Universität Augsburg
Fakultät für Angewandte Informatik

Monte-Carlo Simulation of Light-Tissue Interaction

Biophotonics - Exercise II

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18/12/2024

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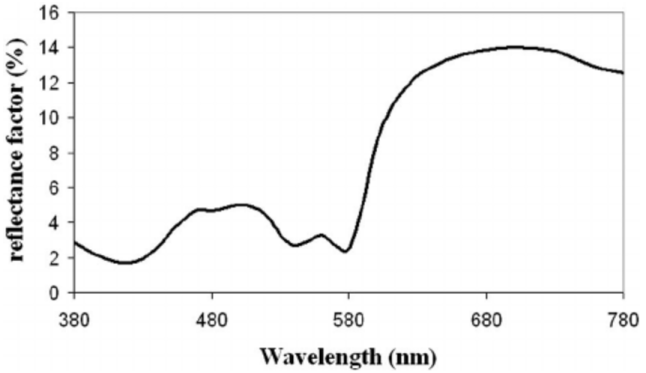
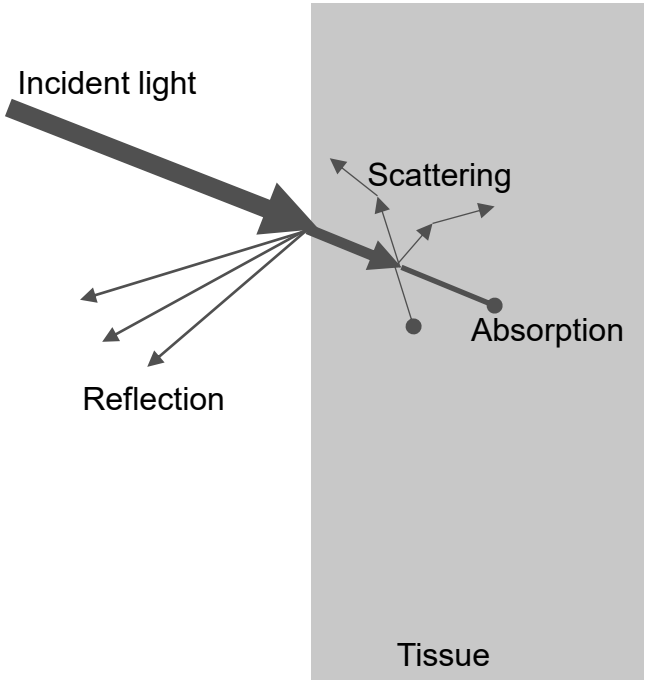
Agenda

1. Interaction of Light
2. Monte Carlo Simulation
3. Exercise

Light-Tissue Interaction

- Important mechanisms
  - **Reflection** (n)
  - **Absorption** (μ_a)
  - **Scattering** (μ_s, g)
  - Refraction
- Effects vary, depending on wavelength and tissue properties





Monte Carlo Simulation

Basics

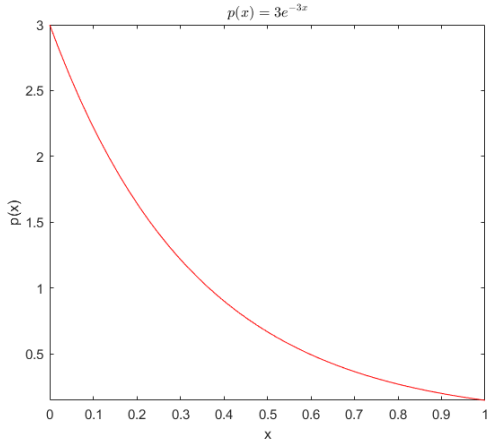
- Simulate systems through random sampling
- Uniform distribution of inputs
  - Normalised probability density function $p(x)$

