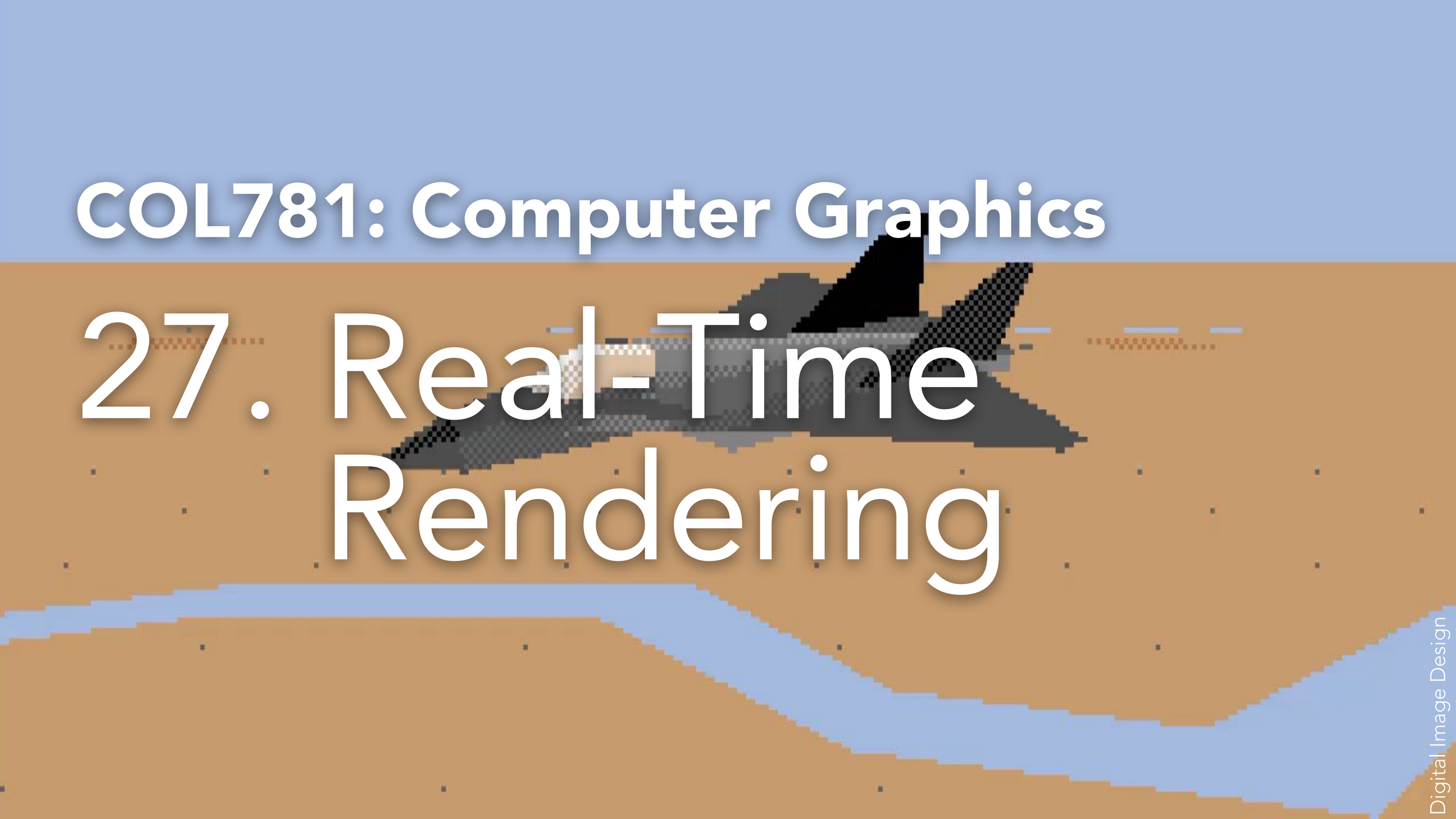
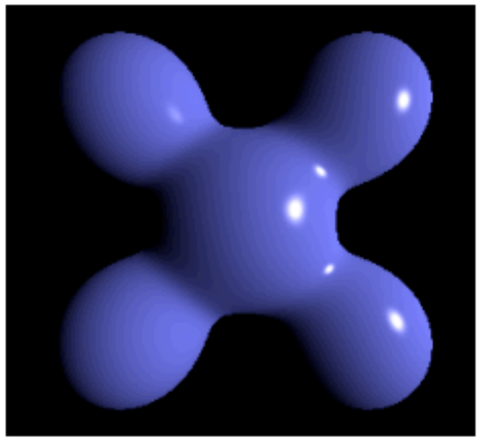
COL781: Computer Graphics

27. Real-Time Rendering



How to do realistic rendering in rasterization?



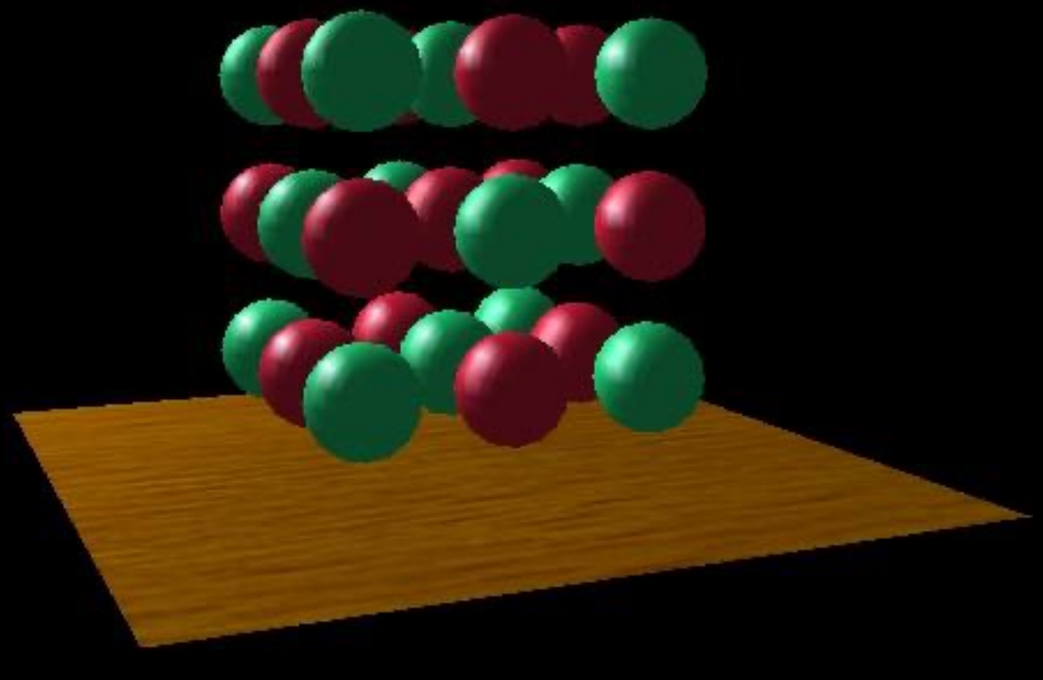
$$L_o = k_a I_a + k_d I \max(0, \mathbf{n} \cdot \boldsymbol{\ell}) + k_s I \max(0, \mathbf{n} \cdot \mathbf{h})^p$$

