Eurographics2019

Analysis of Sample Correlations for Monte Carlo Rendering

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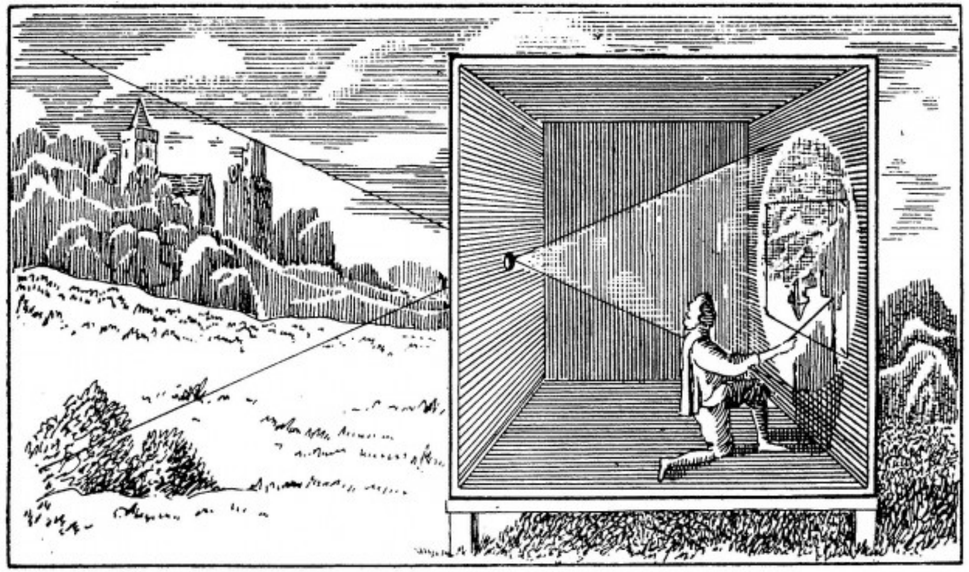
Rendering = Geometry + Radiometry

Geometry / Projection

for pin-hole model is known since 400BC



Rendering = Geometry + Radiometry

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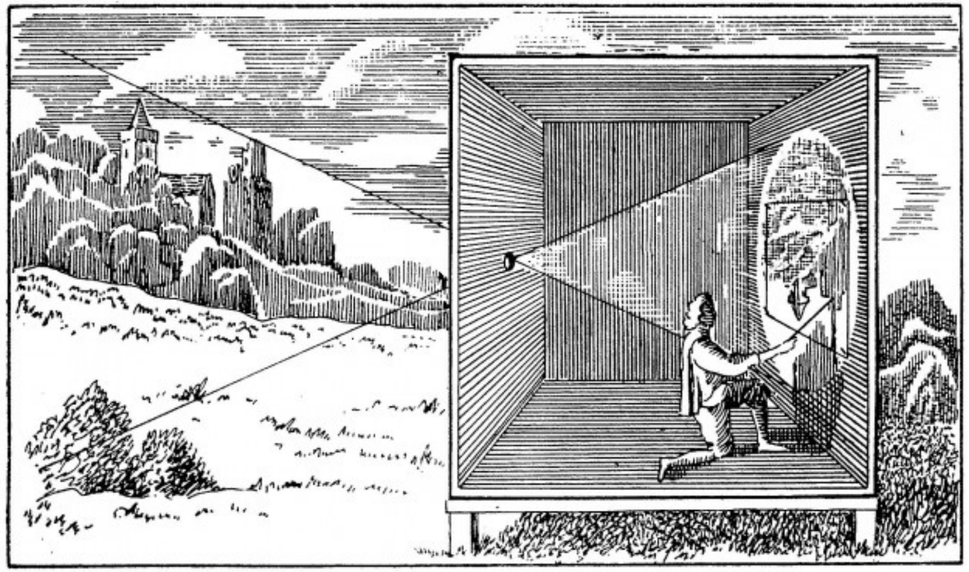


Radiometrically accurate simulation

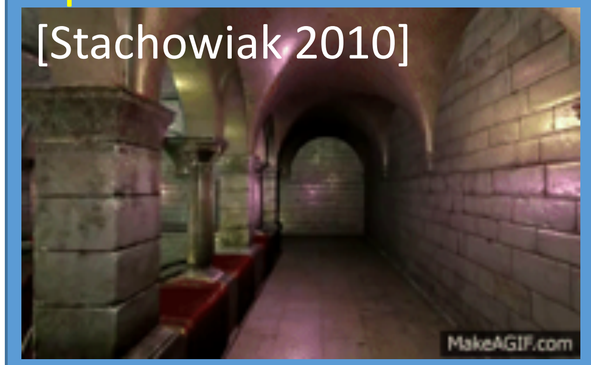
is importance of realism

Rendering = Geometry + Radiometry

Geometry / Projection

for pin-hole model is known since 400BC

OpenGL



Raytracing

[Whitted 1980]

Radiometrically accurate simulation

is importance of realism

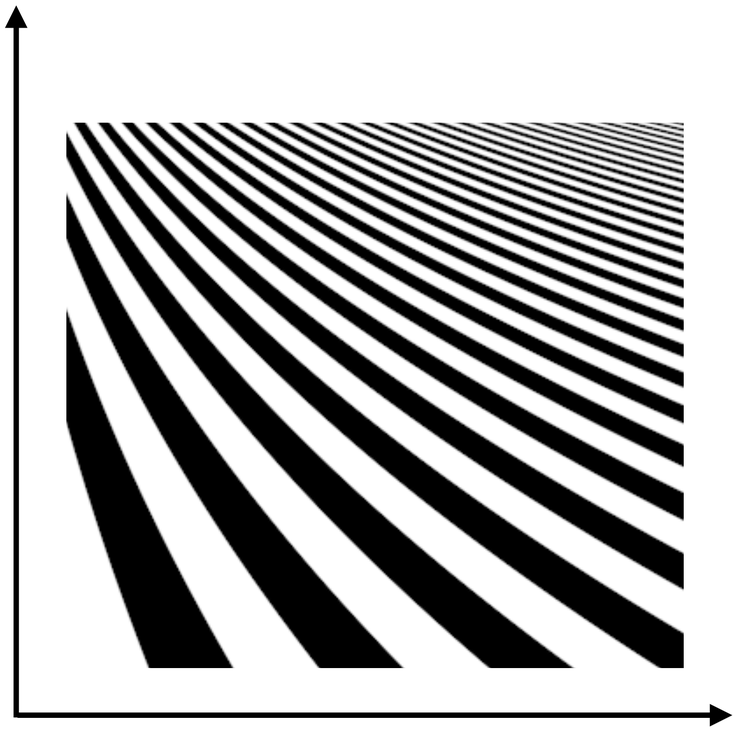
Radiometric fidelity improves photorealism

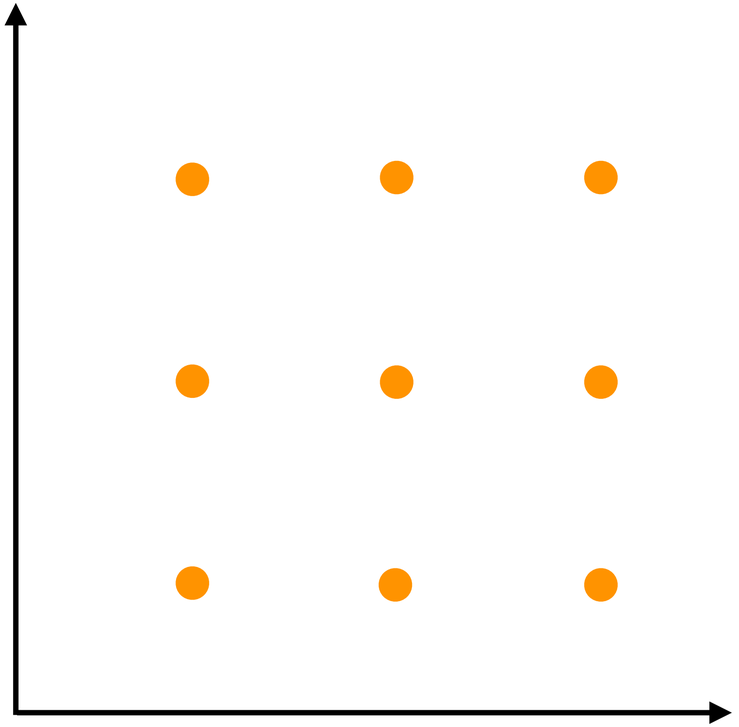
Papas et al. [2013]

