Environment Matting

Blue screen matting

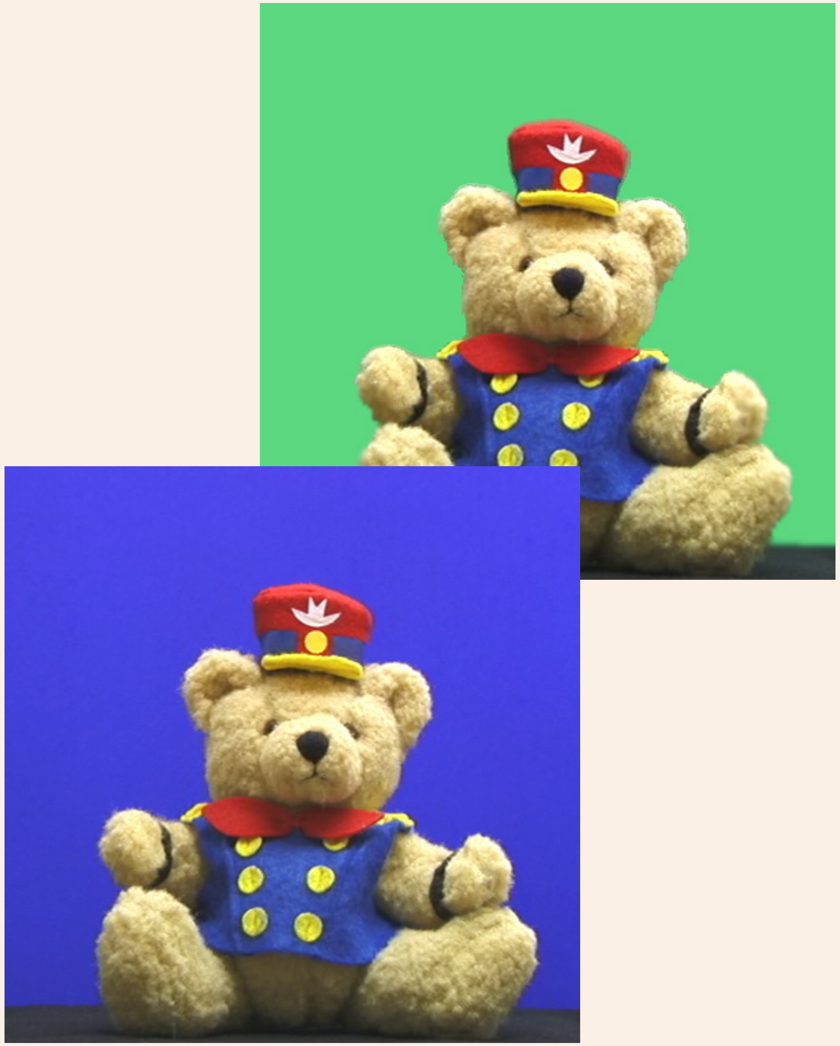
input image **alpha composite**

Problem: blue foreground

source image

alpha composite

Two-screen matting



alpha composite

Problem: refractive object

alpha composite

Problem: refractive object

alpha composite

photograph

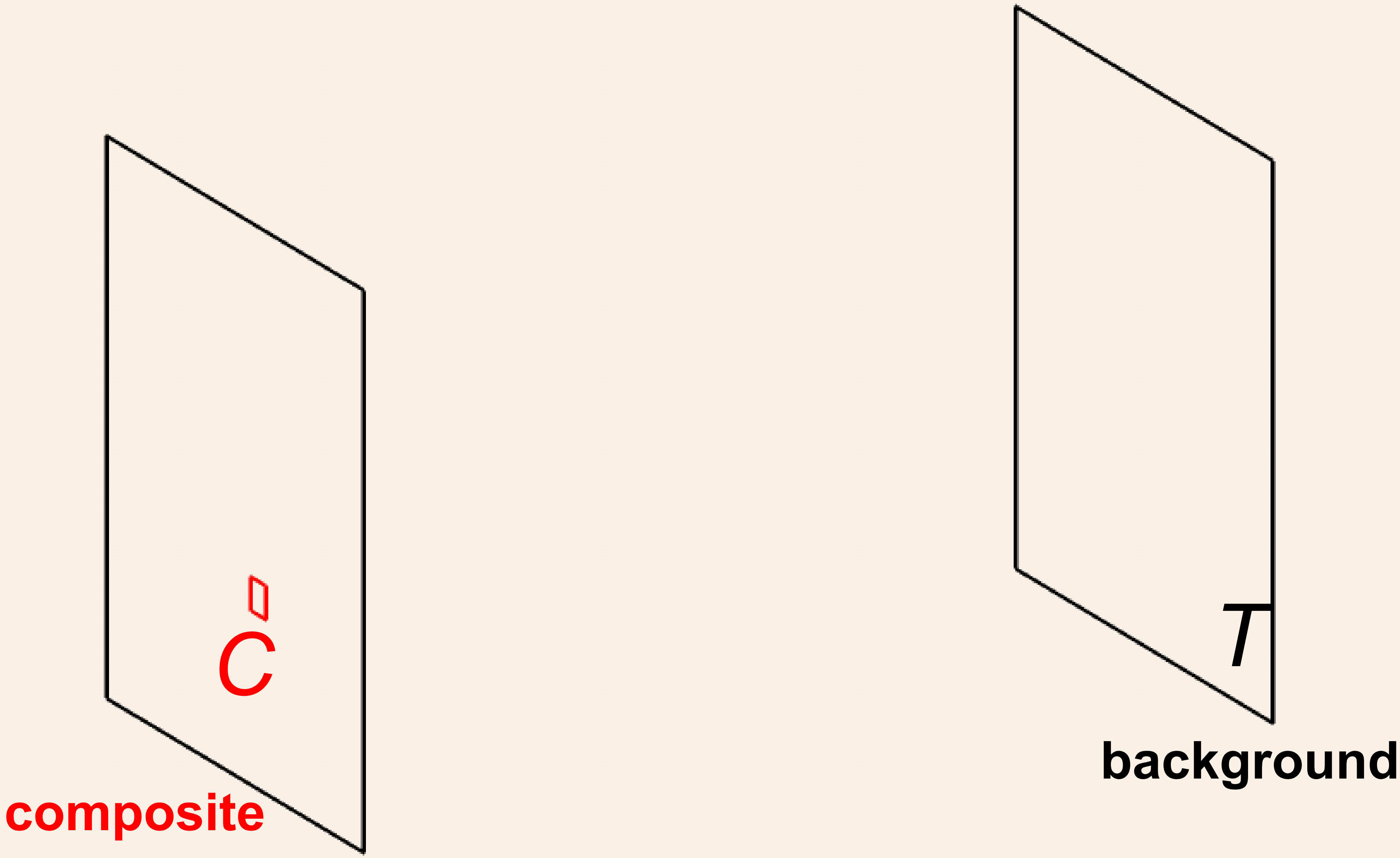
Refracted image of a single pixel

Refracted image of a single pixel

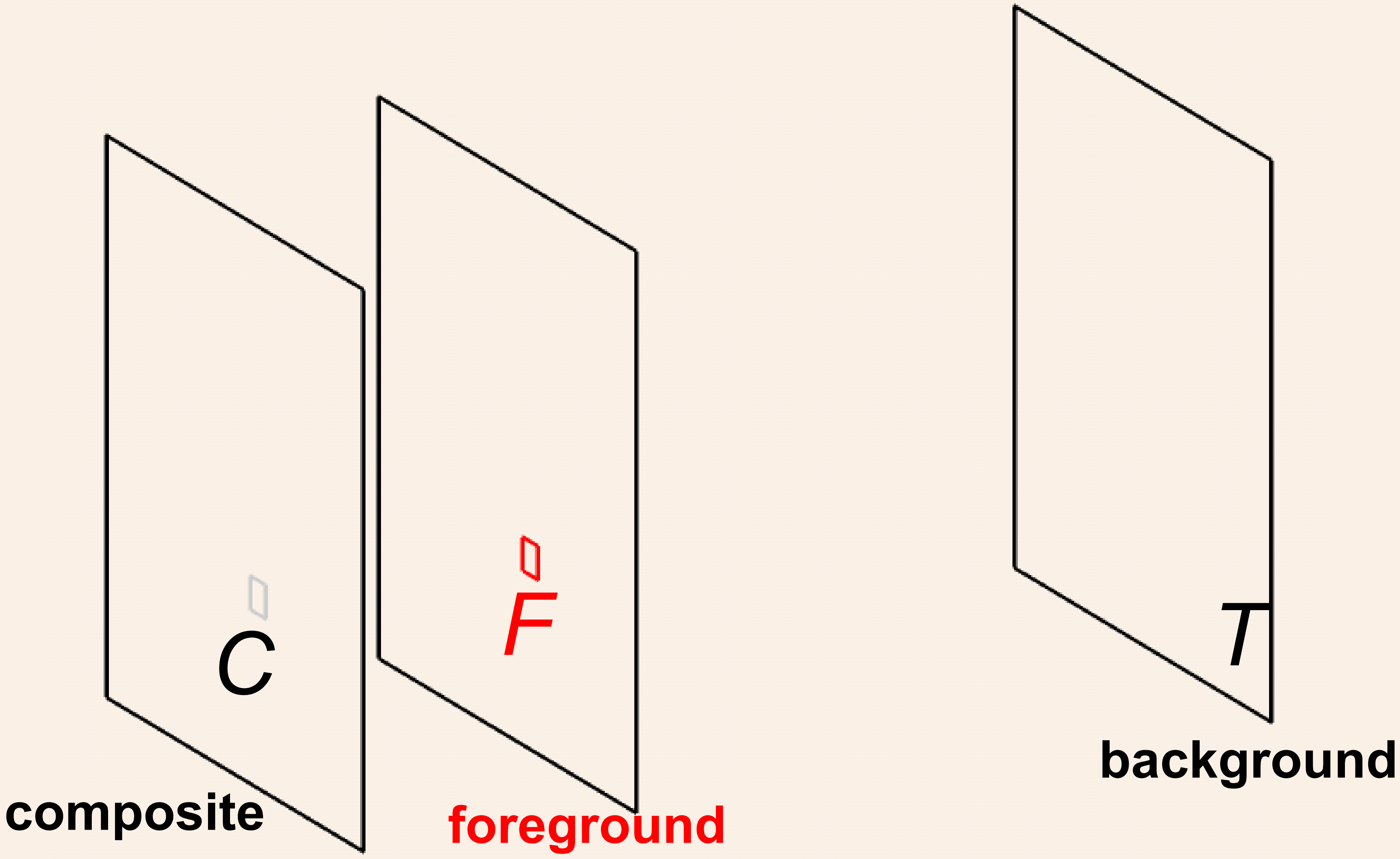
Refracted image of a single pixel

Environment matting framework

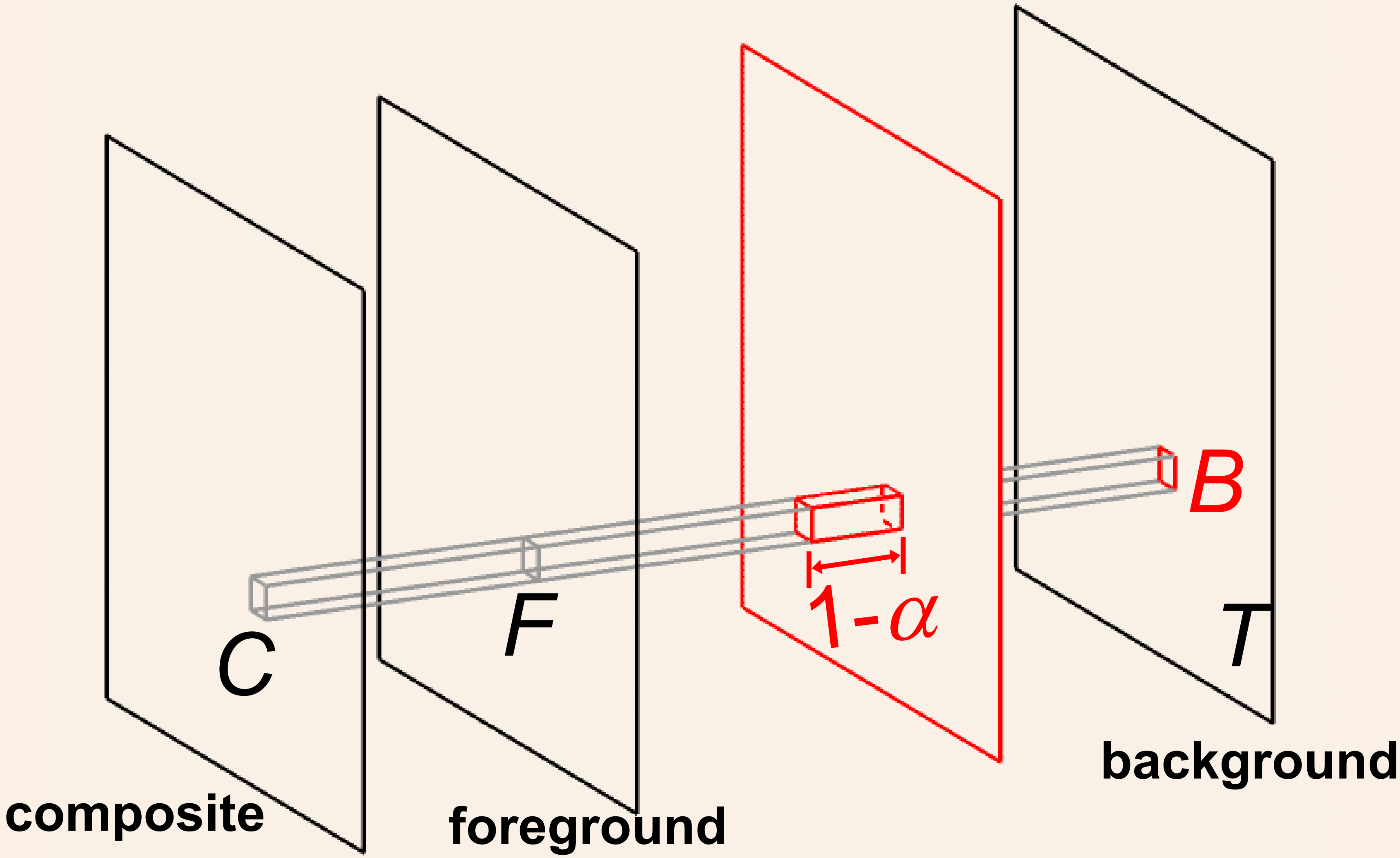
$C =$



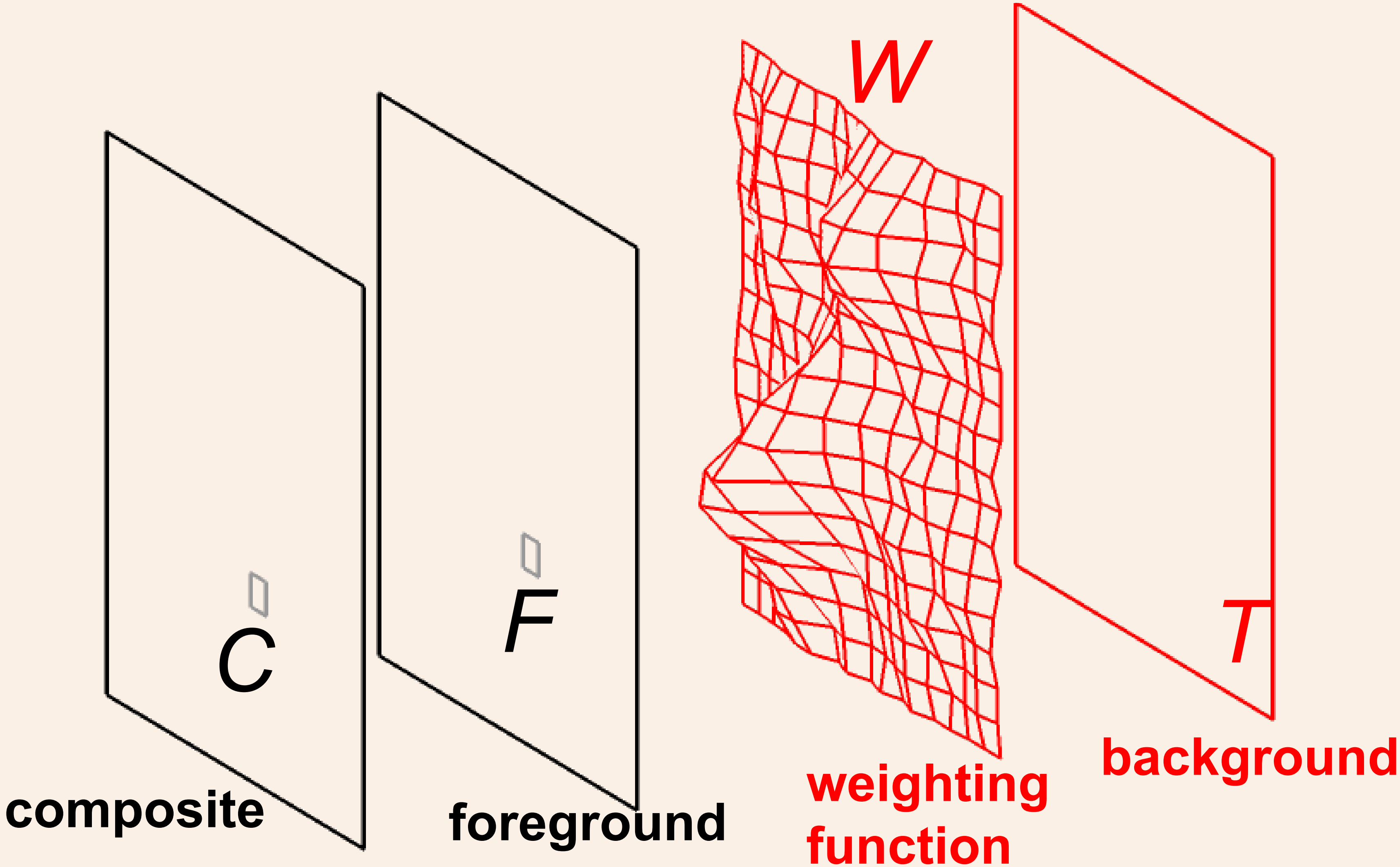
$$C = F$$



$$C = F + (1-\alpha)B$$

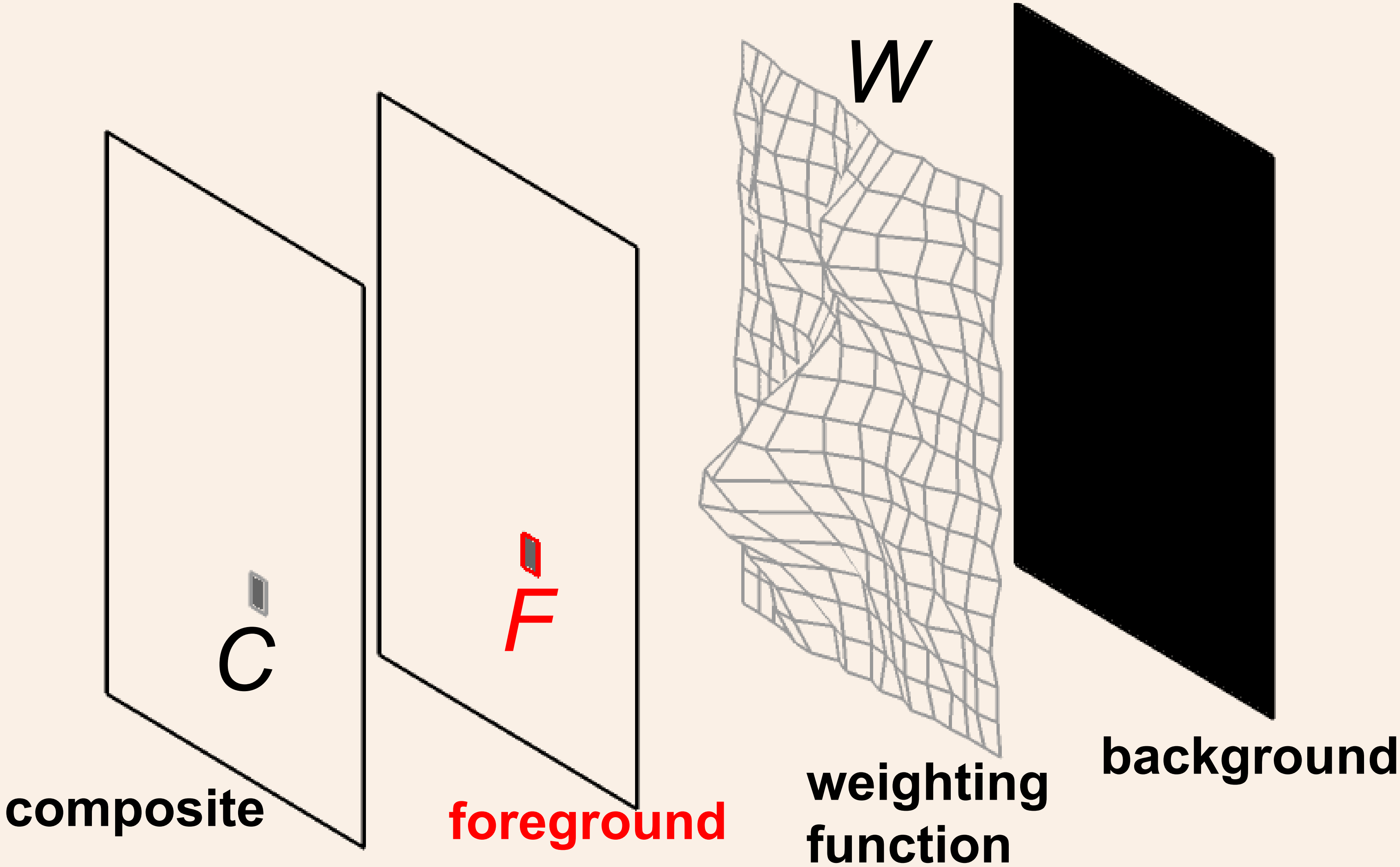


$$C = F + \int W\,T$$

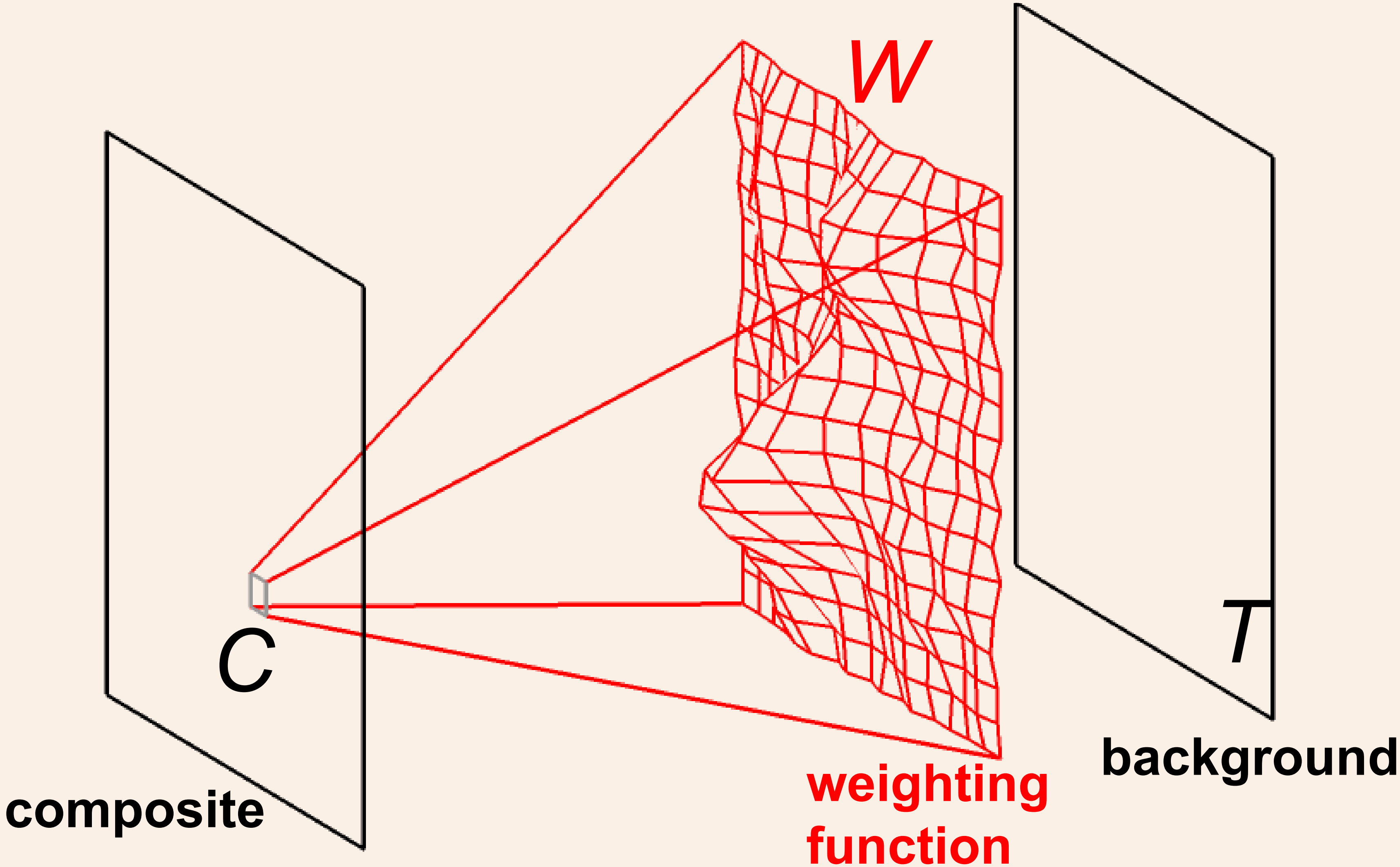


W
C
F
T
composite
foreground
weighting function
background

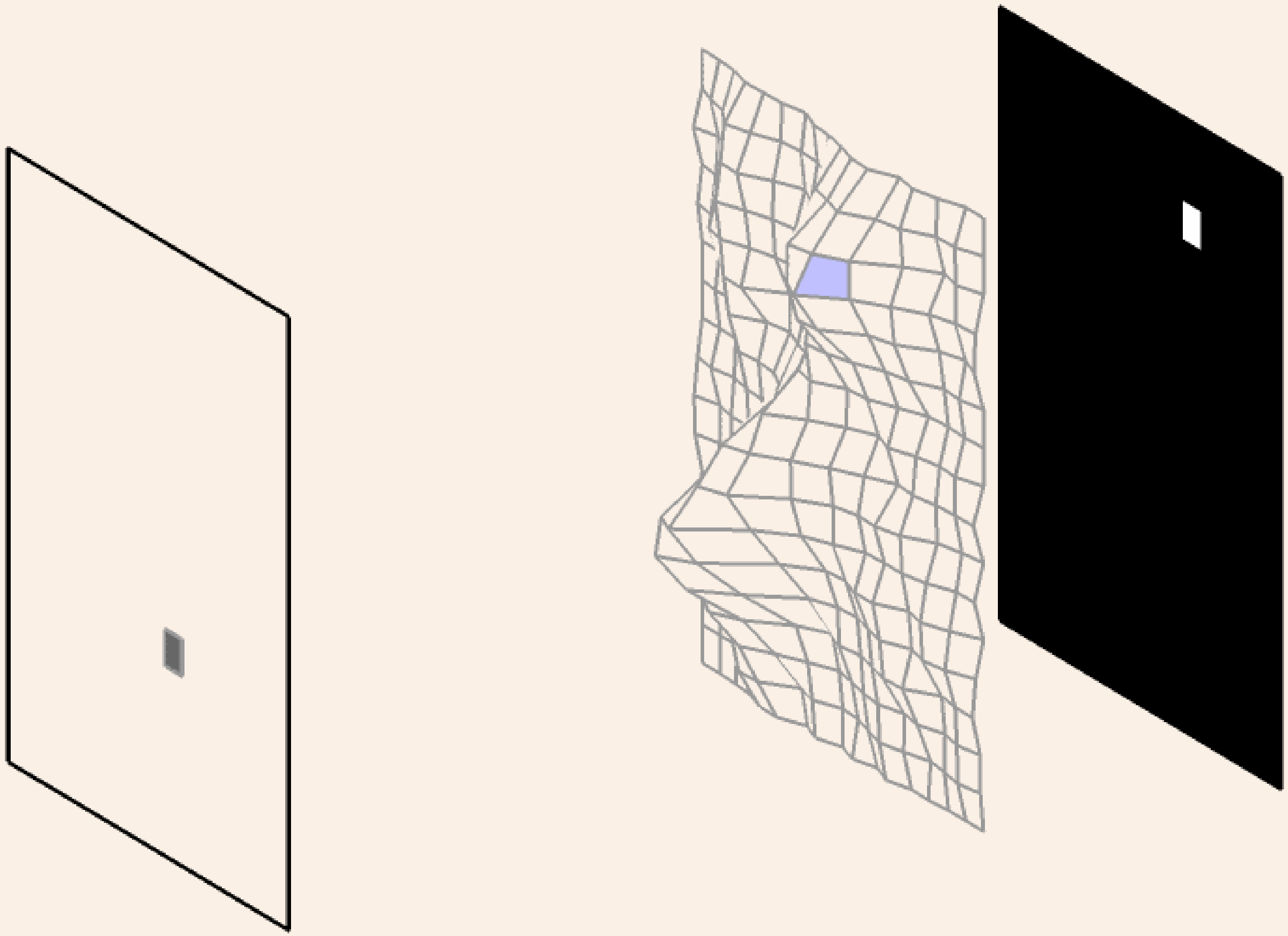
