Mid-term project presentation

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

Overview

1. Reminder of previous presentation
2. Project presentation and related work
3. Underwater light Scattering
4. Underwater Spectral Rendering
5. Improvements proposal
6. Current project state
7. Team Roles

Reminder of previous presentation

Lecture topic : **Spectral rendering**

We covered :

- Intuitive idea of spectral rendering
- New rendering equation with included wavelength parameter :

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

- Where to use spectral rendering : water, clouds, prism ...
- Drawbacks of spectral rendering : slow to compute, not suited for real-time applications

Our project topic

Underwater spectral rendering

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

Related background

State of the art simulation (faking) of underwater rendering in games

Render normal object in normal lighting conditions

Related background

State of the art simulation (faking) of underwater rendering in games

Add a fog effect on the object

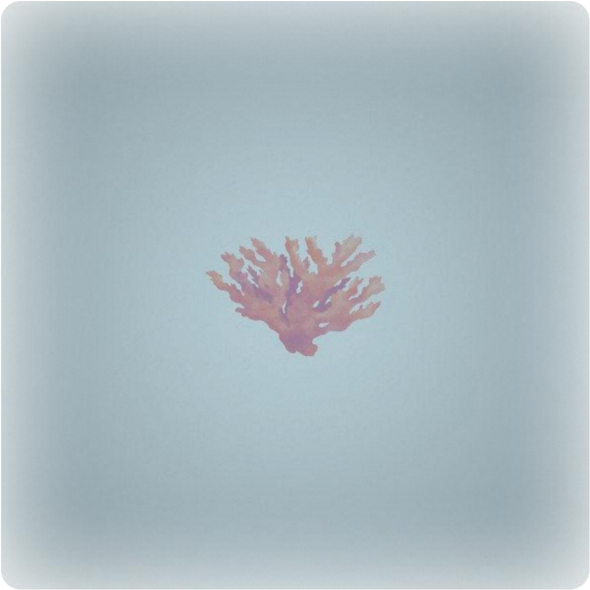
Related background

State of the art simulation (faking) of underwater rendering in games

Add layer of blue color filter

Related background

If the object is further away, blur is more intense, and blue color is darker



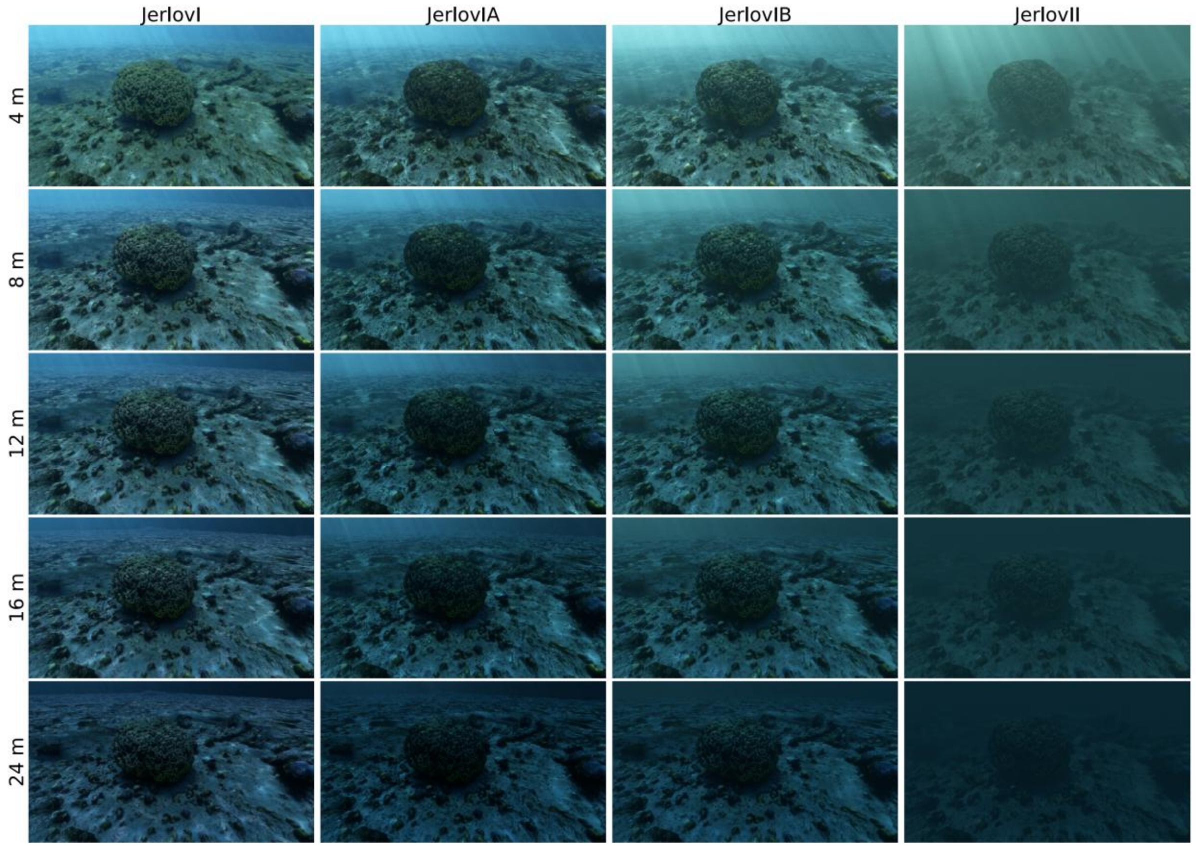
Further away from the camera

Related background

Rendering of Subnautica game using similar method

Source : Subnautica, in-game image

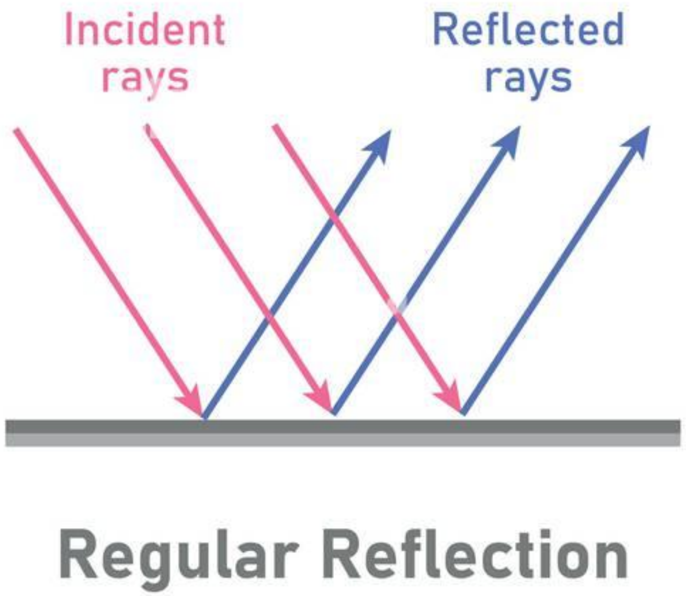
Related background

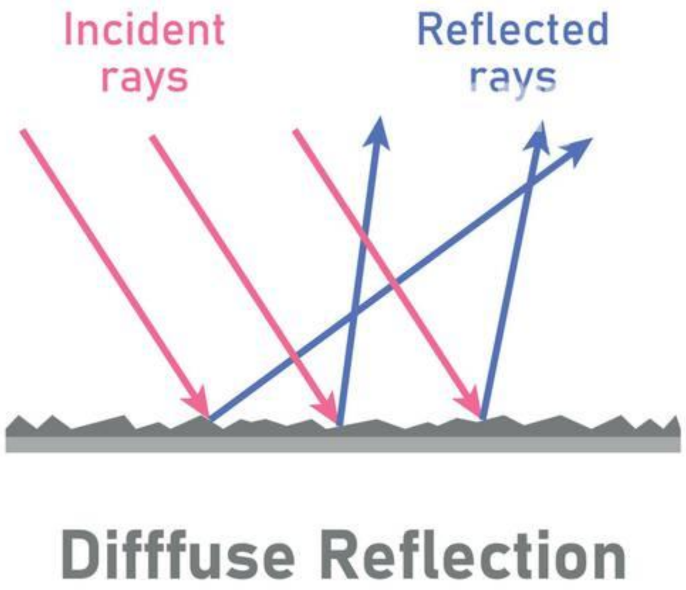


Comparison of multiple water types and depth with spectral rendering

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

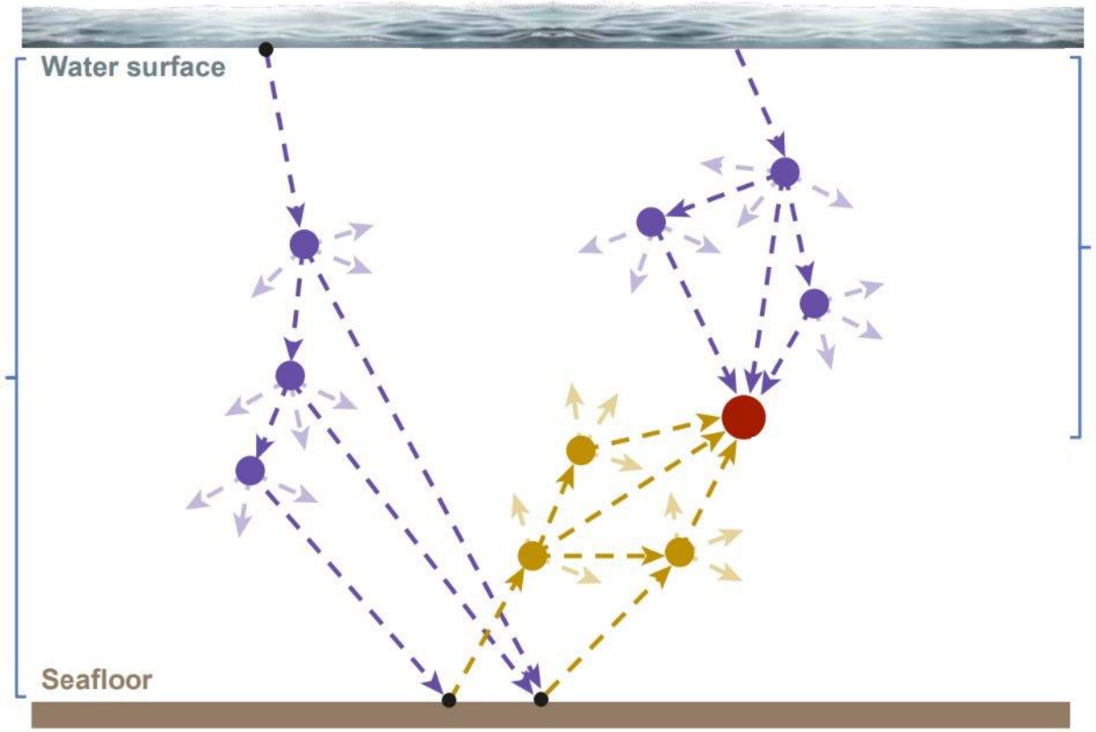
Surface Light Scattering





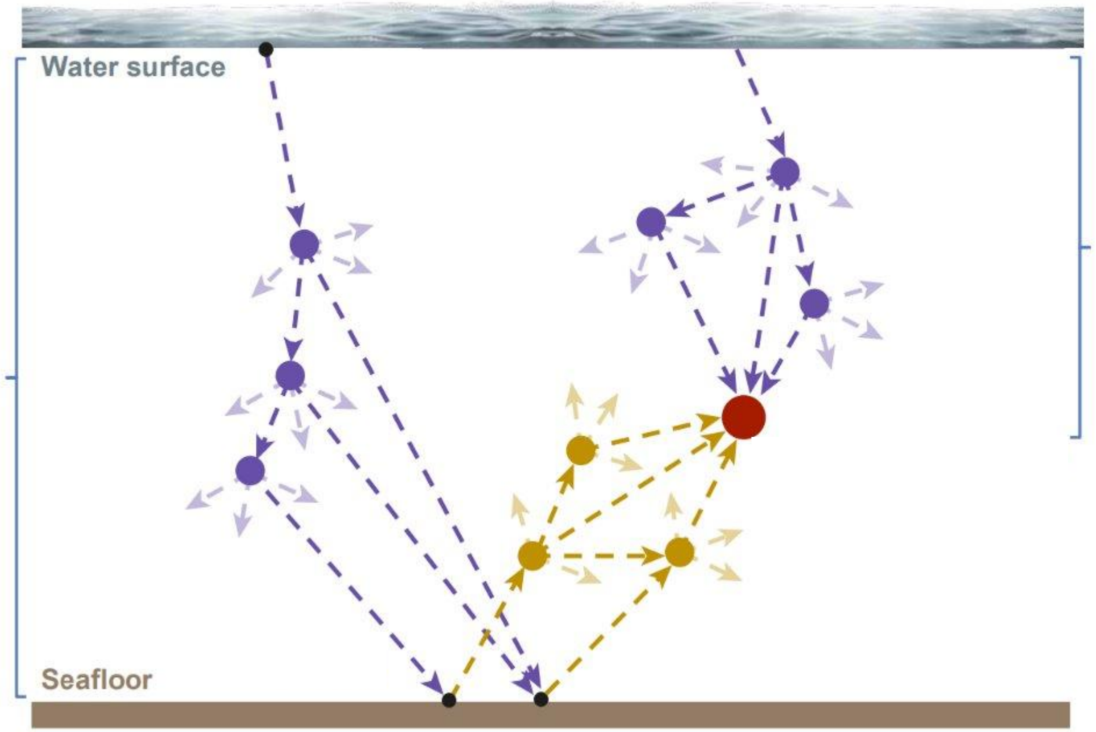
Underwater Light Behavior

- Water => (Formally) **Participation Medium**
- Scattering
- Absorption
- Short Wavelength (Blue)
- Long Wavelength (Red)



