Lab #4 – Path tracing (part 1)

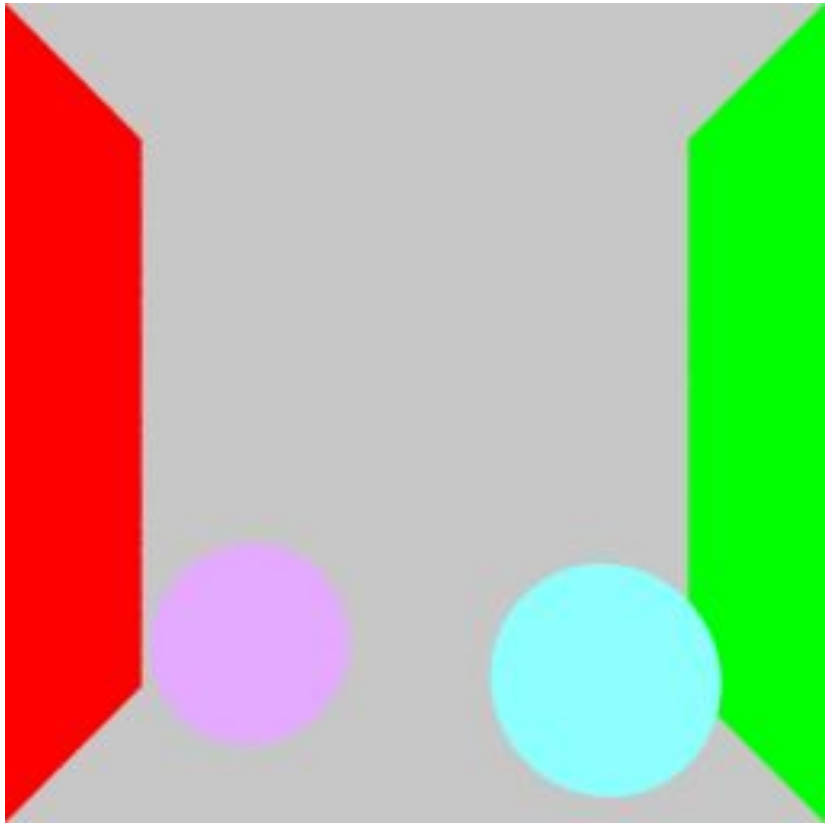
Informática Gráfica

Adolfo Muñoz - Julio Marco
Pablo Luesia - J. Daniel Subías – Óscar Pueyo

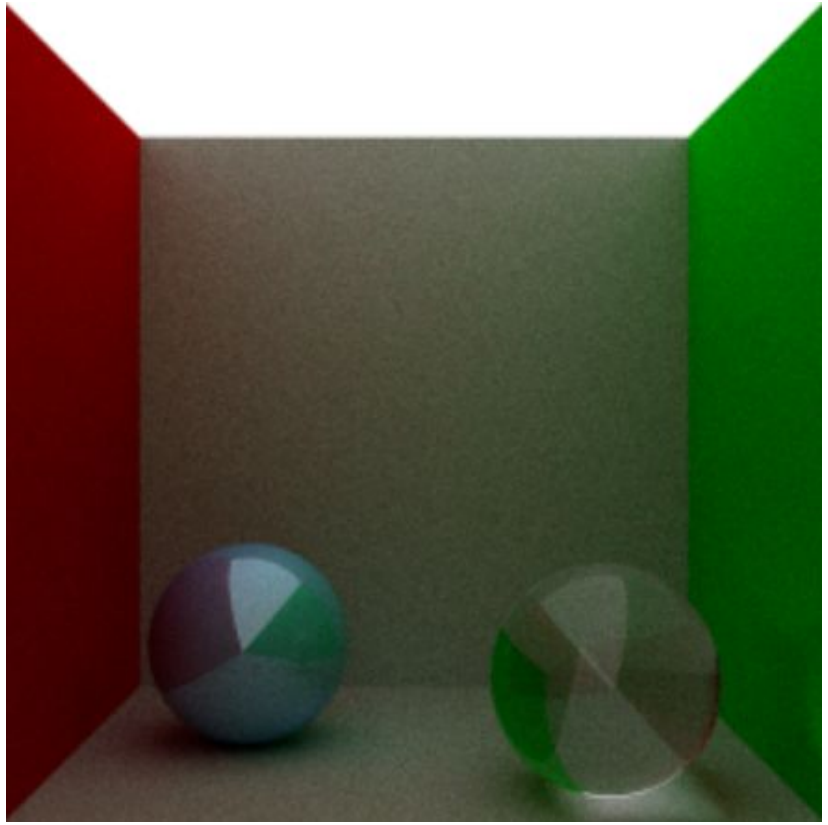
Before we begin…

Graphics and Imaging Lab

- Begin extending ray tracing to the full path tracing algorithm



Lab 3 (ray tracing)



Lab 4 (path tracing)

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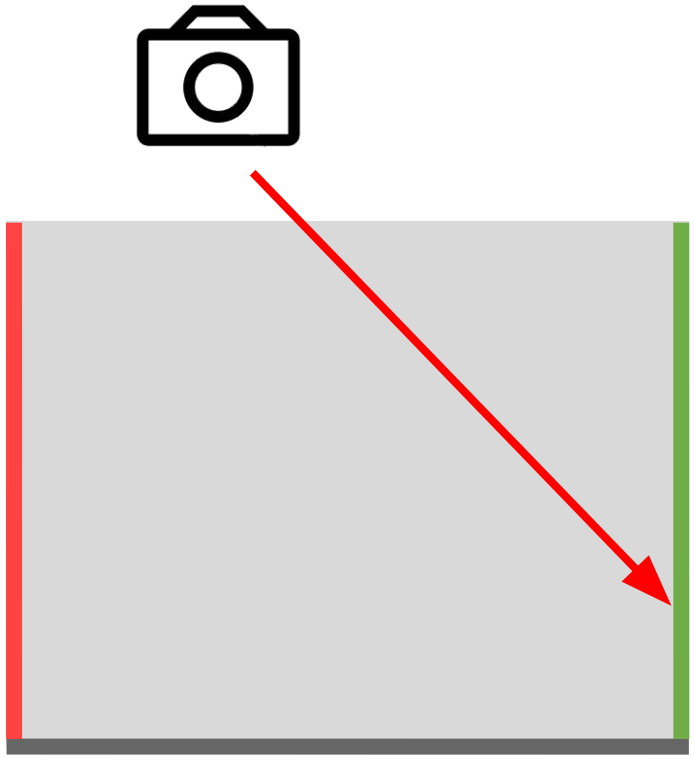

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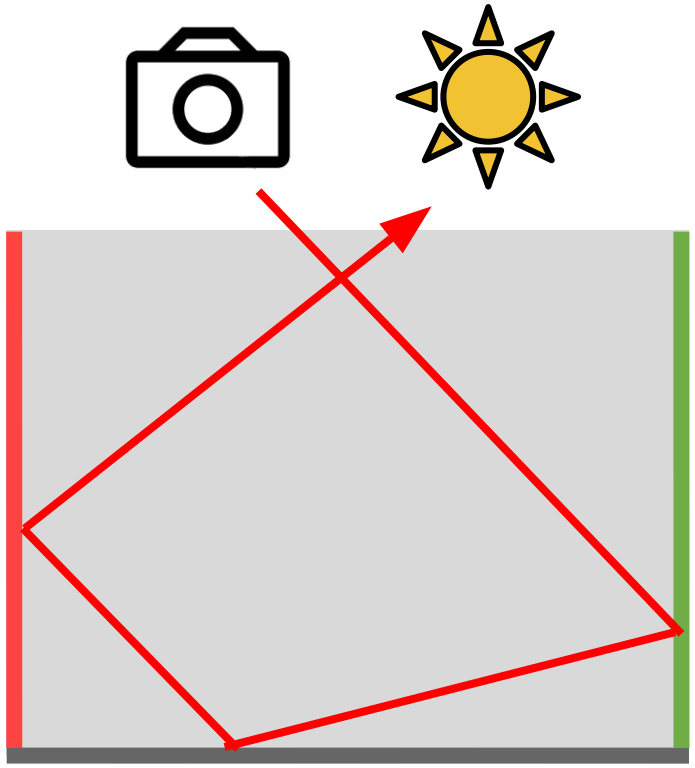

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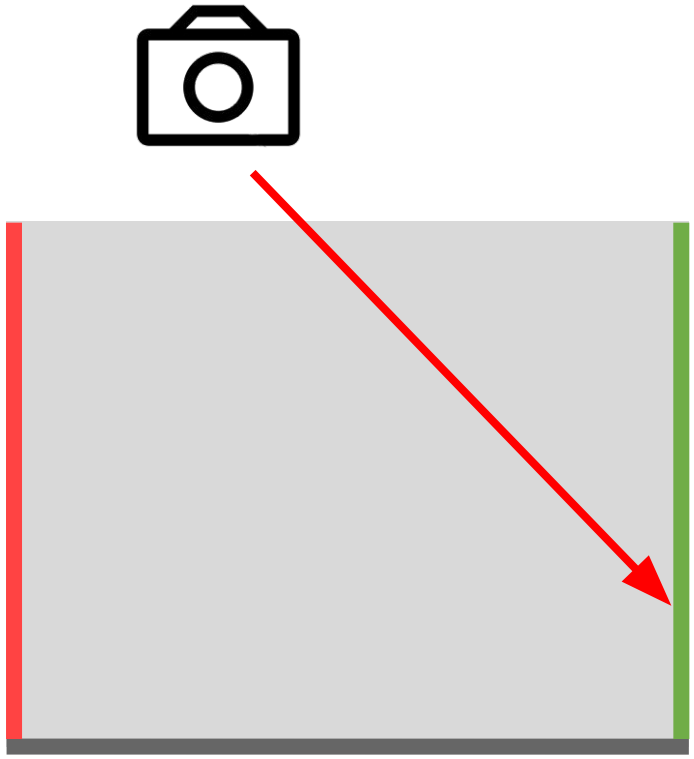

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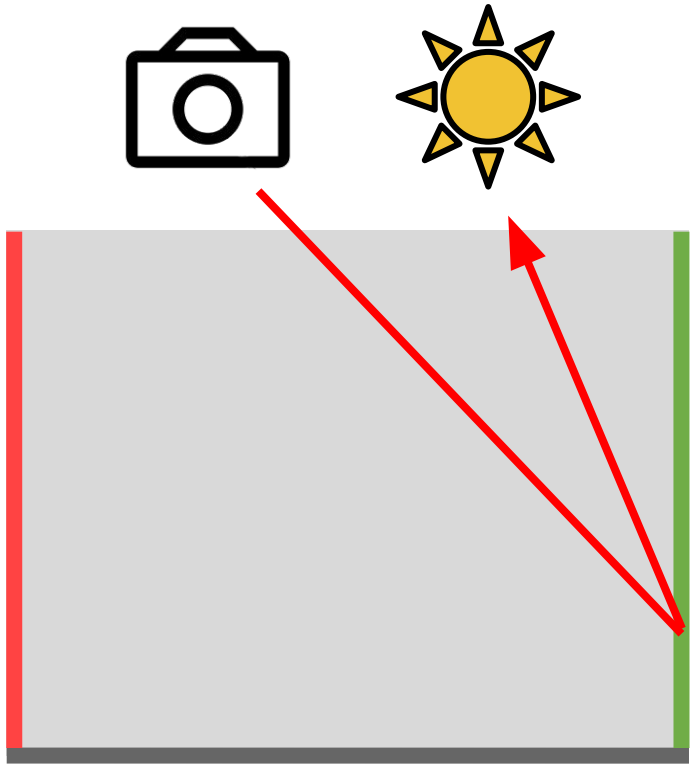


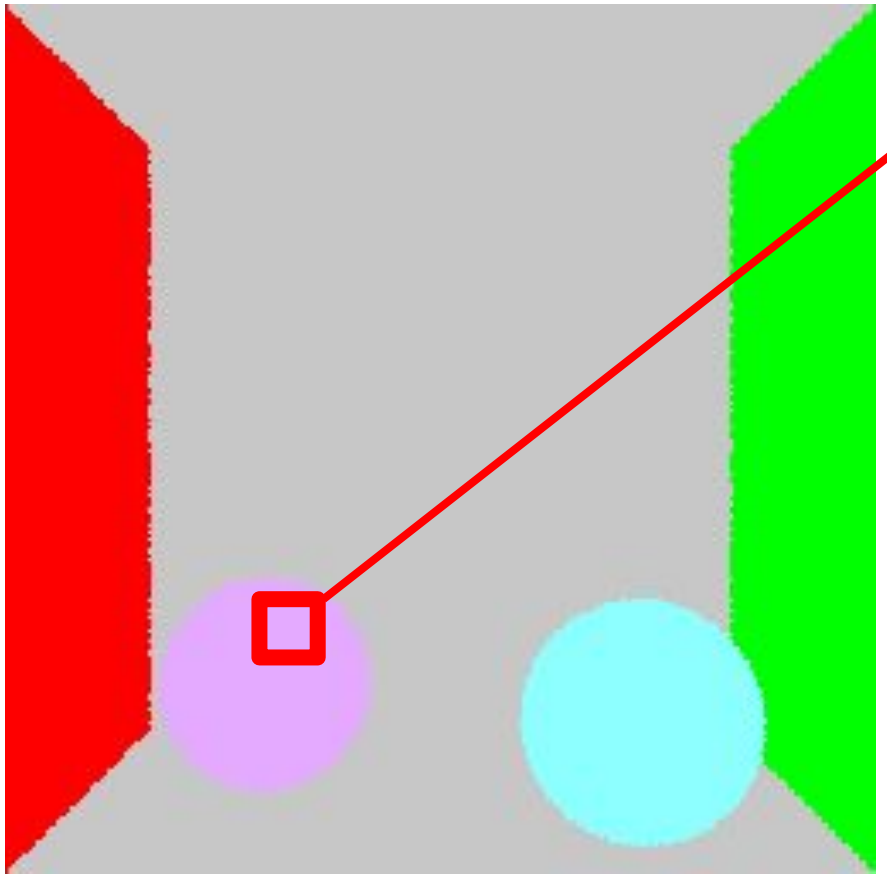
This session

Before we begin…

Graphics and Imaging Lab

- Begin extending ray tracing to the full path tracing algorithm
- Lab 4 (path tracing) **is the first submitted work**
  - You will have 3 sessions before the recommended deadline
    - Recommended deadline: November 13th
    - Moodle: January 11th
  - You will use most of today's code for Lab 5 (photon mapping) too
- Remember: Final work is 80% of the final grade

