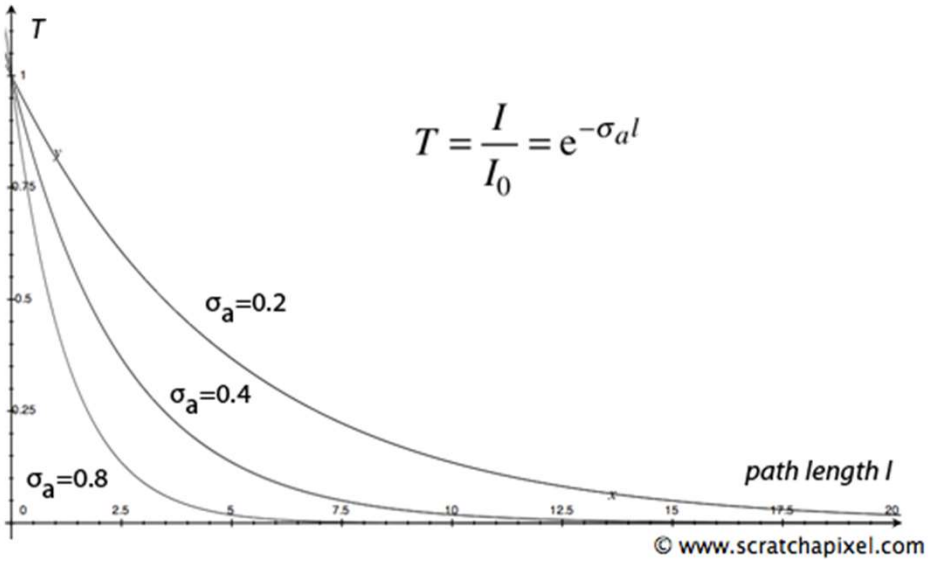
$$T = \frac{I}{I_0}$$



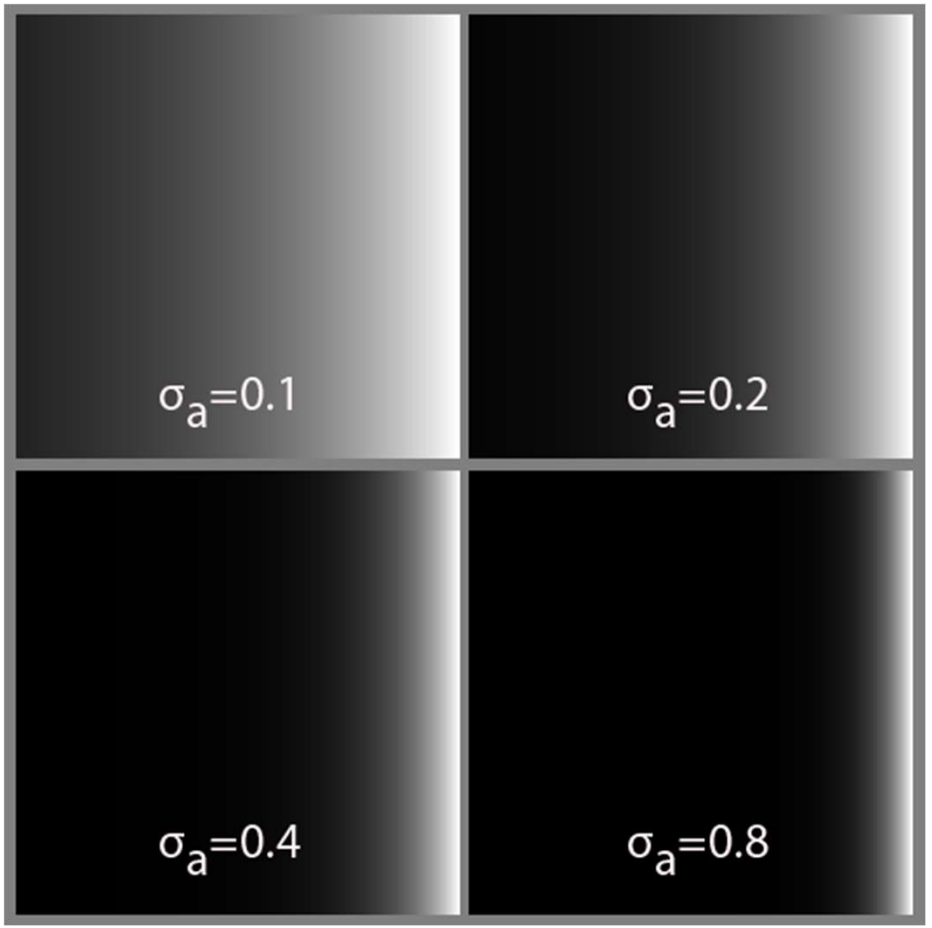
Lambert-Beer's law – Absorption

- Light attenuation due to **absorption**

$$T = e^{-\sigma_a l}$$



$$T = \frac{I}{I_0} = e^{-\sigma_a l}$$

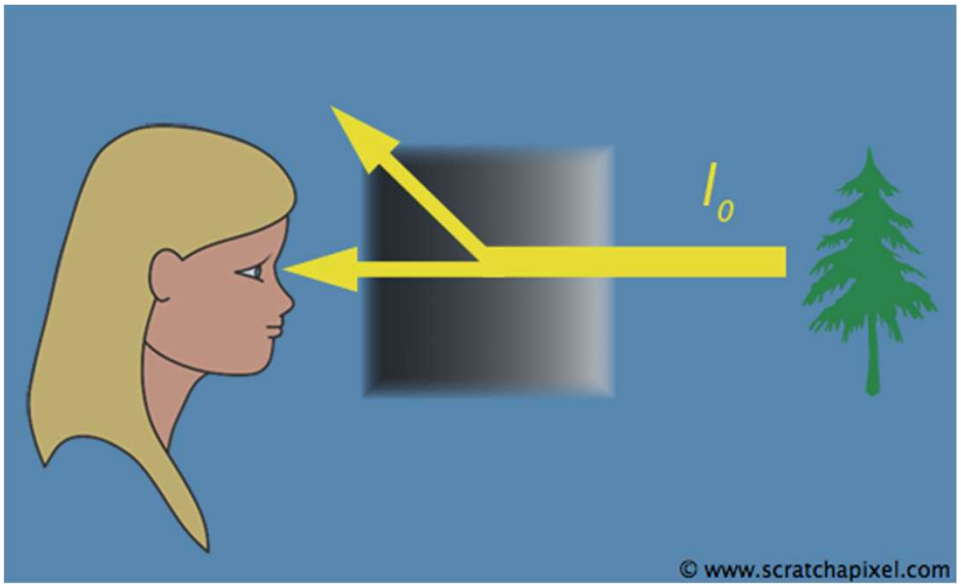