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

Underwater Light Behavior

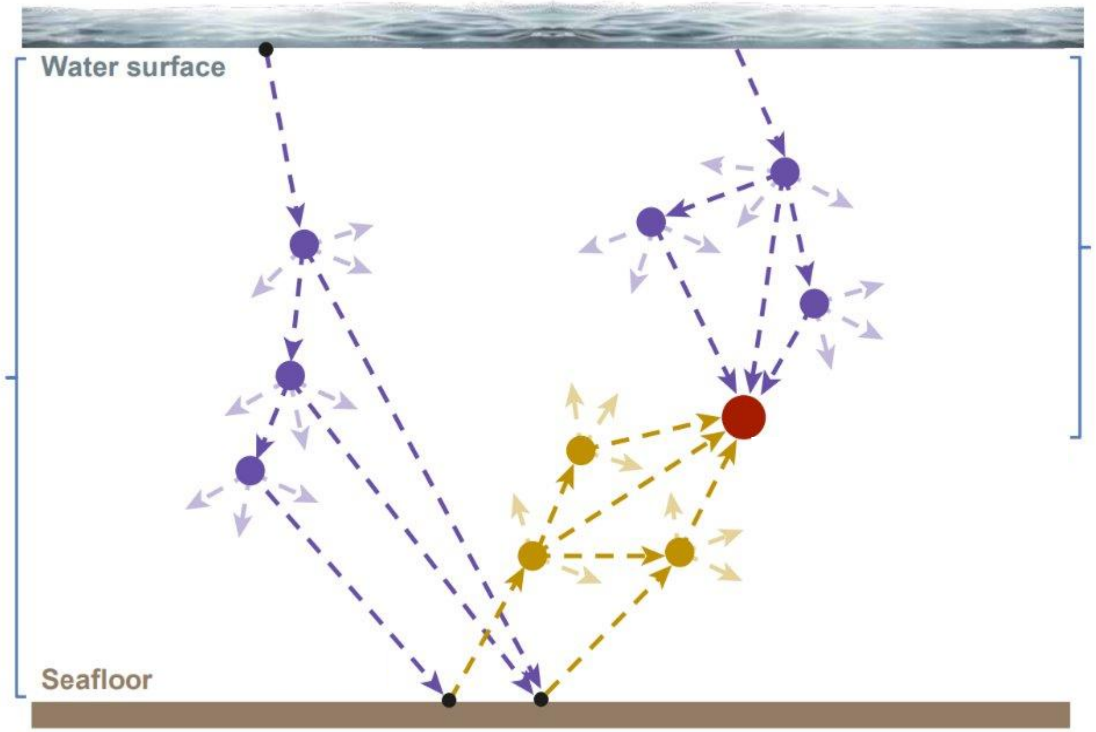


Source : Real-Time Underwater Spectral Rendering, February 2024, Nestor Monzon

Light Scattering and Absorption

- Scattering Coefficient $\boldsymbol{\delta_s}$ - Probability of light being scattered per meter.
- $\boldsymbol{\delta_s L(x_z, \omega)}$ - Differential scattered radiance.
- Absorption Coefficient $\boldsymbol{\delta_a}$ - Probability of light being absorbed per meter.
- $\boldsymbol{\delta_a L(x_z, \omega)}$ - Differential absorbed radiance.

For a ray traveling in direction outgoing $\boldsymbol{\omega}$ from position $\boldsymbol{x}$.

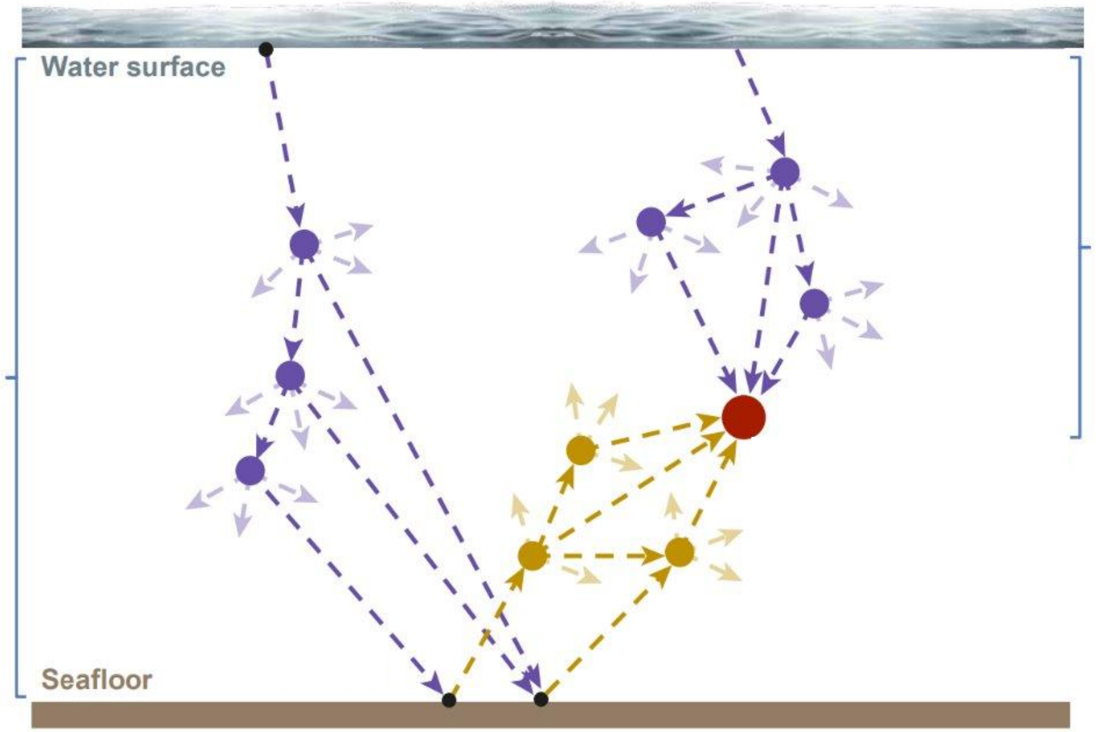


Source : Real-Time Underwater Spectral Rendering, February 2024, Nestor Monzon

Light Scattering and Absorption

- Extinction Coefficient: $\boldsymbol{\delta}_{\mathrm{t}} = \boldsymbol{\delta}_{\mathrm{a}} + \boldsymbol{\delta}_{s}$ - Probability of absorption or scattering.
- $\frac{dL_{extinction}(x,\omega)}{dz} = -\boldsymbol{\delta}_t L(\boldsymbol{x}_z, \boldsymbol{\omega})$ - Differential Total Extinction