Previously: everything is an area light



$$L_o(\mathbf{x}, \omega_\mathbf{o}) = L_e(\mathbf{x}, \omega_\mathbf{o}) + \int_\Omega L_i(\mathbf{x}, \omega_\mathbf{i}) f_r(\mathbf{x}, \omega_\mathbf{i}, \omega_\mathbf{o}) |\mathbf{n} \cdot \omega_\mathbf{i}| d\omega_\mathbf{i}$$

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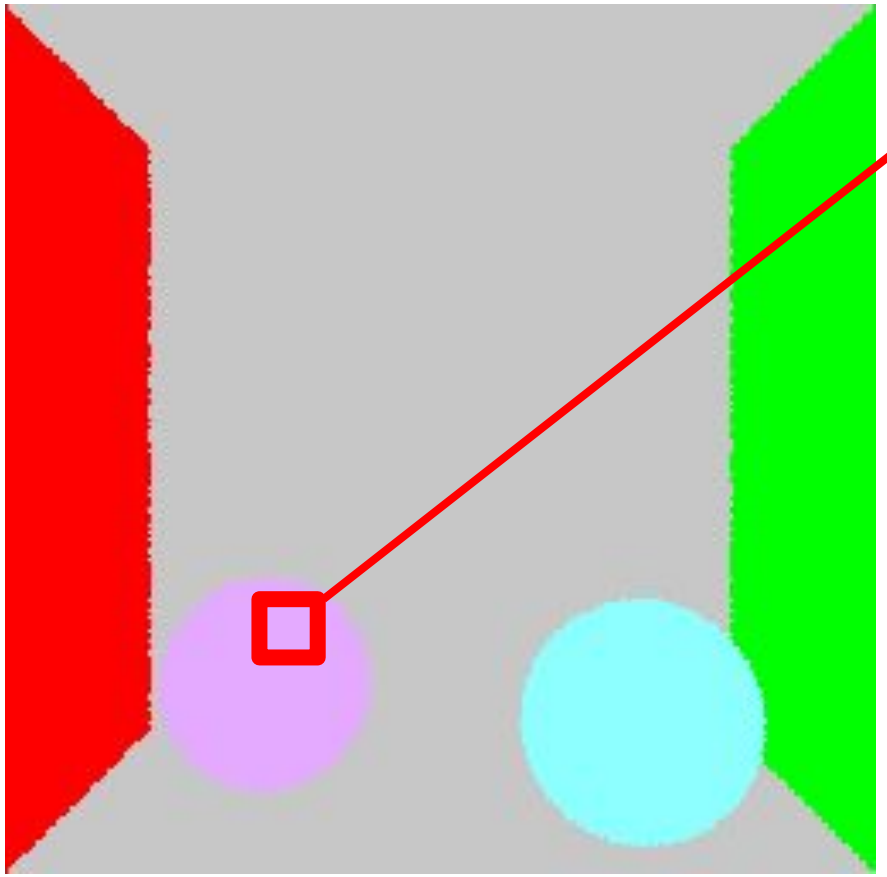

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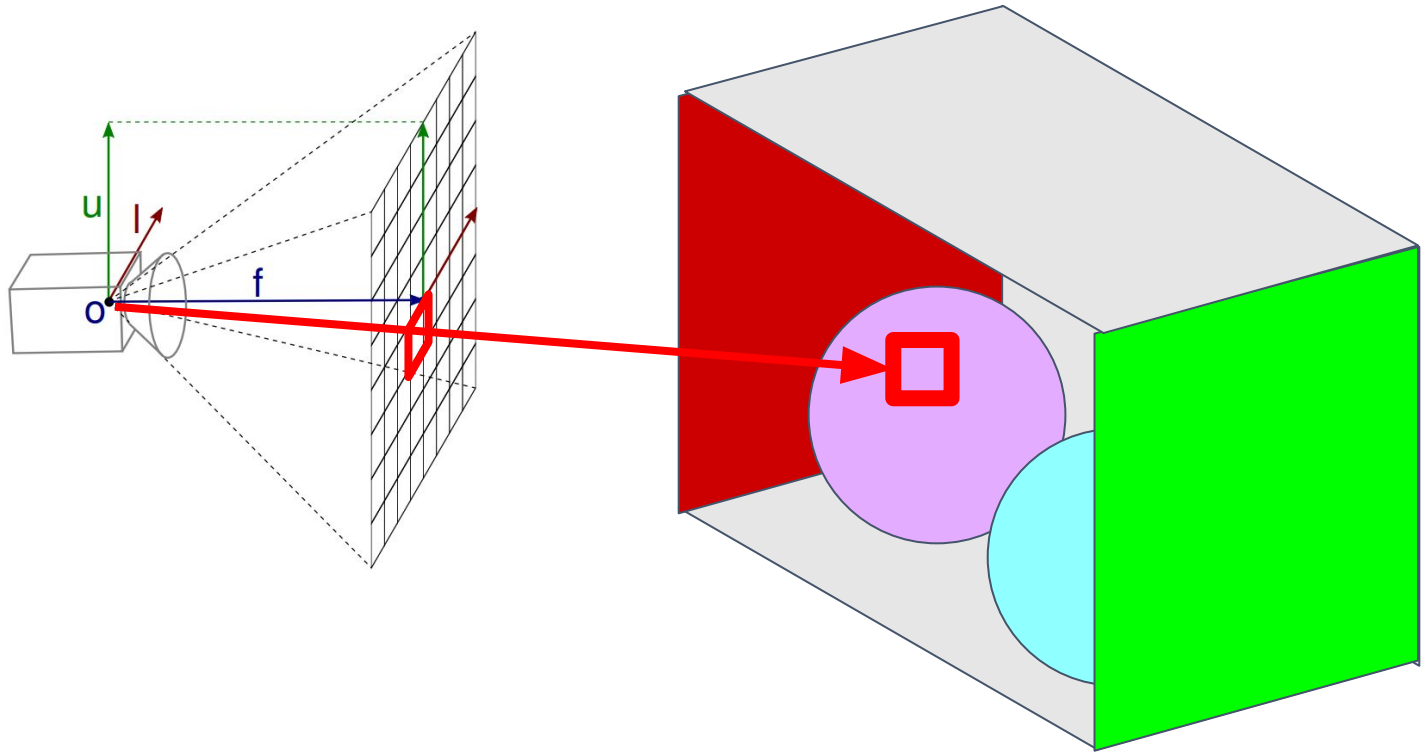
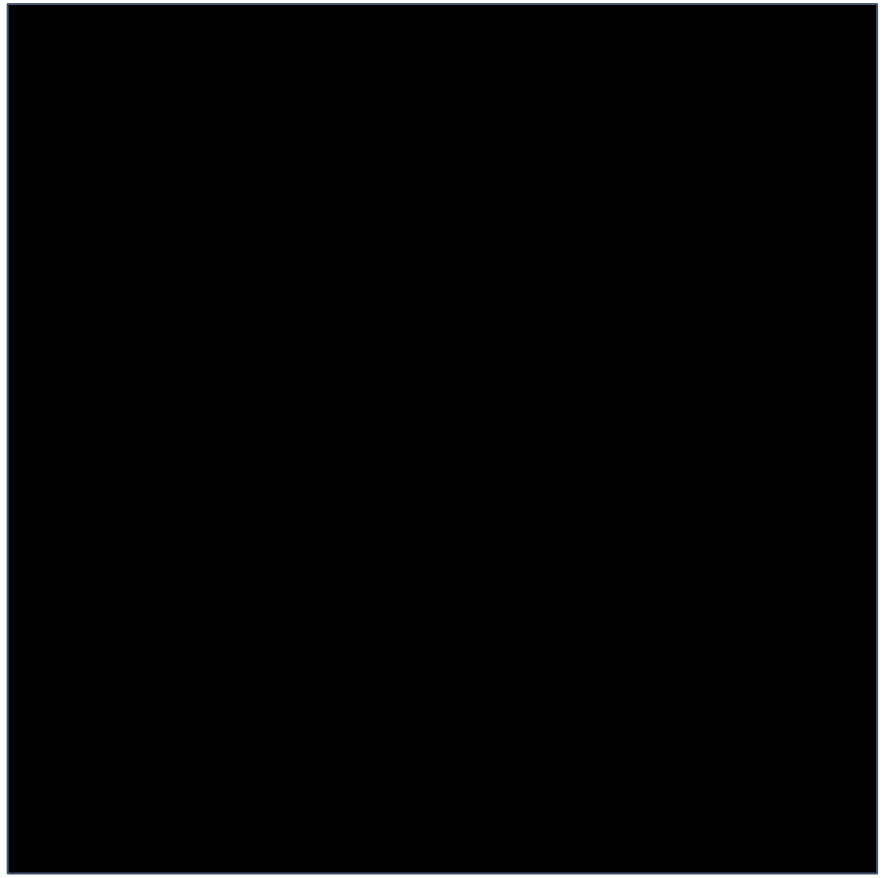


Which color do we fill each pixel with?

Graphics and Imaging Lab



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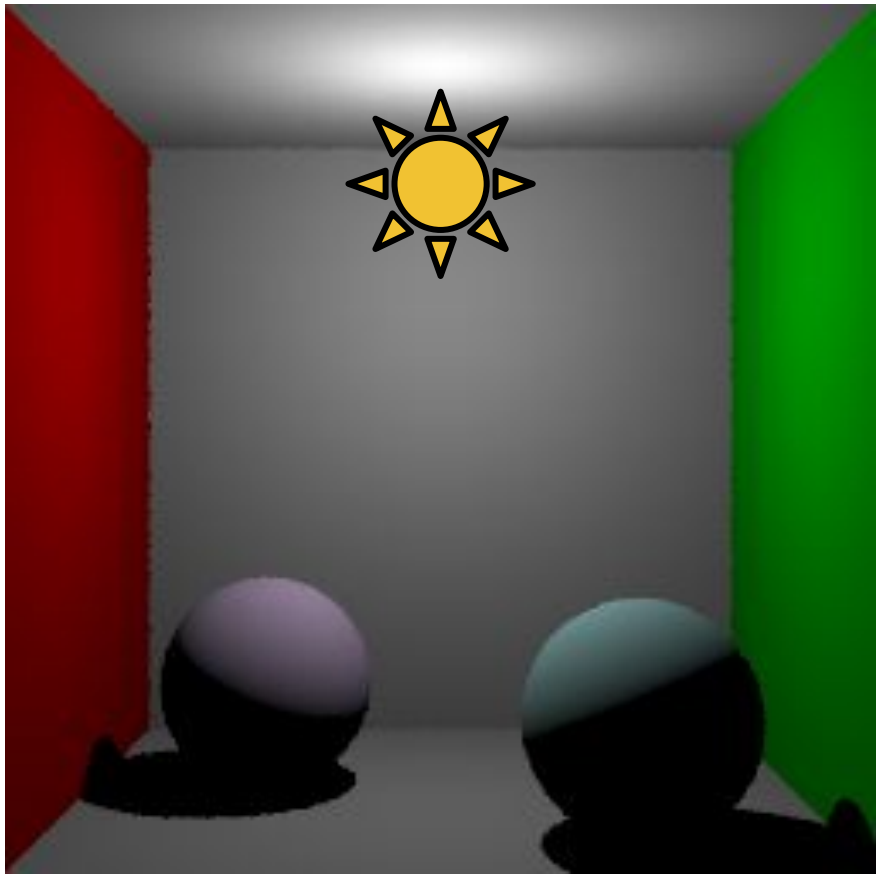

