KAIST

Introduction to Spectral Rendering

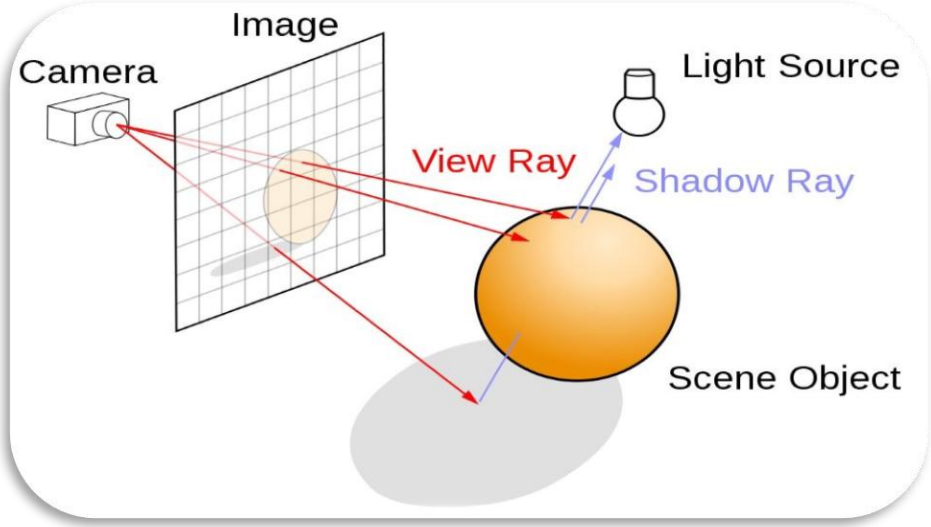
Group 1
Course: CS580
Speakers: Daniel Mocanu, Valentin Le Lièvre

Overview

1. Reminder of rendering equation and comparison to real world light
2. Introduction to spectral rendering
3. Spectral rendering equation
4. When / Where to use spectral rendering
5. Drawbacks and optimizations of spectral rendering

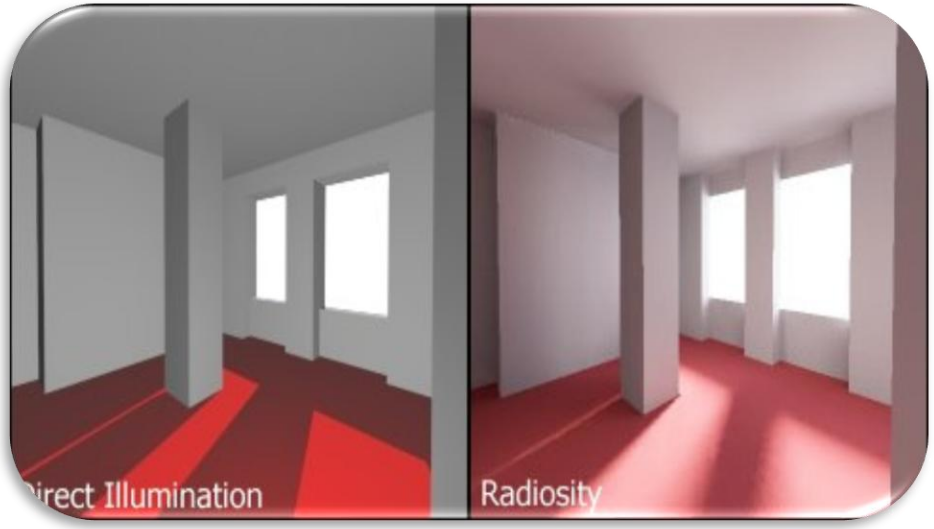
What We Know : Ray Tracing and Radiosity

