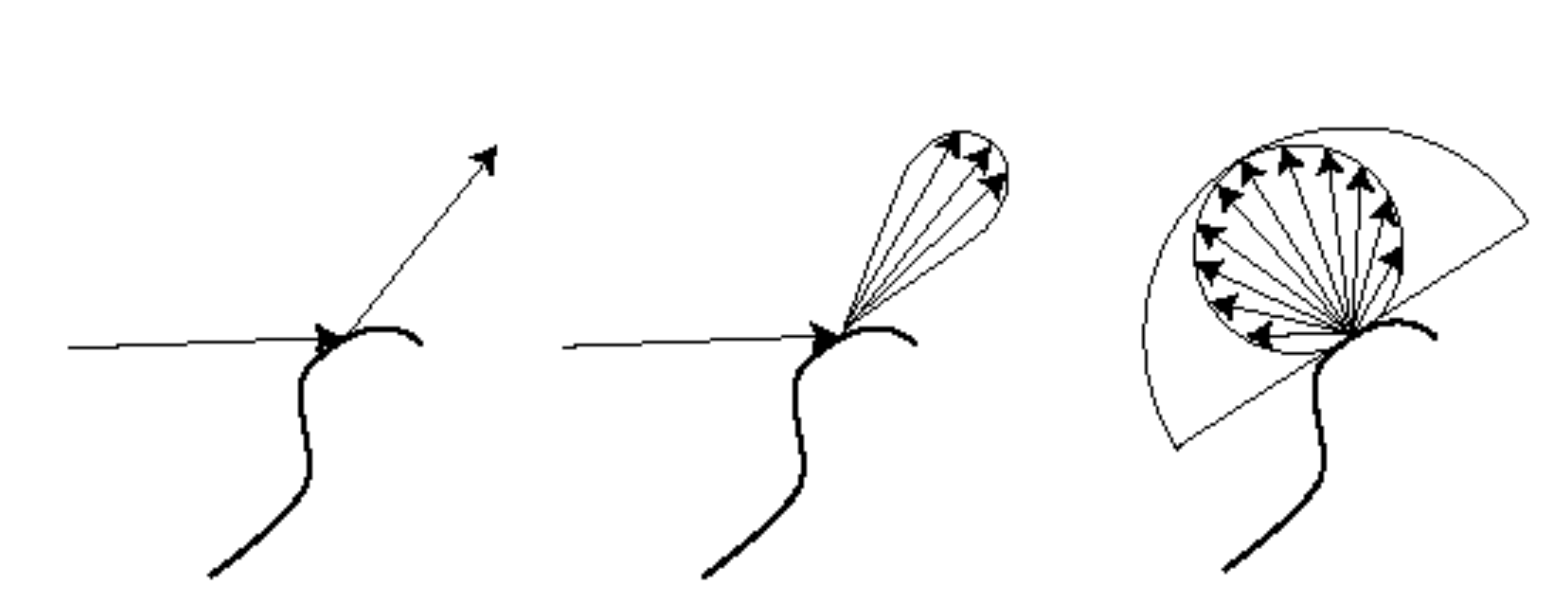
16 Soft Illumination Effects

Steve Marschner

CS5625 Spring 2019

Irradiance environment mapping



Akenine-Möller et al. *RTR 3e*

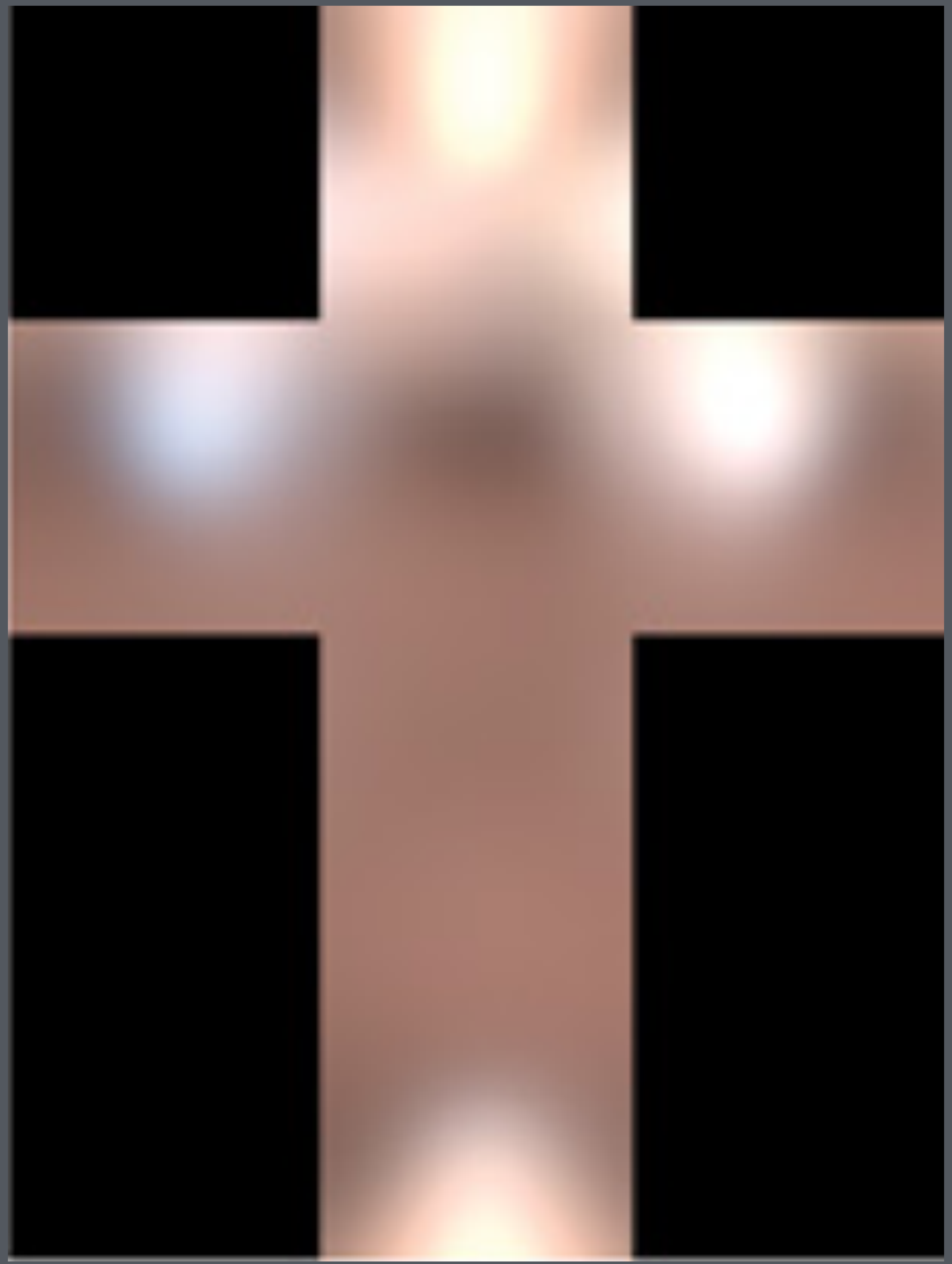
environment map
for specular surface

prefiltered map
for glossy surface

prefiltered map
for diffuse surface

Prefiltered environment map

environment map



prefiltered for Phong

Gary King in GPU Gems 2 http://http.developer.nvidia.com/GPUGems2/gpugems2_chapter10.html

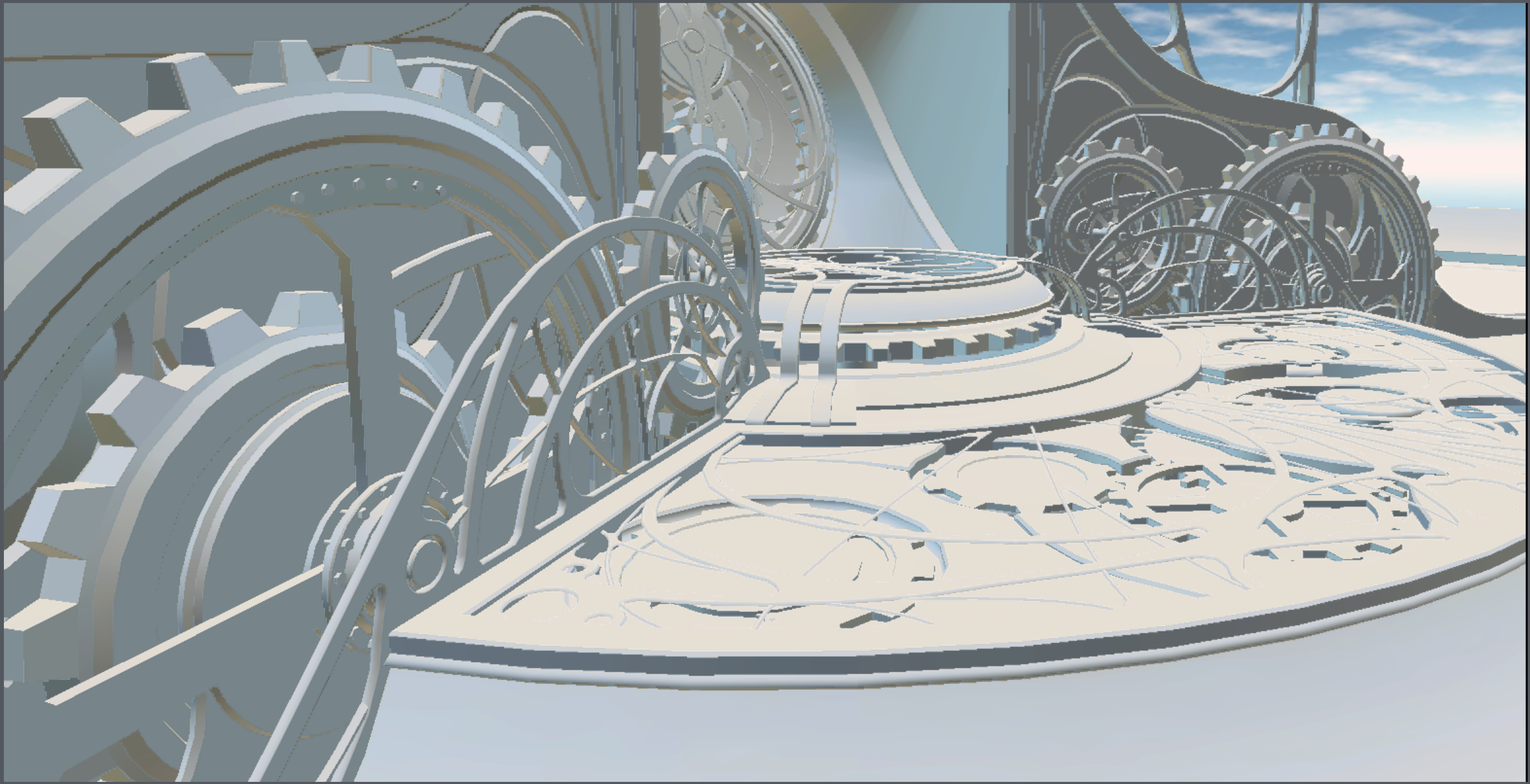
Irradiance environment map

environment map

irradiance map

Gary King in GPU Gems 2 http://http.developer.nvidia.com/GPUGems2/gpugems2_chapter10.html

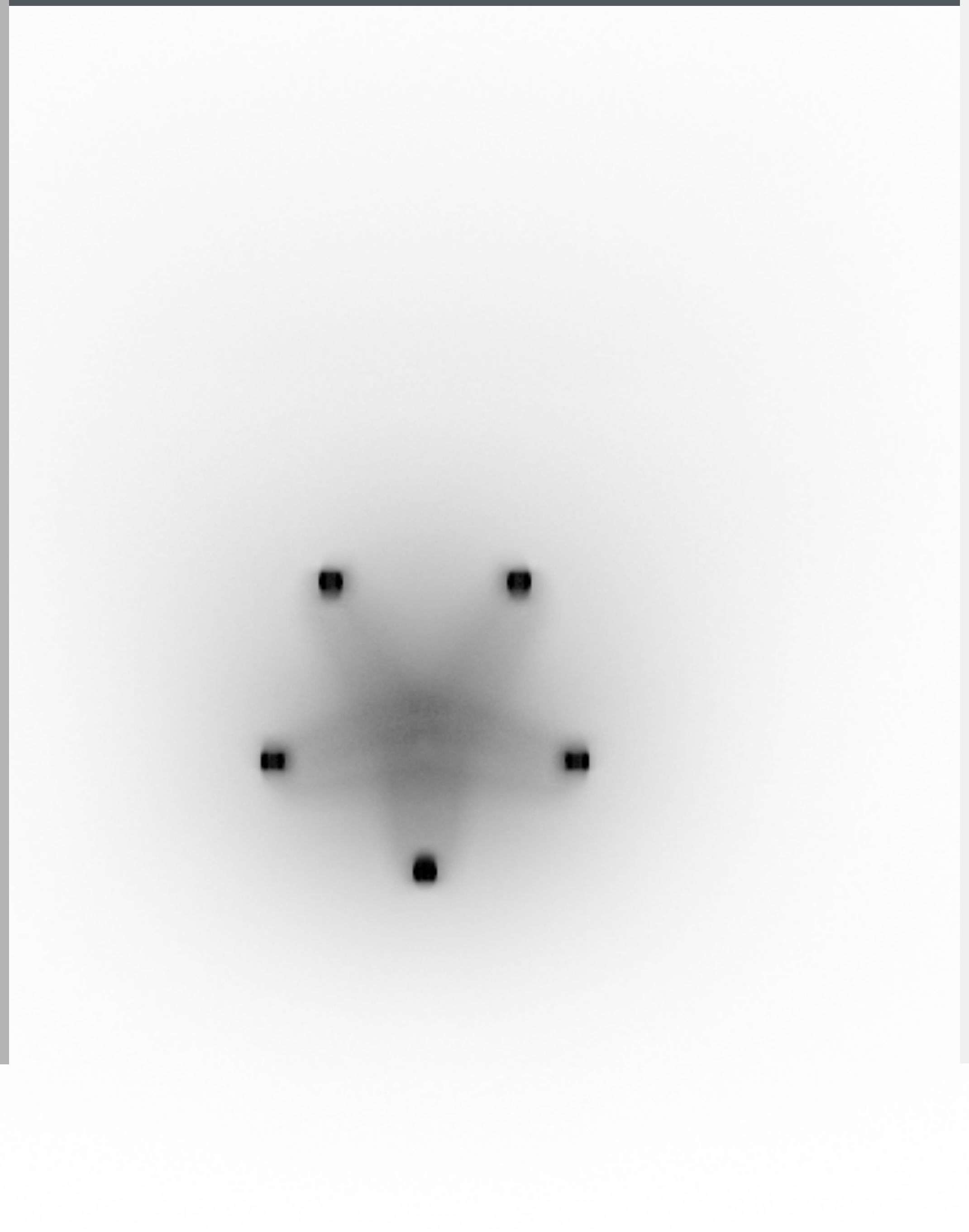
Irradiance map illumination



McGuire et al. HPG '11 10.1145/2018323.2018327

Shadow baking

Rendering with no shadows, darker diffuse floor

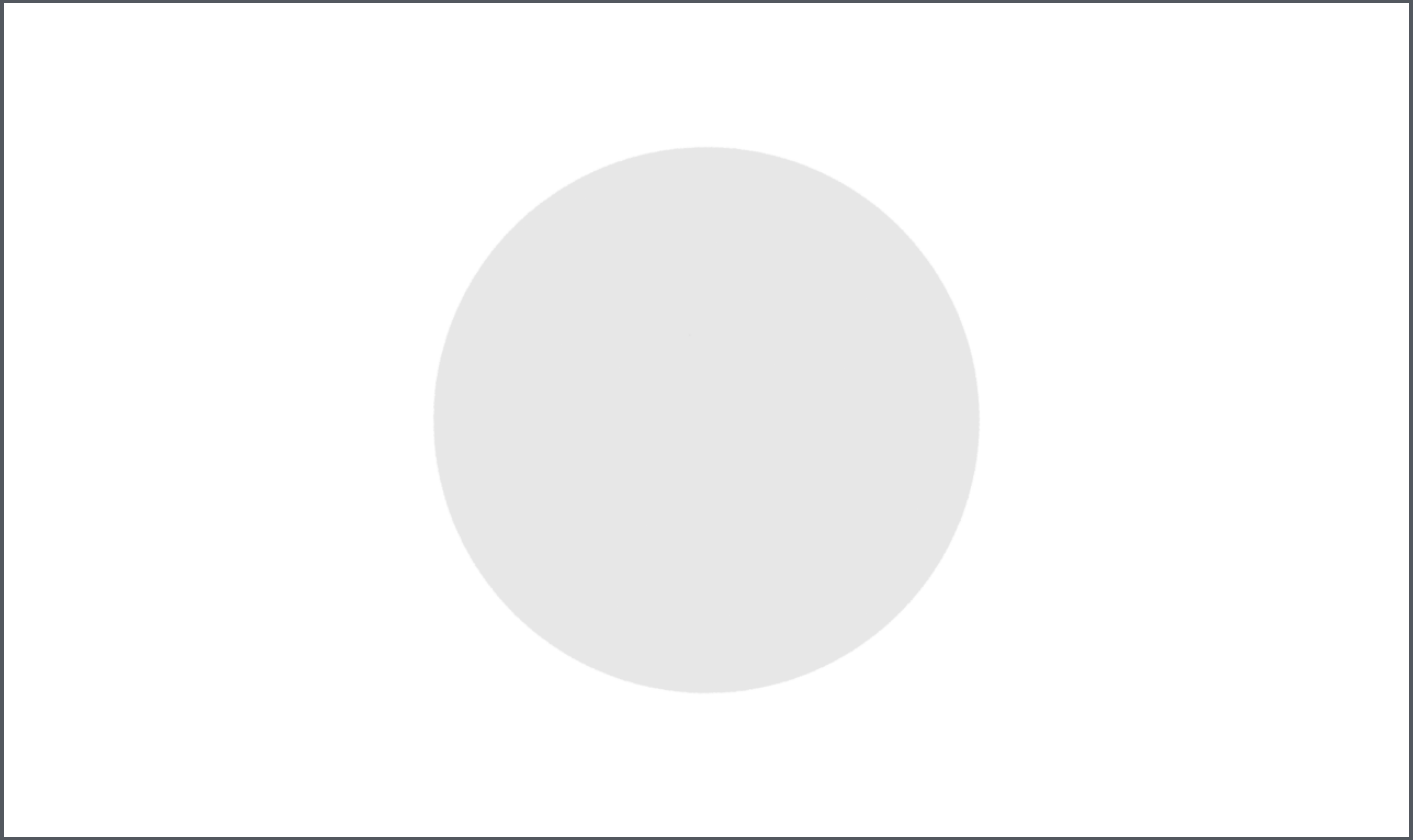


Irradiance texture computed using rectangular light

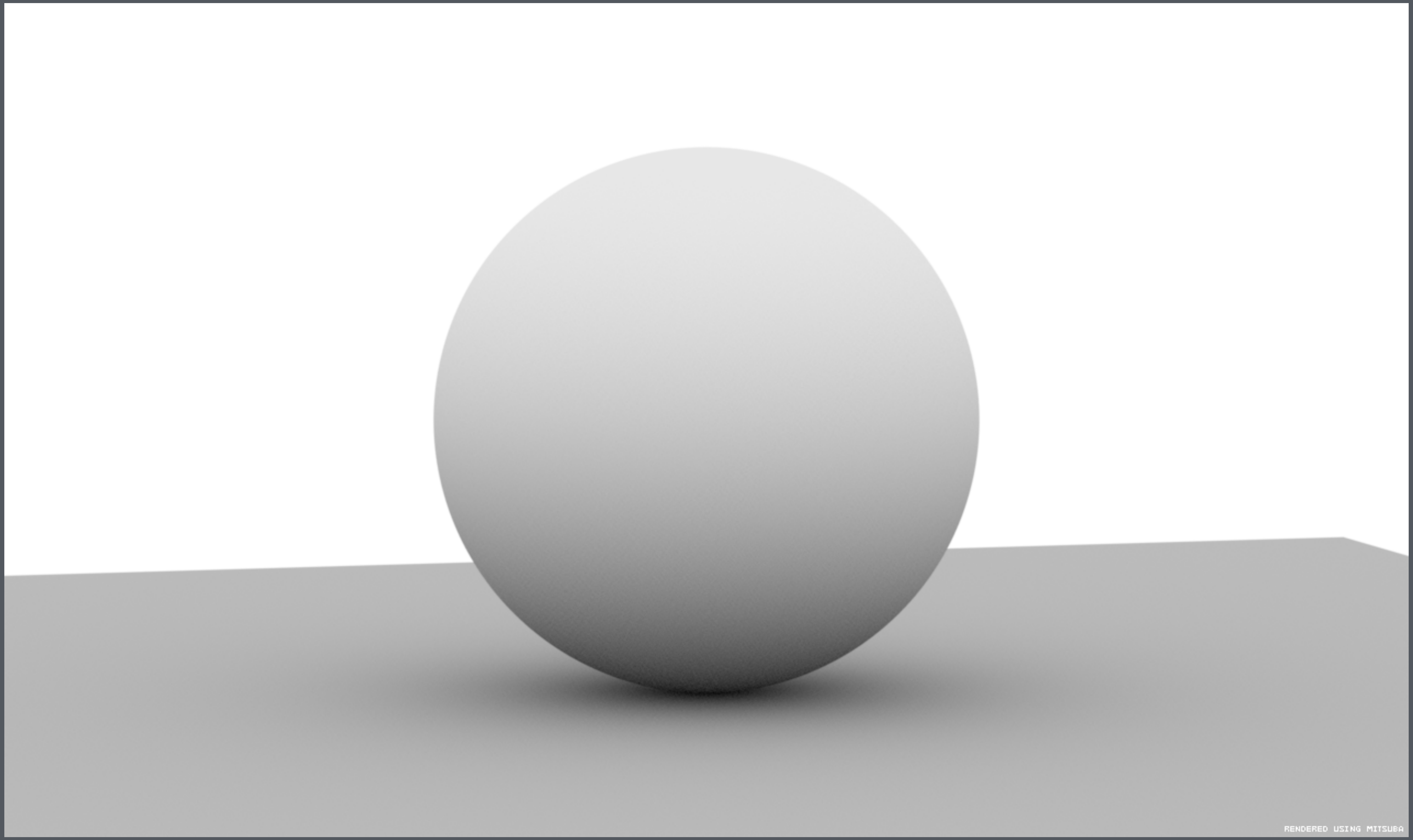
Floor shaded with irradiance from shadow texture