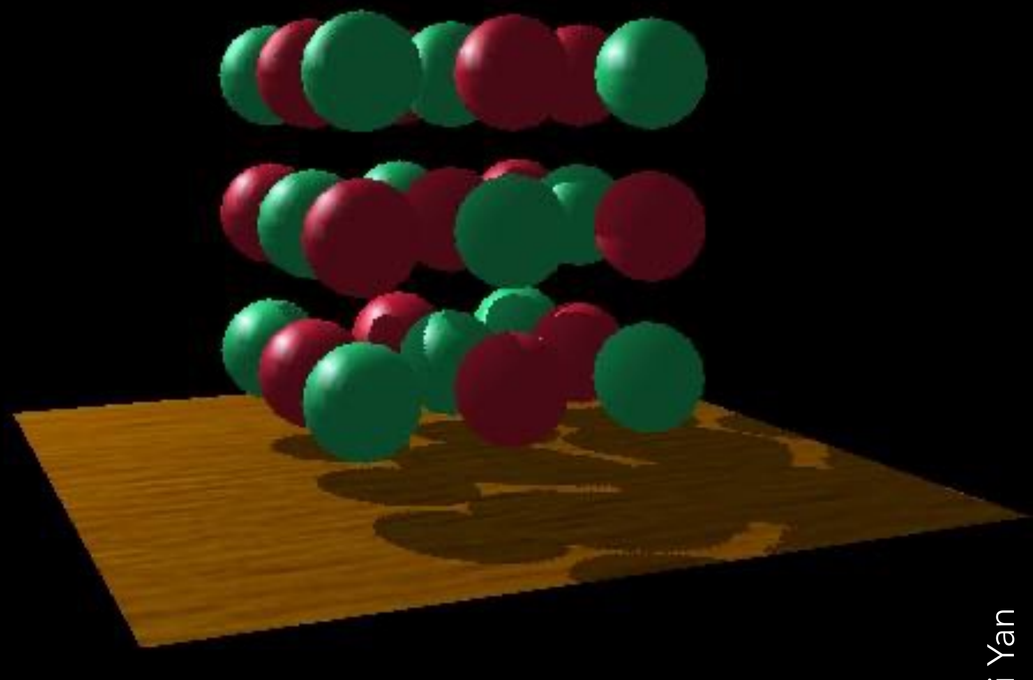
$$L_o(\mathbf{p}, \boldsymbol{\omega}_o) = L_e(\mathbf{p}, \boldsymbol{\omega}_o) + \int_{H^2} f_r(\mathbf{p}, \boldsymbol{\omega}_i \rightarrow \boldsymbol{\omega}_o)\, L_i(\mathbf{p}, \boldsymbol{\omega}_i) \cos(\theta_i)\, \mathrm{d}\boldsymbol{\omega}_i$$

approximate

approximate

Shadows

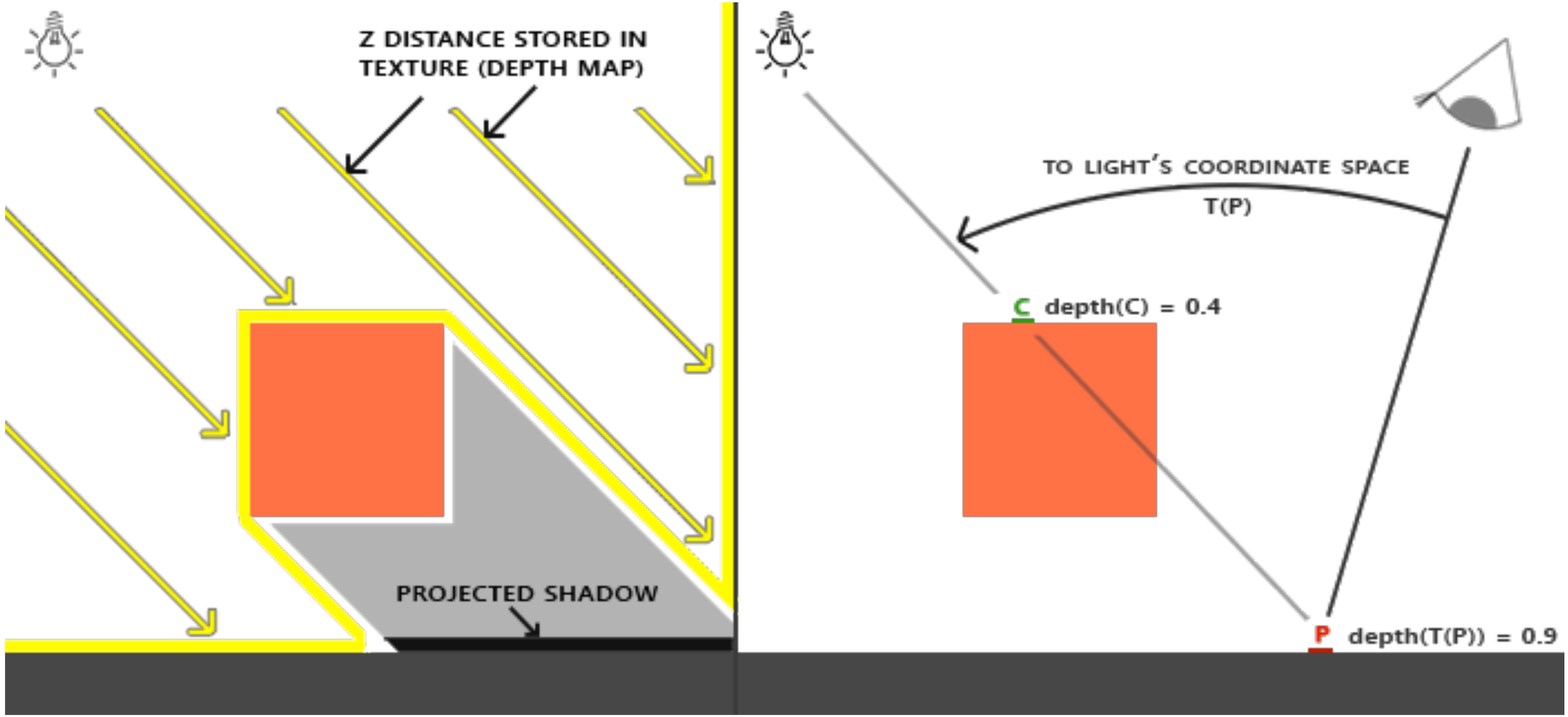


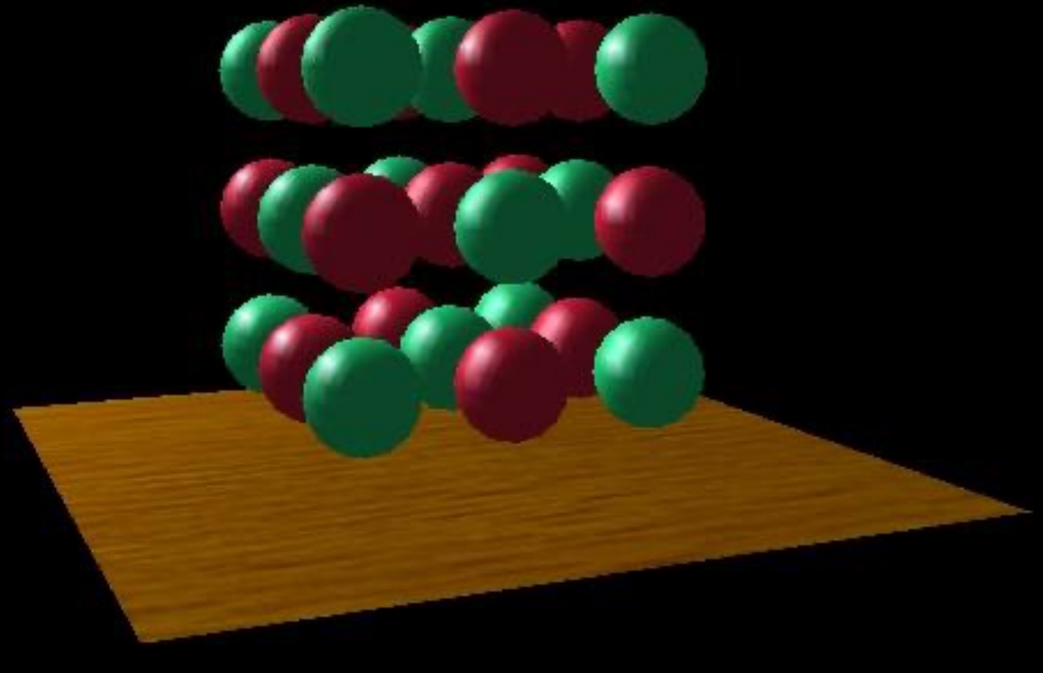


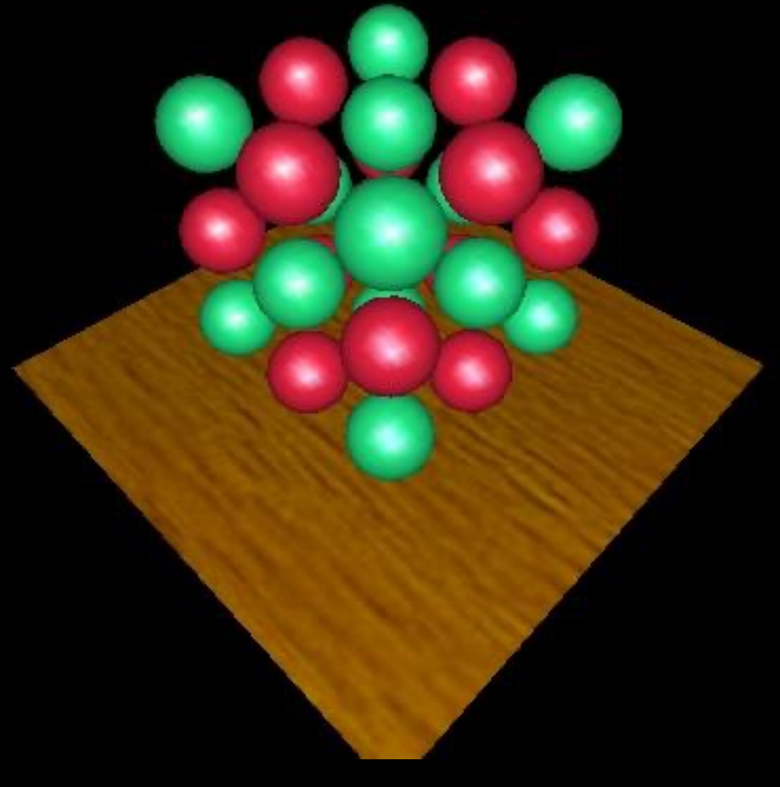
Assume only direct illumination from a point light $\mathbf{p}'$.

