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A non-Lambertian photometric stereo under perspective projection

Key words: Photometric stereo; Three-dimensional reconstruction; Perspective projection; Image decomposition

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Motivation

- The error of surface reflectance and depth reconstruction brought by the complex surface reflectance property is one of the most significant difficulties that prevent photometric stereo from being practical.
- Data-driven methods are robust enough to handle shadows but not applicable for specularities; analytic methods may suffer from expensive computation resources due to the highly nonlinear optimization.
- Physical properties are exploited with sophisticated or specially designed setups, i.e., the light stage or the ring-light.

Main idea

- We present a new approach for separating diffuse and specular components of input images using a coordinate descent method.
- We simultaneously recover the geometry and photometric information.
- We present an effective depth reconstruction algorithm under perspective projection.

Method

- We present a new diffuse-specular separation strategy via a coordinated descent method based on the dichromatic model (Algorithm 1).
- We estimate normal and reflectance by an iterative method and defining “specular confidence.”
- A variational framework is presented to reconstruct surface depth by global optimization.

Major results

- Results of normal estimation (in degrees)

Table 2 MAE of normals for the intermediate results in Fig. 4 with different numbers of iterations

Data	MAE				
	1	2	3	4	5
BUDDHA	10.32	9.41	8.74	8.74	8.74
BEAR	6.51	5.90	5.24	5.10	5.10
POT1	6.74	6.23	6.04	6.04	6.04
POT2	8.11	7.60	7.27	7.27	7.27
READING	14.82	12.31	12.06	11.99	11.99

The bold fonts represent the MAE of final normals

Major results

- Results of shape estimation (in millimeters)

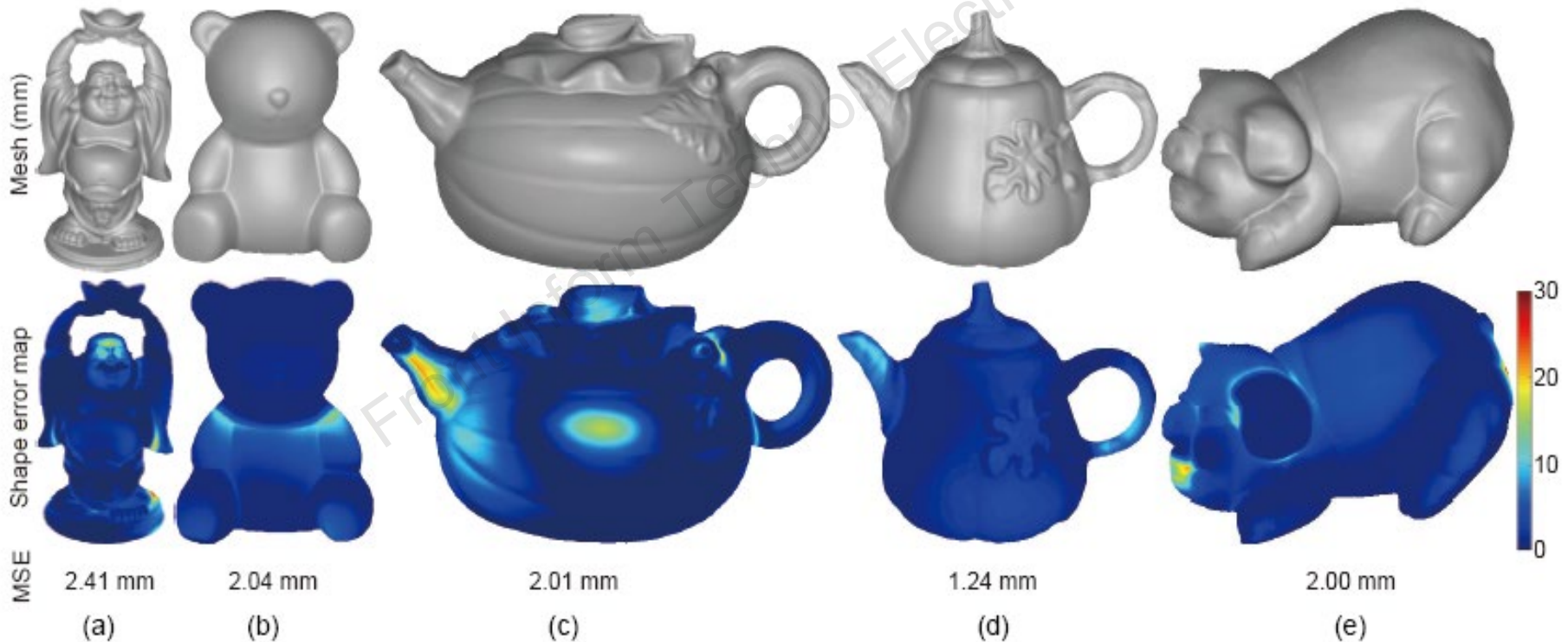


Fig. 9 MSE of BUDDHA (a), BEAR (b), POT1 (c), POT2 (d), and PIG (e)

Conclusions

- We present a new photometric stereo method to capture both surface normal and reflectance of real-world objects.
- Our method is general and works with non-Lambertian BRDFs. The errors of captured surface normal and meshes are comparable to those of the state-of-the-art methods.
- The results prove that our method is effective in extracting specularities from object surfaces, which is quite suitable for a number of applications such as digital preservation of cultural heritage.