Radiometric fidelity improves photorealism

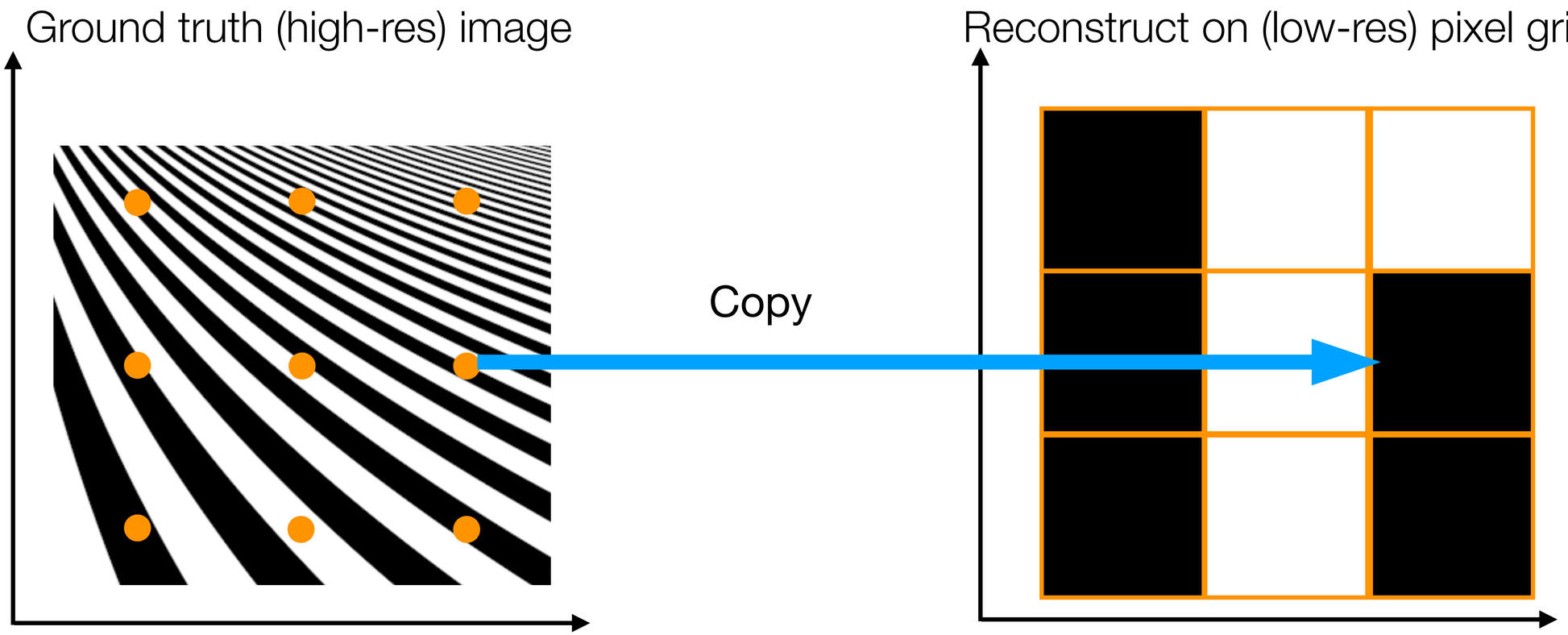
Krivanek et al. [2014]

Reconstruction: Estimate image samples

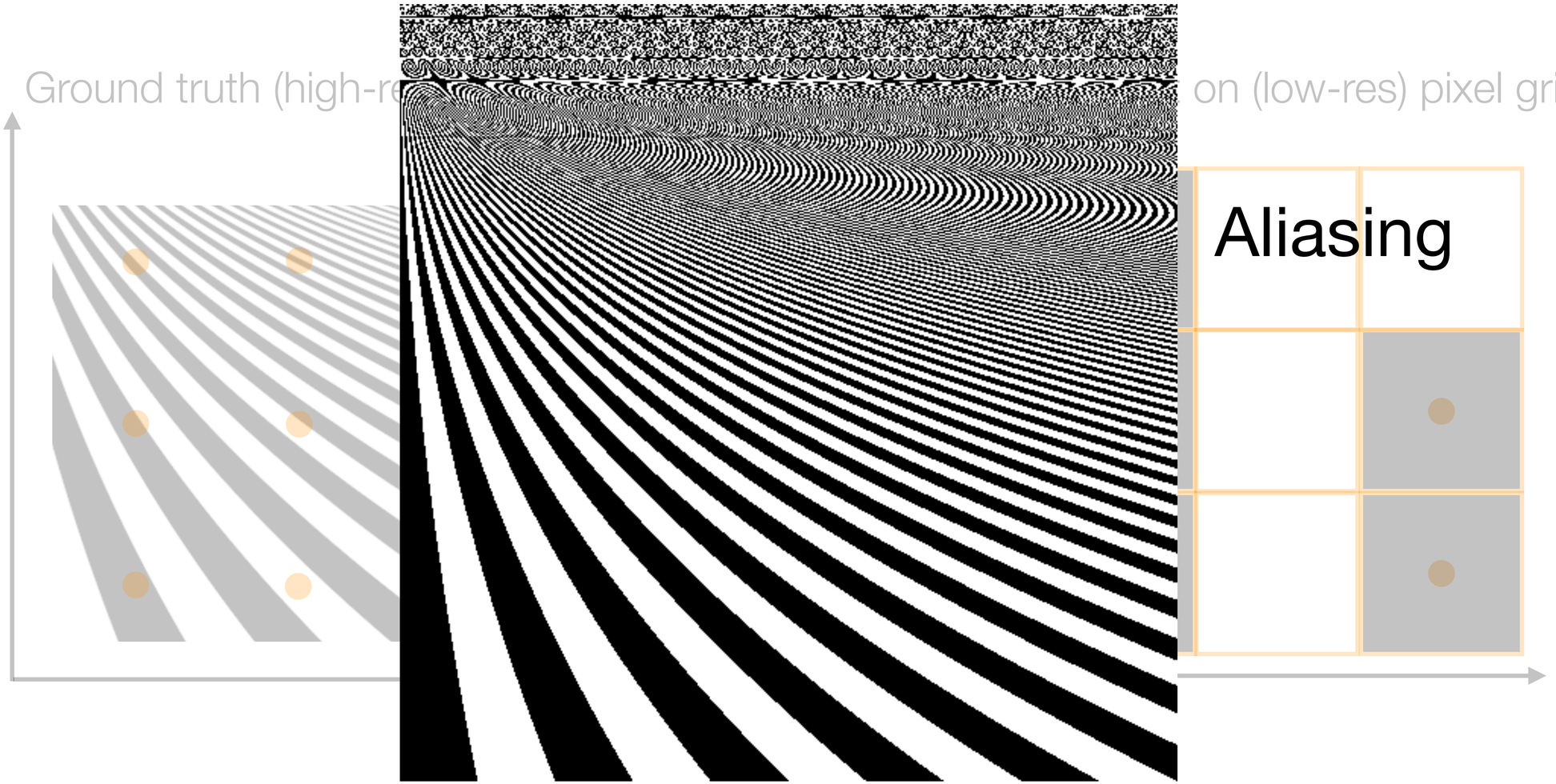




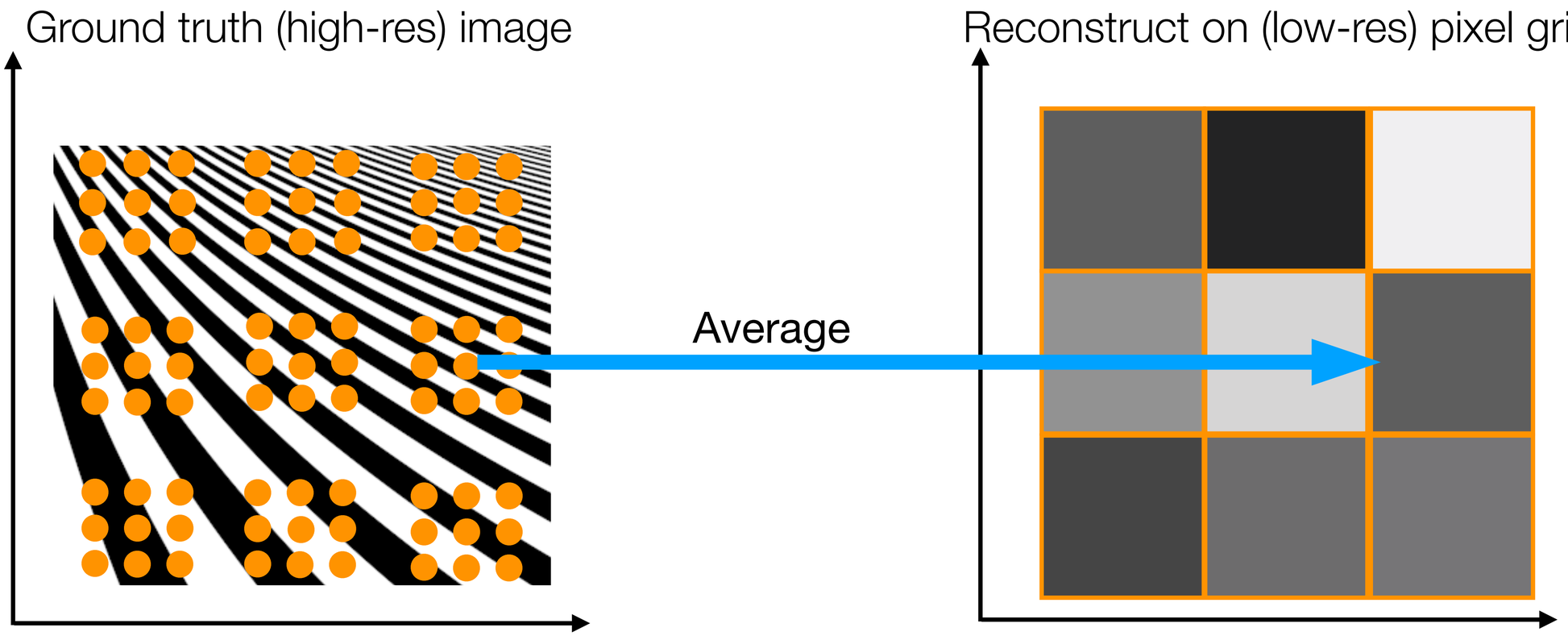
Naive method: sample image at grid locations



