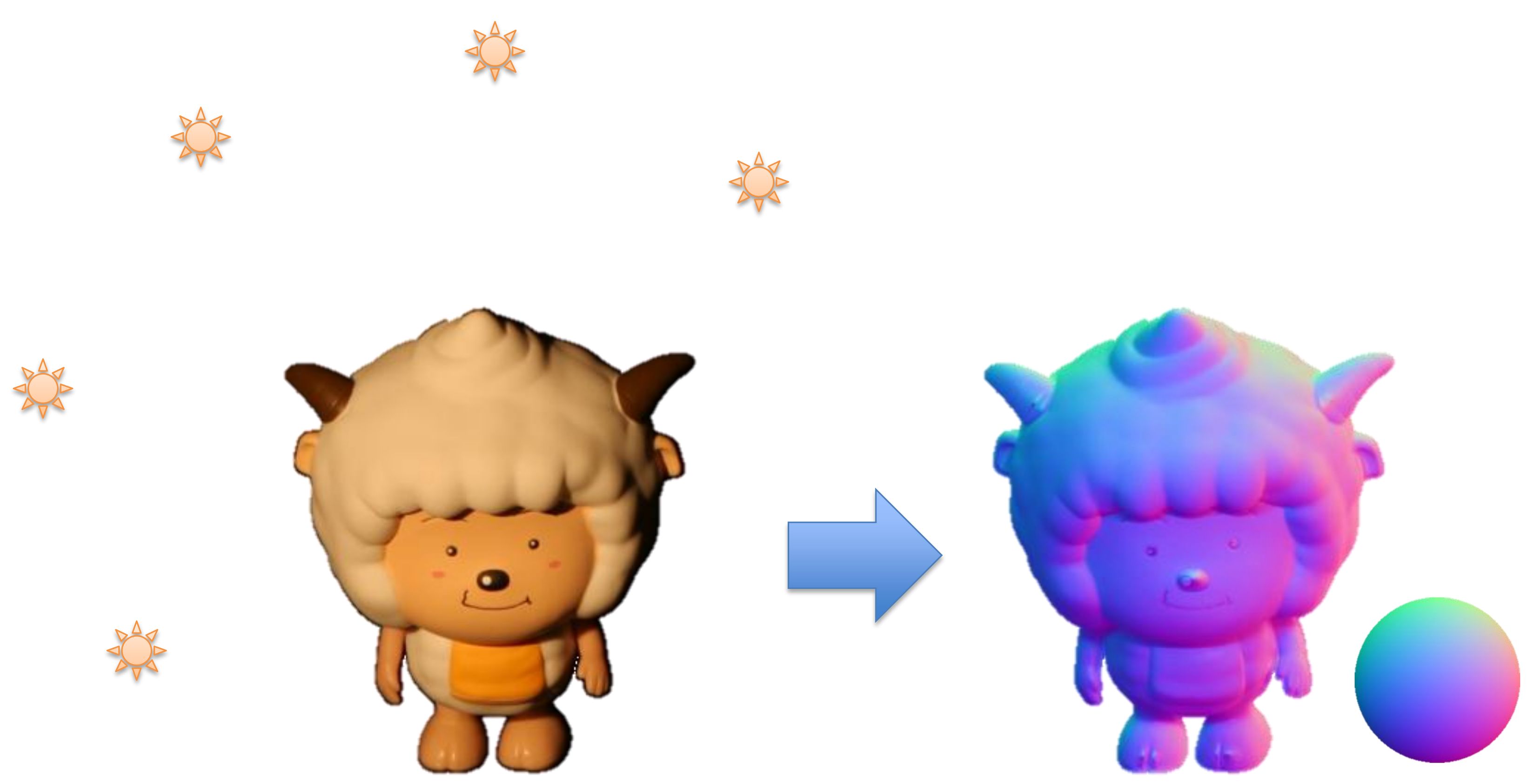
Robust Photometric Stereo via Low-Rank Matrix Completion and Recovery