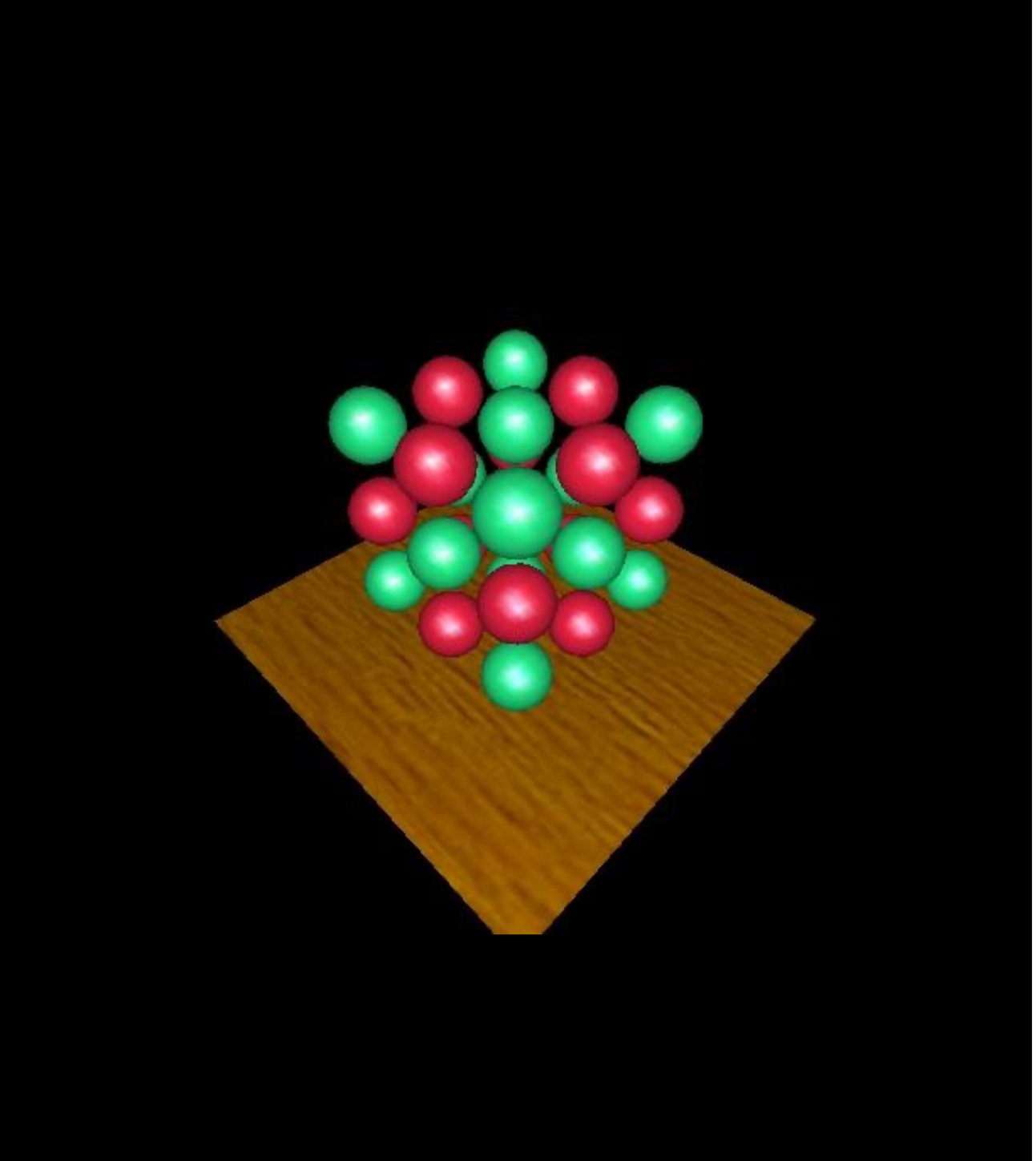
$$L_o(\mathbf{p}, \boldsymbol{\omega}_o) = f_r(\mathbf{p}, \boldsymbol{\omega}_i \rightarrow \boldsymbol{\omega}_o)\, I_o(\mathbf{p}', \boldsymbol{\omega}')\, V(\mathbf{p}, \mathbf{p}')$$