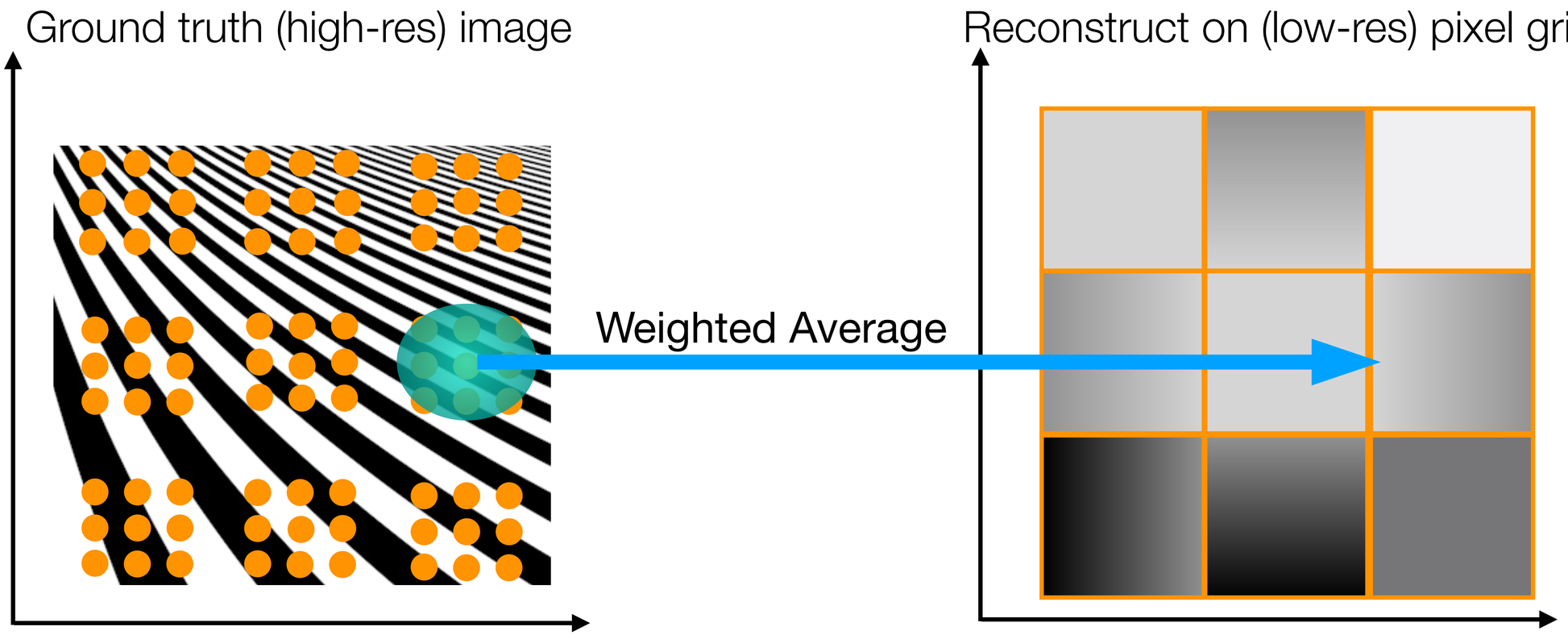
Naive method: sample image at grid locations



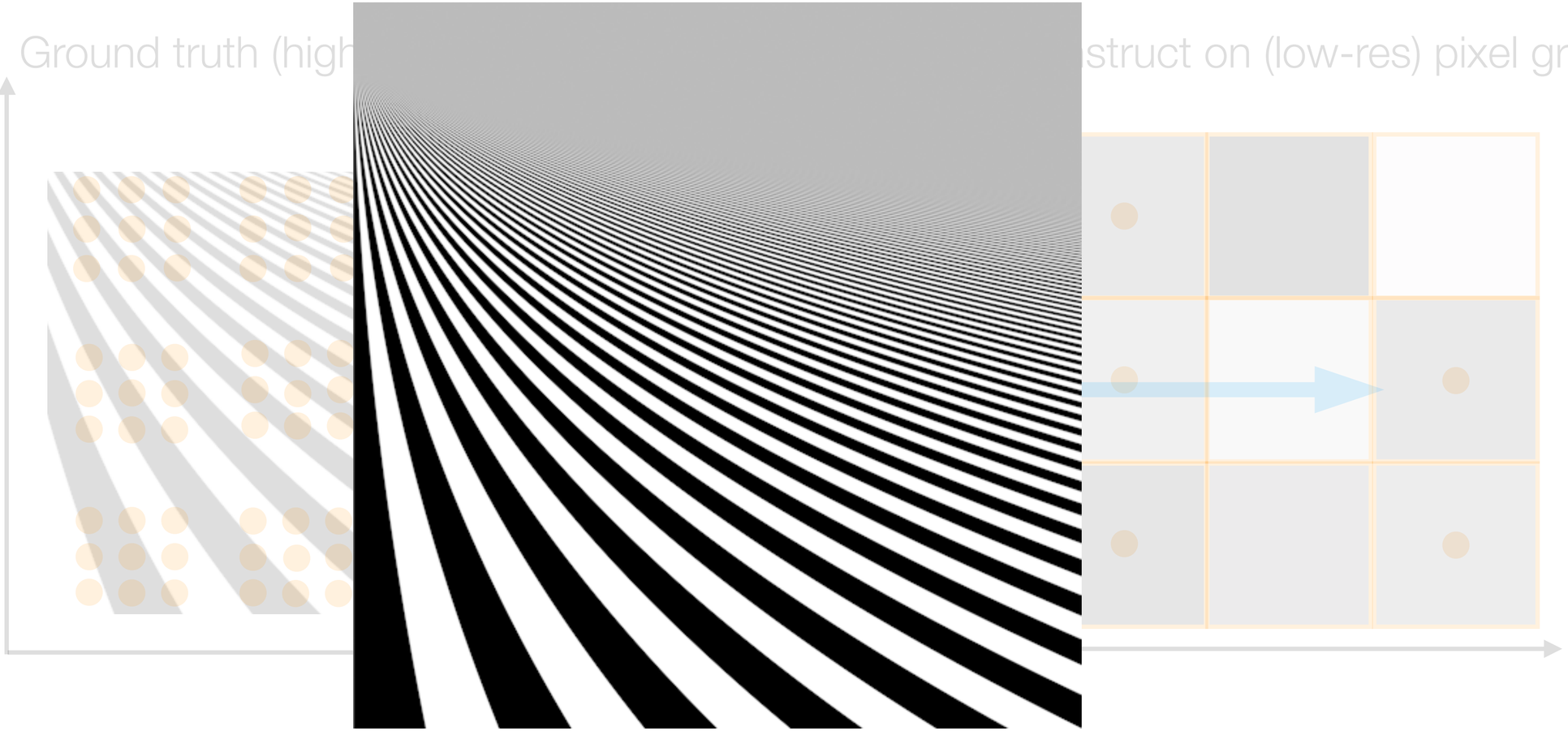
Naive method: sample image at grid locations



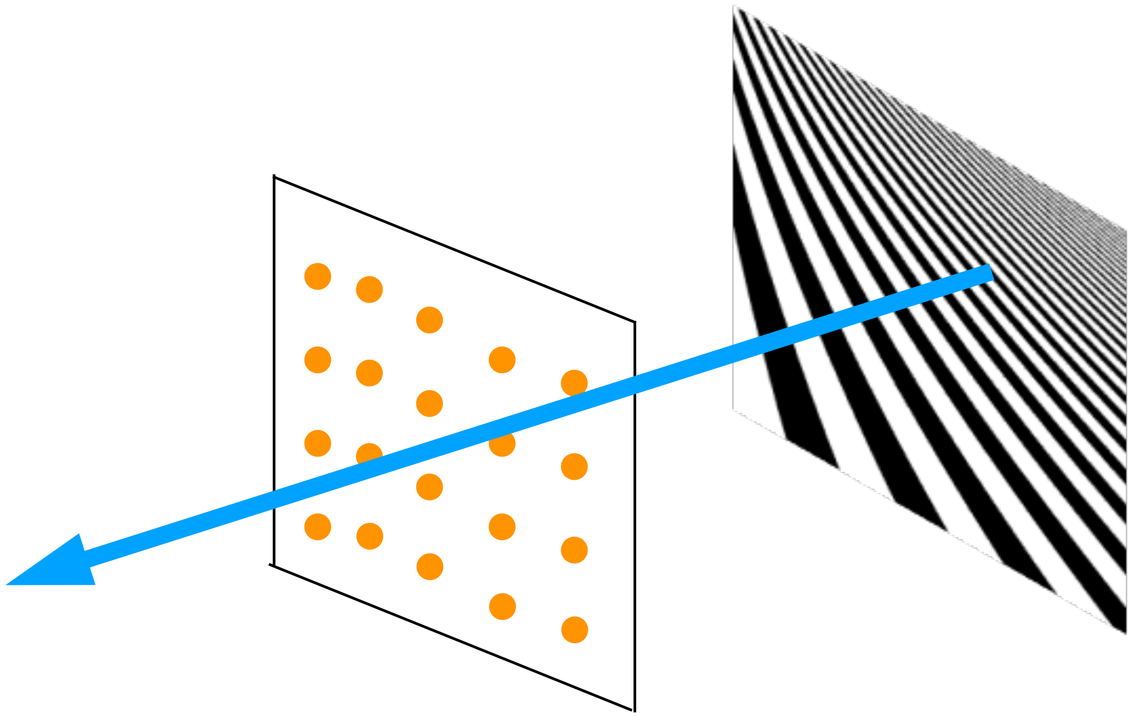
Antialiasing using general reconstruction filters