Irradiance map illumination

McGuire et al. HPG '11 10.1145/2018323.2018327

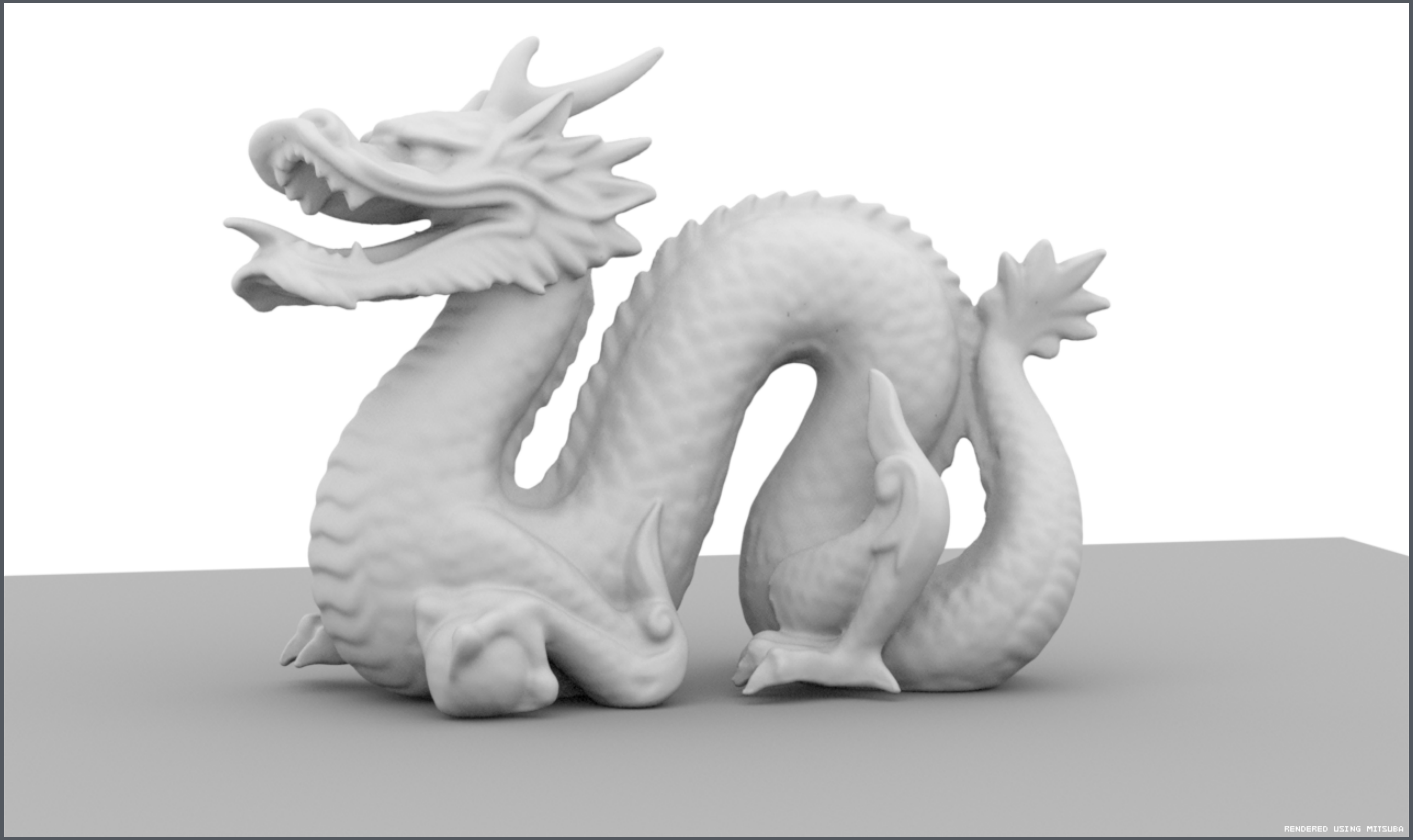


a convex diffuse object in a constant-radiance environment

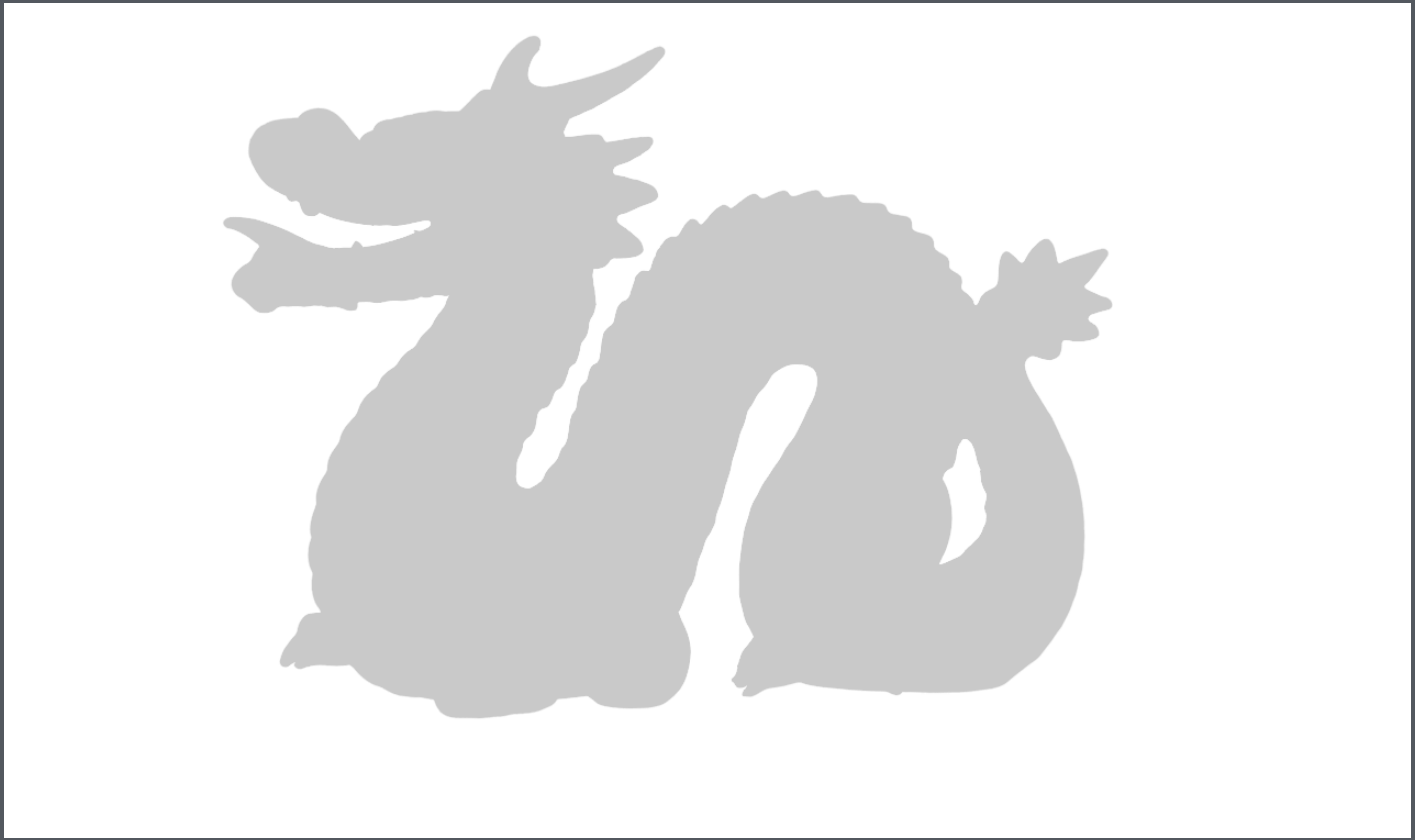


a non-convex diffuse scene under constant-radiance illumination

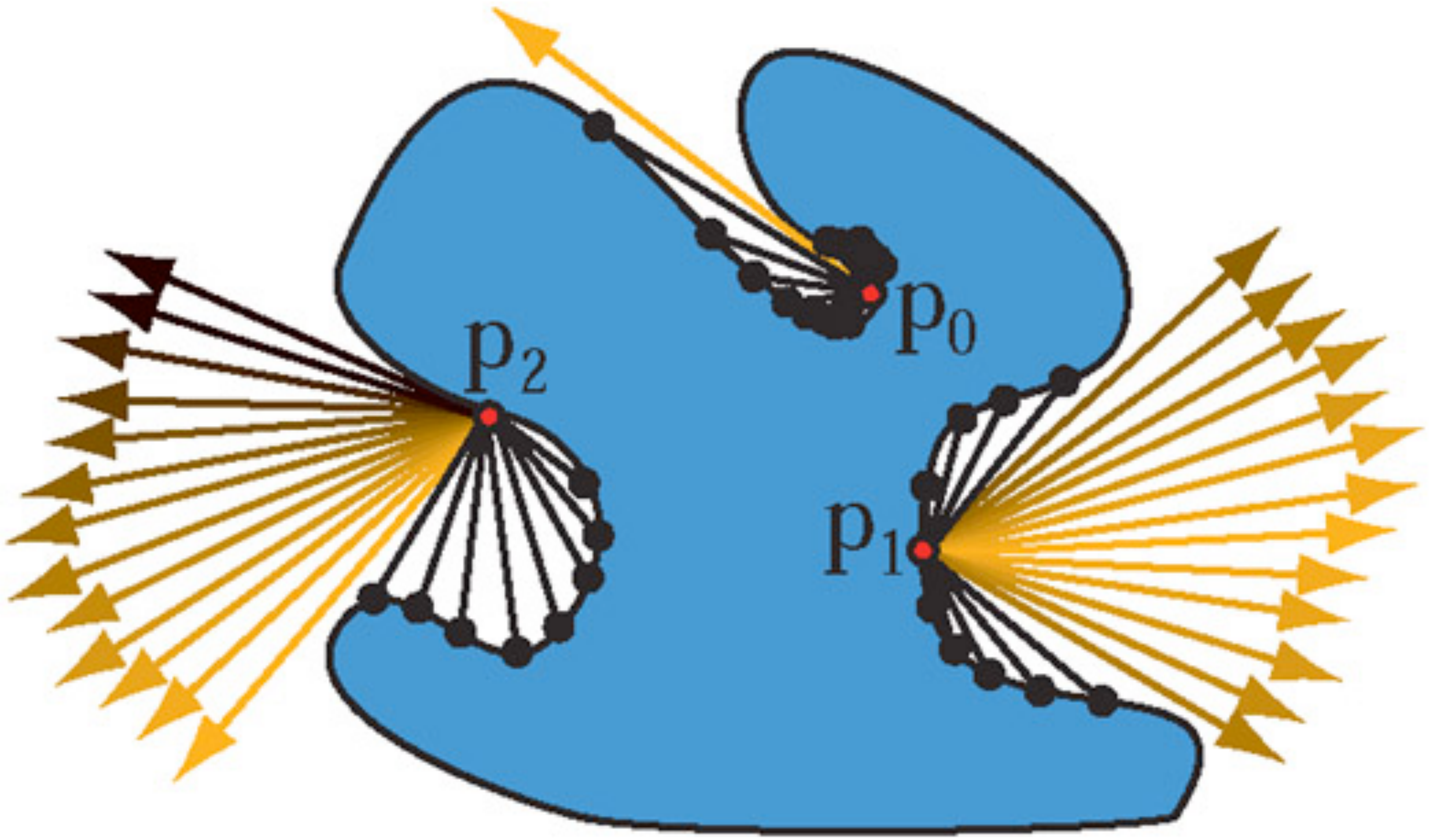
a non-convex diffuse object in a constant-radiance environment



a non-convex diffuse scene under constant-radiance illumination

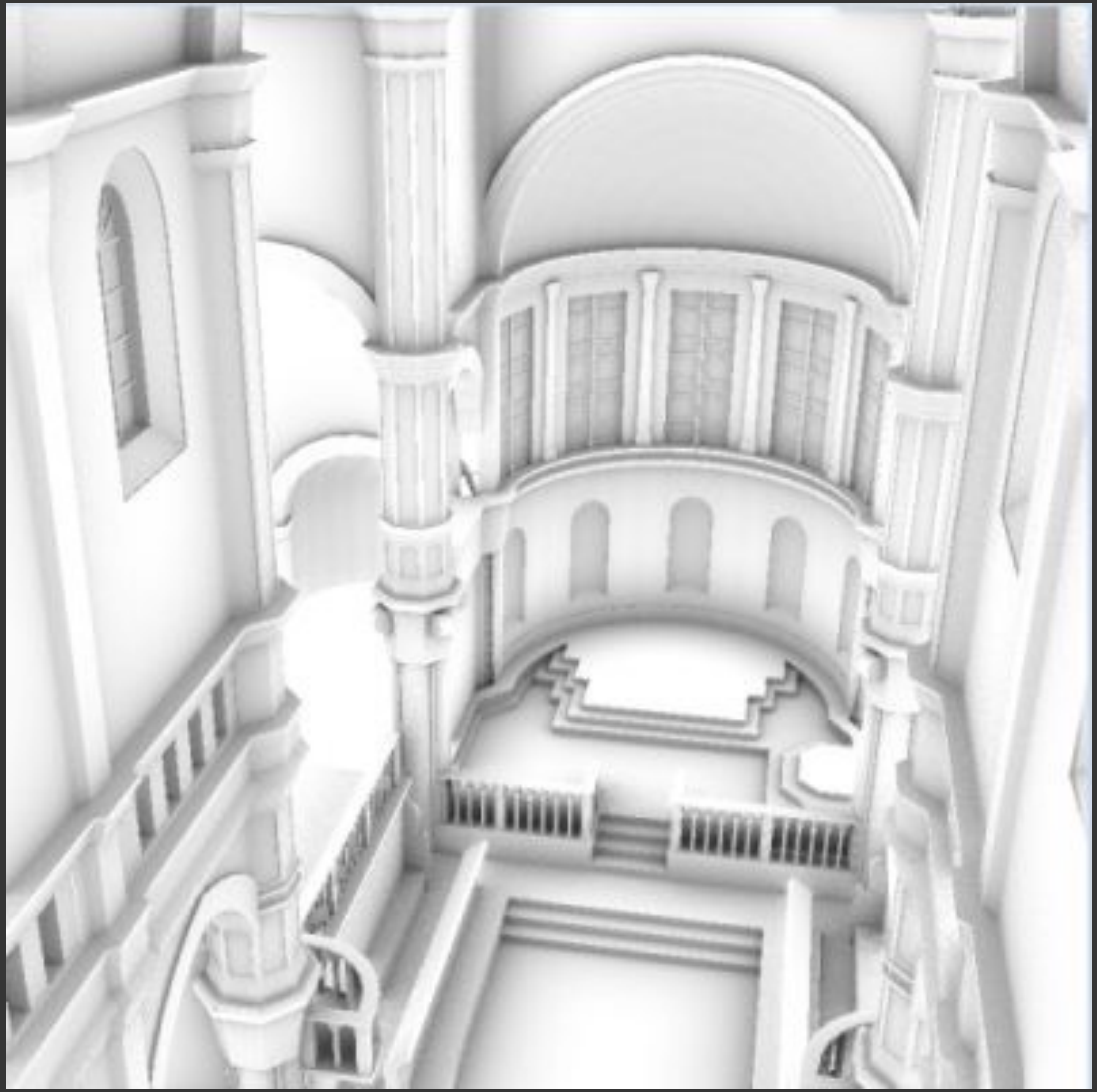


object in a constant-radiance environment with no shadowing



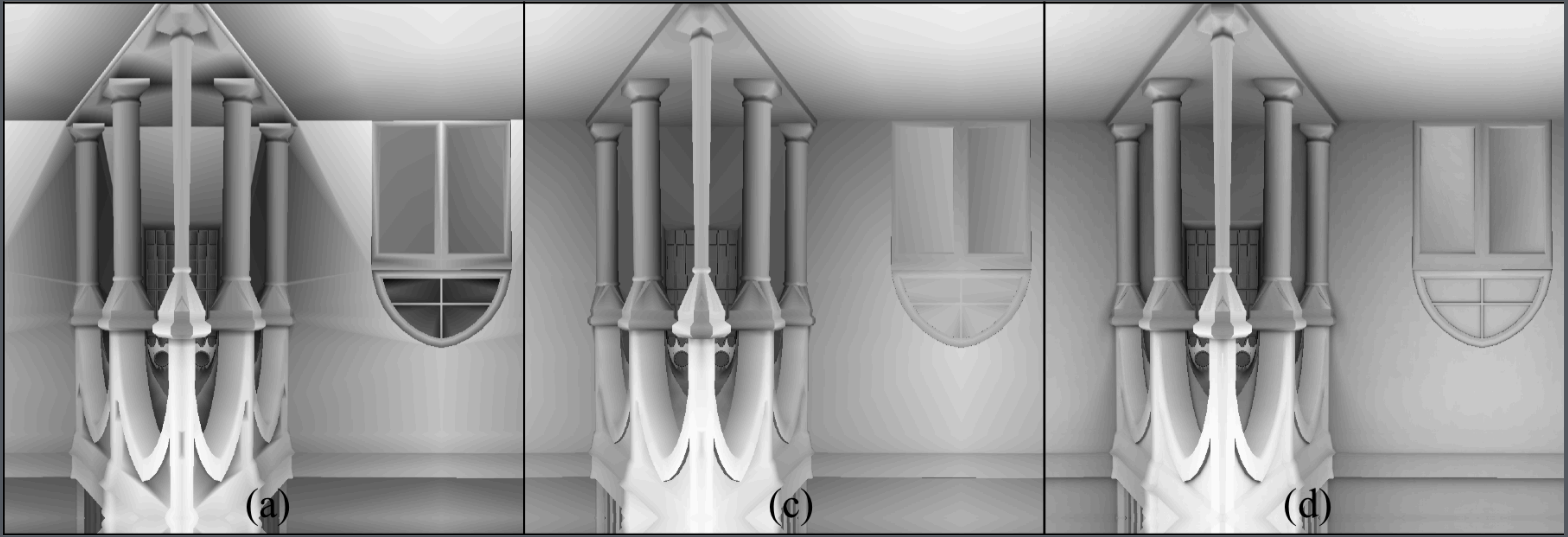
Akenine-Möller et al. *RTR 3e*

AO Maps



slide courtesy of Kavita Bala, Cornell University

Ray traced vertex AO



ambient occlusion sampled at vertices, interpolated as vertex color

ambient occlusion sampled inside triangles, vertex values fit to samples, interpolated as vertex color

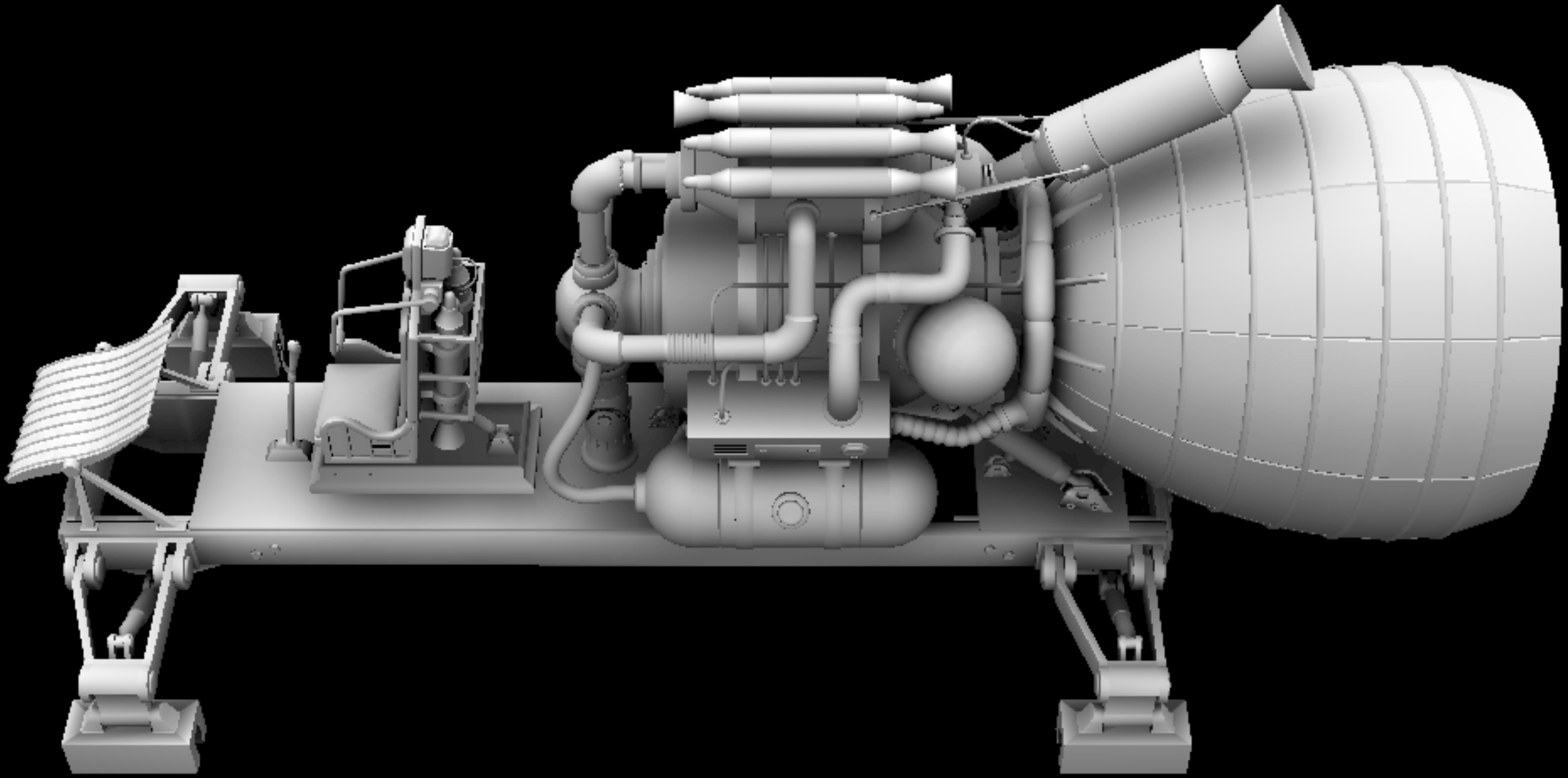
ambient occlusion computed at each pixel (ground truth)

Kavan et al. EGSR 2011

NVIDIA OptiX implementation images

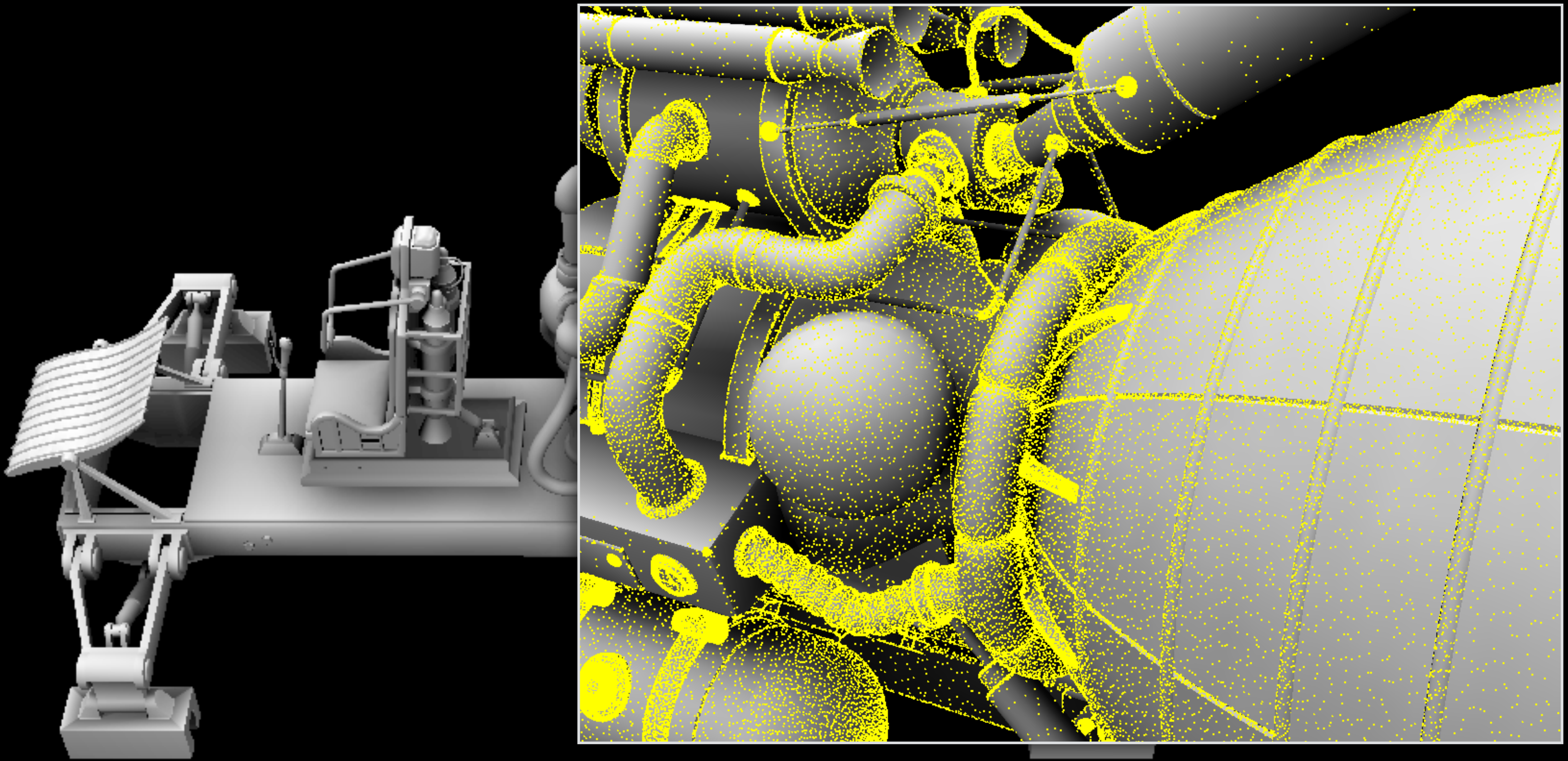
https://developer.nvidia.com/optix-prime-baking-sample