Ray Tracing



- Shadows
- Reflection
- Refraction

Radiosity

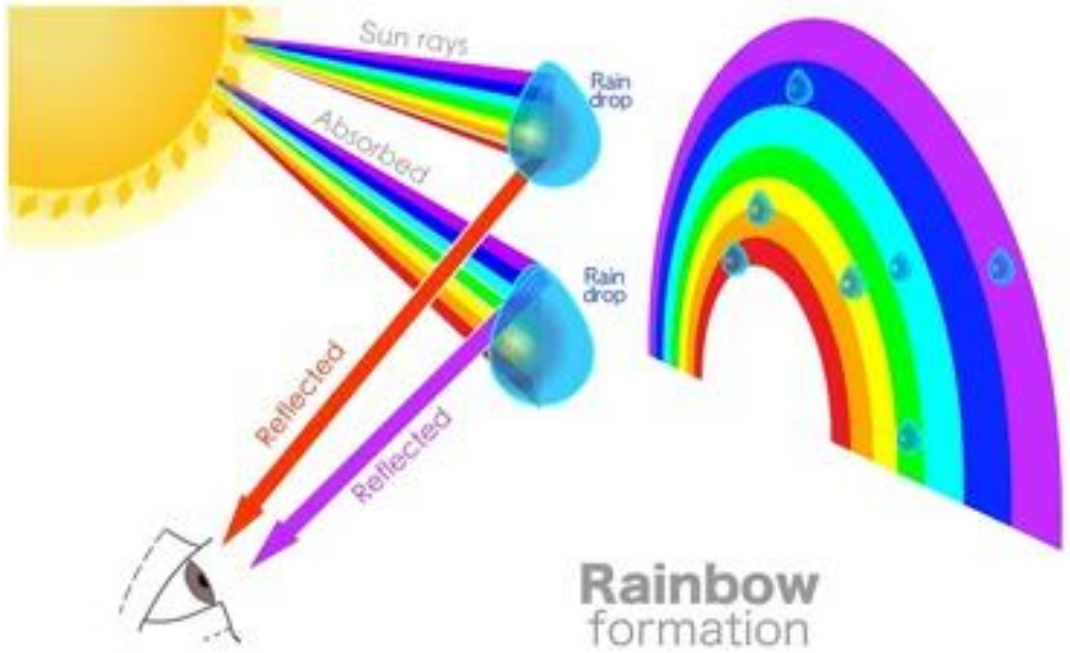


- Diffuse Environments
- Color Bleeding
- Penumbra

Source : Google Images, Class Slides

Real Light Ray

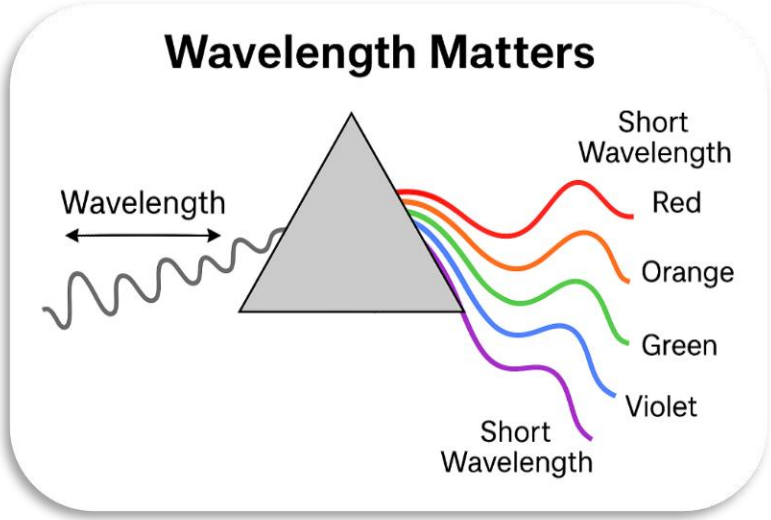
In reality, **White Light** is Composed of Multiple Wavelengths. Basic RGB rendering doesn't fully capture how light of different colors really behaves.



Source : Google Images

From RGB to spectral rendering

Spectral rendering is a physically based rendering technique that **simulates light as a function of wavelength** rather than using only three-color components.

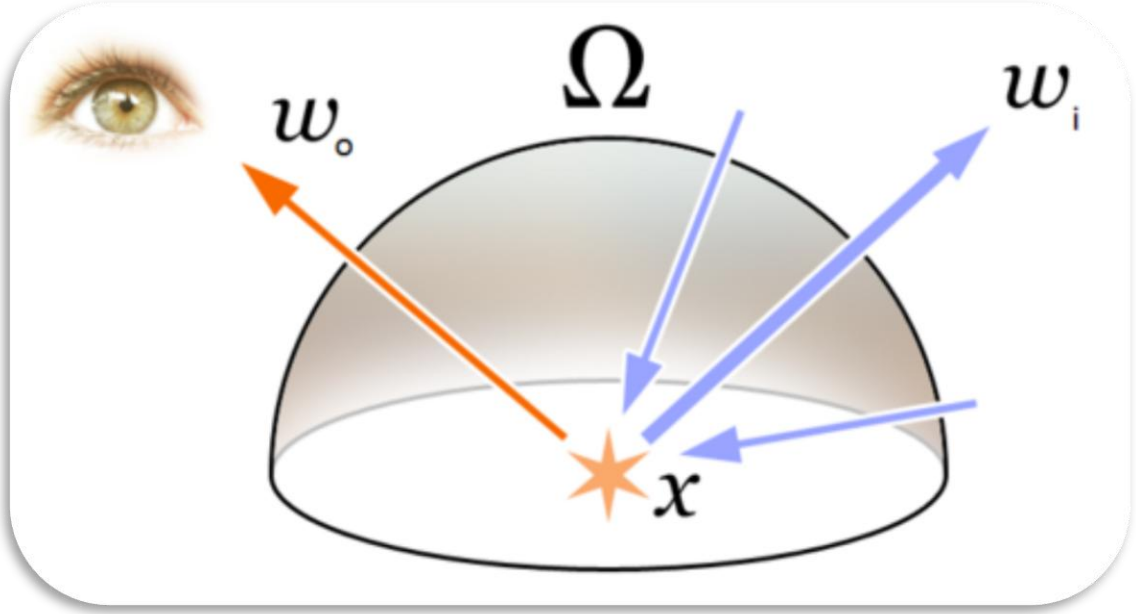


Dispersion

Iridescence

Source : AI generated, Wikipedia

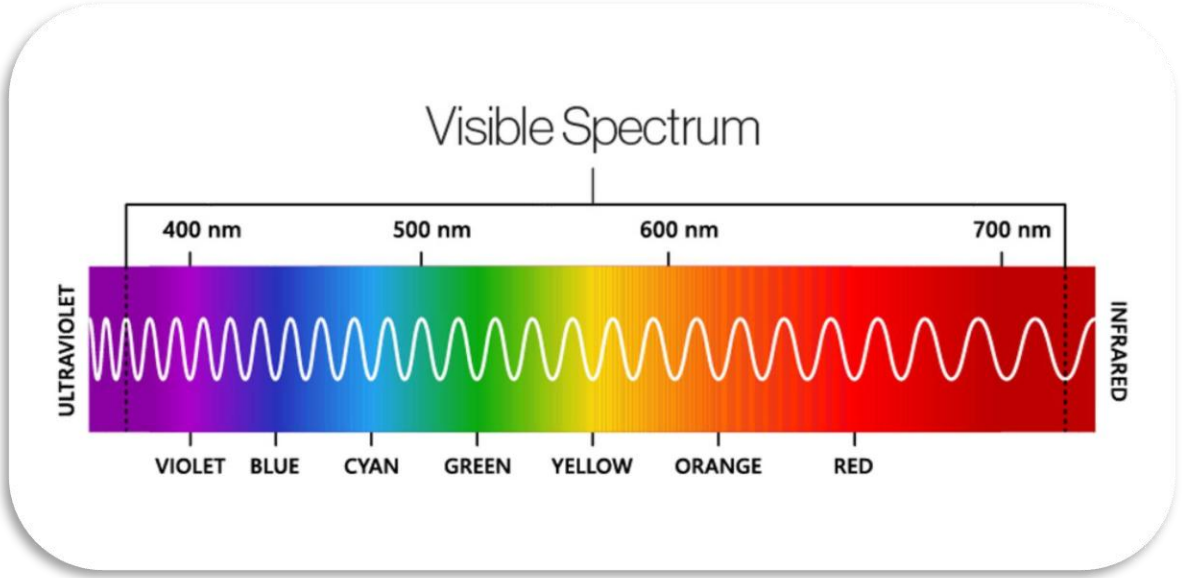
Classic Rendering Equation



$$L_o(x, \omega_o) = L_e(x, \omega_o) + \int_\Omega f_r(x, \omega_i, \omega_o)\ L_i(x, \omega_i)\ \cos\theta_i\ d\omega_i$$

