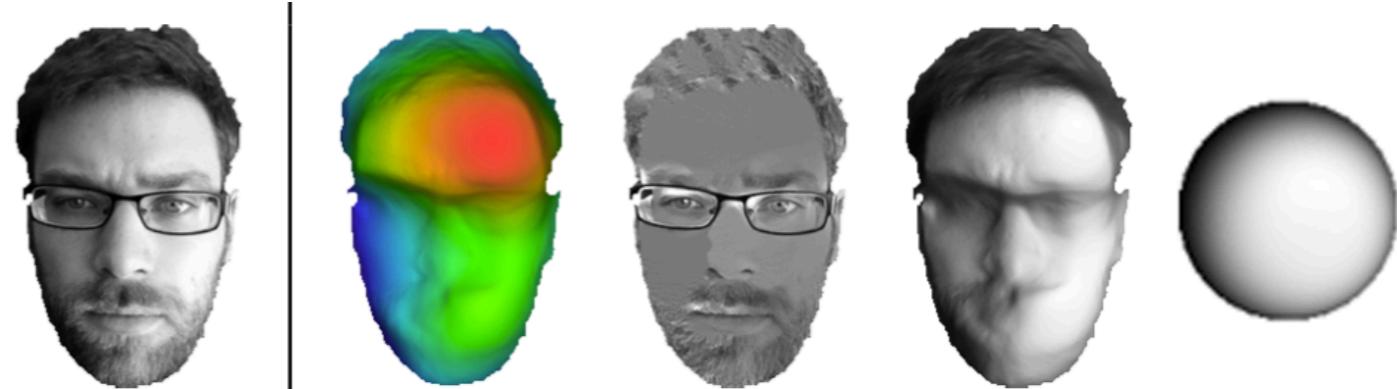
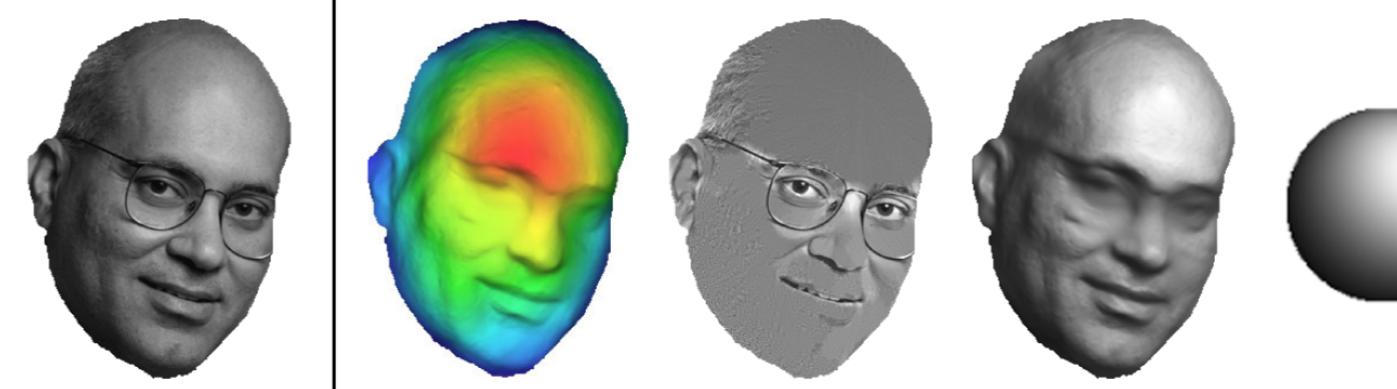