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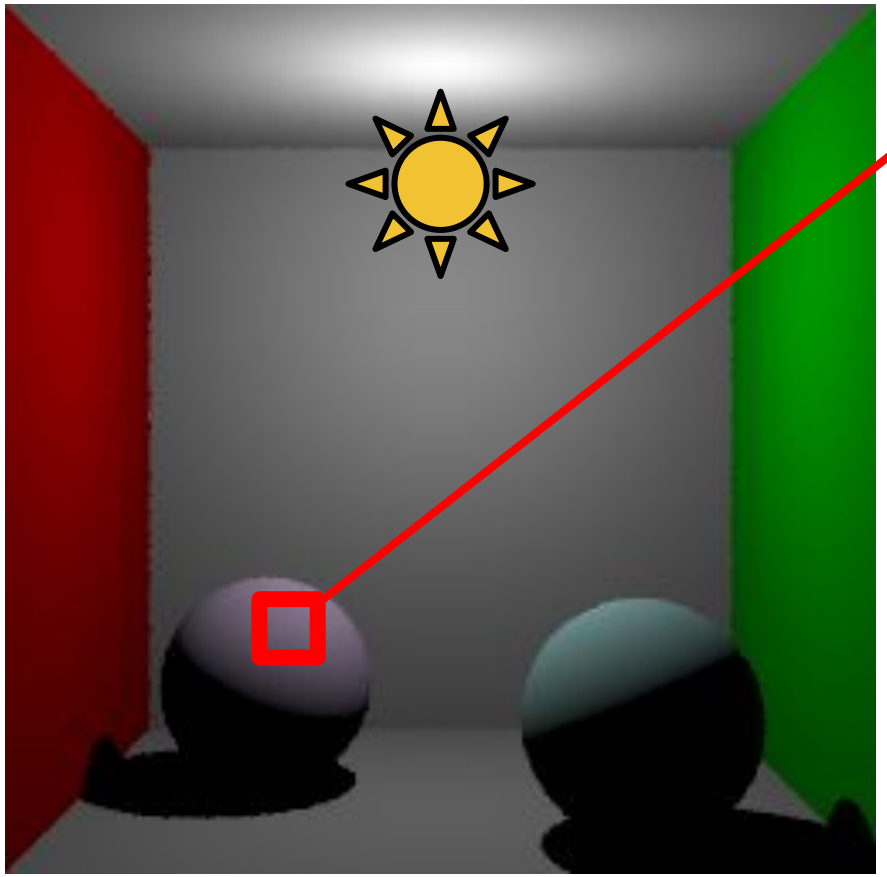

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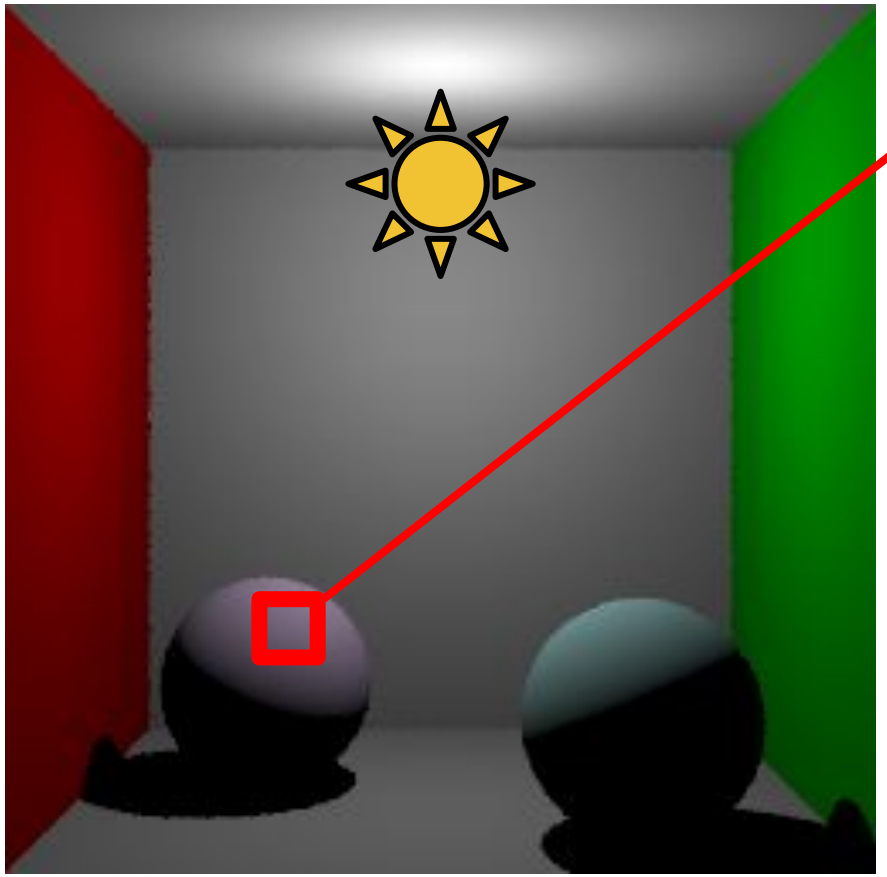

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But just the direct light

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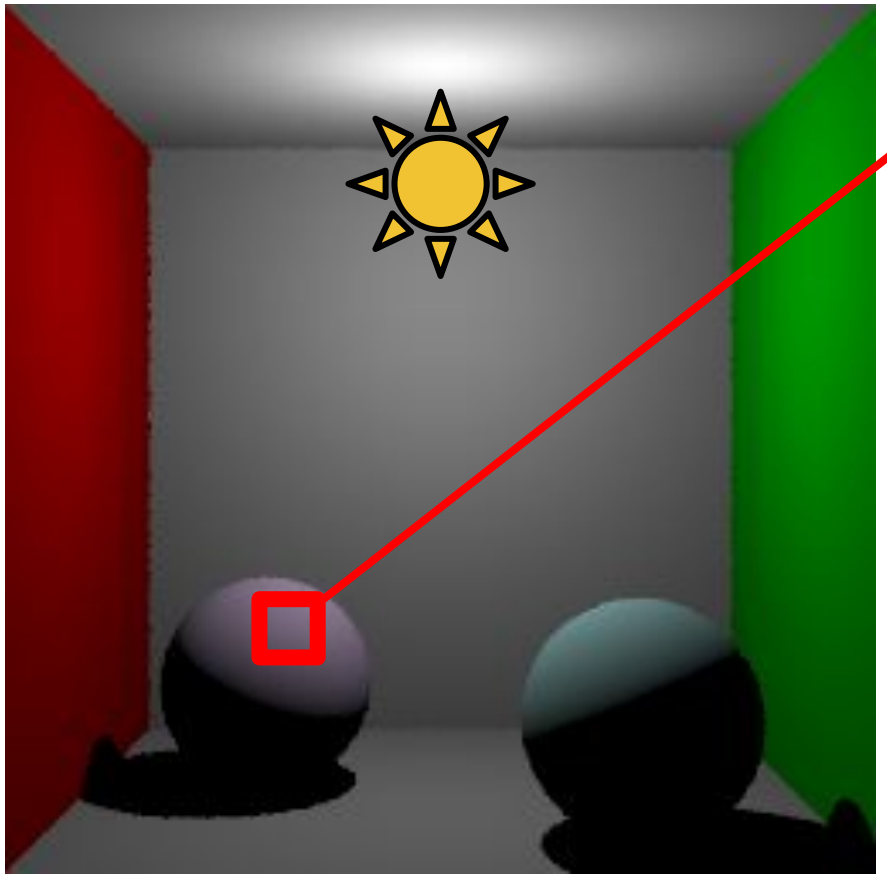

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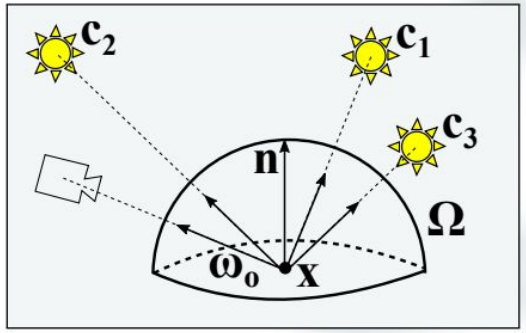

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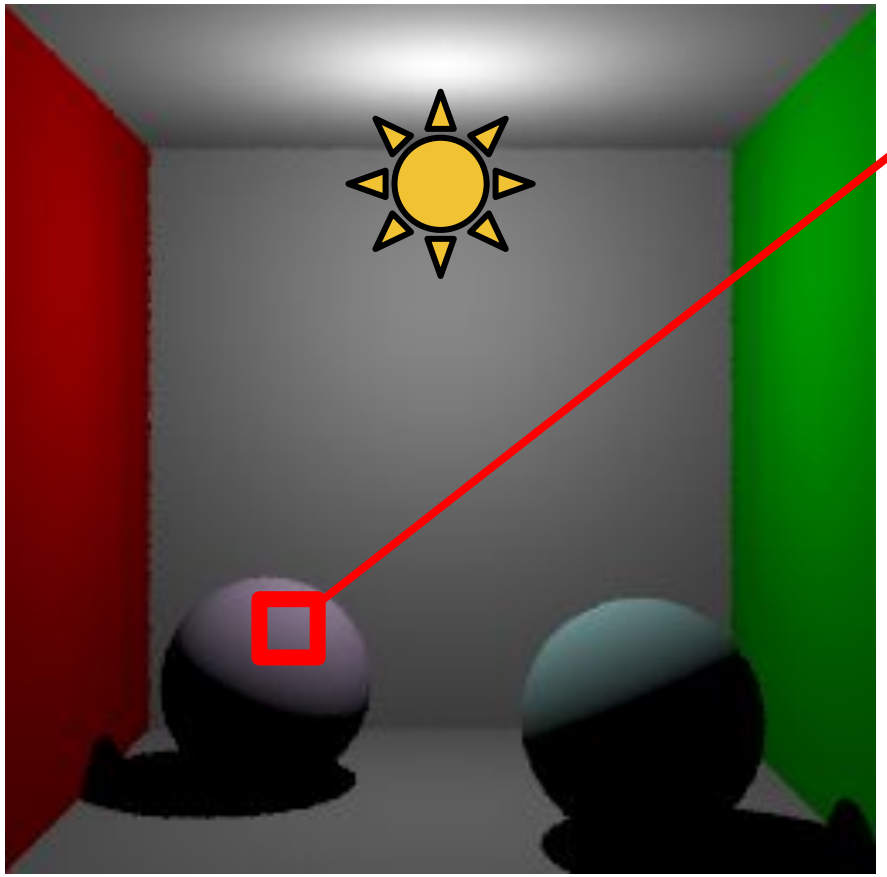
Graphics and Imaging Lab



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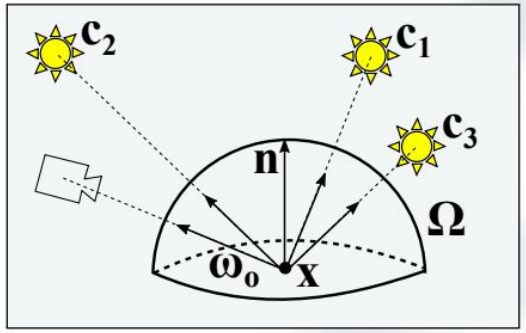

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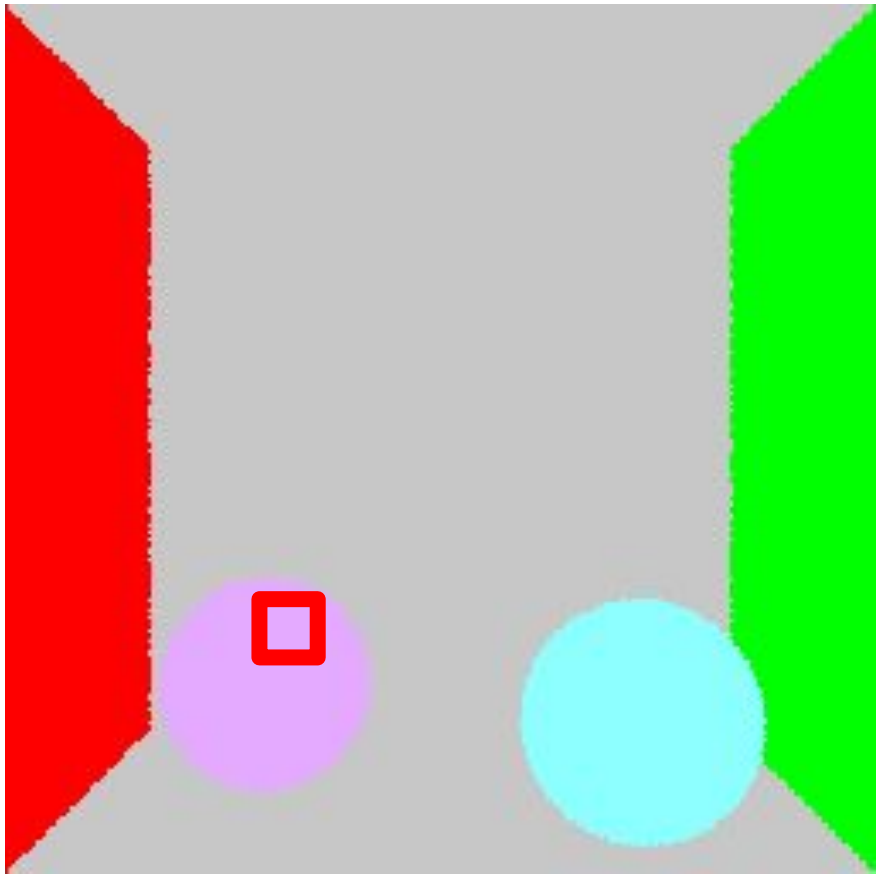
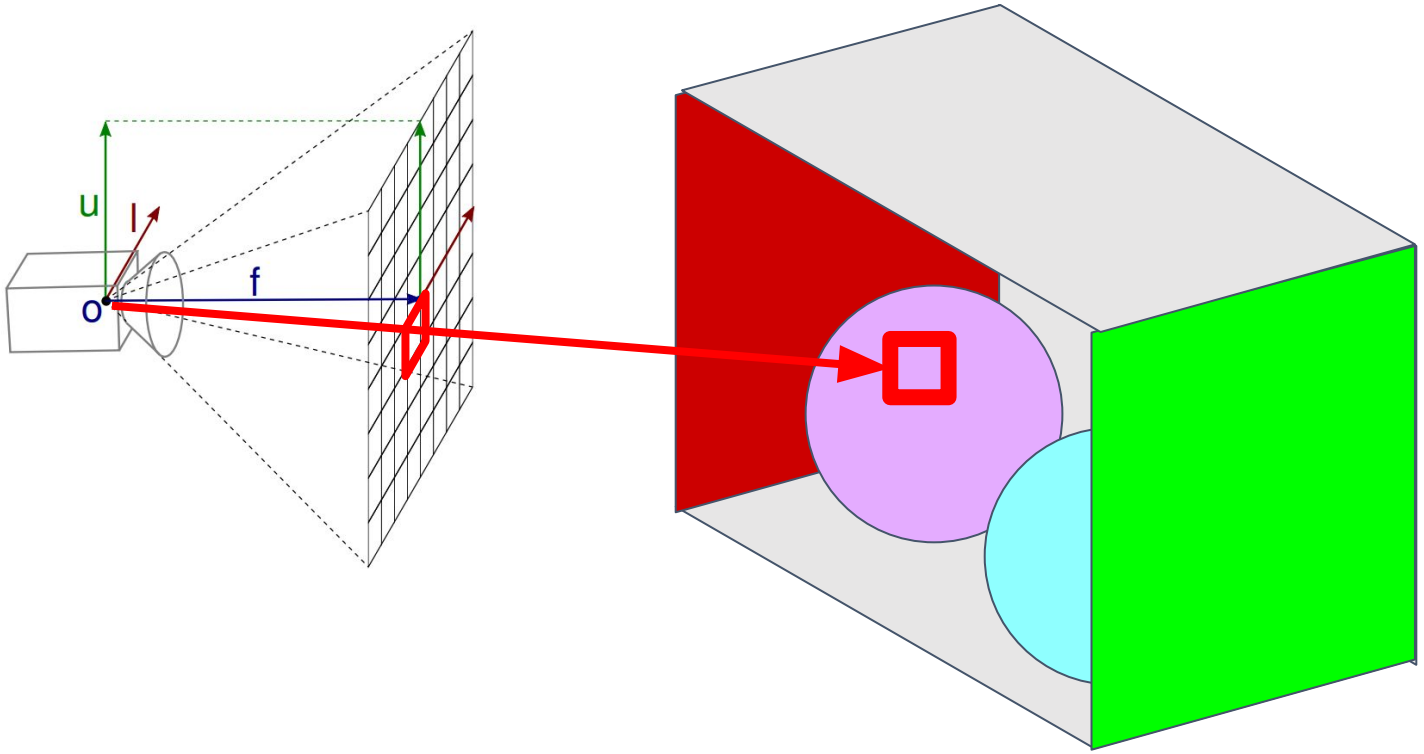
Previously: return emission color