NVIDIA OptiX implementation images



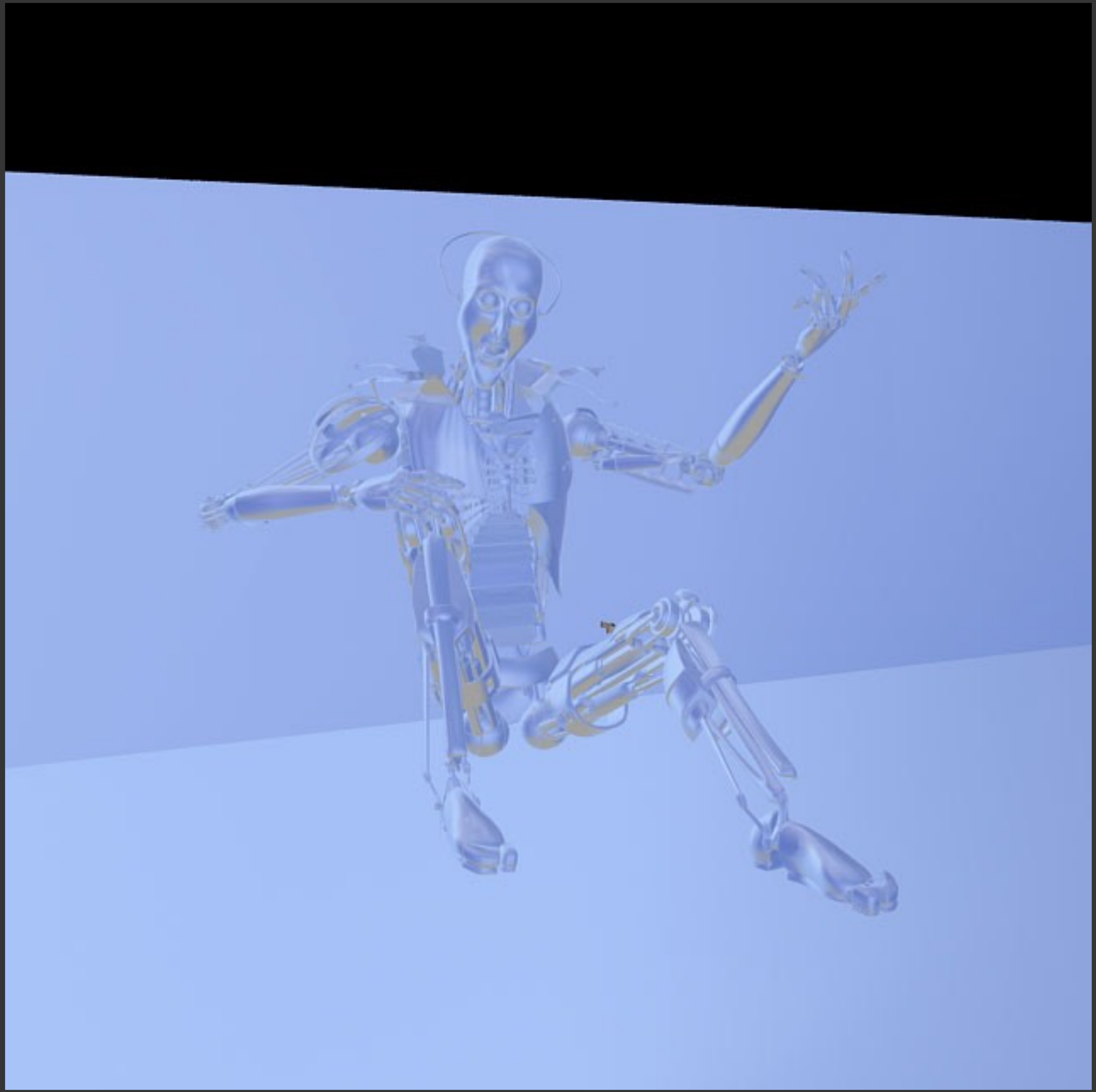
https://developer.nvidia.com/optix-prime-baking-sample

NVIDIA OptiX implementation images



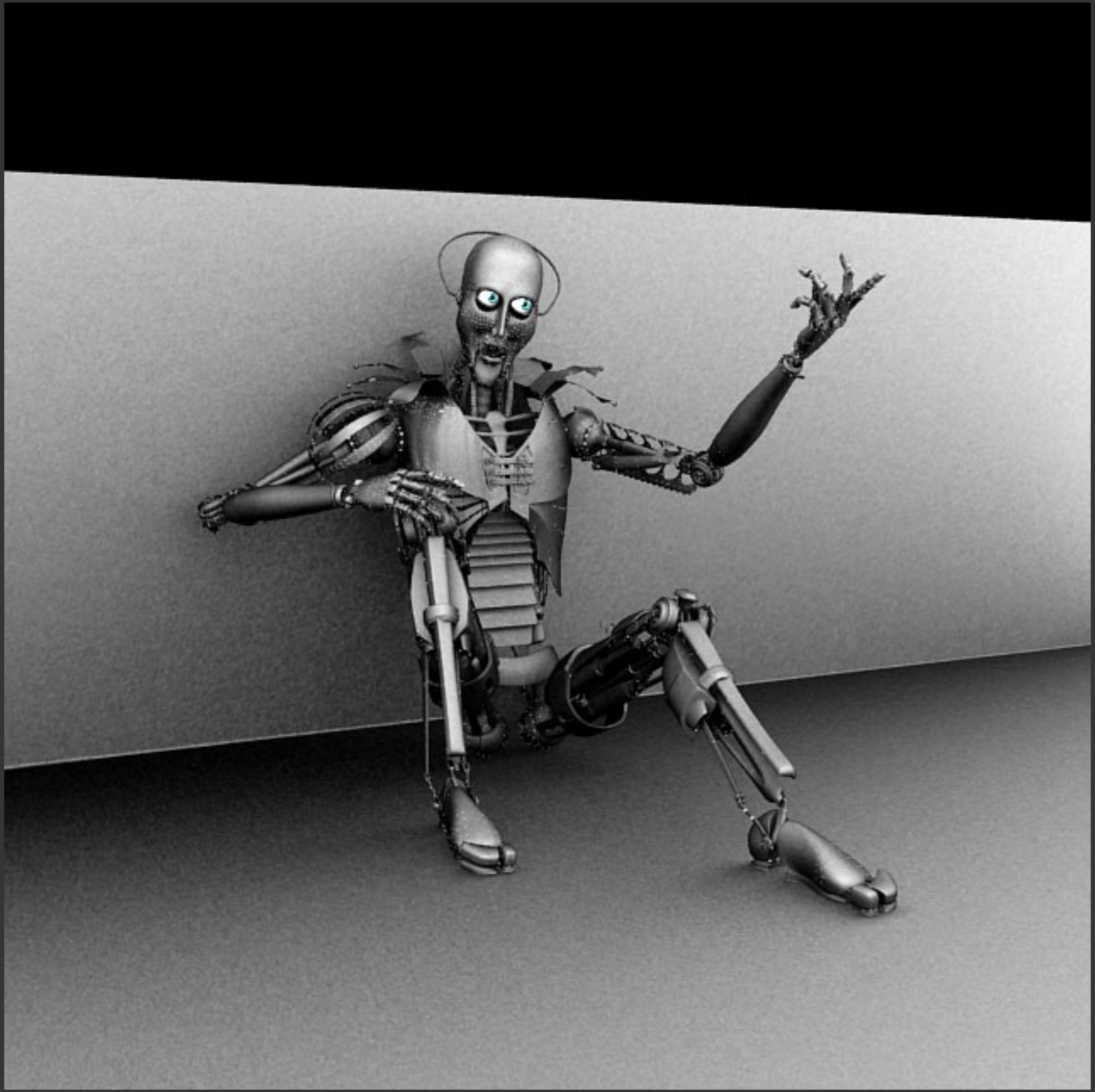
https://developer.nvidia.com/optix-prime-baking-sample

EnvMap



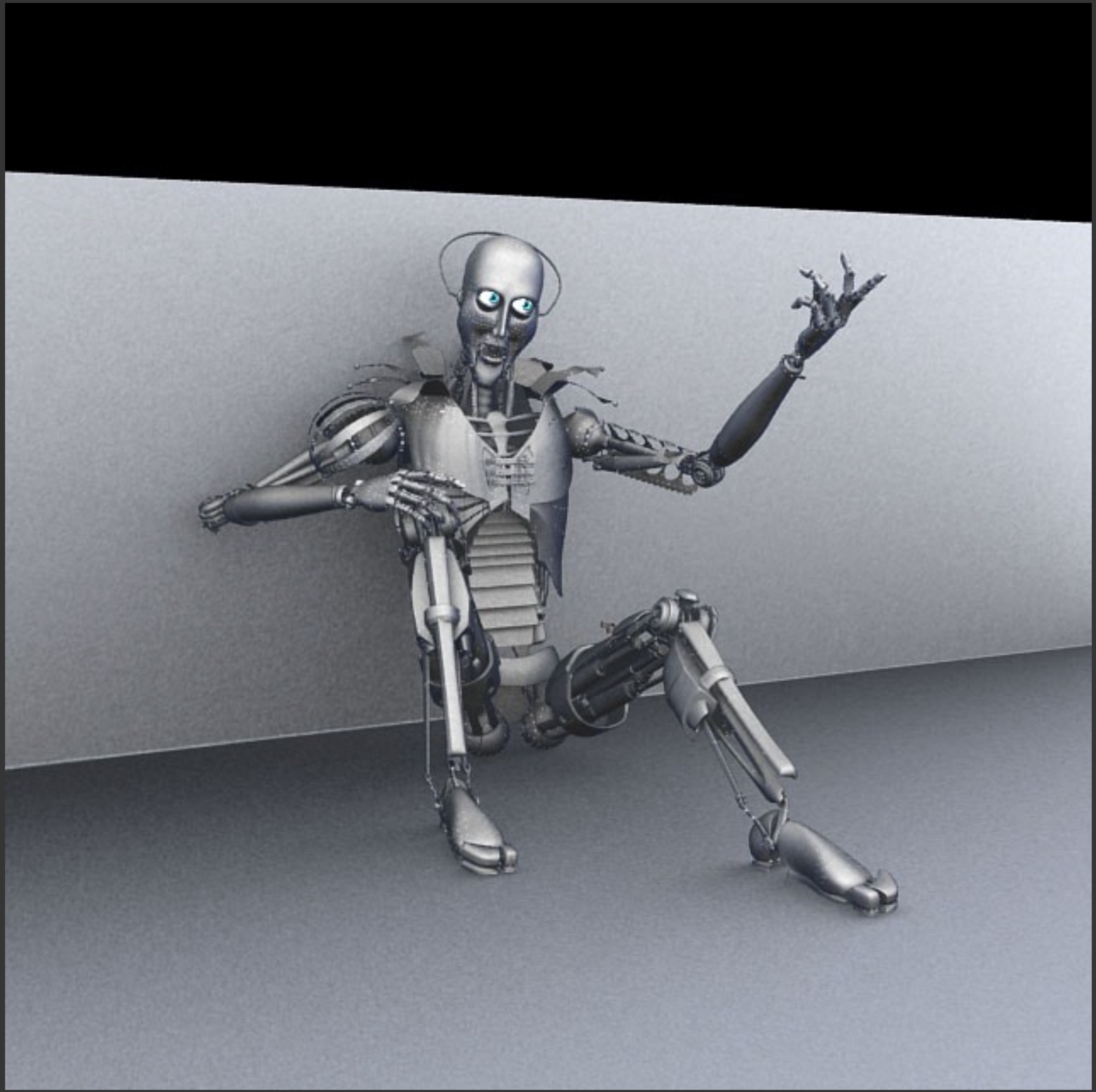
slide courtesy of Kavita Bala, Cornell University

AO



slide courtesy of Kavita Bala, Cornell University

Total



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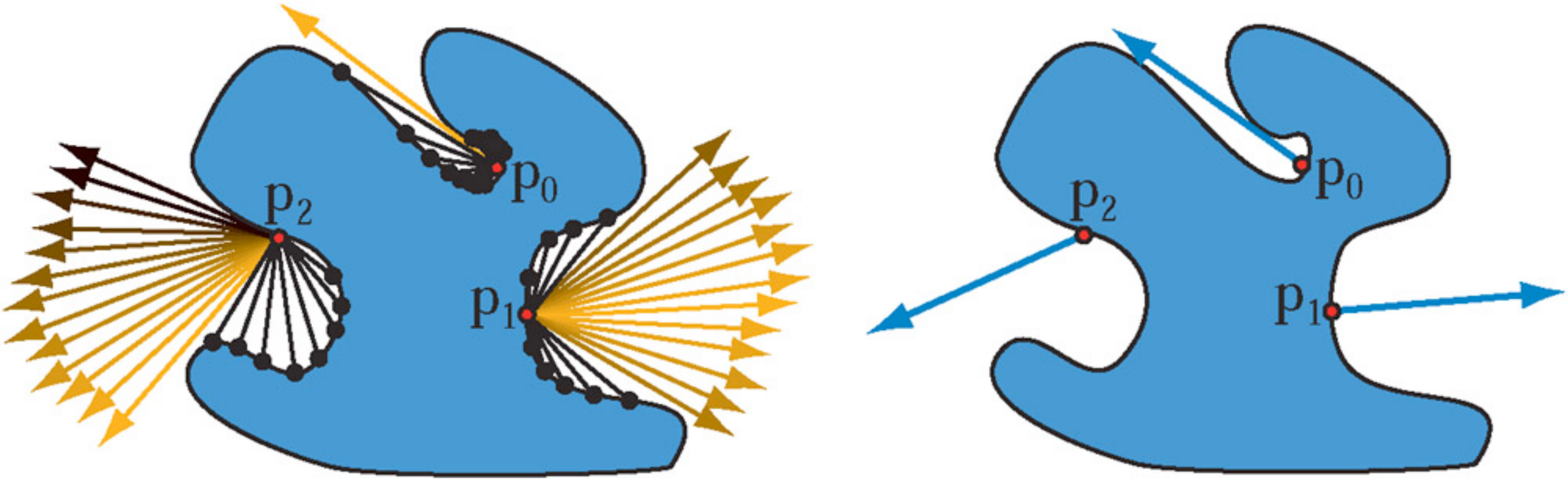
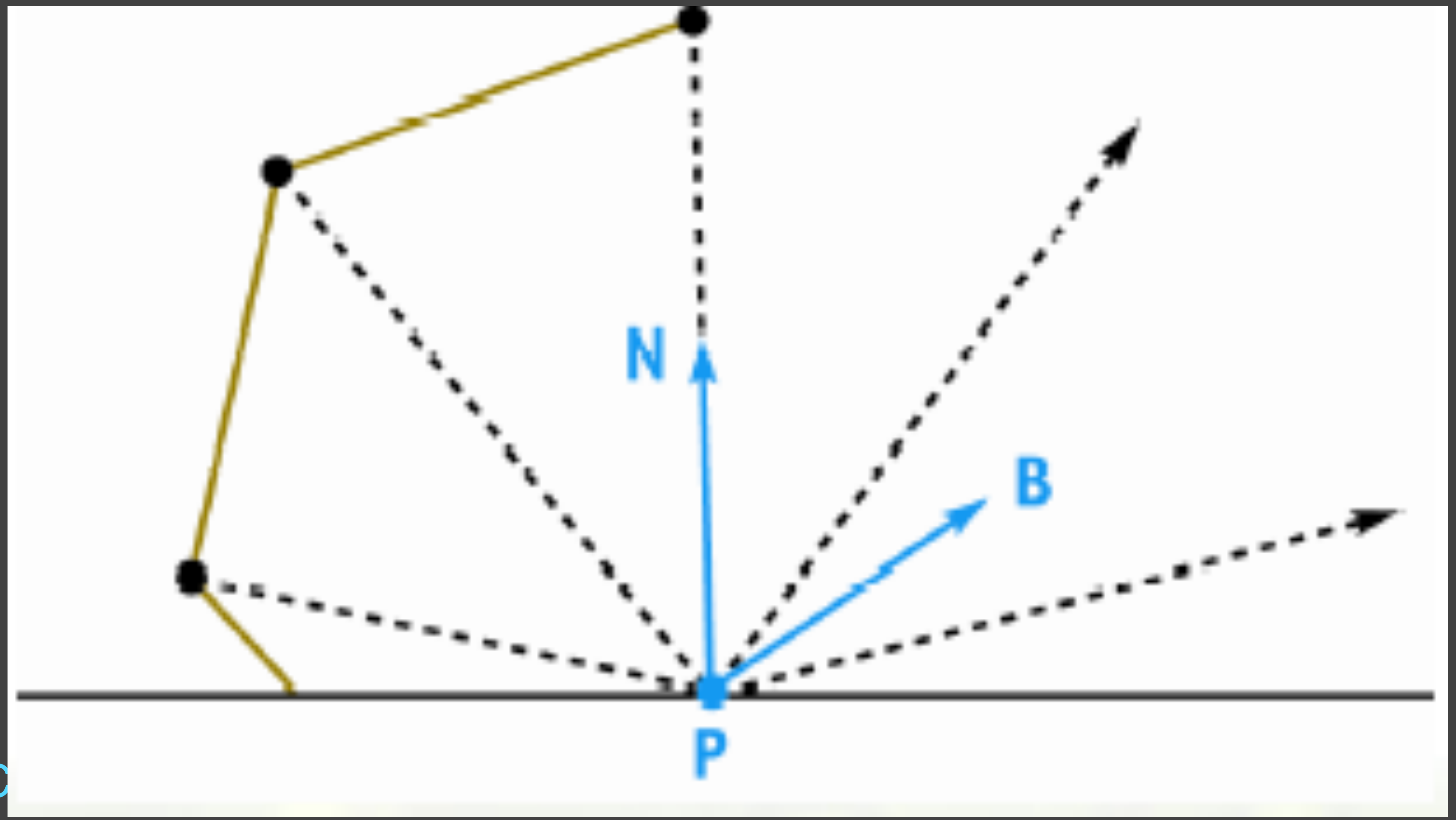


Akenine-Möller et al. *RTR 3e*

Ambient Occlusion: Improvement

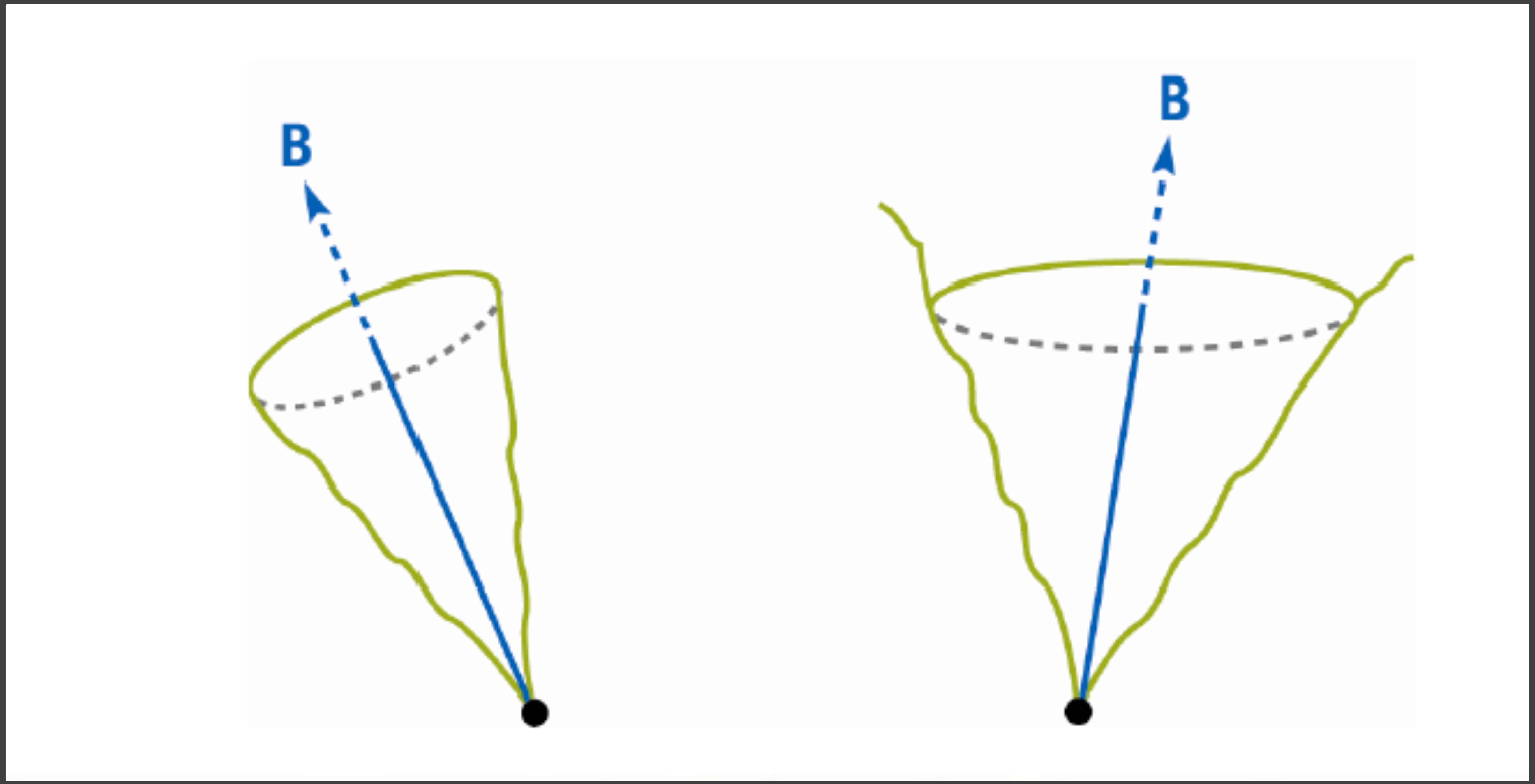
- At each point find
  - Fraction of hemisphere that is occluded
  - Also, average unoccluded direction B
    - (bent normal)
    - Use B for lighting (see later)



slide courtesy of Kavita Bala, C

What about B?

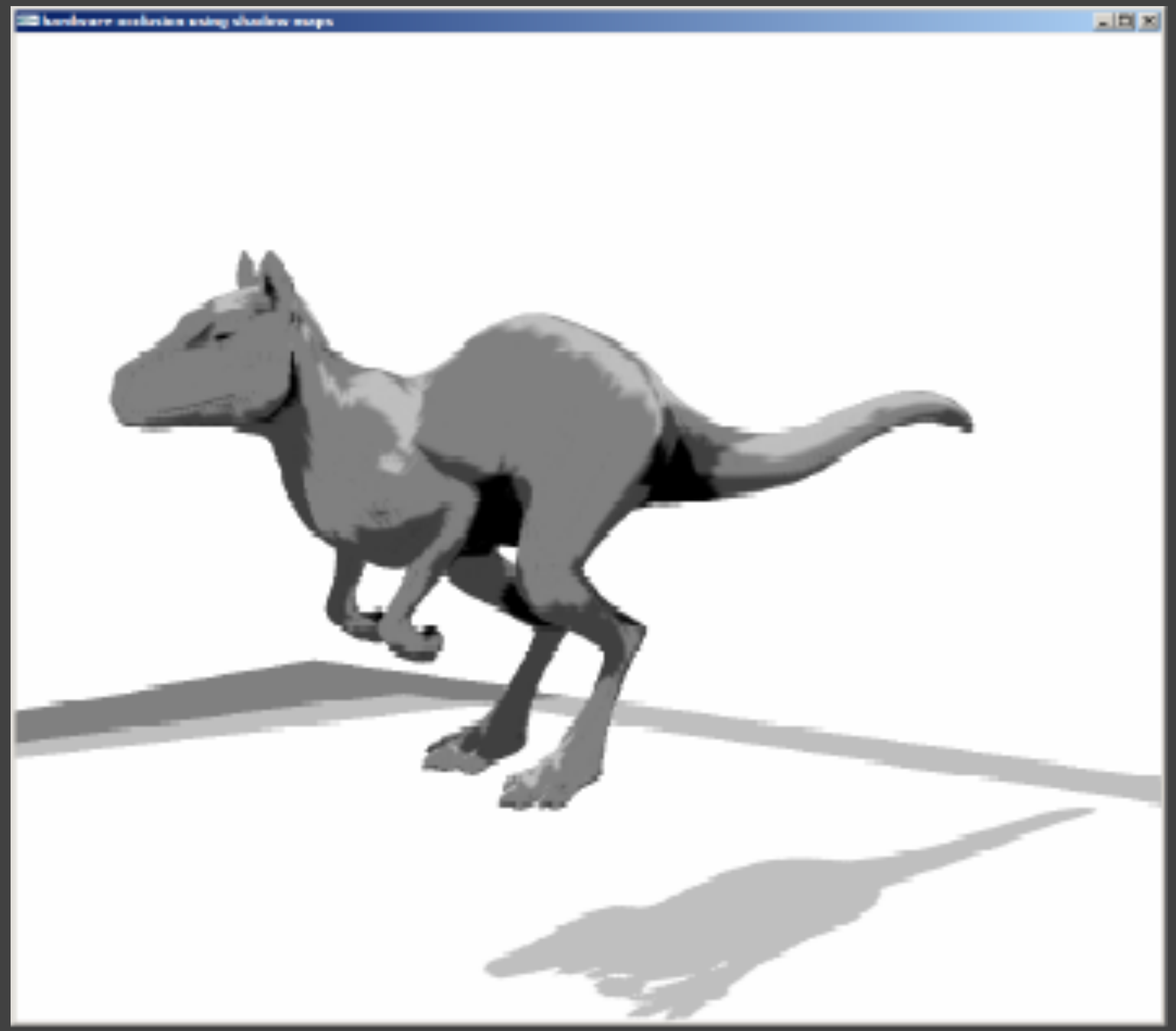
- The unoccluded direction gives an idea of where the main illumination is coming from