Shape, Albedo, and Illumination from a Single Image of an Unknown Object



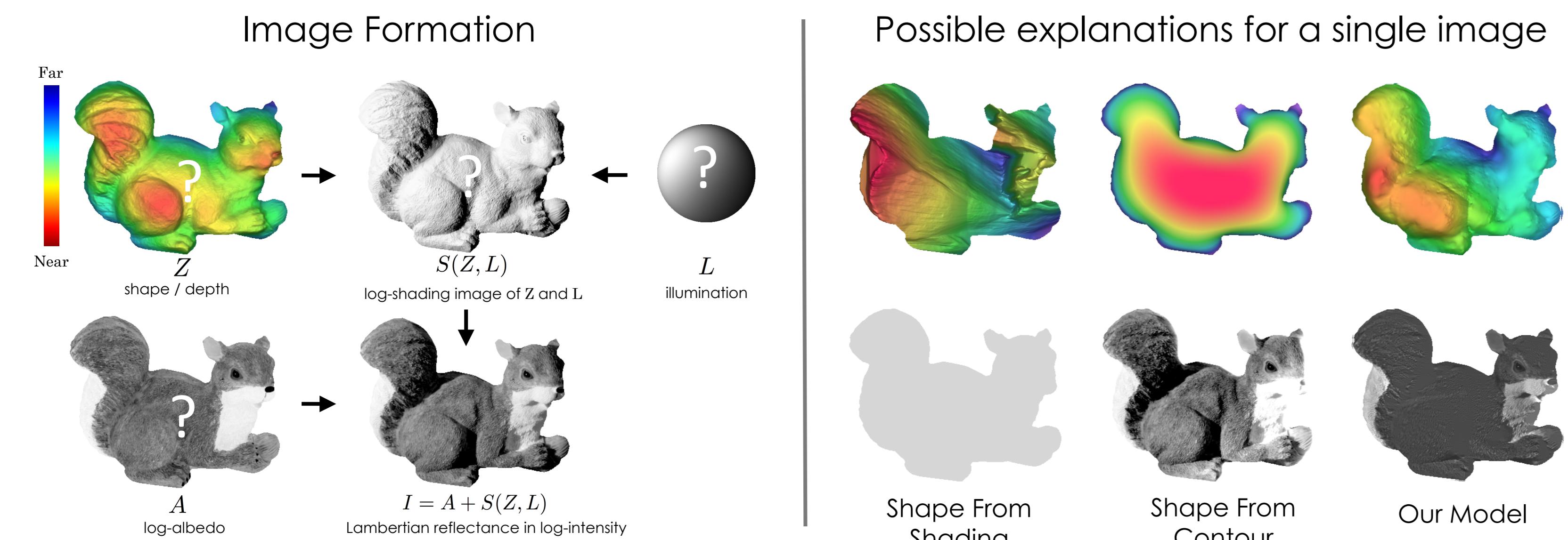
Jonathan T Barron & Jitendra Malik
UC Berkeley



Overview

We present **SAIFS** - "Shape, albedo and illumination from shading". Our model searches for the most likely world (depth map, albedo map, and global illumination) that exactly recreates a single image.

Our model outperforms all previously published "intrinsic images" and "shape from shading" algorithms by a large margin, and produces reasonable output on real-world images of arbitrary objects.



Problem Formulation

$$\underset{Z, A}{\text{maximize}} \quad P(A)P(Z)$$

$$\text{subject to} \quad I = A + S(Z, L)$$

Reduces to a simple optimization problem:

$$\underset{Z}{\text{minimize}} \quad f(Z) + g(I - S(Z, L))$$

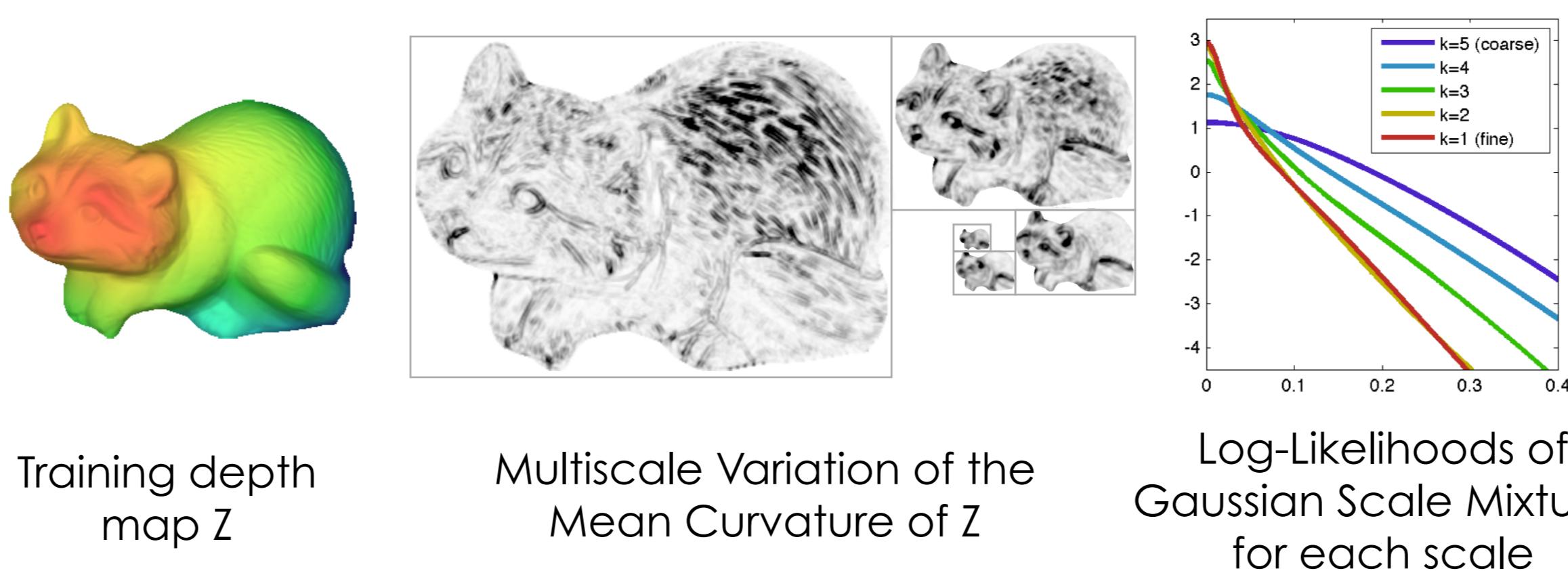
Dealing with unknown illumination requires introducing it as a latent variable:

$$\underset{Z}{\text{minimize}} \quad f(Z) + E_L[g(I - S(Z, L))]$$

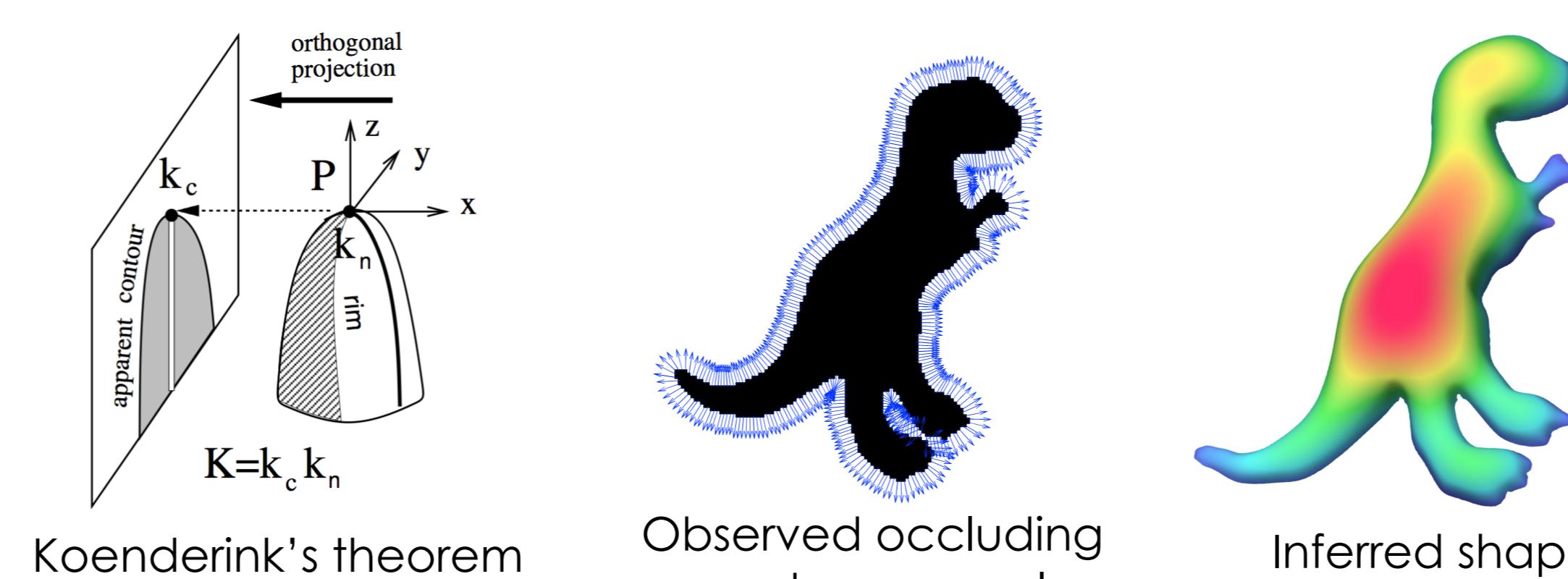
"Maximize the expected complete log-likelihood with respect to a set of possible illuminations"