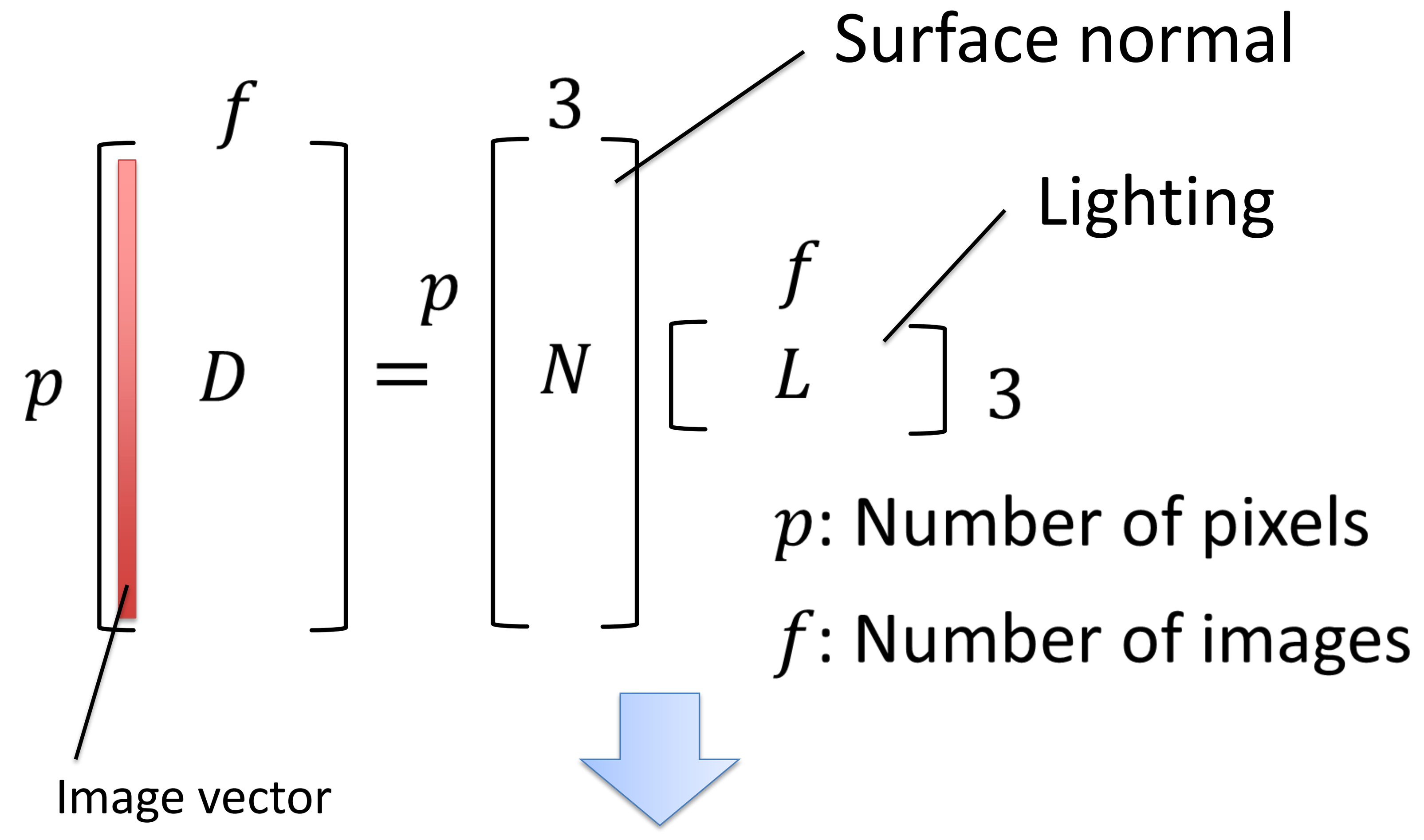
Lun Wu[1], Arvind Ganesh[2], Boxin Shi[3], Yasuyuki Matsushita[4], Yongtian Wang[1], and Yi Ma[2,4]