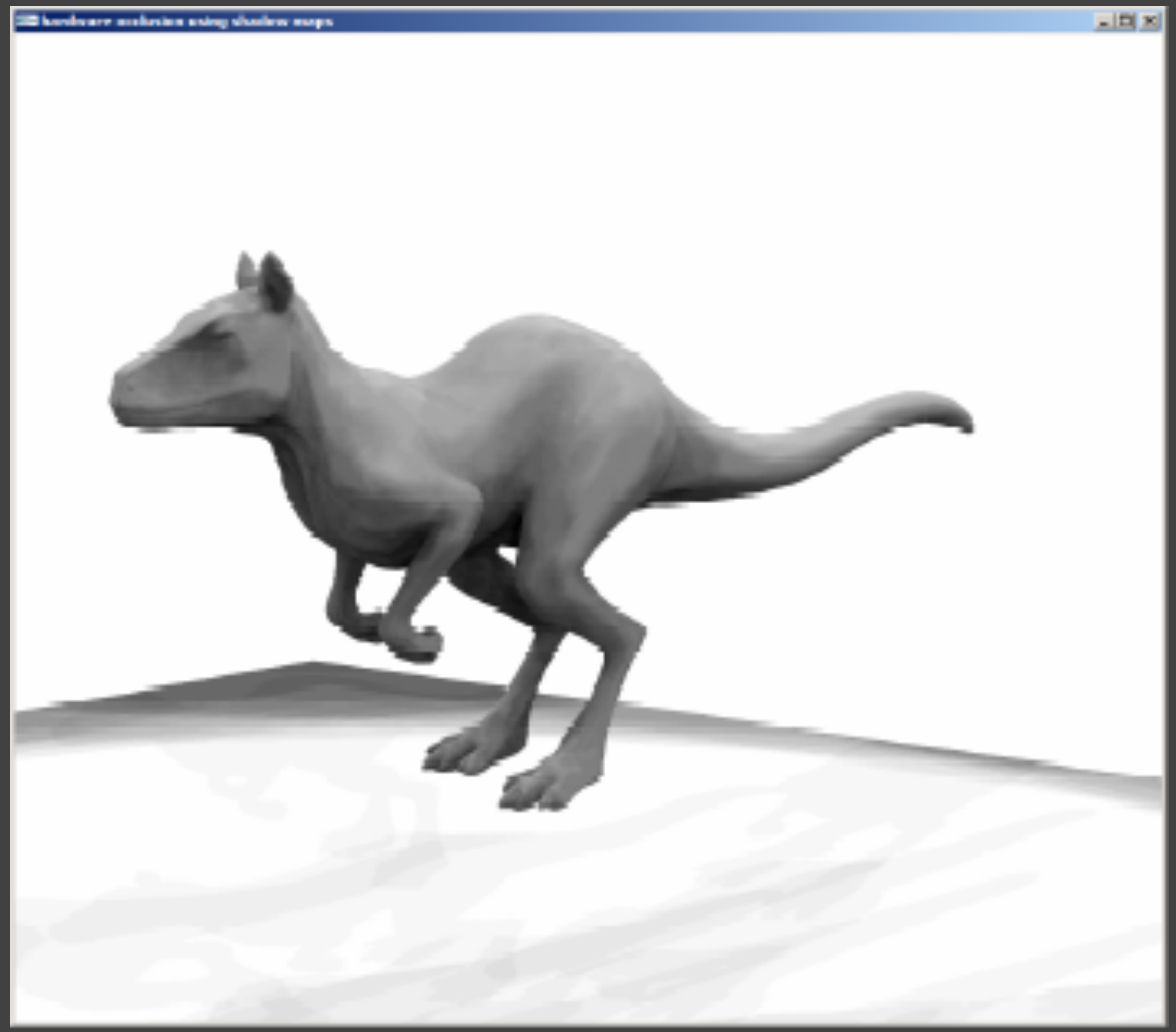
slide courtesy of Kavita Bala, Cornell University

Computing AO using shadow maps

- Create shadow maps from N point lights on sphere
- Check visibility of point wrt each light and determine occlusion: accumulation buffer



4 samples



32 samples

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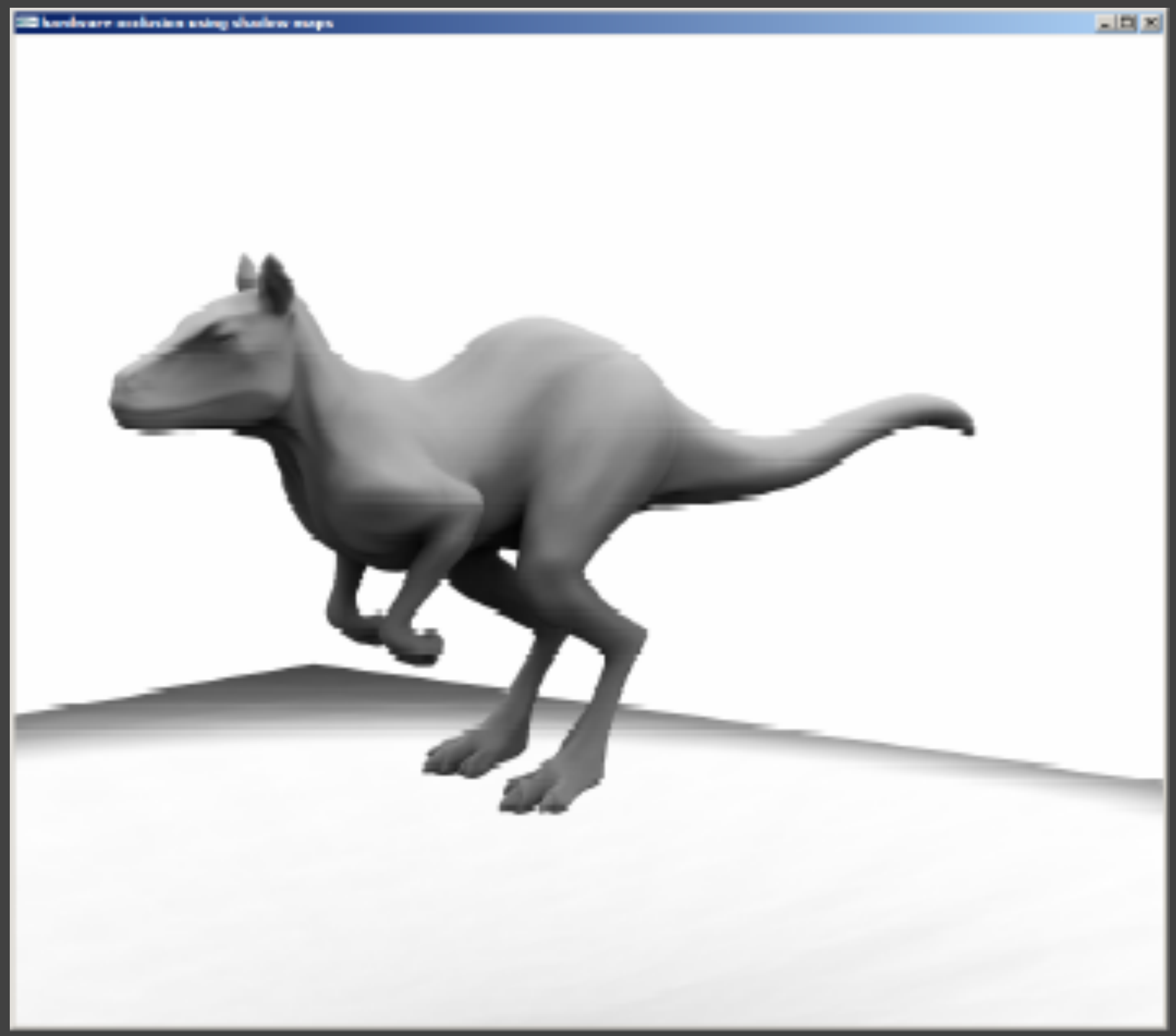
Computing the values: SM



512 samples

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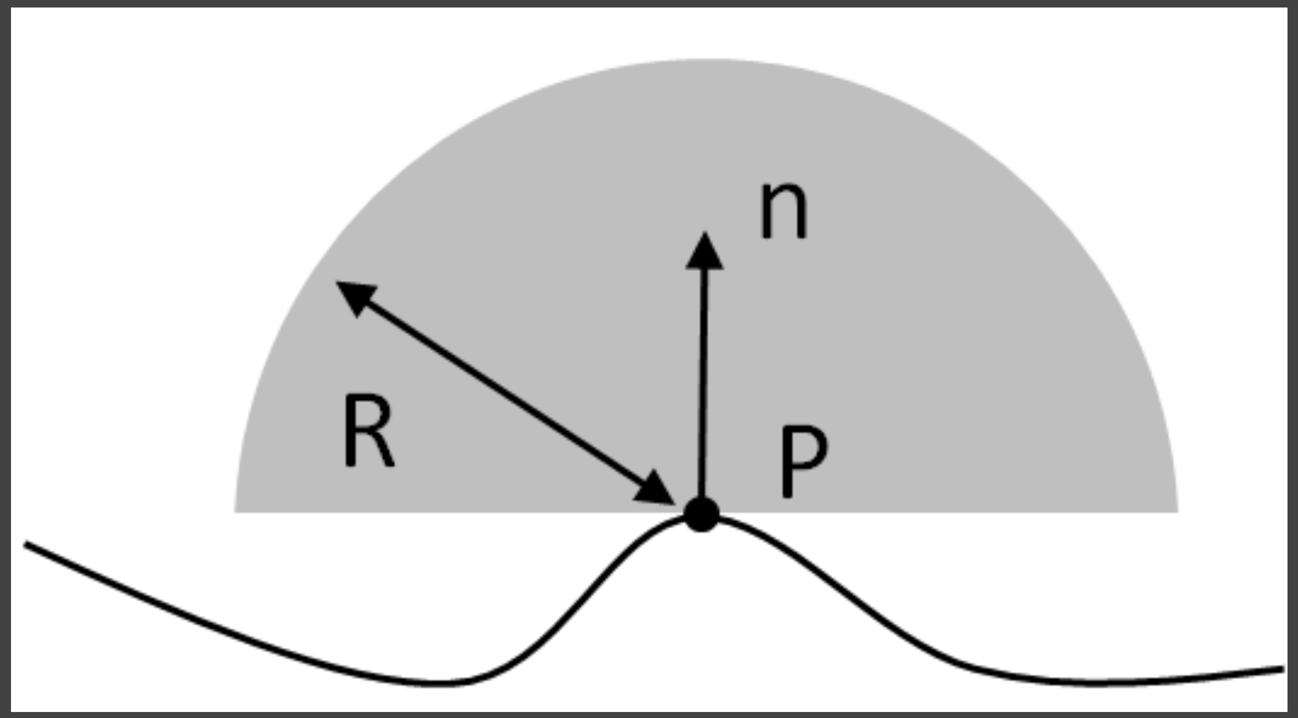
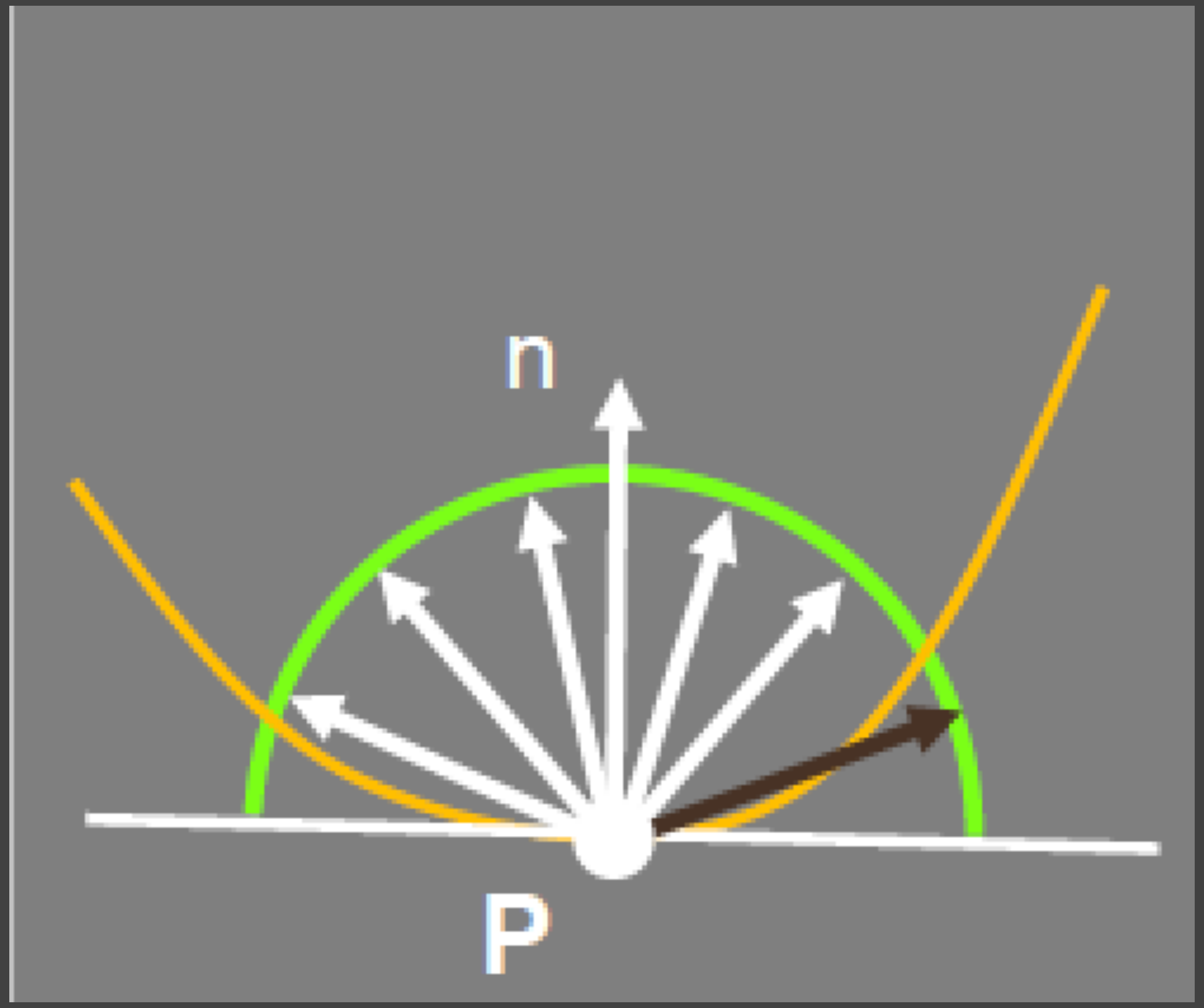
SSAO

- Restrict the hemisphere
  - Why? Think of AO in box

- Typically add a drop-off as you get to the hemisphere boundary





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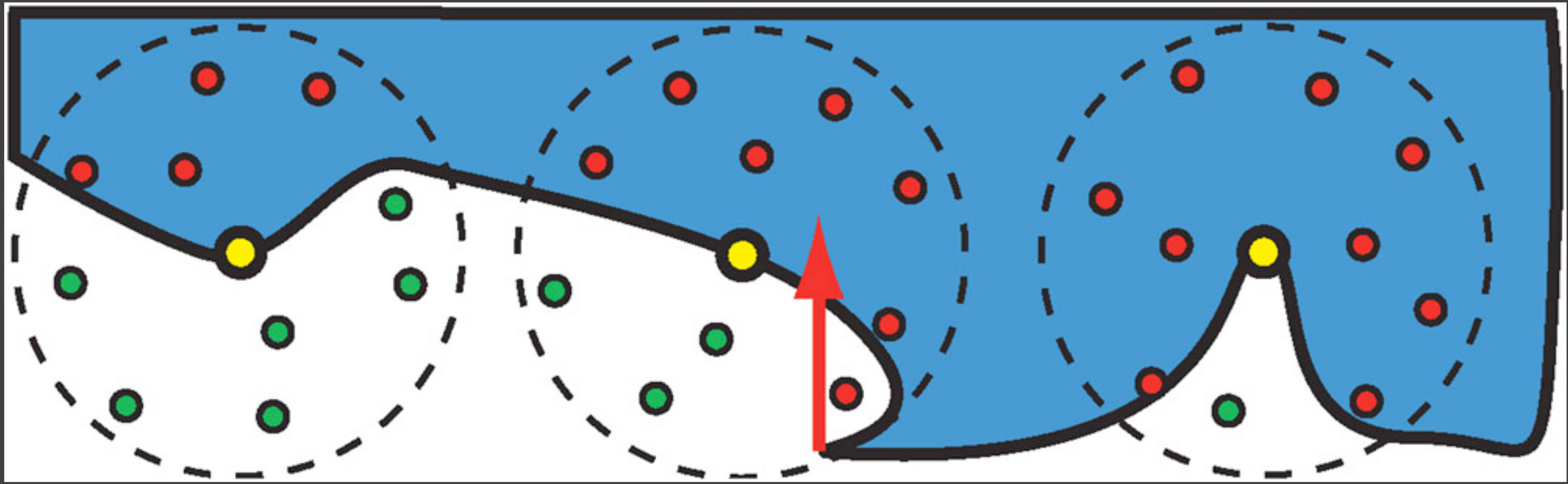
Crytek for Crisis: SSAO

- Take z-buffer
- Consider sphere around a point p



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Martin Mittring, Crysis GmBH http://crytek.com/cryengine/presentations/finding-next-gen-cryengine--2

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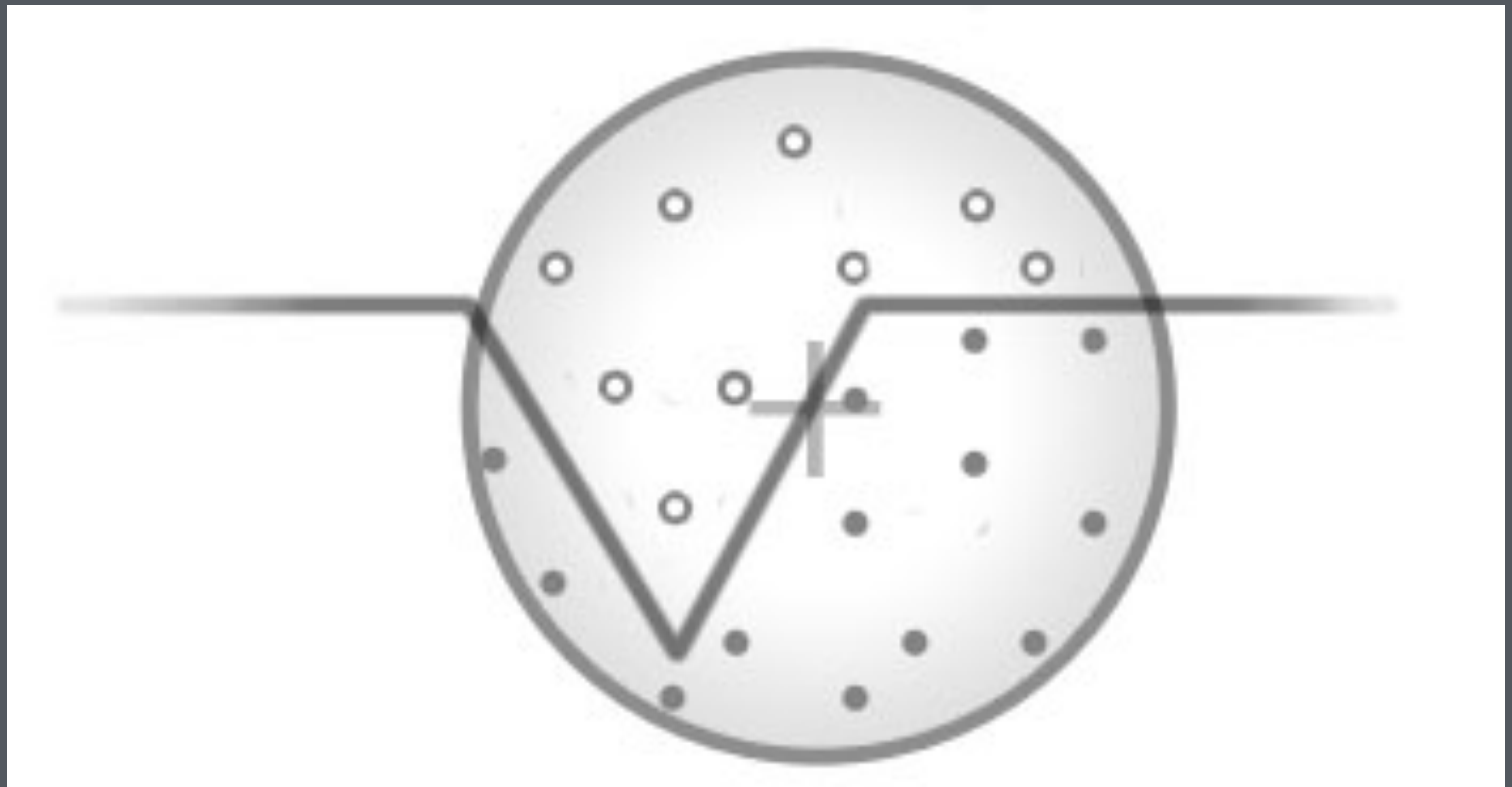
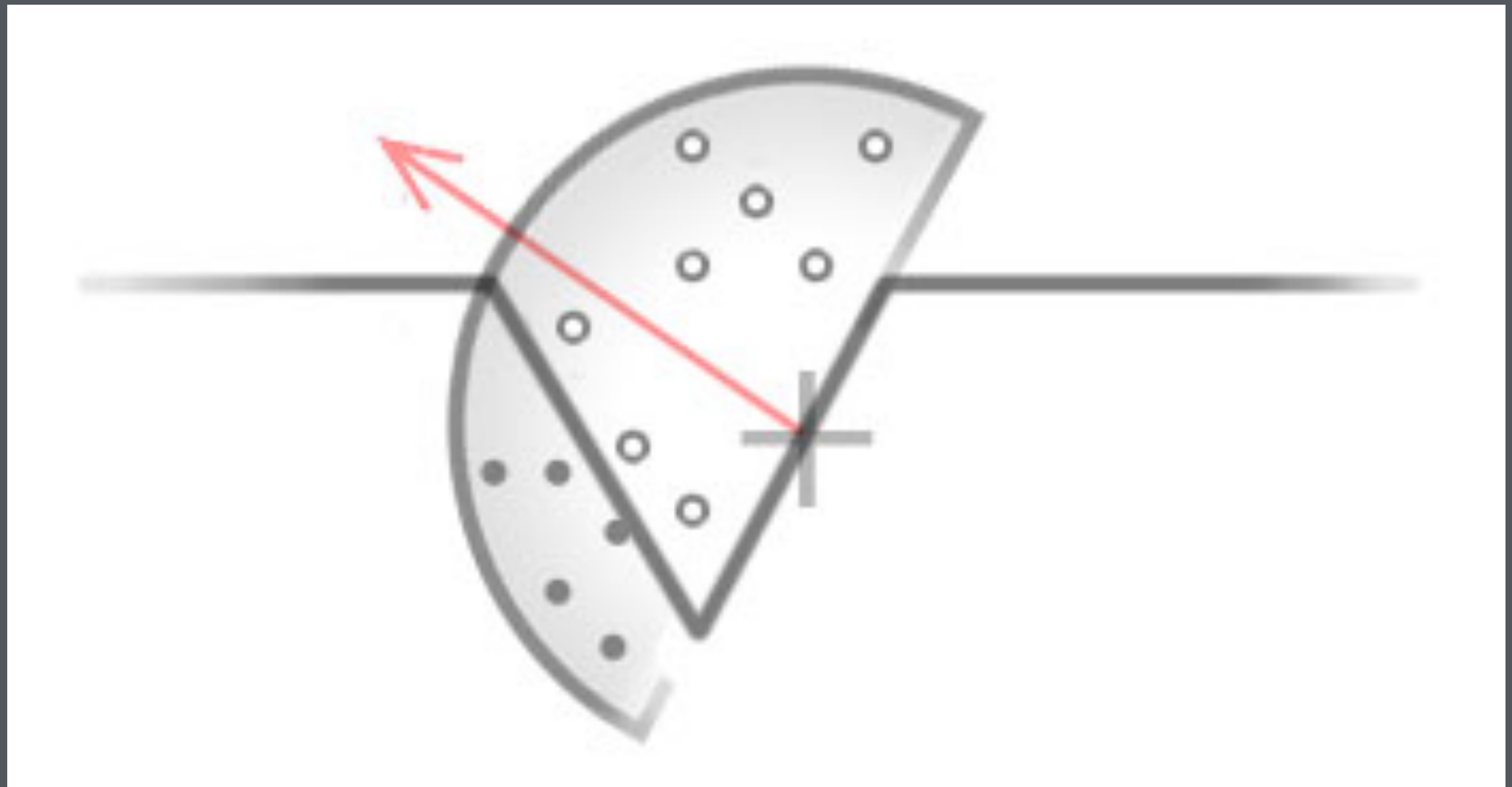
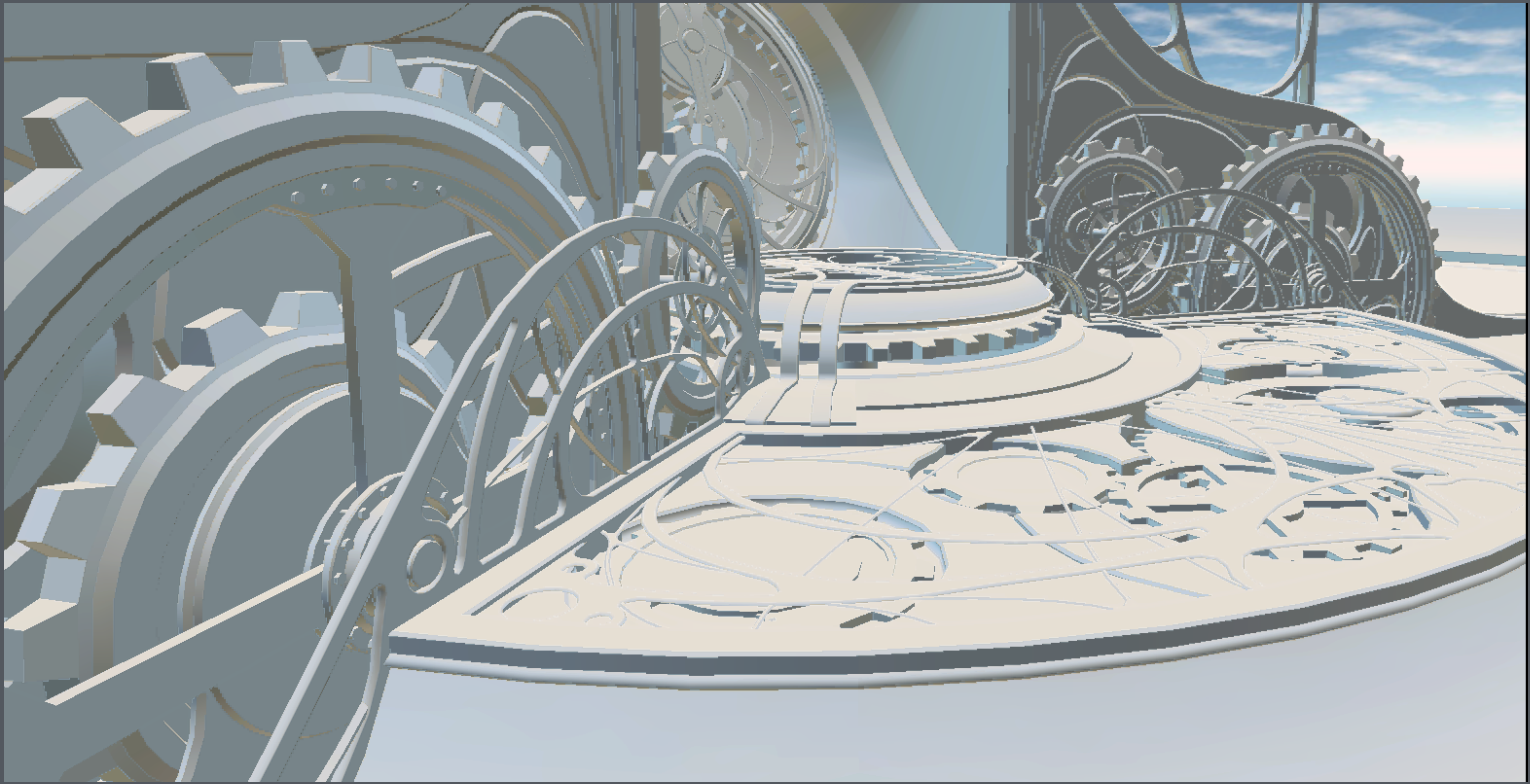
Hemisphere vs. Sphere