$$C = {\color{red}F} + \int W \, 0$$



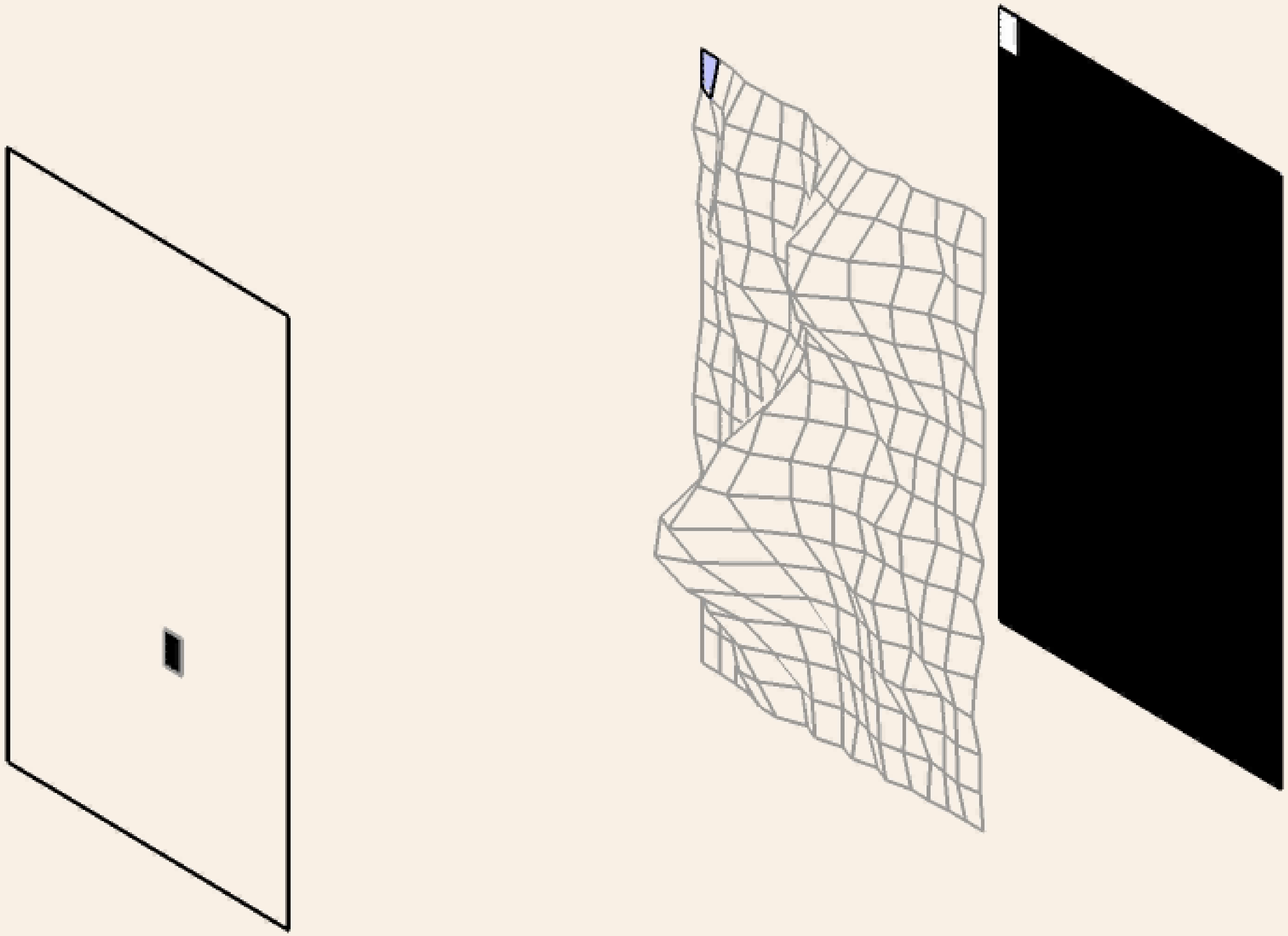
$$C = F + \int W\,T$$



Arbitrary weighting function



Arbitrary weighting function

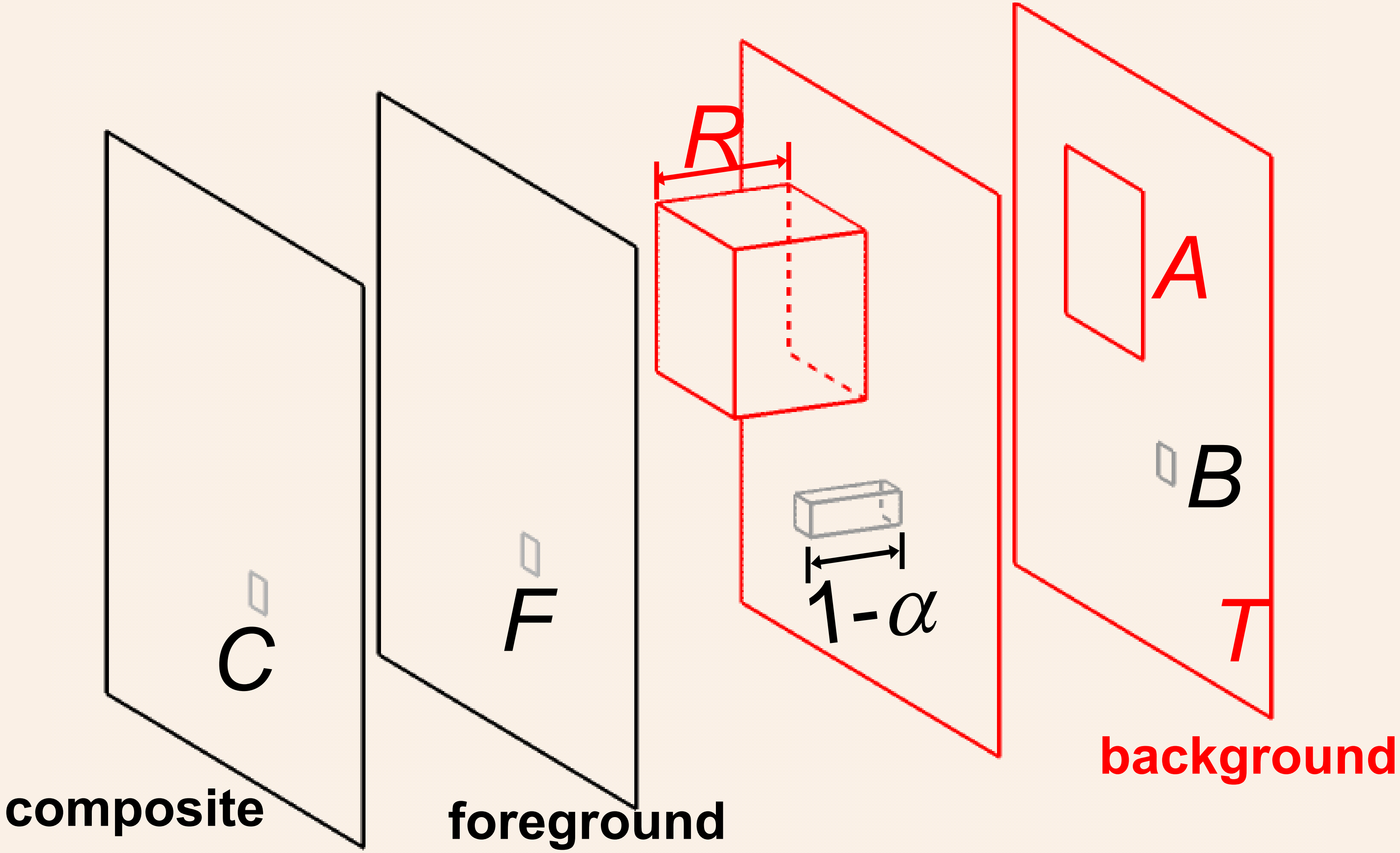


Hierarchical environment matting

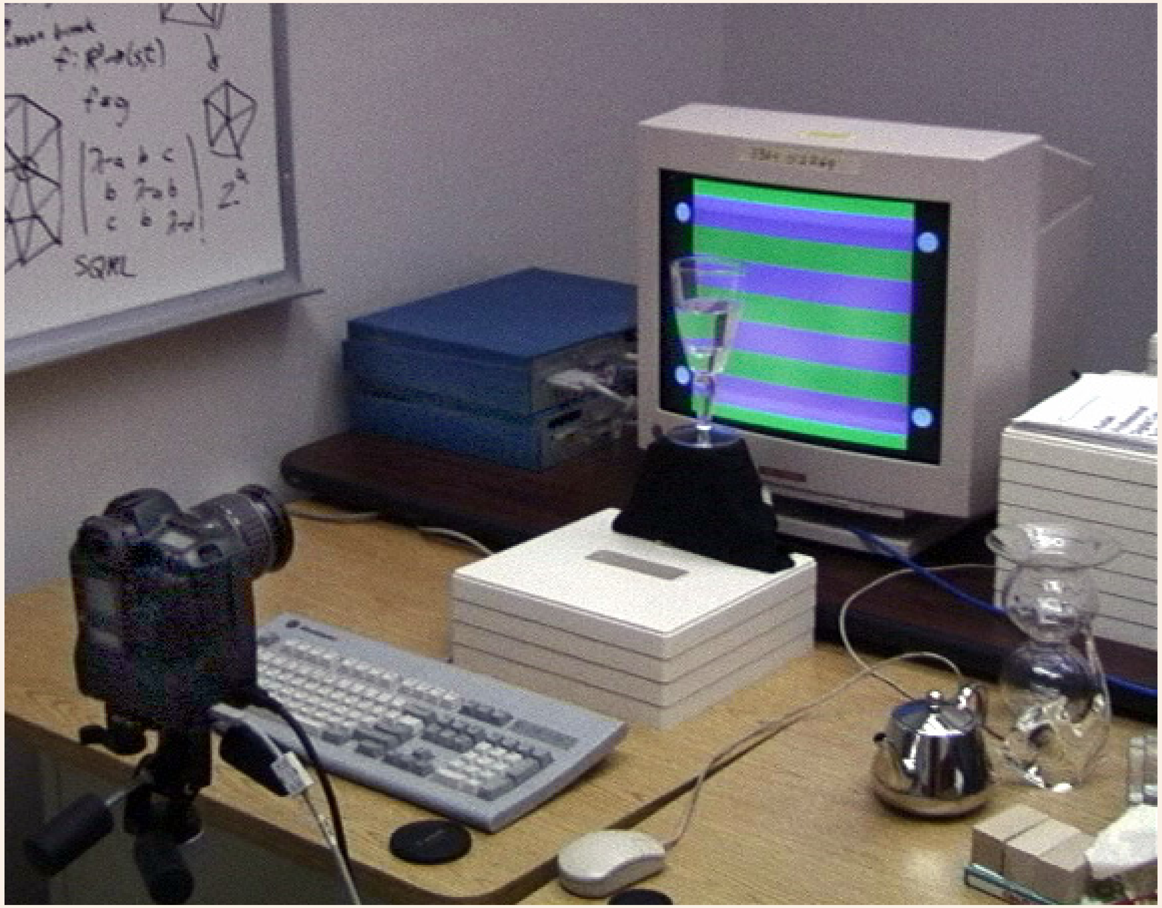
Zongker et. al.

SIGGRAPH 1999

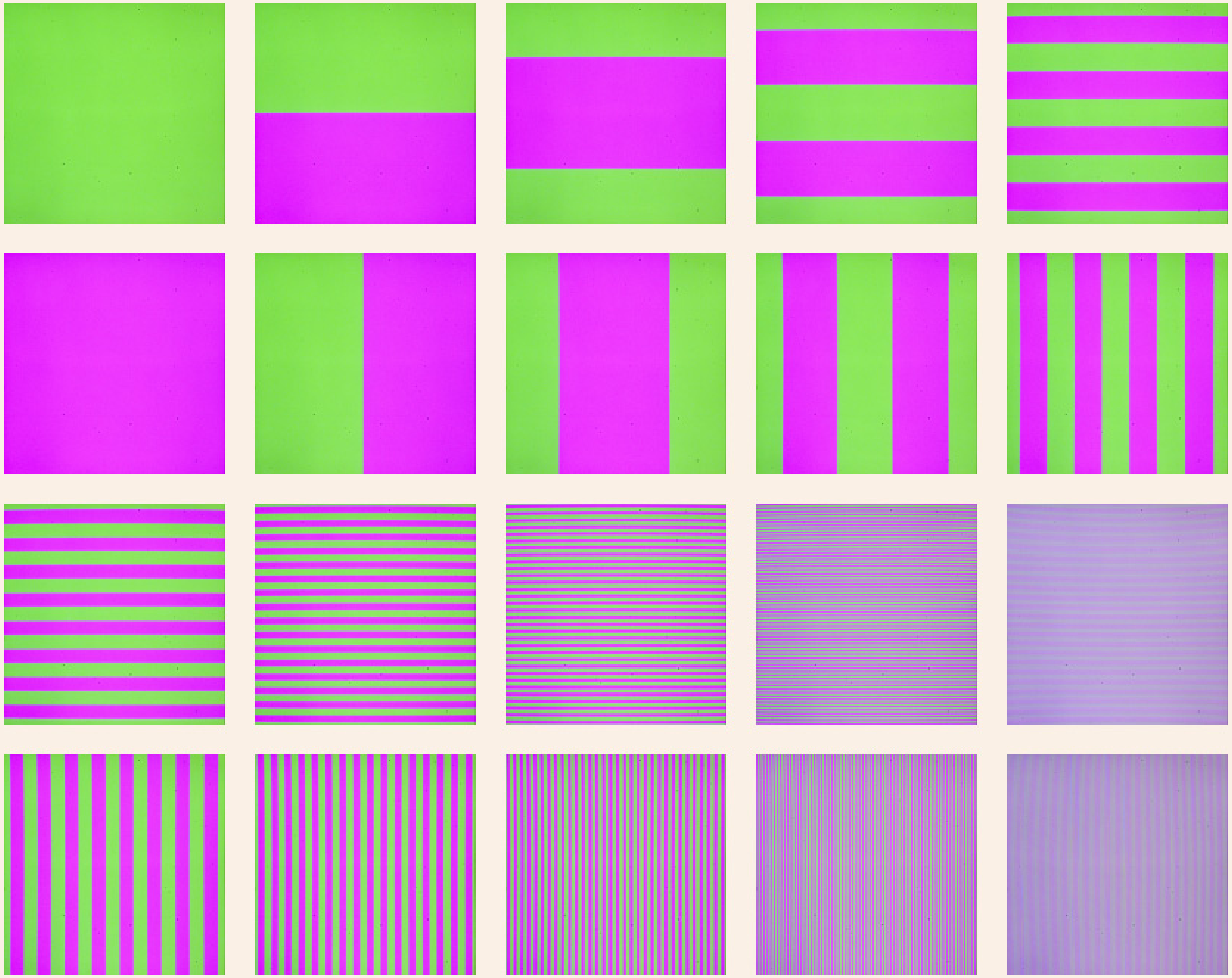
$$C = F + (1-\alpha)B + R\mathcal{M}(T, A)$$



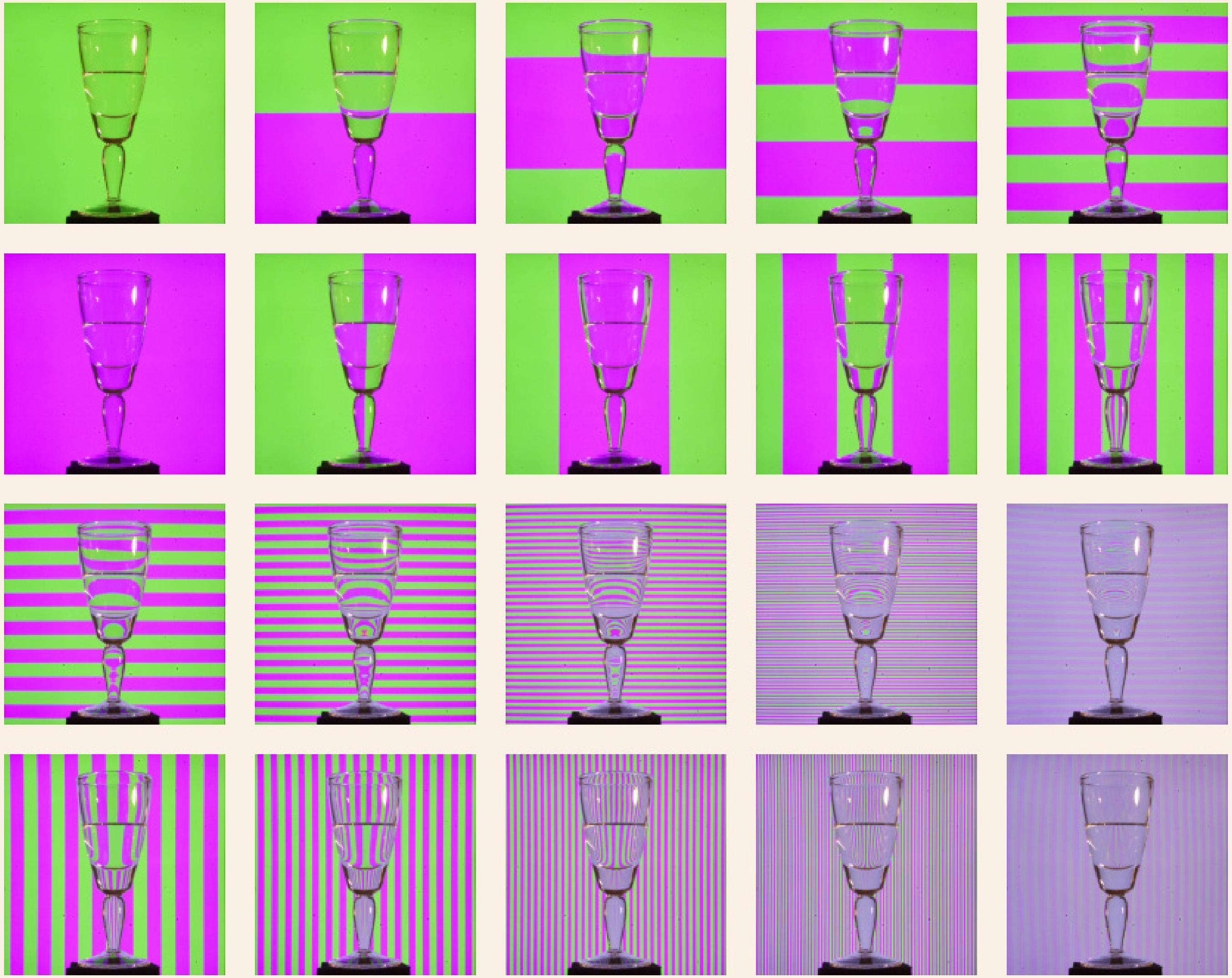
Acquisition setup



Hierarchical backgrounds

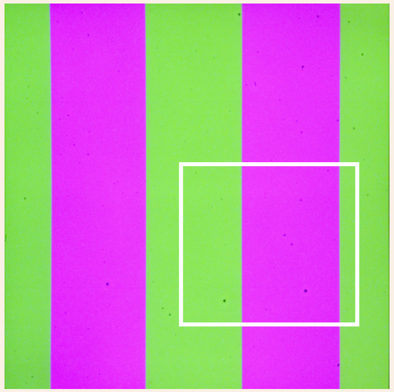


Hierarchical backgrounds



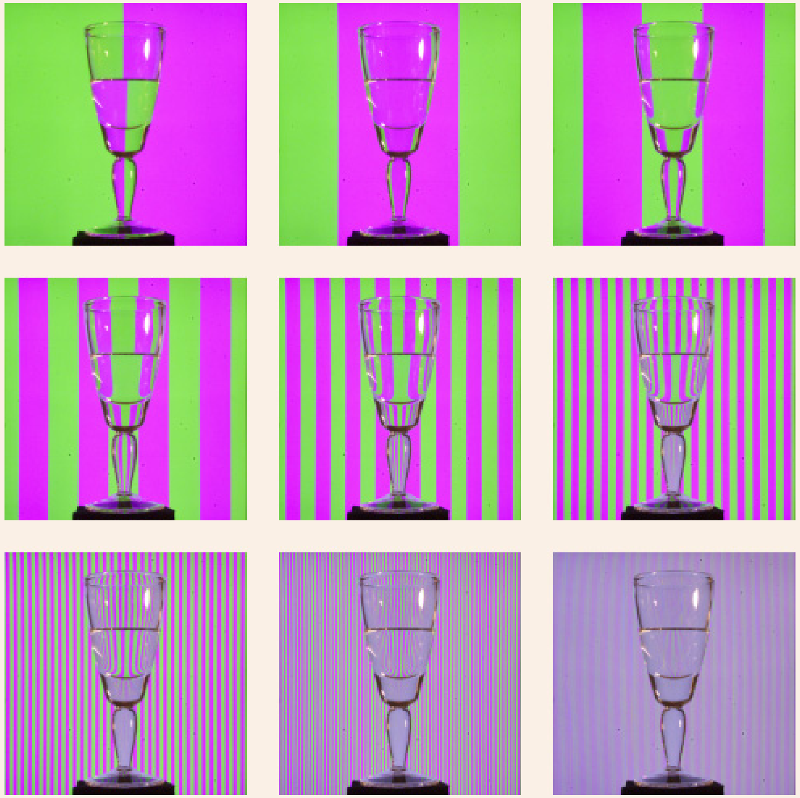
Searching for α and *A*

$$E = \sum \left\| C_{observed} - C_{computed}(\alpha, A) \right\|^2$$

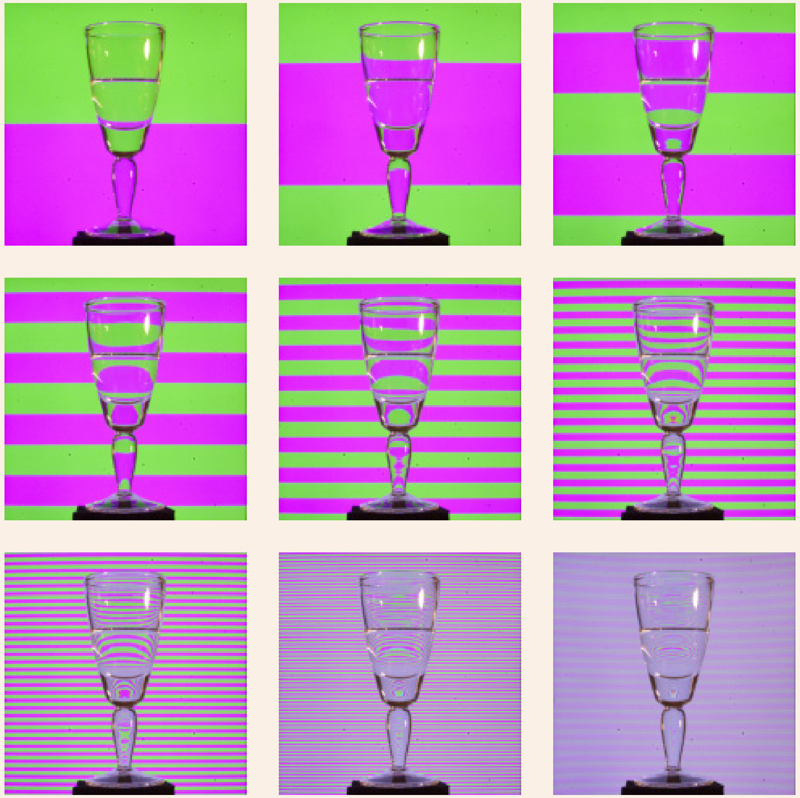


hypothesize
d α and *A*

Separate *x* and *y* extent searches



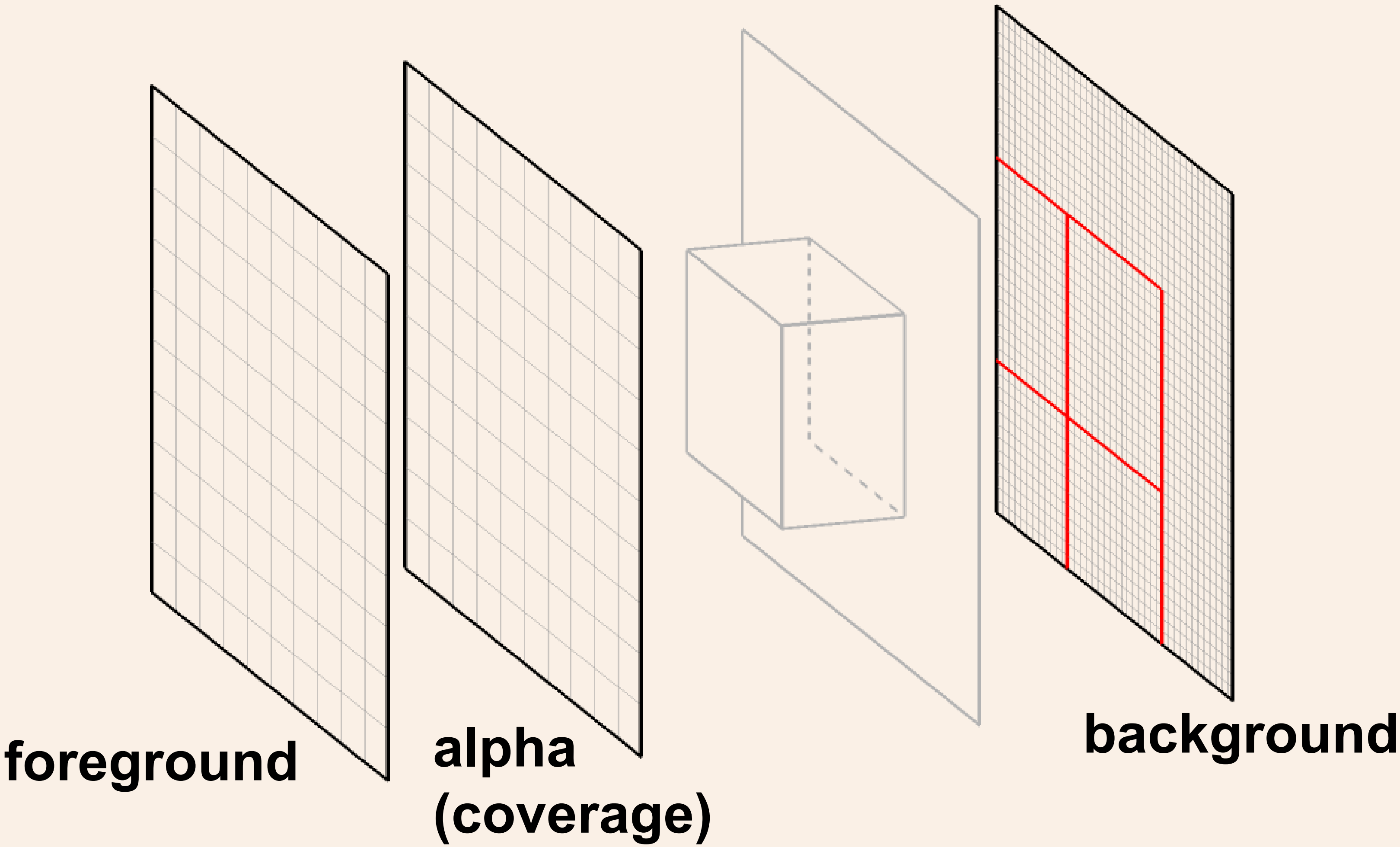
(α, l, r)



(α, t, b)