Source : Google Images

Spectral Rendering Equation



$$L_o(x, \omega_o, \lambda) = L_e(x, \omega_o, \lambda) + \int_\Omega f_r(x, \omega_i, \omega_o, \lambda)\ L_i(x, \omega_i, \lambda)\ \cos\theta_i\ d\omega_i$$

Source : Google Images

When and where to use spectral rendering

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Don’t use :

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- Real-time rendering
- Plain non reflective objects
    - exemple: walls, tables …

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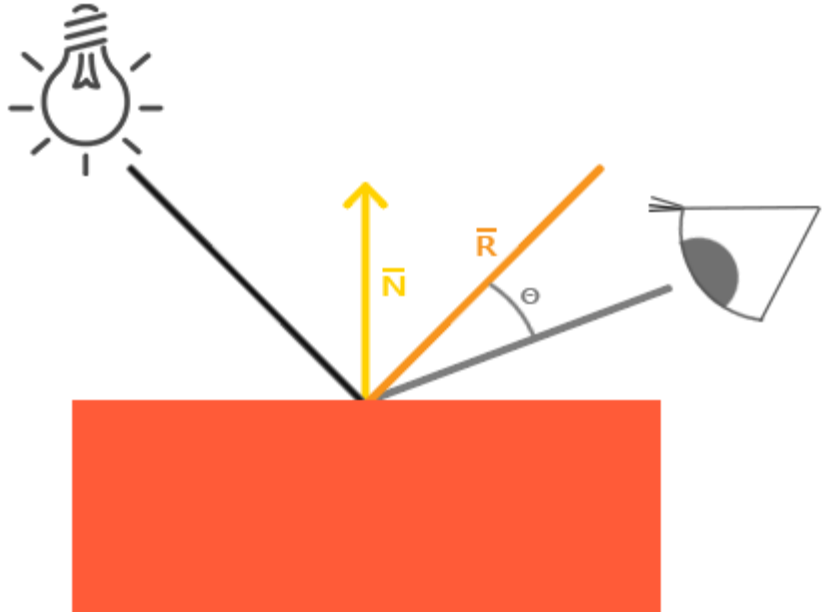

Reflection of light on opaque surface

Source : Class slides

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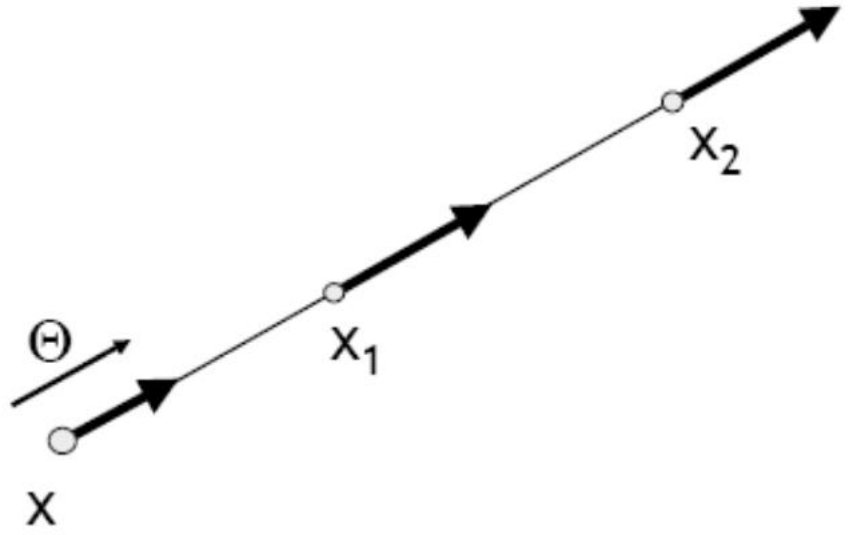

Assumption of straight-line path for light

Source : Class slides

When and where to use spectral rendering

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Do use :

- Simulate real life lighting effects
- Environment with a lot of light scattering
- Special objects and volumes
    - exemple : sky, water, prism …

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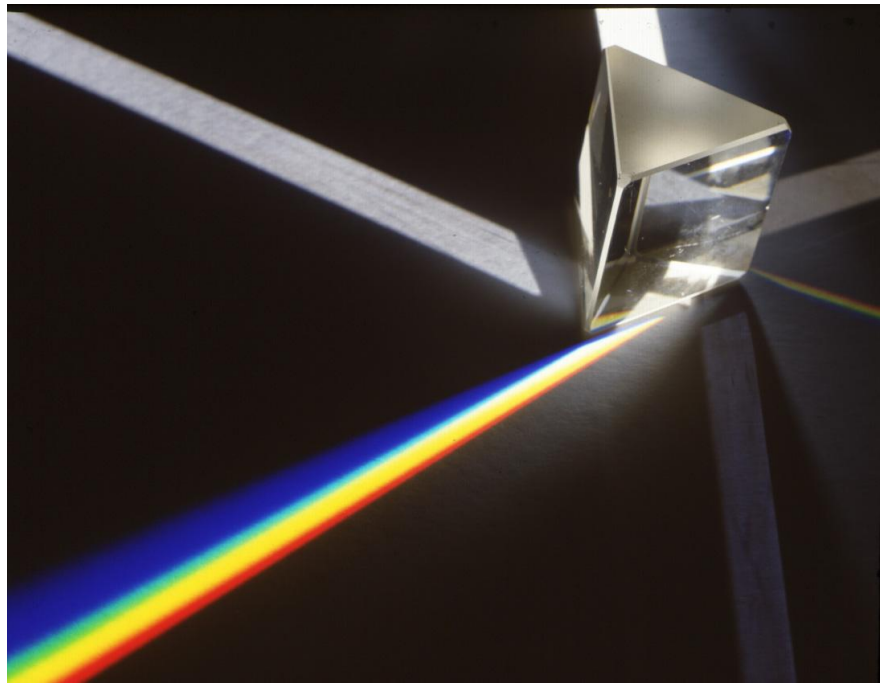