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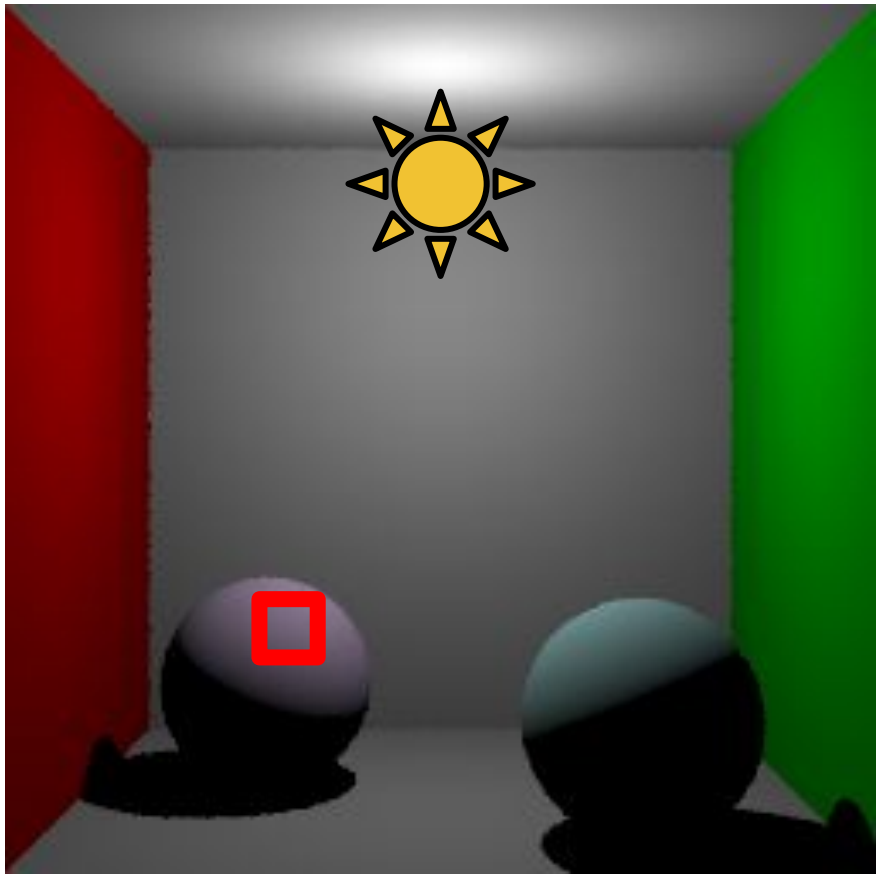
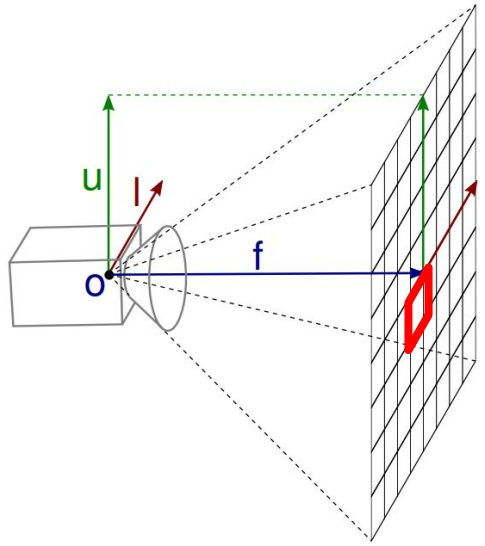
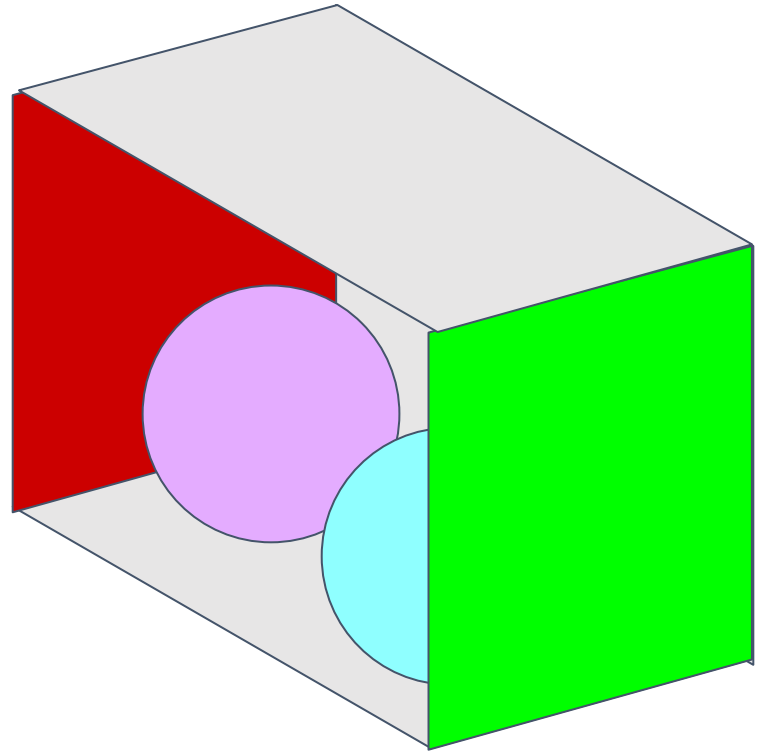
Graphics and Imaging Lab



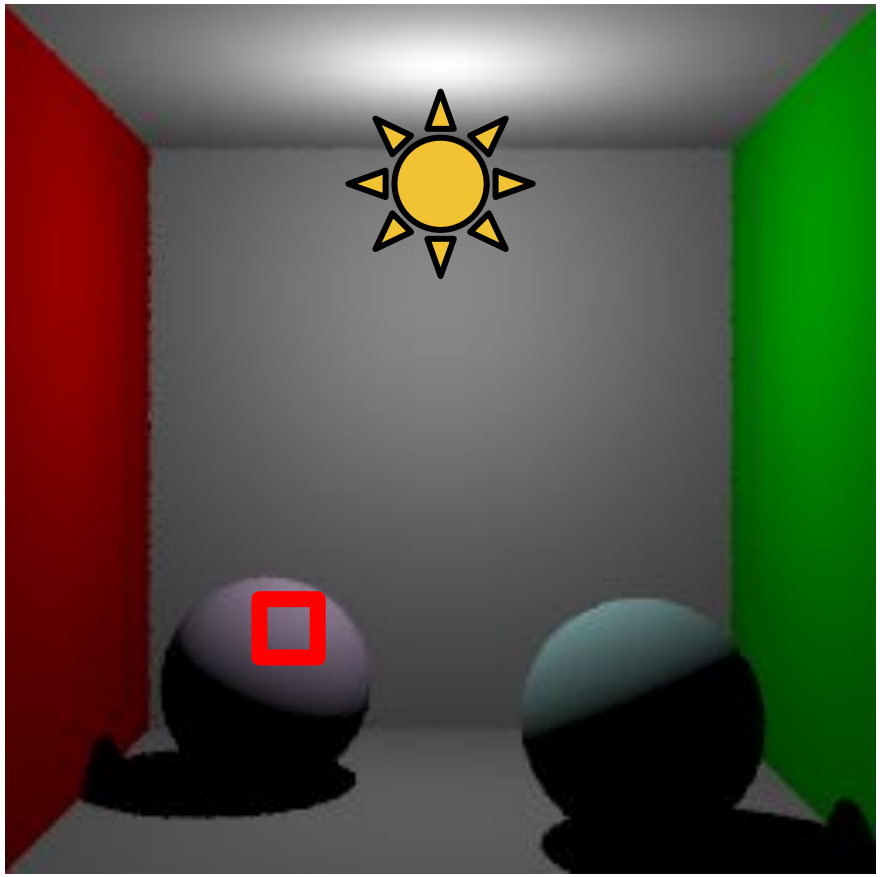


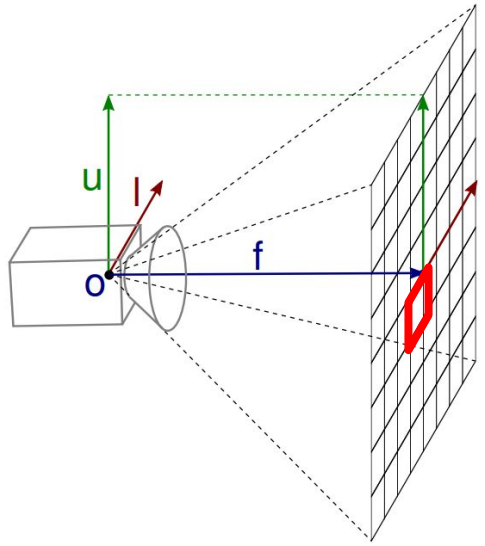


Which color do we fill each pixel with?