Environment matte composite

$$C = F + (1-\alpha)B + R\,\mathcal{M}(T, A)$$



Results and comparisons

environment matte composite

alpha matte composite

Results and comparisons

environment matte composite

photograph

Results and comparisons

environment matte composite

alpha matte composite

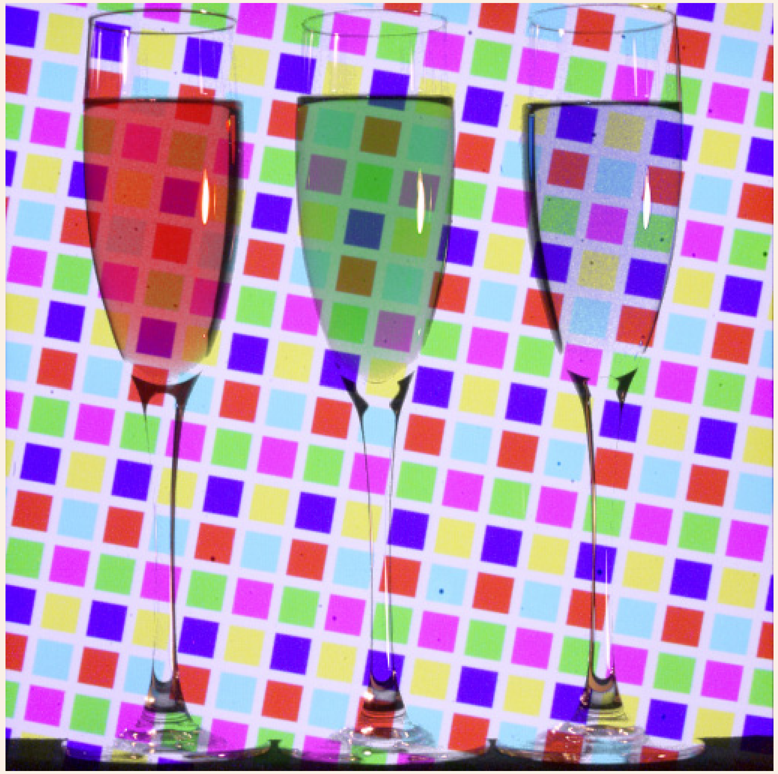
Results and comparisons

environment matte composite

photograph

Results and comparisons

environment matte composite



alpha matte composite

Results and comparisons

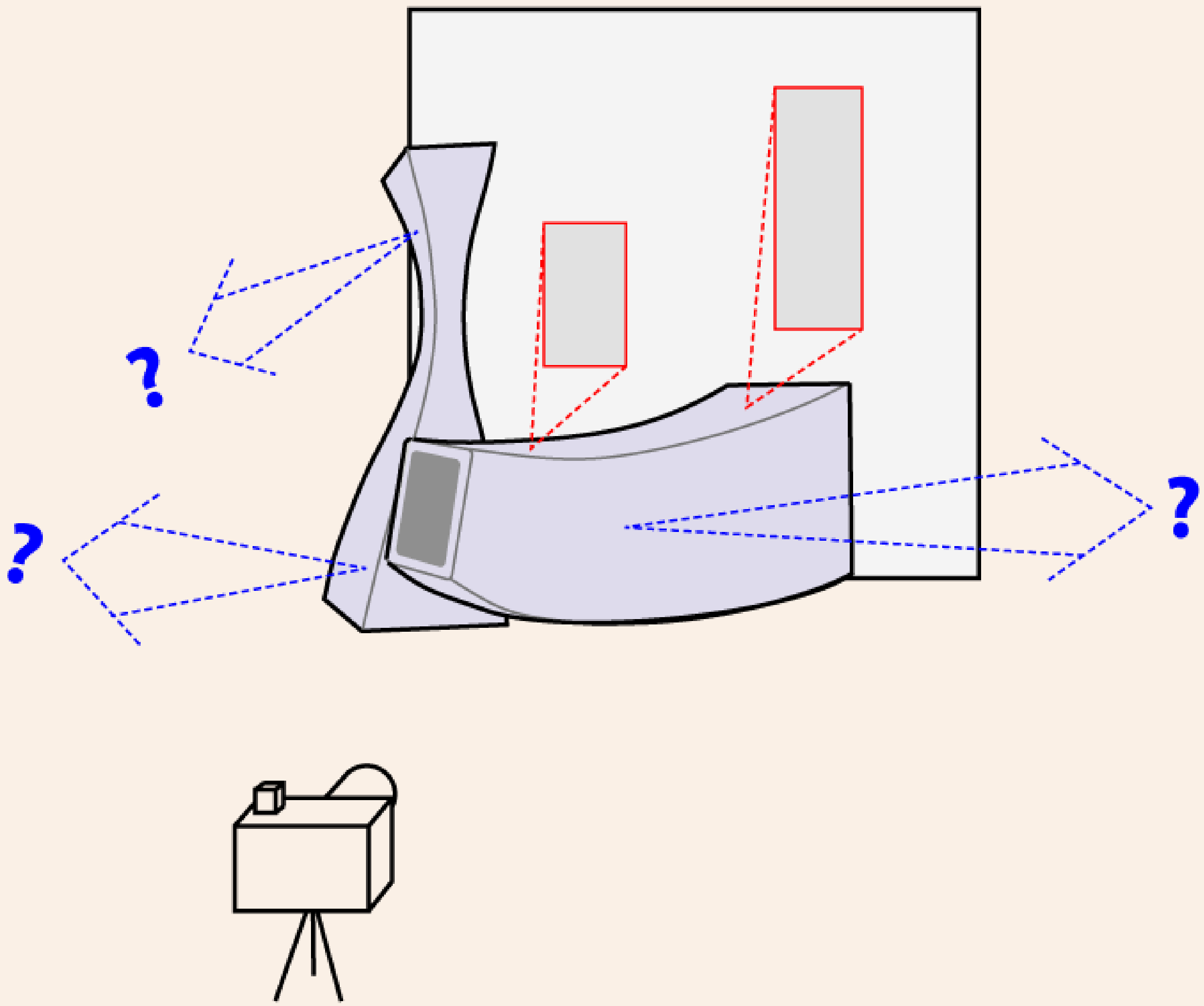
environment matte composite

photograph

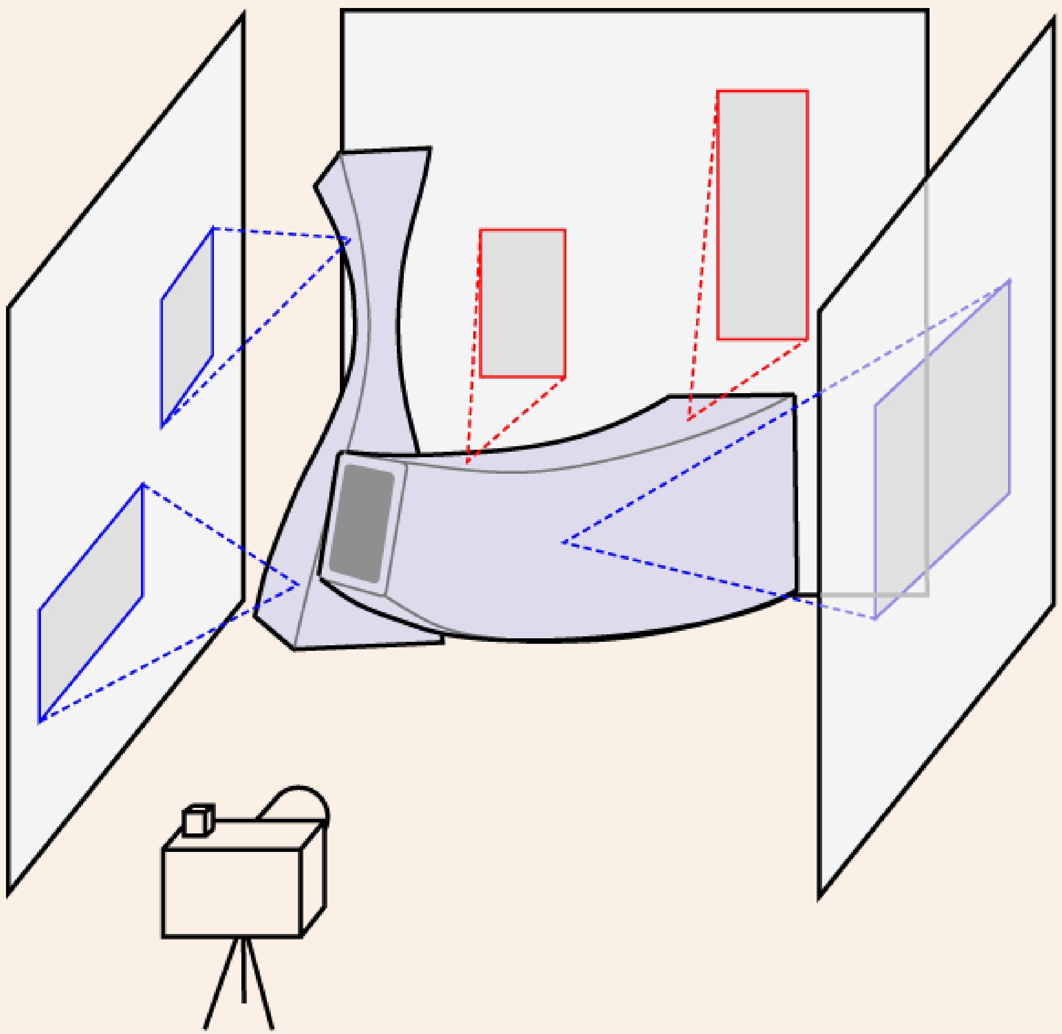
Results

Reflective objects

Many rays not captured



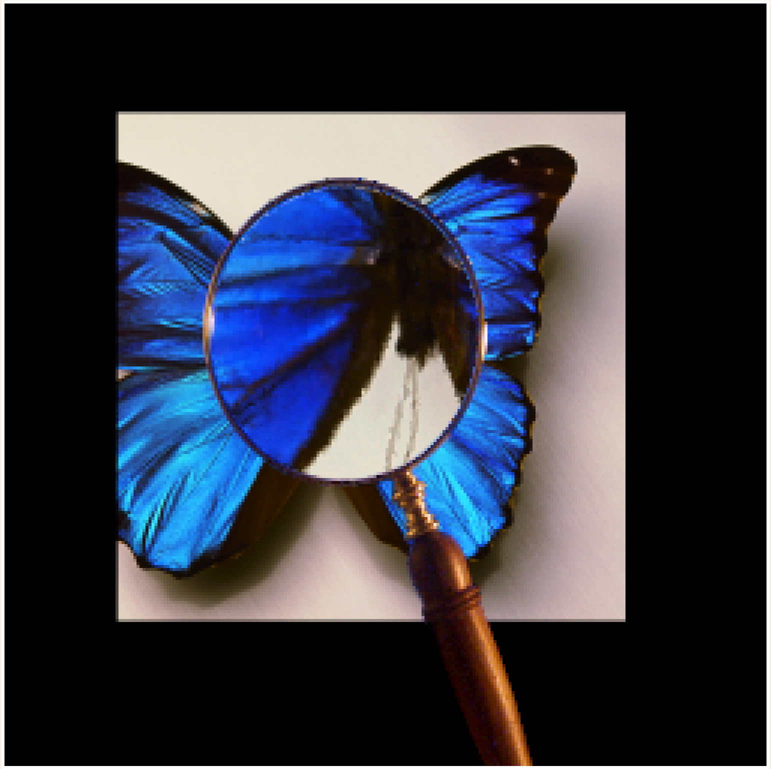
Add sidedrops to capture these rays

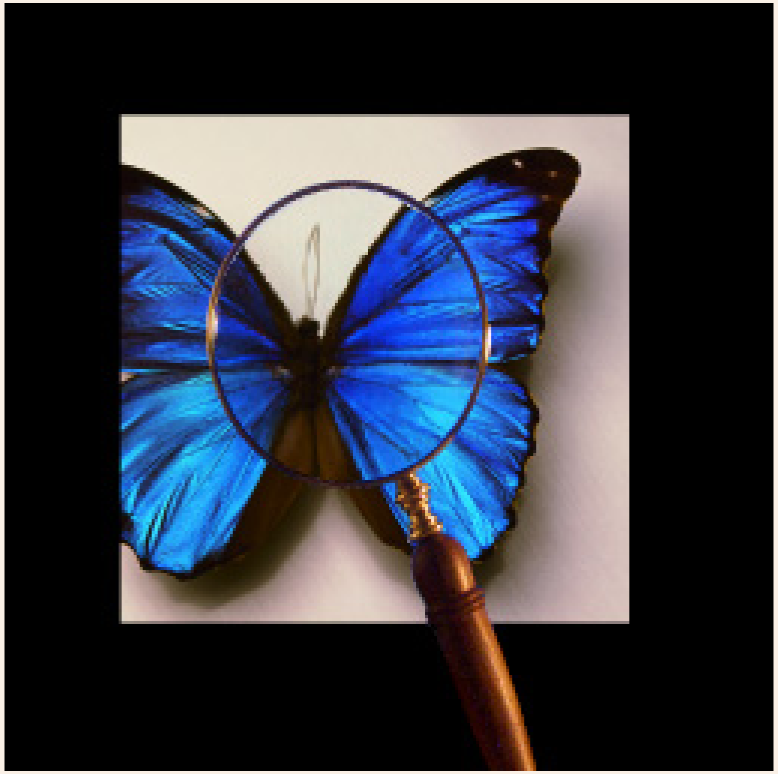


Capturing multiple sides

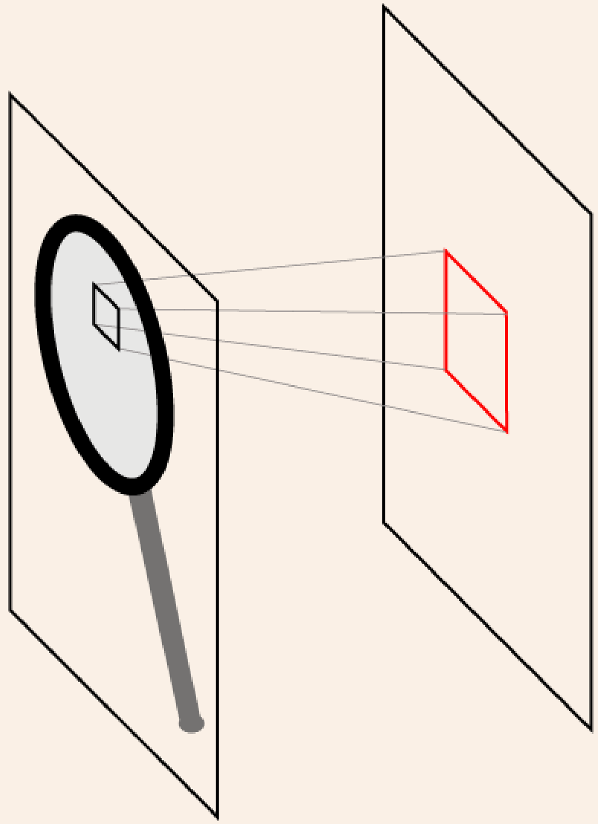
Contributions from multiple sides

Depth correction

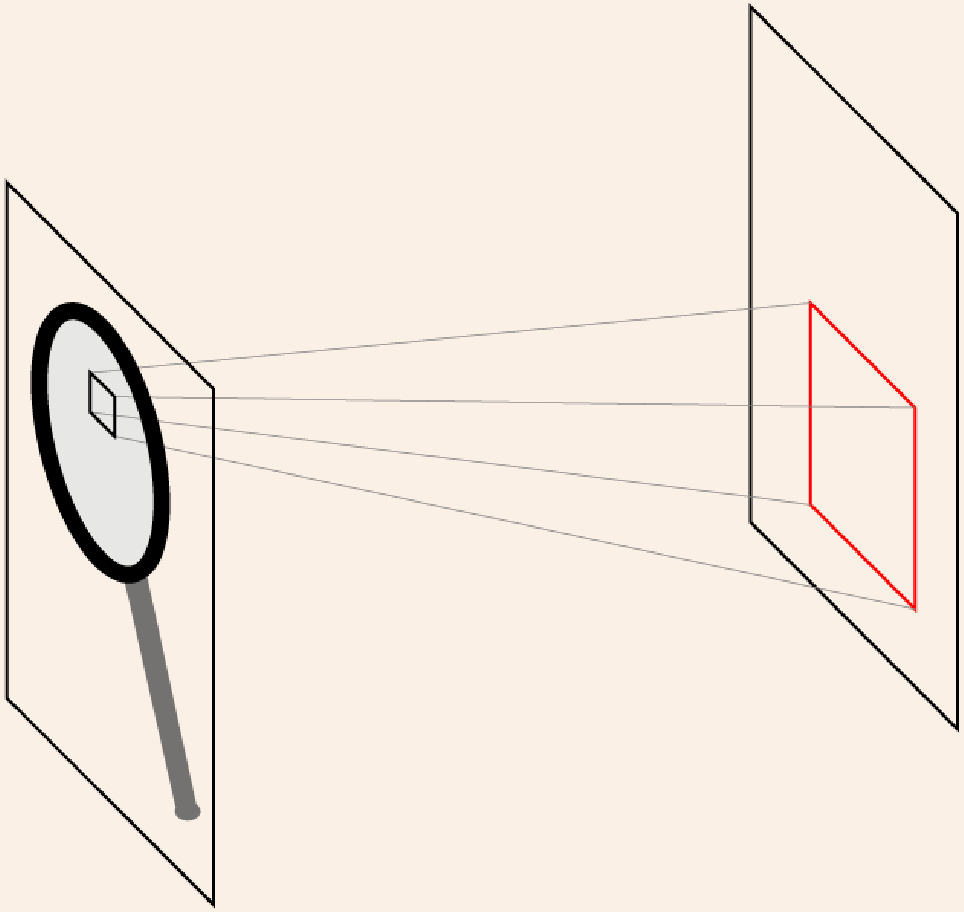




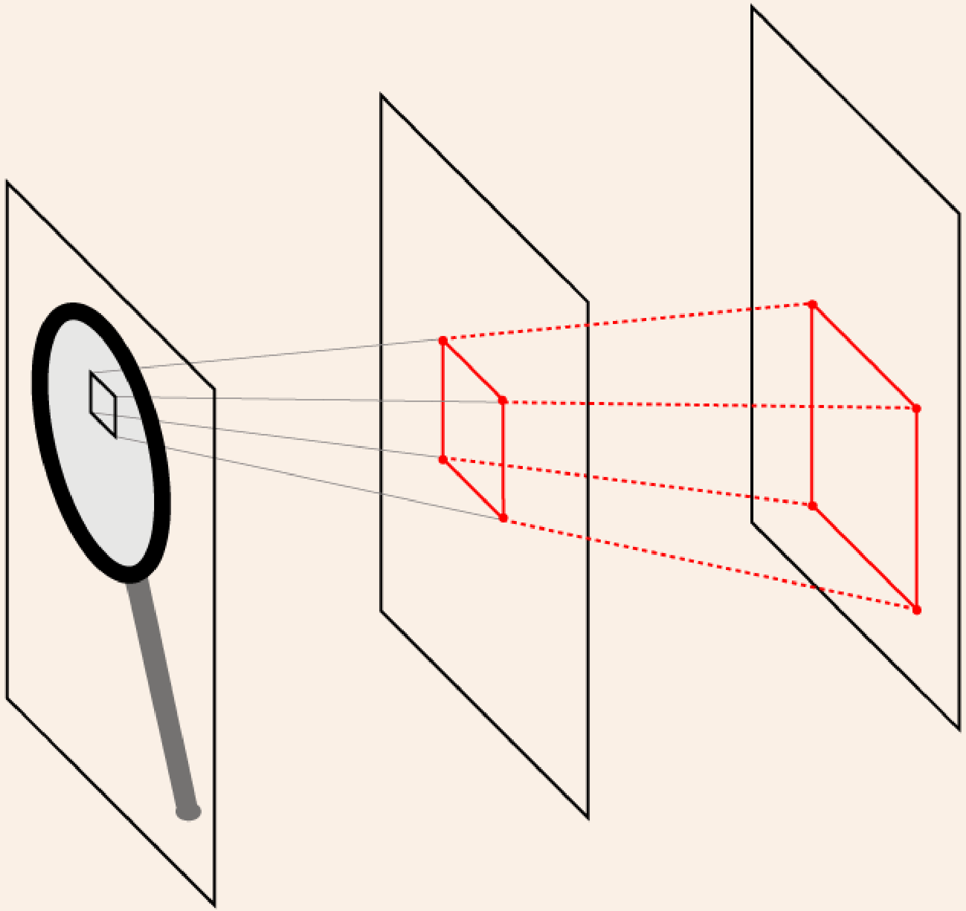
Capturing at a single depth



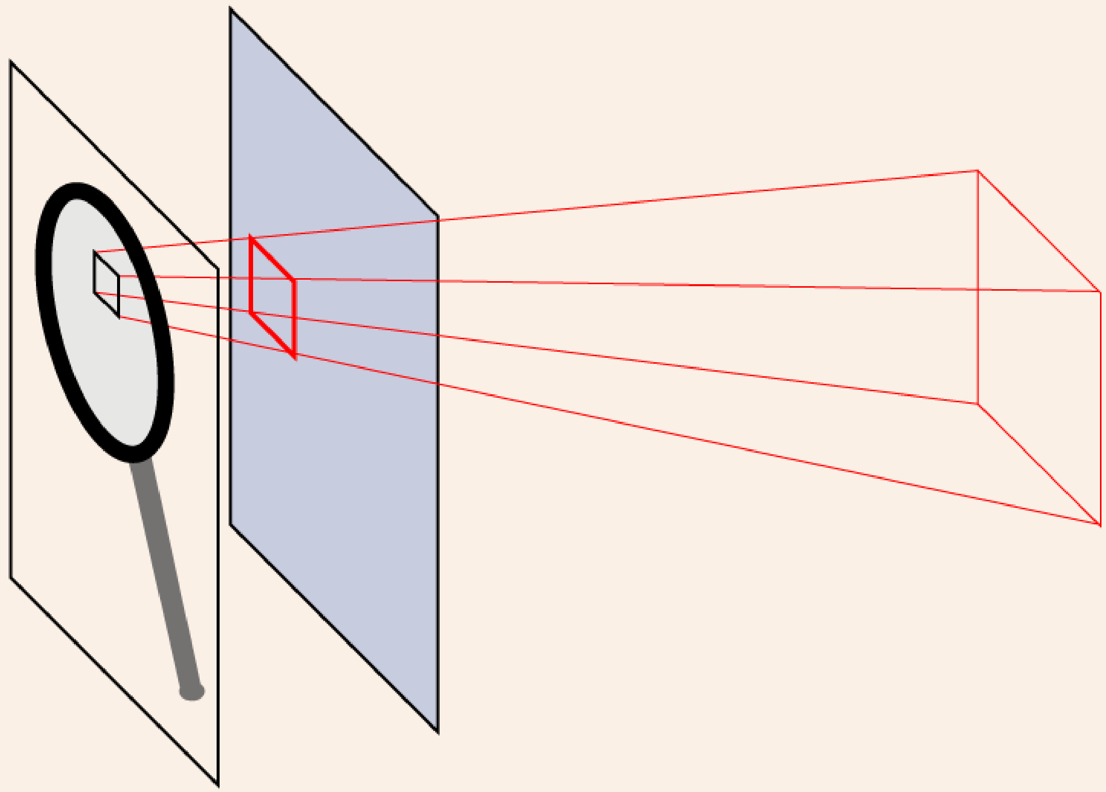
Capturing a second depth



Constructing the 3D beam



Rendering at novel depths



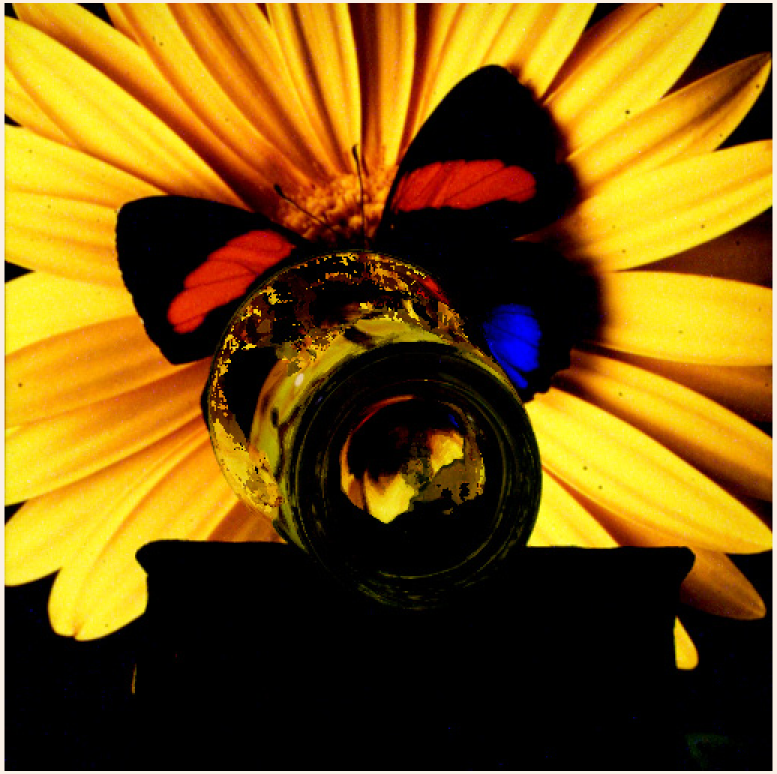
Rendering at novel depths

Problem: glossy surface

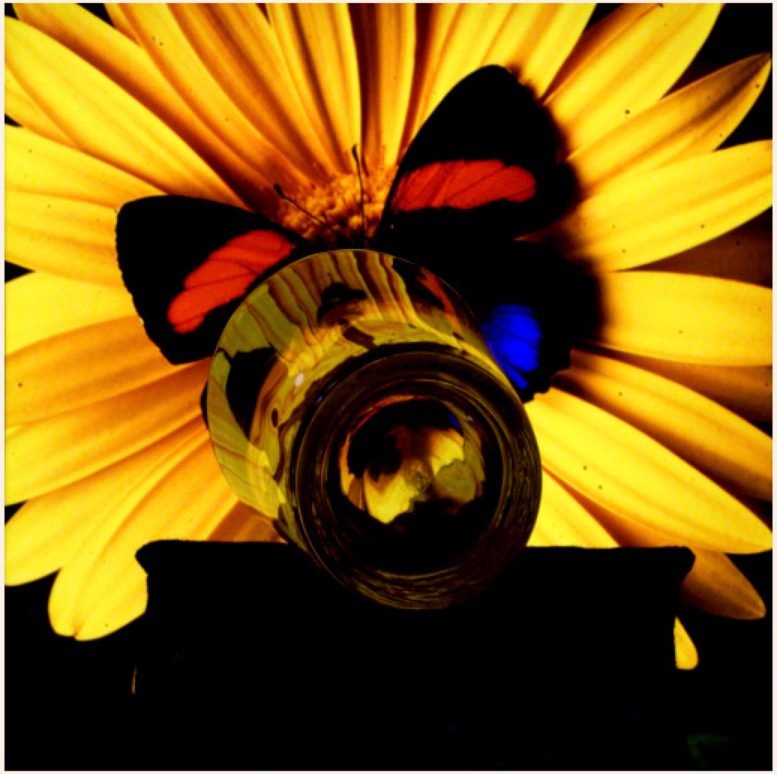
environment matte composite

photograph

Problem: multiple mappings



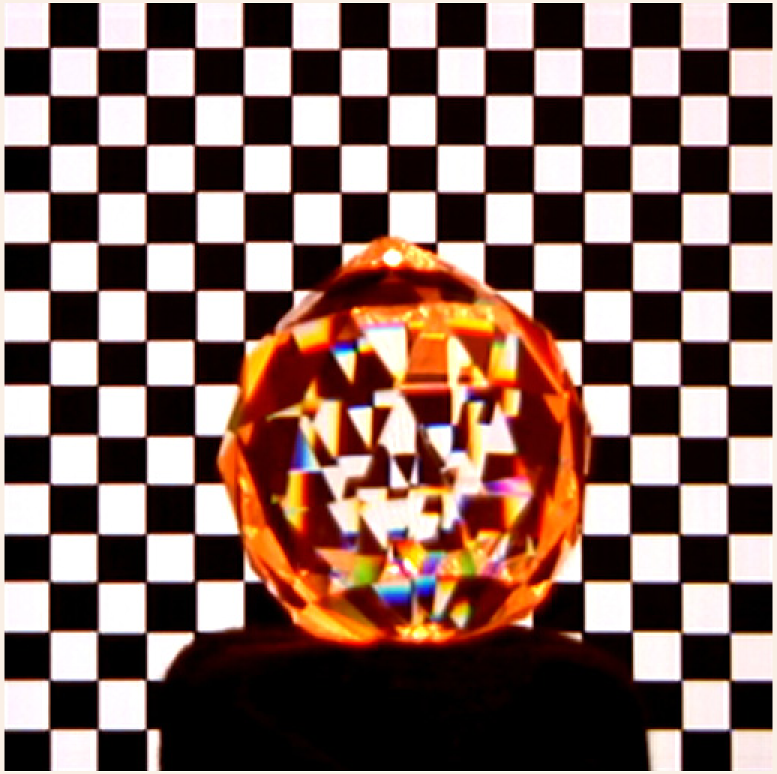
environment matte composite



photograph

Problem: color dispersion

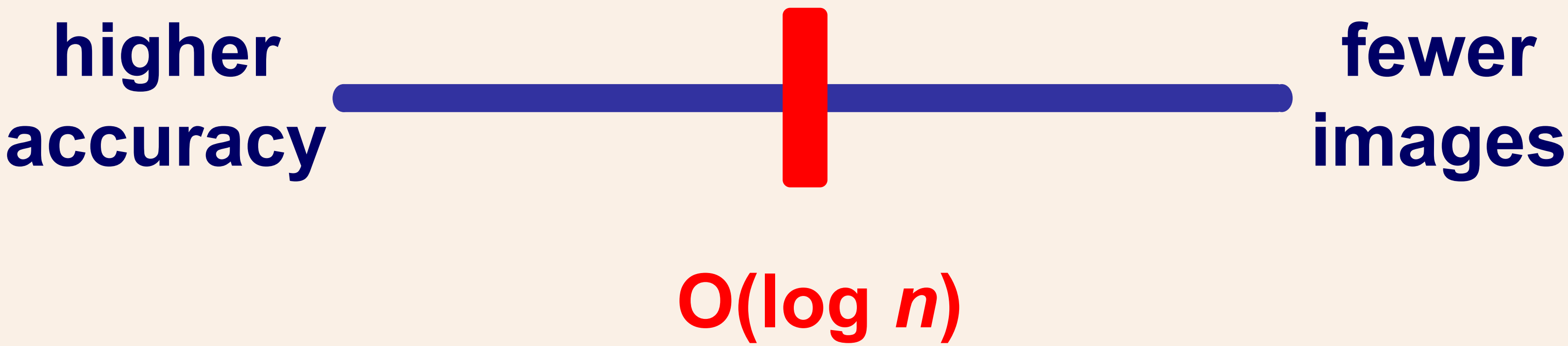
environment matte composite



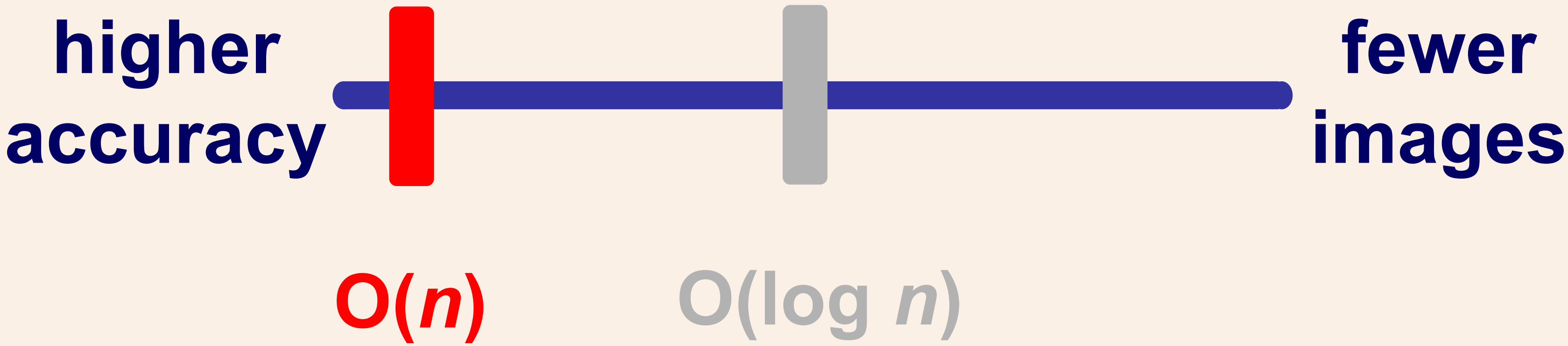
photograph

Problem: many photographs needed

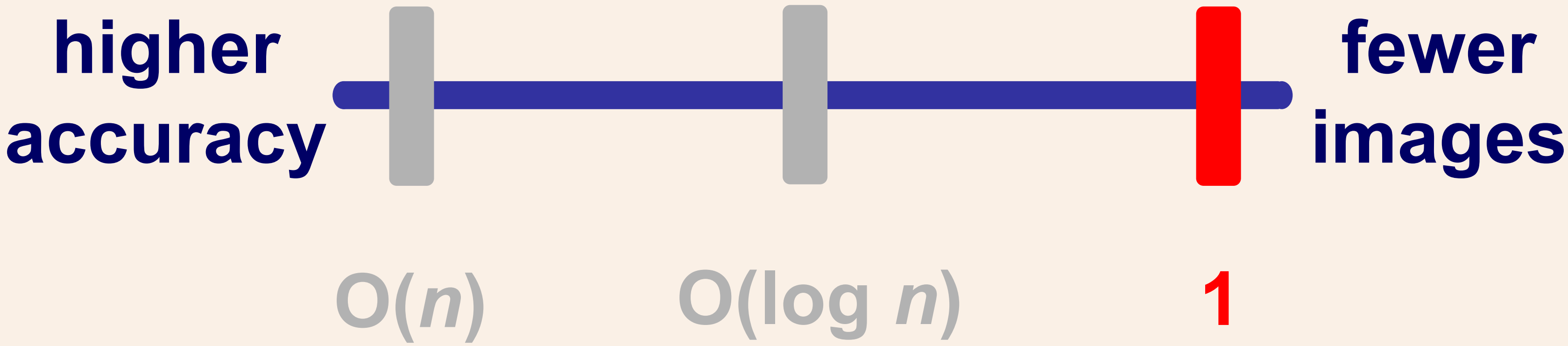
Environment matting



Towards higher accuracy



Towards real-time capture

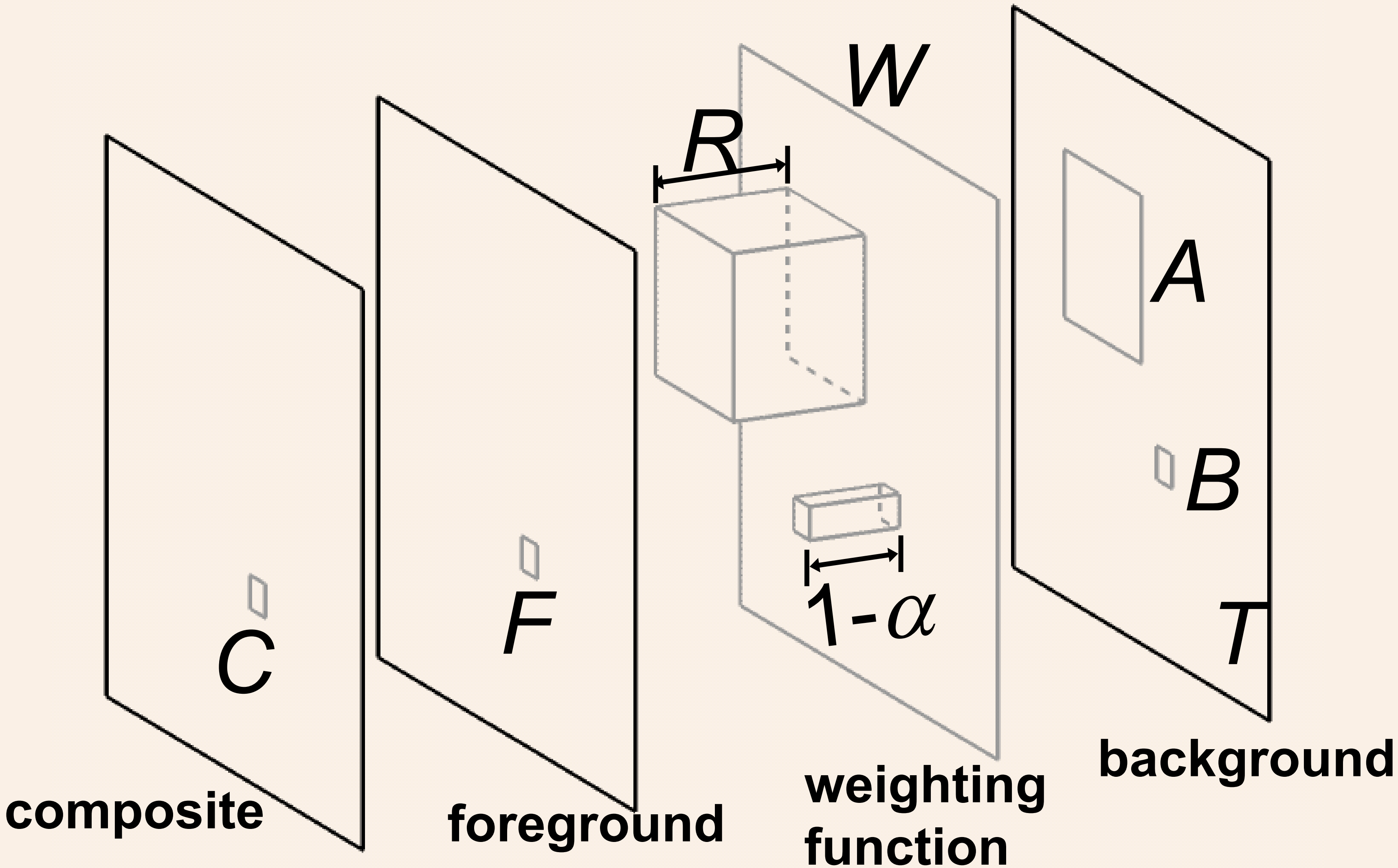


Real-time environment matting

Chuang et. al.