For a ray traveling in direction outgoing $\boldsymbol{\omega}$ from position $\boldsymbol{x}$.

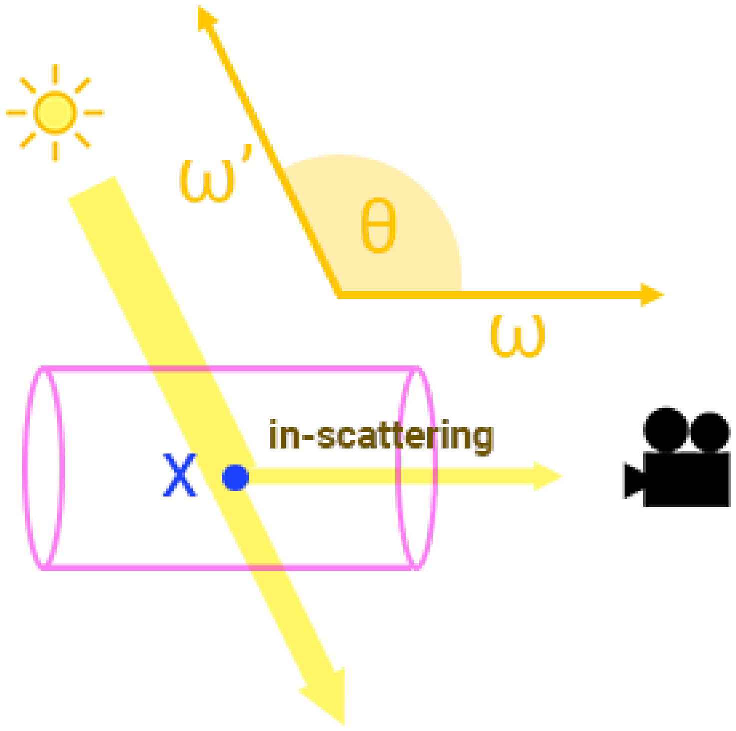


Source : Real-Time Underwater Spectral Rendering, February 2024, Nestor Monzon

Light In-scattering

- Incoming Incident Light from all directions.
- $\frac{dL_{in-scattering}(x,\omega)}{dz} = \delta_s L_i(x,\omega)$
- Where, $L_i(x,\omega) = \int_{\Omega} L(x,\omega_i) f_s(x,\omega_i,\omega) d\omega_i$
- $f_s(x,\omega_i,\omega)$ – Phase Function the likely-hood of scattering towards ω.

For a ray traveling in direction outgoing ω from position x.

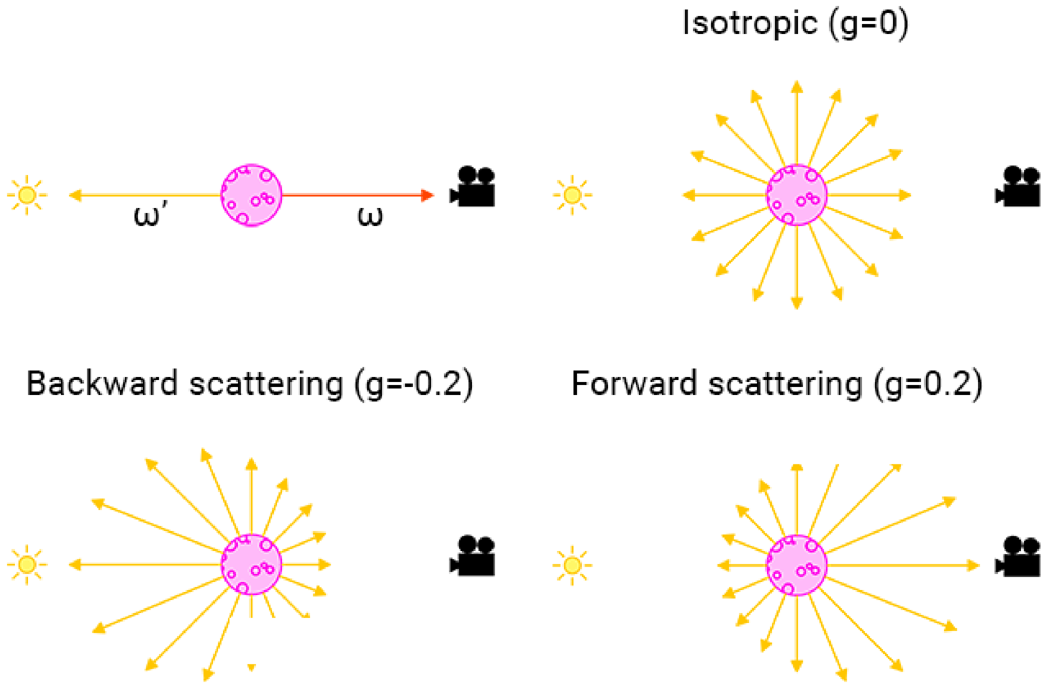


Sources : Real-Time Underwater Spectral Rendering, February 2024, Nestor Monzon; https://www.scratchapixel.com

Radiative Transfer Equation (RTE) in Water

- Differential Equation describing the amount of Radiance Gained.
- $\frac{dL(x_z,\omega)}{dz} = \frac{dL_{extinction}(x,\omega)}{dz} + \frac{dL_{in-scattering}(x,\omega)}{dz}$
- $\frac{dL(x_z,\omega)}{dz} = -\delta_t L(x_z,\omega) + \int_{\Omega} L(x,\omega_i) f_s(x,\omega_i,\omega) d\omega_i$

For a ray traveling in direction outgoing $\boldsymbol{\omega}$ from position $\boldsymbol{x}$.