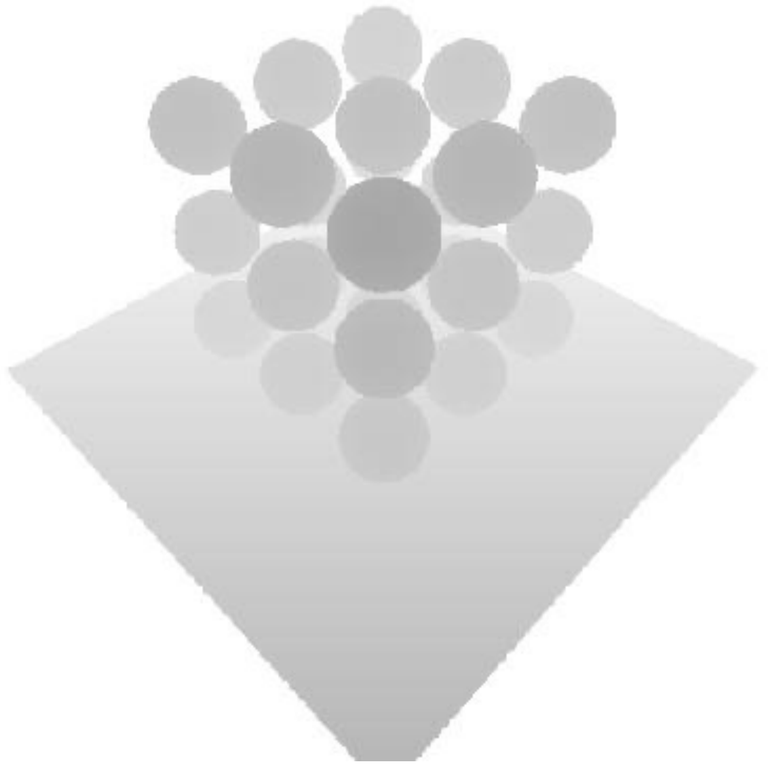
Shadow maps











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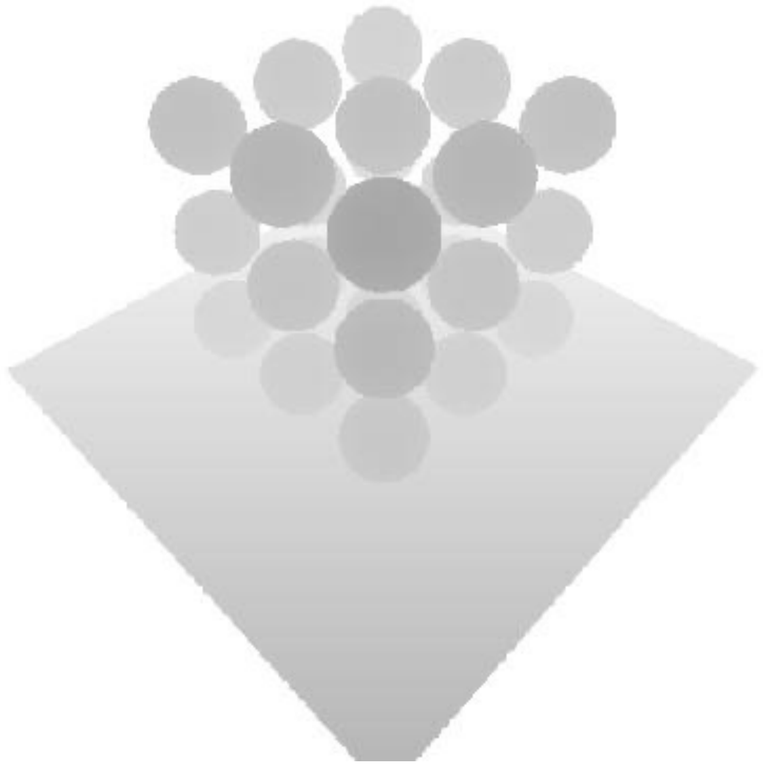
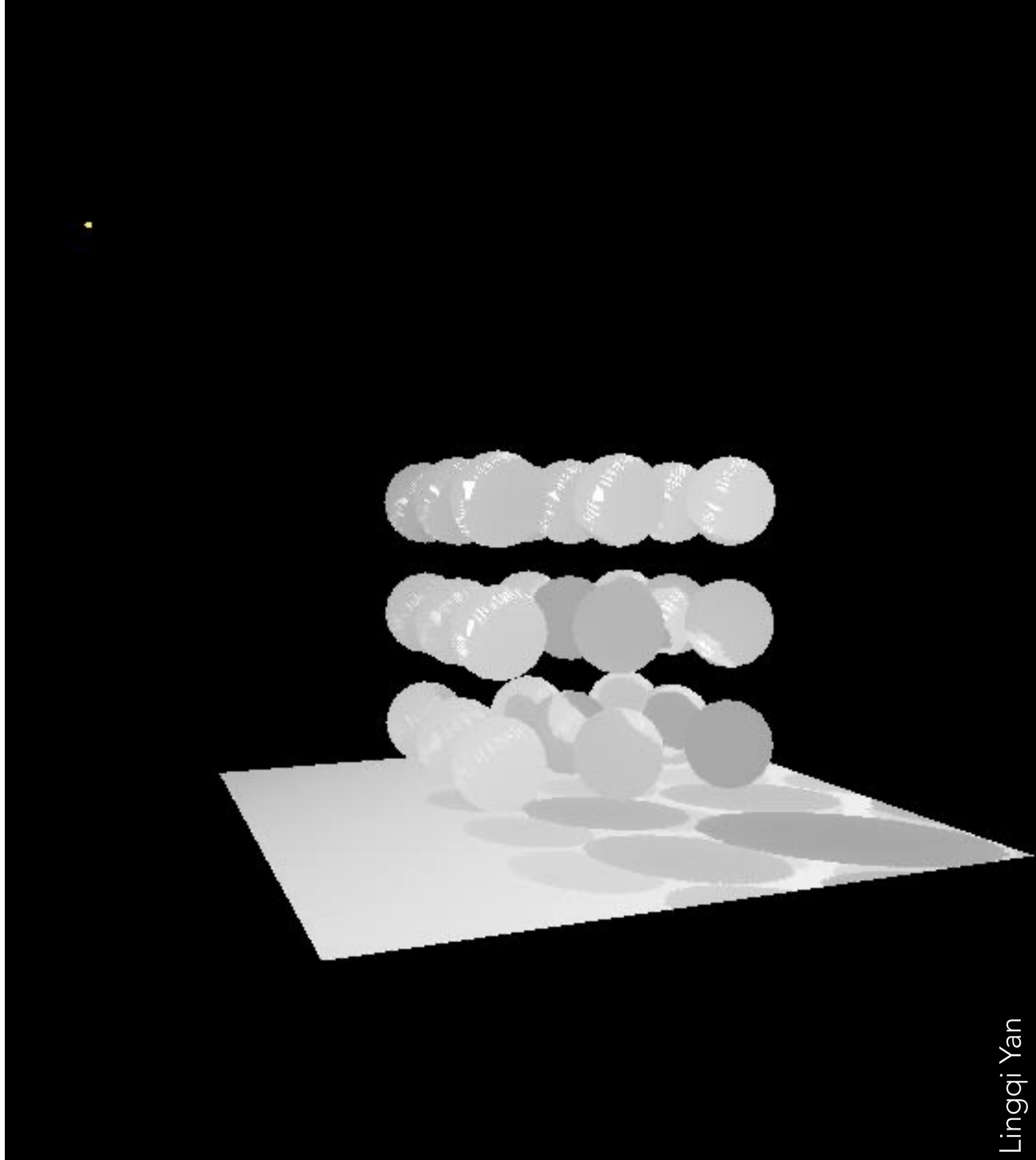
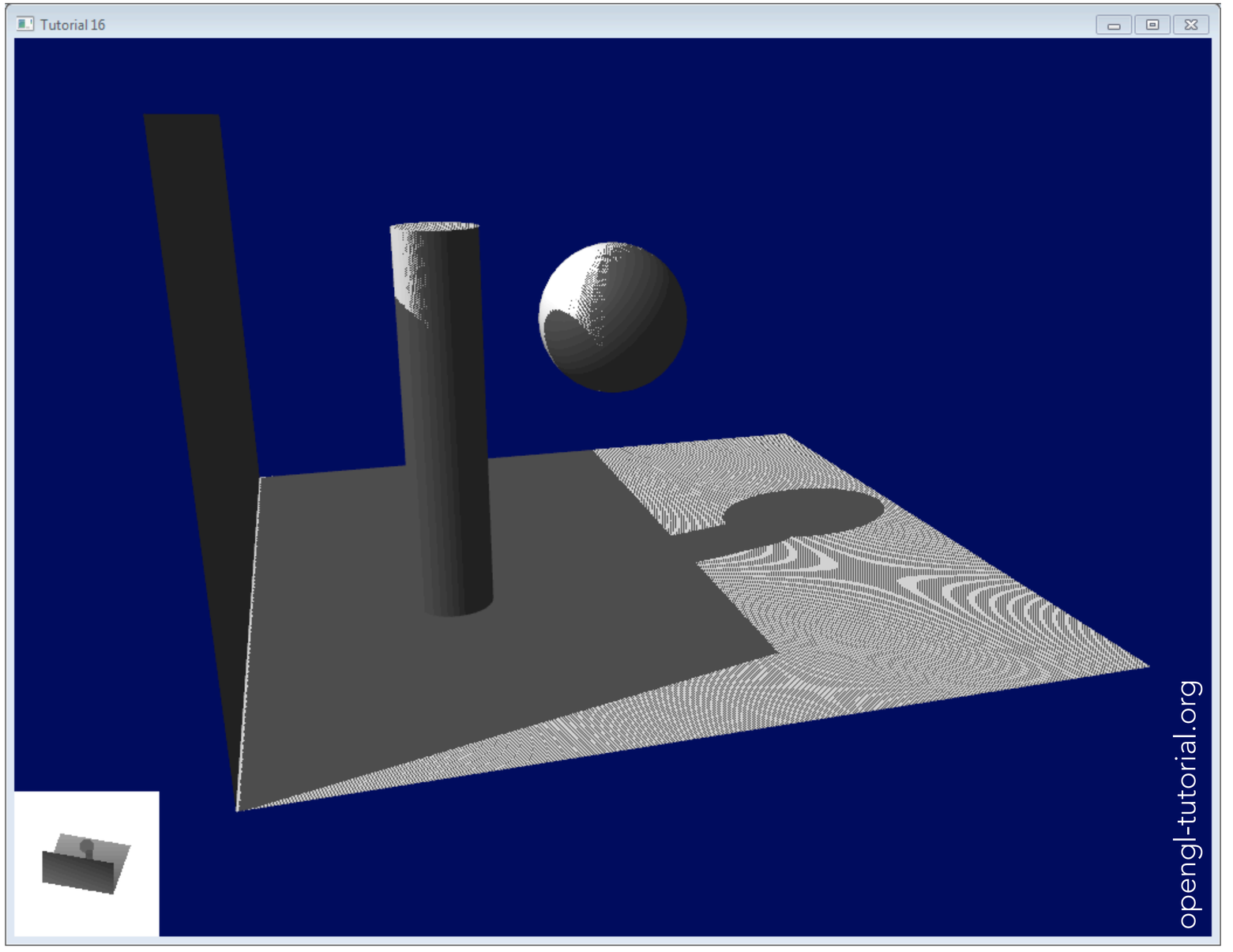
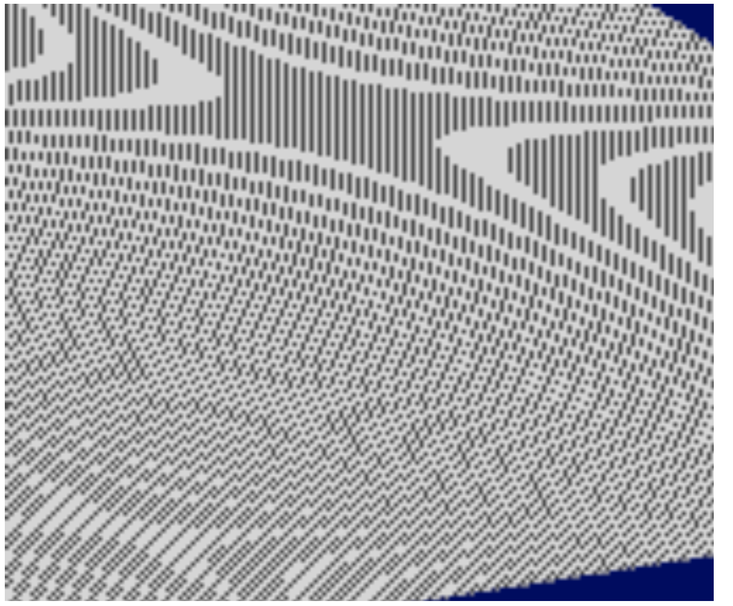
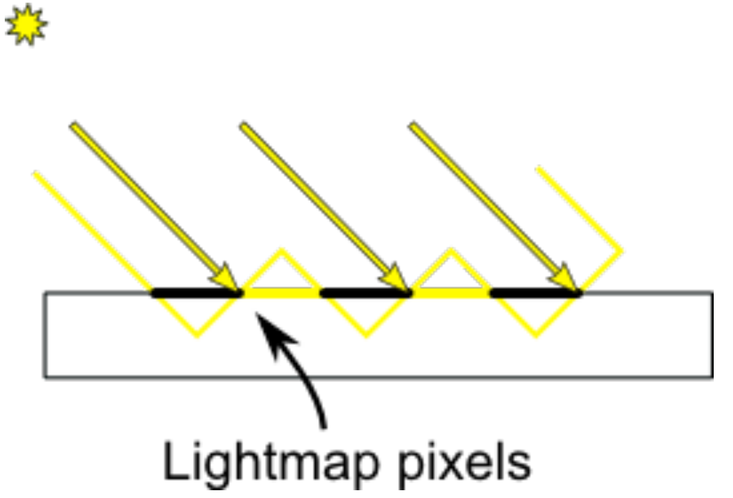