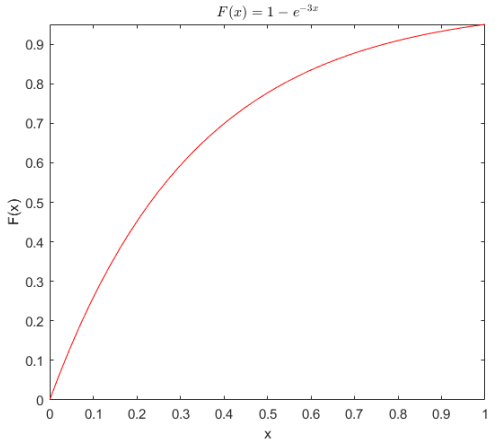
$$\int_{\Omega} p(x)\,dx = 1$$

  - And probability distribution function $F(x)$

$$F(x) = \int_{0}^{x} p(x')dx'$$

  - Draw random number r
    and solve $r = F(x)$ for x





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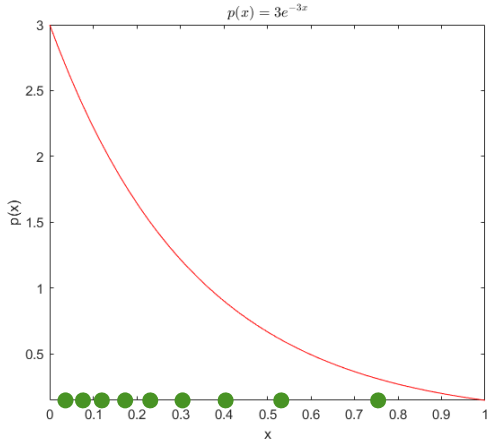
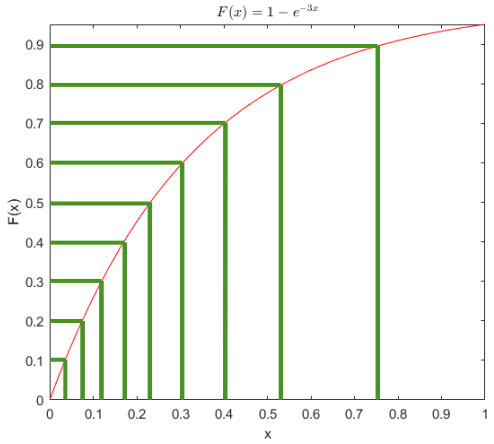
  - Draw random number RND and solve $\mathrm{RND} = F(x)$ for x
  - I.e. $\mathrm{RND} = 0.6$, $x = \frac{-\ln(1-\mathrm{RND})}{3} = 0.305$

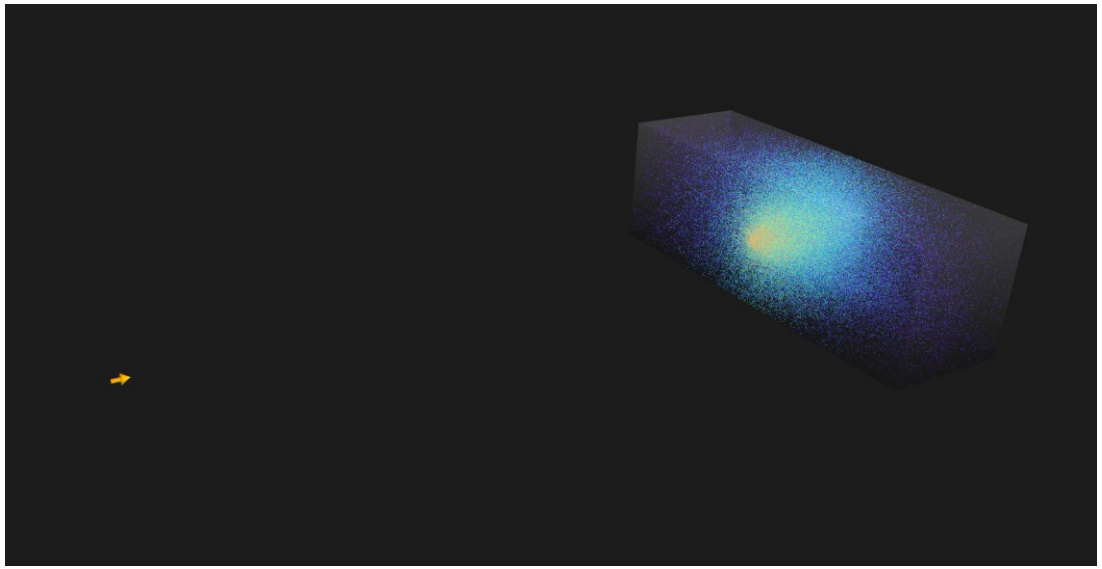




Monte Carlo Simulation

Light-Tissue Interaction

- Simulate the propagation of photons through tissue objects
- Launches single photons and calculates their path and energy loss
- Combination of multiple Monte Carlo simulations
  - Absorption
  - Reflection
  - Scattering
- Lost energy is stored in the corresponding voxel of the environment