[1]Beijing Institute of Technology
[2]University of Illinois at Urbana-Champaign
[3]University of Tokyo
[4]Microsoft Research Asia

Photometric stereo

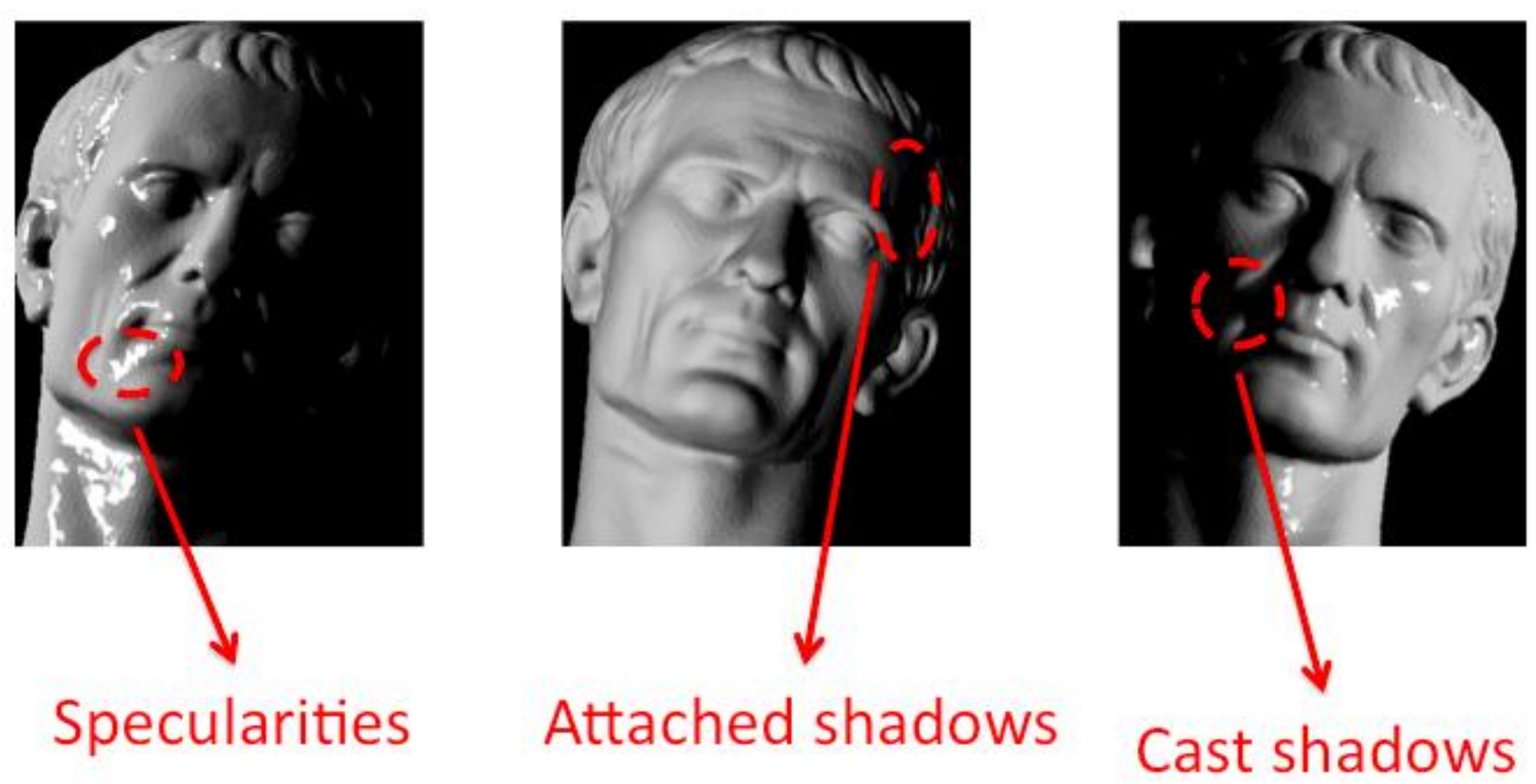


Lambertian photometric stereo



Least squares solution : $N = DL^{\dagger}$

Deviations from Lambertian