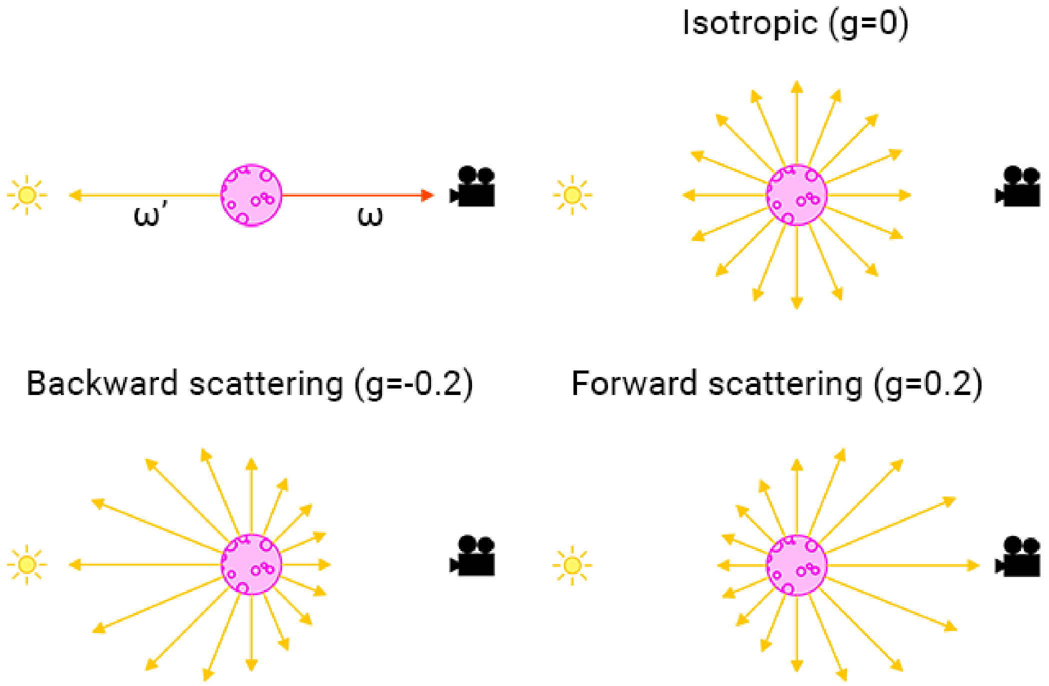
Sources : Real-Time Underwater Spectral Rendering, February 2024, Nestor Monzon; https://www.scratchapixel.com

RTE in Participation Medium

- General RTE:

$$\frac{dL(x_z,\omega)}{dz} = -\delta_t L(x_z,\omega) + \int_{\Omega} L(x,\omega_i) f_s(x,\omega_i,\omega) d\omega_i + \delta_a L_e(x,\omega)$$

- Where: $\delta_a L_e(x,\omega)$ – Lighted emitted by the Participation Medium.
- For Non-Emissive Media (such as water) this term is equals 0.
- Emissive Media: Fire, Flames, Plasma etc.



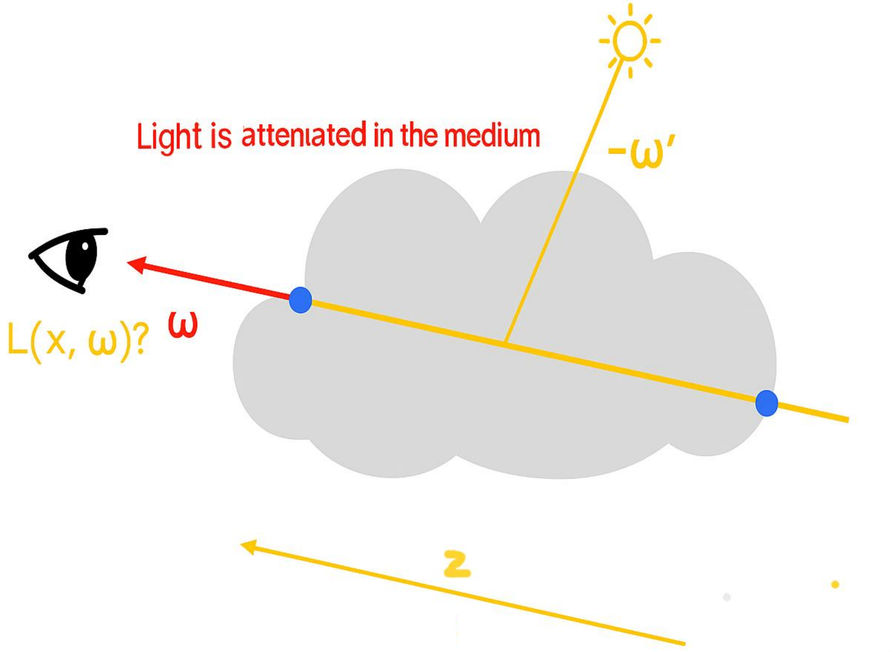
Sources : Real-Time Underwater Spectral Rendering, February 2024, Nestor Monzon; *Fong, Julian, et al. "Production volume rendering: Siggraph 2017 course." ACM SIGGRAPH 2017 Courses. 2017. 1-79.*; https://www.scratchapixel.com

Volumetric Rendering Equation (VRE)

- RTE in water:

$$\frac{dL(x_z, \omega)}{dz} = -\delta_t L(x_z, \omega) + \int_{\Omega} L(x, \omega_i) f_s(x, \omega_i, \omega) d\omega_i$$

- Integrate over traveling distance Z.



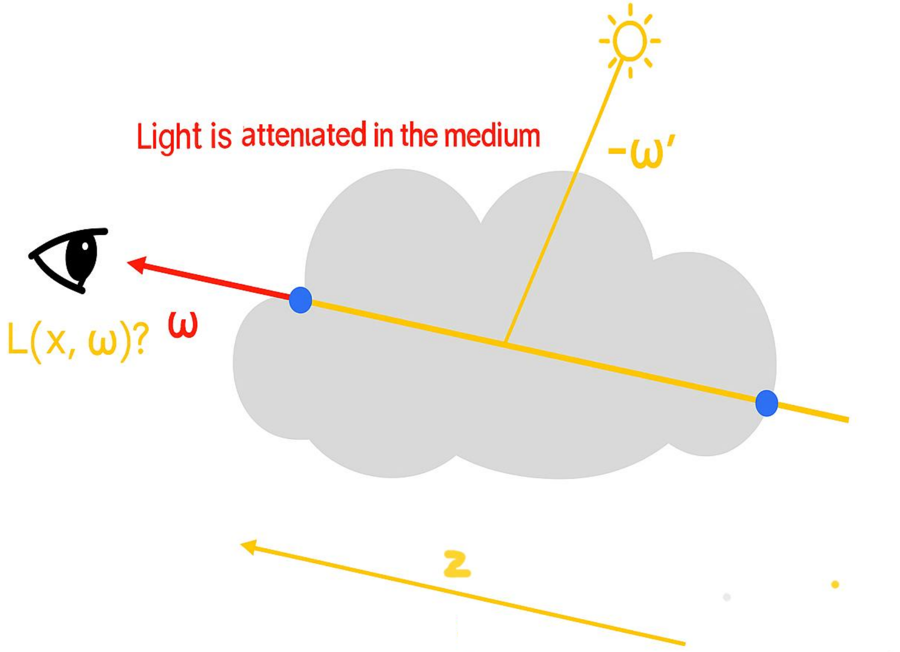
Sources : Real-Time Underwater Spectral Rendering, February 2024, Nestor Monzon; *AI Generated*.