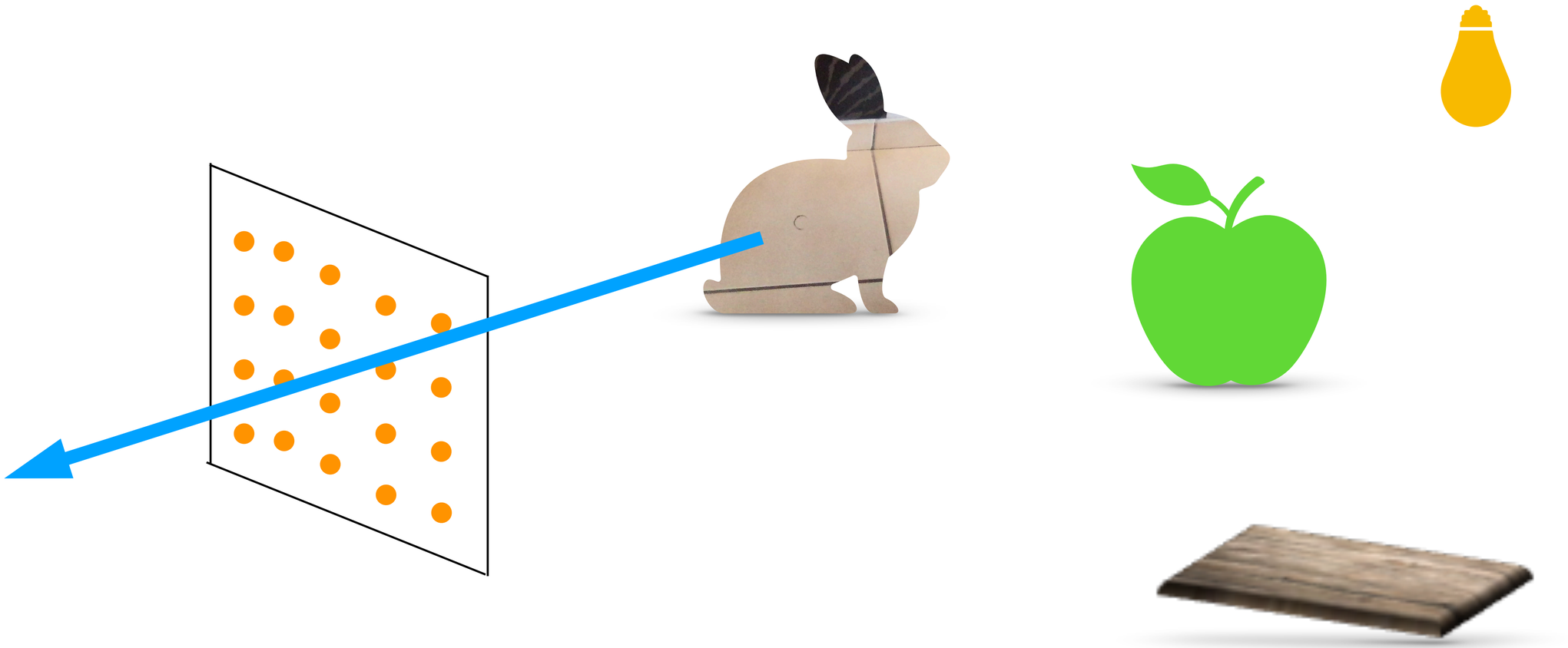
Naive method: sample image at grid locations



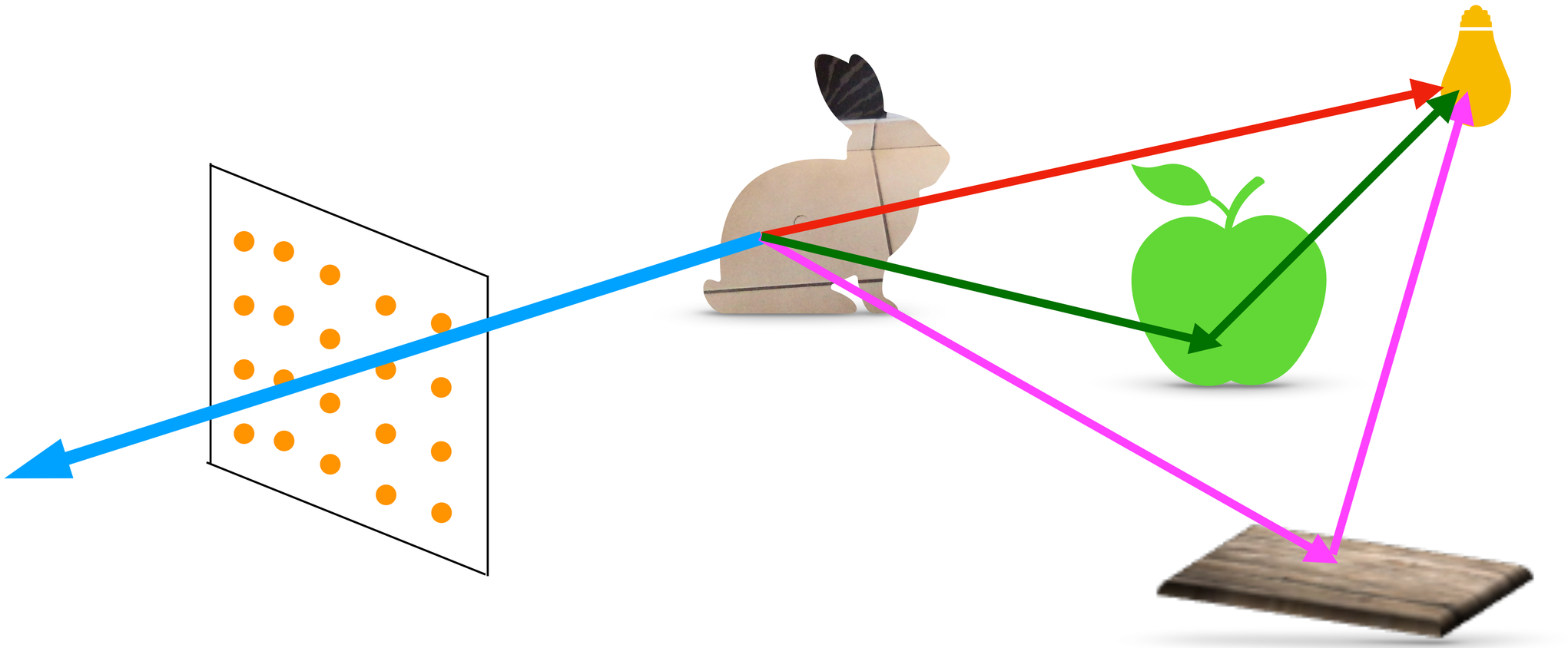
Rendering: reconstructing integrals



Rendering: reconstructing integrals

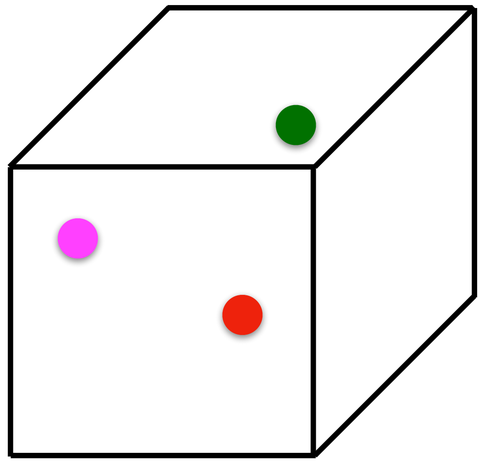


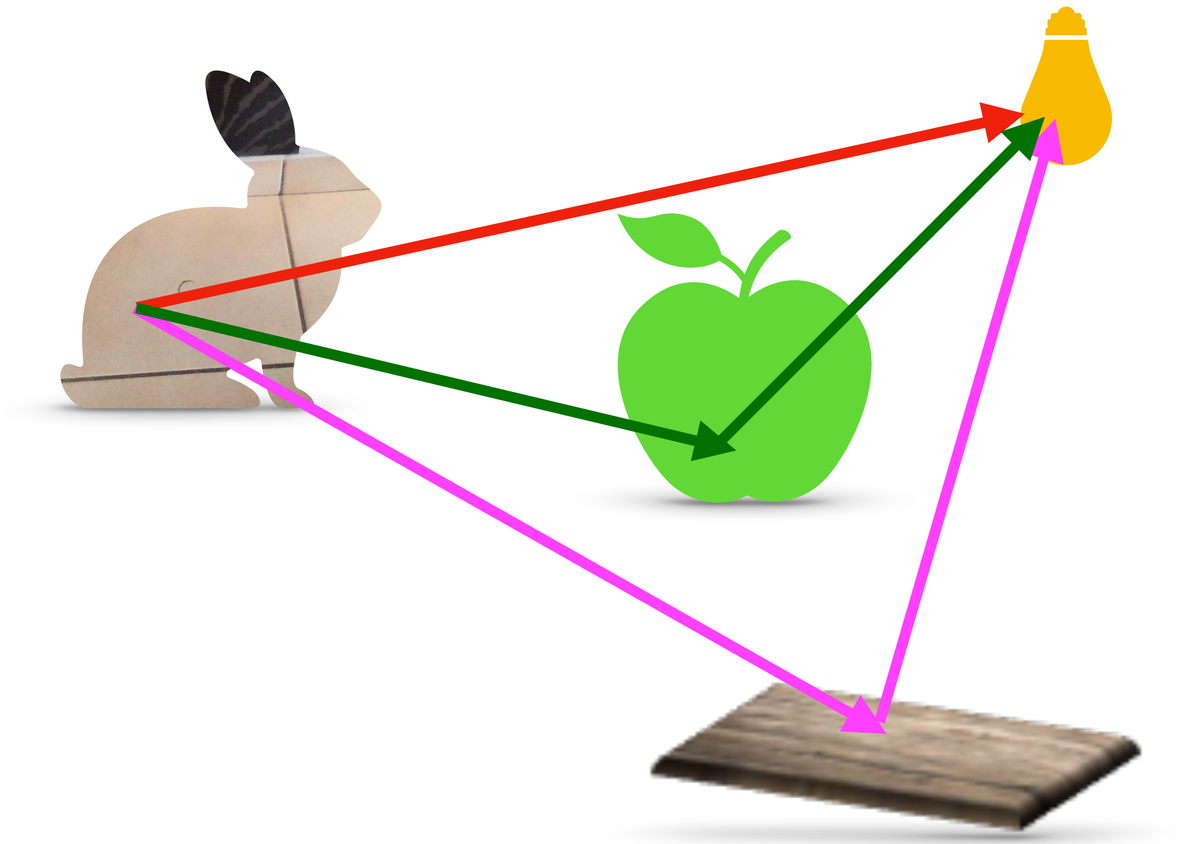
Rendering: reconstructing integrals



Rendering: reconstructing integrals

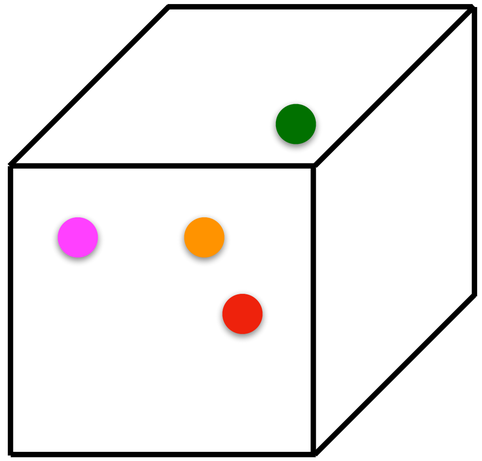
Each path has an associated radiance value