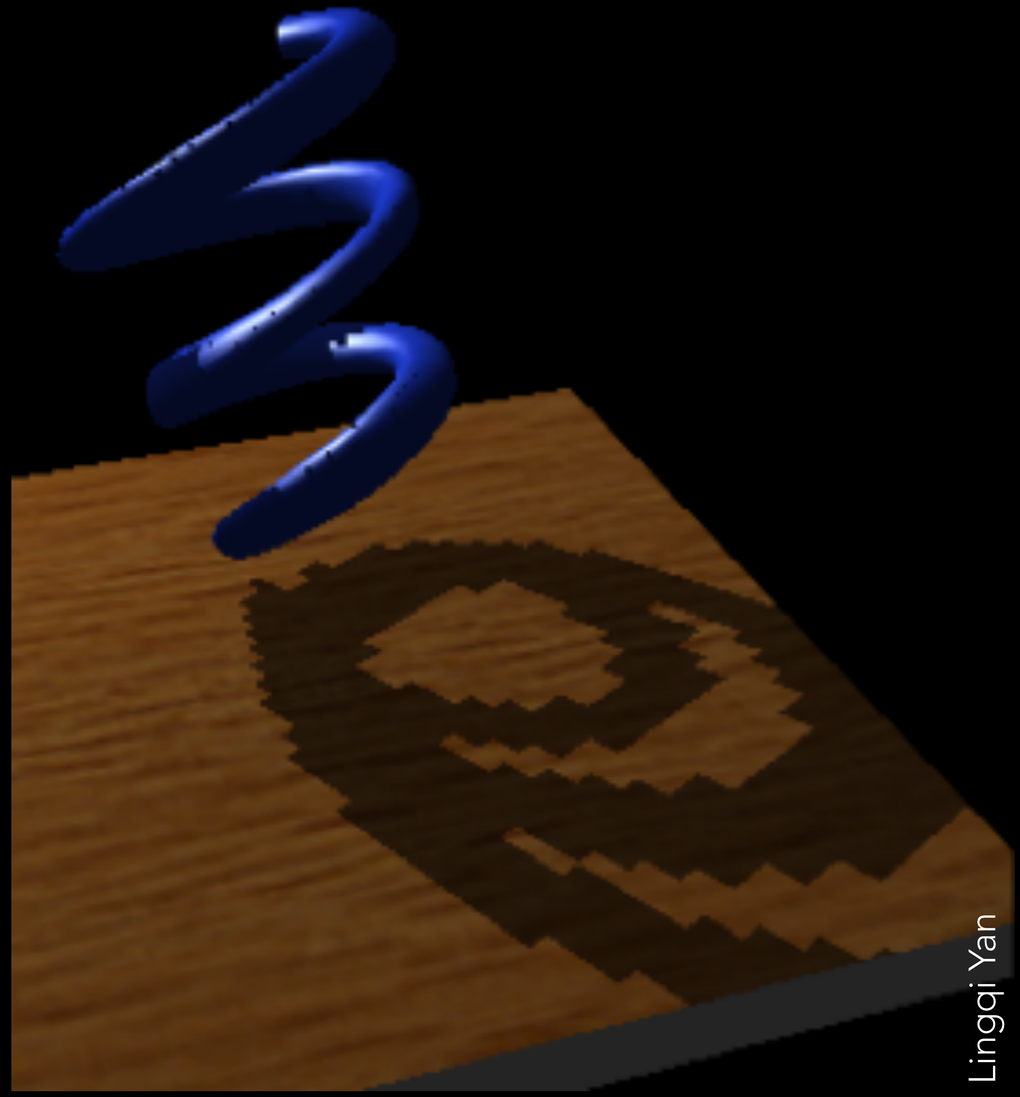




"Shadow acne"



Aliasing



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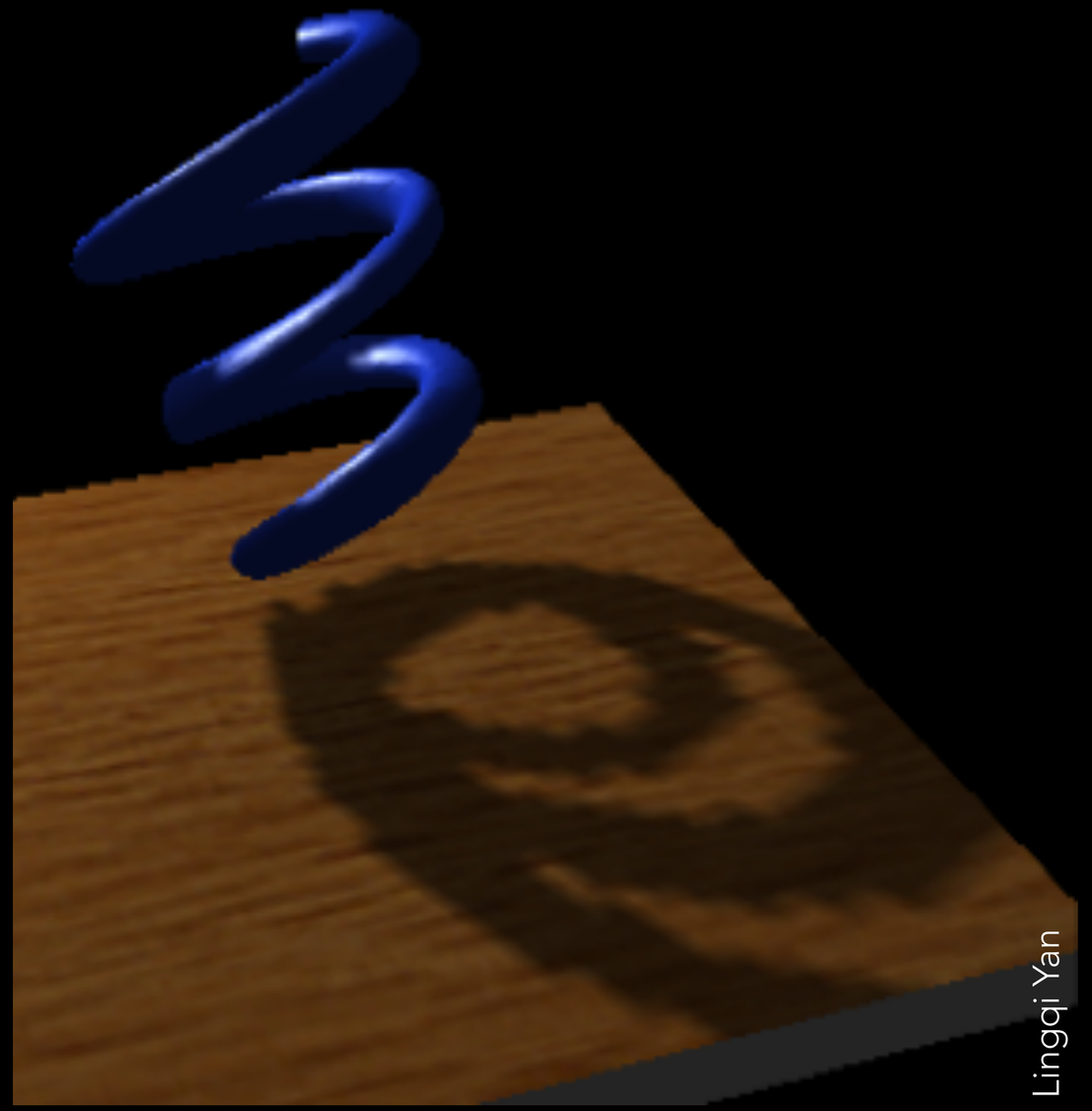
Percentage closer filtering (PCF)