Volumetric Rendering Equation (VRE)

- VRE in water:

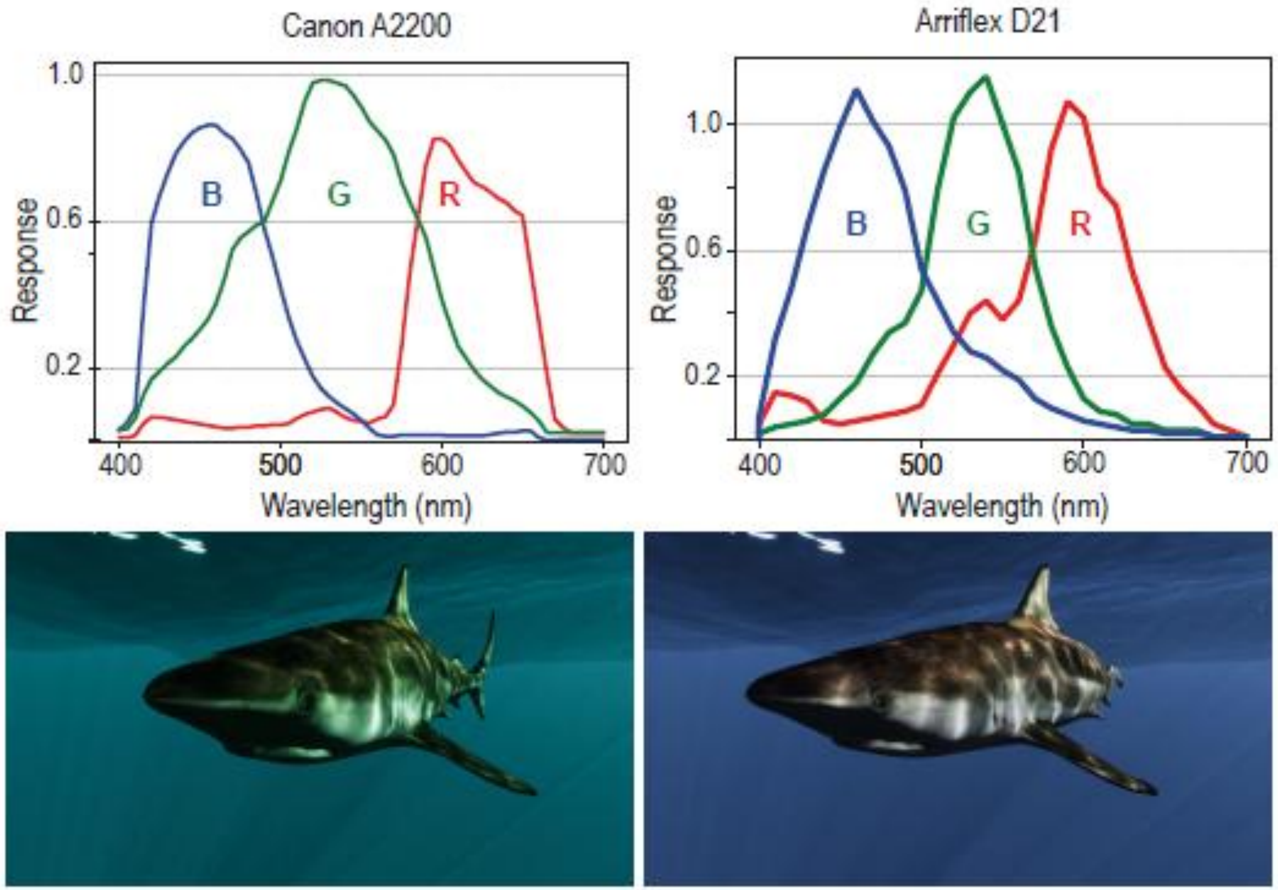
$$L(x_Z, \omega) = T(x_Z) L_s(x, \omega) + \int_{z=0}^{Z} T(x_z) L_i(x_z, \omega) dz$$

- Where, $L_i = \int_{\Omega} L(x, \omega_i) f_s(x, \omega_i, \omega) d\omega_i$;
- L_s - at the surface (or exit) point x_Z.
- $T(x_Z) = e^{-\sigma_t Z}$ - Transmittance of water over distance Z



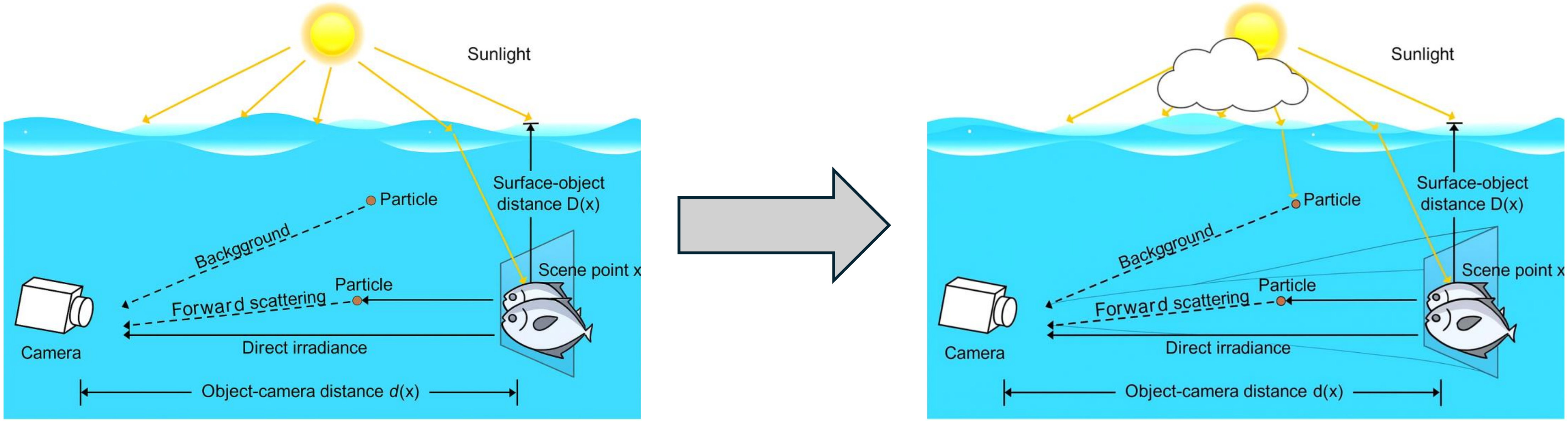
Sources : Real-Time Underwater Spectral Rendering, February 2024, Nestor Monzon; AI Generated