$P(Z)$: What do we know about Shape?

- 1) Shapes tend to bend infrequently (or, the gradient norm of mean curvature is small and sparse)

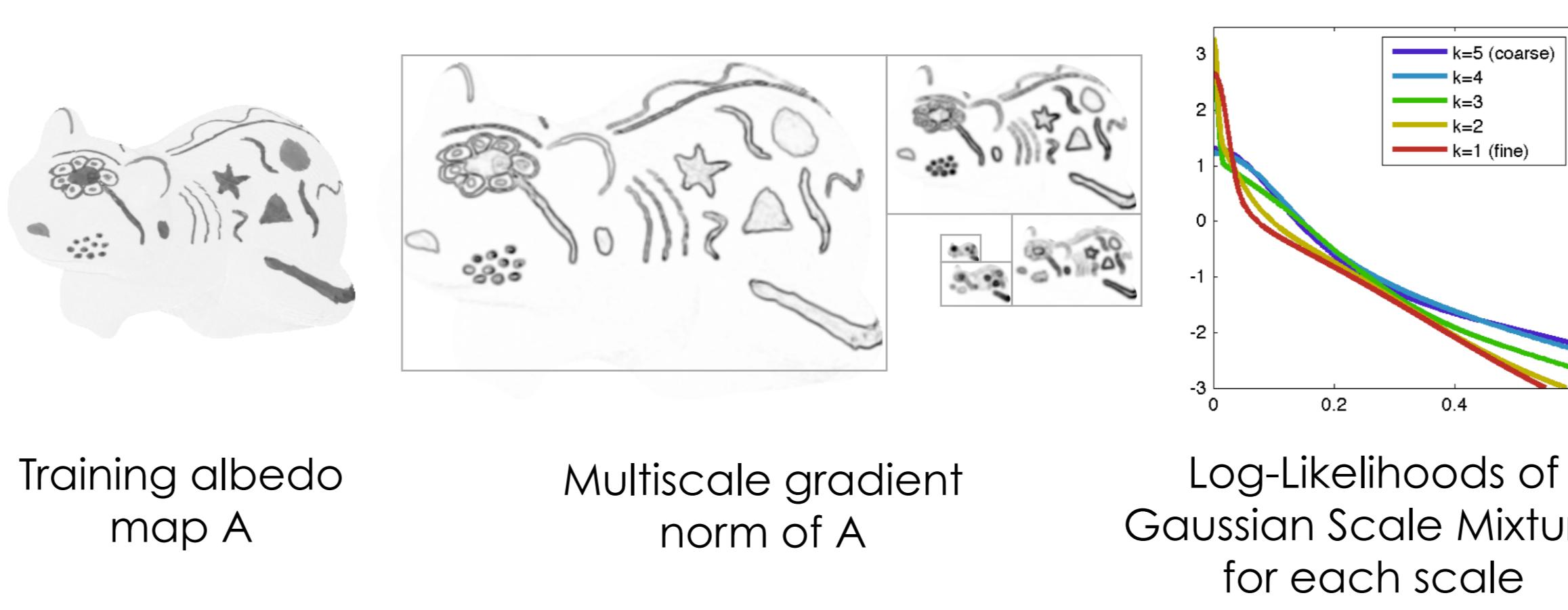


- 2) Shapes tend to face outwards at the occluding contour

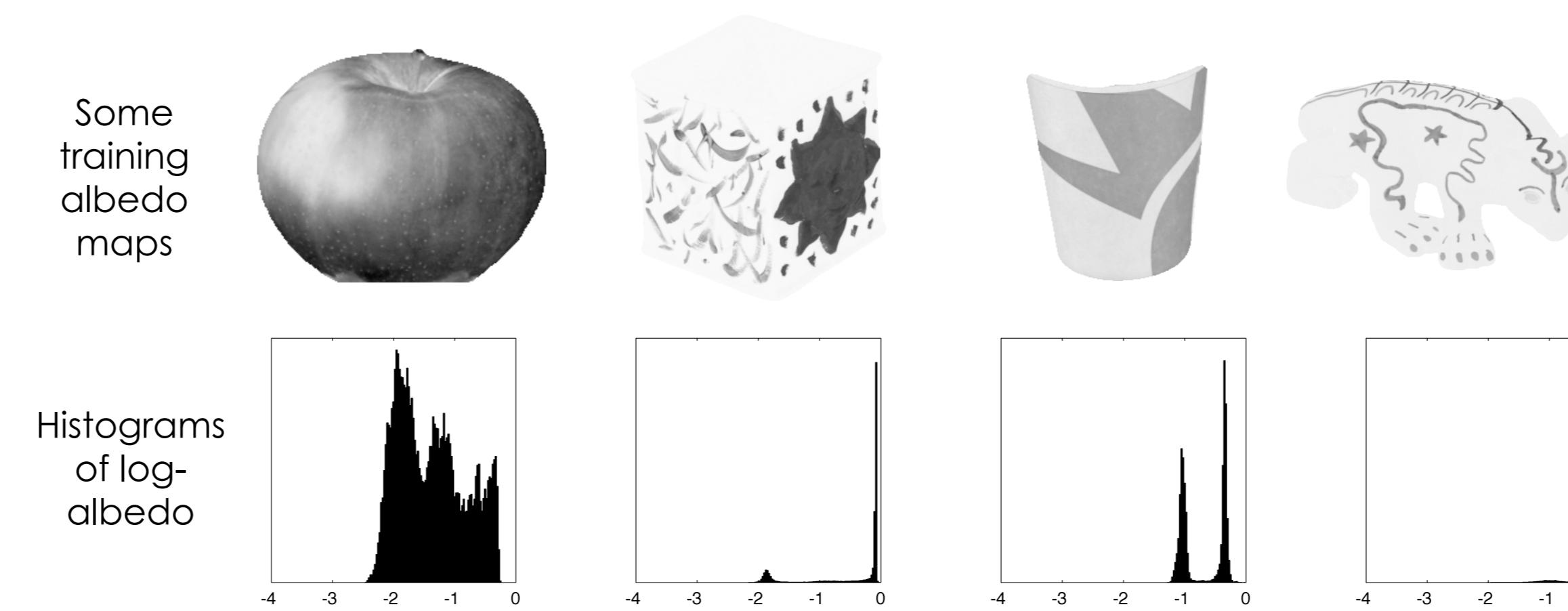


$P(A)$: What do we know about Albedo?

- 1) Albedo tends to change infrequently (or, the gradient norm of log-albedo is small and sparse)



- 2) Albedo tends to take on a few discrete values in an image (or, log-albedo has a low Rényi entropy)



Evaluation

MIT Intrinsic Images Dataset

Algorithm	Known Illumination				
	Z-MAE	I-MSE	LMSE	S-MSE	ρ -MSE
Flat Baseline	25.56	0.1369	0.0385	0.0563	0.0427
Retinex + SFS	82.06	0.1795	0.0289	0.0291	0.2064
Tappen <i>et al.</i> 2005 + SFS	43.30	0.1522	0.0292	0.0343	0.0256
Barron & Malik 2011	21.10	0.0829	0.0584	0.0282	0.0468
J. Shen <i>et al.</i> 2011 + SFS	48.51	0.1629	0.0445	0.0478	0.0450
Our Shape from Contour	21.42	0.0805	0.0350	0.0280	0.0311
Our Model (No $ \nabla A $)	17.50	0.0620	0.0289	0.0188	0.0238
Our Model (No $ \nabla H(Z) $)	21.81	0.1011	0.0341	0.0205	0.0194
Our Model (No Flatness)	35.11	0.0651	0.0190	0.0148	0.0157
Our Model (No Contour)	28.45	0.0811	0.0204	0.0167	0.0189
Our Model (No Albedo Entropy)	21.23	0.0523	0.0196	0.0138	0.0162
Our Model (All Priors)	21.86	0.0521	0.0191	0.0136	0.0156