SIGGRAPH 2000

$$C = F + (1\text{-}\alpha)B + R\mathcal{M}(T, A)$$



$$C = F + (1\text{-}\alpha)B + R\mathcal{M}(T, A)$$

3 3 1 3 4

3 observations

11 variables

- A, R
- α
- F

$$C = R\mathcal{M}(T, A)$$

3 3 4

3 observations

7 variables

- A, R
- α
- F

$$C = \rho \mathcal{M}(T, A)$$

3 1 4

3 observations

5 variables

- A, R $\longrightarrow$ A, ρ
- α colorless
- F

$$C = \rho\, T(c_x, c_y)$$

3 1 1 1

3 observations

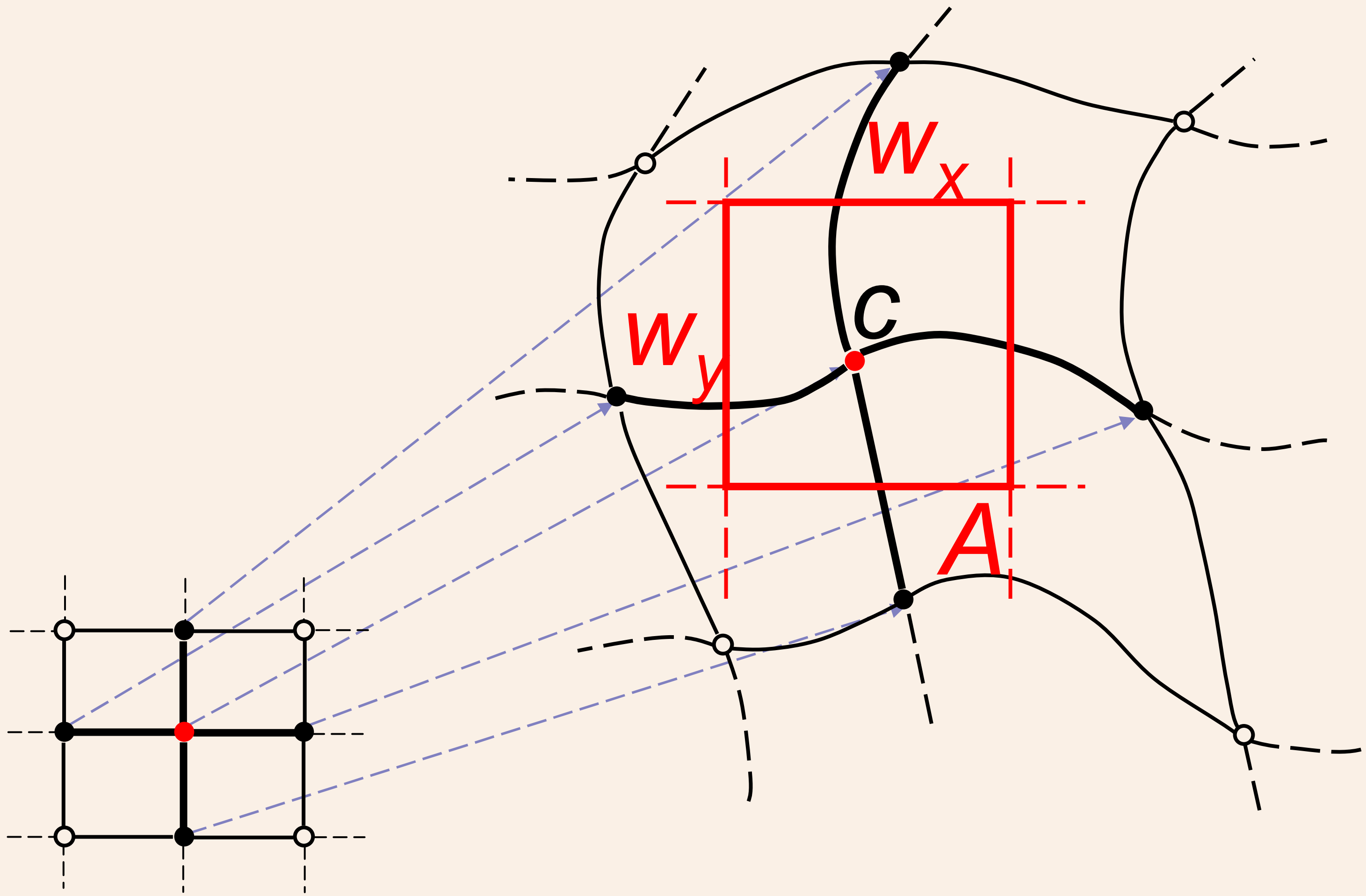
3 variables

- $A, R \longrightarrow A, \rho \longrightarrow c_x, c_y, \rho$
- α
- F

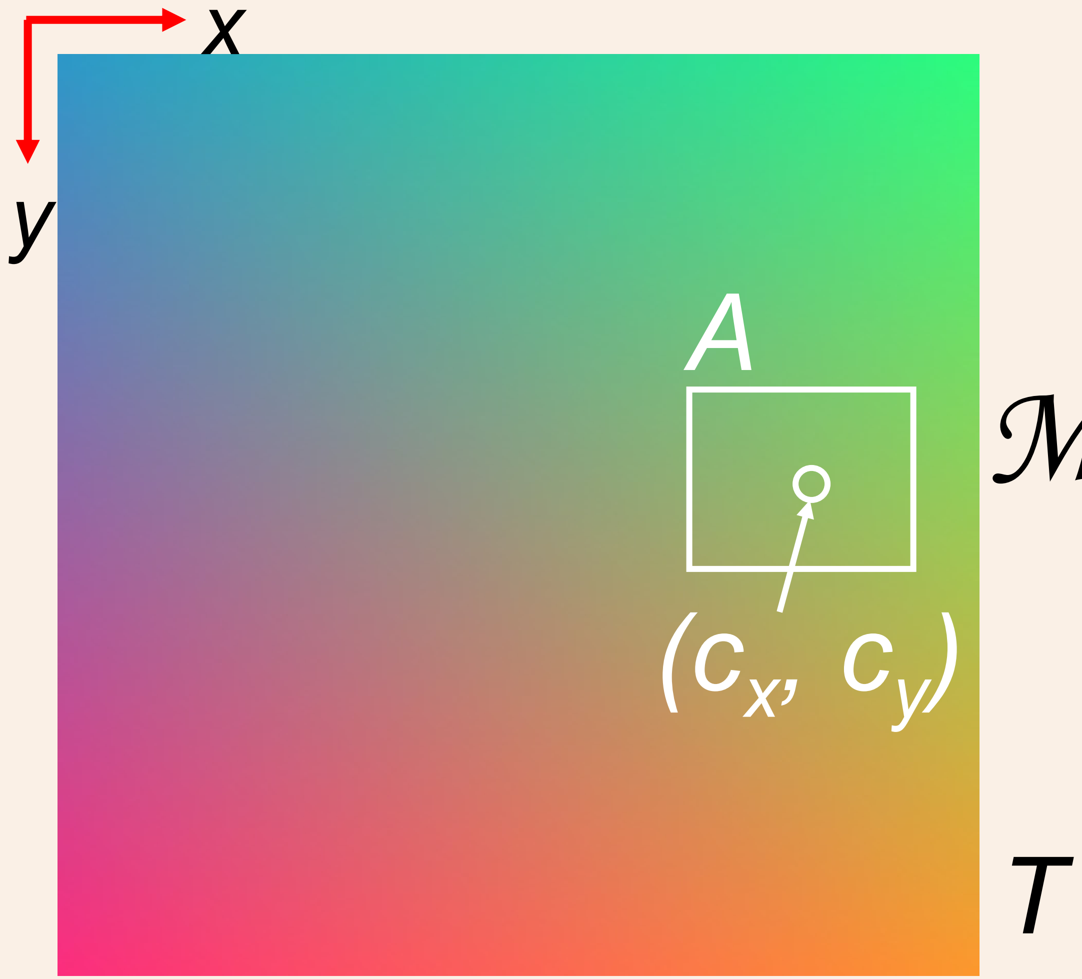
colorless

specularly refractive

Estimate w_x ,w_y

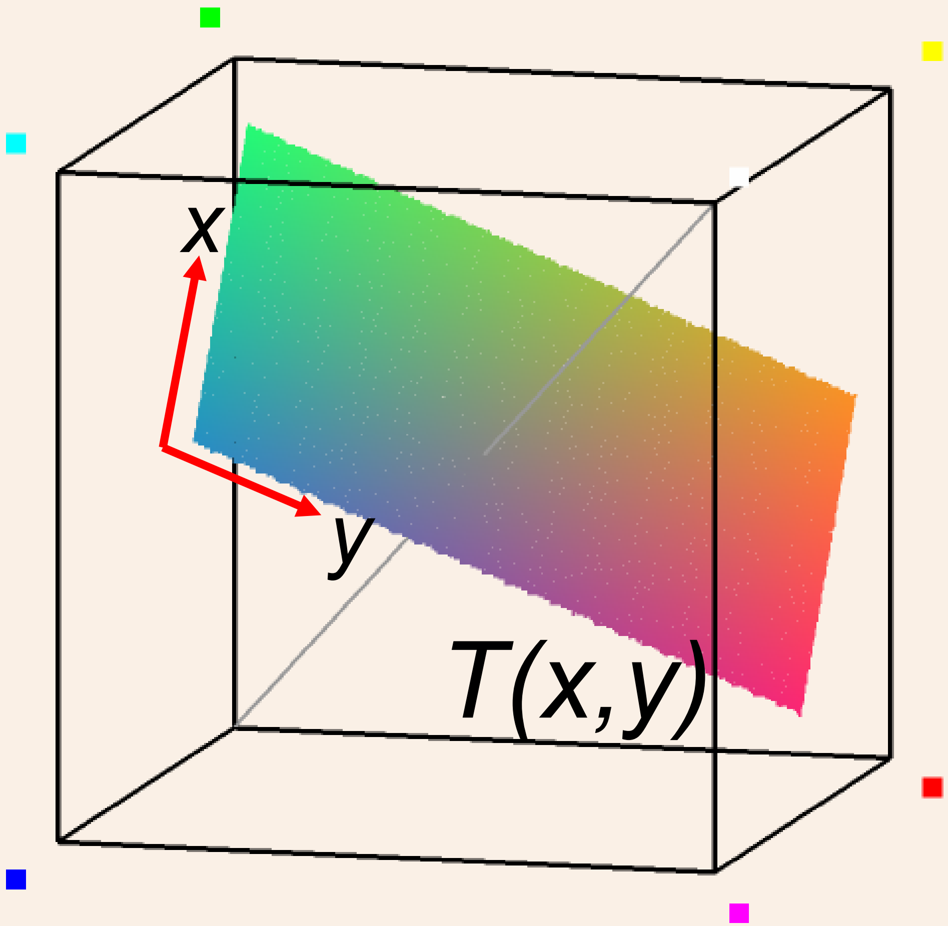


Stimulus function

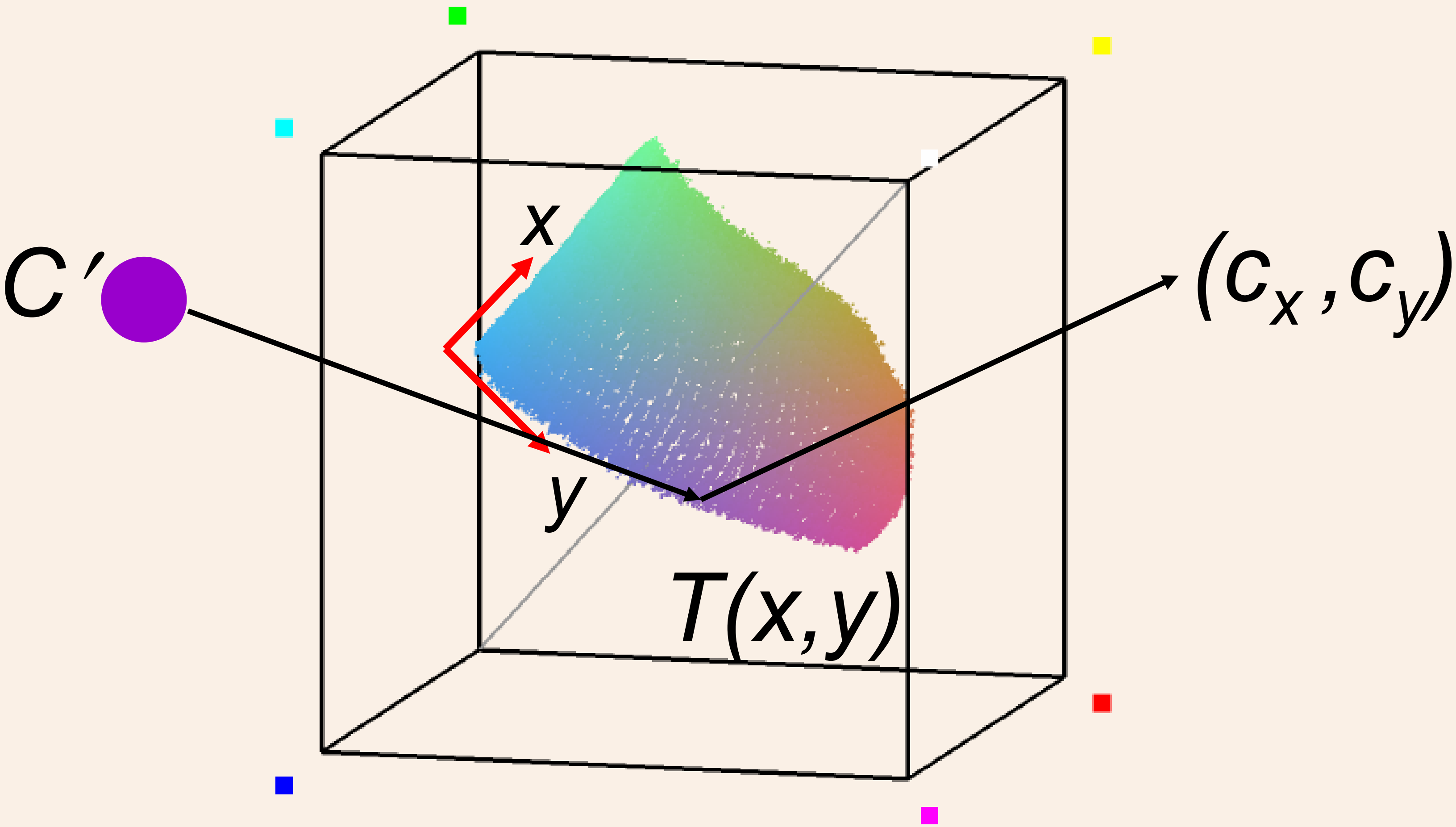


$$\mathcal{M}(T, A) \approx T(c_x, c_y)$$

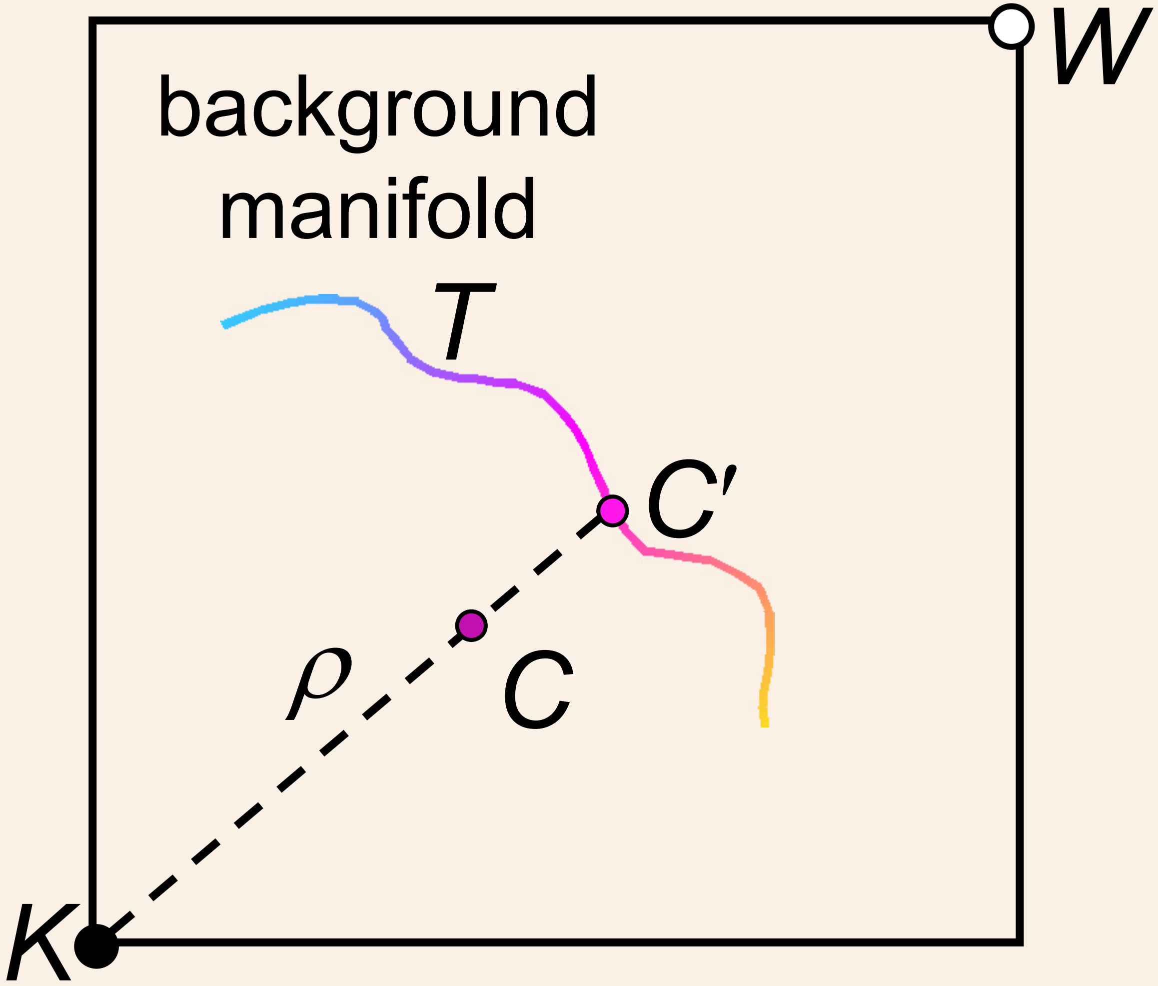
Ideal plane in RGB cube



Calibrated manifold in RGB cube



Estimate c_x ,c_y and ρ



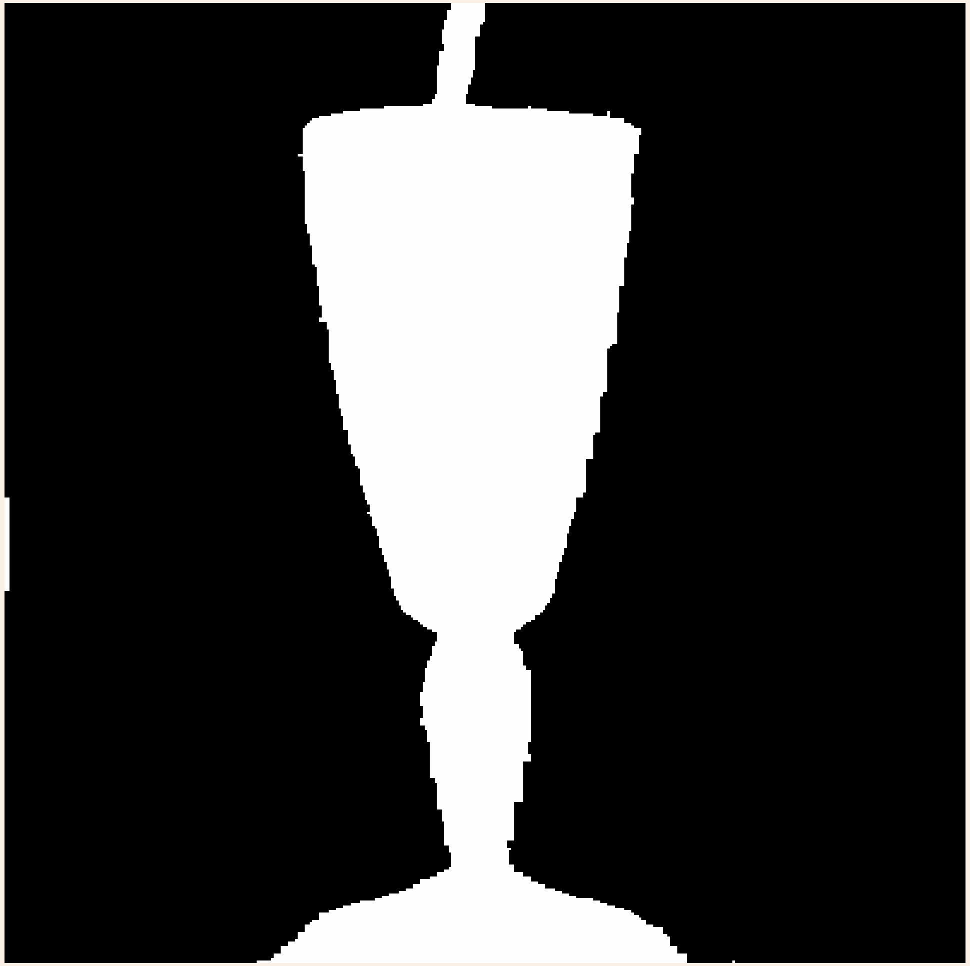