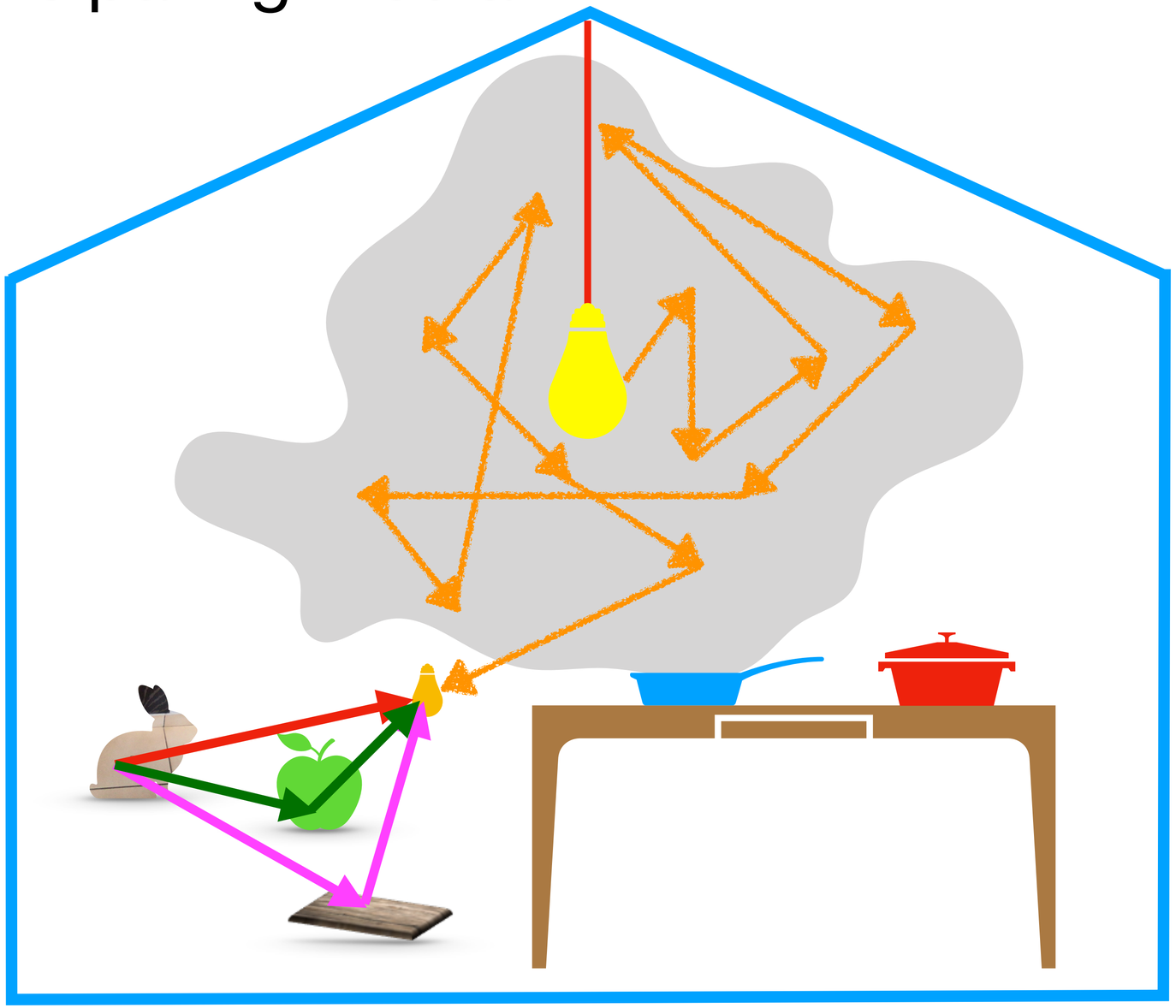


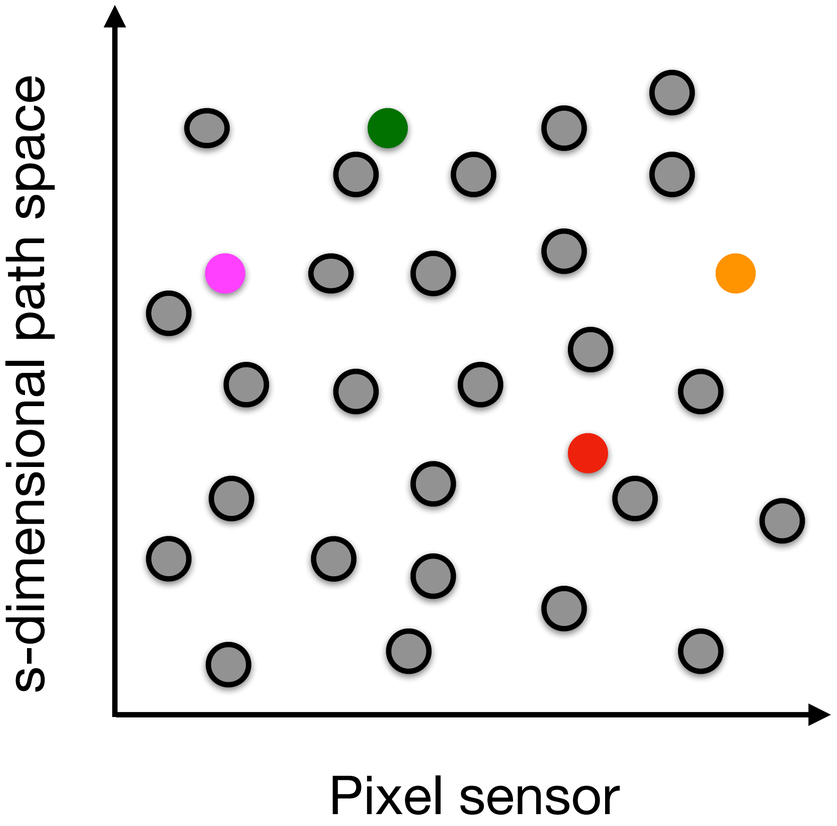


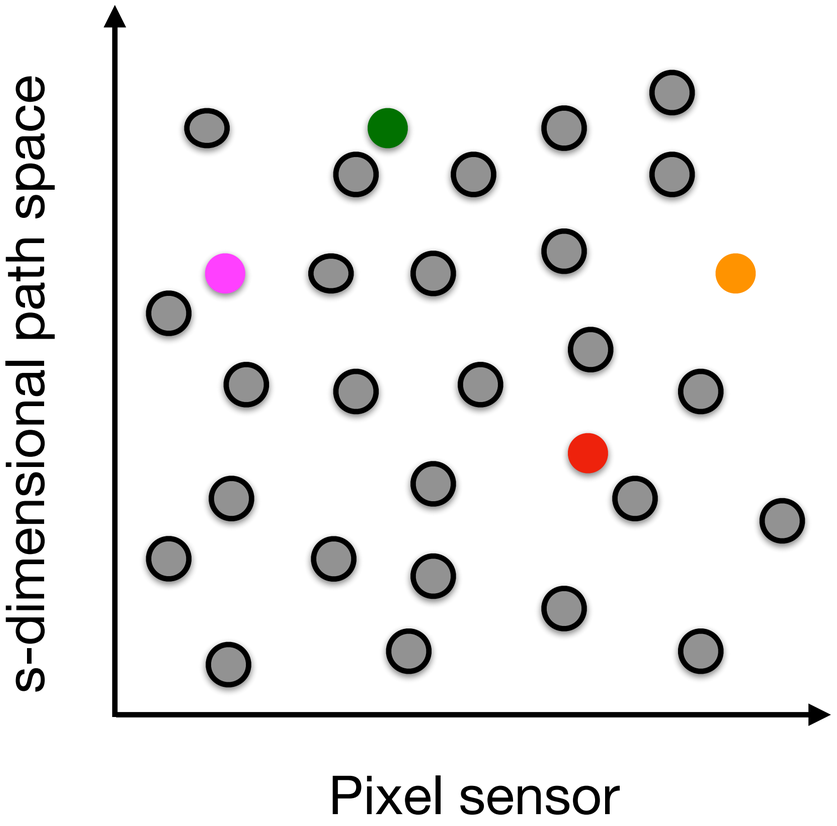
Global Illumination: Participating media