Prism effect on light

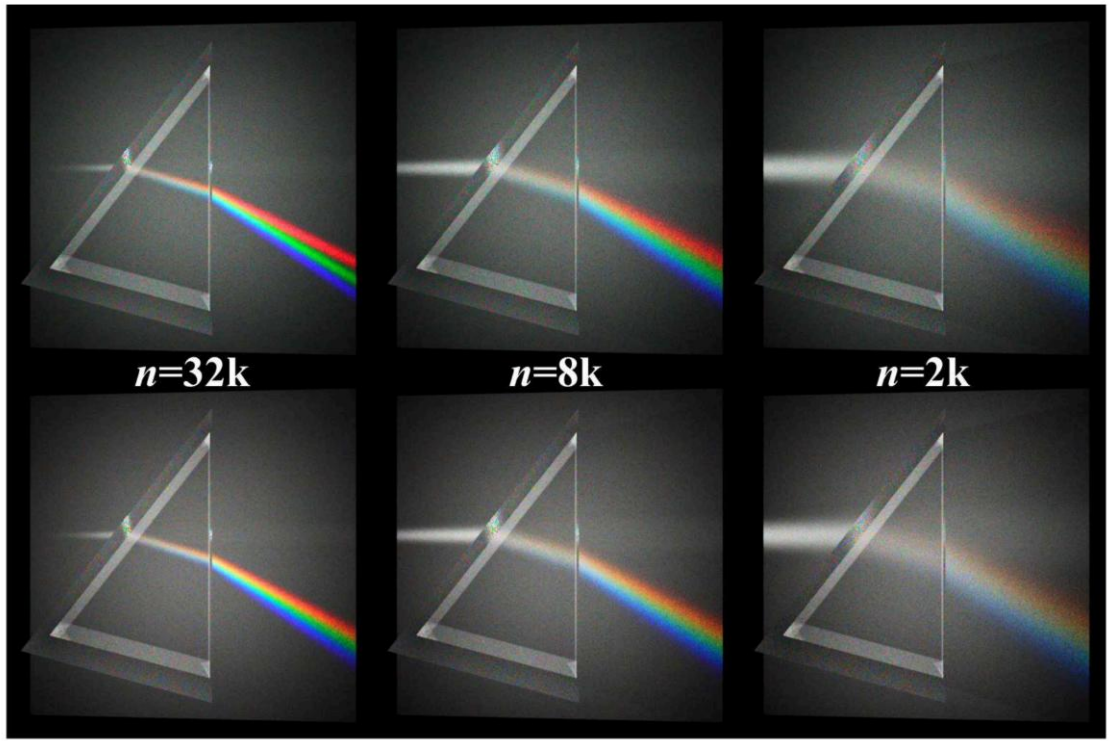
Source : Google image

When and where to use spectral rendering

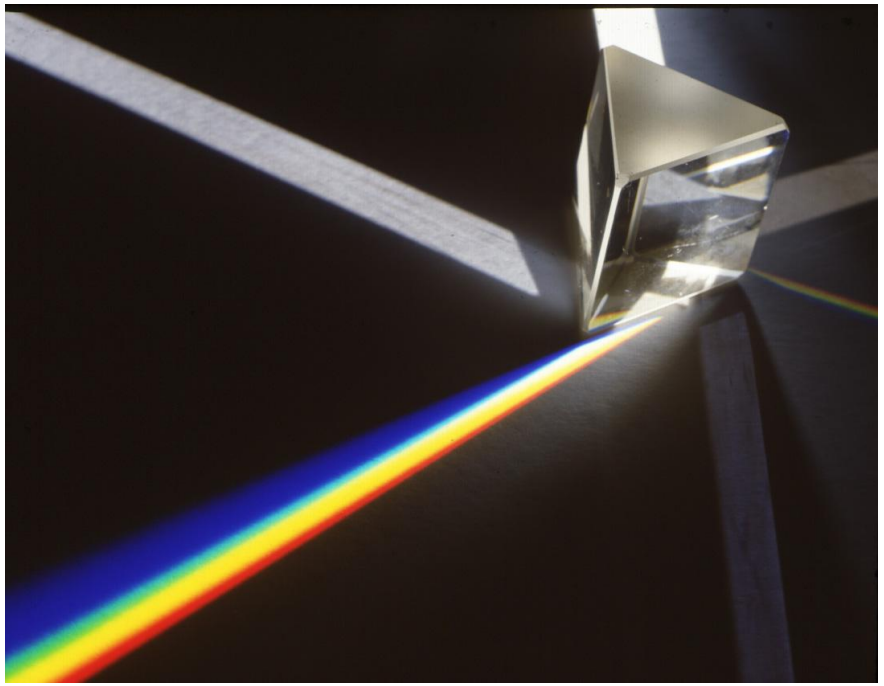
RGB rendering

N : scattering intensity

Spectral rendering



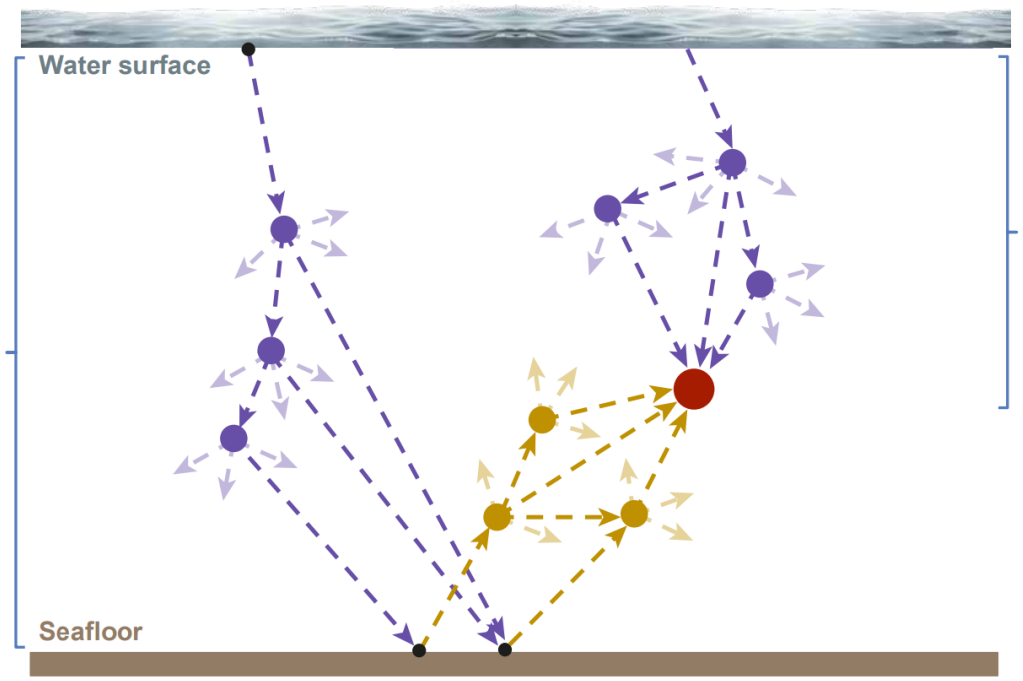
RGB rendering vs spectral rendering comparison