Proposal: Different Camera Sensors



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

Proposal: Non-Homogeneous Surface Light



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

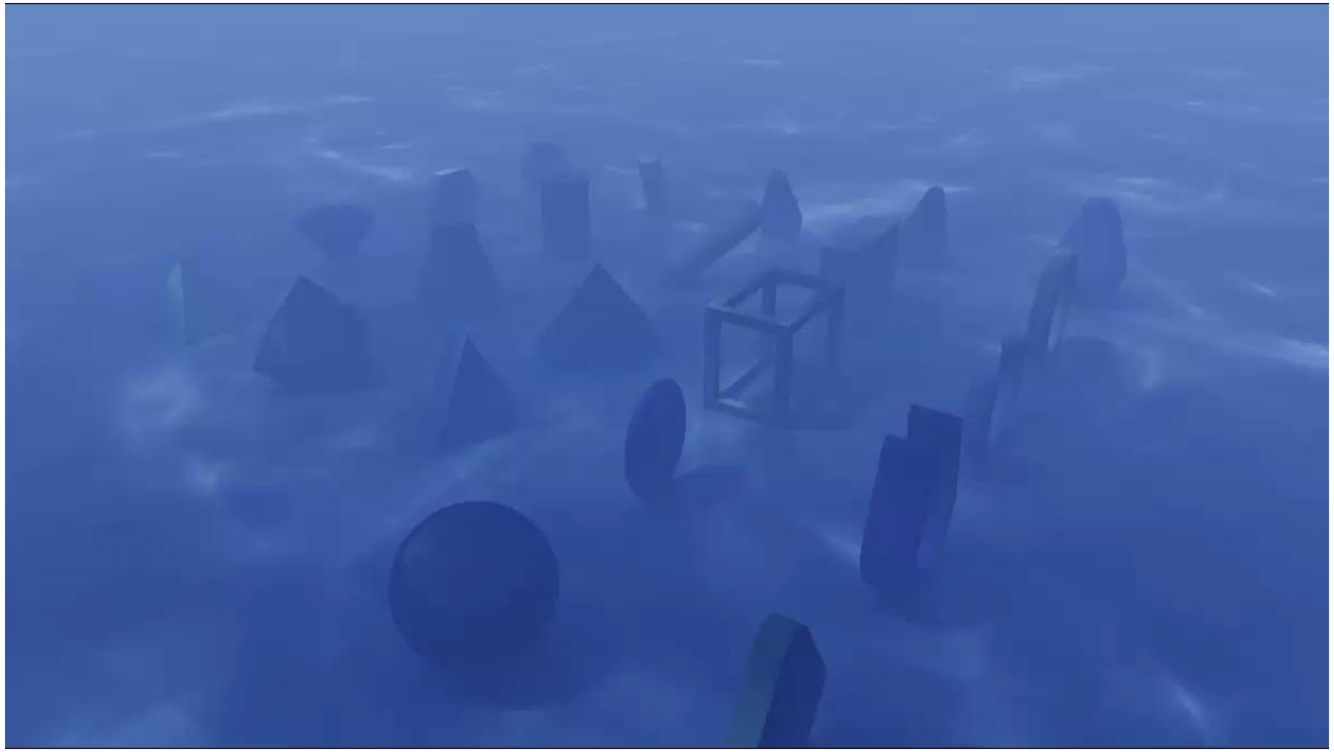
Current project state

Our paper had demo code we used to get started with

We are able to run the simple demo code and played with the settings to get some different results

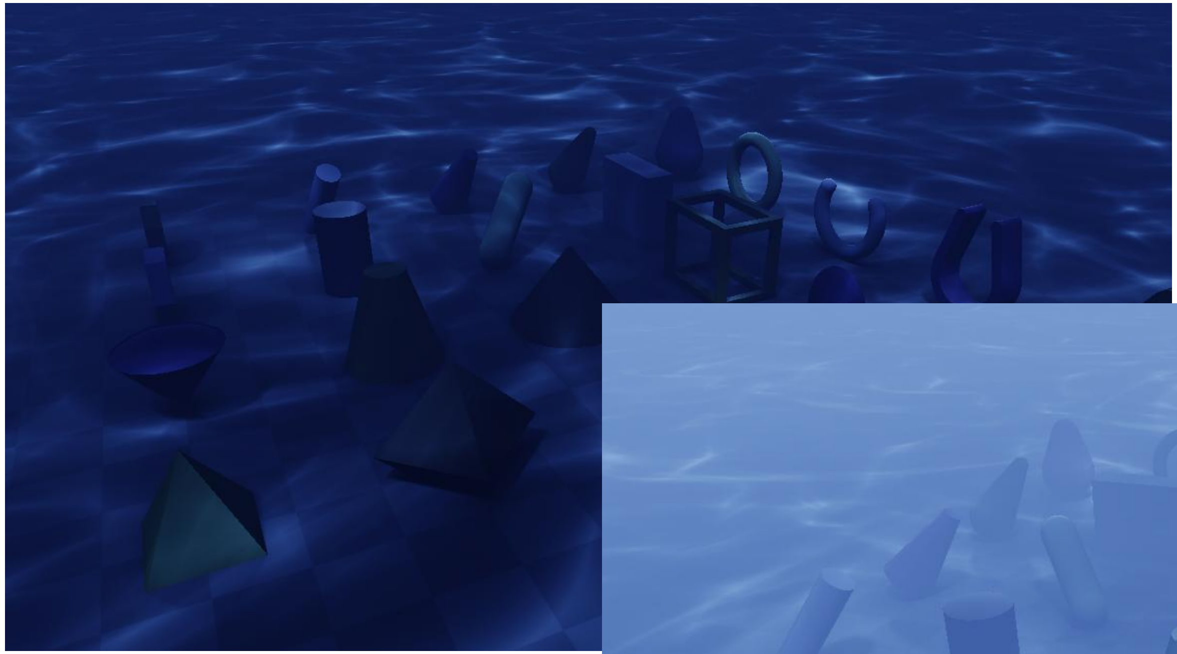
We started re-implementing the light equations of the paper to add our improvements we talked about