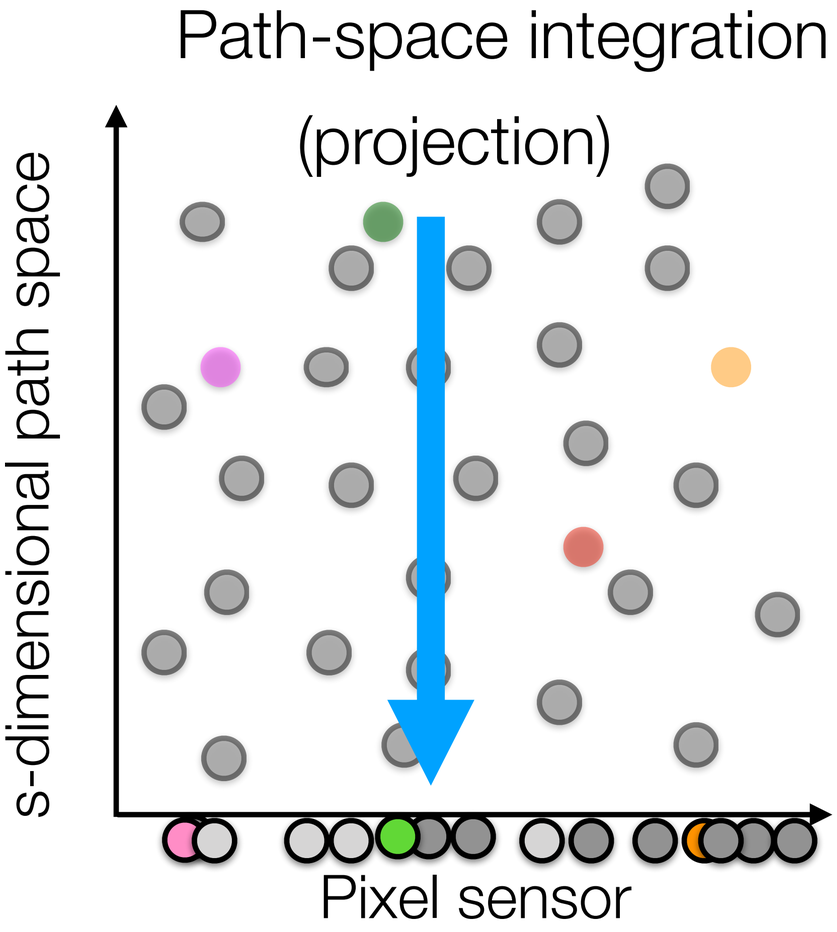
Each path has an
associated radiance value



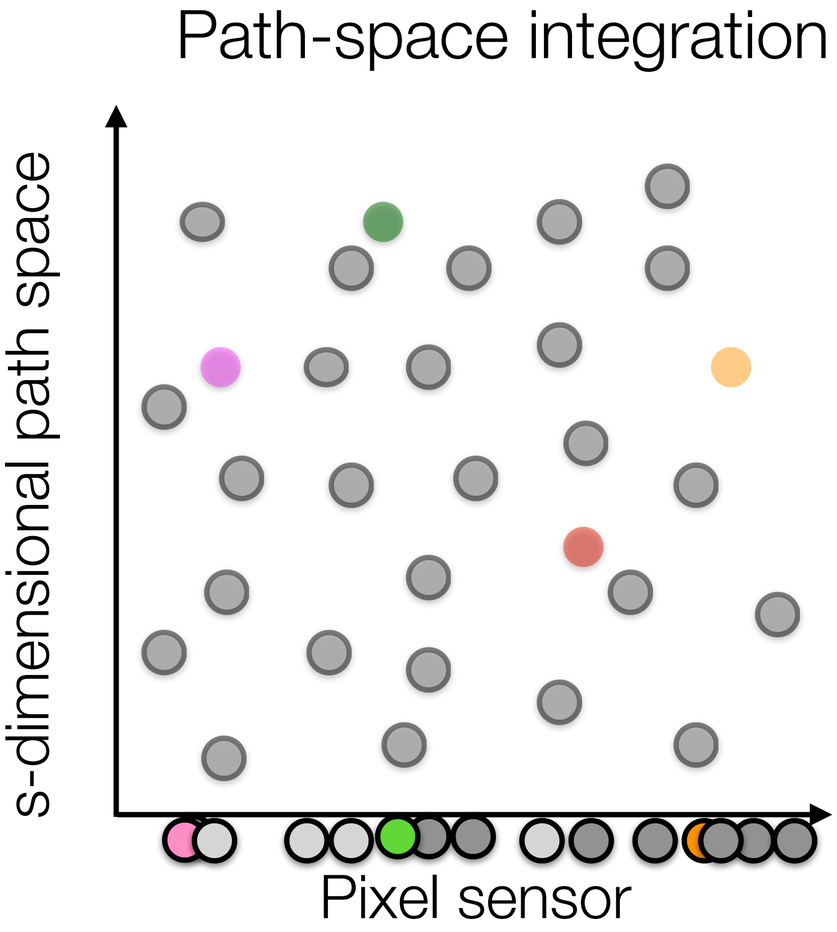


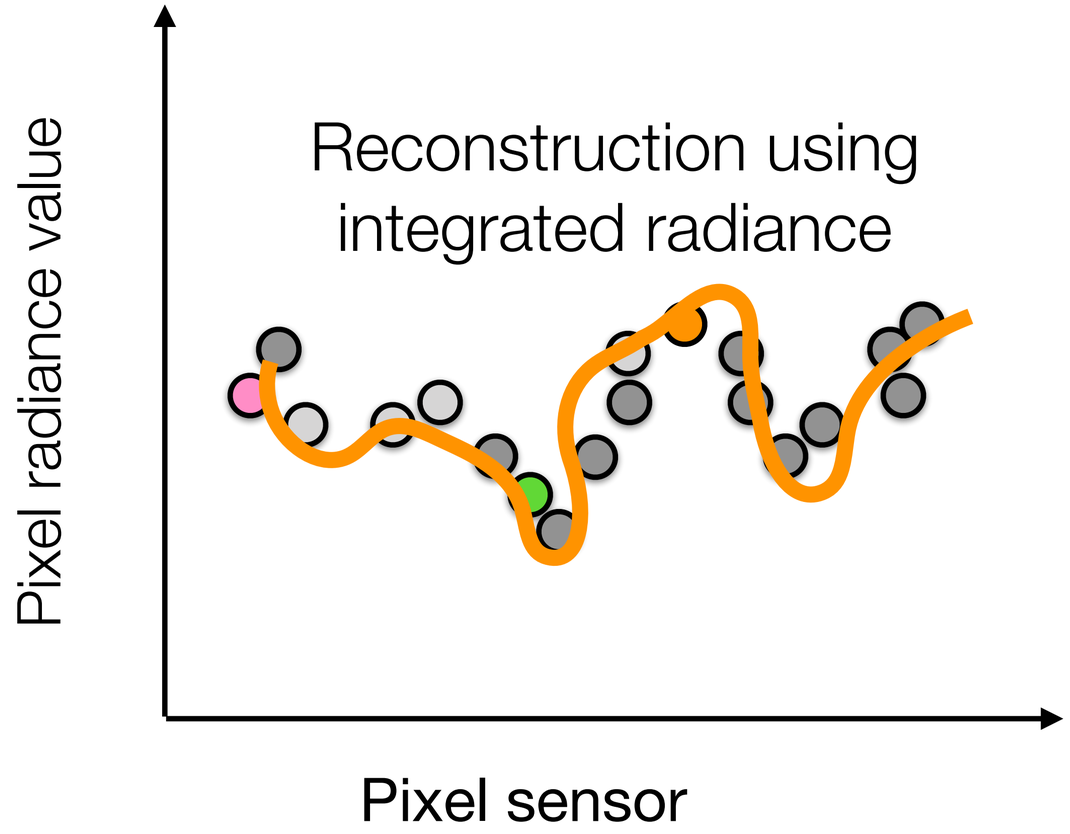

s-dimensional path space
Pixel sensor


s-dimensional path space
Pixel sensor


Path-space integration
(projection)
s-dimensional path space
Pixel sensor

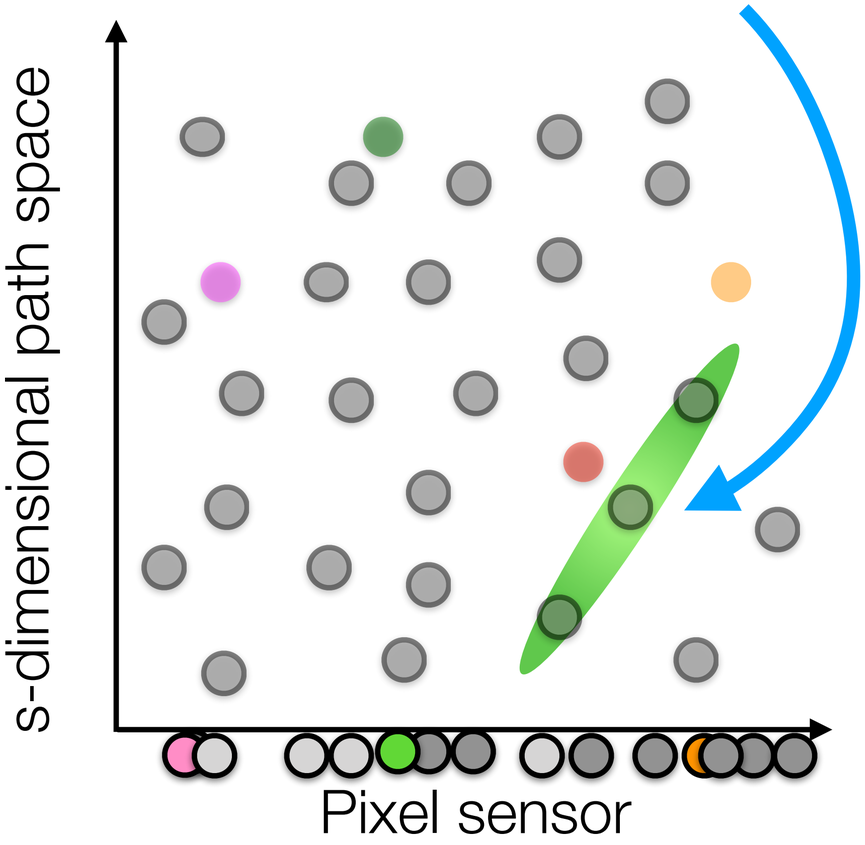
Rendering = integration + reconstruction