$$C' \rightarrow (c_x, c_y)$$

$$\rho = \frac{\|KC\|}{\|KC'\|}$$

Input image

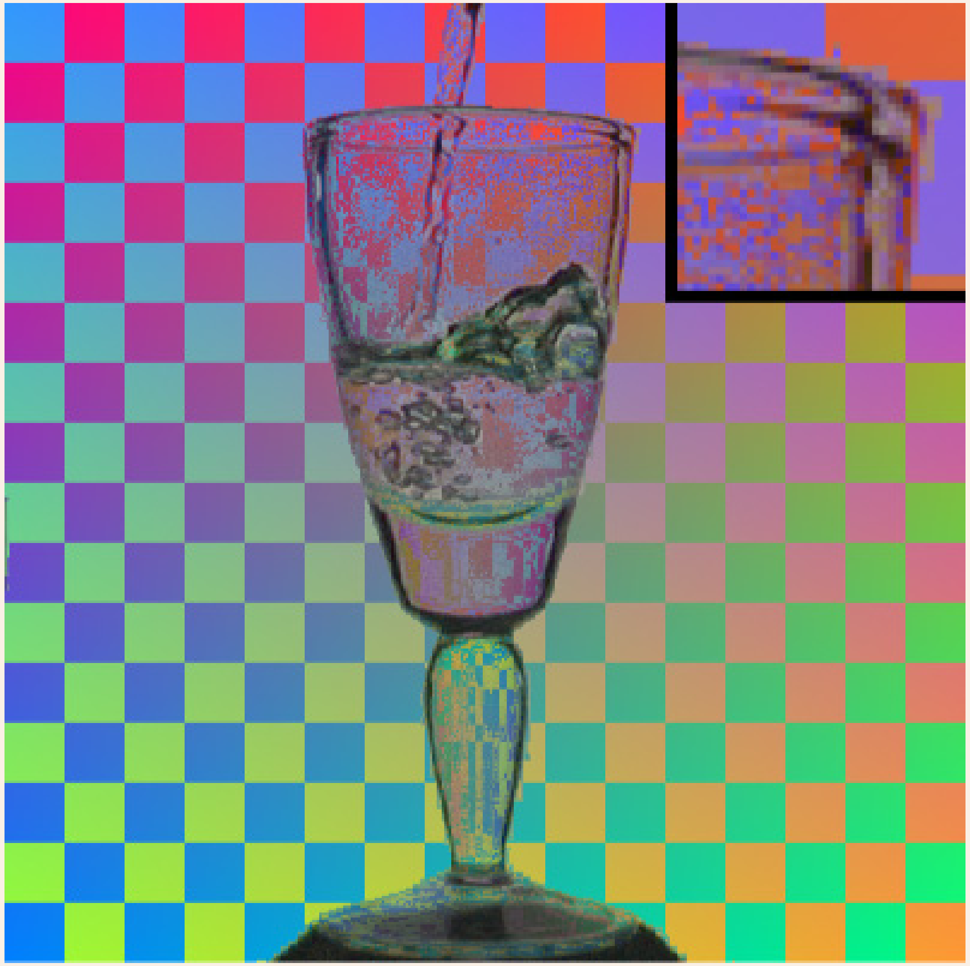
Difference thresholding

Morphological operation

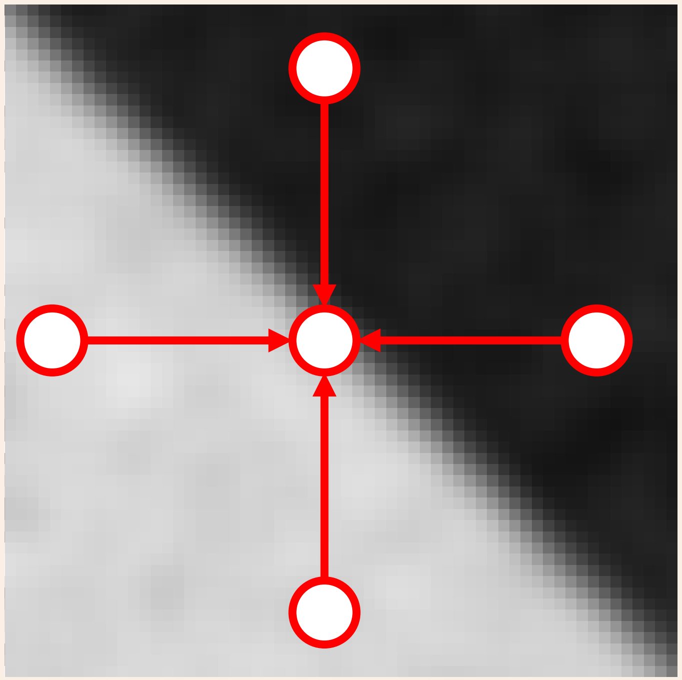


Feathering

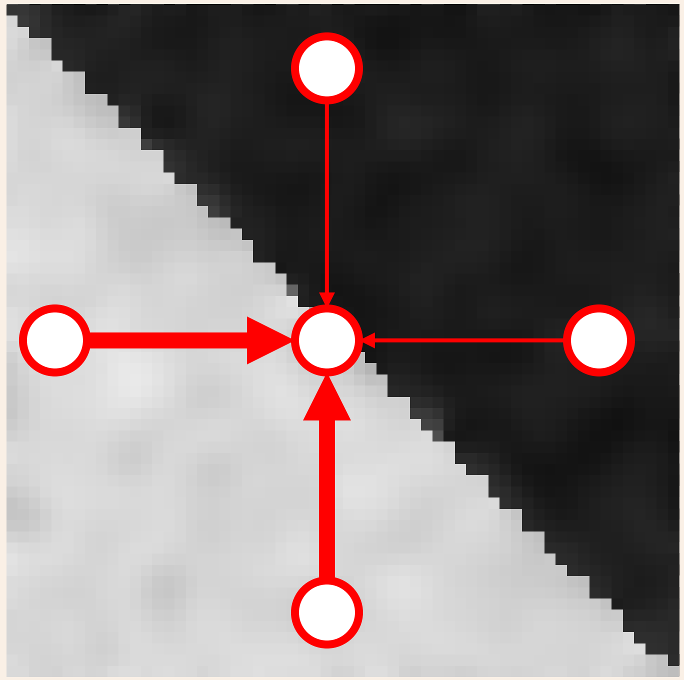
Problem: noisy matte



Edge-preserving filtering

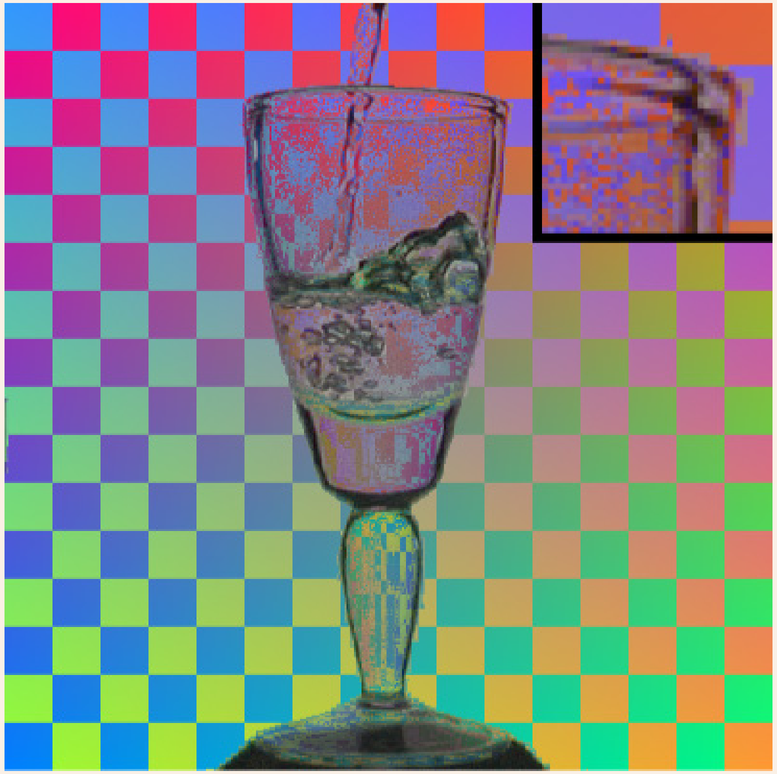


isotropic filter

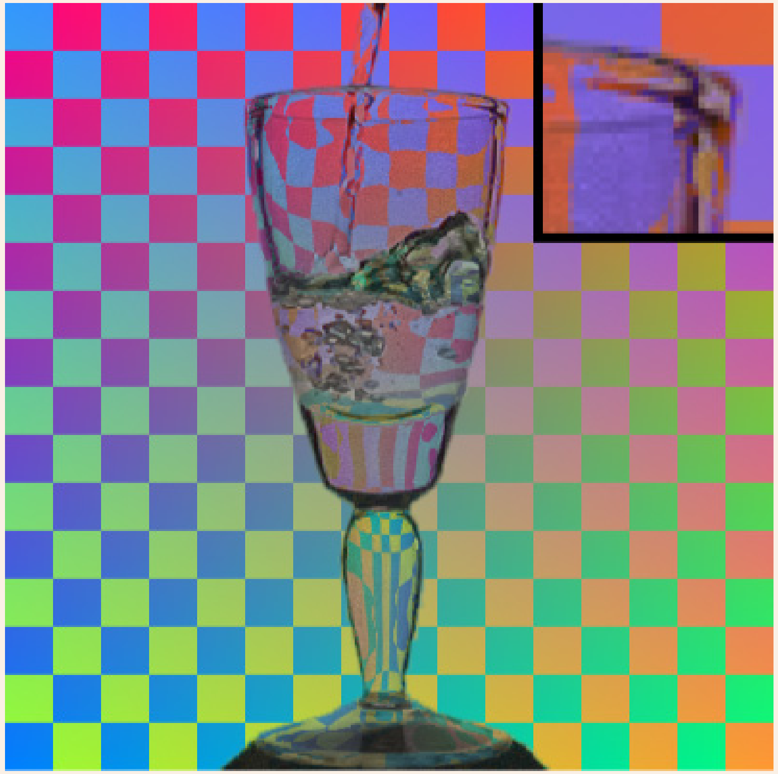


anisotropic filter

Edge-preserving filtering

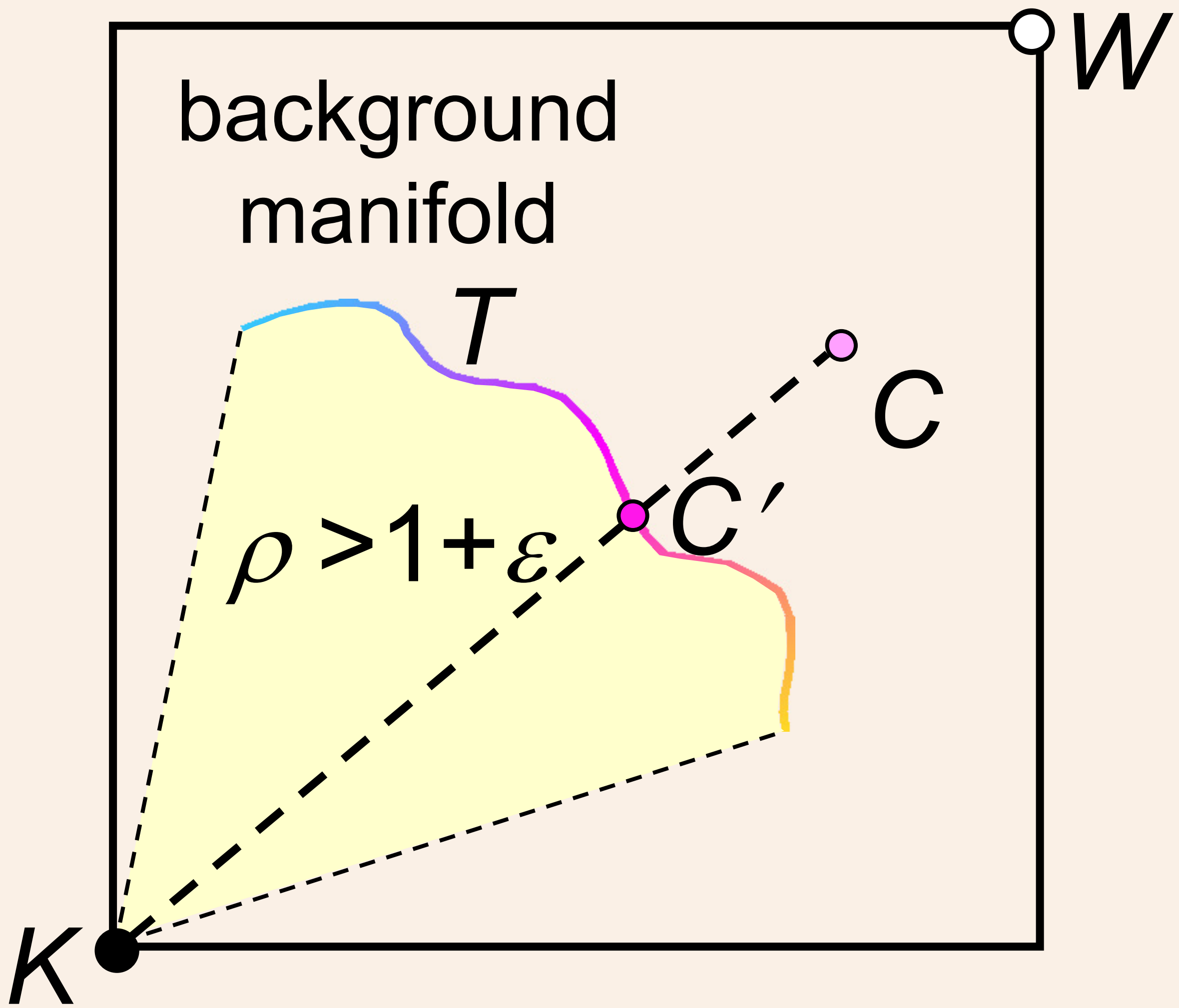


without filtering

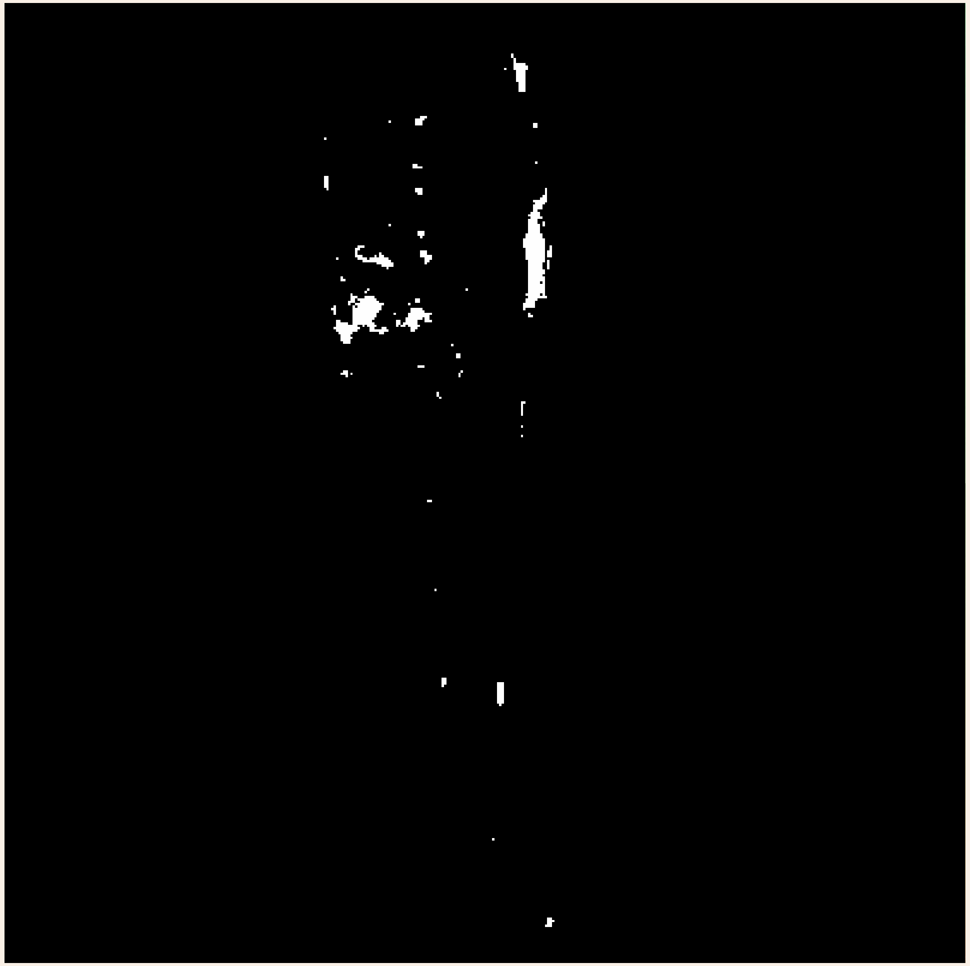


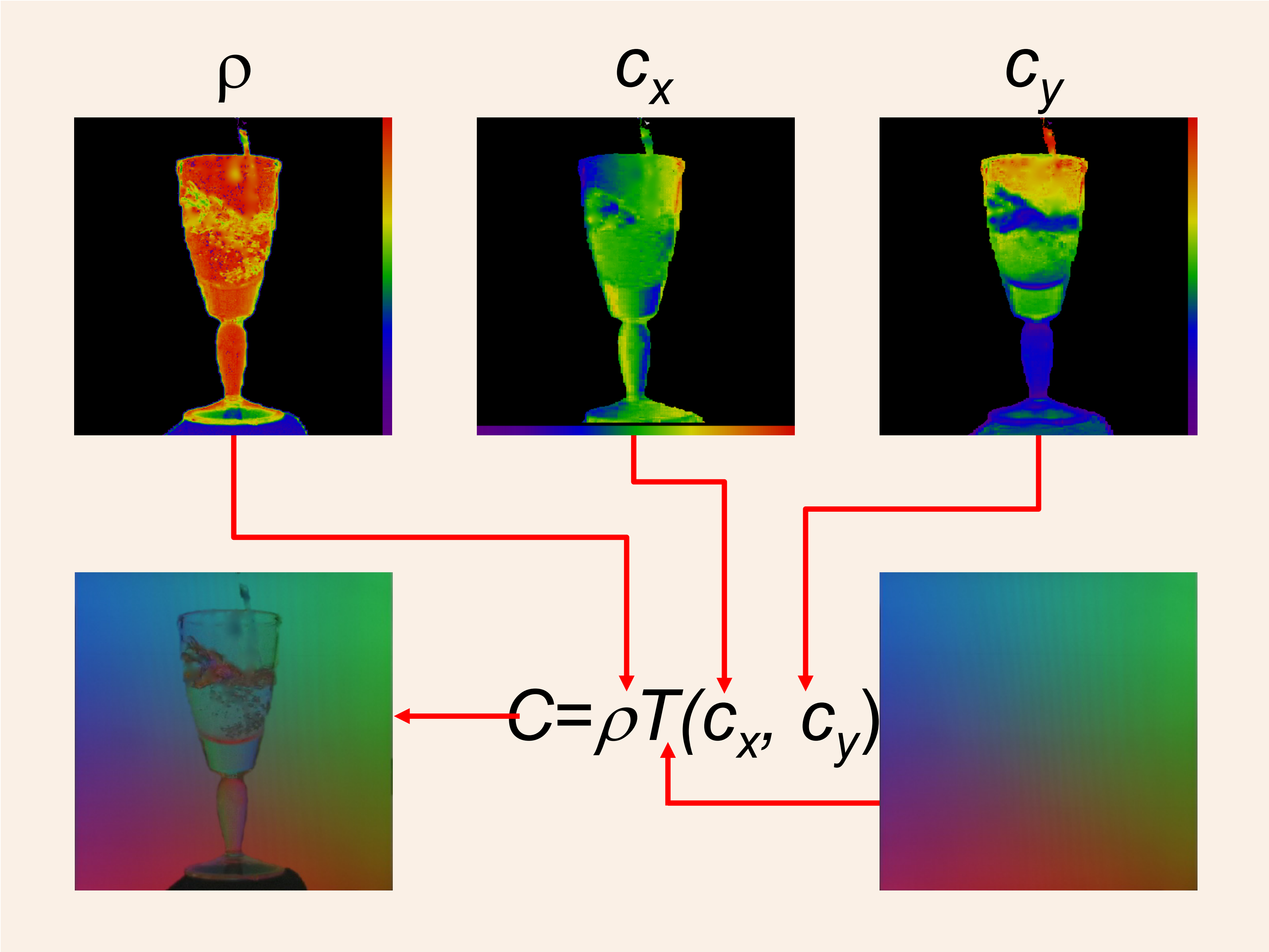
with filtering

Heuristics for specular highlights



Heuristics for specular highlights

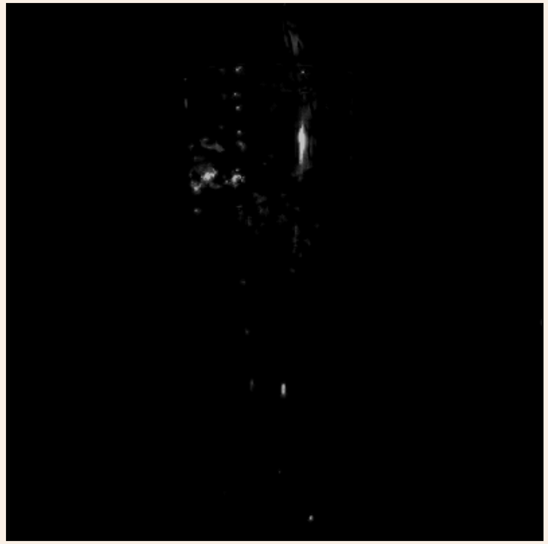



ρ
c_x
c_y
$C = \rho T(c_x, c_y)$

Heuristics for specular highlights

−

=

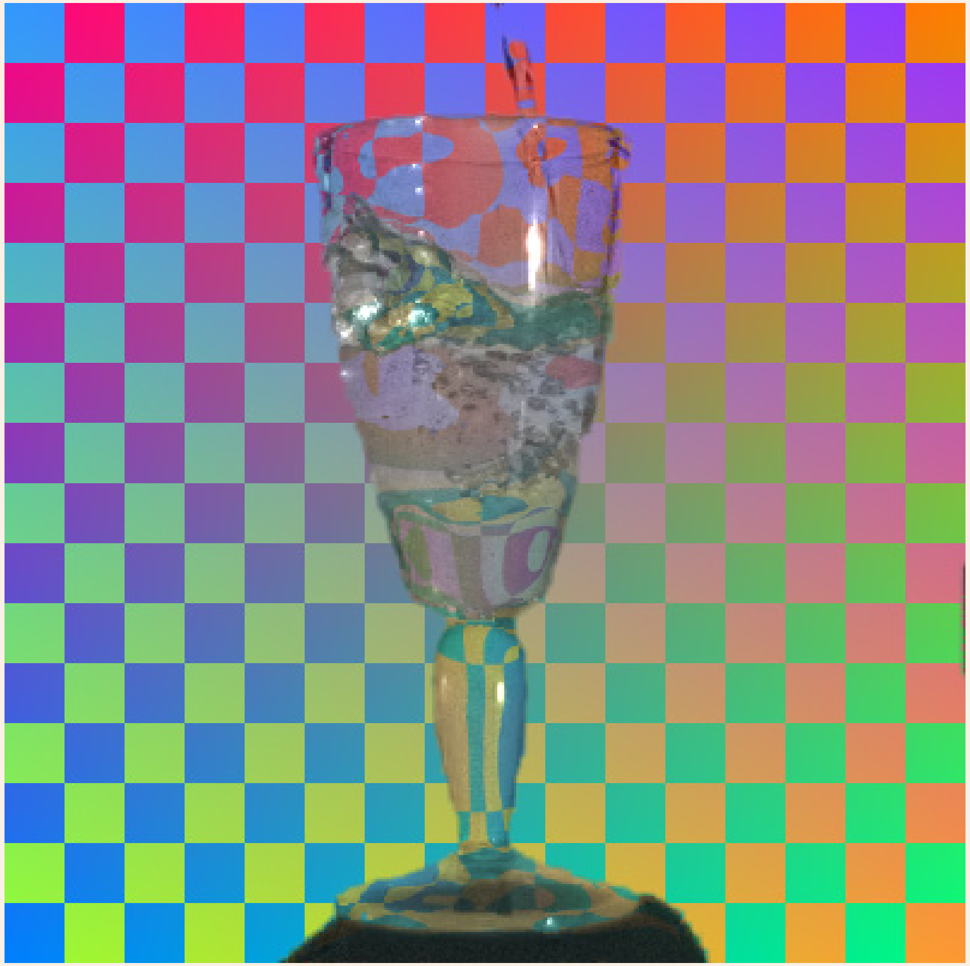


input

estimation

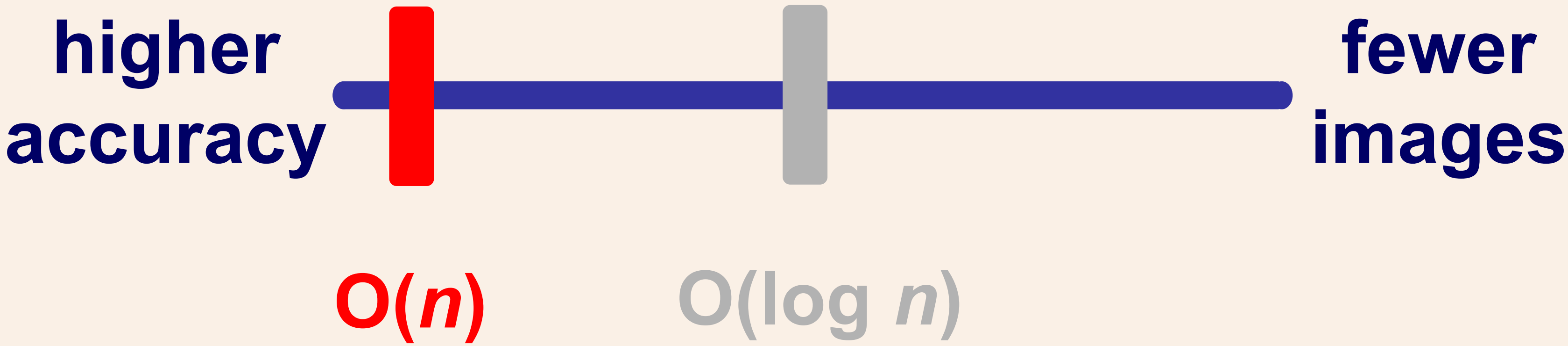
foreground (highlights)