Prism effect on light

Source : An Improved Technique for Full Spectral Rendering, Michal Radziszewski

When and where to use spectral rendering

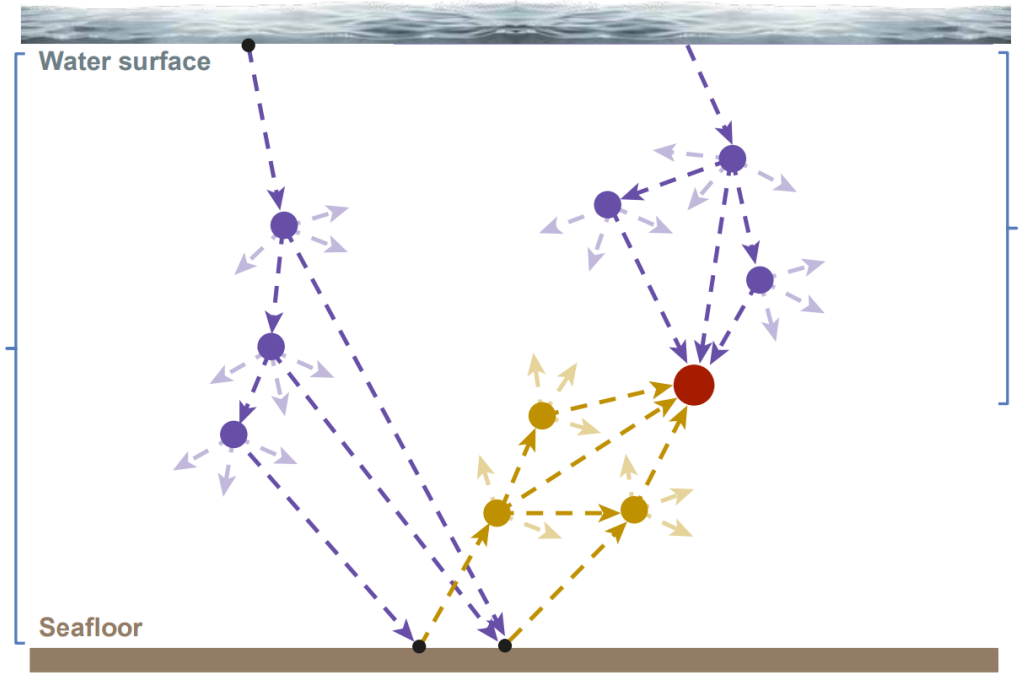


Underwater scattering

Source : Real-Time Underwater Spectral Rendering, February 2024, Nestor Monzon

When and where to use spectral rendering

Underwater lighting (low wavelength scattering)



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Simulating eye and camera spectral response

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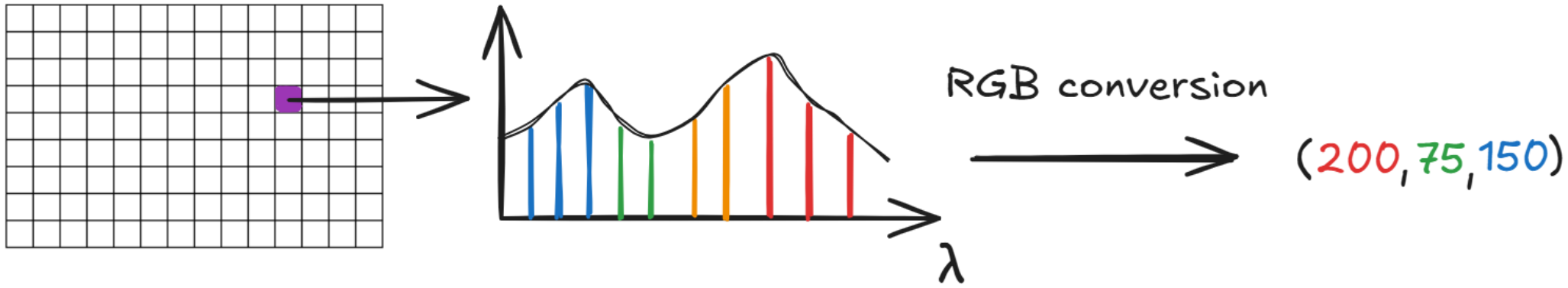
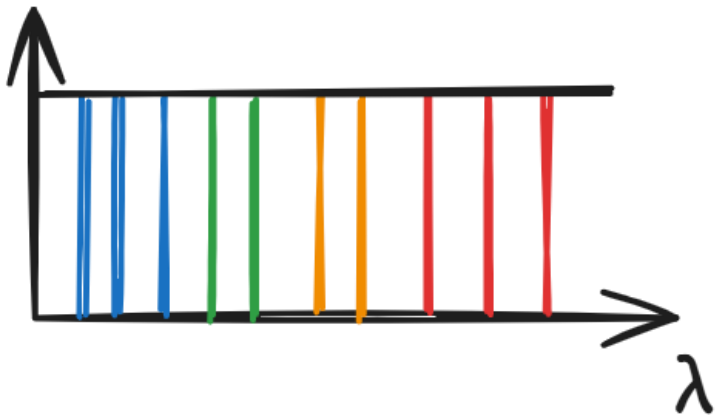