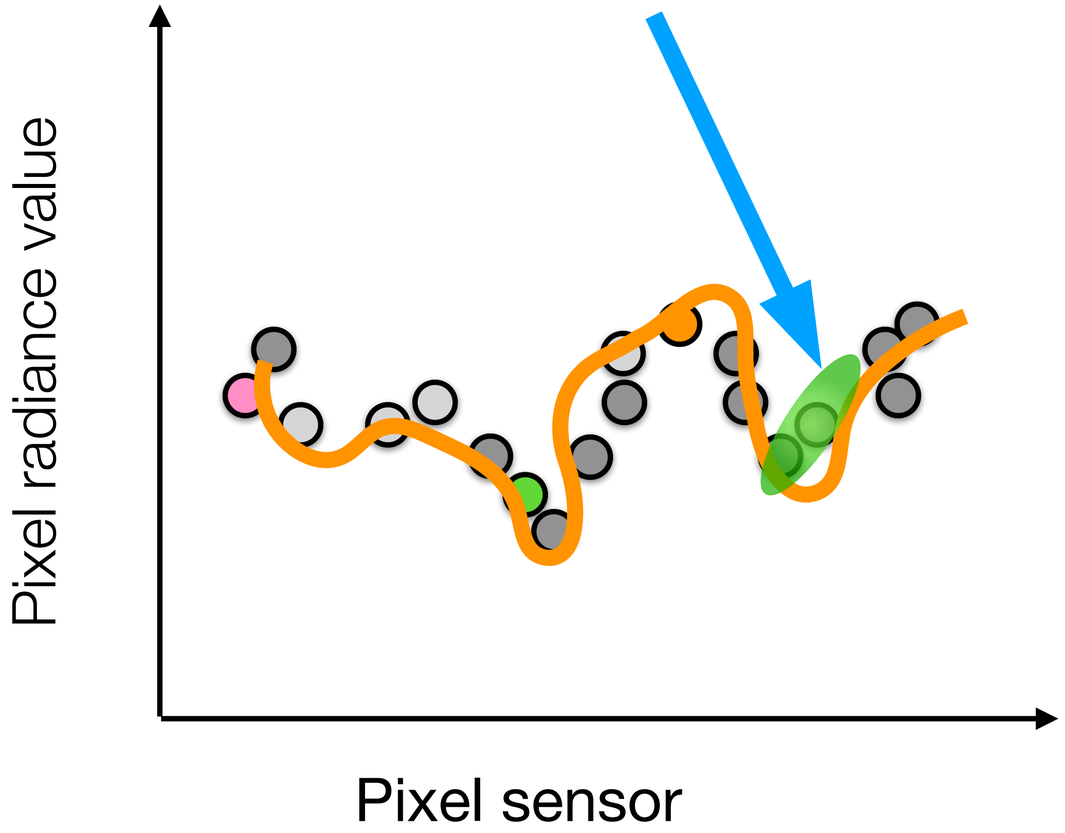


Frequency analysis of light fields in rendering

Local variation of the integrand



Reconstruction filter



A Frequency Analysis of Light Transport

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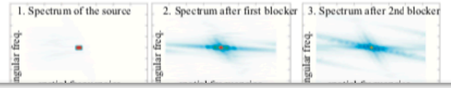
Nicolas Holzschuch, Cyril Soler, ARTIS* GRAVIR/IMAG-INRIA
Eric Chan, MIT-CSAIL
François X. Sillion, ARTIS* GRAVIR/IMAG-INRIA

Abstract

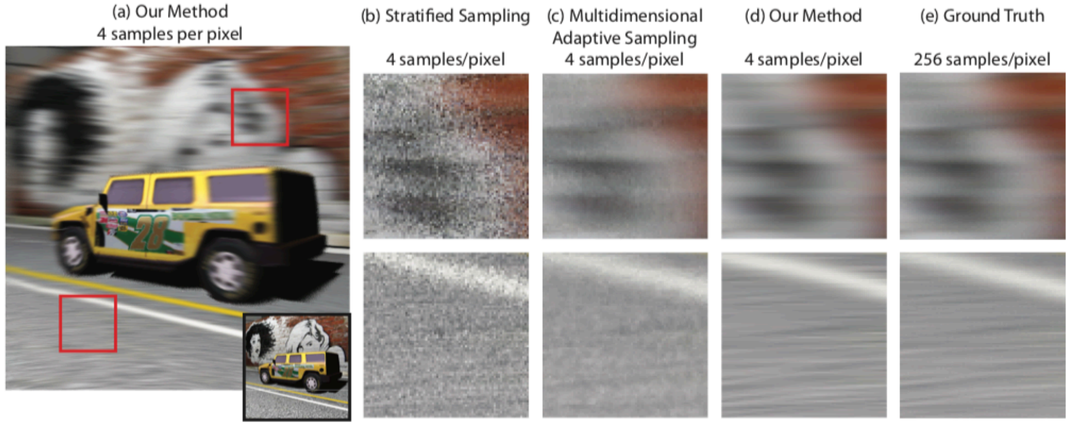
We present a signal-processing framework for light transport. We study the frequency content of radiance and how it is altered by



To appear in the ACM SIGGRAPH conference proceedings

Frequency Analysis and Sheared Reconstruction for Rendering Motion Blur

Kevin Egan *, Columbia University
Yu-Ting Tseng, Columbia University
Nicolas Holzschuch, INRIA — LJK
Frédo Durand, MIT CSAIL
Ravi Ramamoorthi, UC Berkeley



4D Frequency Analysis of Computational Cameras for Depth of Field Extension

Anat Levin[1,2] Samuel W. Hasinoff[1] Paul Green[1] Frédo Durand[1] William T. Freeman[1]
[1]MIT CSAIL [2]Weizmann Institute

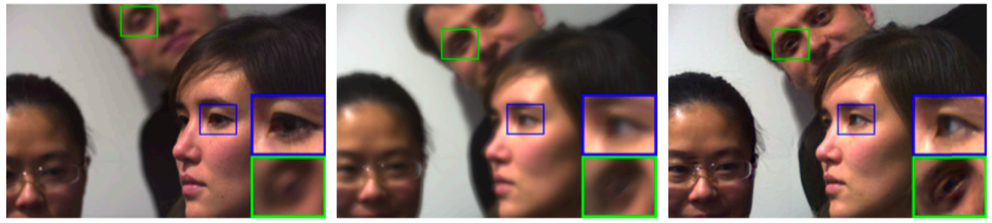


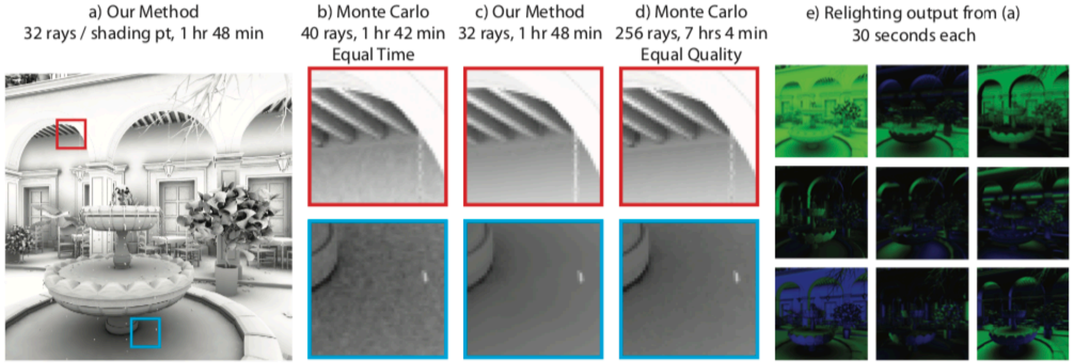
Figure 1: *Left: Image from a standard lens showing limited depth of field, with only the rightmost subject in focus. Center: Input from our lattice-focal lens. The defocus kernel of this lens is designed to preserve high frequencies over a wide depth range. Right: An all-focused image processed from the lattice-focal lens input. Since the defocus kernel preserves high frequencies, we achieve a good restoration over the*

5D Covariance Tracing for Efficient Defocus and Motion Blur

LAURENT BELCOUR[1], CYRIL SOLER[2], KARTIC SUBR[3], NICOLAS HOLZSCHUCH[2], and FREDO DURAND[4]

Practical Filtering for Efficient Ray-Traced Directional Occlusion

Kevin Egan *, Columbia University
Frédo Durand, MIT CSAIL
Ravi Ramamoorthi, University of California, Berkeley



Temporal Light Field Reconstruction for Rendering Distribution Effects

Jaakko Lehtinen, NVIDIA Research
Timo Aila, NVIDIA Research
Jiawen Chen, MIT CSAIL
Samuli Laine, NVIDIA Research
Frédo Durand, MIT CSAIL