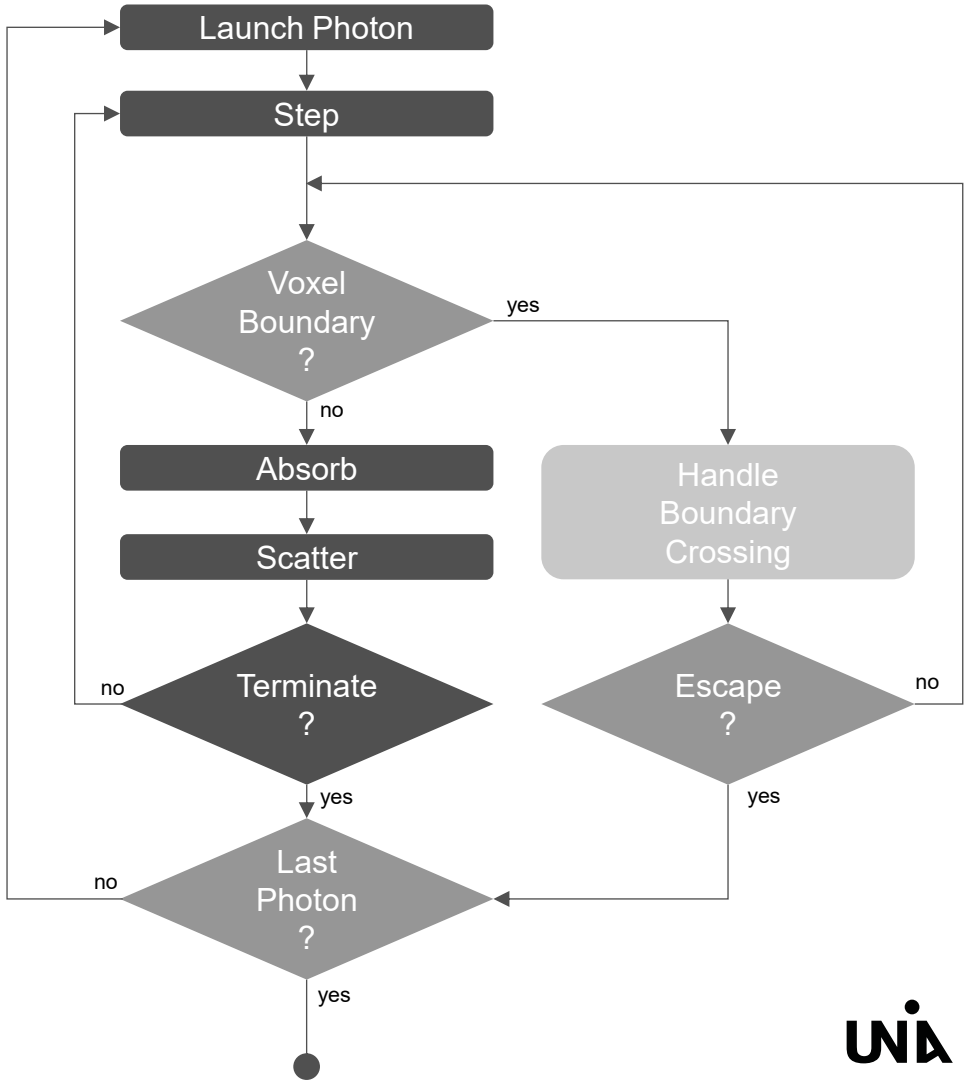
Monte Carlo Simulation

Light-Tissue Interaction

- Absorption
  - Intensity after distance d: $I(d) = I_0 e^{-\mu_a d}$
- Scattering
  - Step size until scatter event: $s = \frac{-\ln(\mathrm{RND})}{\mu_s}$
  - Direction: Henyey-Greenstein scattering

$$\mathrm{p}(\cos(\theta)) = \frac{1}{2} \frac{1 - g^2}{(1 + g^2 - 2g\cos(\theta))^{3/2}}$$

- Reflection
  - In case of changing material: **Fresnel coefficient** r
    if $\mathrm{RND} < r$: reflect, else transmit
- Termination
  - If Photon weight < threshold:
    increase weight (10%) or terminate (90%)



Due date: Sunday 08/12/2023, 23:59

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