0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	1	1	1
0	0	0	0	0	1	1	1	1
0	0	0	0	0	1	1	1	1
0	0	0	0	1	1	1	1	1
0	0	0	0	1	1	1	1	1
1	1	1	1	1	1	1	1	1

0	0	0	1
0	0	1	1
1	1	1	1
1	1	1	1



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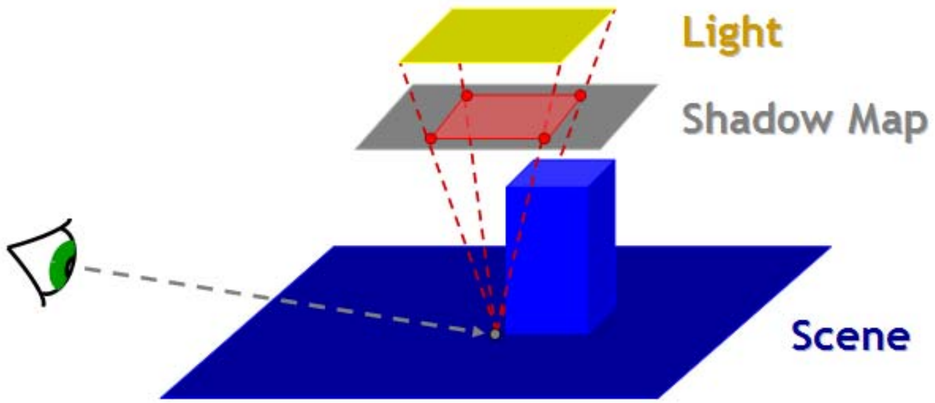
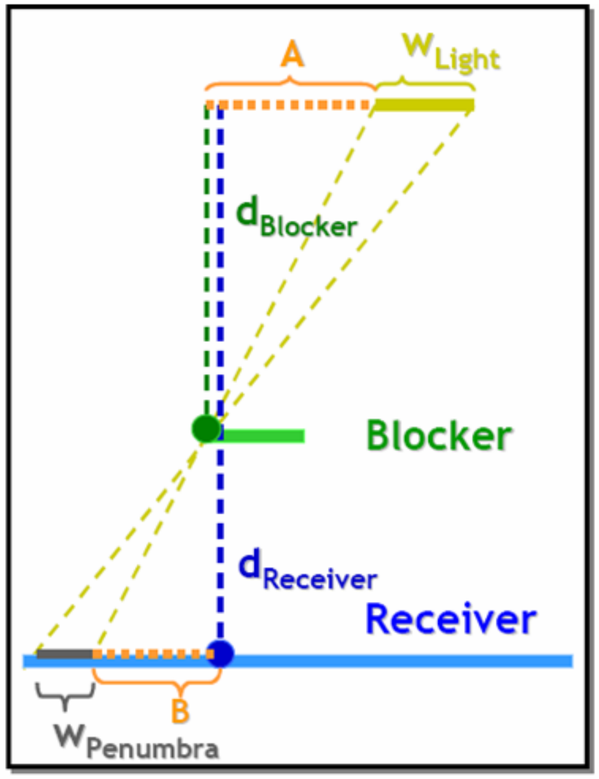
Soft shadows

Fernando 2005

Percentage-closer soft shadows (PCSS)





$$w_{Penumbra} = \frac{(d_{Receiver} - d_{Blocker}) \cdot w_{Light}}{d_{Blocker}}$$

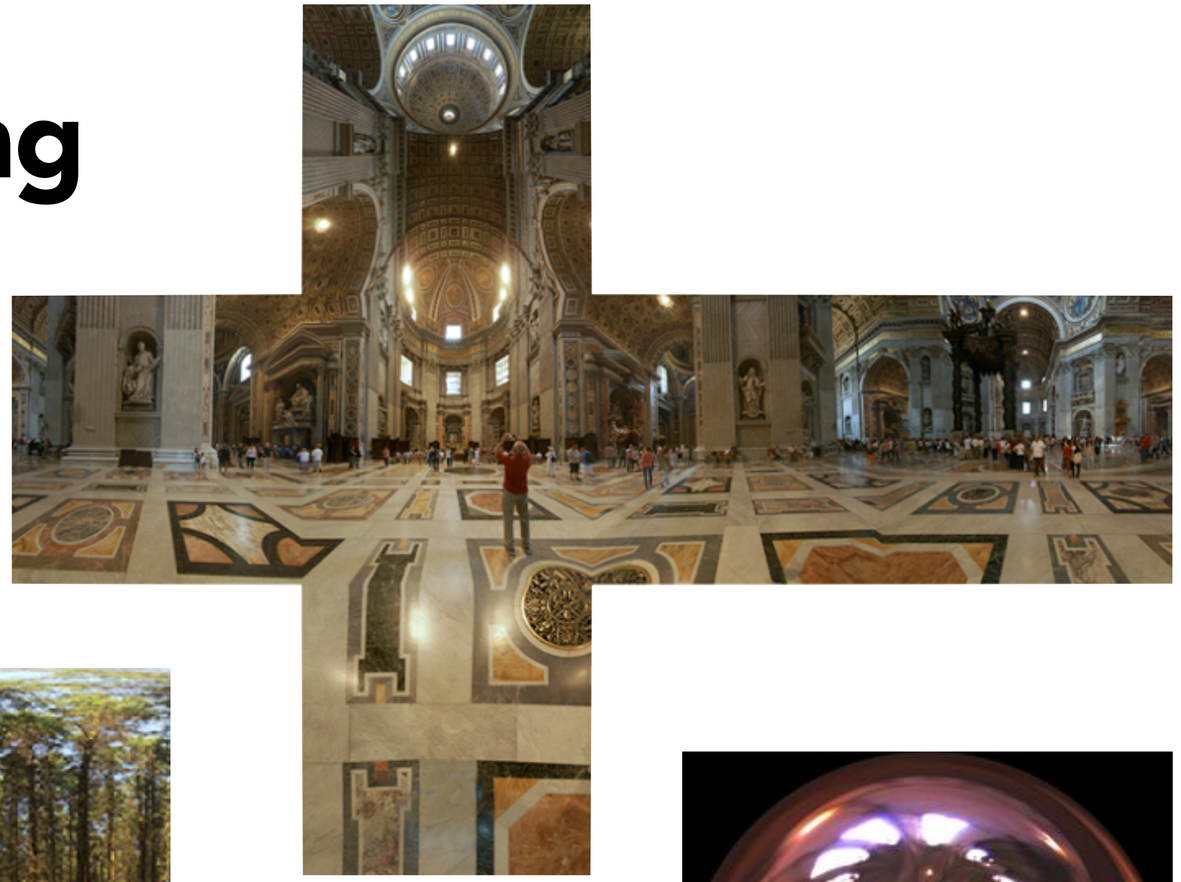
- Assumes that blocker, receiver, and light are parallel