Current project state



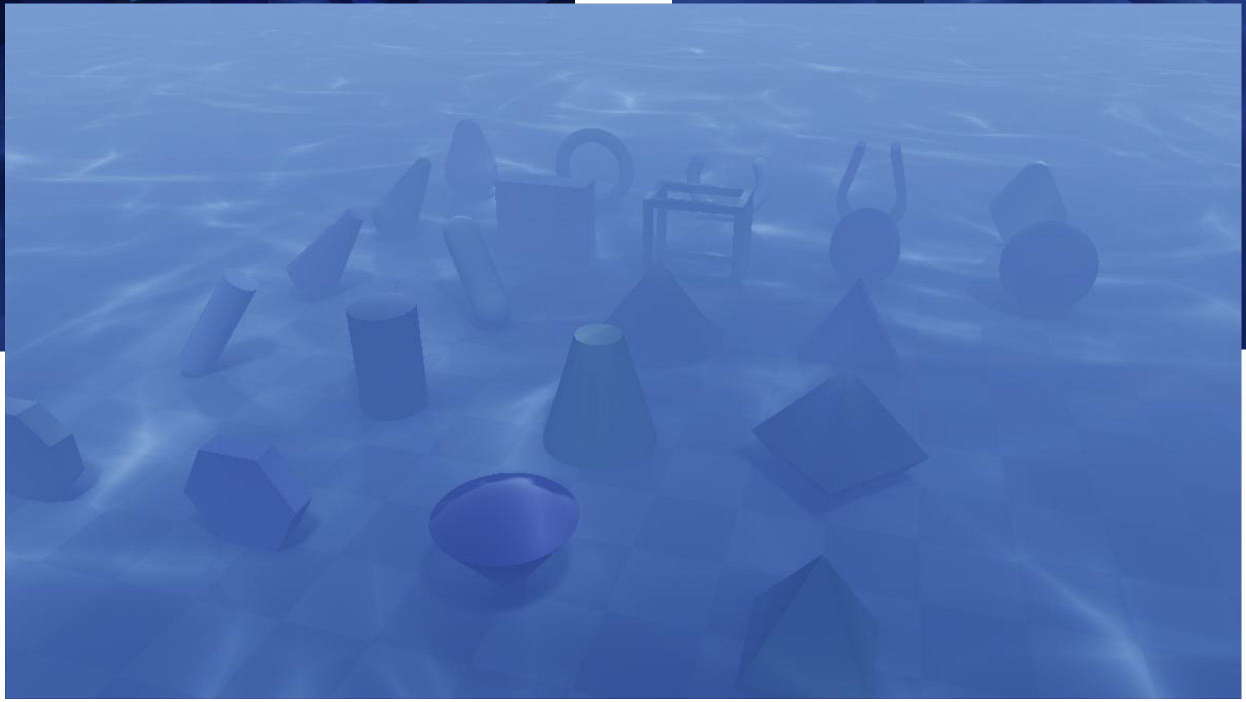
Demo code of our paper

Current project state



40m

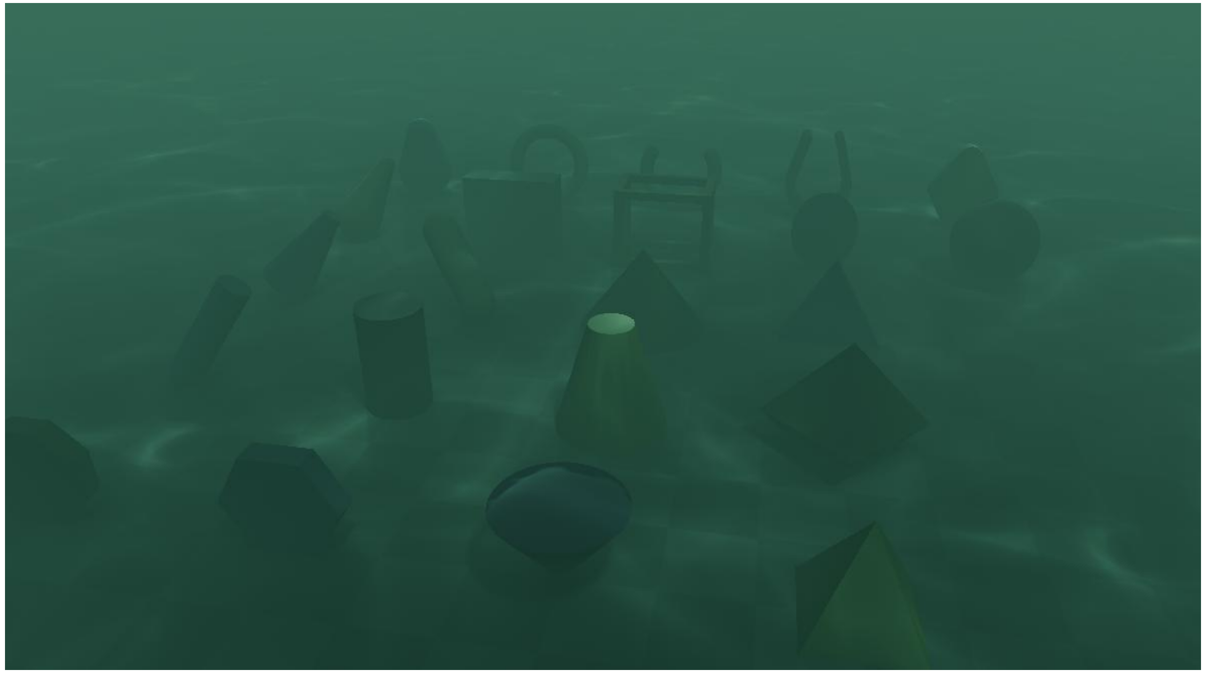
30m



15m

Current project state

Different water types



Team work

Split the work evenly to both team member :

- Half the slides and presentation per team member
- Each read multiple related papers to gather ideas and related work

Daniel will focus more on the implementation of **non-homogeneous surface light**

Valentin will work on the implementation of **multiple camera sensors**

Thank you

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