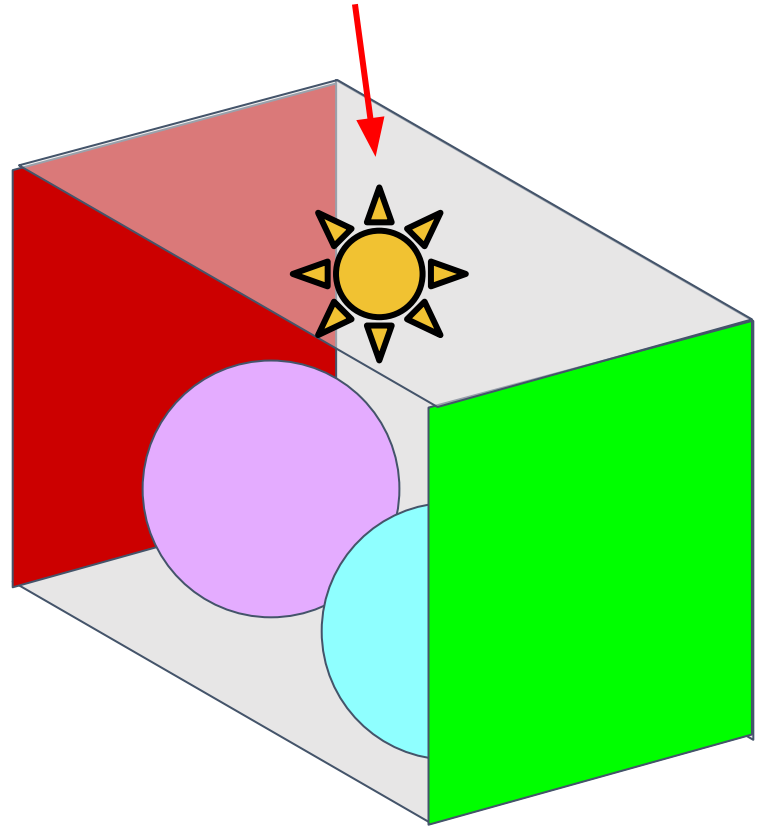
Graphics and Imaging Lab

- Define your scene's point light sources





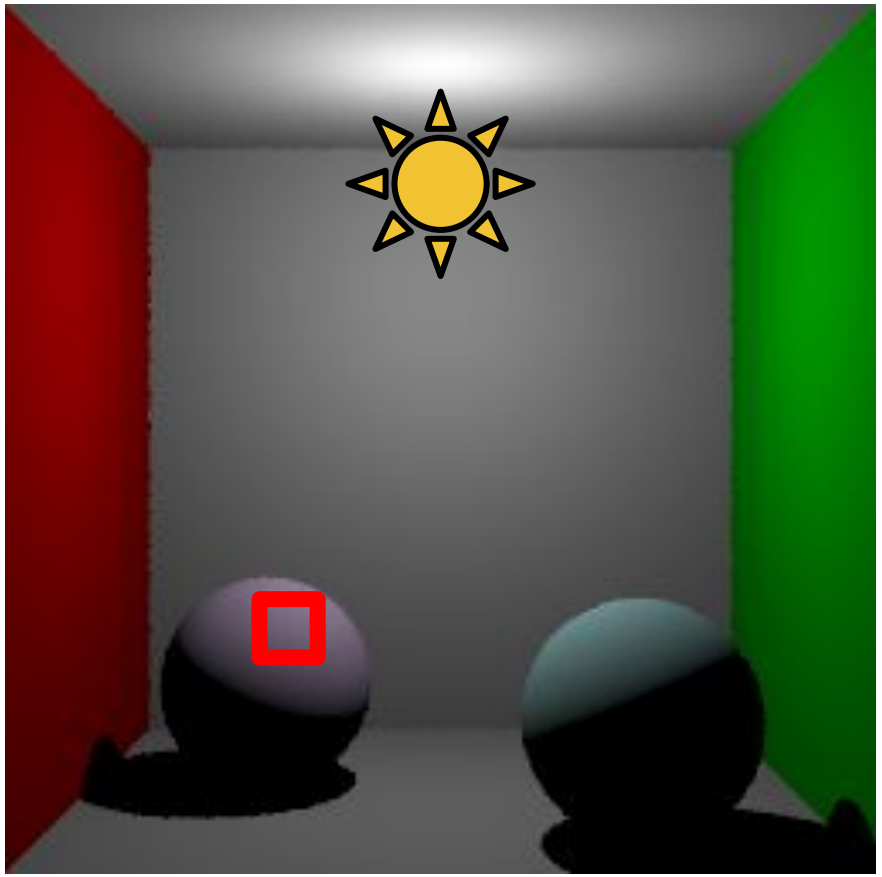
- Center: (x, y, z)
- Power: (r, g, b)

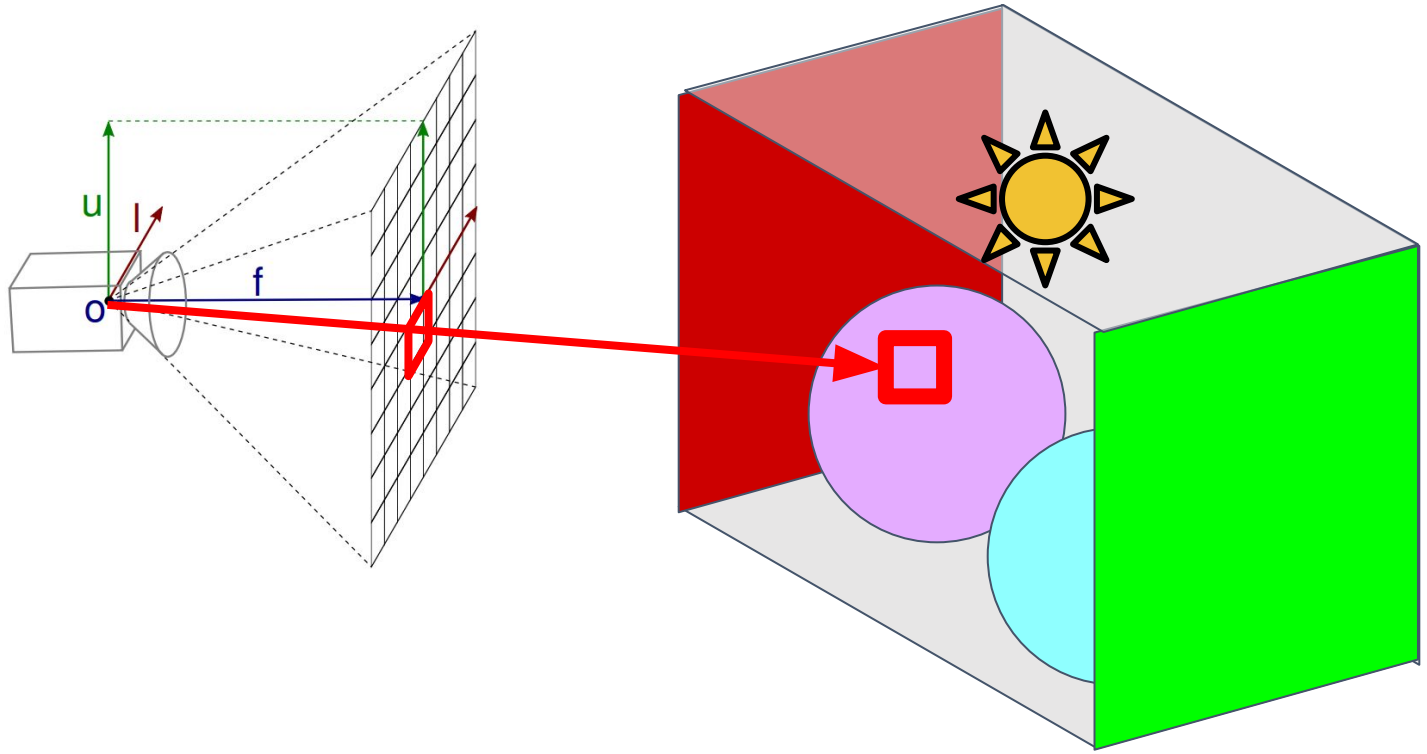


Which color do we fill each pixel with?

Graphics and Imaging Lab

- Generate a ray from the camera and intersect





Which color do we fill each pixel with?

Graphics and Imaging Lab

- Calculate direct light

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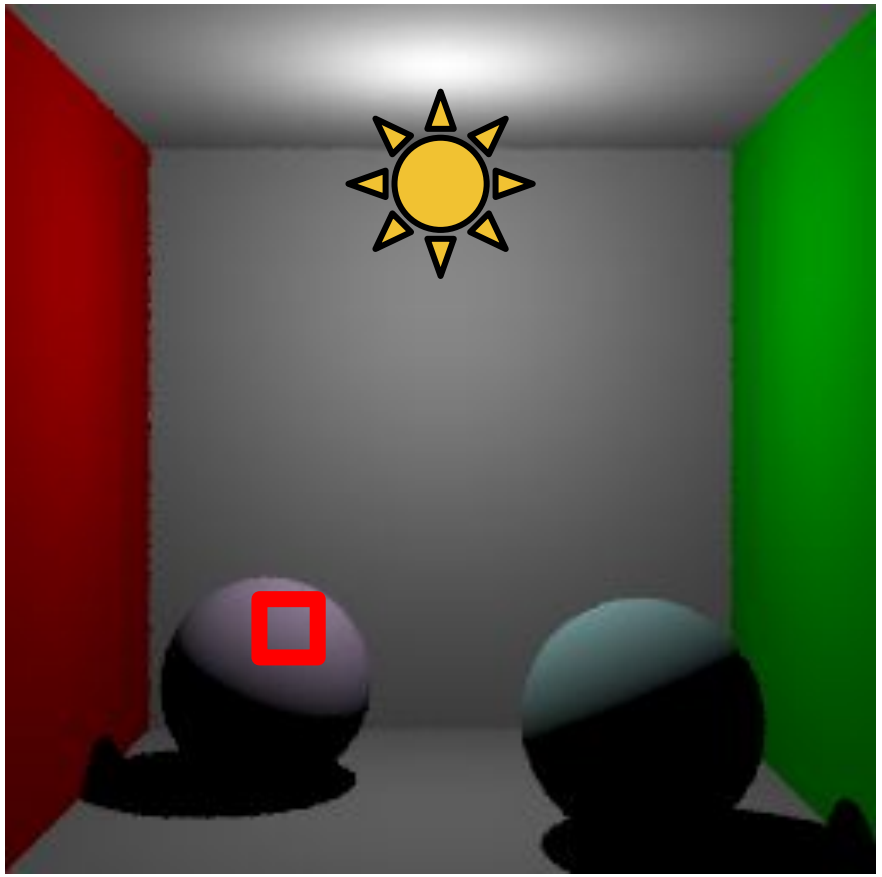

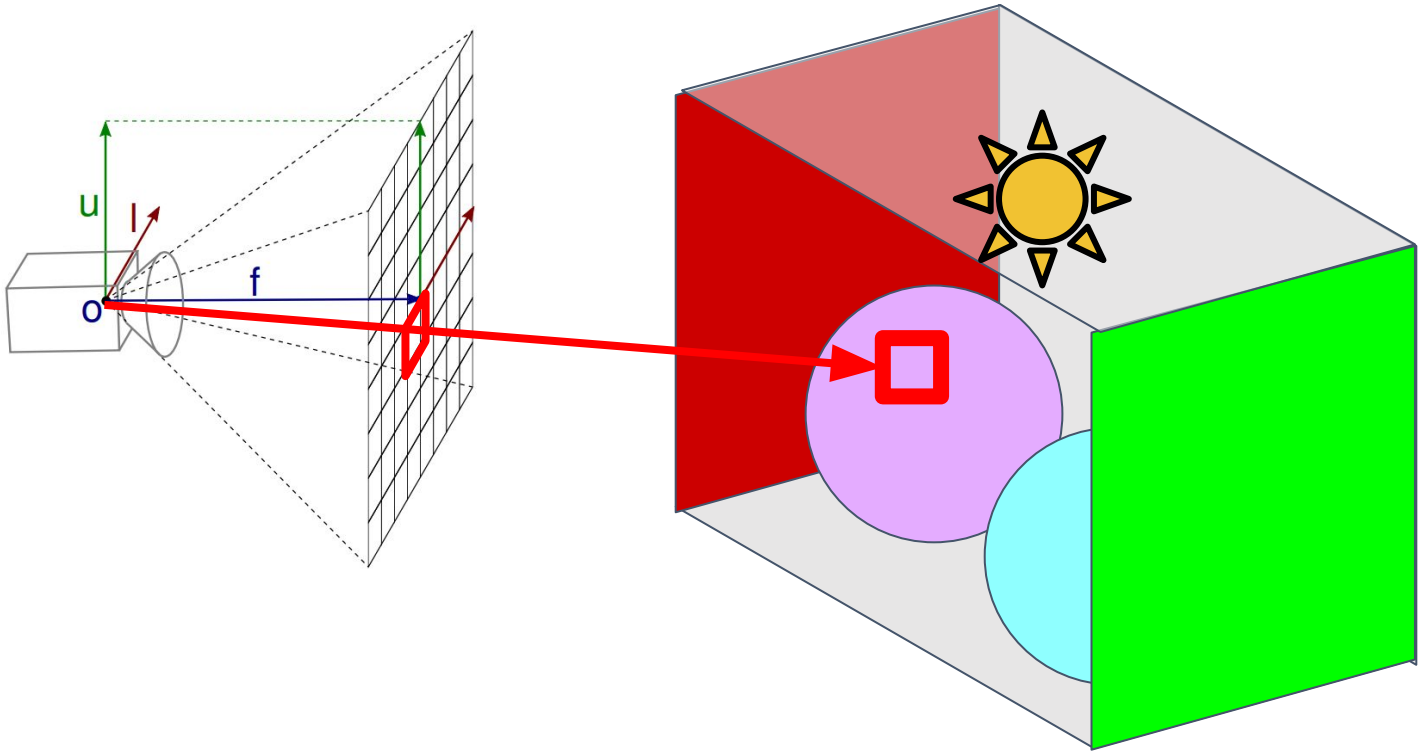

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Graphics and Imaging Lab

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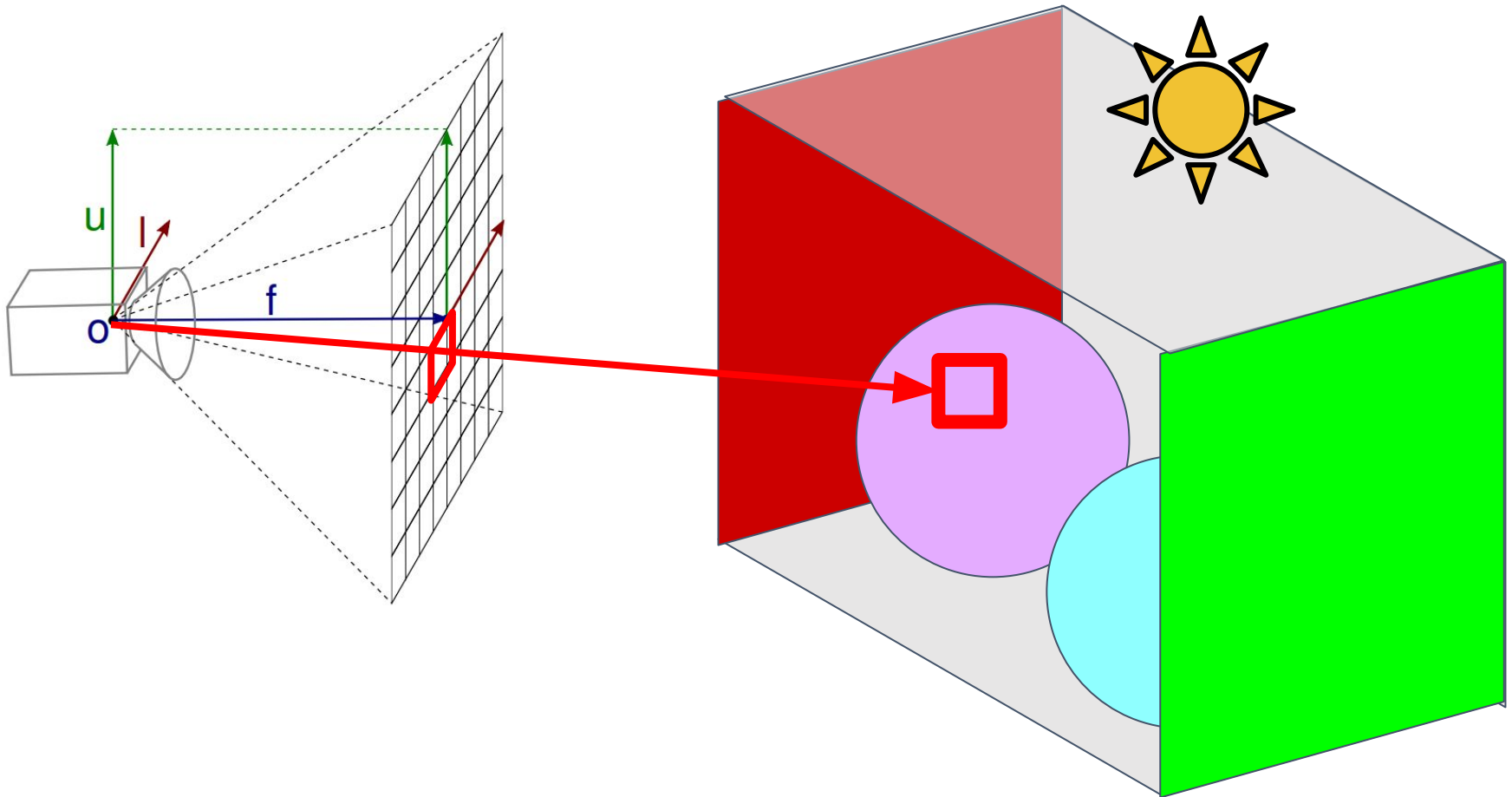