Algorithm	Unknown Illumination				
	Z-MAE	I-MSE	LMSE	S-MSE	ρ -MSE
Our Model (All Priors)	19.41	0.0577	0.0197	0.0178	0.0193

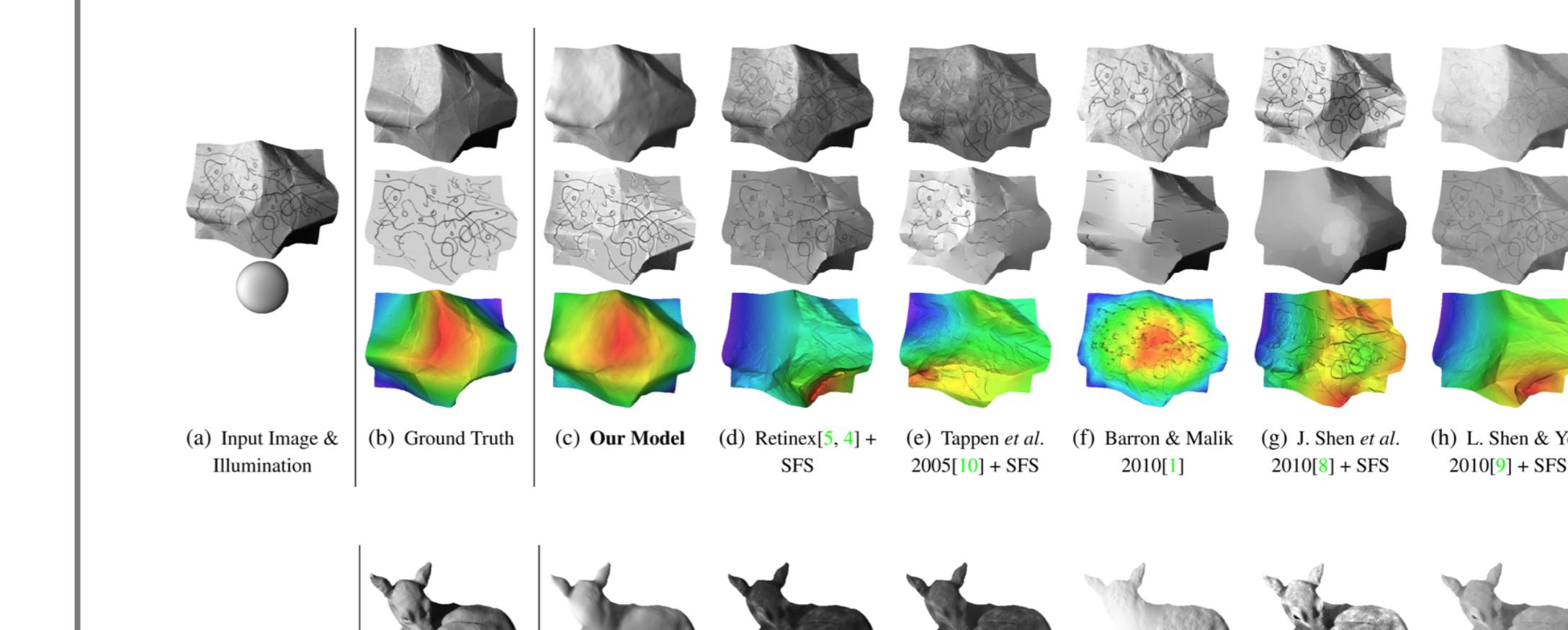


Image Manipulation



Real World Images

(taken from the internet and my iPhone)