Spectral representation to RGB display conversion

Source : Taylor made drawing

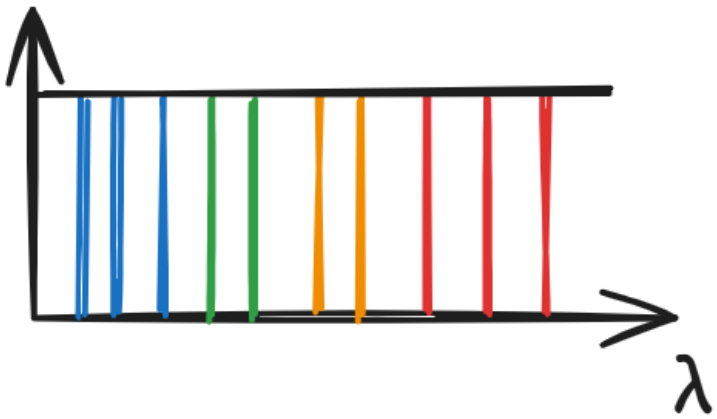
Simulating eye and camera spectral response



Ideal camera sensor response

Source : Taylor made drawing

Simulating eye and camera spectral response



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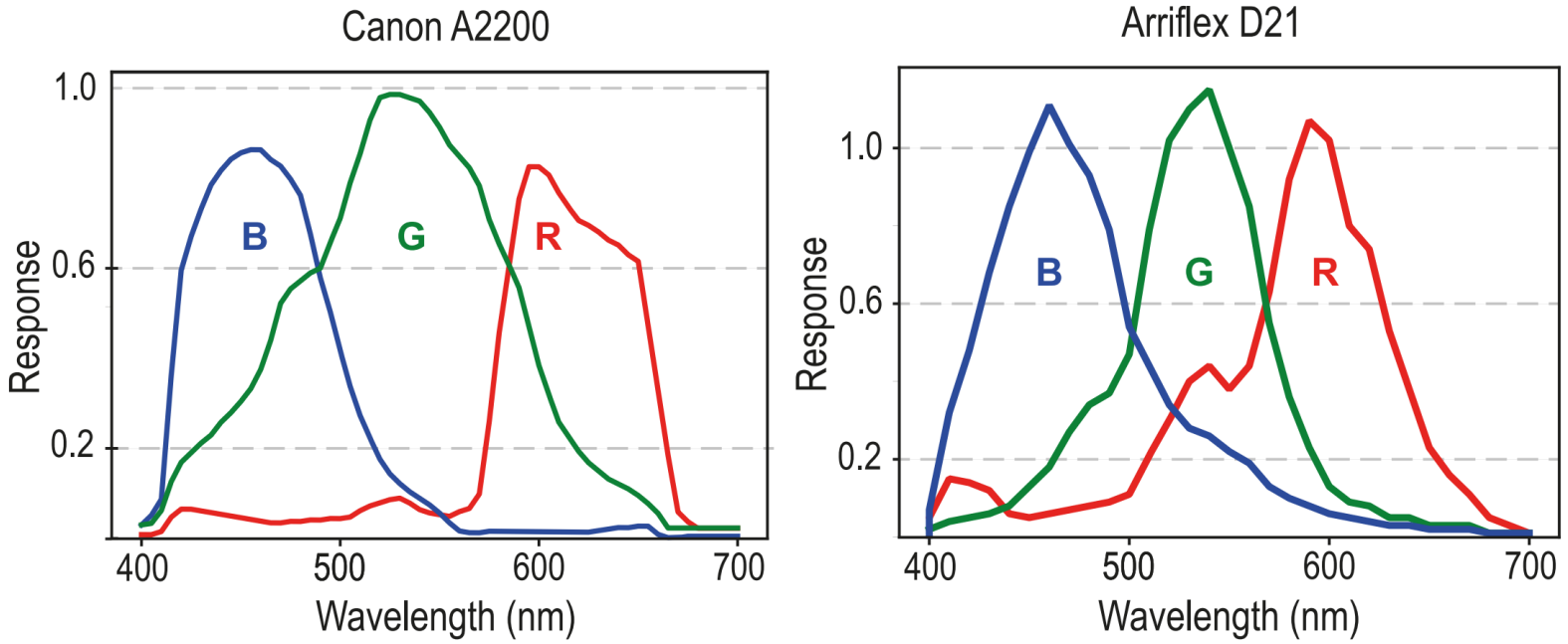
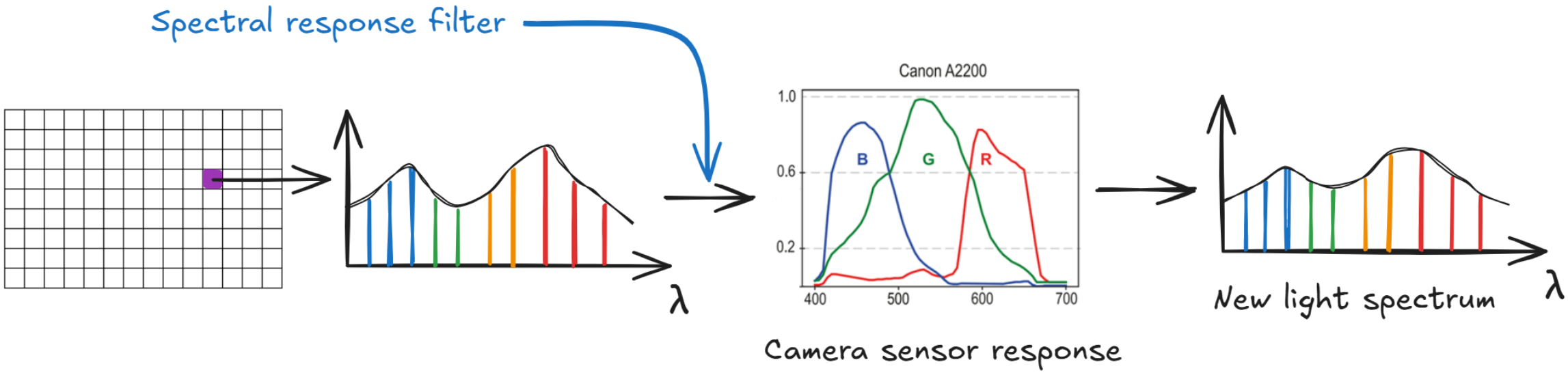