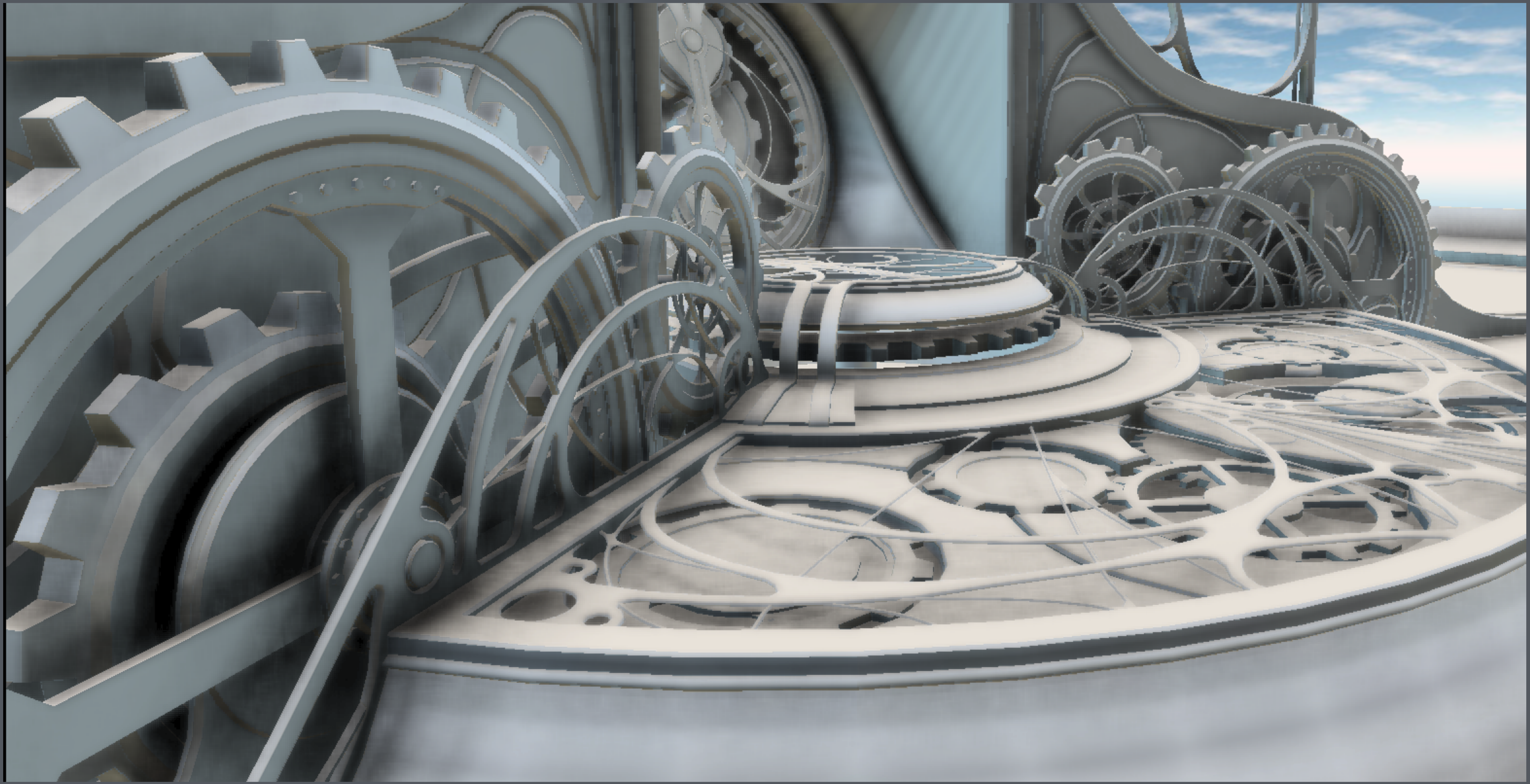
John Chapman http://john-chapman-graphics.blogspot.co.uk/2013/01/ssao-tutorial.html

Irradiance map + SSAO



McGuire et al. HPG ’11 10.1145/2018323.2018327

Irradiance map + SSAO



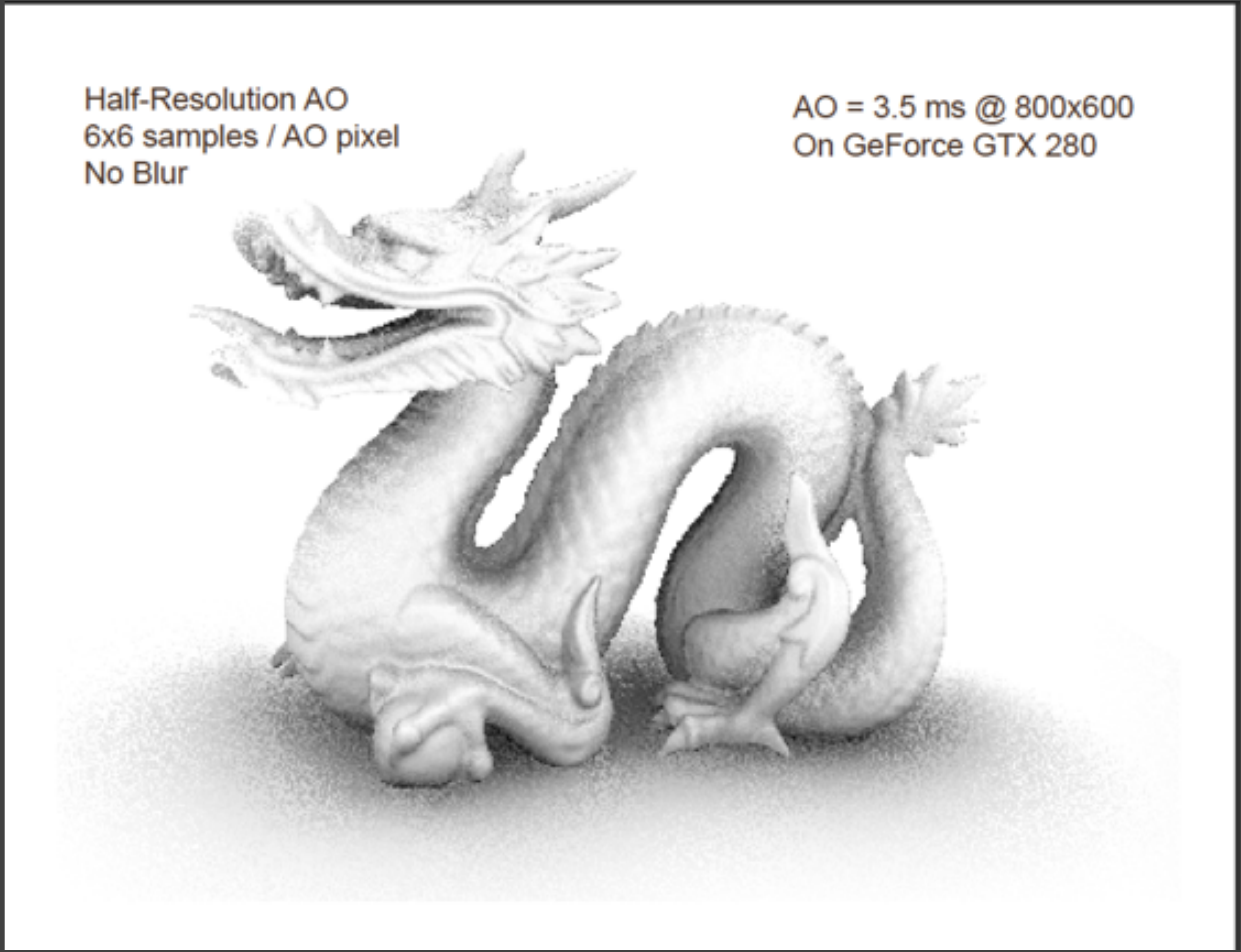
McGuire et al. HPG ’11 10.1145/2018323.2018327

Irradiance map + SSAO

McGuire et al. HPG '11 [10.1145/2018323.2018327](https://doi.org/10.1145/2018323.2018327)

Irradiance map + SSAO

McGuire et al. HPG '11 10.1145/2018323.2018327



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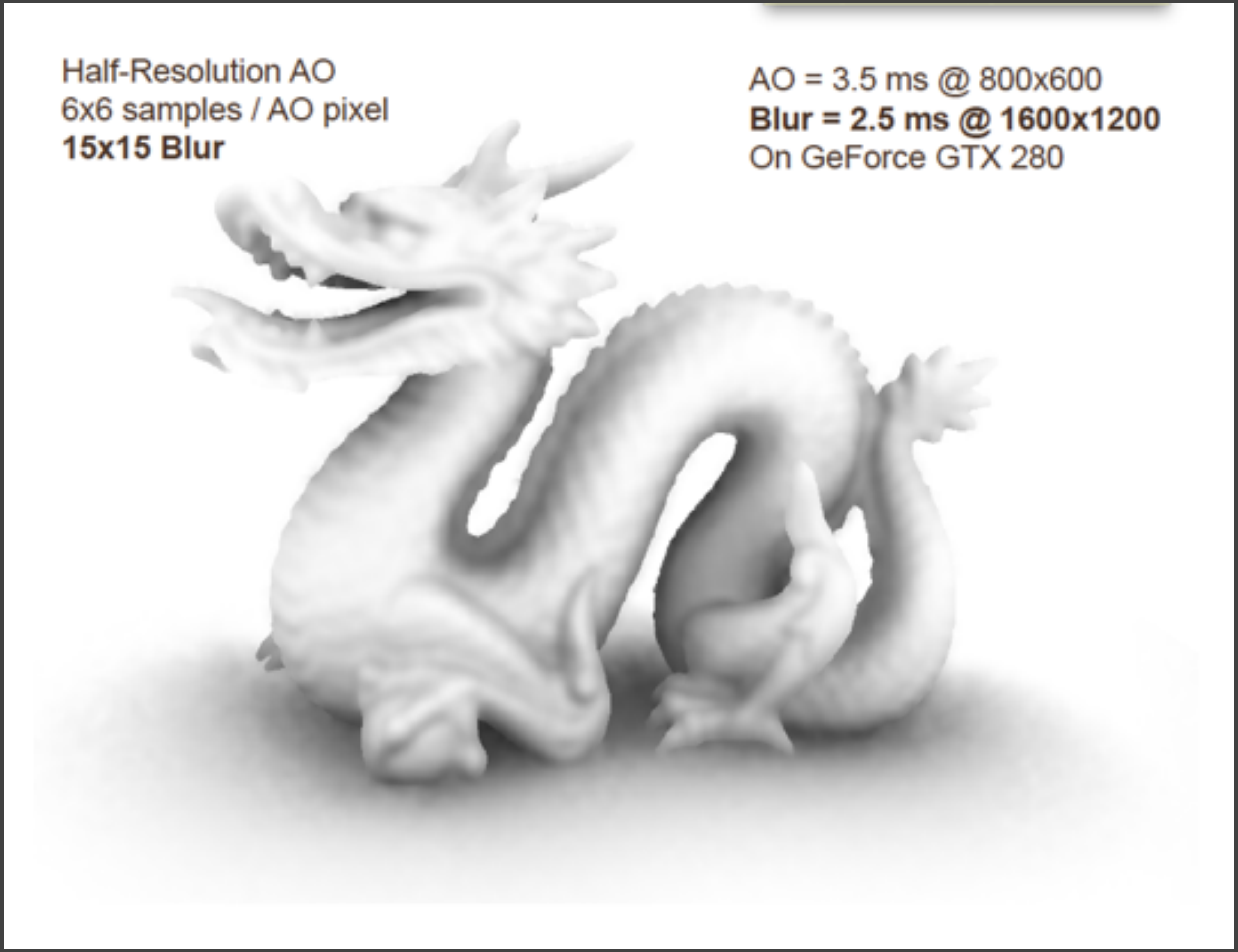

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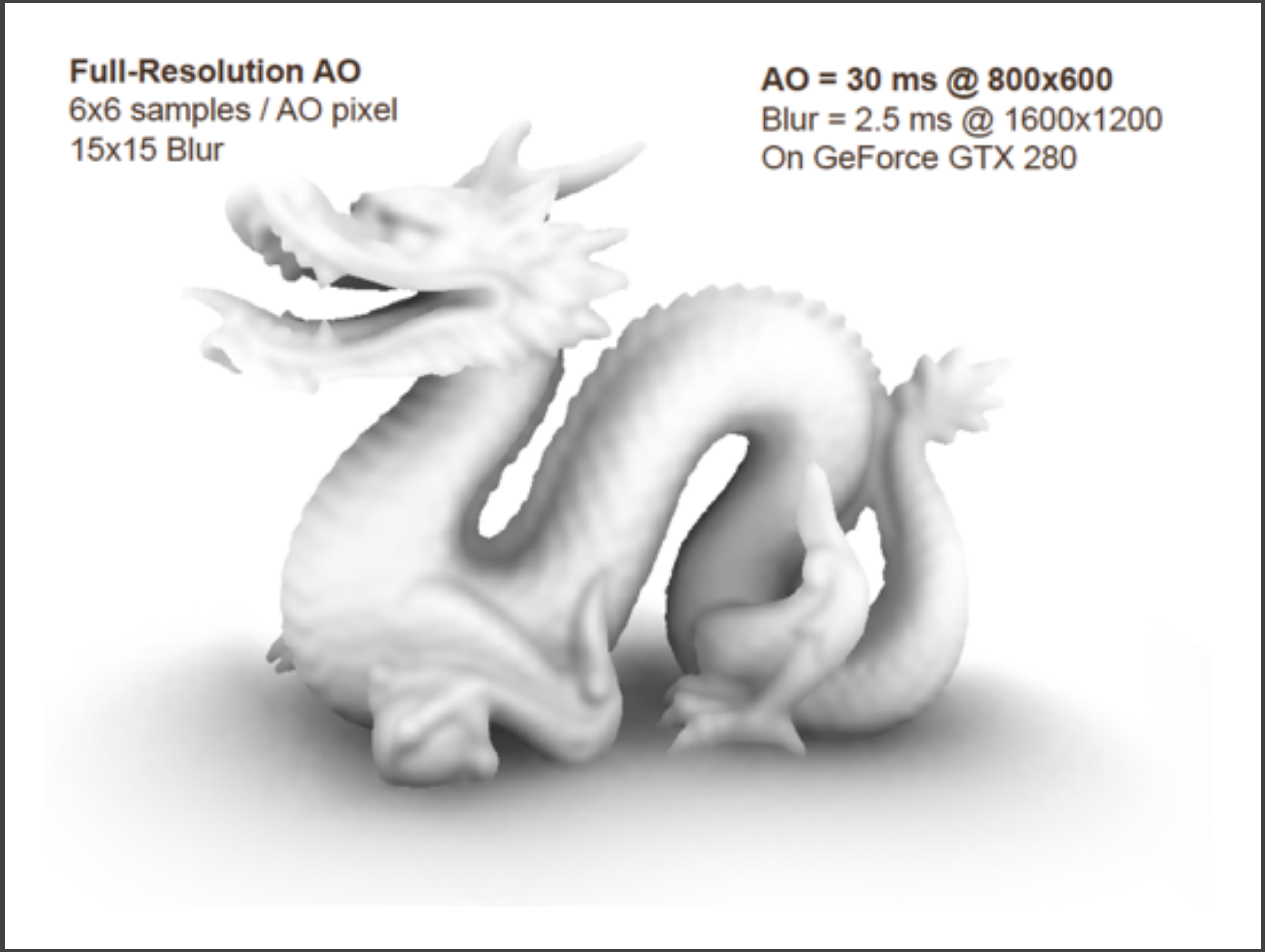

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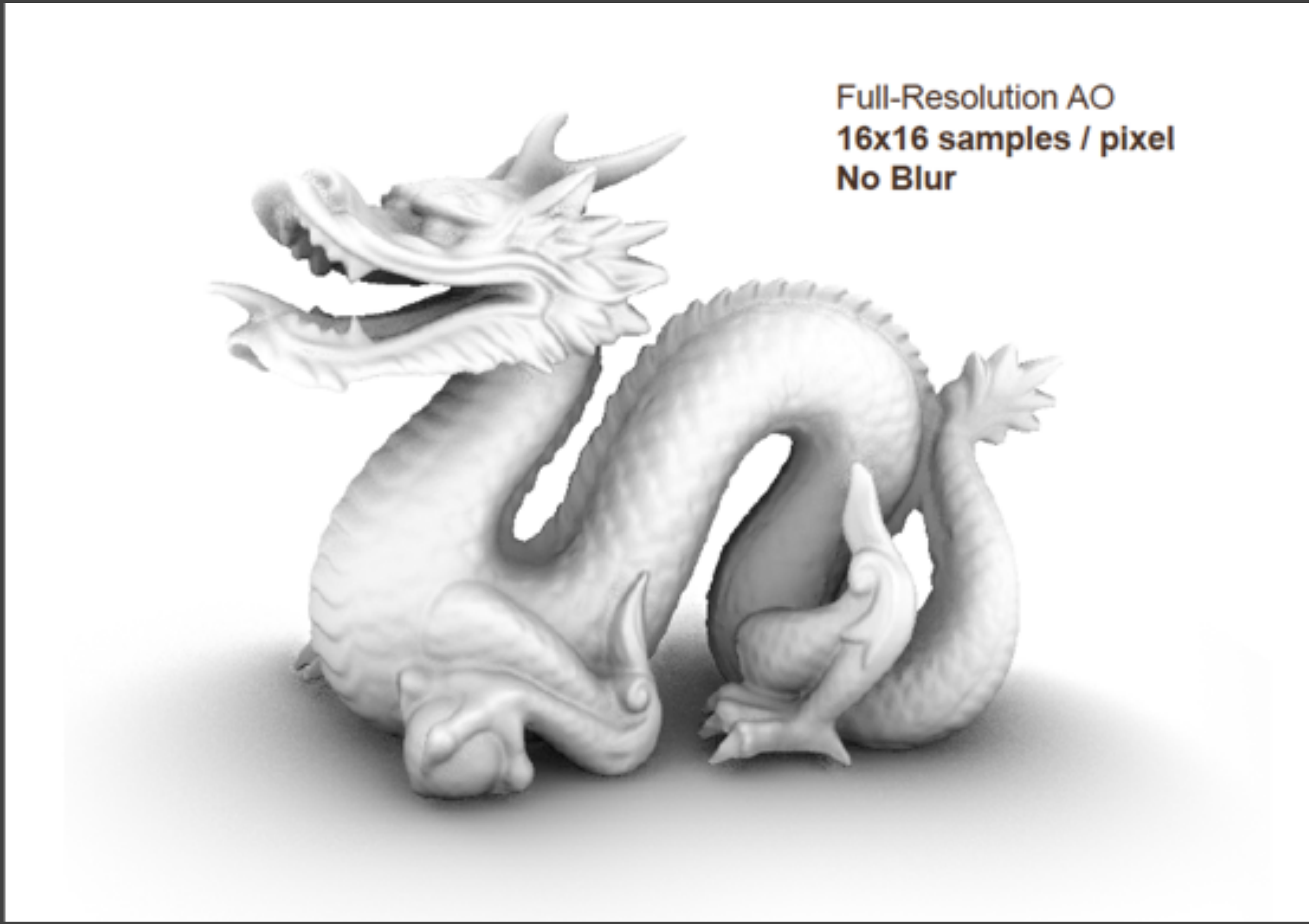

slide courtesy of Kavita Bala, Cornell University

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slide by Frédo Durand, MIT

Denoising from 1 image

- We can’t take average over multiple images

slide by Frédo Durand, MIT

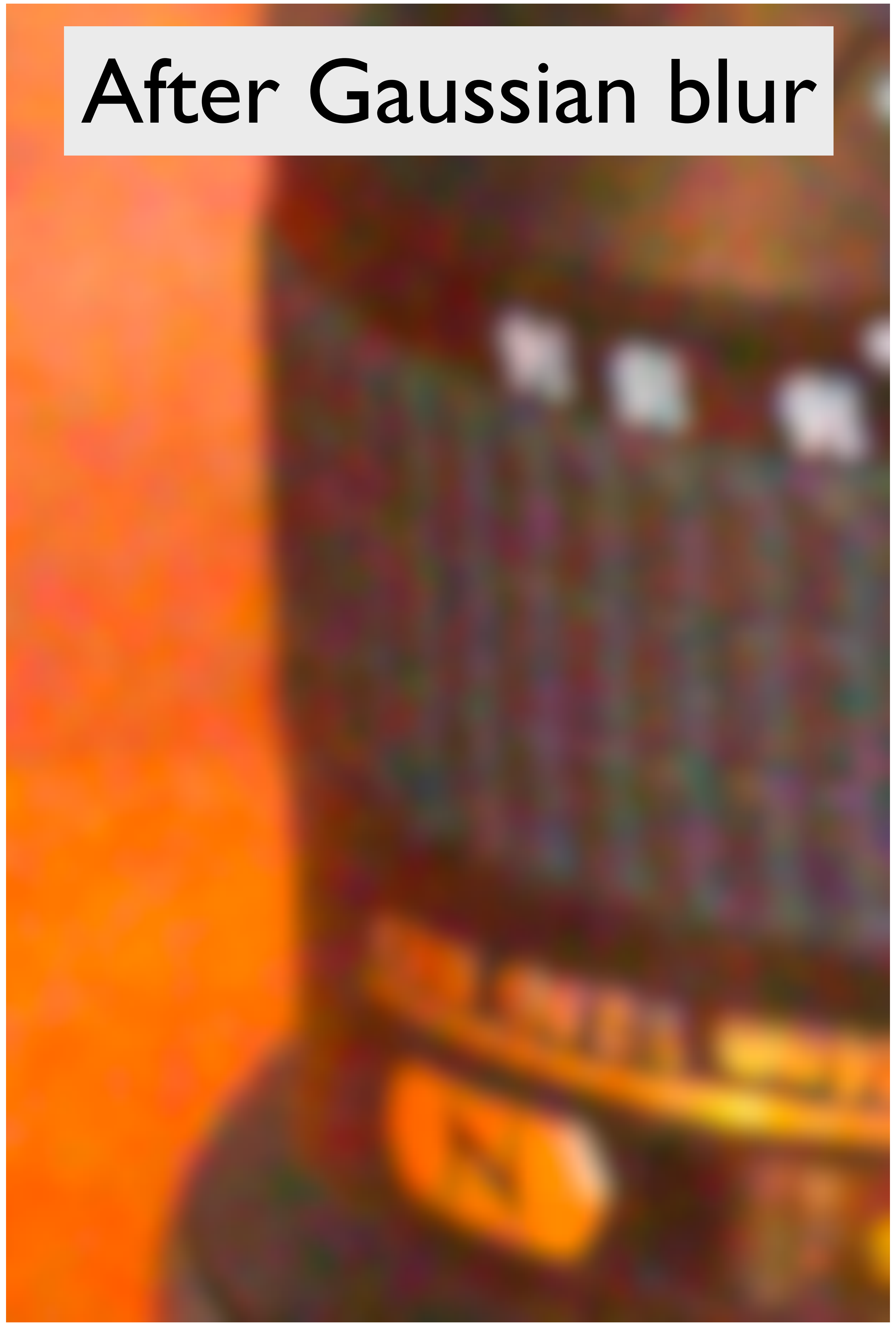
Denoising from 1 image

- We can’t take average over multiple images
- Idea 1: take a spatial average
  - Most pixels have roughly teh same color as their neighbor
  - Noise looks high frequency => do a low pass
- Here: Gaussian blur

slide by Frédo Durand, MIT

Gaussian blur

- Noise is mostly gone
- But image is blurry
  - duh!