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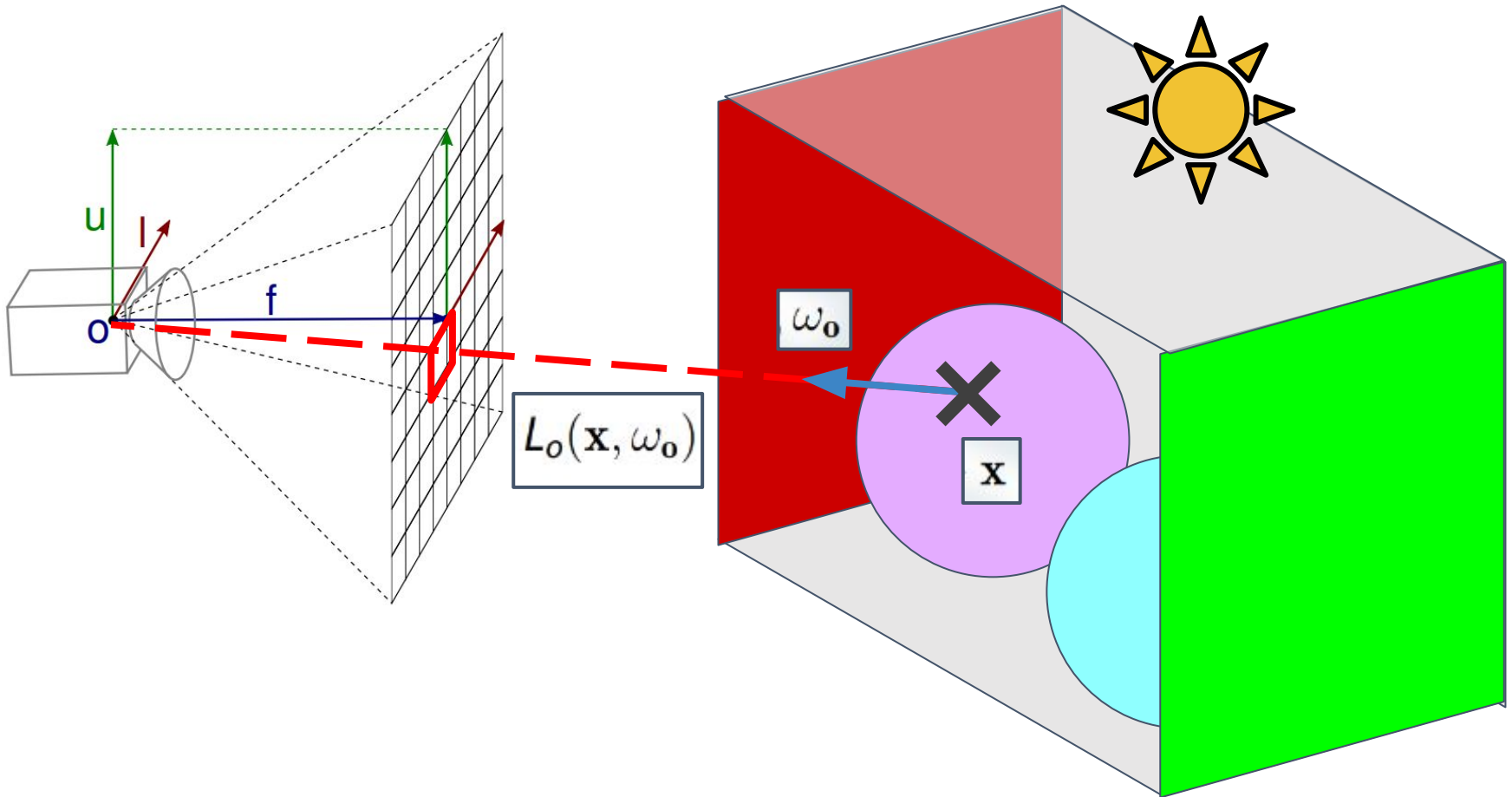

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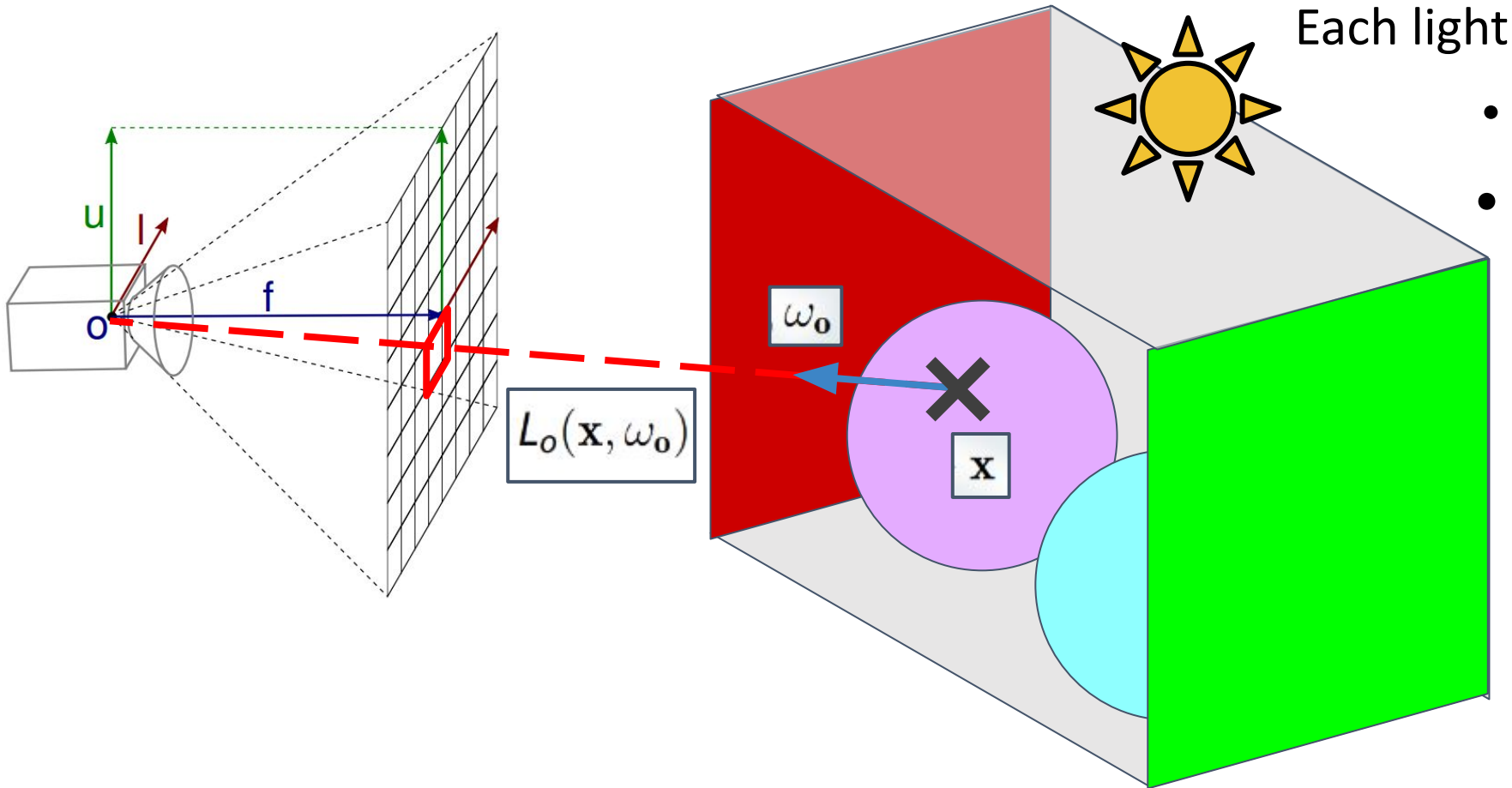

Each light source $\sum_{i=1}^{n}$

- Center $\mathbf{c_i}$
- Power p_i

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Graphics and Imaging Lab

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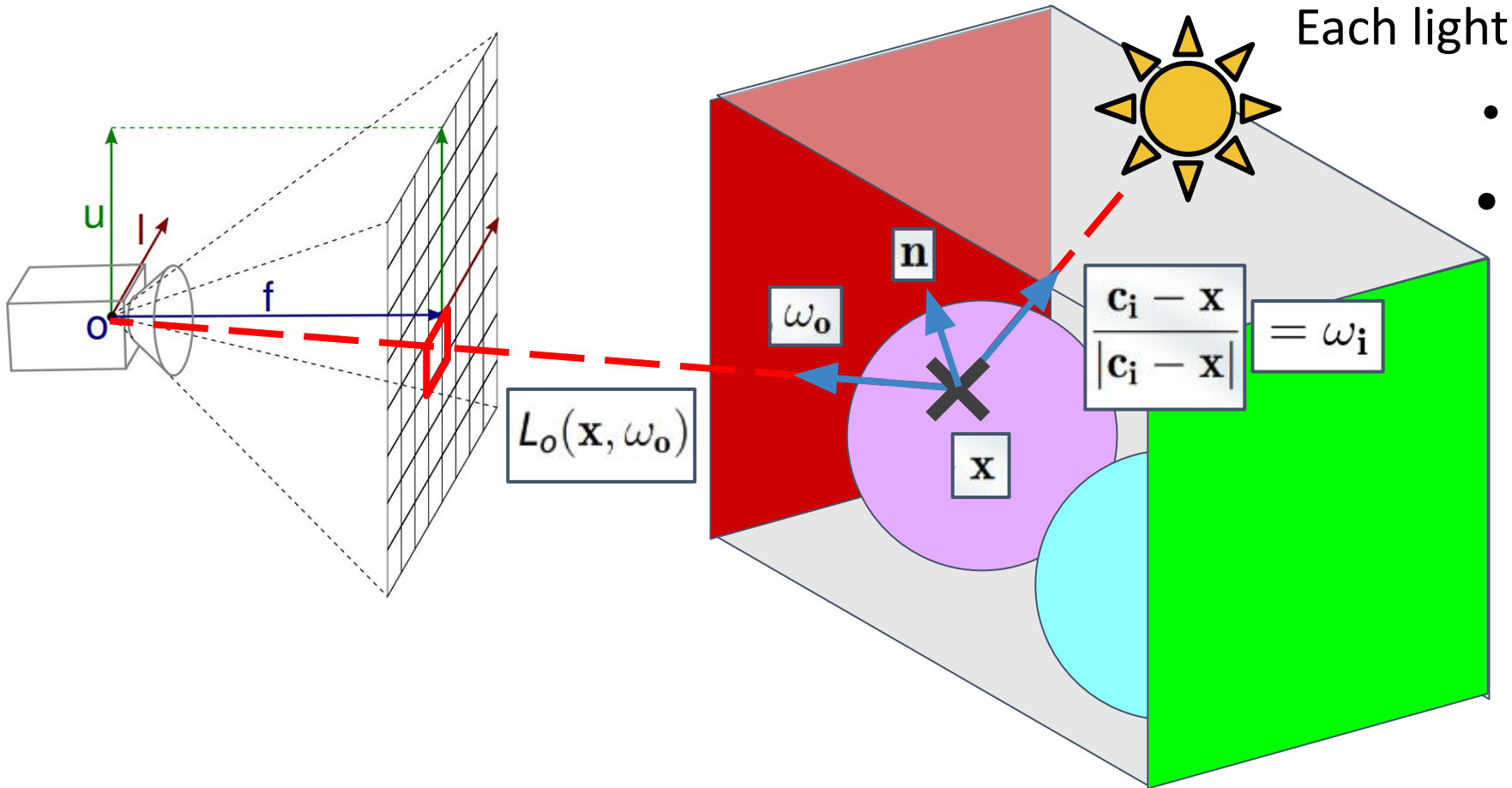