Real camera sensor response

Source : Real-Time Underwater Spectral Rendering, February 2024, Nestor Monzon

Simulating eye and camera spectral response



Source : Taylor made drawing

Simulating eye and camera spectral response

Comparison between two simulated camera sensor response

Canon A2200

Arriflex D21

Source : Real-Time Underwater Spectral Rendering, February 2024, Nestor Monzon

Drawbacks of Spectral Rendering

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Spectral rendering is computational heavy

x100 ray count to sample each wavelength → slower render time

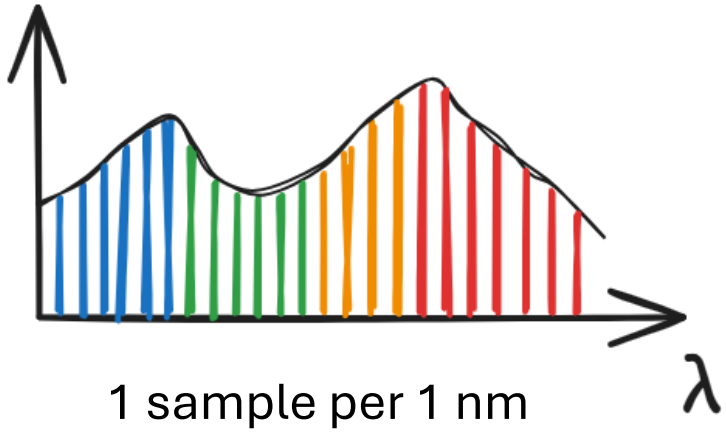
Drawbacks of Spectral Rendering

How to optimize spectral rendering ?

- Optimize calculations
- Approximate solutions
- Mix rendering

Optimizations : Sampling reduction

Reduce the number of sampled wavelength



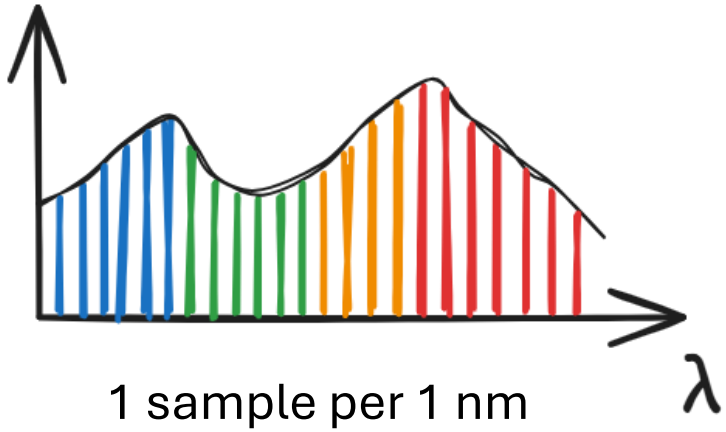
1 sample per 1 nm

→ Perfect spectrum representation

Source : Taylor made drawing

Optimizations : Sampling reduction

Reduce the number of sampled wavelength



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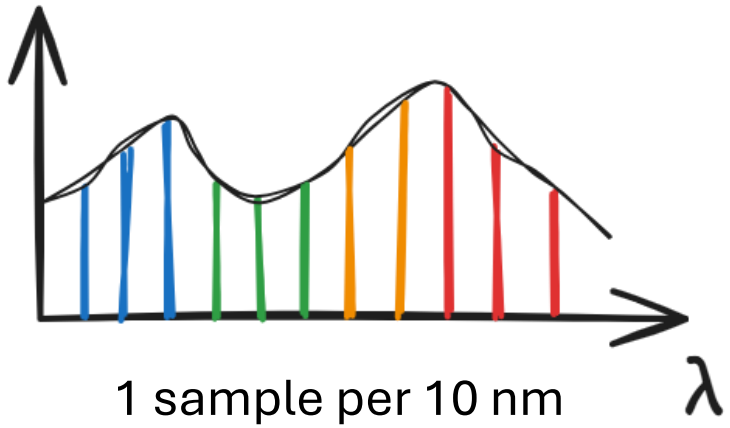


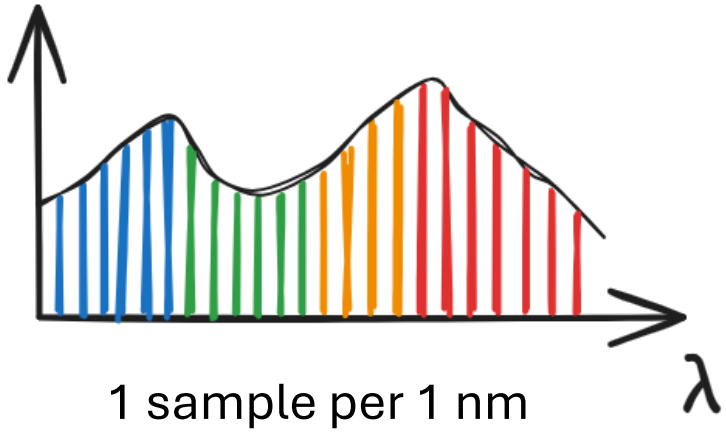
1 sample per 10 nm

→ Reconstruction possible with minimal errors

Source : Taylor made drawing

Optimizations : Sampling reduction

Reduce the number of sampled wavelength



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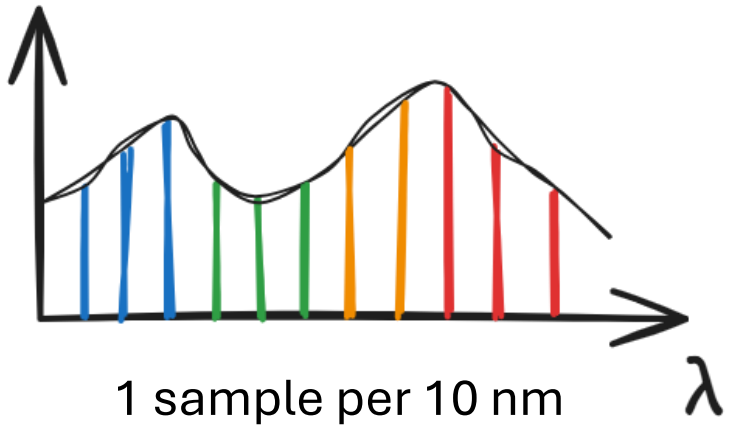