Lambert-Beer's law – Absorption + Scattering

- Light attenuation due to **absorption** and **out-scattering**

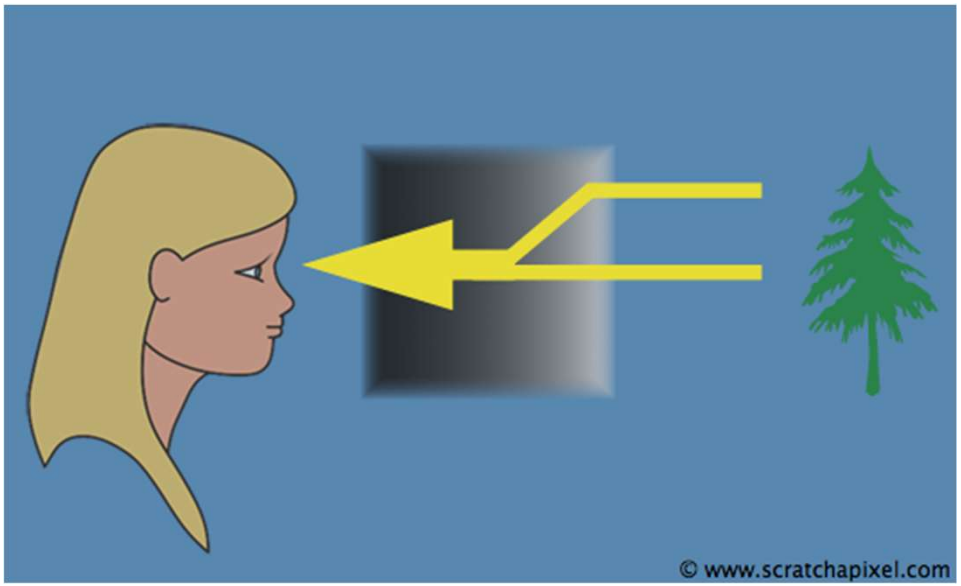
$$T = e^{-(\sigma_a+\sigma_s)l} = e^{-\sigma_t l}$$

- σ_t is also known as **extinction** or **attenuation** coefficient
- For solids $\sigma_t = \infty$