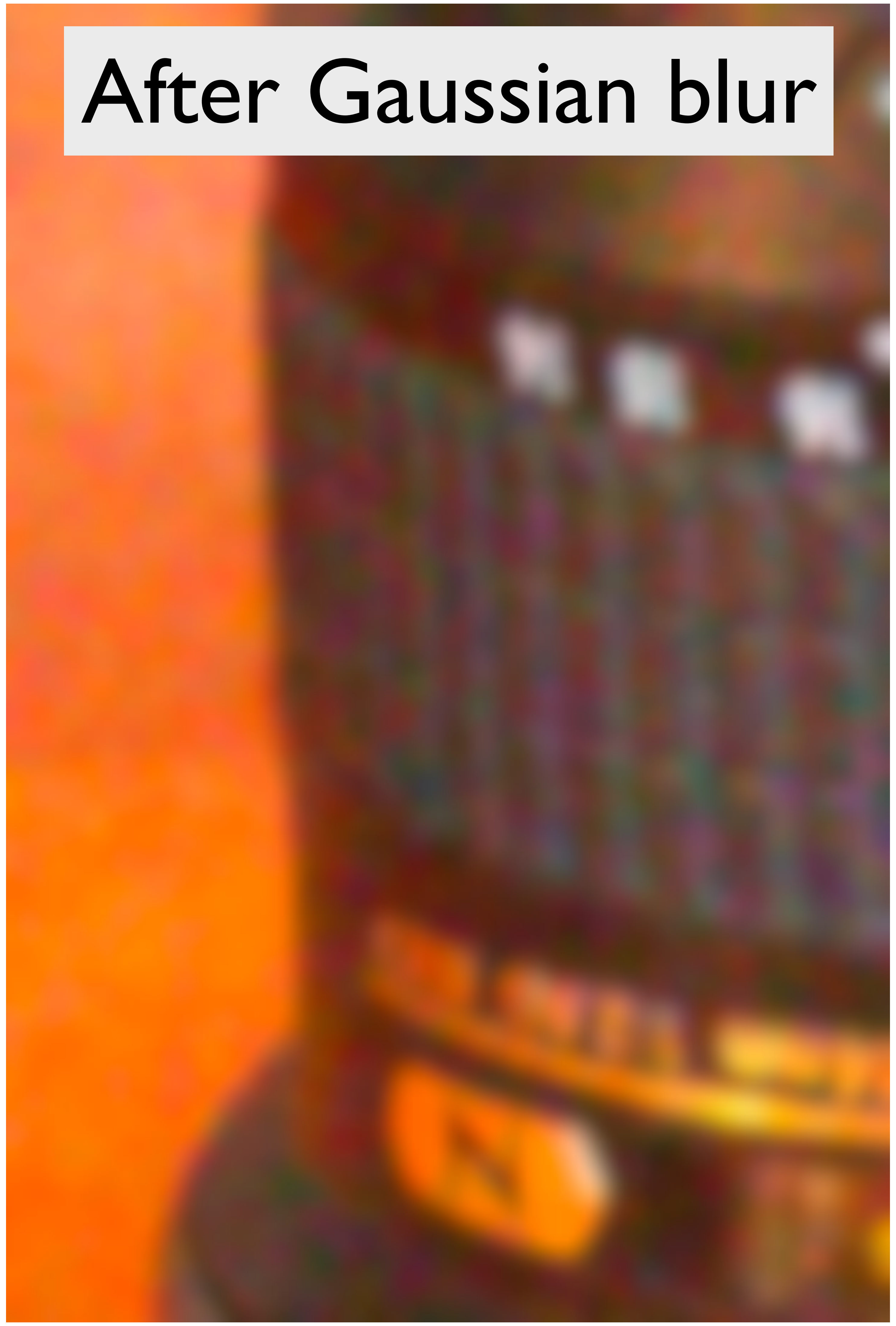


Gaussian blur

adapted from slide by Frédo Durand, MIT

- Noise is mostly gone
- But image is blurry
  - duh!

- Question: how to blur/smooth/abstract image, but without destroying important features?



Bilateral filter

slide by Frédo Durand, MIT

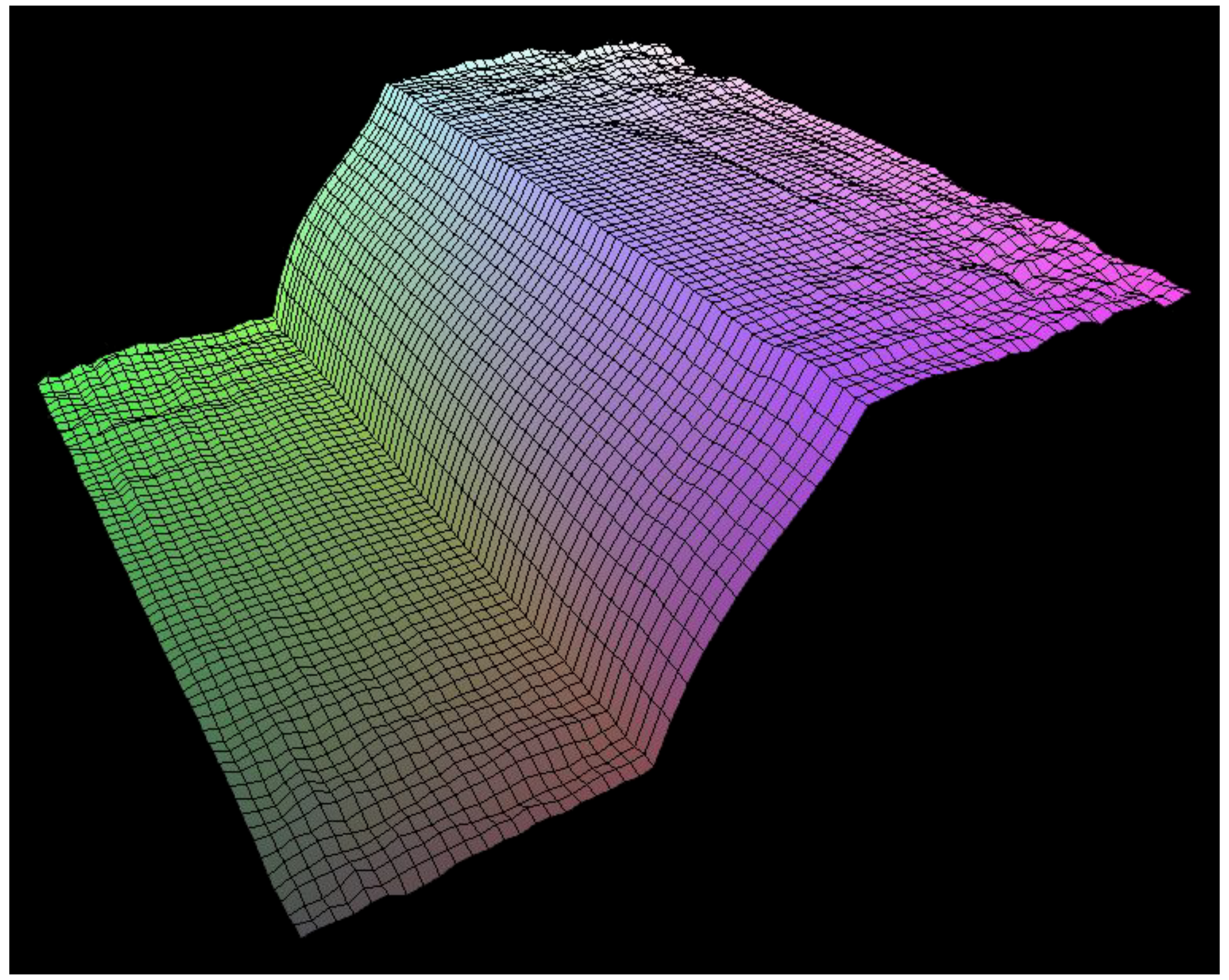
- [Tomasi and Manduci 1998]
  - http://www.cse.ucsc.edu/~manduchi/Papers/ICCV98.pdf
- Developed for denoising
- Related to
  - SUSAN filter [Smith and Brady 95] http://citeseer.ist.psu.edu/smith95susan.html
  - Digital-TV [Chan, Osher and Chen 2001] http://citeseer.ist.psu.edu/chan01digital.html
  - sigma filter http://www.geogr.ku.dk/CHIPS/Manual/f187.htm
- Full survey: http://people.csail.mit.edu/sparis/publi/2009/fntcgv/Paris_09_Bilateral_filtering.pdf