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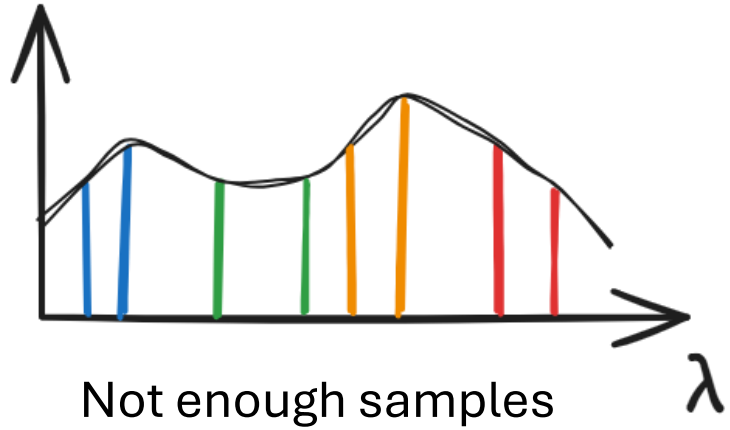

Not enough samples

Non accurate reconstruction

Source : Taylor made drawing

Optimizations : Importance sampling

Select most important waves to sample instead of random sampling

→ Improvements over the Monte Carlo estimation

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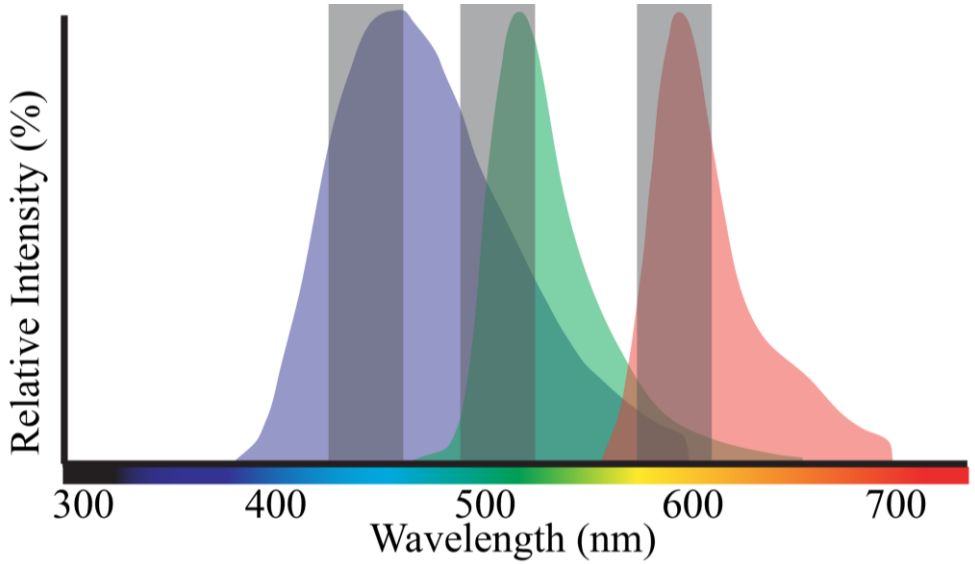


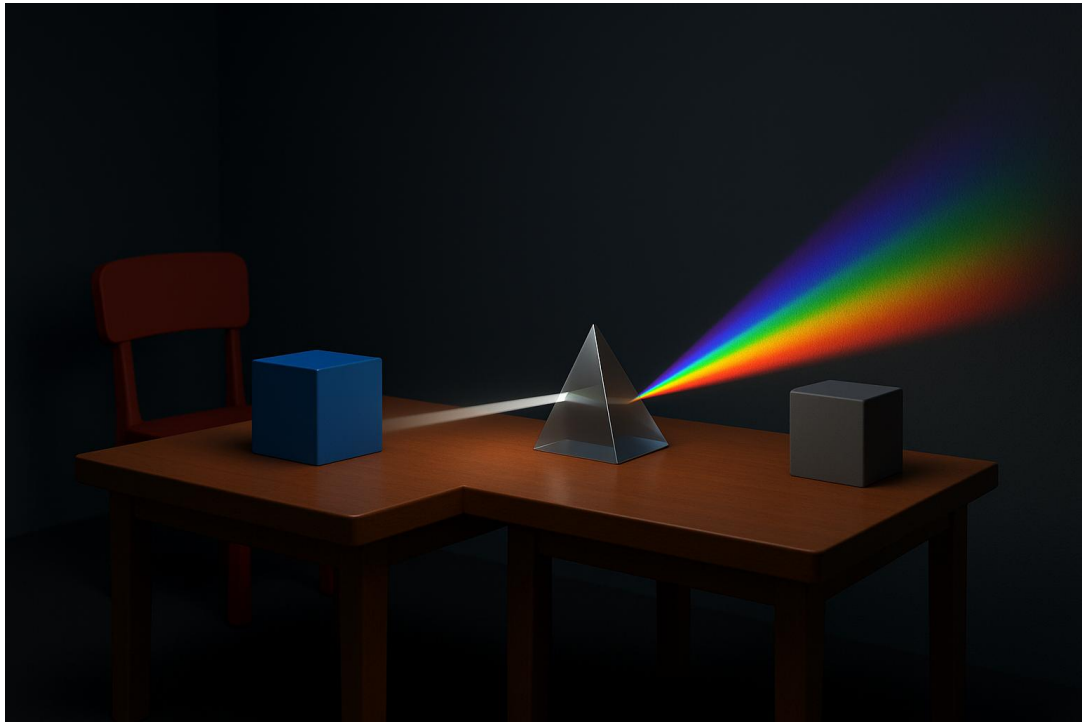
Select most important wavelengths

Source : Google image

Optimizations : Mix rendering

Use RGB rendering for simple objects

Use spectral rendering only for complicated objects



Source : AI generated

Thank you

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Quiz