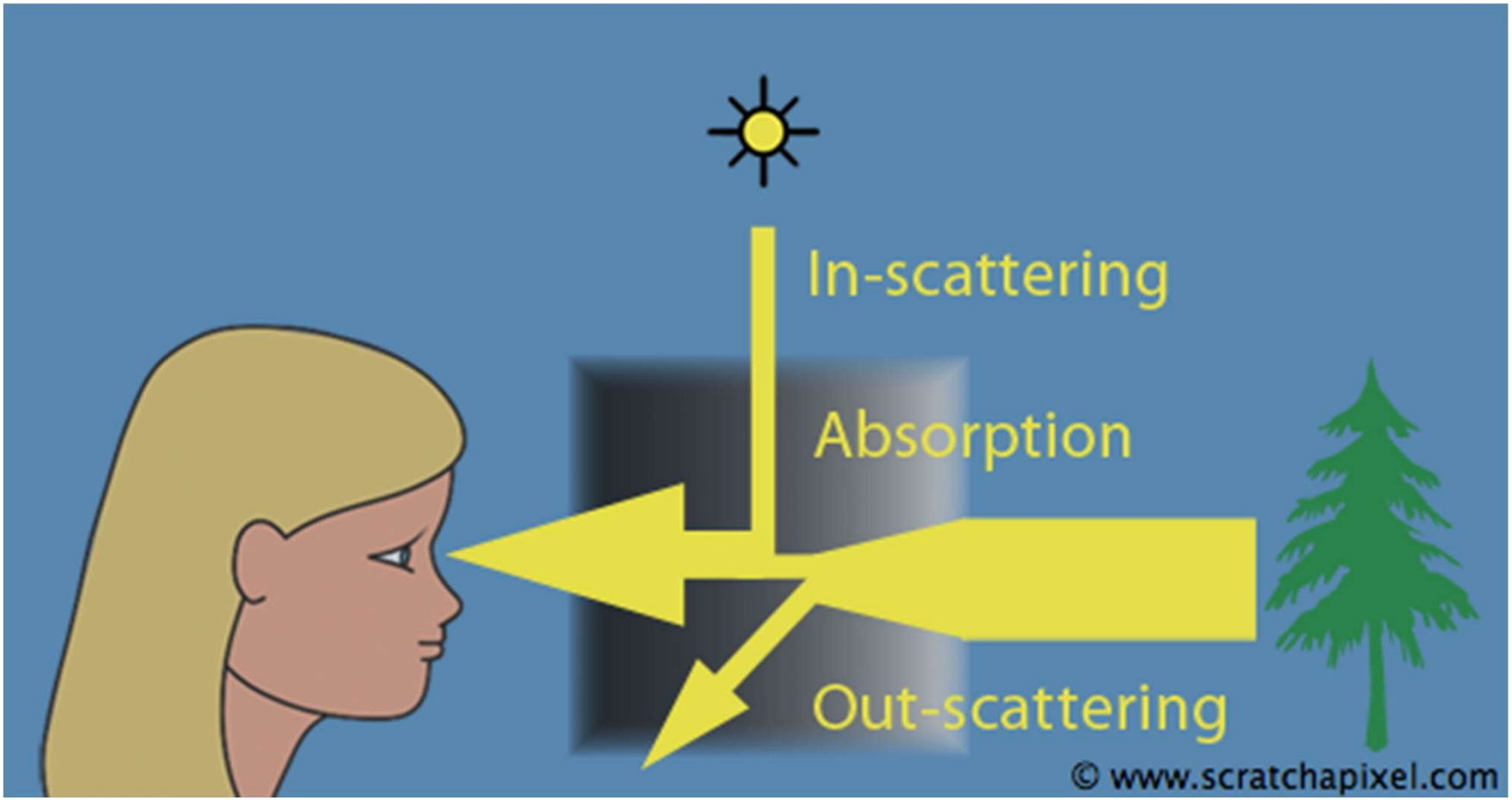


In-Scattering

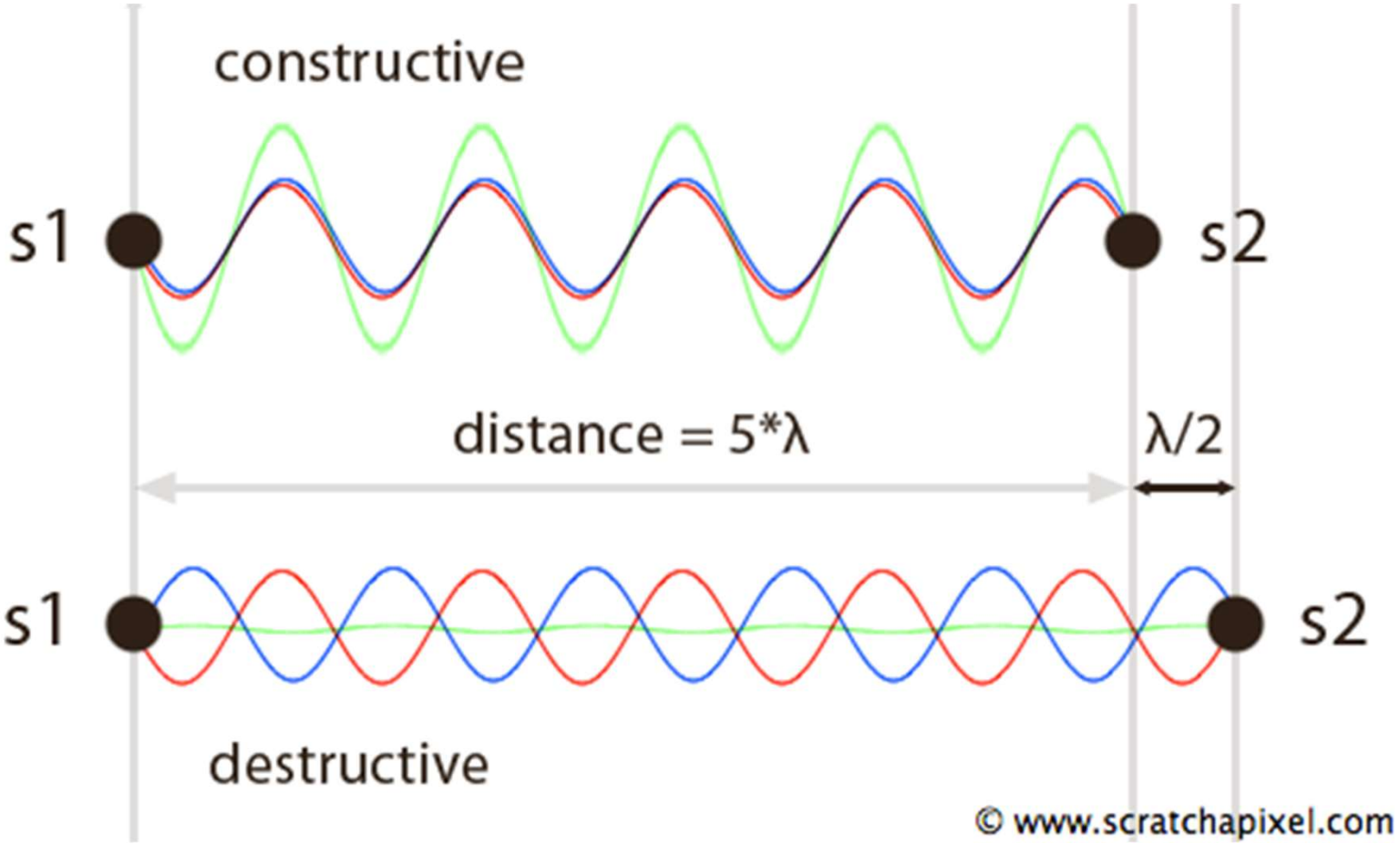
- Photons from other light paths join the light path that carries photons to the eye.