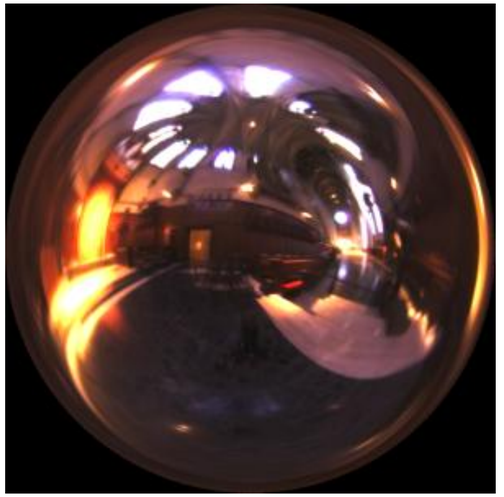
Moral(s) of the story:

1. Precompute as much as possible! Sample only as a last resort
2. Render the scene from the right viewpoint to gather the information you need

Environment mapping

A.K.A. image-based lighting





Assume all incident light is from environment map (i.e. ignore all other objects in the scene!)

$$L_o(\mathbf{p}, \boldsymbol{\omega}_o) = \int_{H^2} f_r(\mathbf{p}, \boldsymbol{\omega}_i \rightarrow \boldsymbol{\omega}_o)\, L_i(\boldsymbol{\omega}_i) \cos(\theta_i)\, \mathrm{d}\boldsymbol{\omega}_i$$

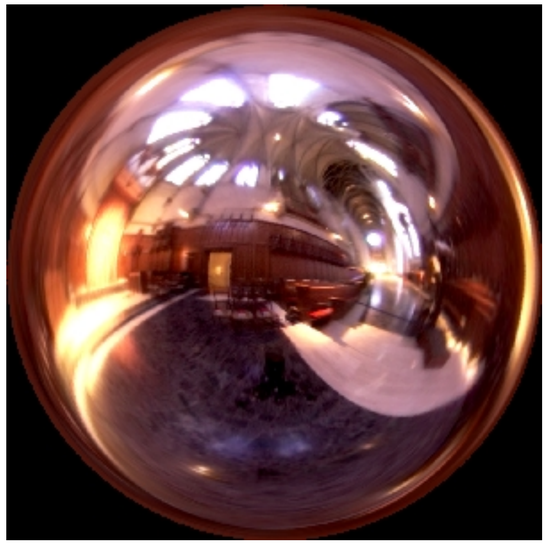
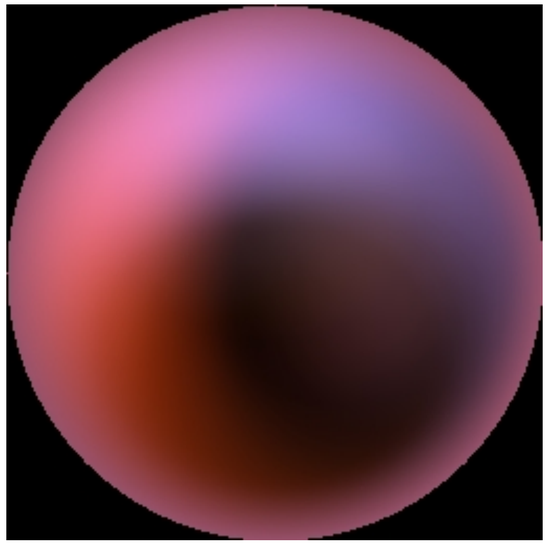
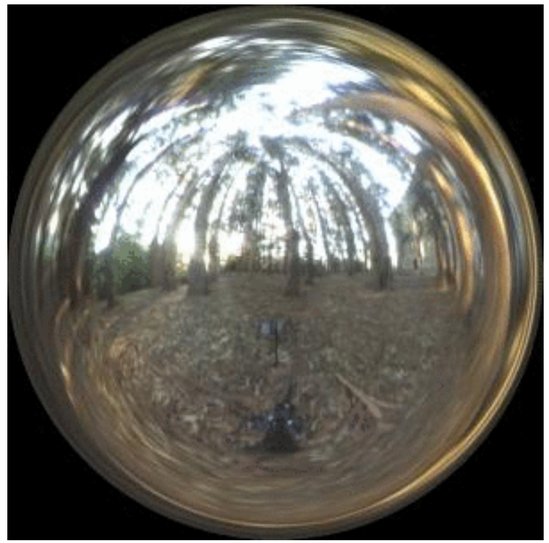
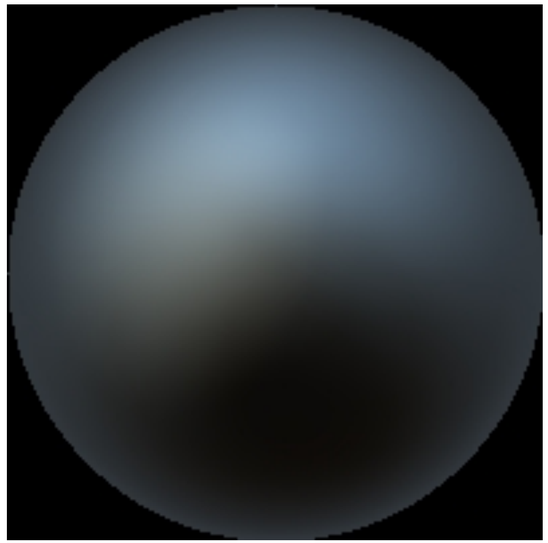
Easy case: perfect specular reflection

Another easy case: diffuse surface

$$L_o(\mathbf{p}, \boldsymbol{\omega}_o) = f_r \int_{H^2} L_i(\boldsymbol{\omega}_i) \cos(\theta_i) \, \mathrm{d}\boldsymbol{\omega}_i$$

$$= f_r \, I_i(\mathbf{n})$$

Precompute $I_i(\mathbf{n})$: **irradiance environment map**

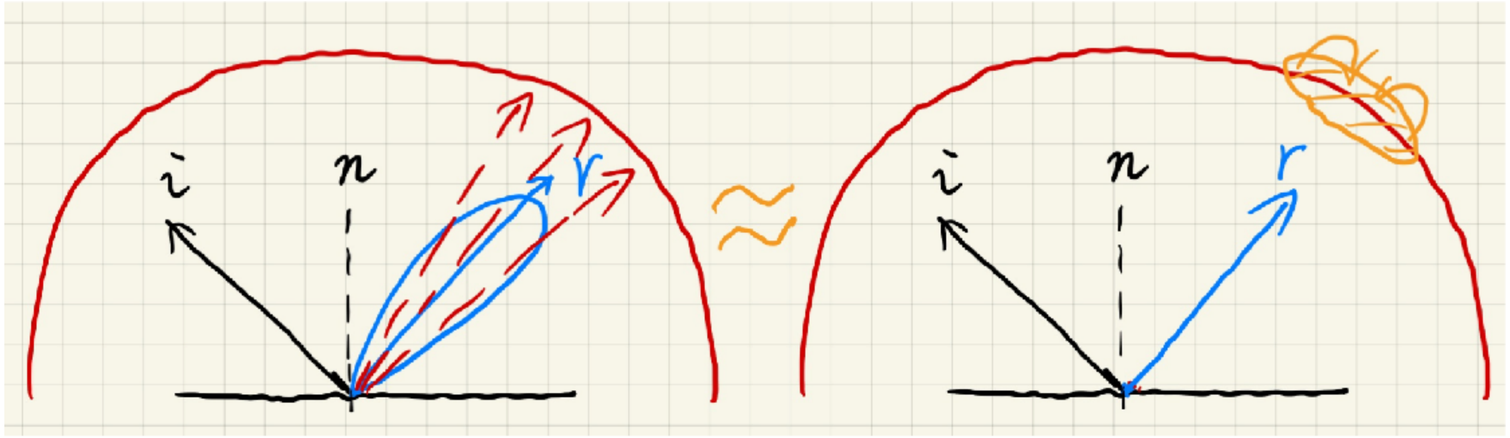





Ramamoorthi and Hanrahan 2001

What about glossy surfaces? **Split sum approximation**

$$L_o(\mathbf{p}, \boldsymbol{\omega}_o) = \int_{H^2} f_r(\mathbf{p}, \boldsymbol{\omega}_i \rightarrow \boldsymbol{\omega}_o)\, L_i(\boldsymbol{\omega}_i) \cos(\theta_i)\, \mathrm{d}\boldsymbol{\omega}_i$$

$$\approx \mathrm{avg}_{fr}(L_i) \int_{H^2} f_r(\mathbf{p}, \boldsymbol{\omega}_i \rightarrow \boldsymbol{\omega}_o) \cos(\theta_i)\, \mathrm{d}\boldsymbol{\omega}_i$$