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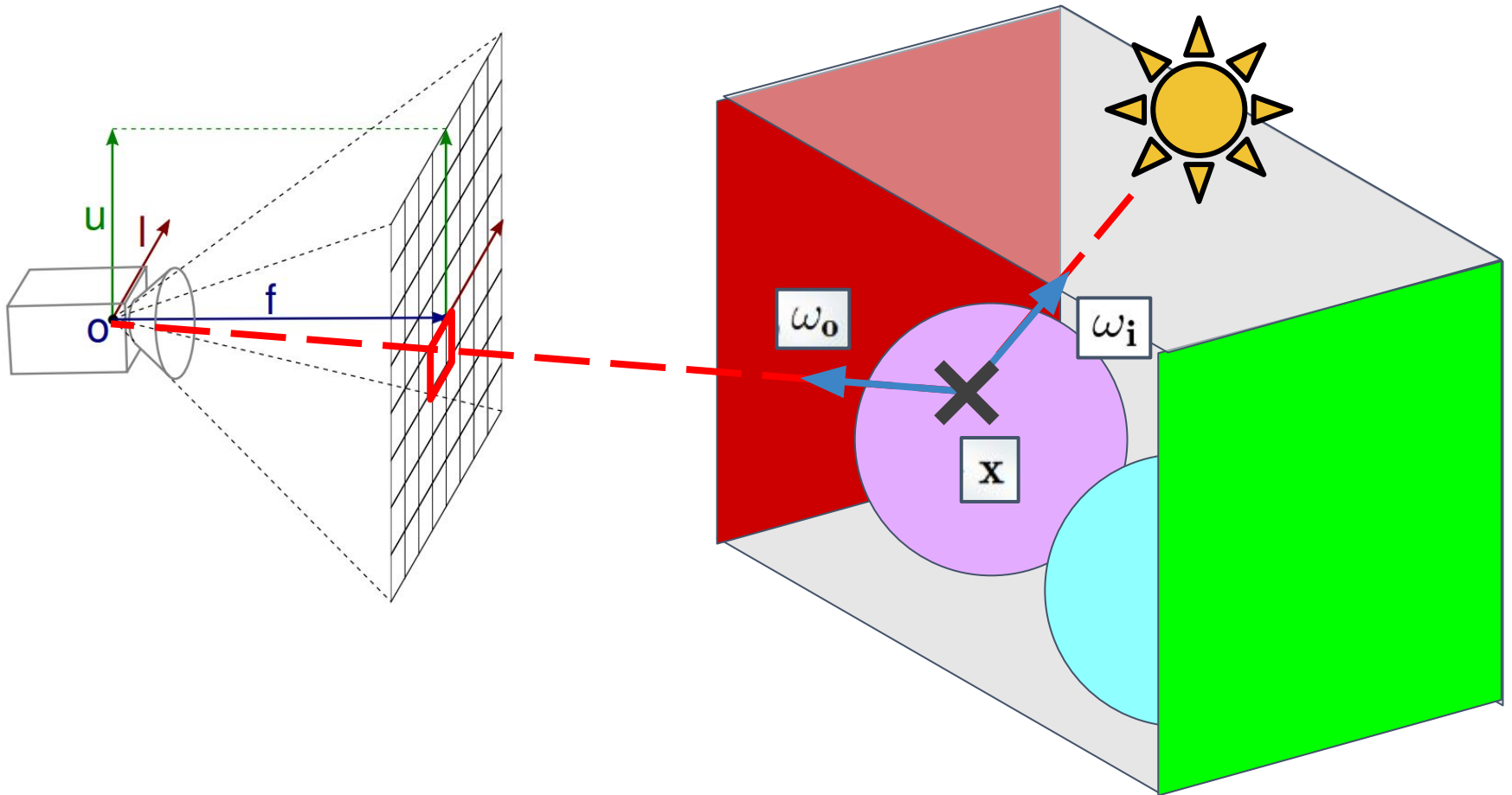

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$$f_r(\mathbf{x}, \omega_\mathbf{i}, \omega_\mathbf{o}) = \frac{k_d}{\pi}$$

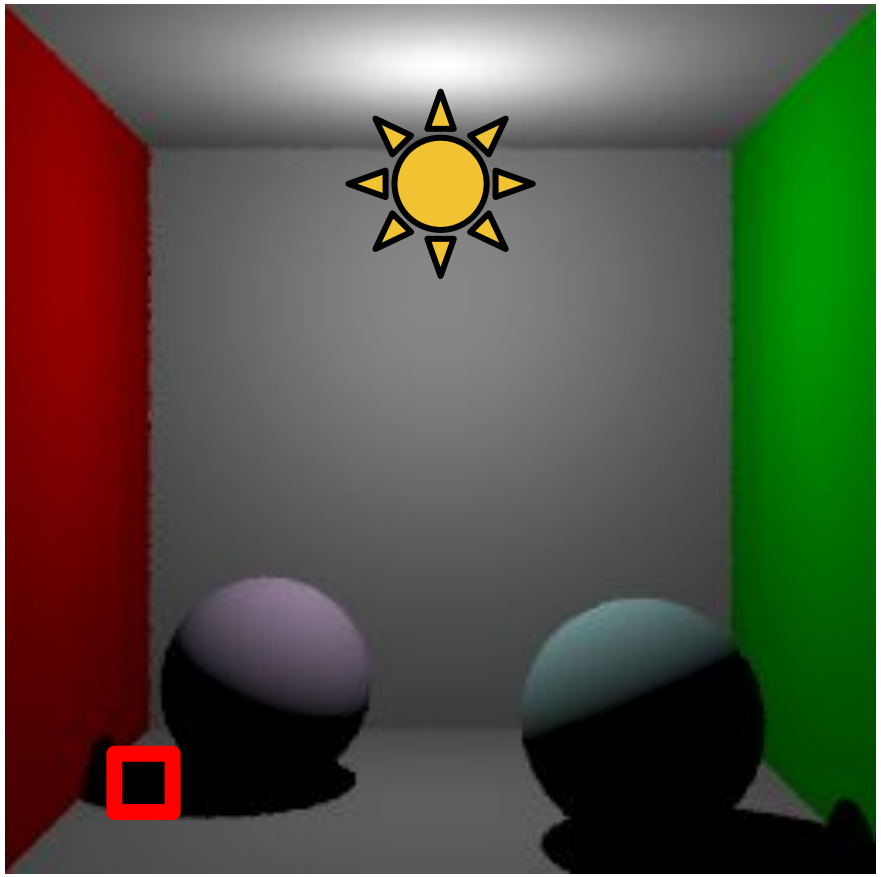
k_d is the *diffuse coefficient*.

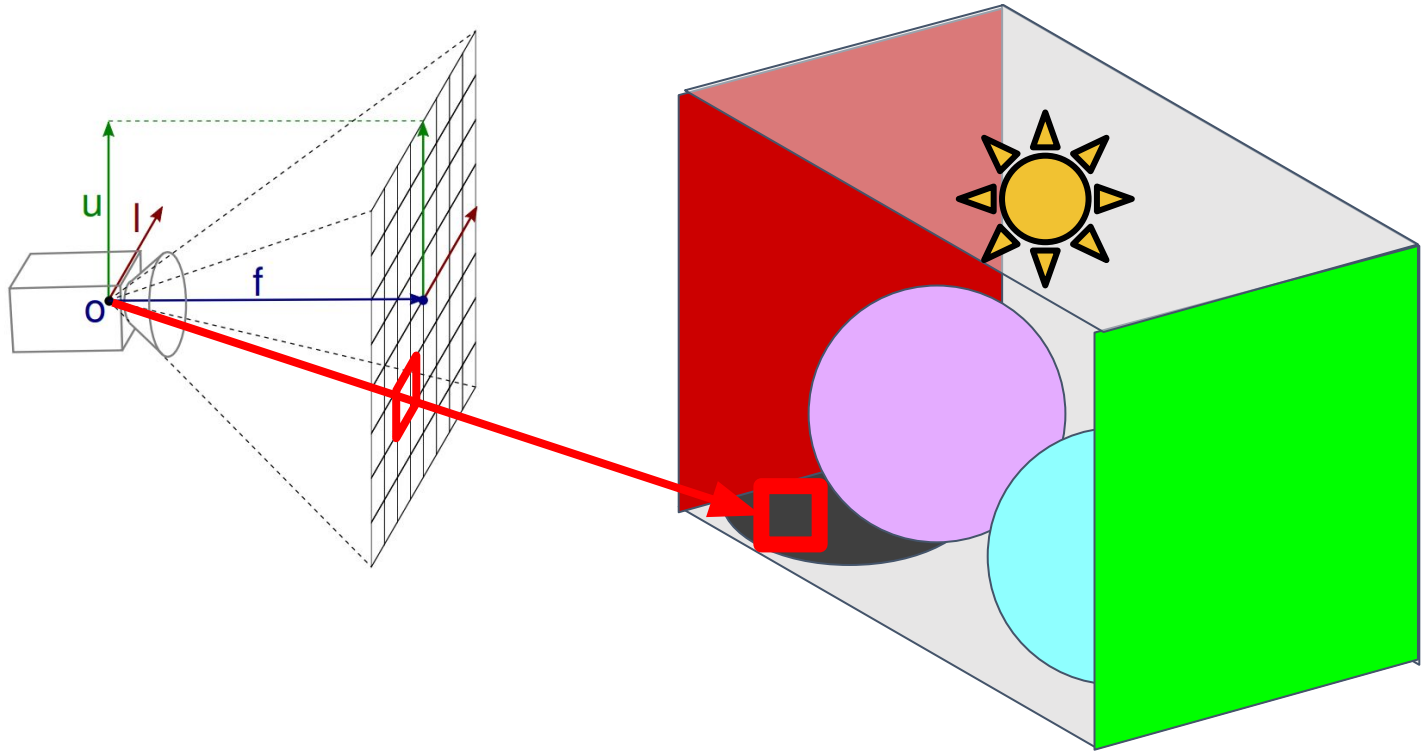
Lambertian BRDF is constant. Therefore lighting depends only on the cosine and it is independent from the point of view.

Which color do we fill each pixel with?