Robust Photometric Stereo

$$D = A + E \; (= NL + E)$$

observations — low-rank — sparse

- Rank of A should be at most 3, irrespective to p and f.
- Modeling corruptions as sparse errors E.

Formulation

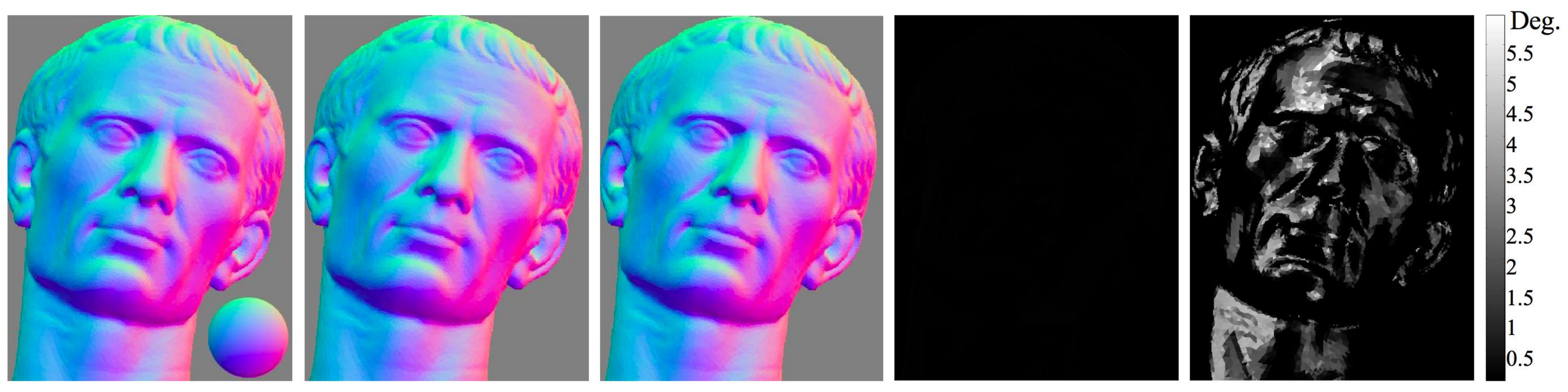
$$\min_{A,E} \operatorname{rank}(A) + \gamma \|E\|_0 \text{ s.t. } D = A + E$$