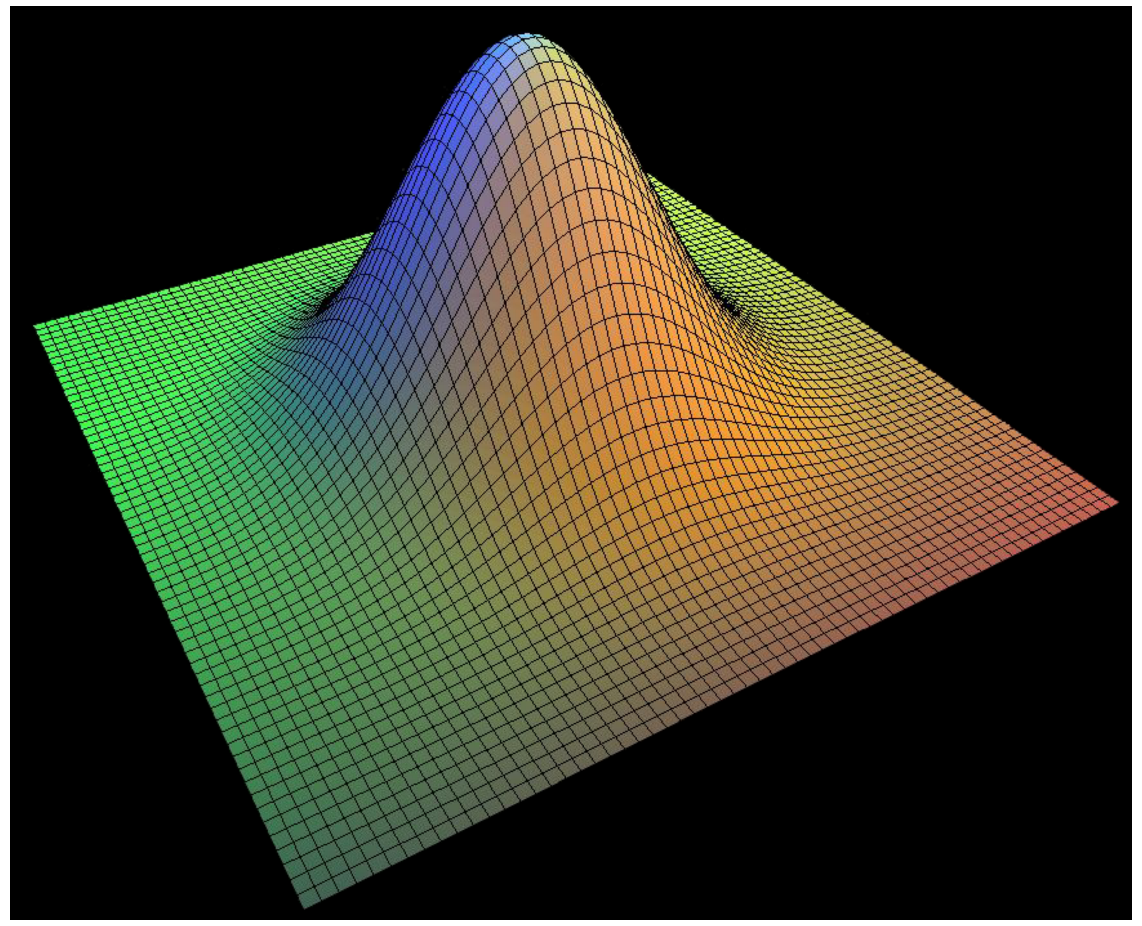
slide by Frédo Durand, MIT

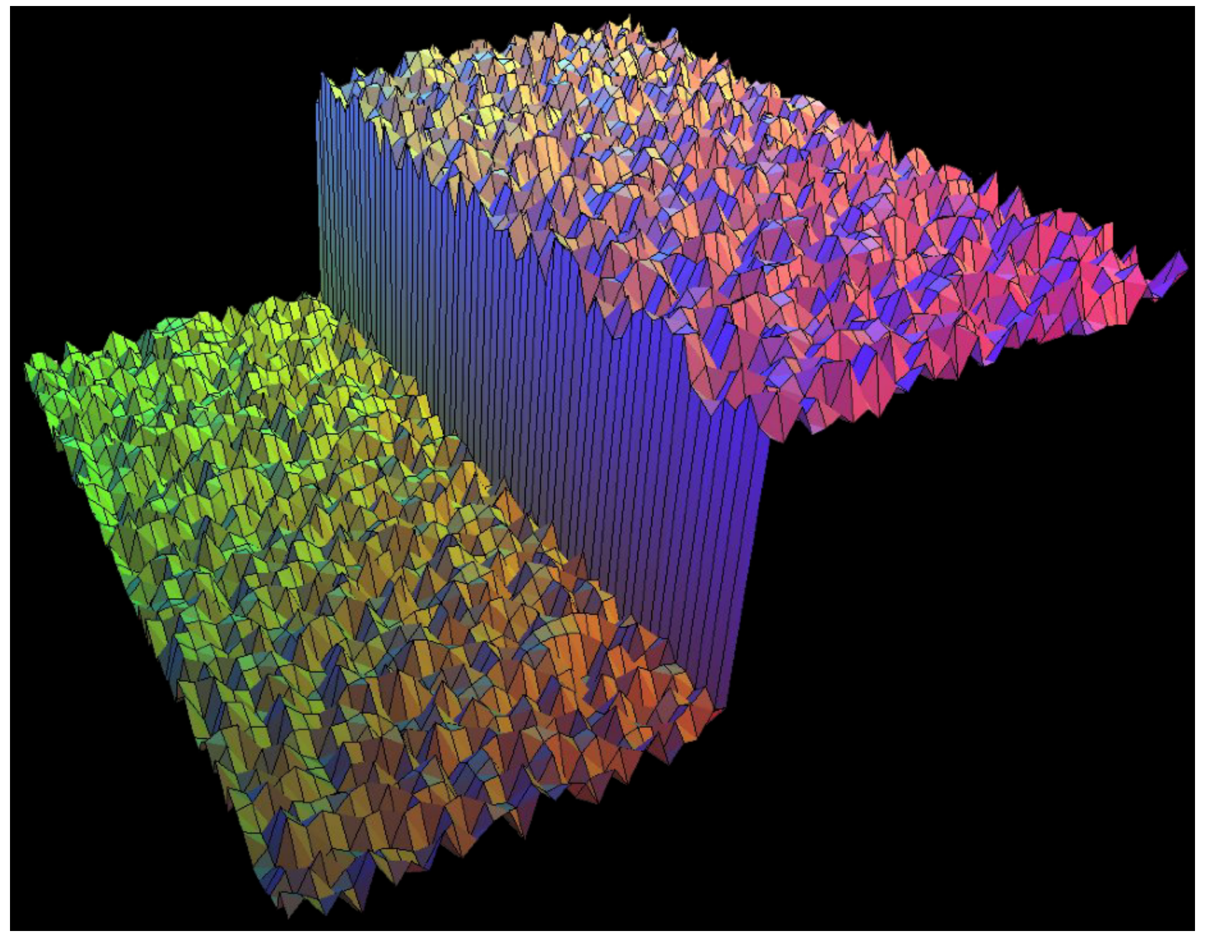
Start with Gaussian filtering

- Here, input is a step function + noise

$$J \quad = \quad f \quad \otimes \quad I$$







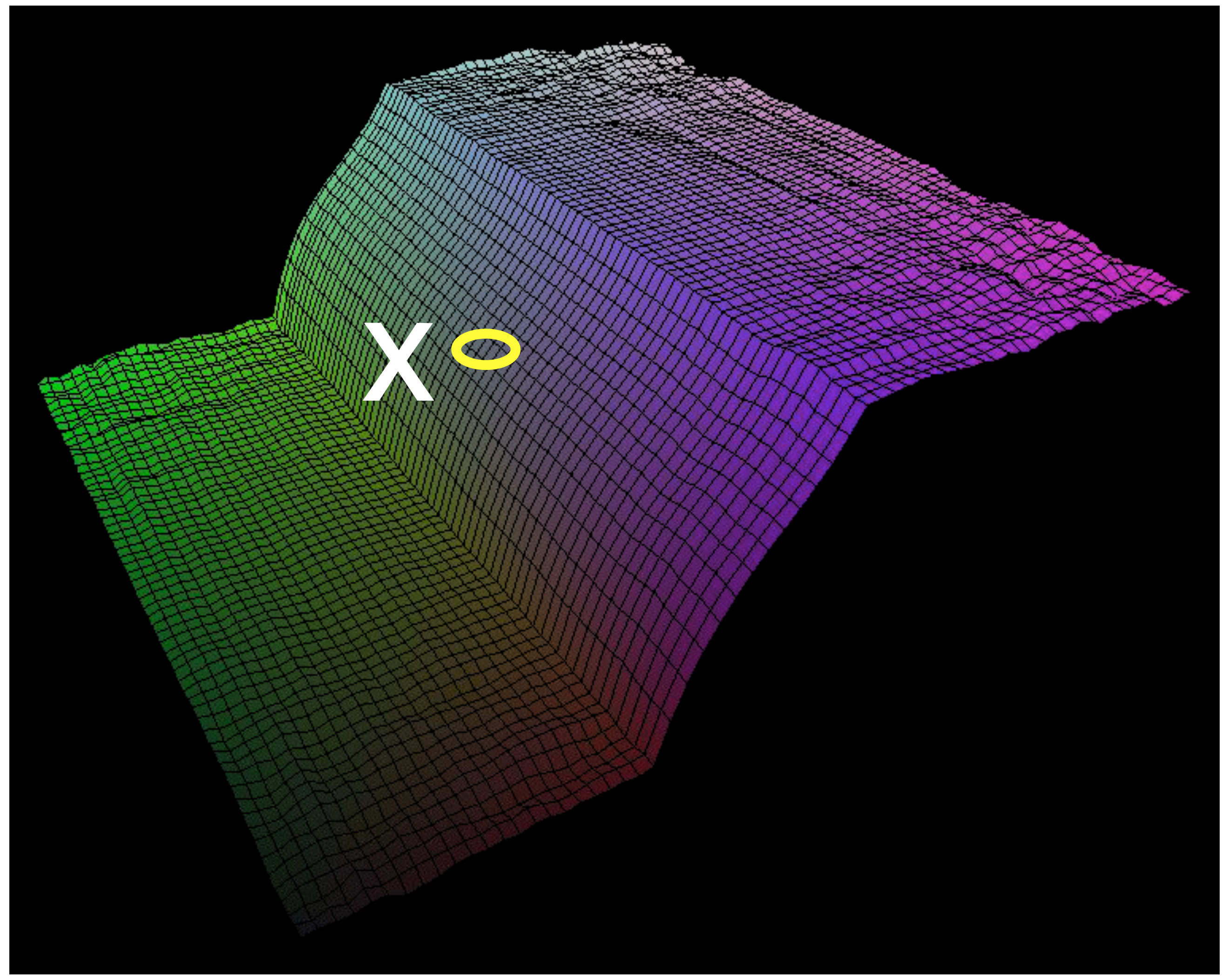
output ⟵ input

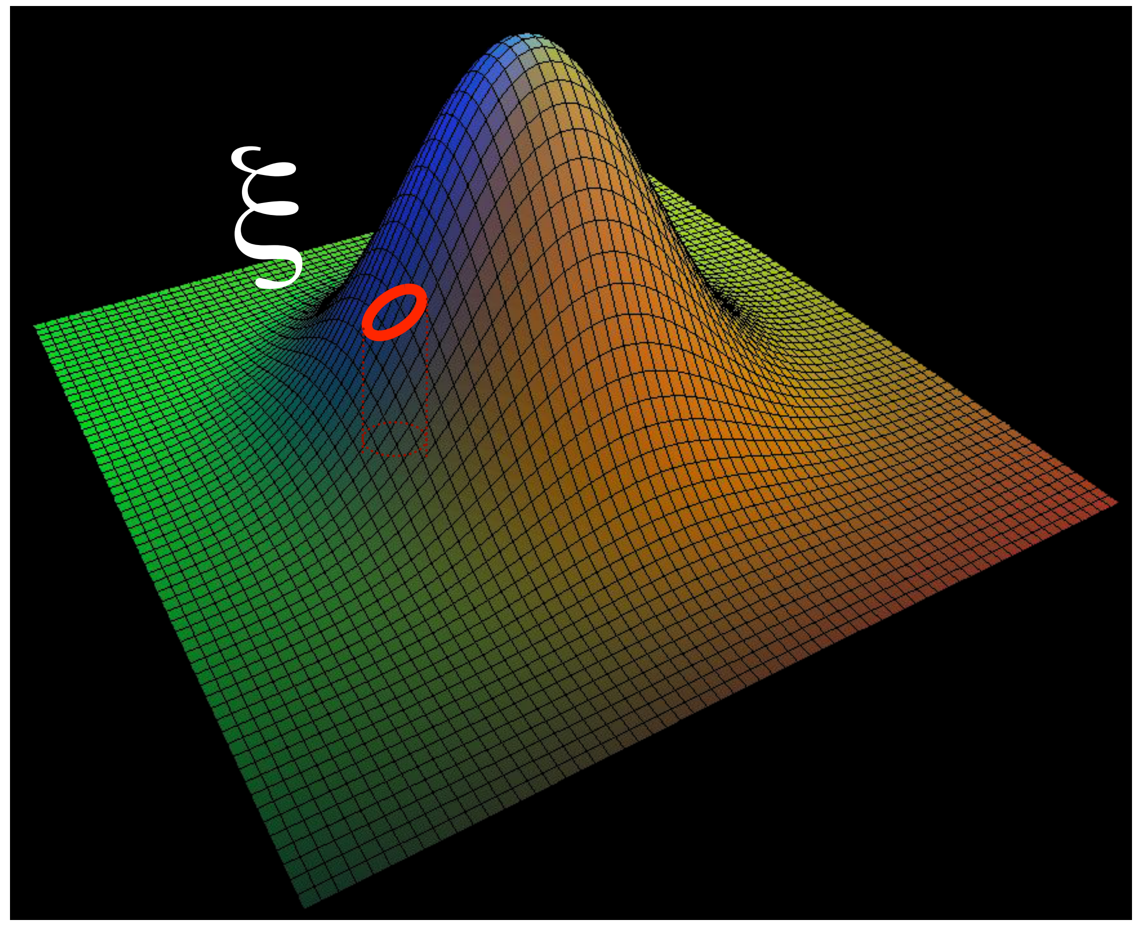
Gaussian filter as weighted average

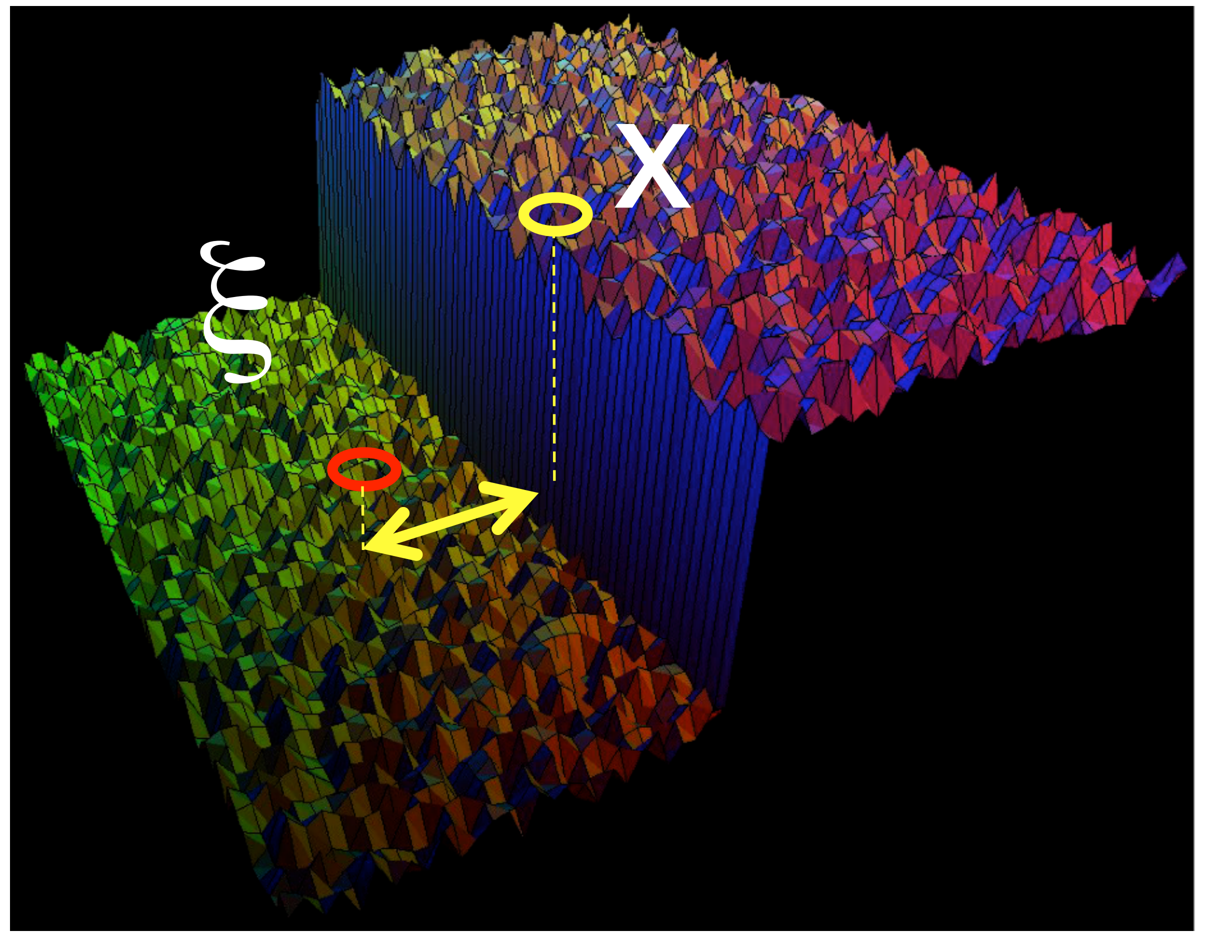
slide by Frédo Durand, MIT

- Weight of ξ depends on distance to x

$$J(x) = \sum_{\xi} f(x,\xi) \, I(\xi)$$







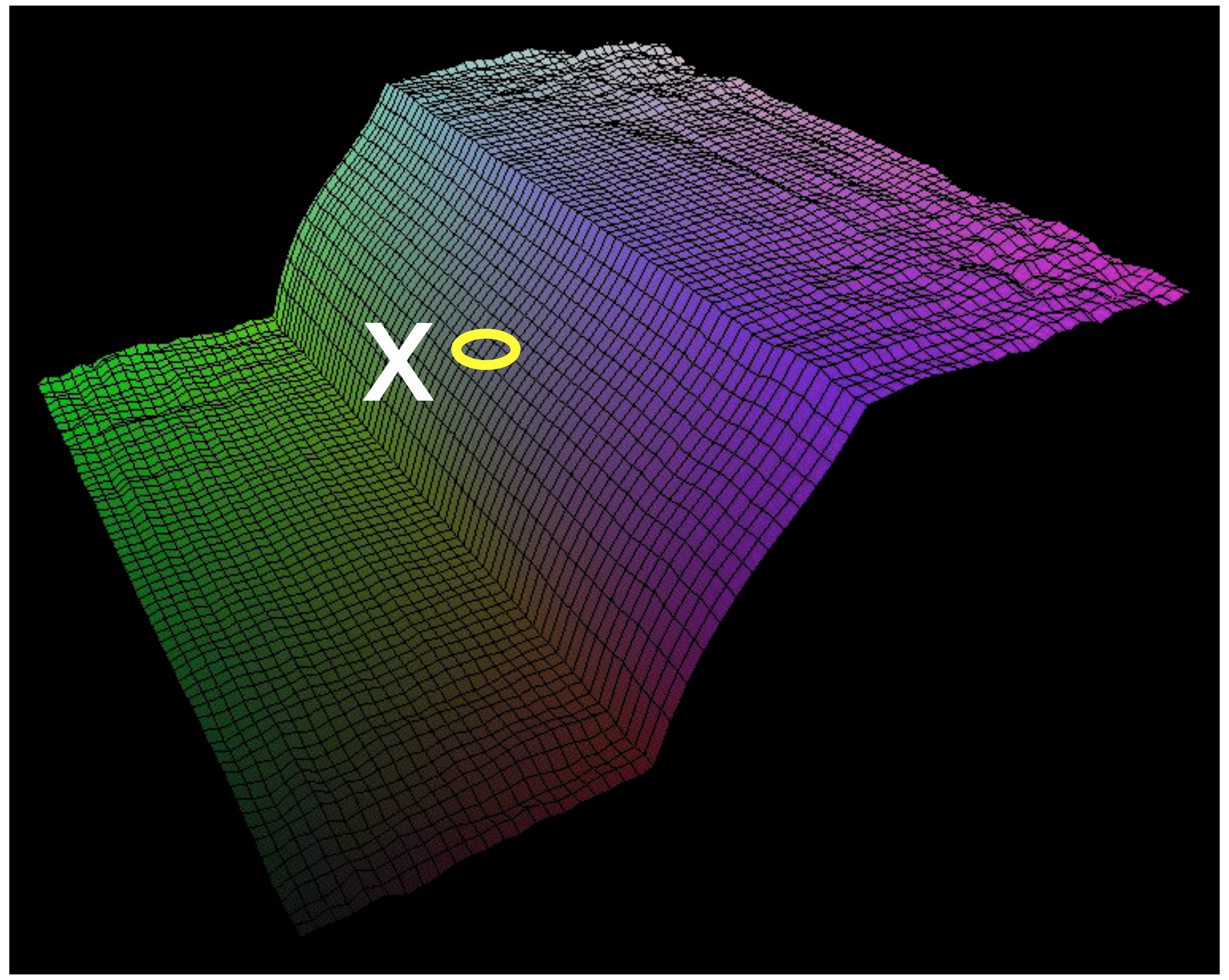
output ⟵ input

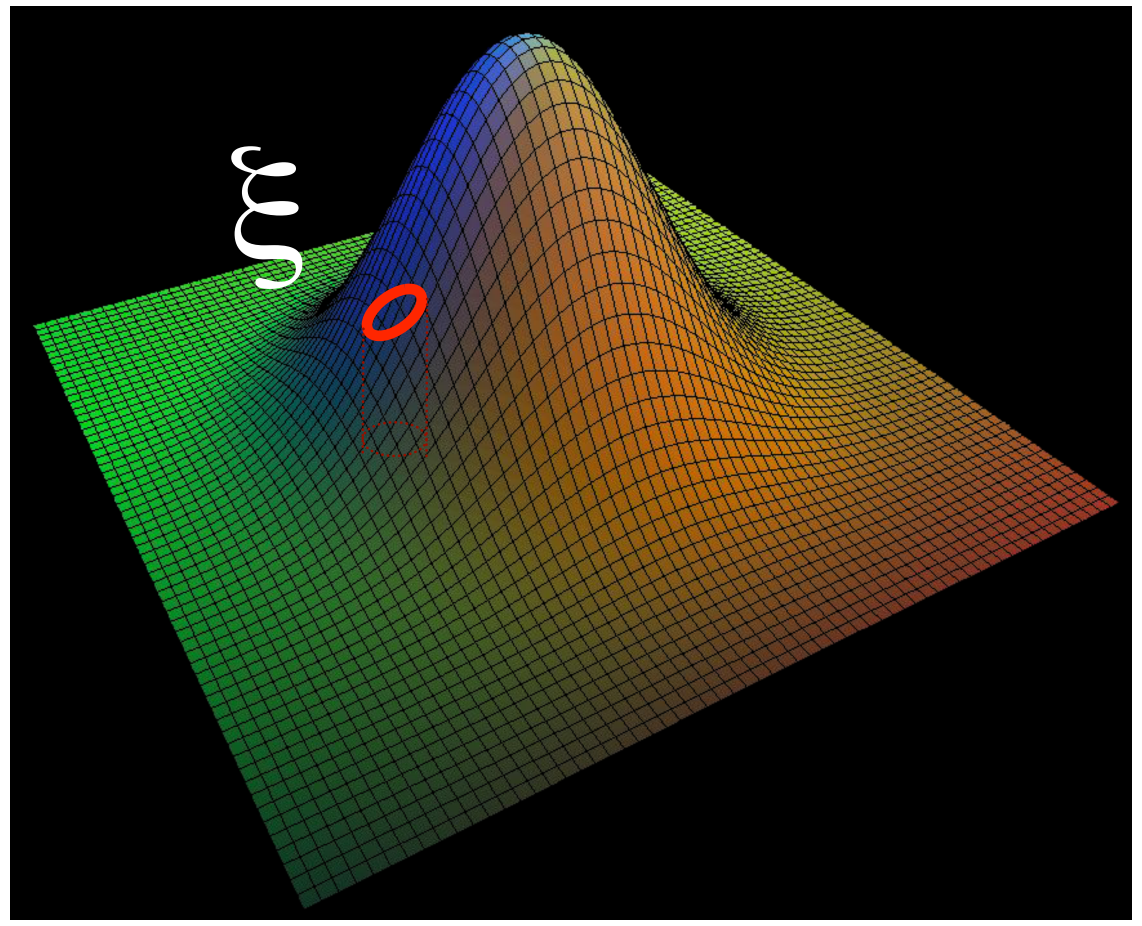
slide by Frédo Durand, MIT

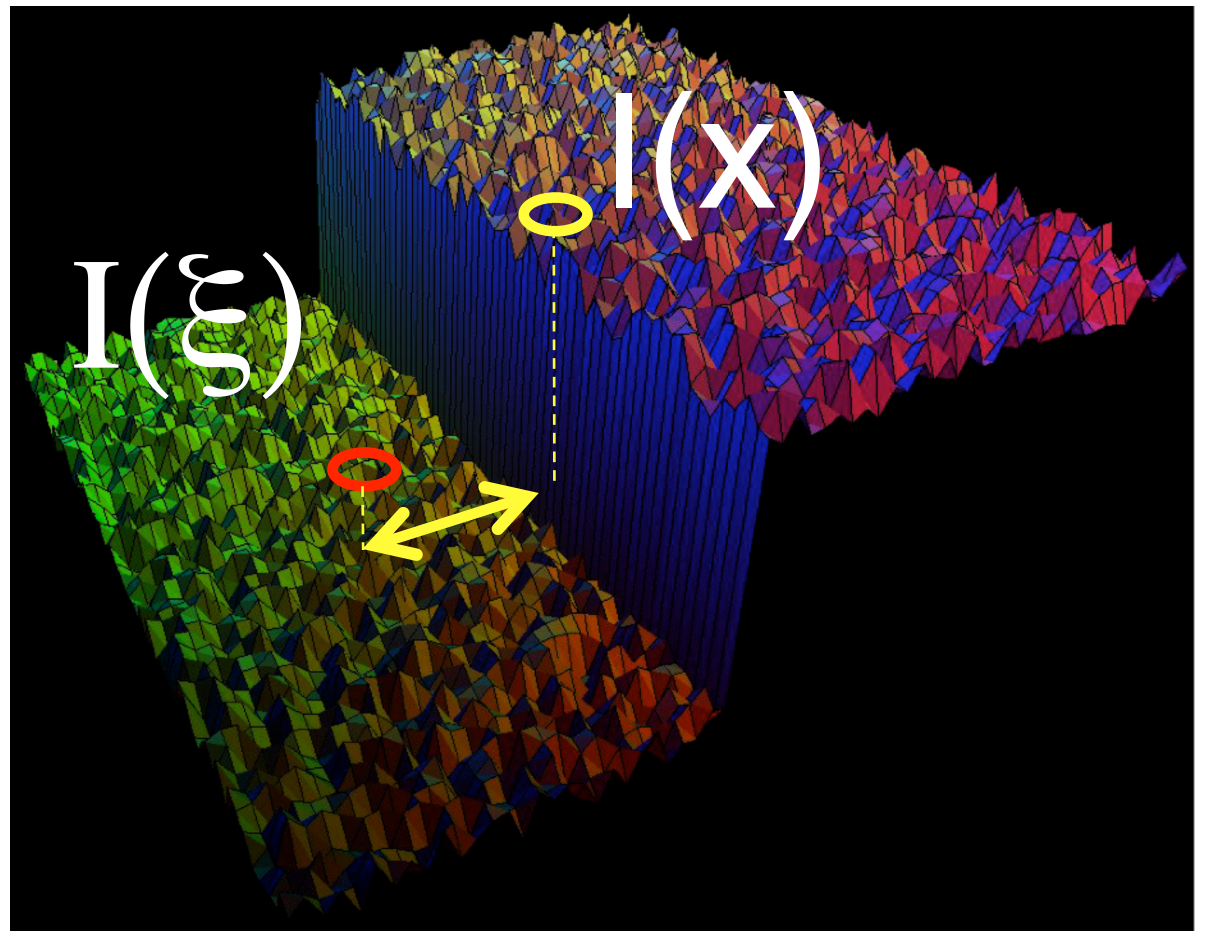
The problem of edges

- Here, $I(\xi)$ "pollutes" our estimate J(x)
- It is too different

$$J(x) = \sum_{\xi} f(x,\xi) \; I(\xi)$$







output ⟵ input

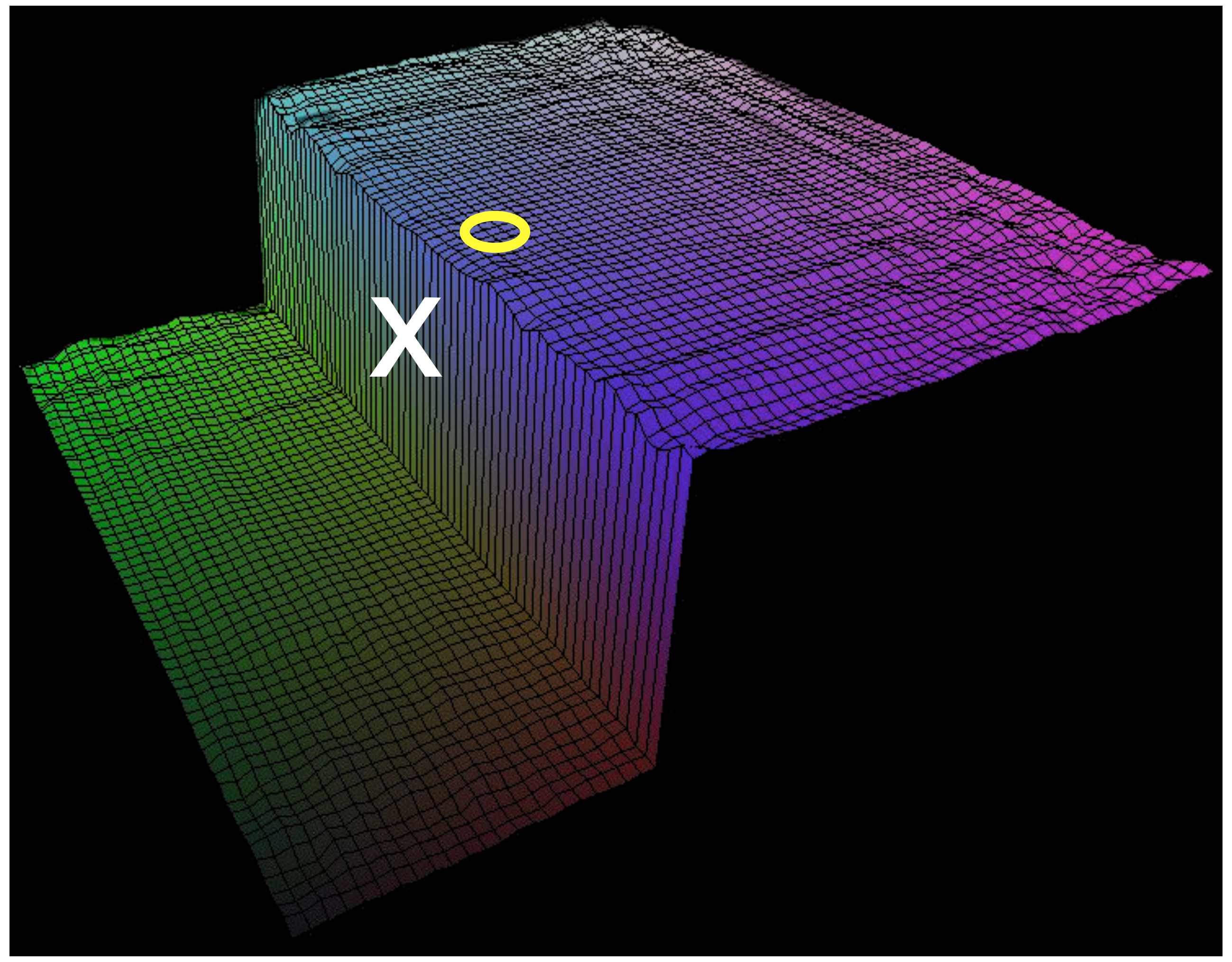
slide by Frédo Durand, MIT

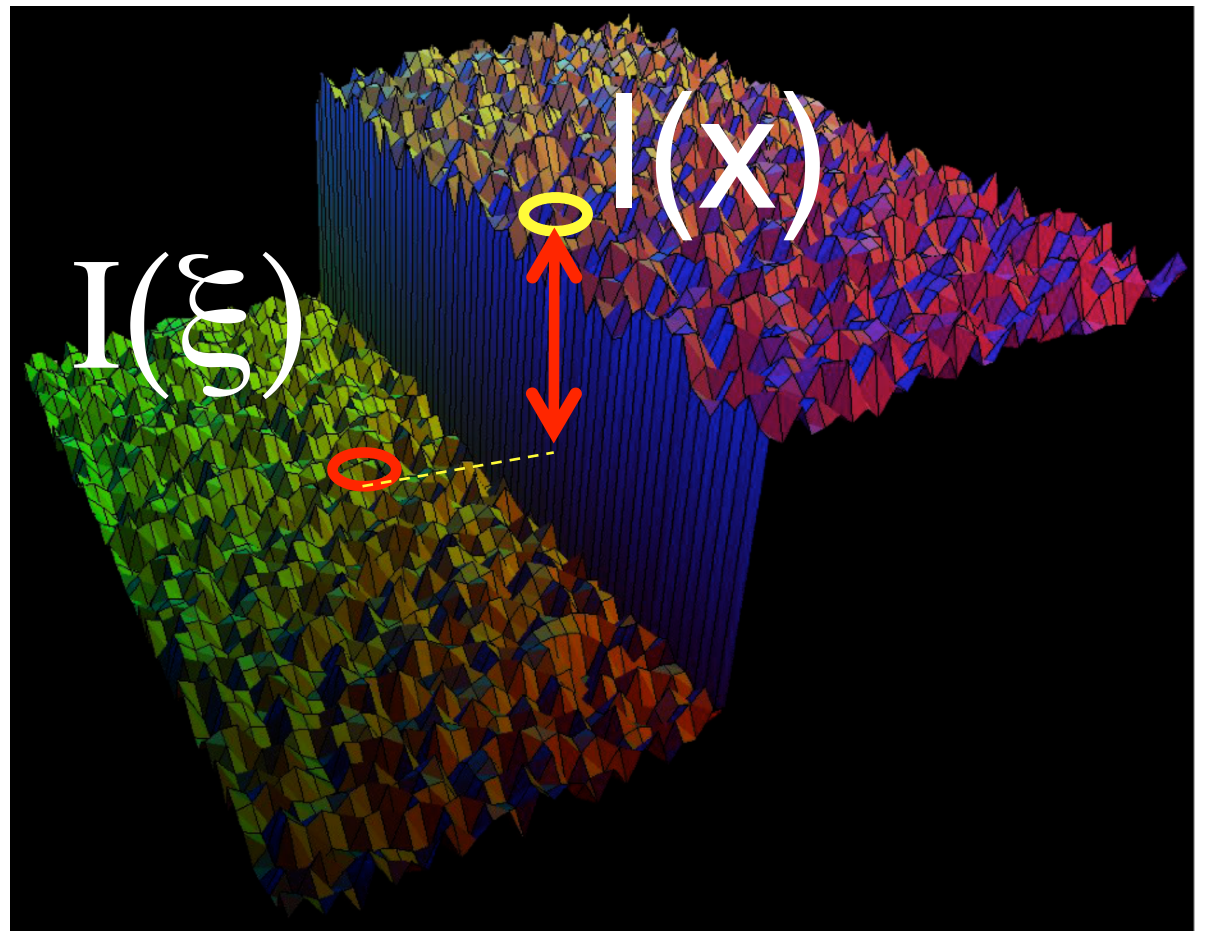
Principle of Bilateral filtering

[Tomasi and Manduchi 1998]