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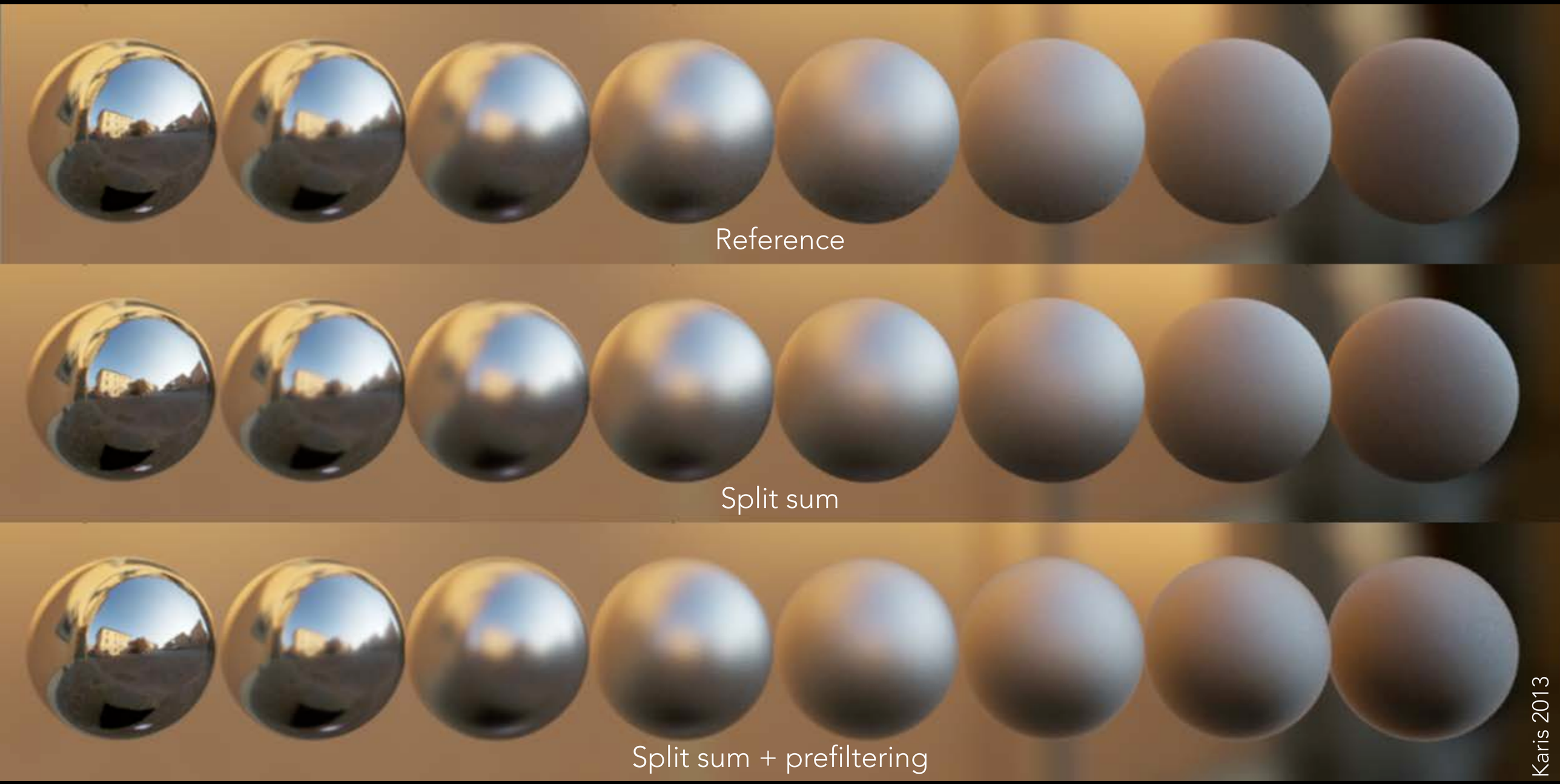
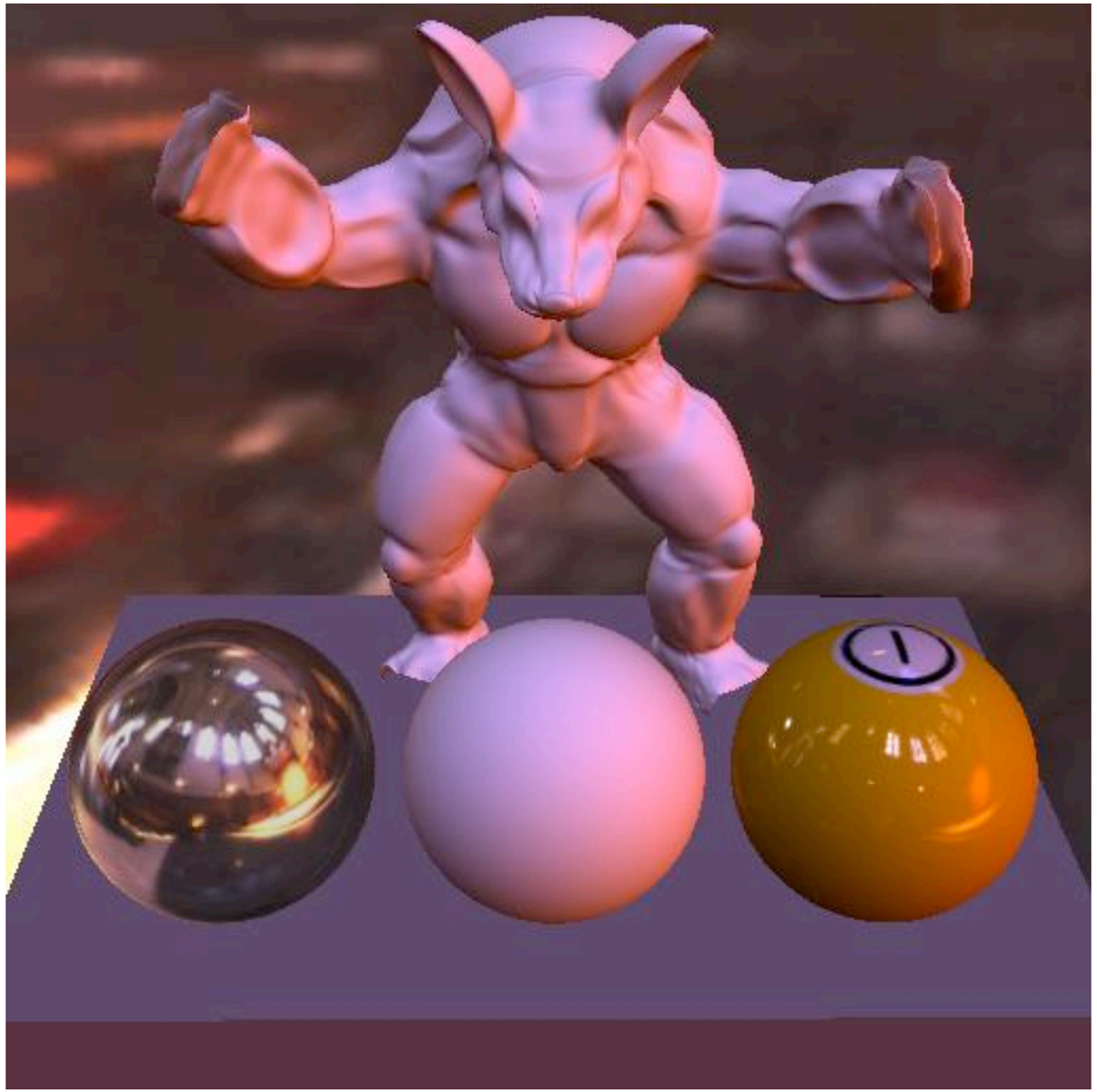

Reference
Split sum
Split sum + prefiltering
Karis 2013

Problems with basic environment maps:

- No reflections of other objects
- No shadows



Light probes