Graphics and Imaging Lab

- Remember to cast **shadow rays**





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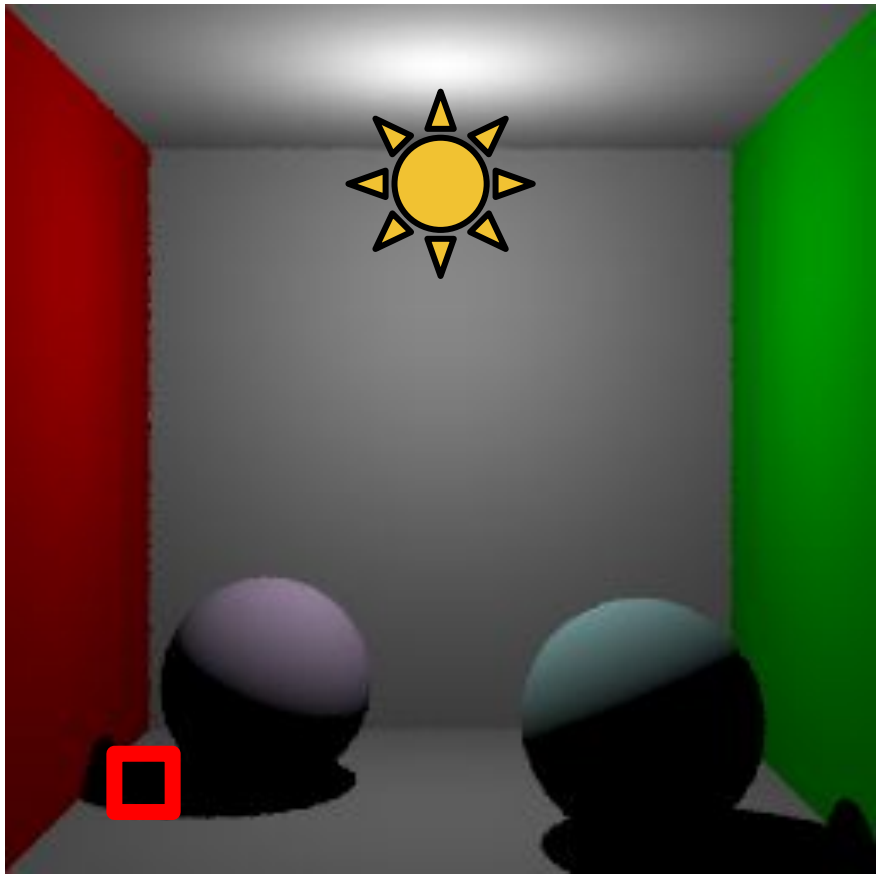
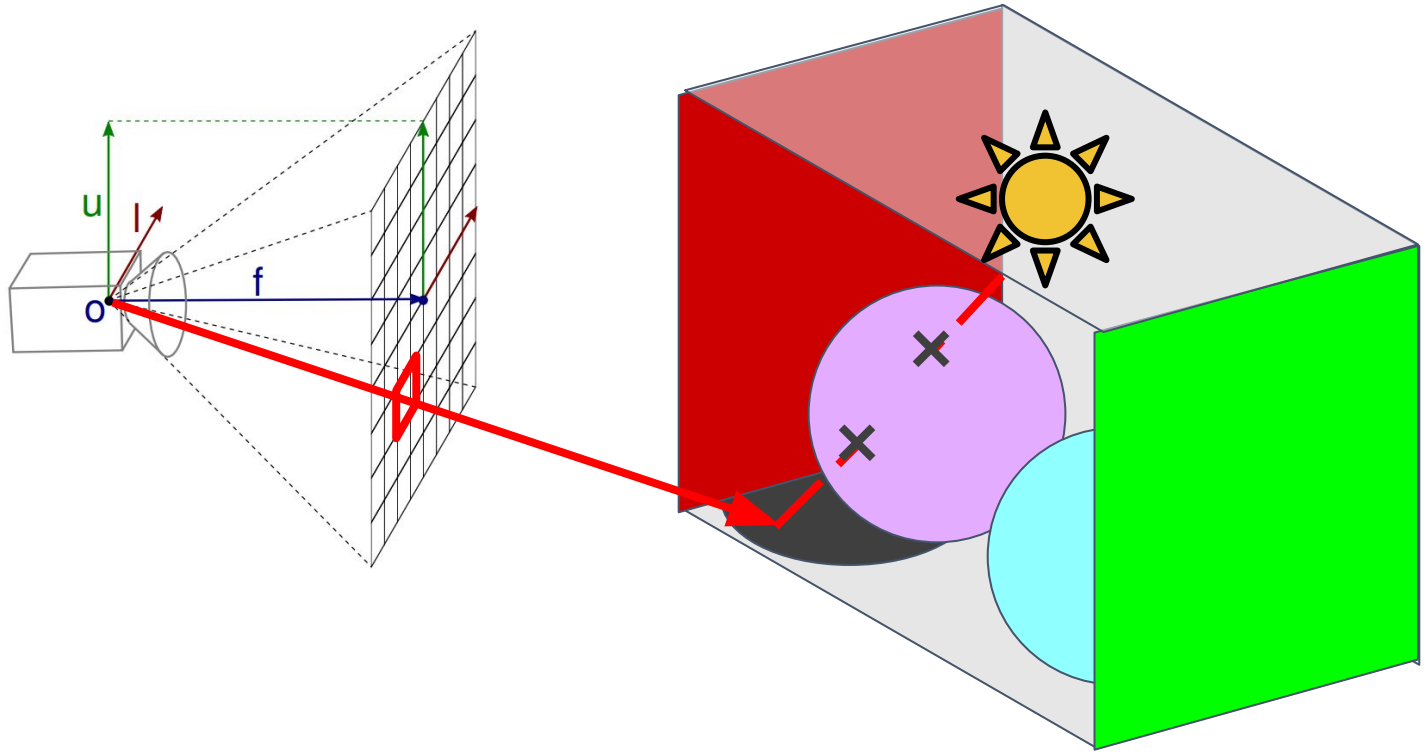
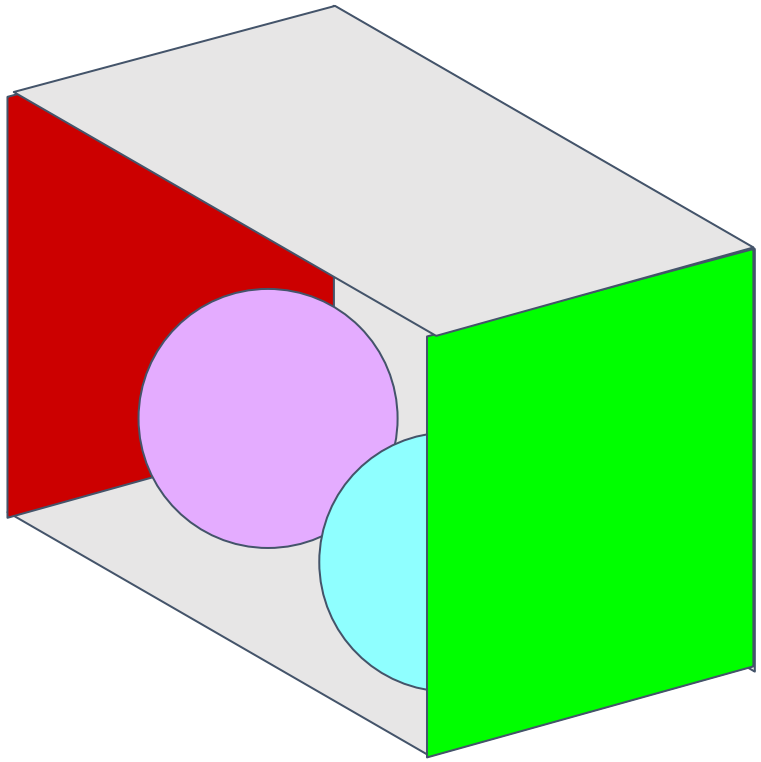




Example scene: Cornell Box

Graphics and Imaging Lab

- **Geometry**



Planes defined by normal (n) and distance (d)

Left plane	n = (1, 0, 0), d = 1
Right plane	n = (-1, 0, 0), d = 1
Floor plane	n = (0, 1, 0), d = 1
Ceiling plane	n = (0, -1, 0), d = 1
Back plane	n = (0, 0, -1), d = 1

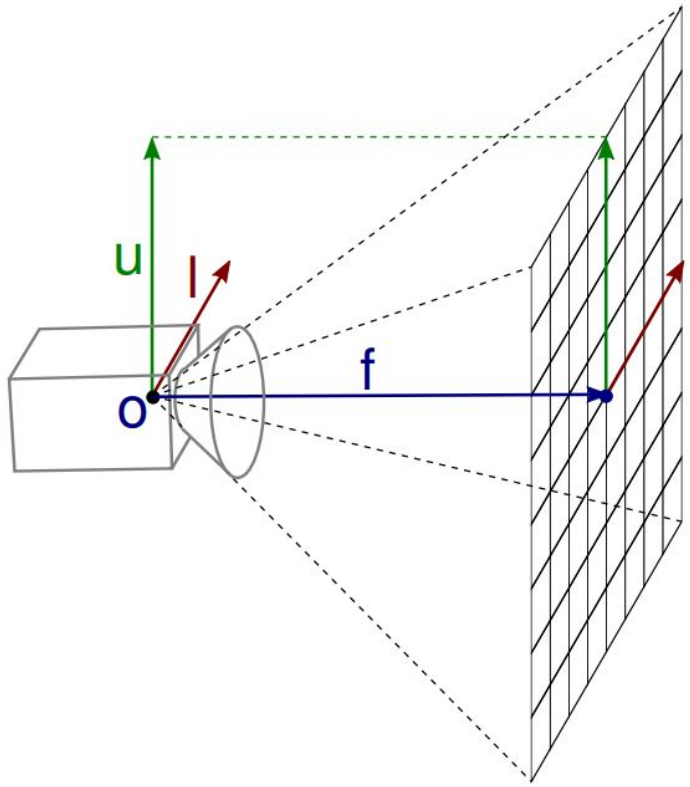
Spheres defined by center (c) and radius (r)

Left sphere	c = (-0.5, -0.7, 0.25), r = 0.3
Right sphere	c = (0.5, -0.7, -0.25), r = 0.3

Example scene: Cornell Box

Graphics and Imaging Lab

- **Camera & light sources**



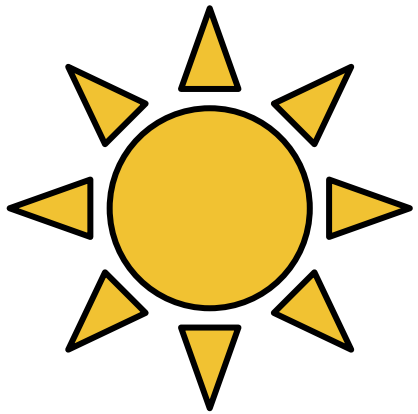
Camera and image plane defined by

Origin	O = (0, 0, -3.5)
Left	L = (-1, 0, 0)
Up	U = (0, 1, 0)
Forward	F = (0, 0, 3)
Size	256x256 pixels

Example scene: Cornell Box

Graphics and Imaging Lab

- **Light sources**



Center and power (emission)

Center c = (0, 0.5, 0)

Power can be any number e.g. p = (1, 1, 1)

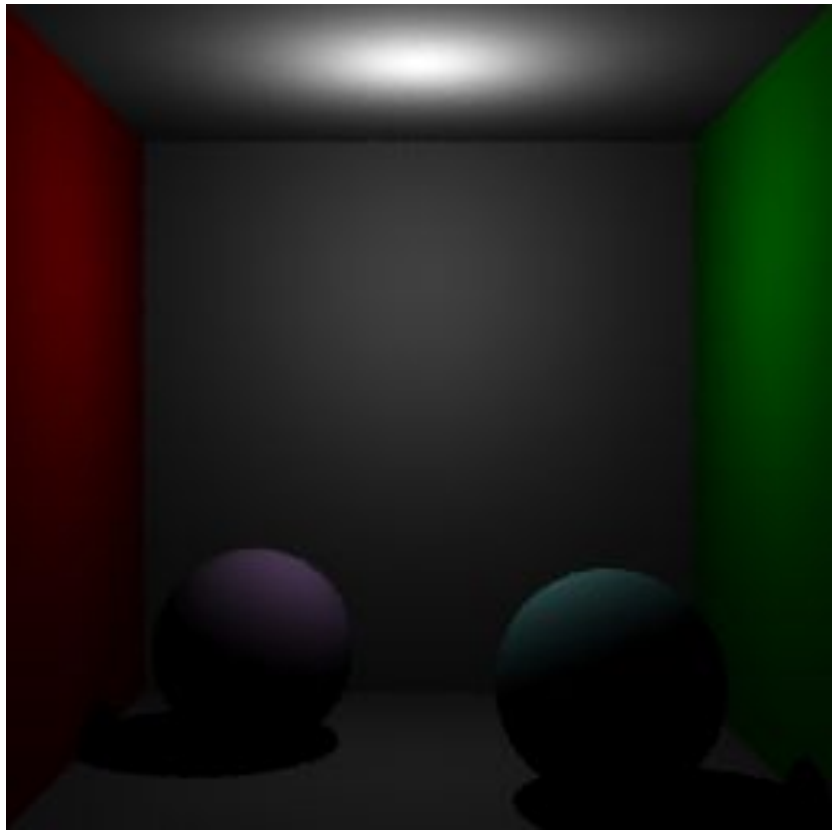
Just be careful with the #MAX

```
1  P3
2  # feep.ppm
3  #MAX=<maximum of your RGB memory values>
4  4 4
5  15
6   0   0   0     0   0   0     0   0   0    15   0 15
```

Example scene: Cornell Box

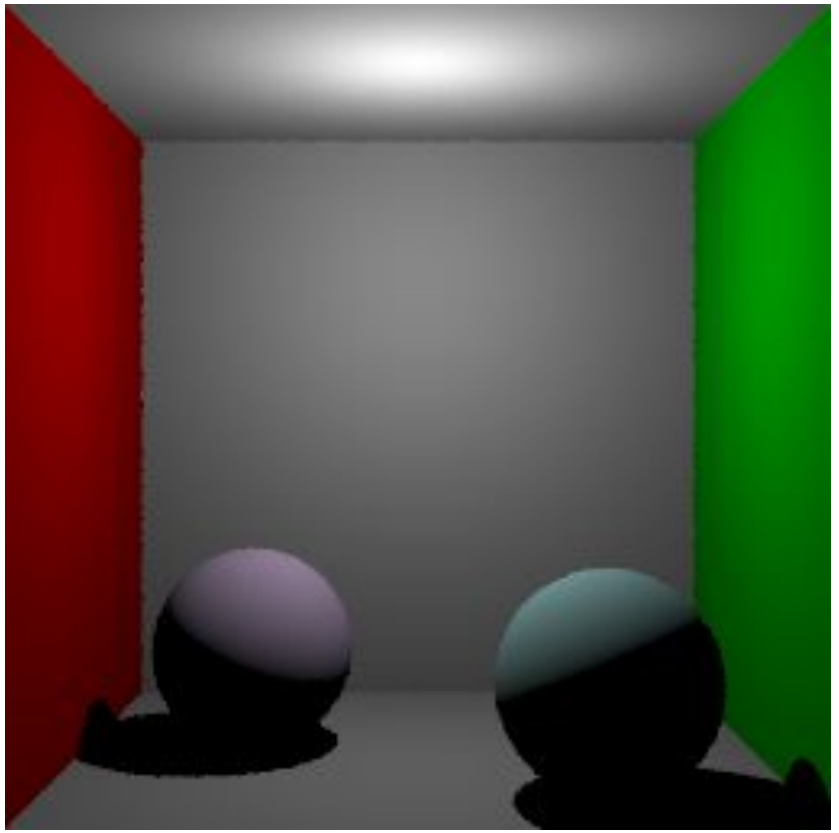
Graphics and Imaging Lab

- **Results**



Today's result

Equalization
Gamma = 2.2



With tone mapping

Questions

Graphics and Imaging Lab

DO ASK questions, either now or after the lab

But be reasonable, please :)

pluesia@unizar.es | dsubias@unizar.es | o.pueyo@unizar.es

What to expect from this session

Graphics and Imaging Lab

In the programming language of your choice implement:

- Add **point light sources** to your scene
  - Point sources are defined by **center (x, y, z)** and **power (r, g, b)**
- Extend ray tracing to **calculate direct light** from point lights
  - Cast shadow rays, calculate direct light contribution if path is not occluded
- Recommended deadline: November 13th (moodle: January 11th)
  - Extensions (do not count towards recommended deadline):
    - **Textures:** make diffuse coefficient k_d depend on hit position $\mathrm{k}_d(\mathbf{x})$
    - **Fresnel effects:** make diffuse coefficient k_d depend on viewing direction $\mathrm{k}_d(\omega_\mathbf{o})$
    - **Parallelization:** divide work between several threads, estimate time to finish execution
    - **More:** importance sampling next-event estimation, etc. (see the lab assignment or ask us)