Composite with highlights

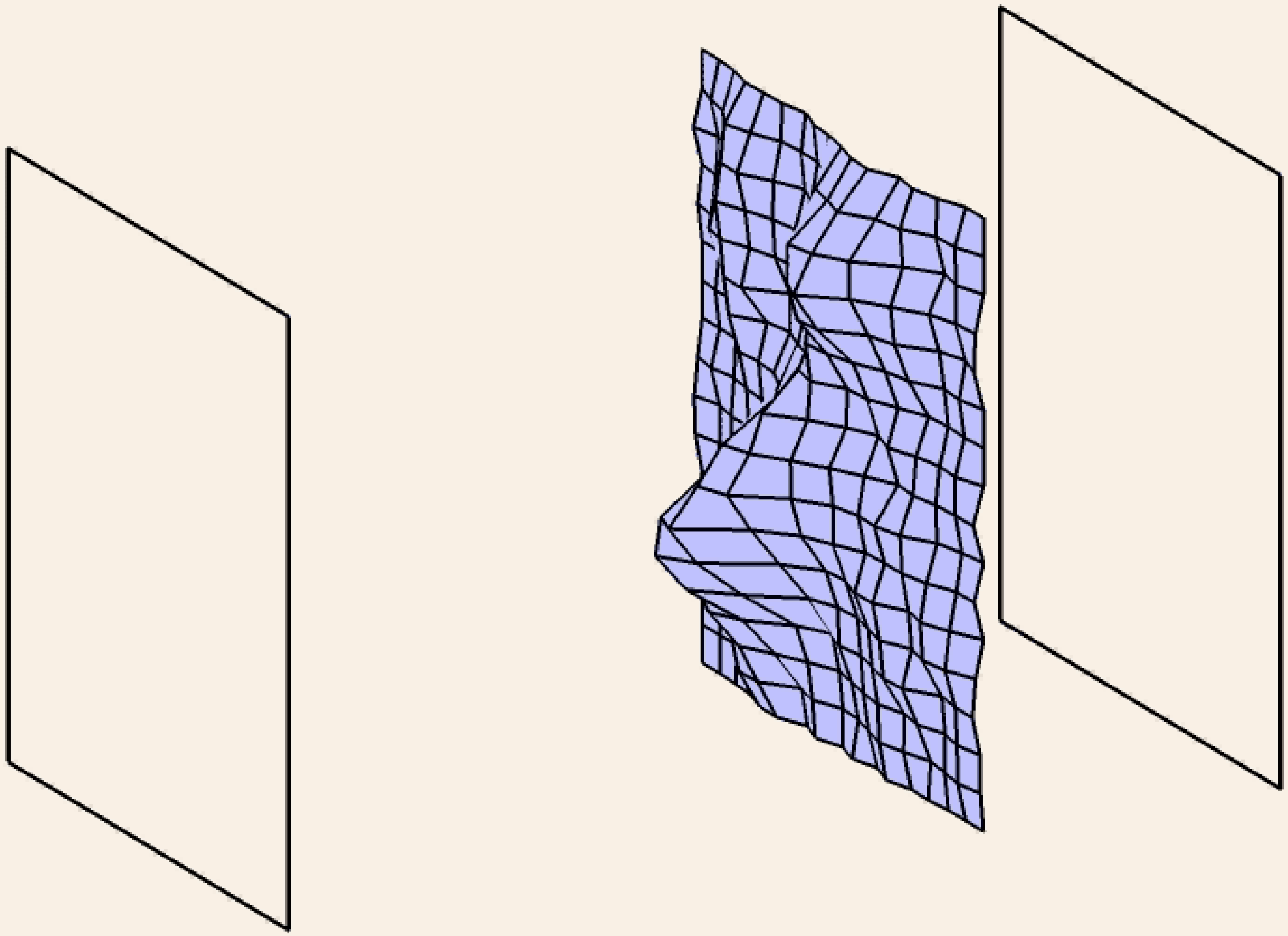



3369 52264

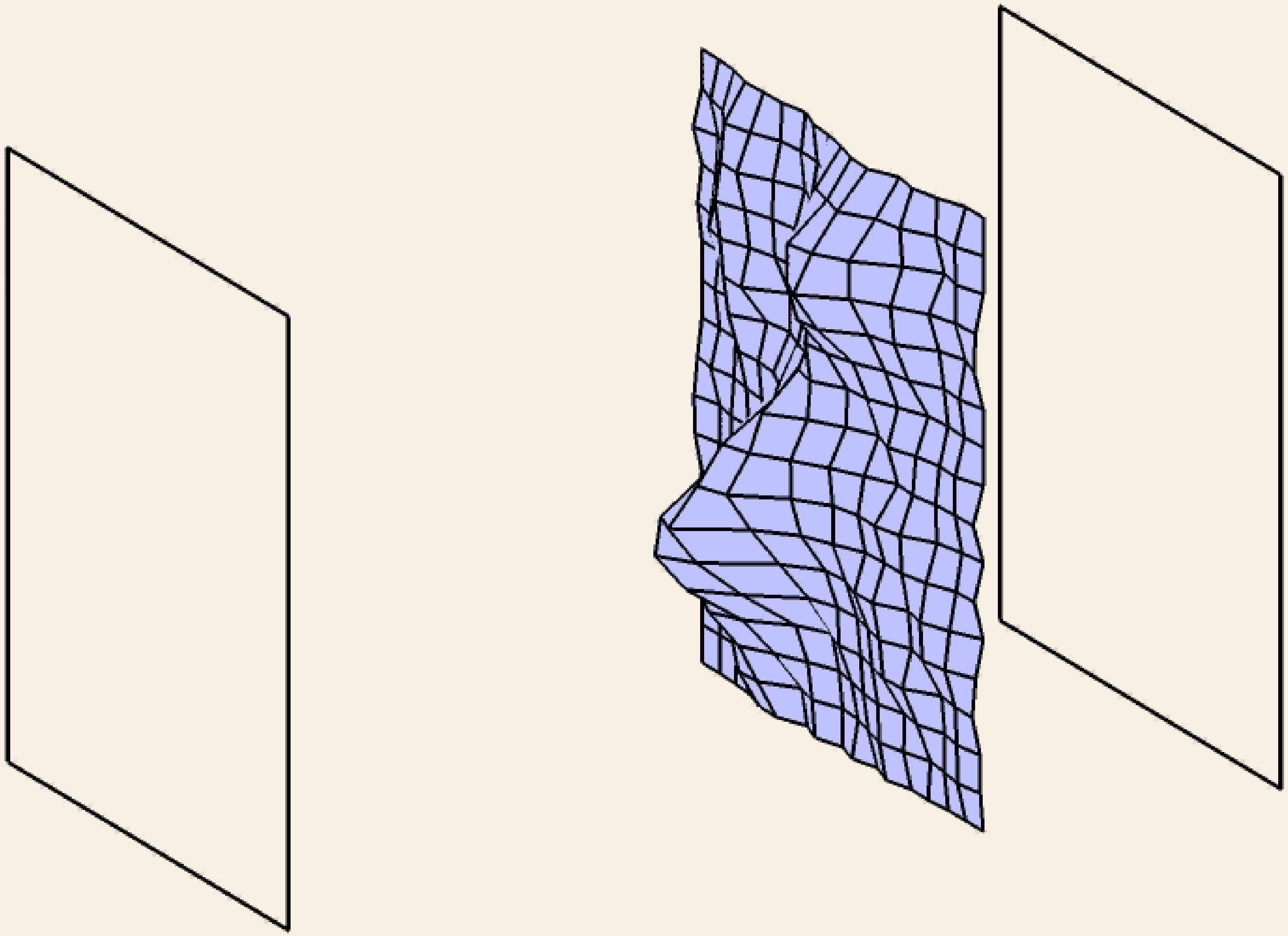
Towards higher accuracy



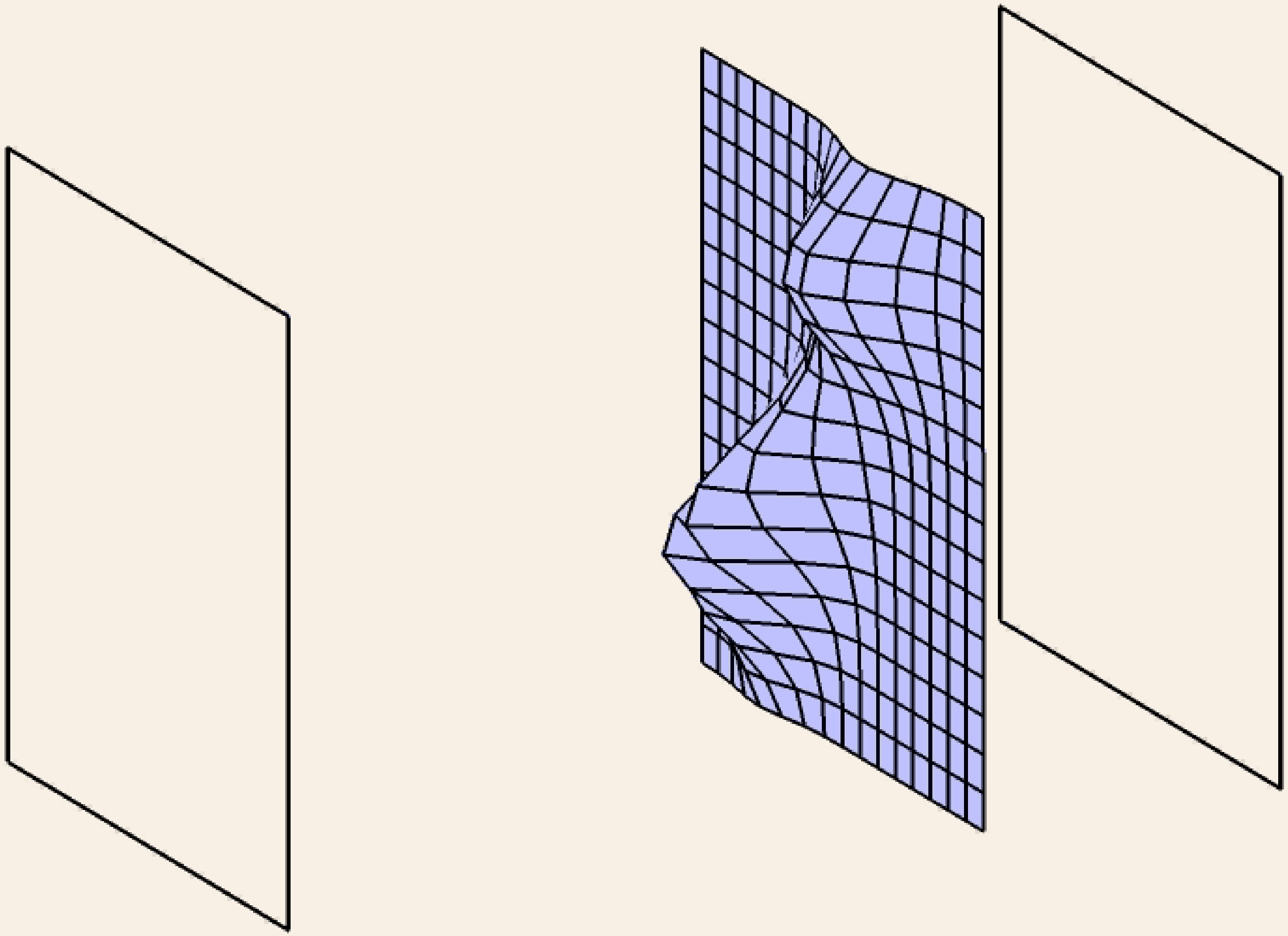
Arbitrary weighting function



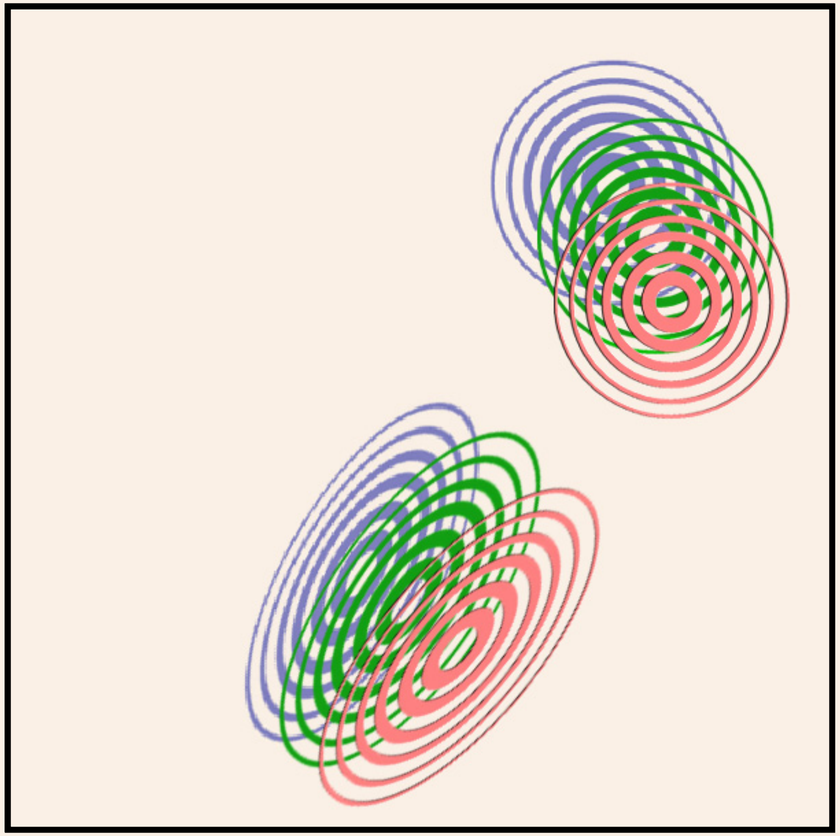
Multimodal oriented Gaussian



Multimodal oriented Gaussian

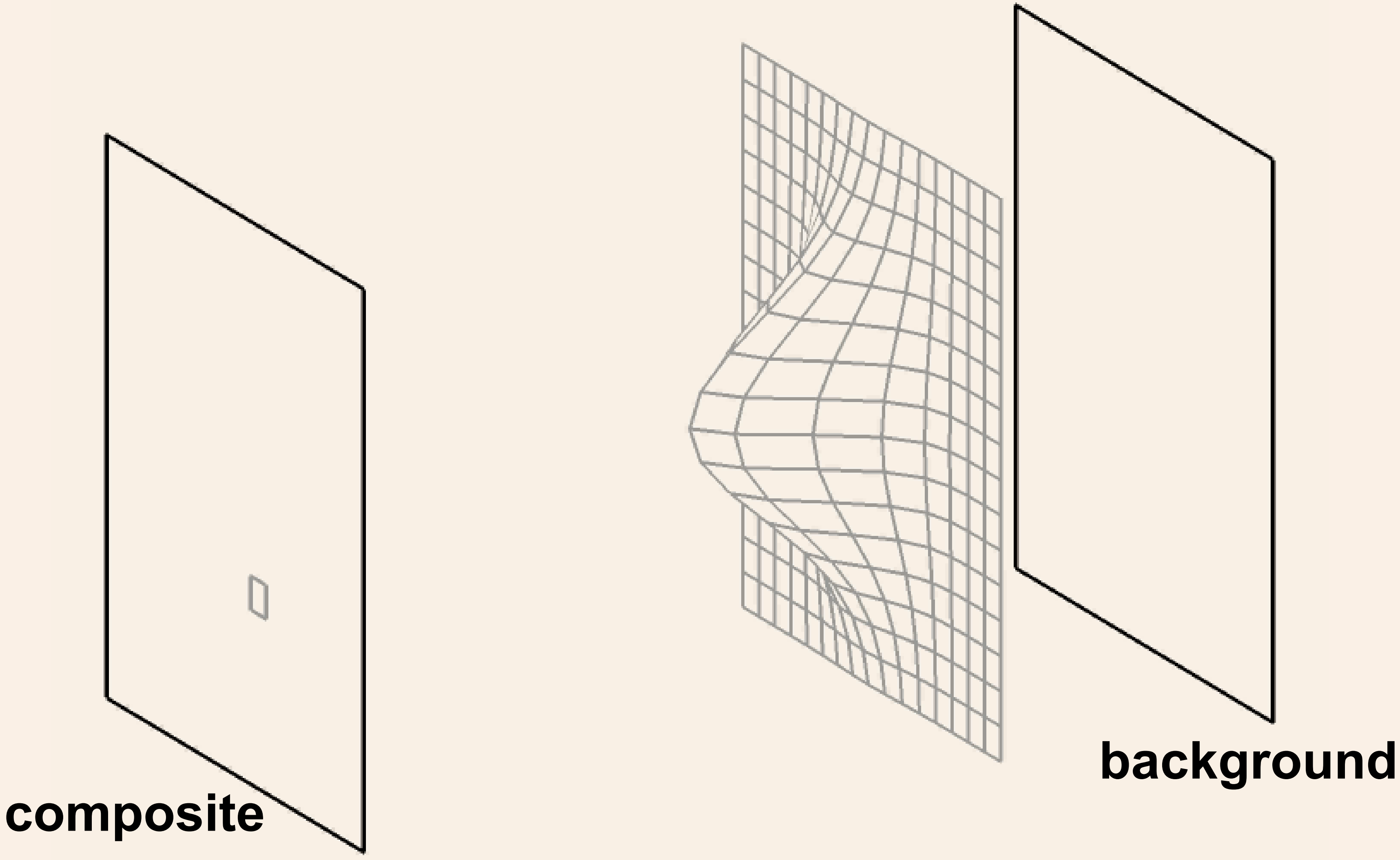


Multimodal oriented Gaussian

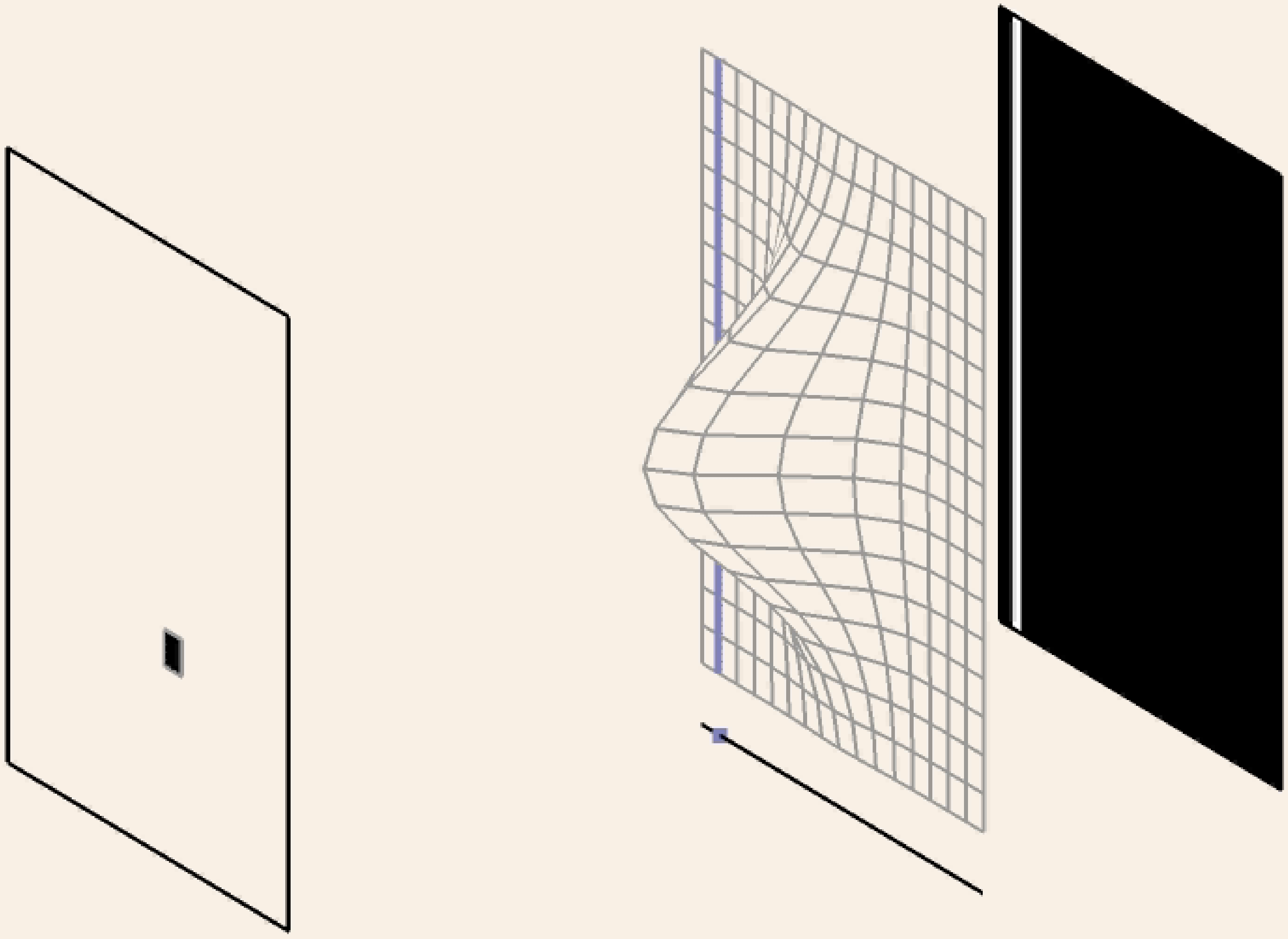


- Better BRDF approximation
- Multiple mappings
- Wavelength-coupled variation

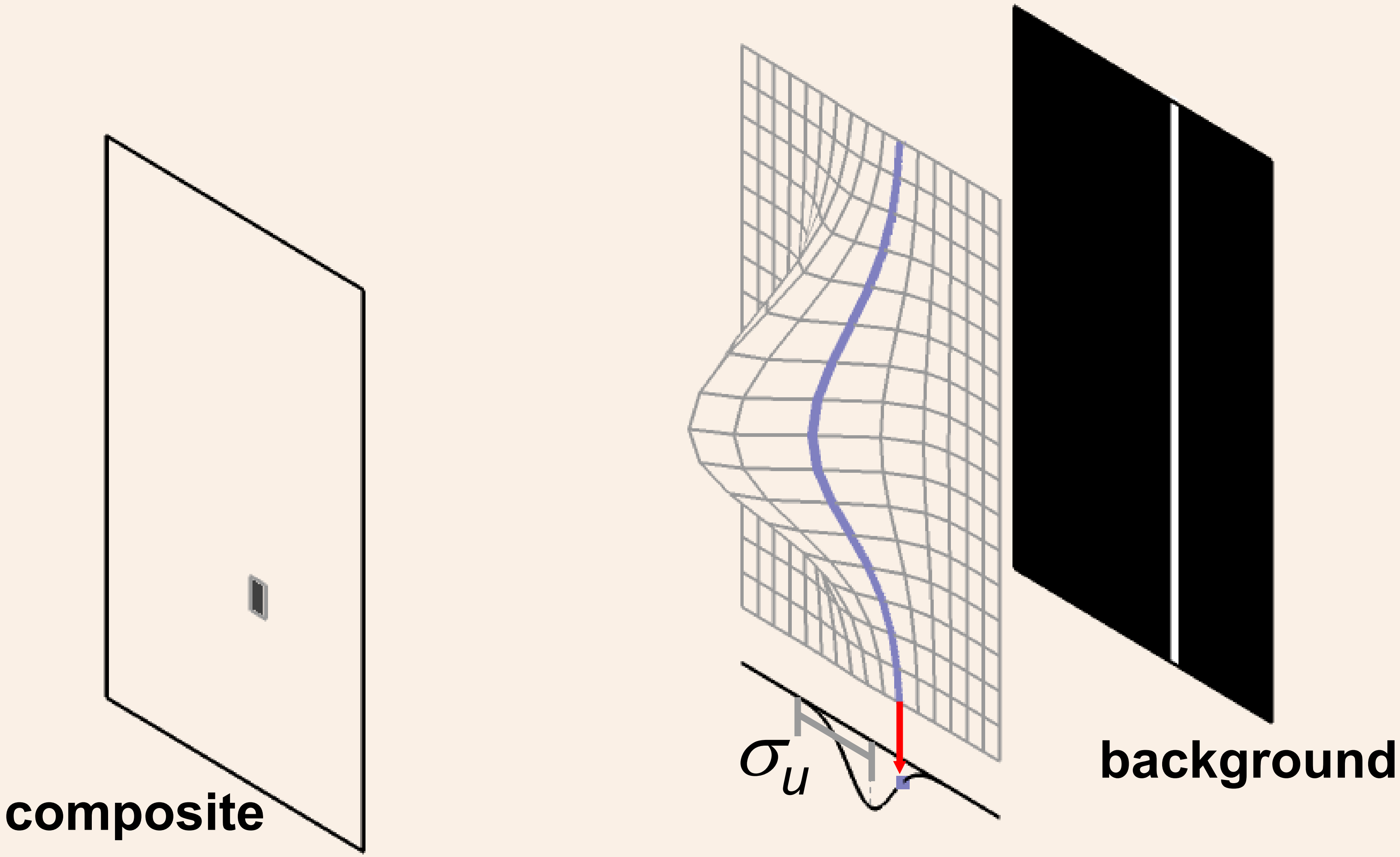
Unimodal axis-aligned Gaussian



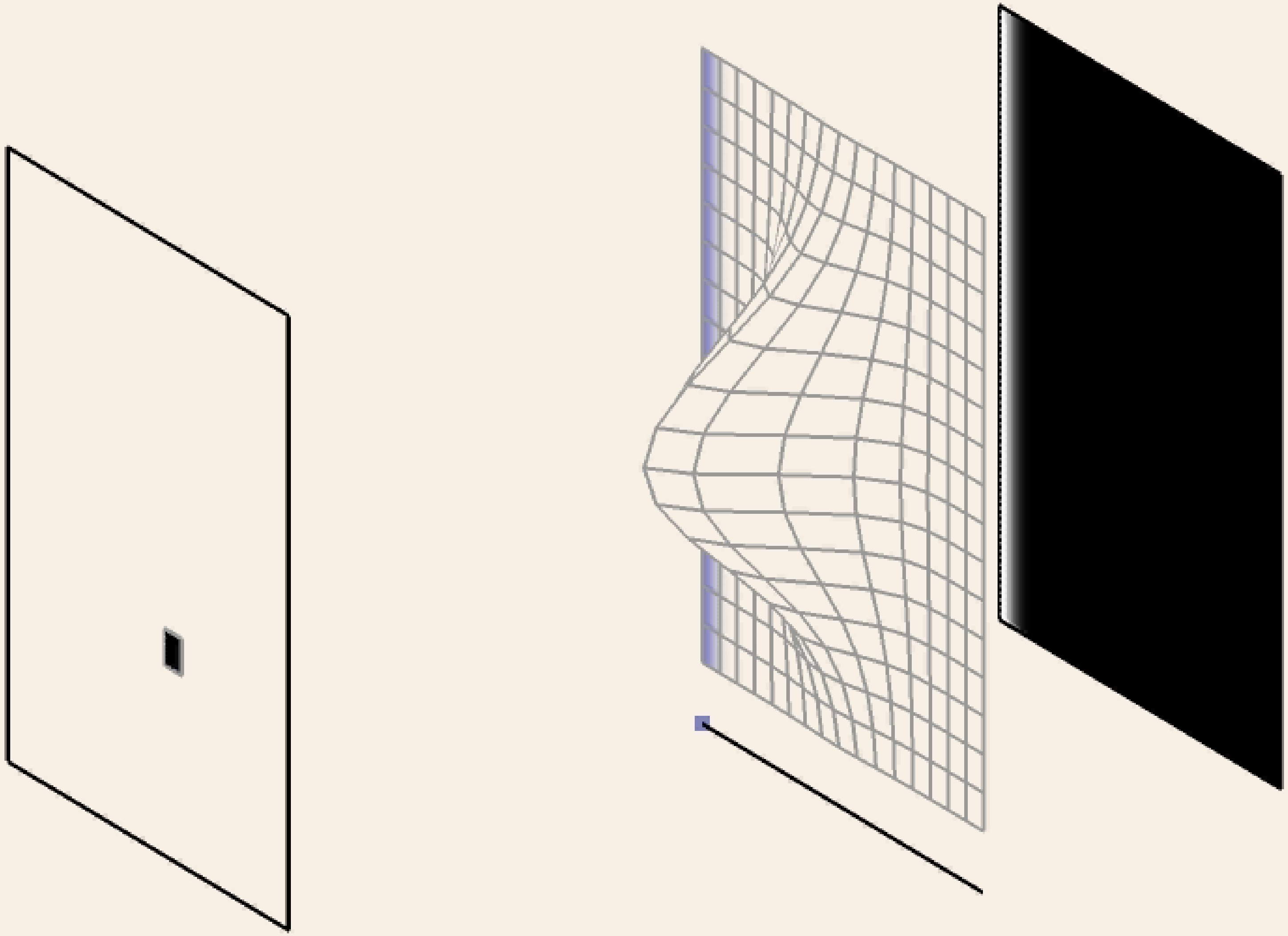
Unimodal axis-aligned Gaussian



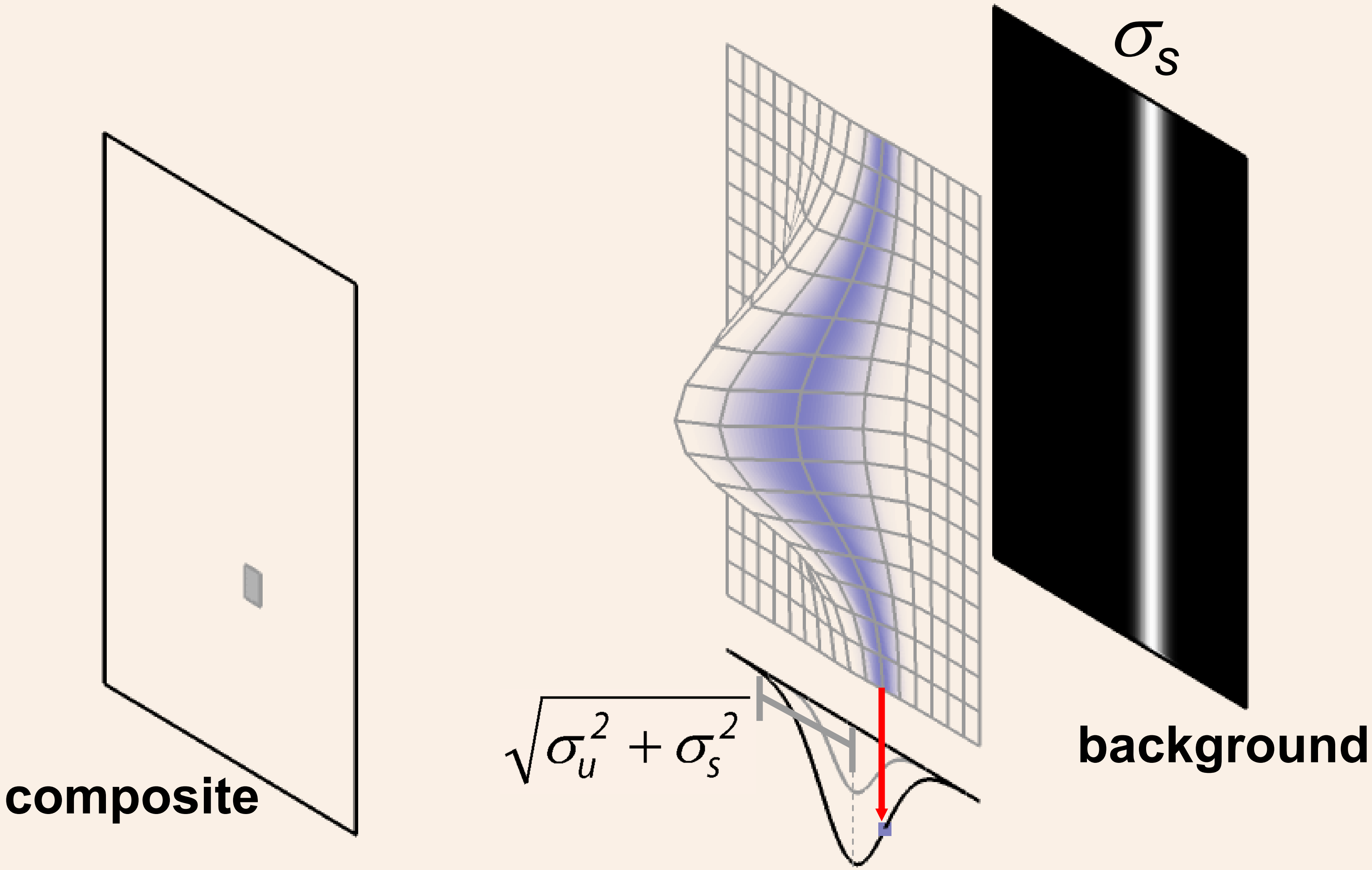
Unimodal axis-aligned Gaussian



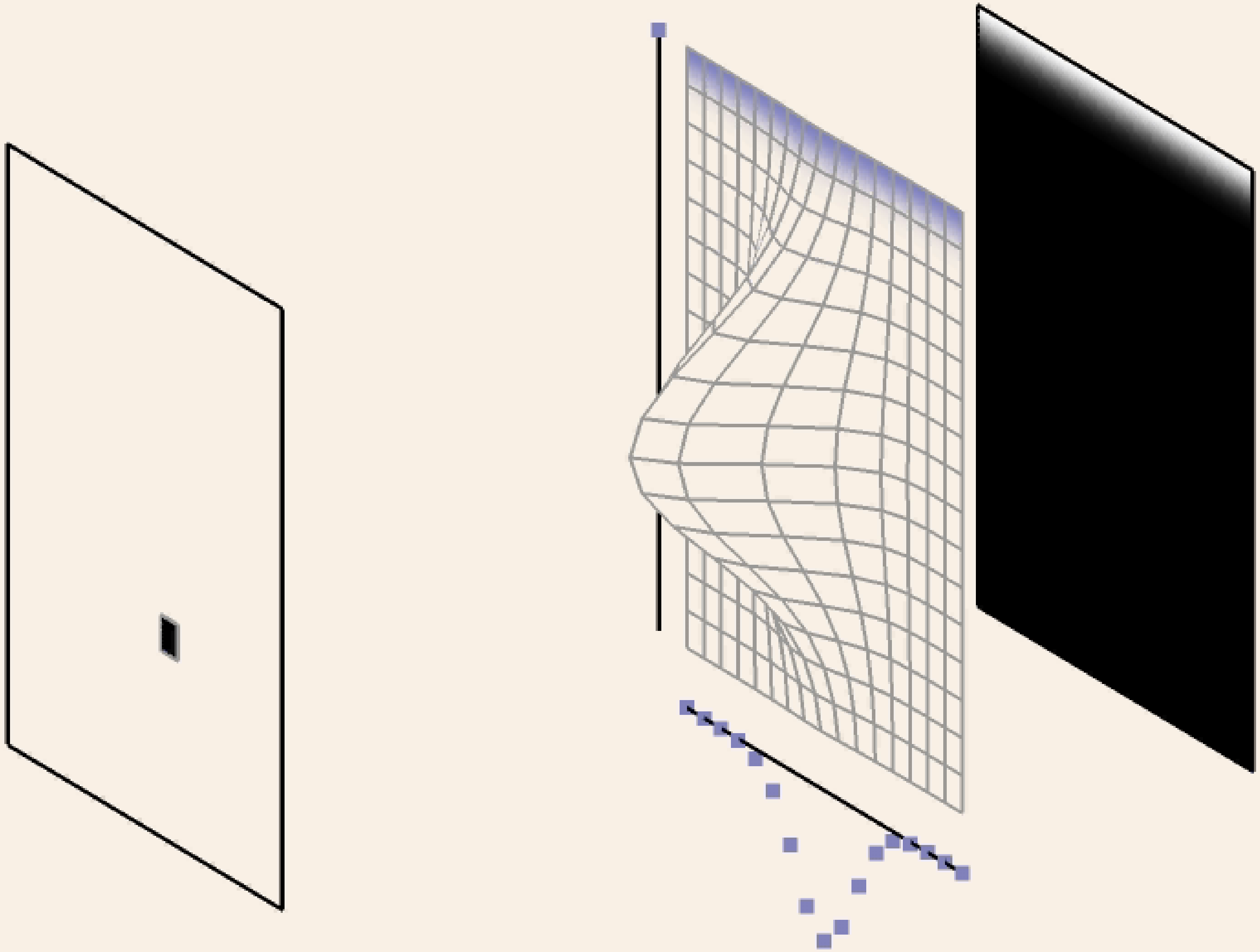
Unimodal axis-aligned Gaussian



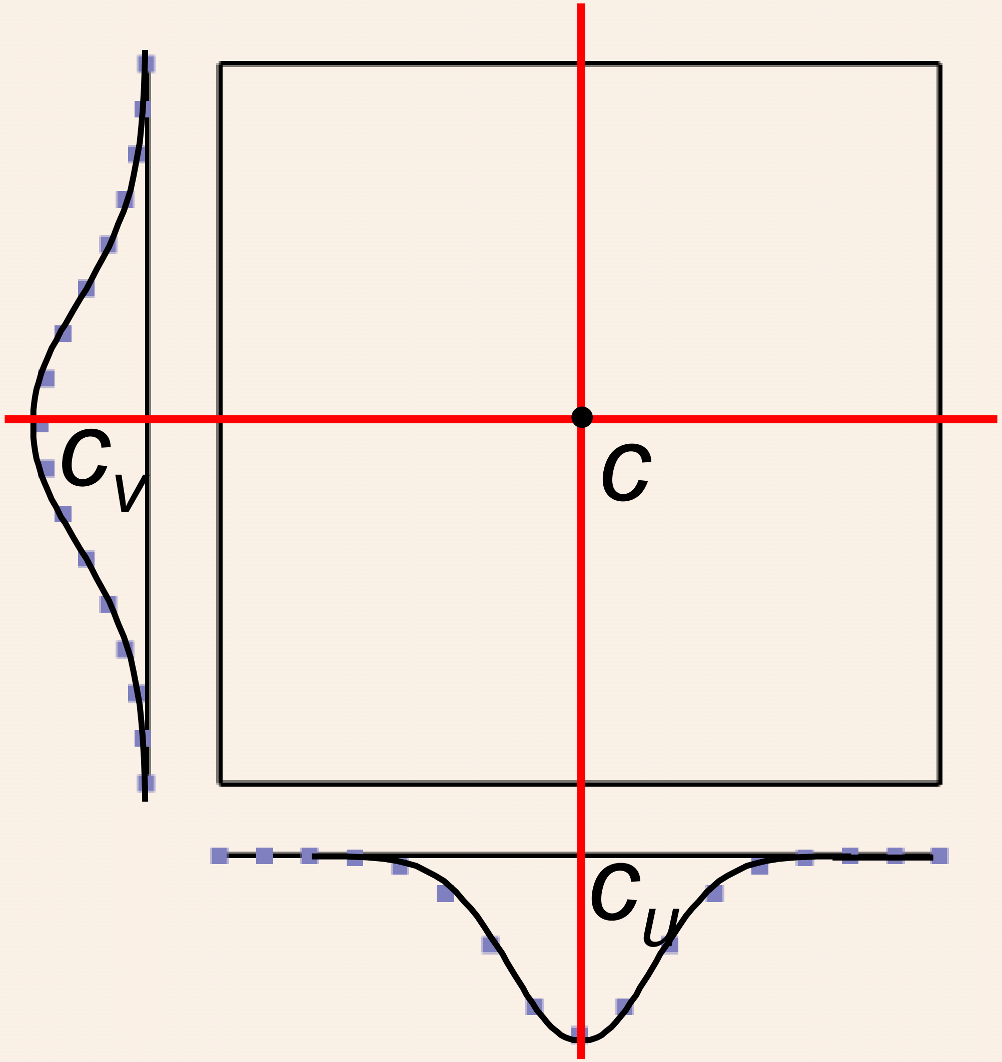
Unimodal axis-aligned Gaussian



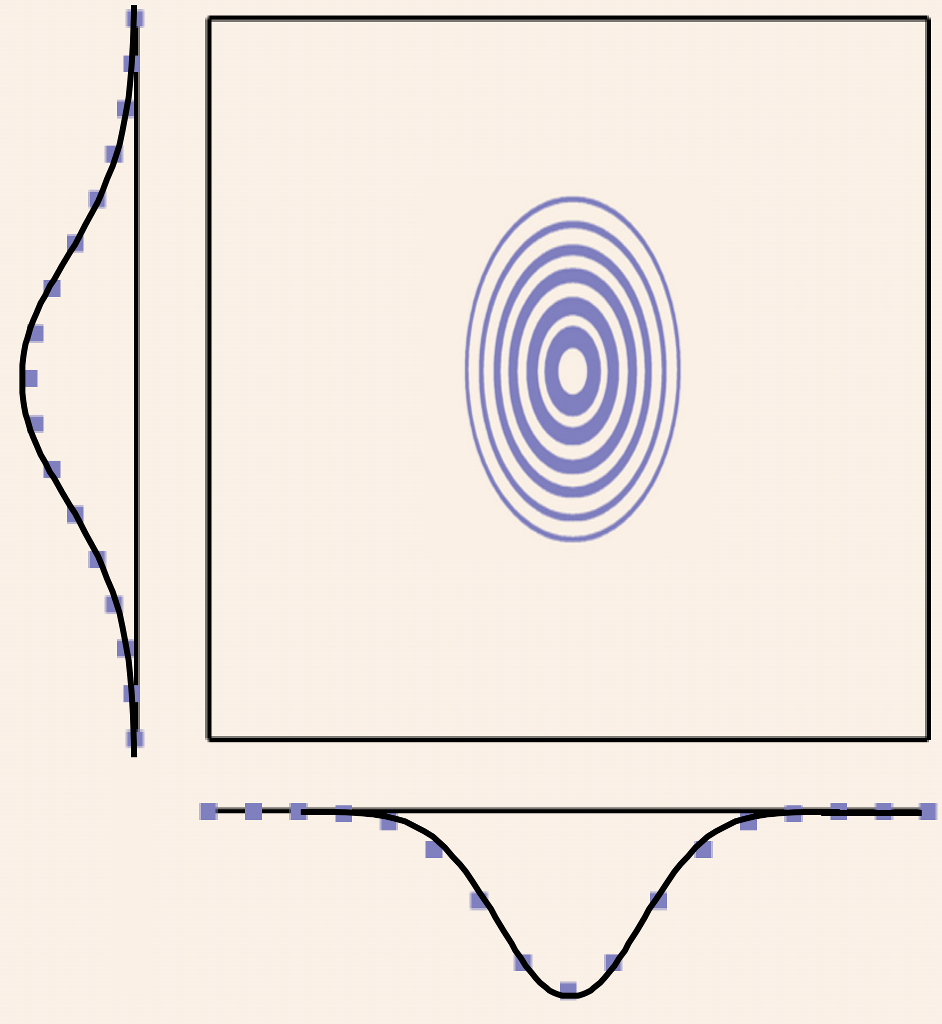
Unimodal axis-aligned Gaussian



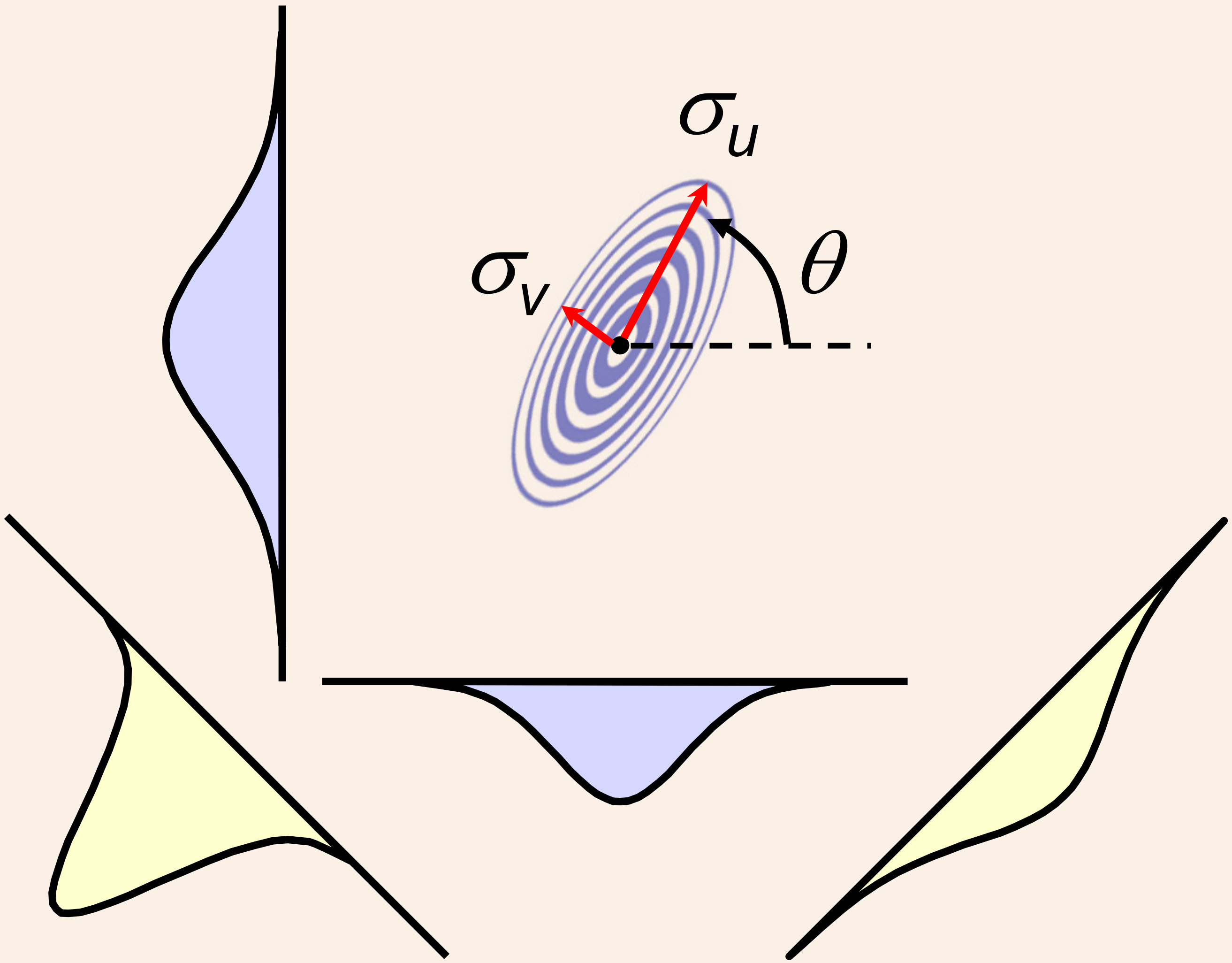
Unimodal axis-aligned Gaussian