- Penalty g on the intensity difference

$$J(x) = \frac{1}{k(x)} \sum_{\xi} f(x,\xi) \quad g(I(\xi) - I(x)) \quad I(\xi)$$





output

input

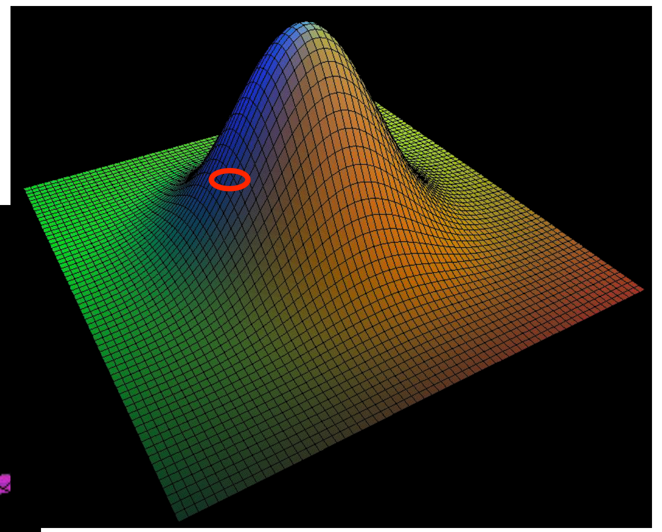
slide by Frédo Durand, MIT

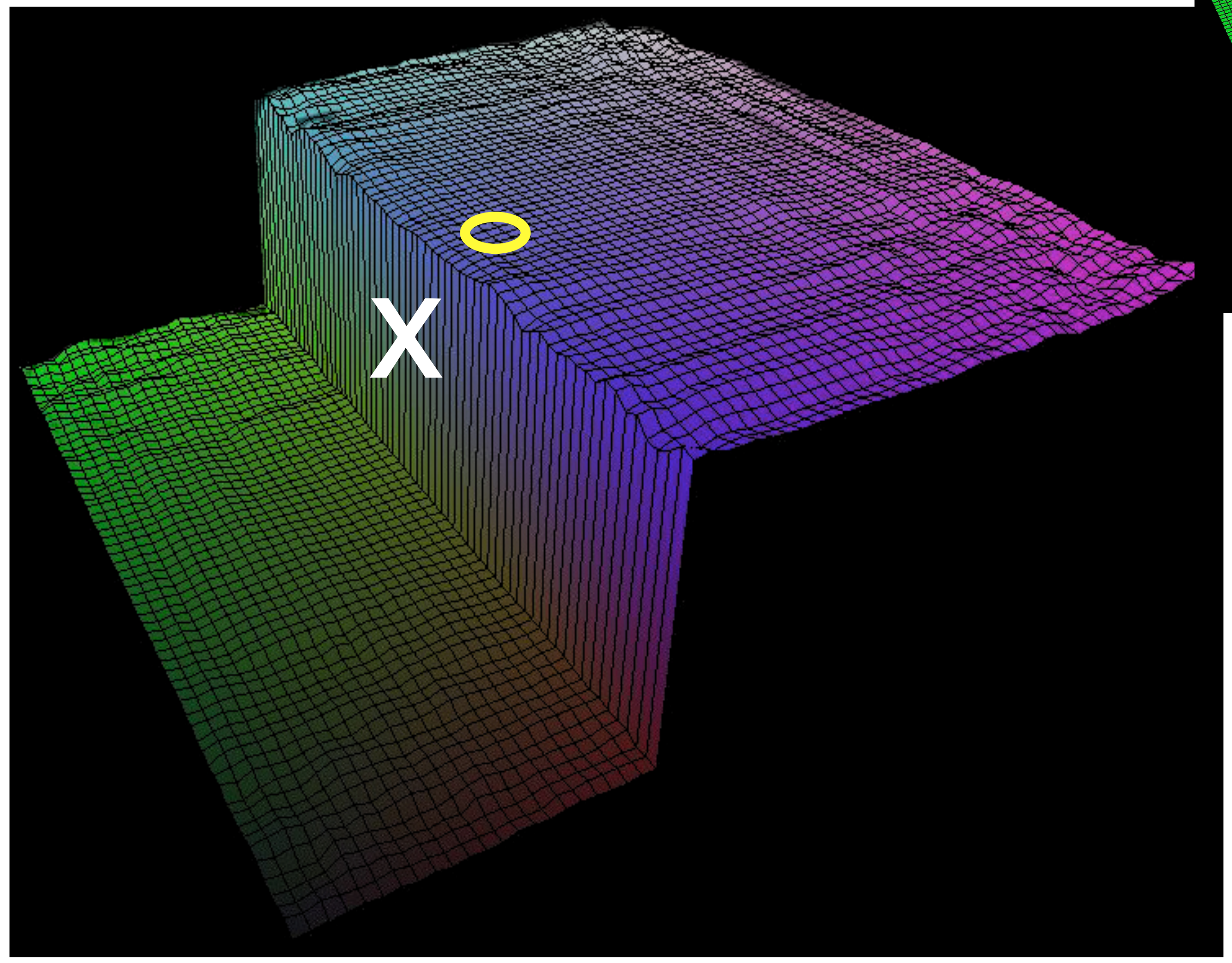
Bilateral filtering

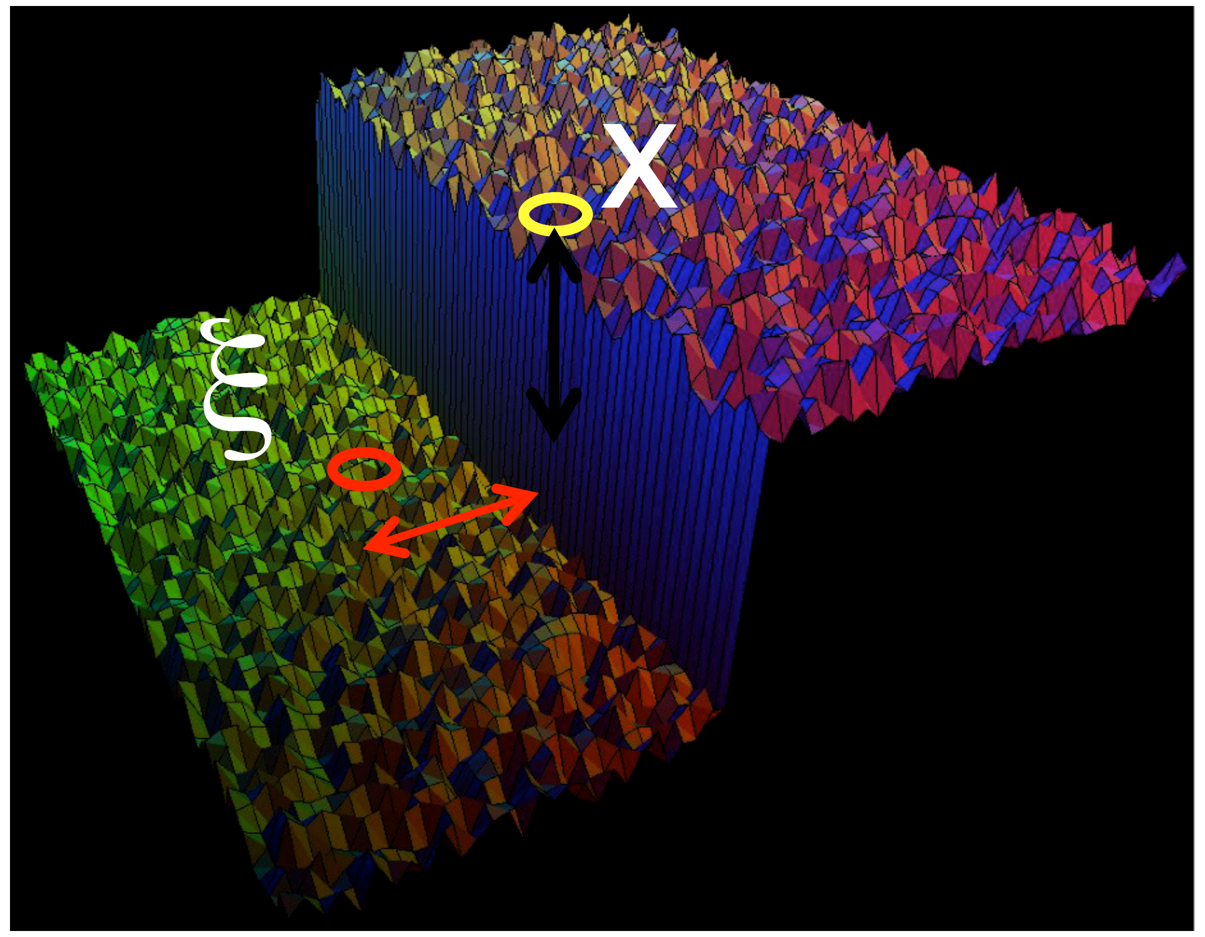
[Tomasi and Manduchi 1998]

- Spatial Gaussian f

$$J(x) = \frac{1}{k(x)} \sum_{\xi} f(x,\xi)\, g(I(\xi) - I(x)) \quad I(\xi)$$







output input

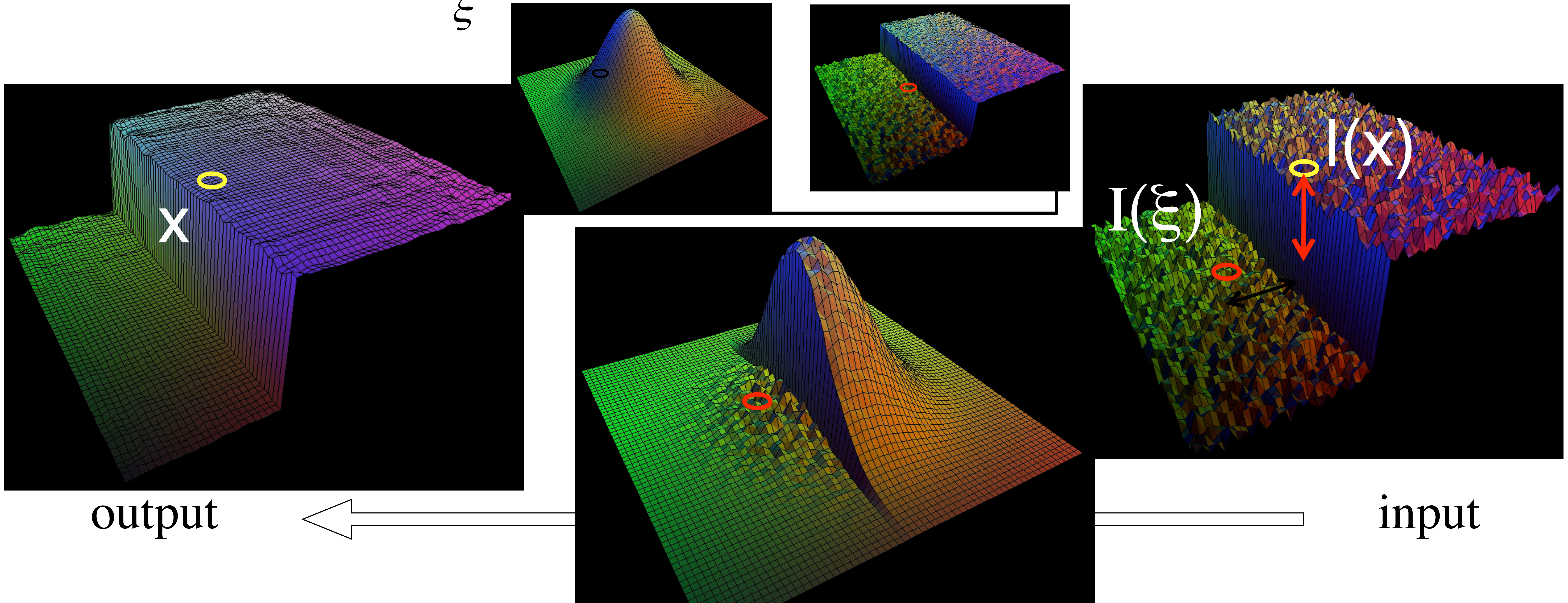
slide by Frédo Durand, MIT

Bilateral filtering

[Tomasi and Manduchi 1998]

- Spatial Gaussian f
- Gaussian g on the intensity difference

$$J(x) = \frac{1}{k(x)} \sum_{\xi} f(x,\xi)\, g(I(\xi) - I(x))\, I(\xi)$$



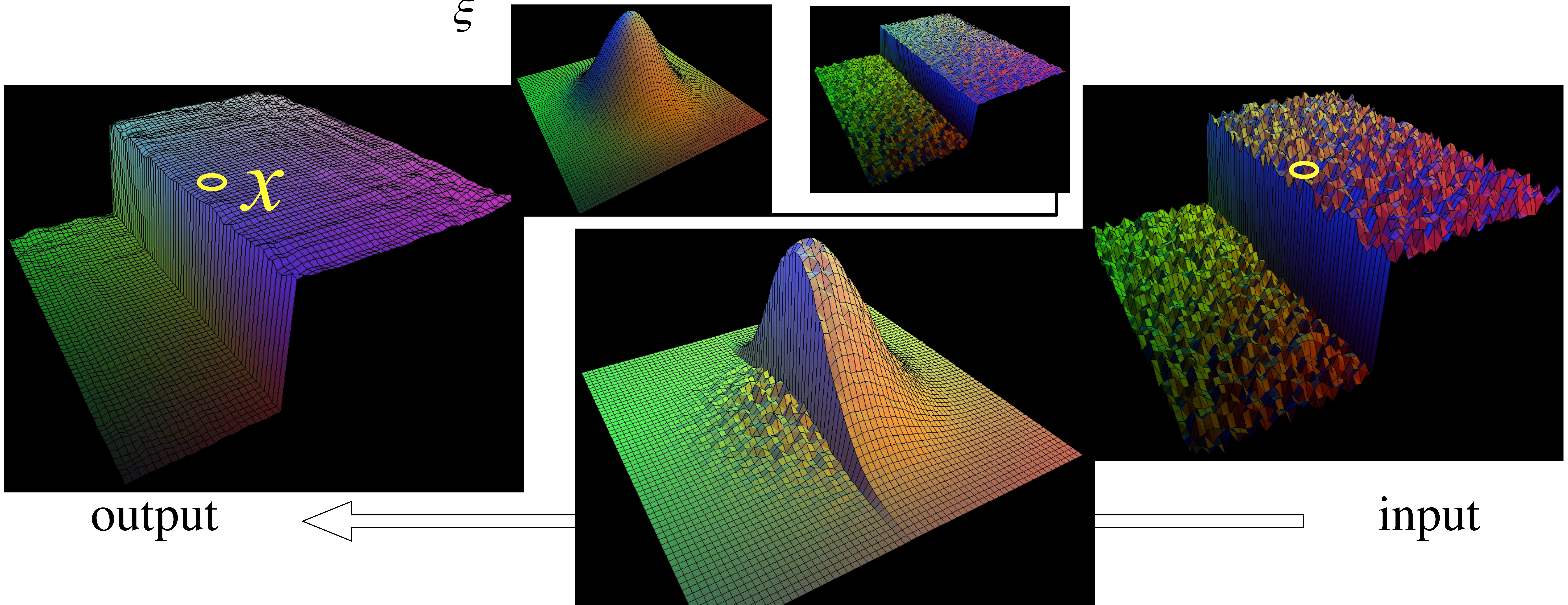
slide by Frédo Durand, MIT

Normalization factor

[Tomasi and Manduchi 1998]

- k(x)= $\sum_{\xi} f(x,\xi) \quad g(I(\xi)-I(x))$

$$J(x) = \frac{1}{k(x)} \sum_{\xi} f(x,\xi) \quad g(I(\xi)-I(x)) \quad I(\xi)$$



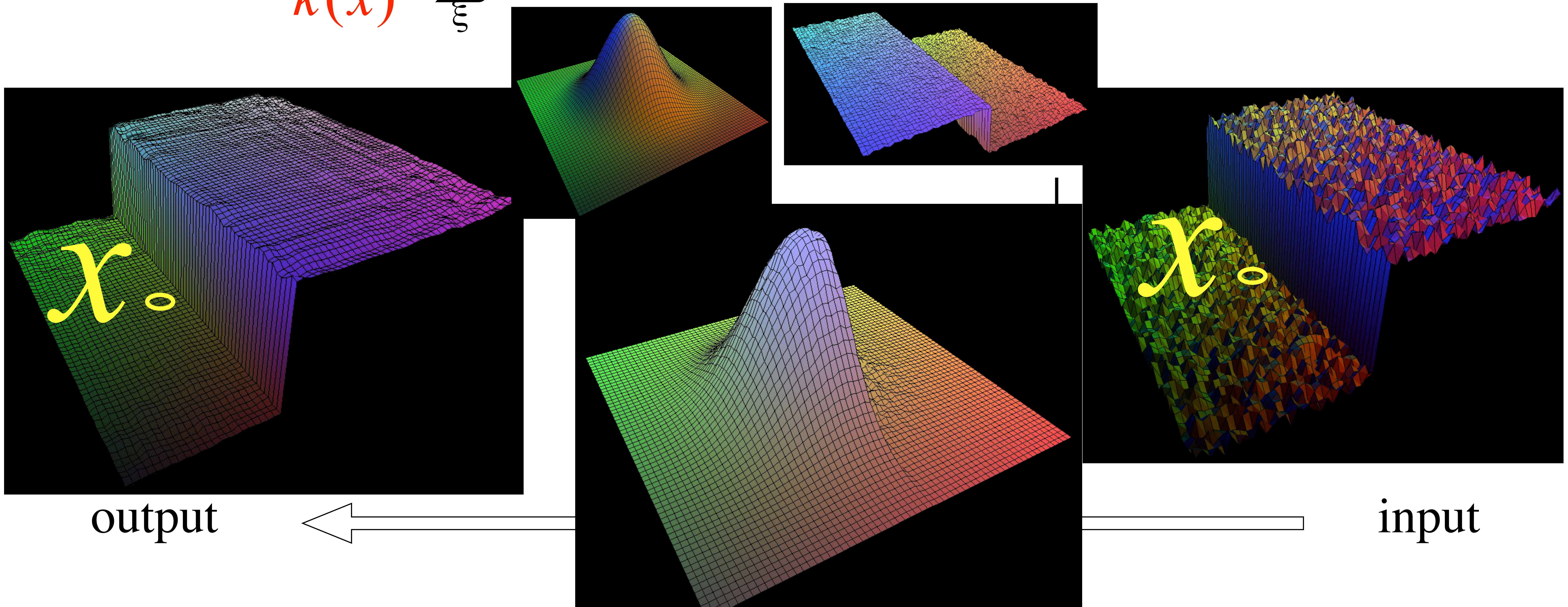
slide by Frédo Durand, MIT

Bilateral filtering is non-linear

[Tomasi and Manduchi 1998]

- The weights are different for each output pixel

$$J(x) = \frac{1}{k(x)} \sum_{\xi} f(x,\xi) \quad g(I(\xi) - I(x)) \quad I(\xi)$$



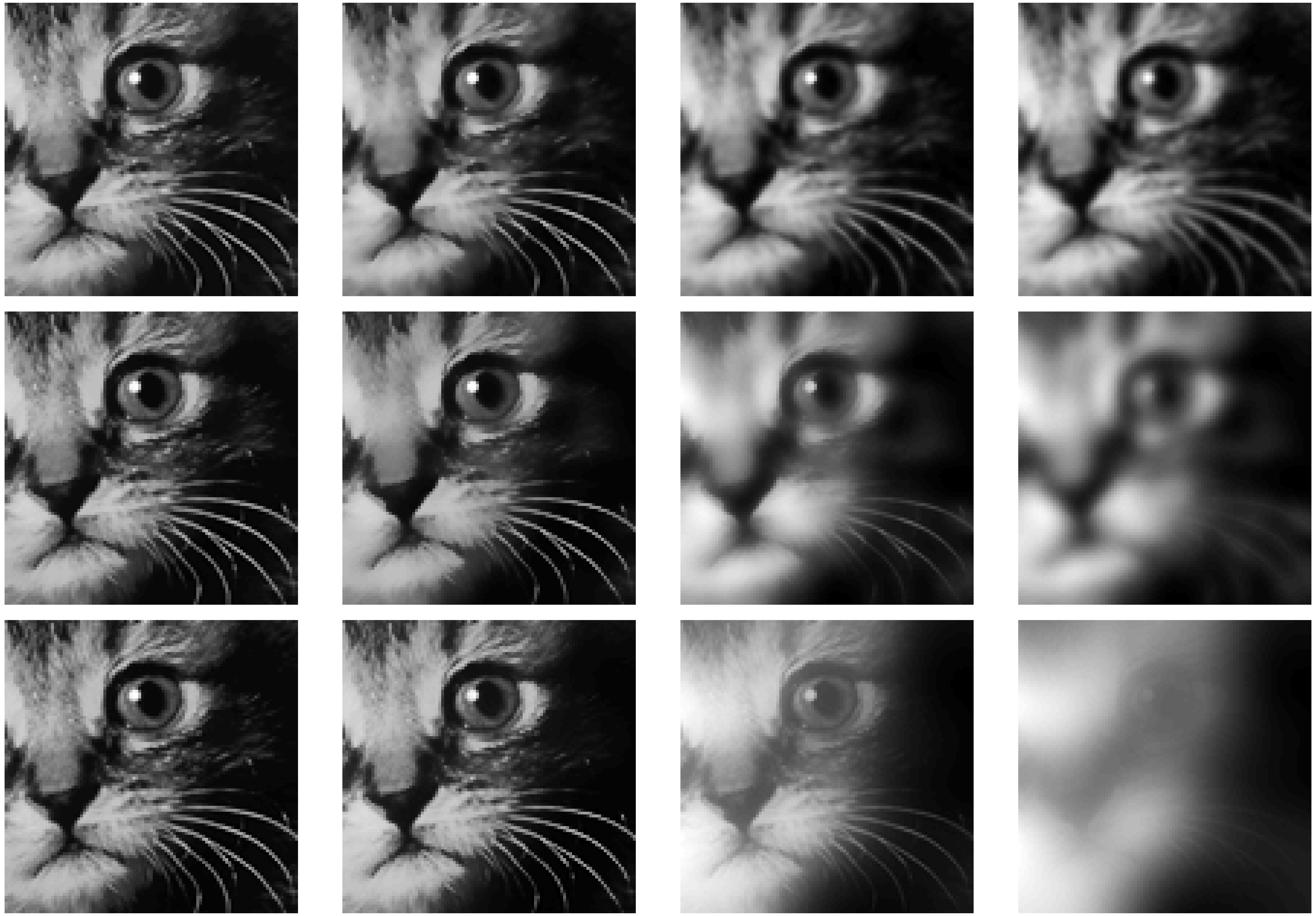
Effects of bilateral filter

size of **domain** filter →

$\sigma_d = 1$

$\sigma_d = 3$

$\sigma_d = 10$



$\sigma_r = 10$ $\sigma_r = 30$ $\sigma_r = 100$ $\sigma_r = 300$

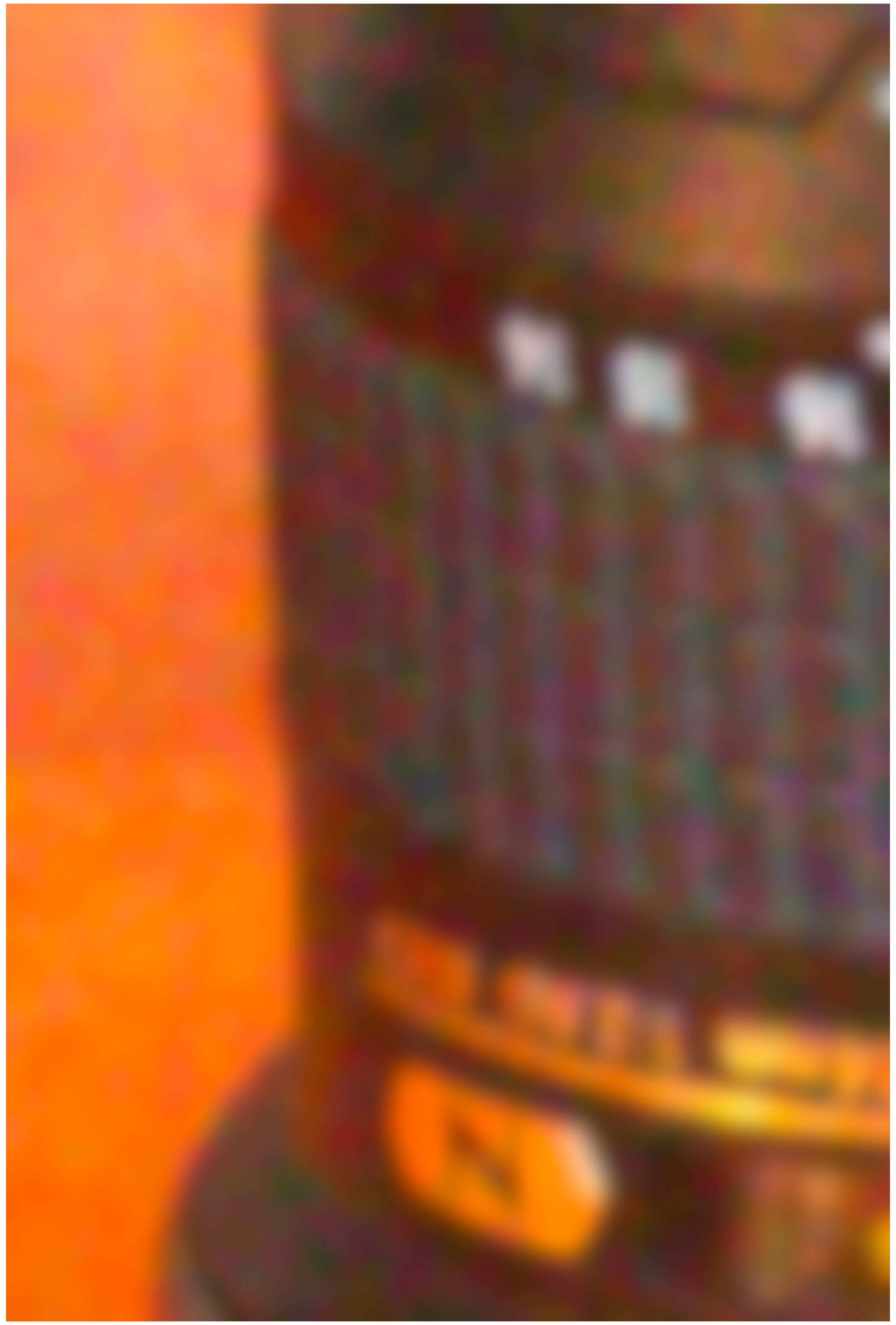
size of **range** filter →

[Tomasi & Manduchi 1998]

Bilateral filter

adapted from slide by Frédo Durand, MIT

Noisy input



After gaussian blur

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Bilateral filter

Noisy input

After bilateral filter