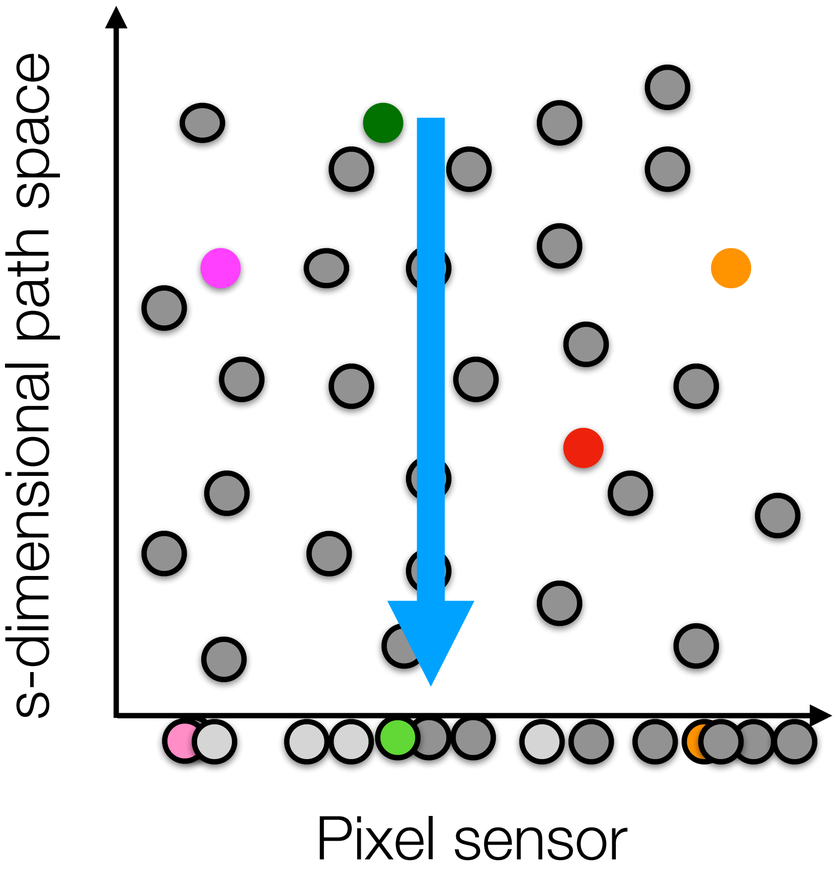
Figure 1: *A scene with complex occlusion rendered with depth of field. Left: Images rendered by PBRT [Pharr and Humphreys 2010] using 16 and 256 low-discrepancy samples per pixel (spp) and traditional axis-aligned filtering. Right: Image reconstructed by our algorithm in 10 seconds from the same 16 samples per pixel. We obtain defocus quality similar to the 256 spp result in approximately 1/16th of the time.*

Abstract

Traditionally, effects that require evaluating multidimensional integrals for each pixel, such as motion blur, depth of field, and

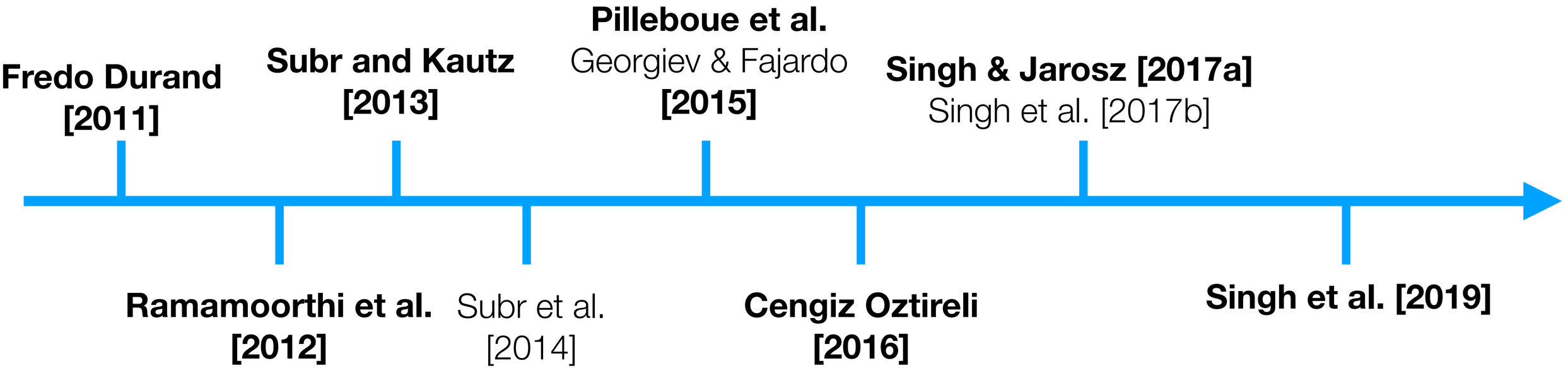
dramatic reductions in sampling rate, they rely on fairly simple reconstruction that suffers from a number of limitations. First, because they use linear reconstruction kernels and a simple model of

This STAR: Analyze sample correlations for MC sampling



Assessing MSE, bias, variance and convergence of Monte Carlo estimators using spatial and spectral tools

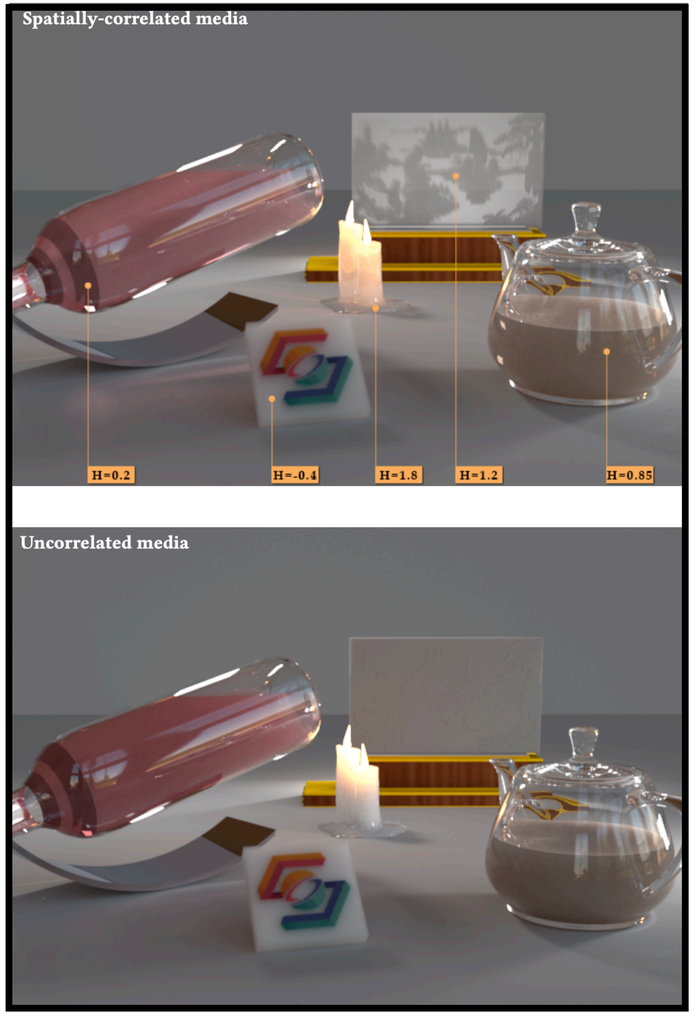
This STAR: Analyze sample correlations for MC sampling

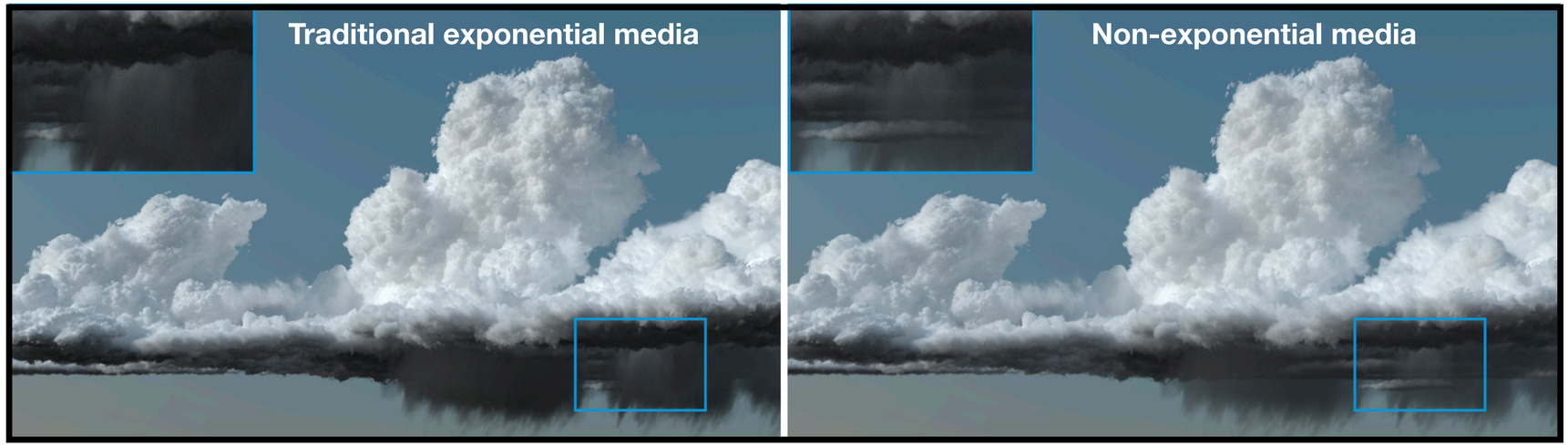


Sample correlations affect light transport / appearance

Jarabo et al. [2018]

Guo et al. [2019]





Bitterli et al. [2018]

Theoretical Tools

Point Processes

Fourier transform / Series

Samples Quality Assessment

Pair Correlation Function

Fourier Transform / Series

Error Formulations

Spatial Domain Formulations

Fourier Domain Formulations

Error Analysis

Stratification Strategies

Low Discrepancy Samplers

Stochastic Samplers