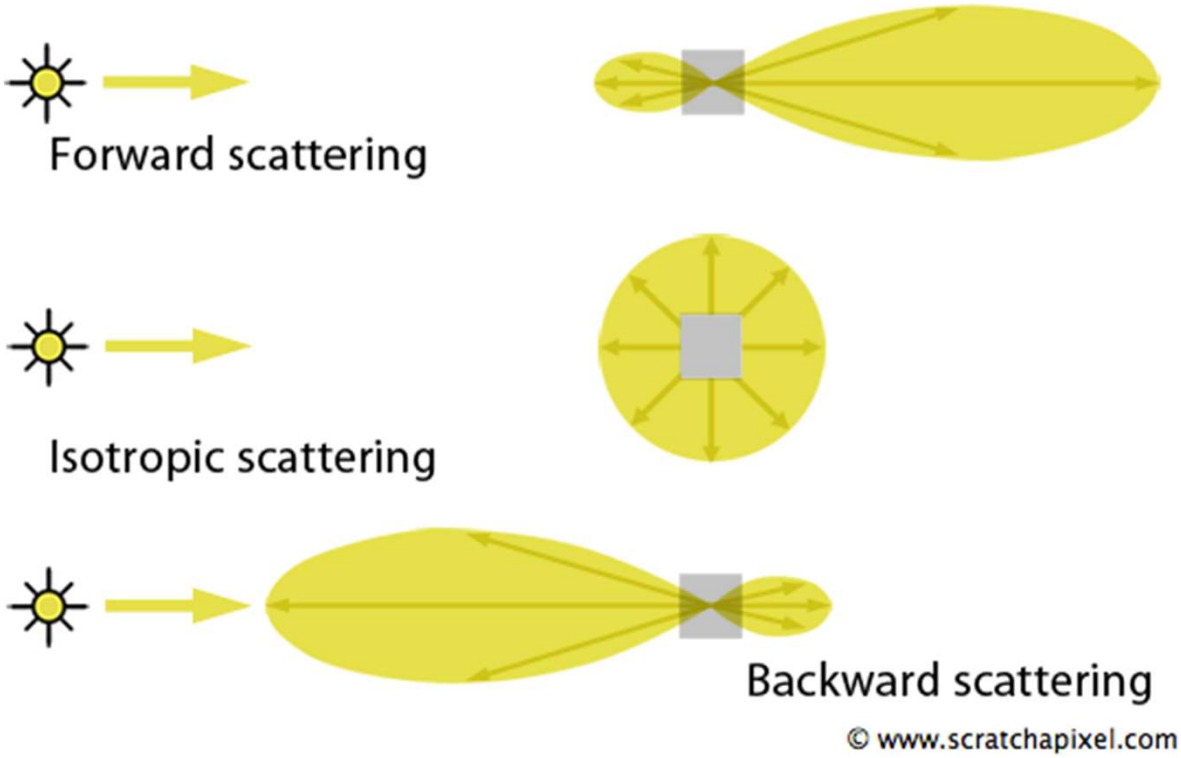
Light Travelling Through a Media



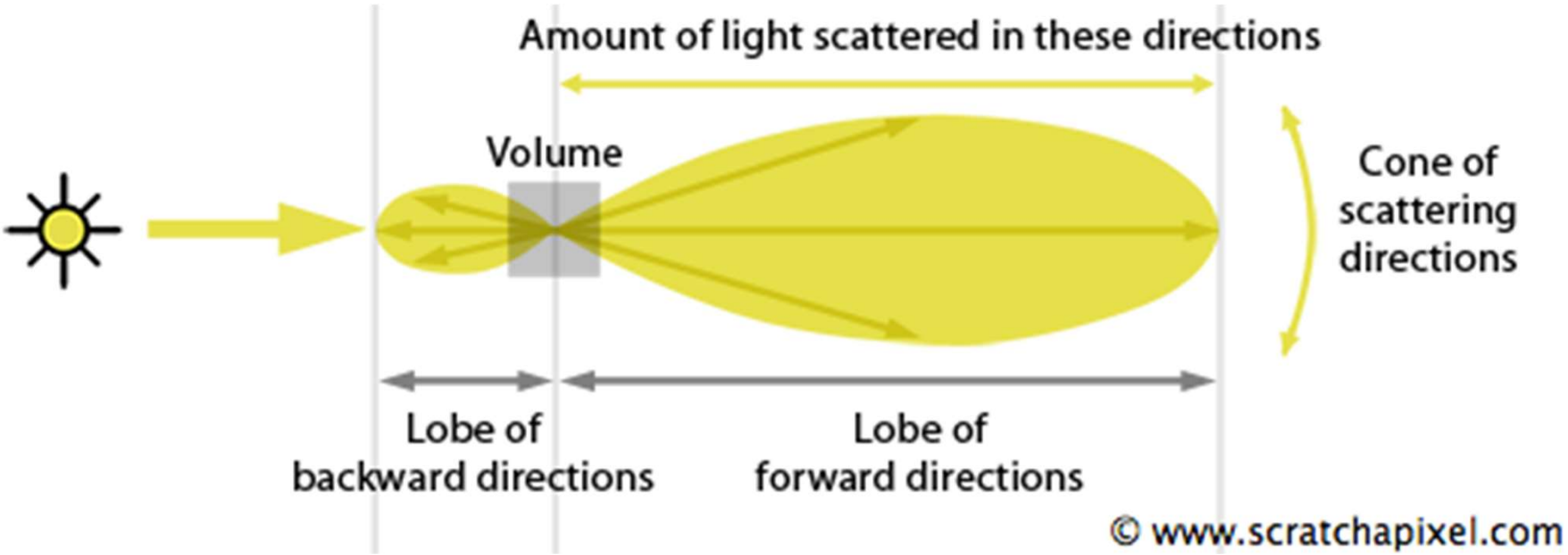
Interference



Anisotropic Scattering Due to Interference



Anisotropic Scattering Due to Interference



Anisotropic Scattering Due to Interference