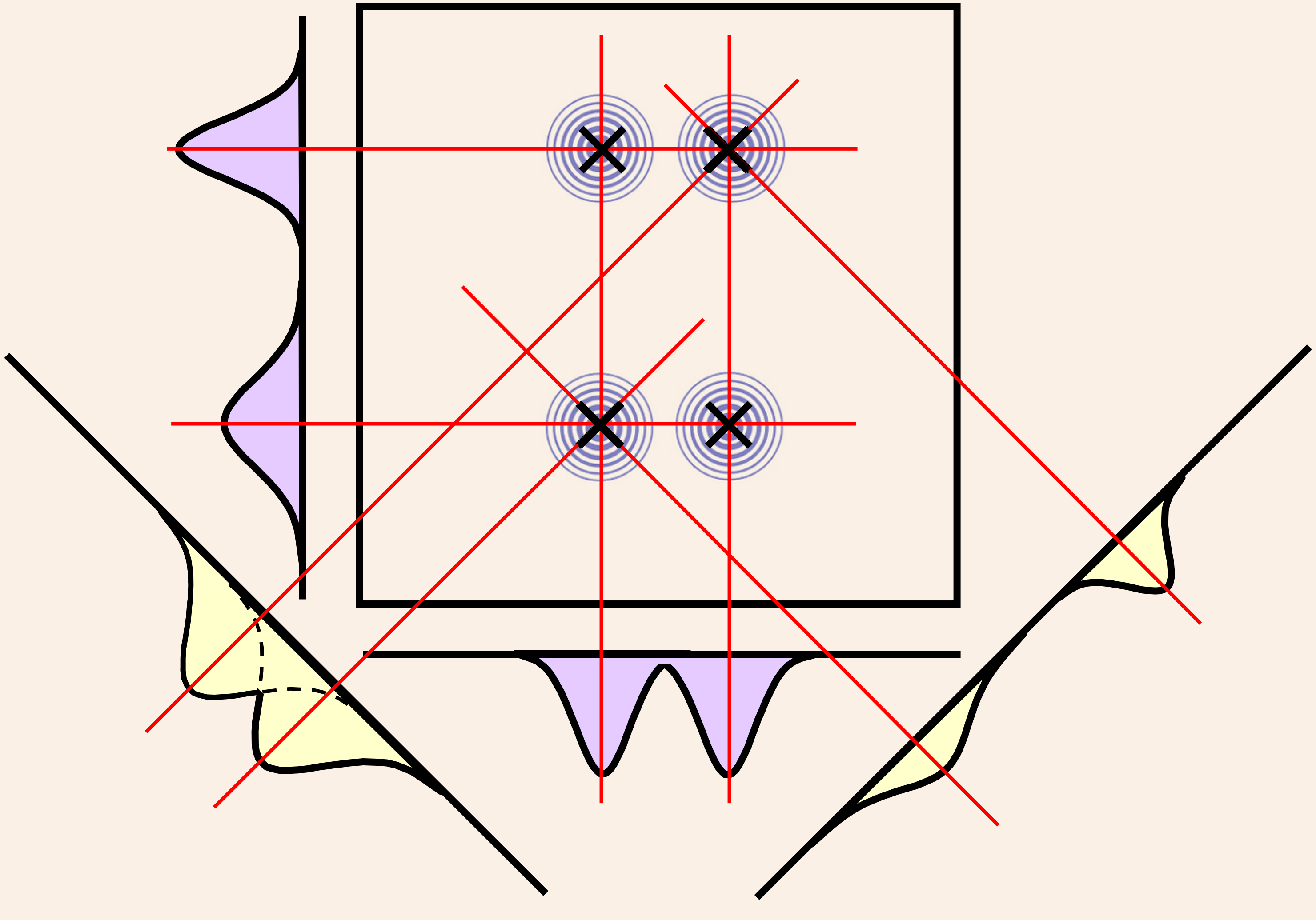
Unimodal axis-aligned Gaussian



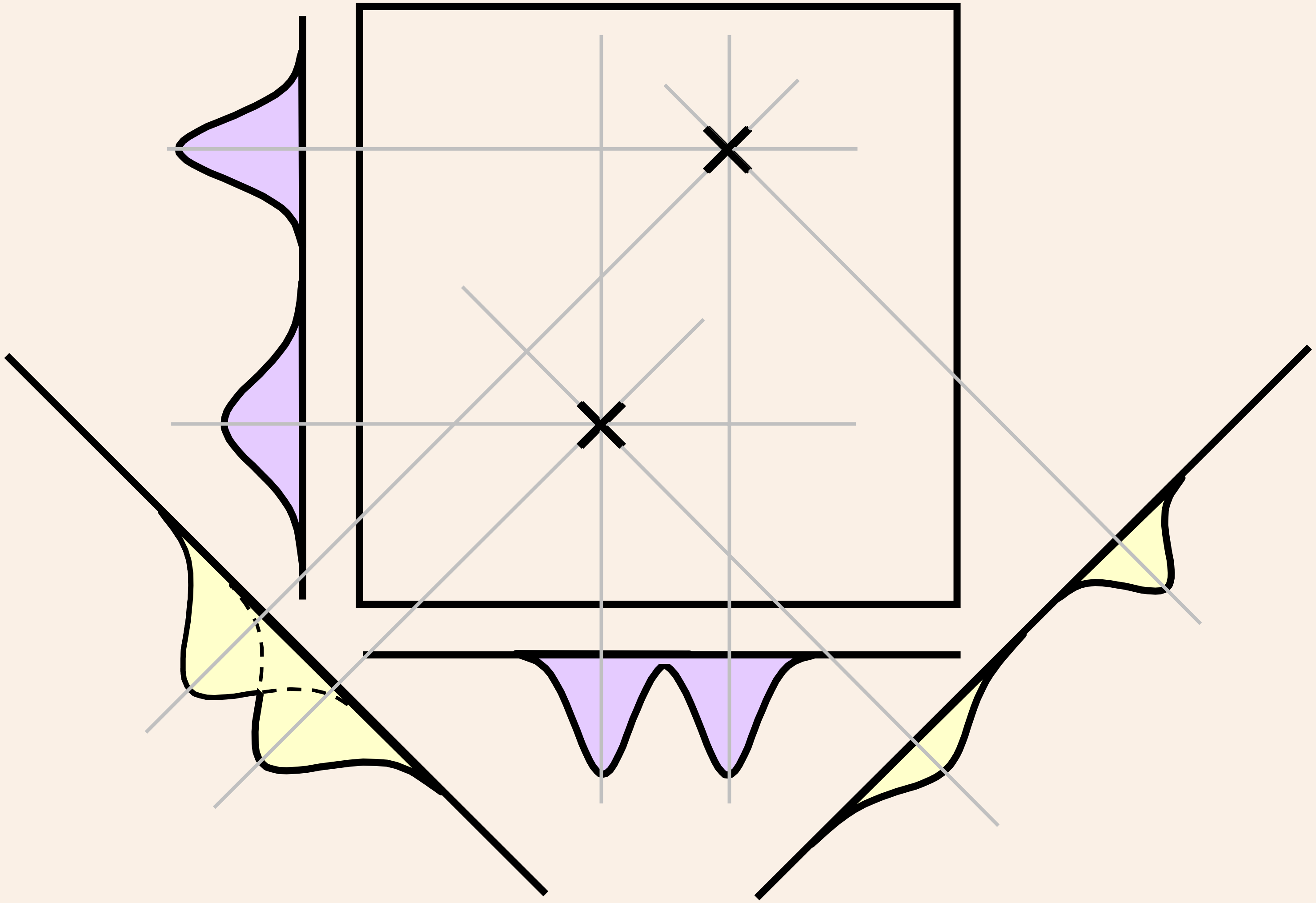
Unimodal oriented Gaussian



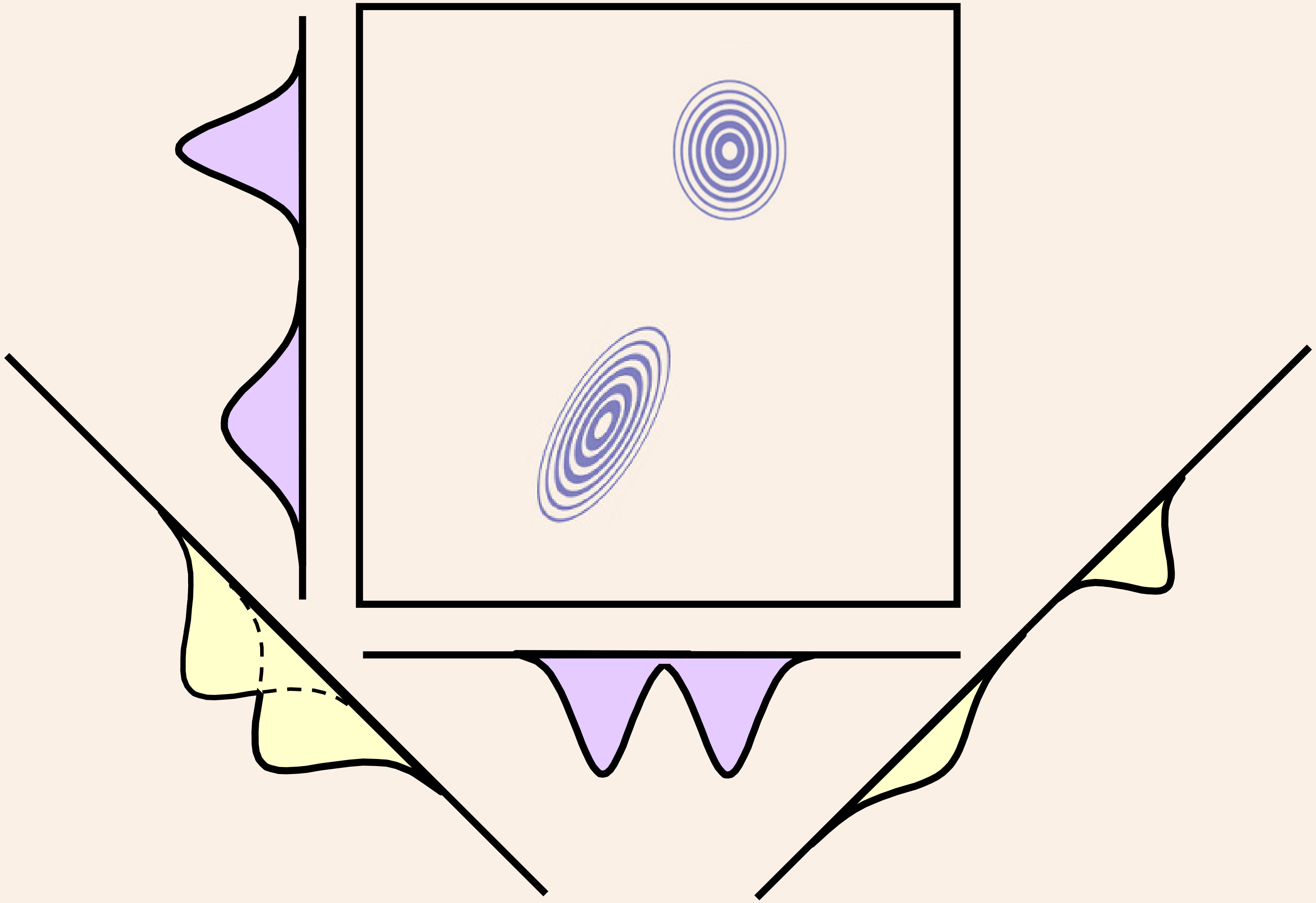
Multimodal oriented Gaussian

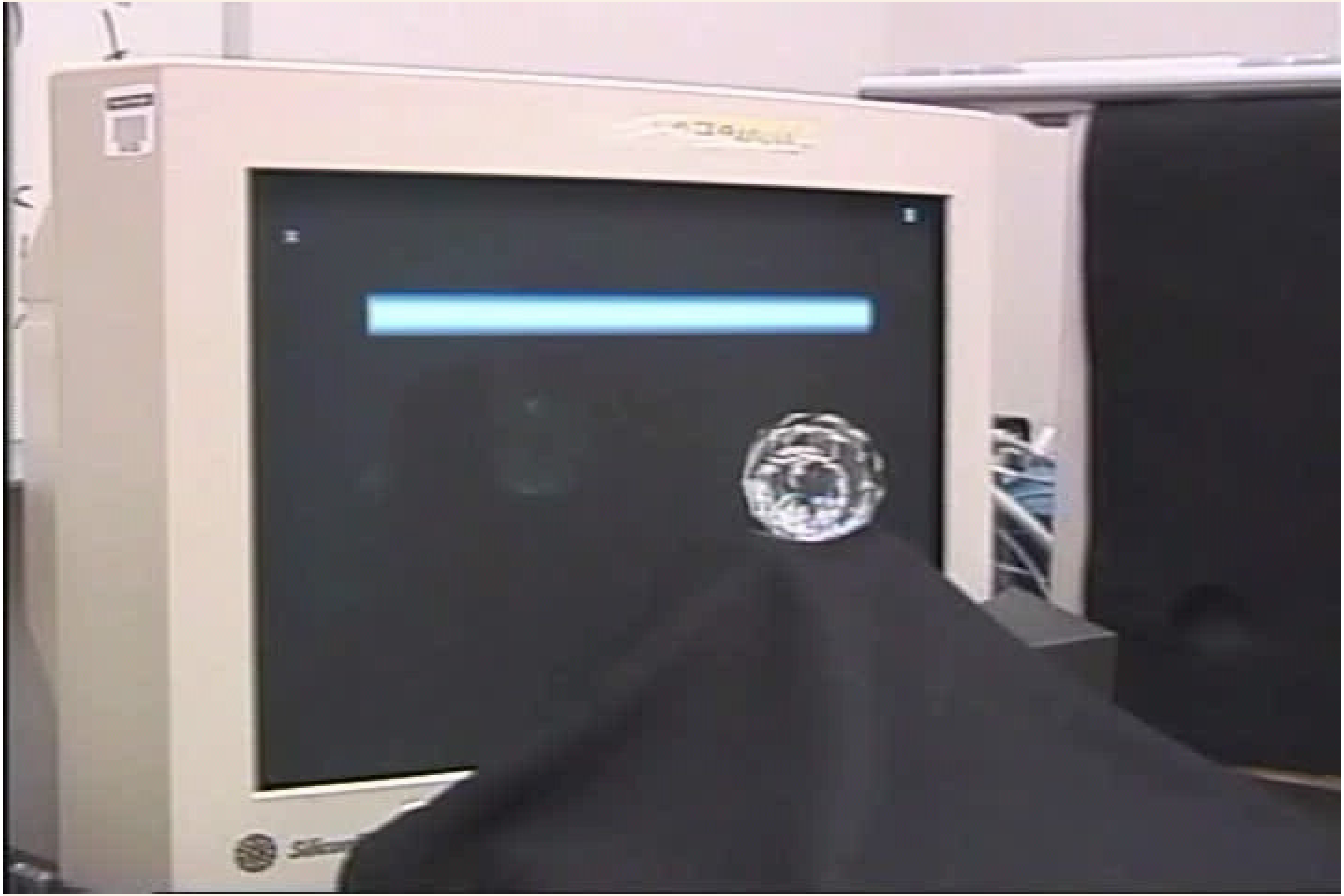


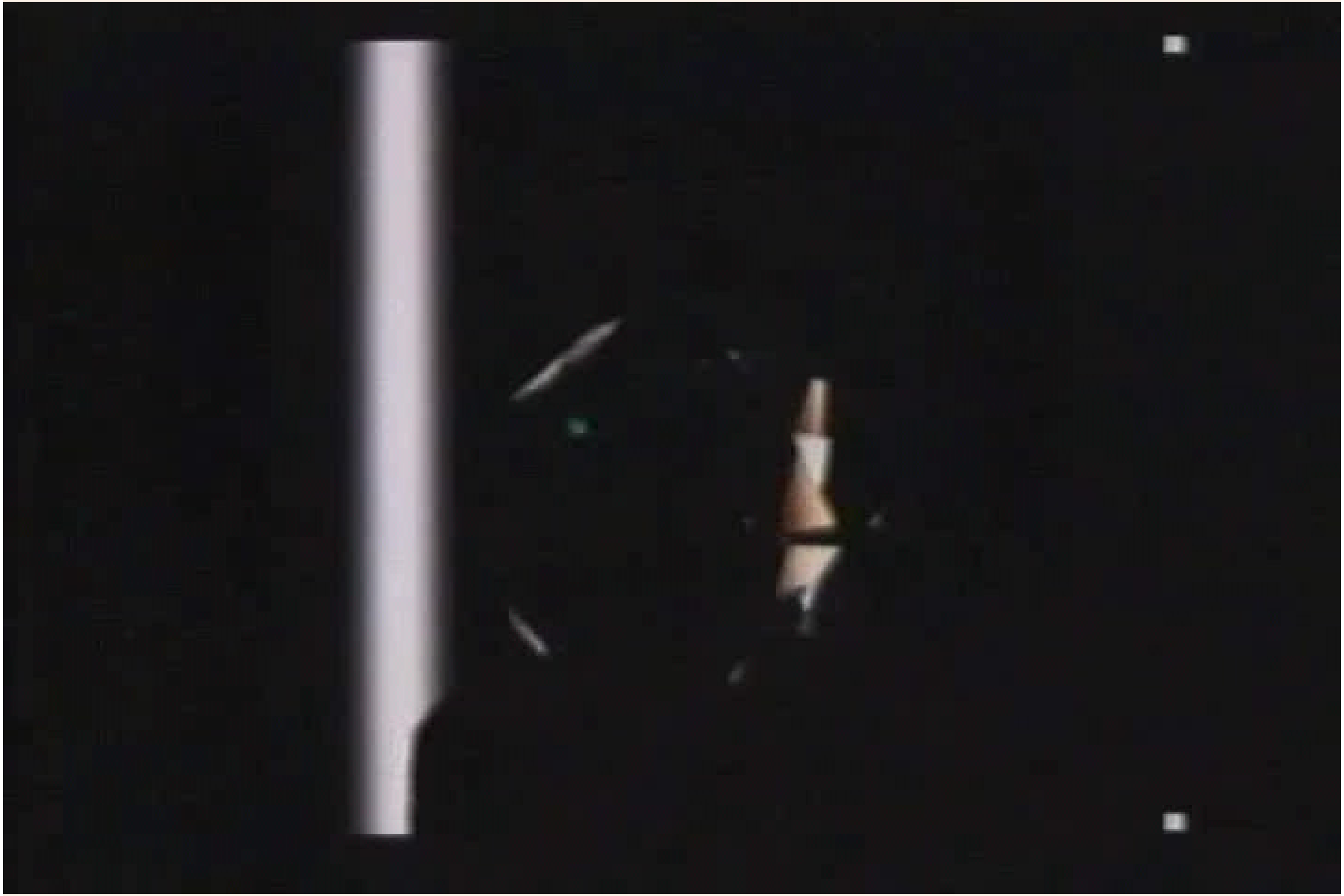
Multimodal oriented Gaussian



Multimodal oriented Gaussian







Glossy surface

SIGGRAPH 99

photograph

Glossy surface

higher accuracy algorithm

photograph

Oriented Gaussian

without orientation

photograph

Oriented Gaussian

with orientation

photograph

Multiple mappings

SIGGRAPH 99

photograph

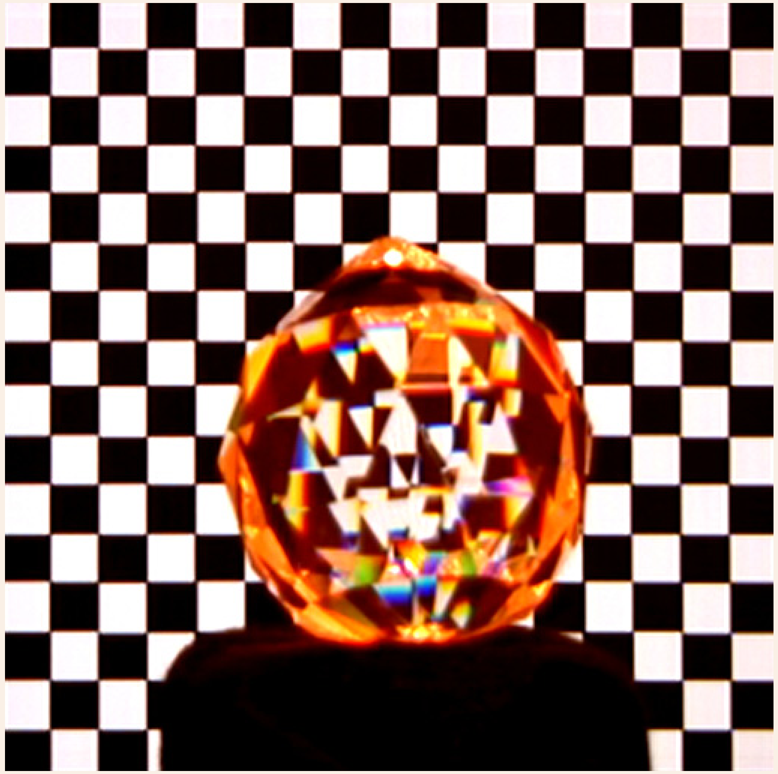
Multiple mappings

higher accuracy
algorithm

photograph

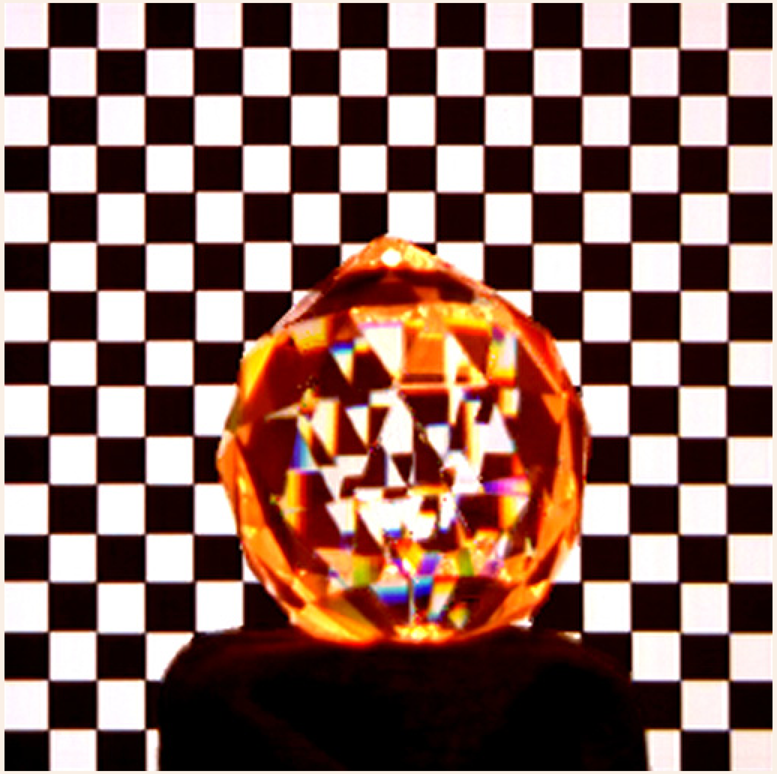
Color dispersion

SIGGRAPH 99

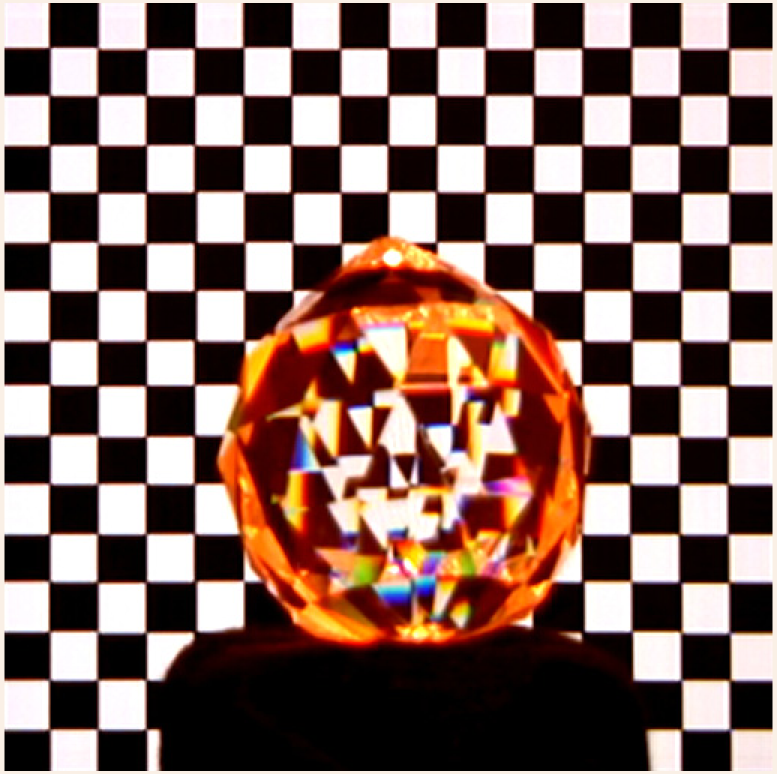


photograph

Color dispersion



higher accuracy algorithm



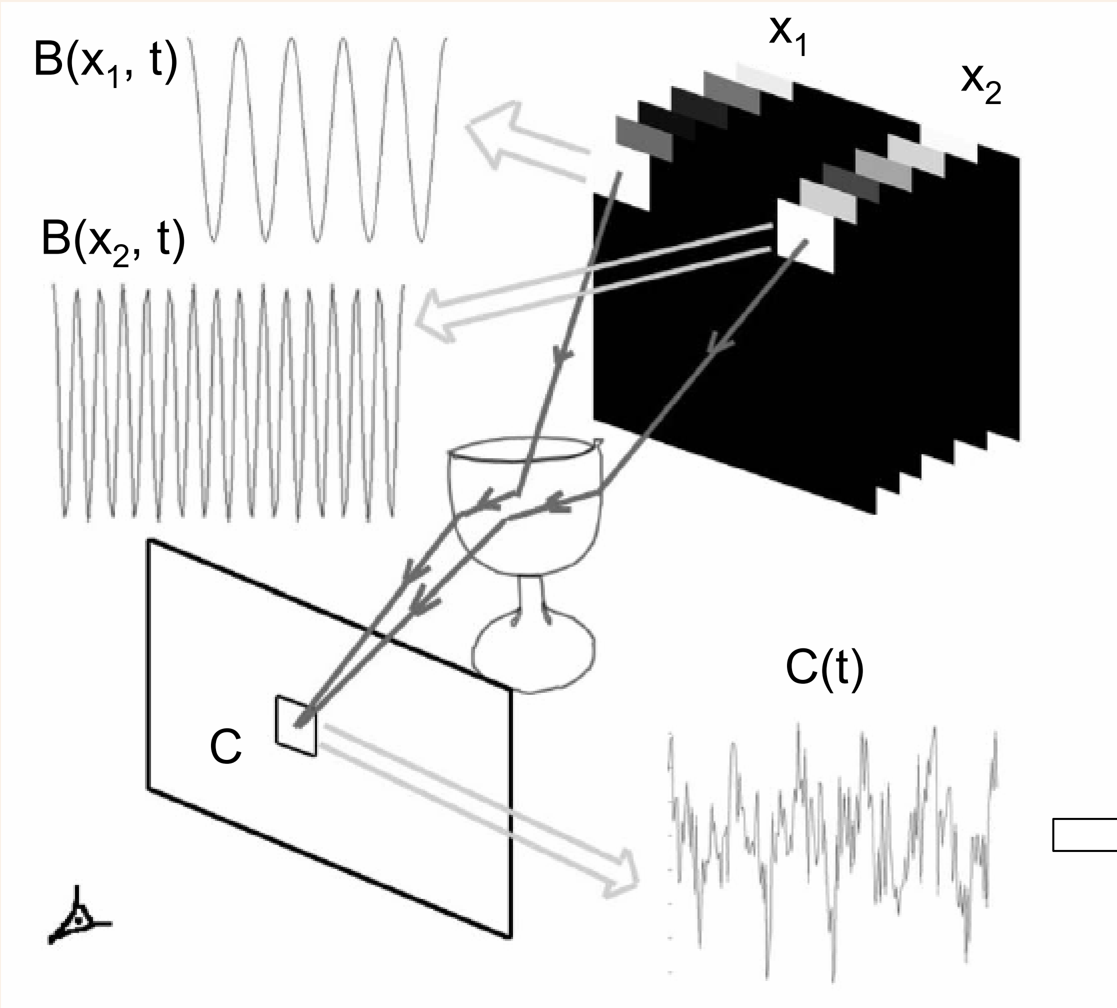
photograph

Frequency-based environment matting

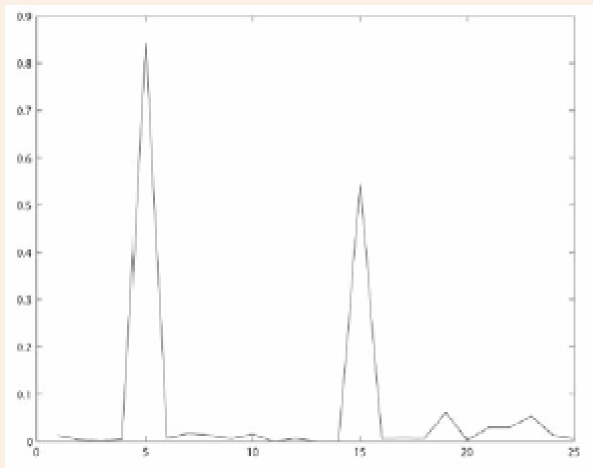
Zhu et. al.