Solution via convex programming

$$\min_{A,E} \|A\|_* + \gamma \|E\|_1 \text{ s.t. } D = A + E$$

Experiments: Specular Scene

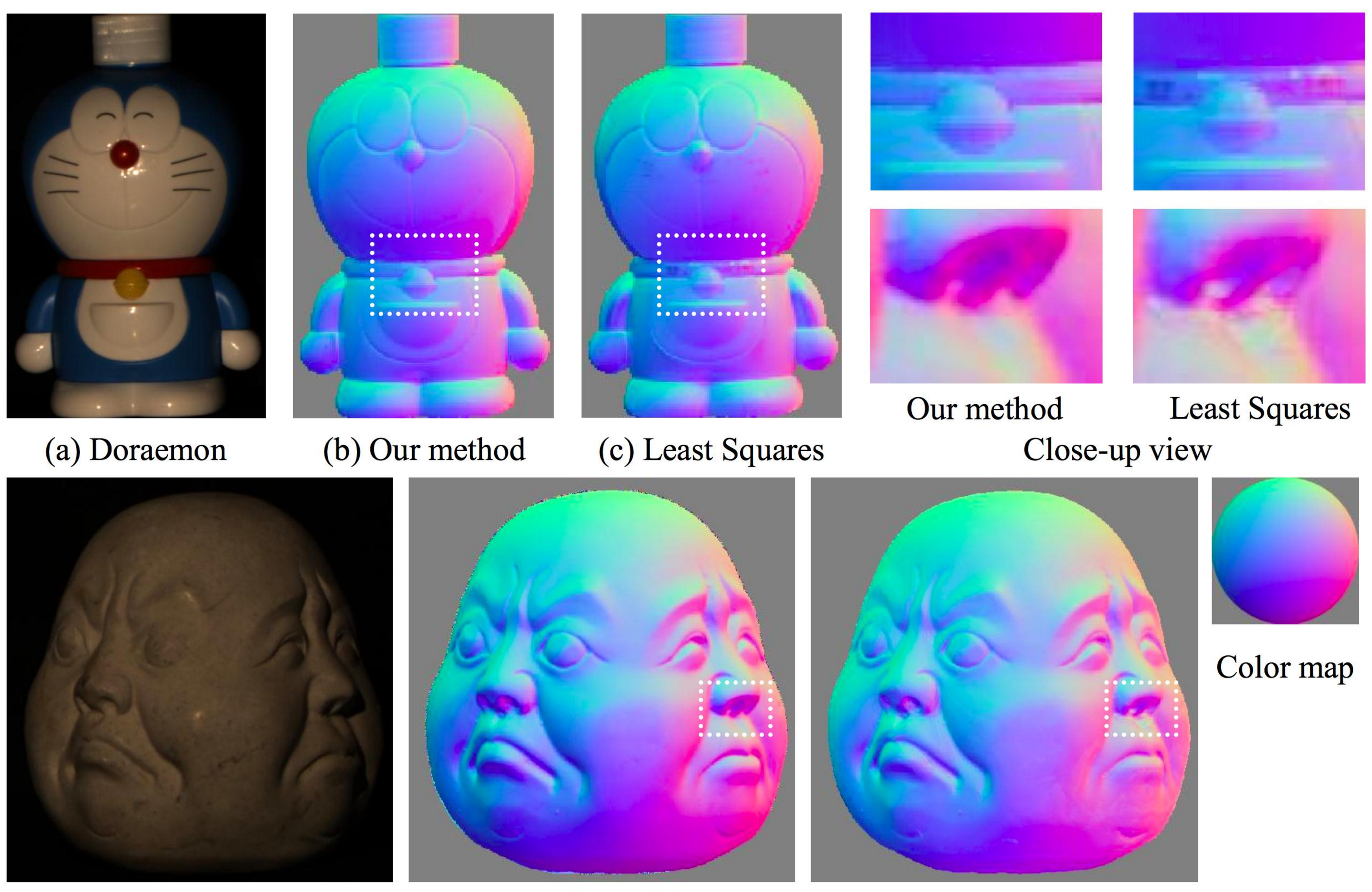
40 input images



(a) Ground truth (b) Our method (c) Least Squares (d) Error map (our method) (e) Error map (LS)

Object	Mean error (in degrees)		Max. error (in degrees)		Avg. % of corrupted pixels	
	LS	Our method	LS	Our method	Shadow	Specularity
Sphere	0.99	$\mathbf{5.1 \times 10^{-3}}$	8.1	**0.20**	18.4	16.1
Caesar	0.96	$\mathbf{1.4 \times 10^{-2}}$	8.0	**0.22**	20.7	13.6
Elephant	0.96	$\mathbf{8.7 \times 10^{-3}}$	8.0	**0.29**	18.1	16.5

Experiments: Real Images



(a) Doraemon (b) Our method (c) Least Squares

(d) Two-face (e) Our method (f) Least Squares