Pacific Graphics 2004

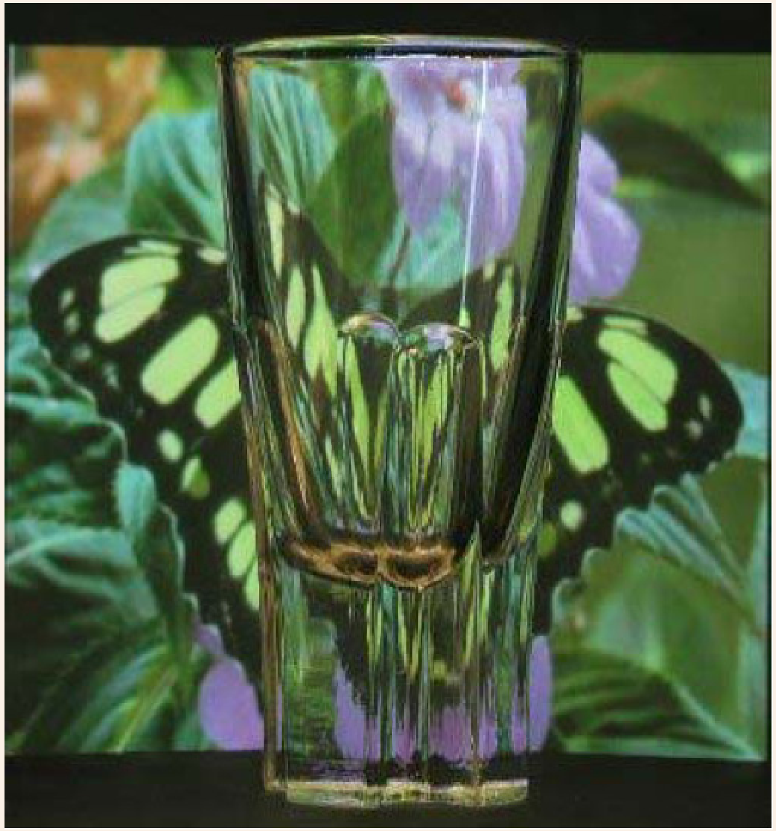
Frequency-based environment matting



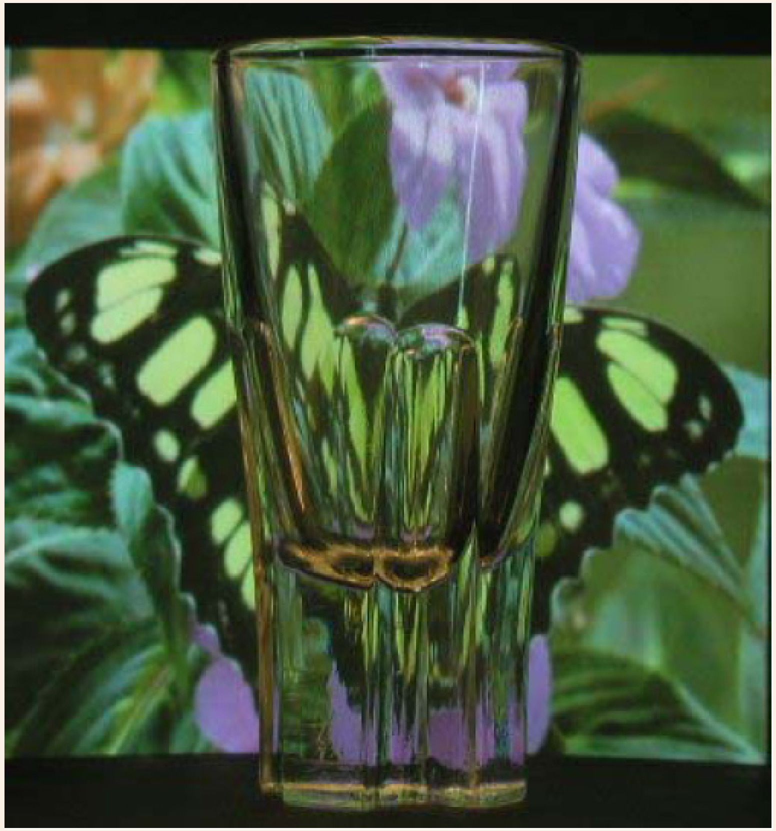
spectrum of C



Results: refraction

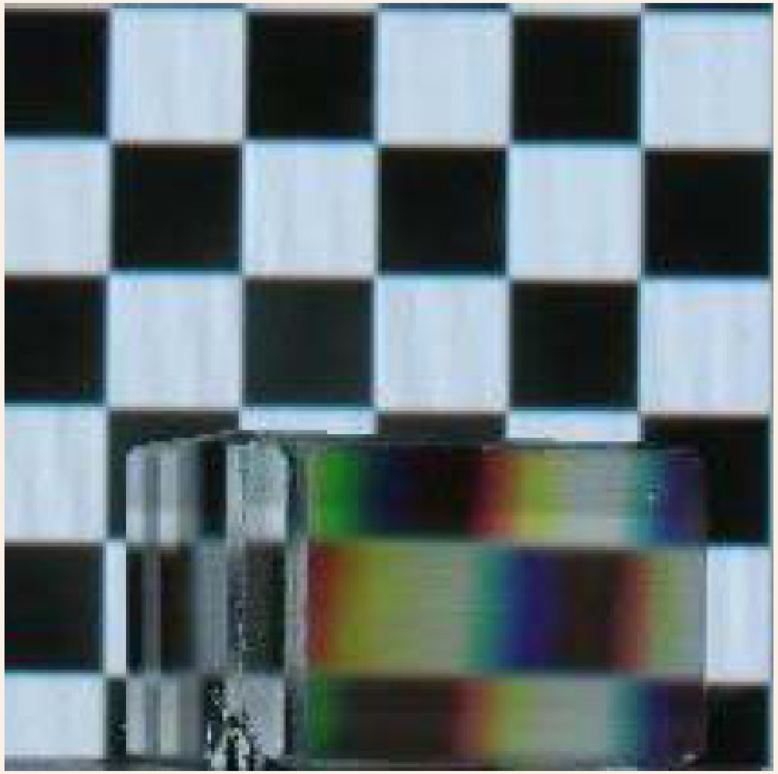


frequency-based environment matting

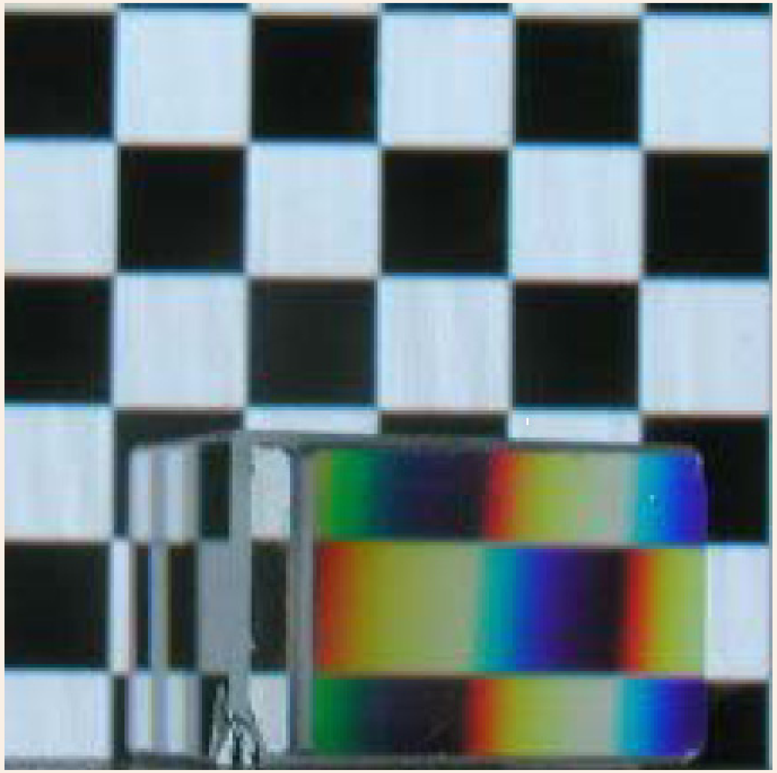


photograph

Results: color dispersion



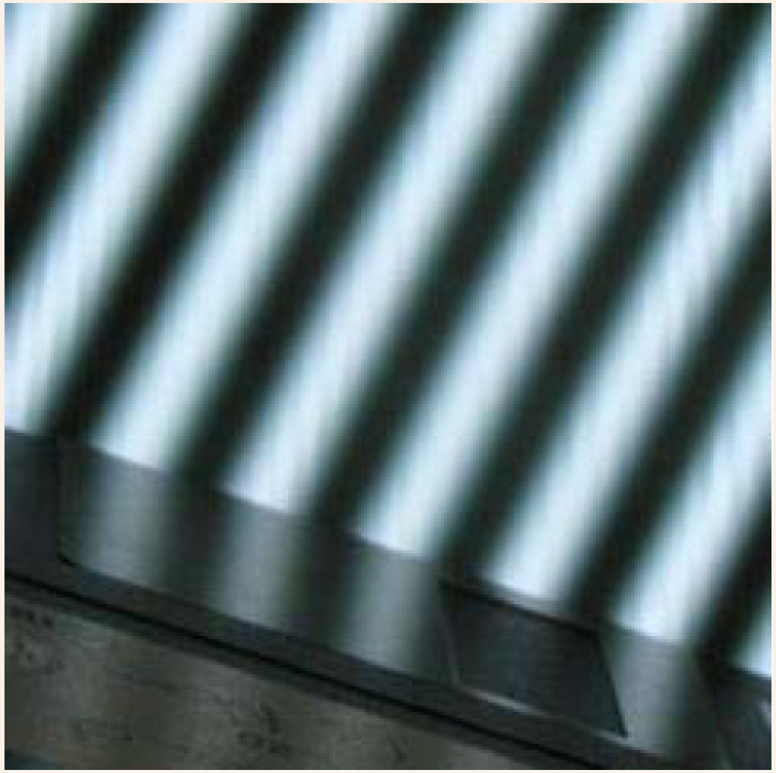
frequency-based
environment matting



photograph

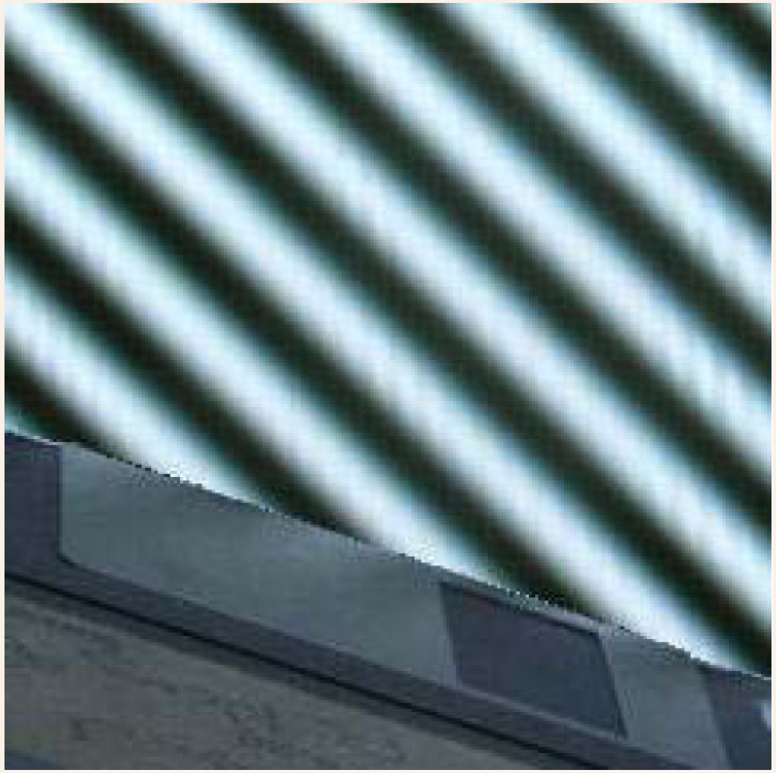
Results: oriented

frequency-based environment matting



photograph

Results: oriented



frequency-based
environment matting

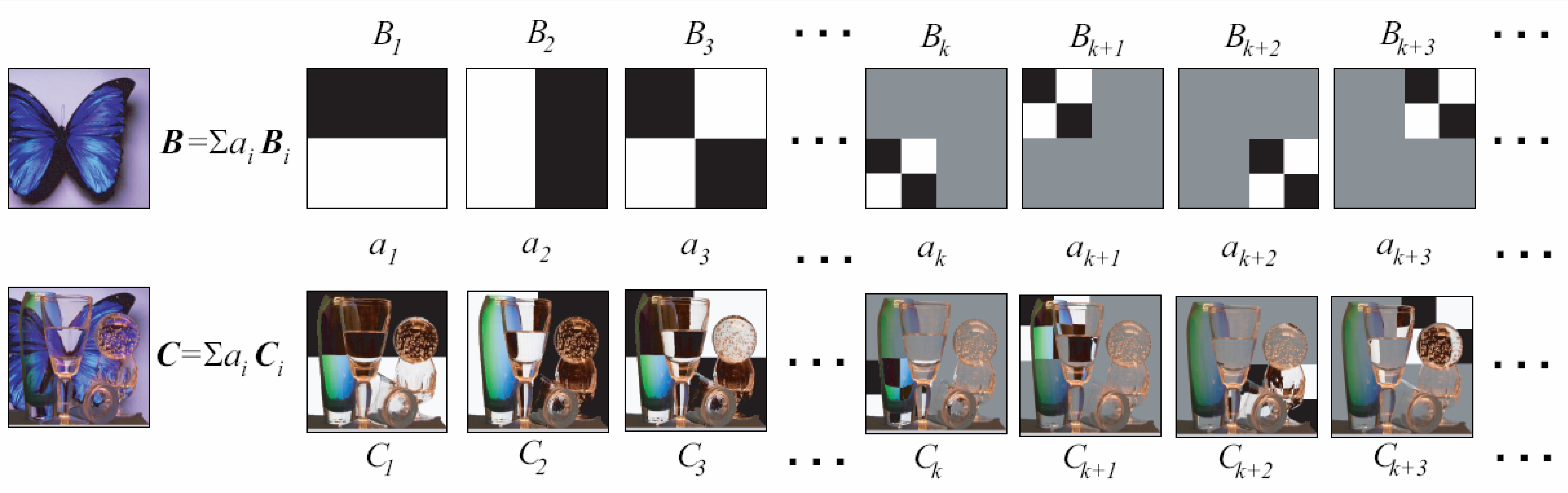
photograph

Wavelet environment matting

Peers et. al.

EGSR 2003

Wavelet environment matting



Results: number of basis images

reference image

1200 basis images

Results: number of basis images

reference image

1200 basis images

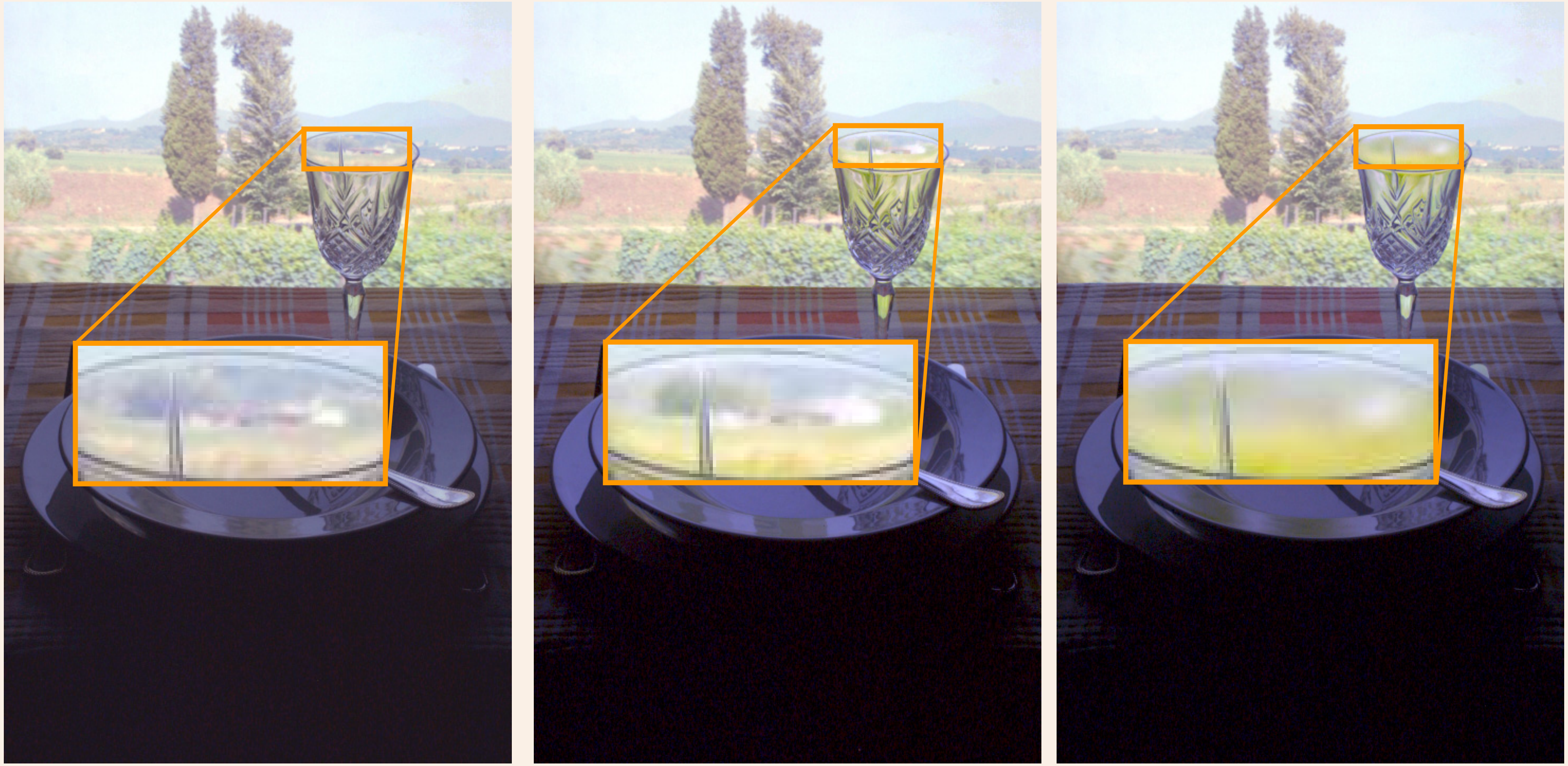
Results: wavelet patterns

reference image

1000 Haar patterns

1000 Daubechies (9,7) patterns

Results: wavelet patterns

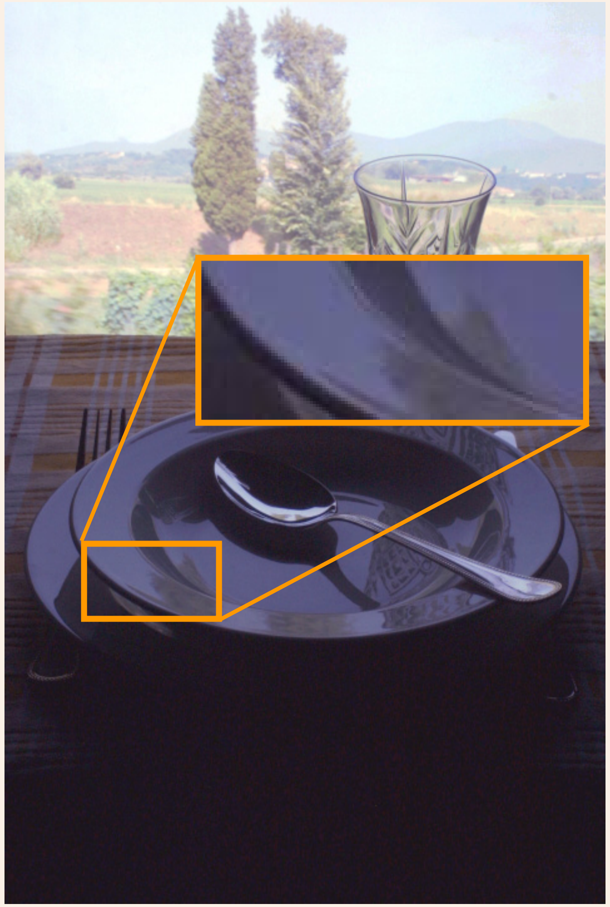


reference image

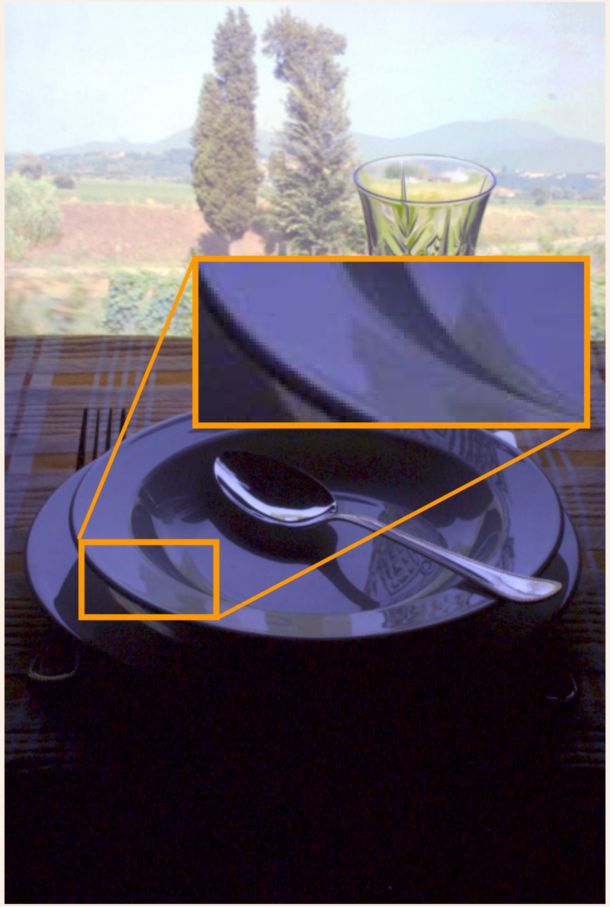
1000 Haar patterns

1000 Daubechies (9,7) patterns

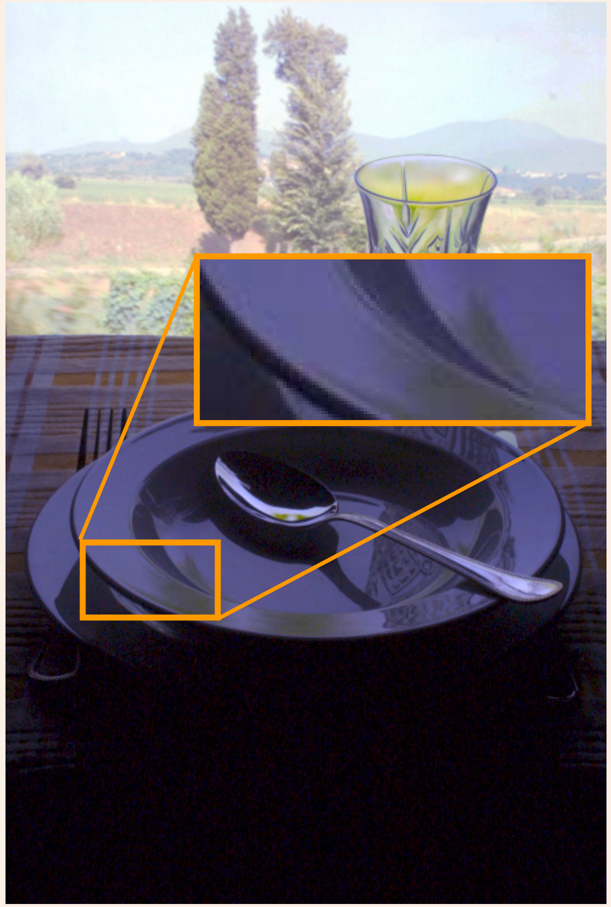
Results: wavelet patterns



reference image

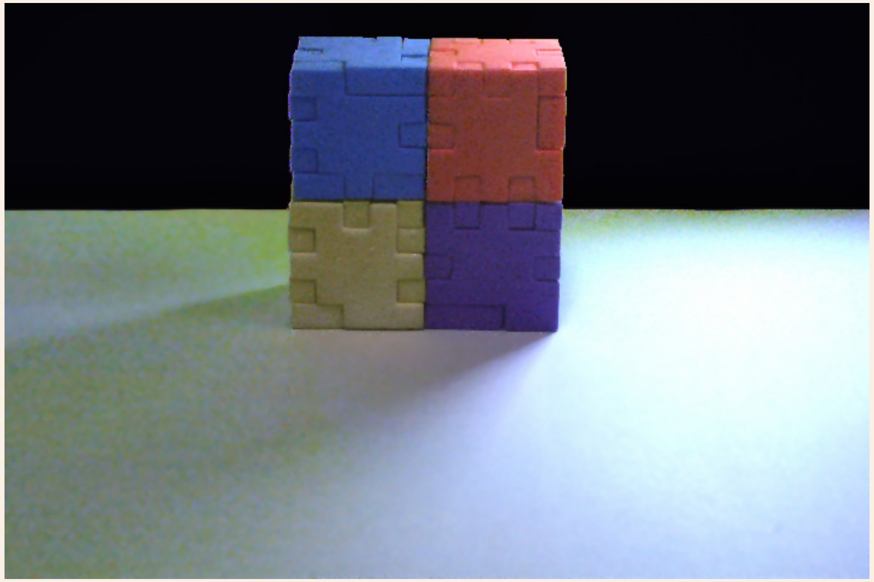


1000 Haar patterns



1000 Daubechies (9,7) patterns

Results: diffuse materials



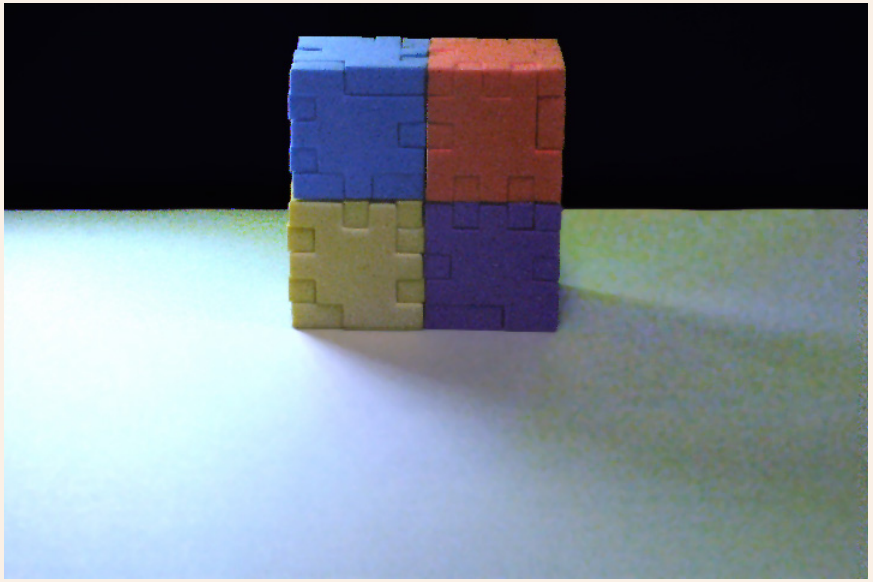


Image-based environment matting

Wexler et. al.

EWSR 2002

Image-based environment matting

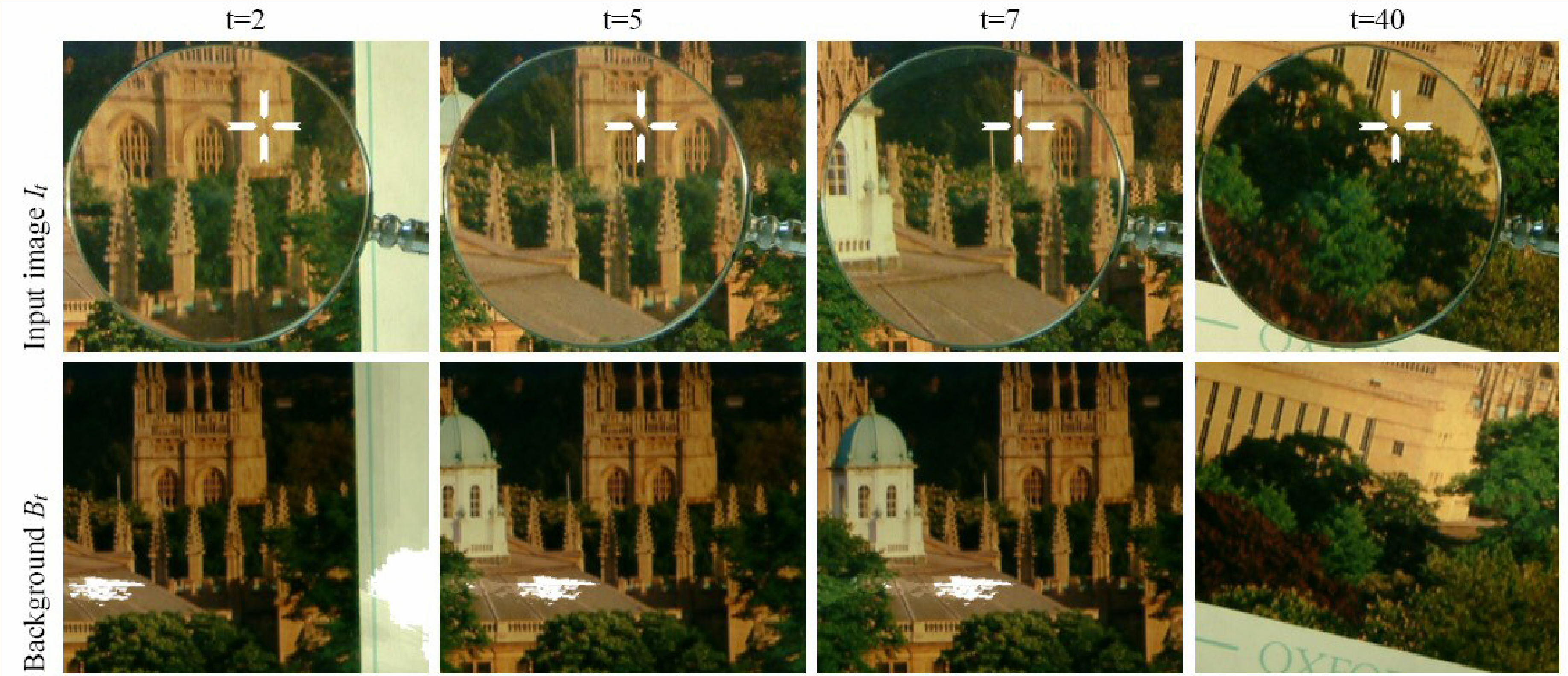


Image-based environment matting

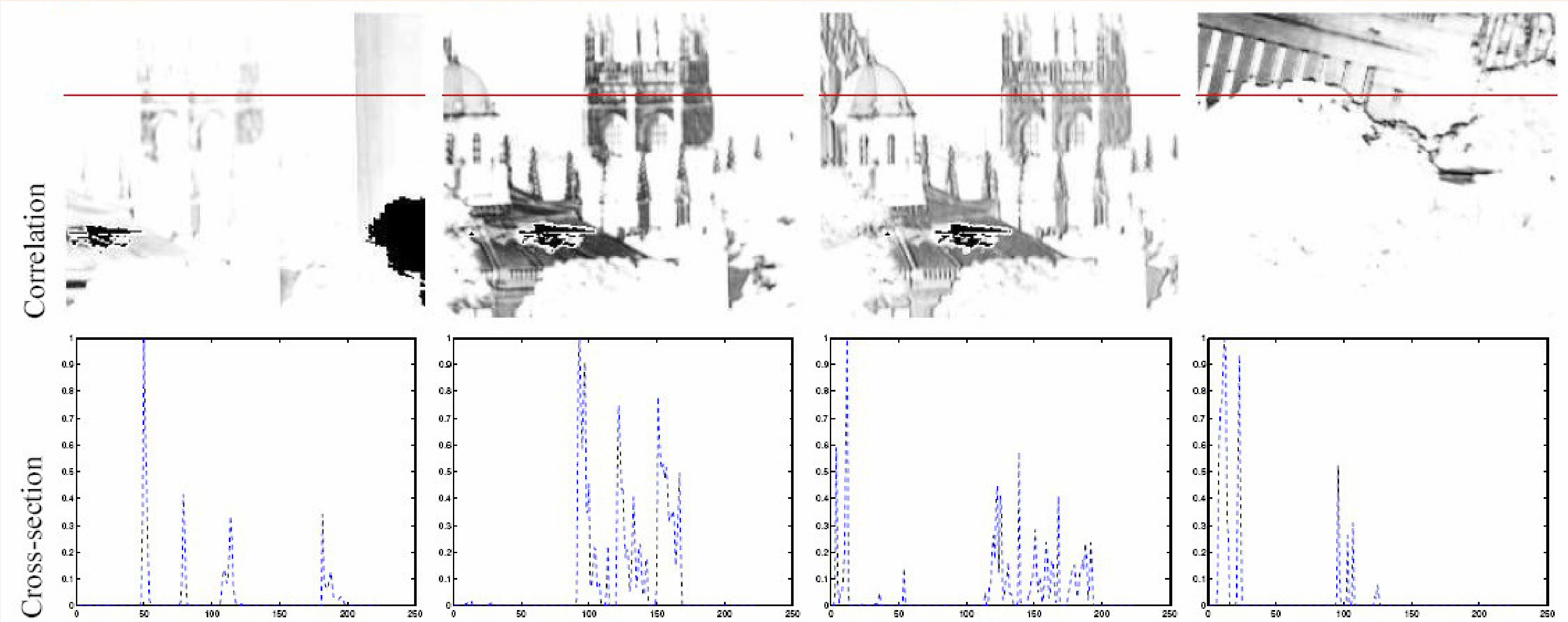
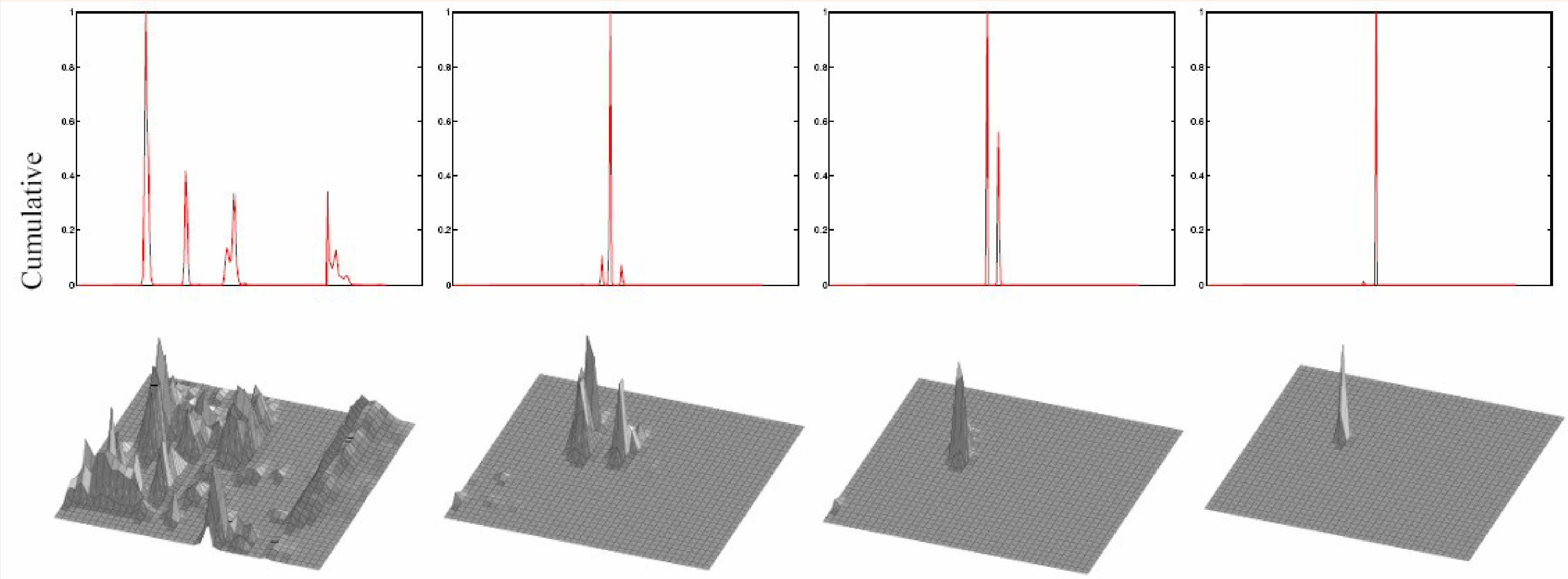


Image-based environment matting



Results

Results

Comparisons

category	method	asymptotic # of images	typical # of images	weighting function	materials
active	RTEM	1	1	warping function	colorless, specularly refractive
	HEM	$O(\log k)$	20	box filter	refraction, translucency, highly specular, color transparency
	GEM	$O(k)$	600	sum of Gaussians	+color dispersion, multiple mappings and glossy reflection
	FBEM	$O(k)$	1,200	product of two 1D functions	-multiple mappings
	WEM	$O(k^2)$	1,200	object images	+diffuse reflection
passive	IBEM	N/A	40	probability map	colorless, specularly refractive
	ROEM	N/A	200	warping function	colorless, specularly refractive

Reference

- D. Zongker, D. M. Werner, B. Curless, and D. H. Salesin. Environment Matting and Compositing, SIGGRAPH 1999, pp205-214.
- Yung-Yu Chuang, Douglas E. Zongker, Joel Hindorff, Brian Curless, David H. Salesin, Richard Szeliski, Environment Matting Extensions: Towards Higher Accuracy and Real-Time Capture, SIGGRAPH 2000.
- P. Peers and P. Dutre. Wavelet Environment Matting, EGSR 2003.
- J. Zhu and Y.-H. Yang. Frequency-Based Environment Matting, Pacific Graphics 2004.
- Y. Wexler, A. Fitzgibbon and A. Zisserman. Image-Based Environment Matting, EGWR 2002, pp279-289.