Multi-view Photometric Stereo with Spatially Varying Isotropic Materials

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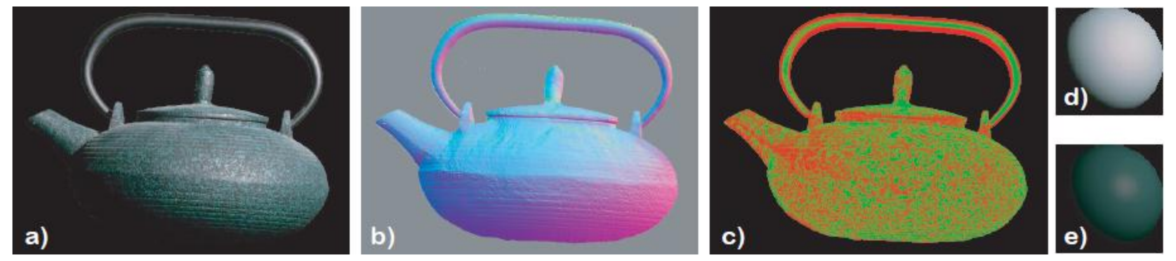
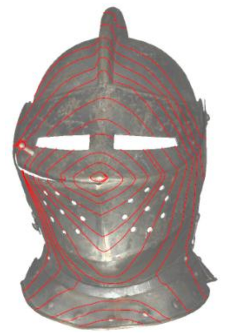
Motivation

Photometric stereo with mixture of Ward's BRDFs [1]



Multi-view photometric stereo [2] with Lambert's BRDF



Iso-depth contours for arbitrary isotropic BRDFs [3].

Features of Our Method

- ❑ *Arbitrary isotropic* materials;
- ❑ Full 360-degree reconstruction of shape and BRDF;
- ❑ Simple & inexpensive capture setup;
- ❑ Simple optimization;
- ❑ High accuracy: shape error ~0.3mm, BRDF error: ~9% relative RMSE, (re-rendered image error ~6-8 intensity levels).

References

[1] D. B. Goldman, B. Curless, A. Hertzmann, and S. M. Seitz. Shape and spatially-varying brdfs from photometric stereo. *ICCV*2005

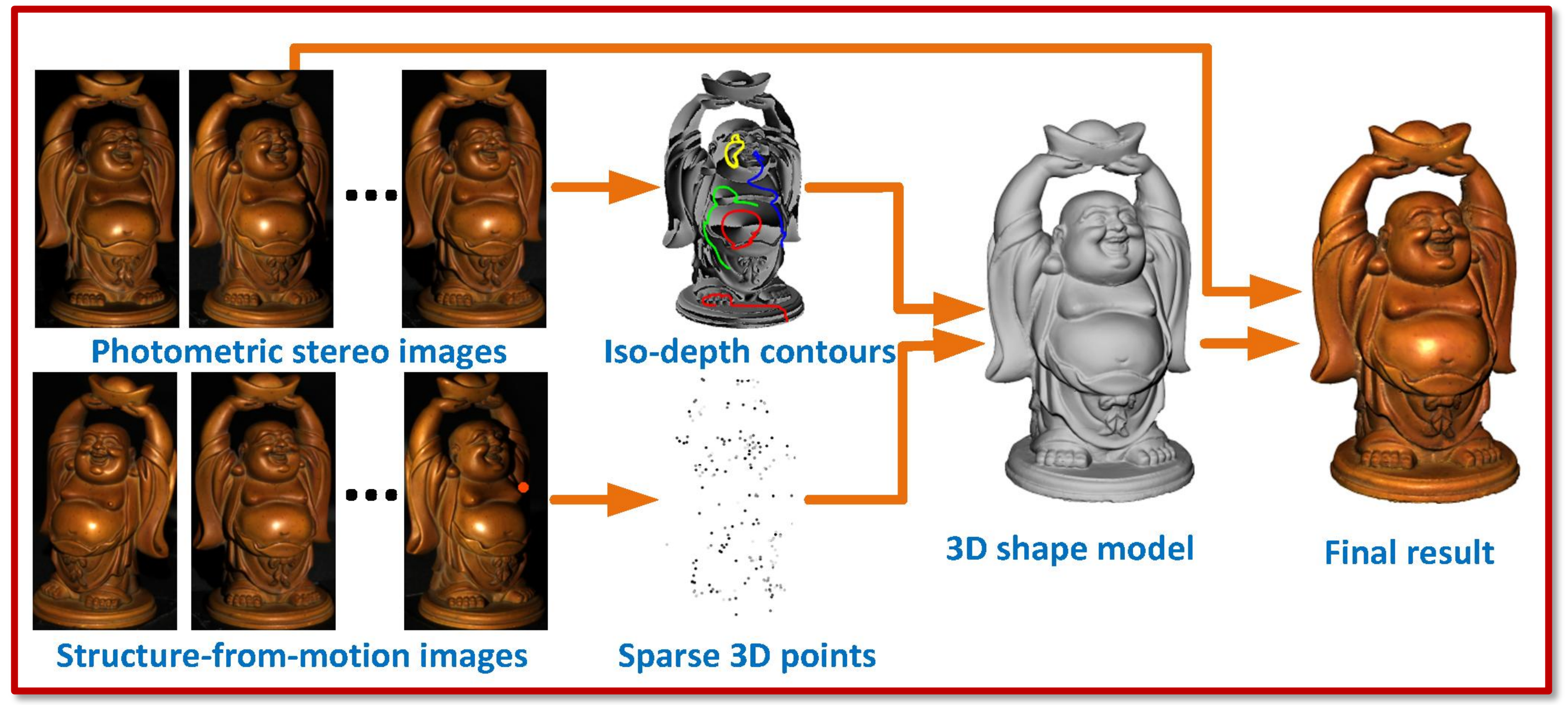
[2] C. Hernandez, G. Vogiatzis, and R. Cipolla. Multiview photometric stereo. *TPAMI* 2008

[3] N. Alldrin and D. Kriegman. Toward reconstructing surfaces with arbitrary isotropic reflectance: a stratified photometric stereo approach. *ICCV*2007

[4] J. Lawrence, A. Ben-Artzi, C. DeCoro, W. Matusik, H. Pfister, R. Ramamoorthi, and S. Rusinkiewtz. Inverse shade trees for non-parametric material representation and editing. *SIGGRAPH*2006

[5] D. Nehab, S. Rusinkiewicz, J. Davis, and R. Ramamoorthi. Efficiently combining positions and normals for precise 3d geometry. *SIGGRAPH*2005

Overview



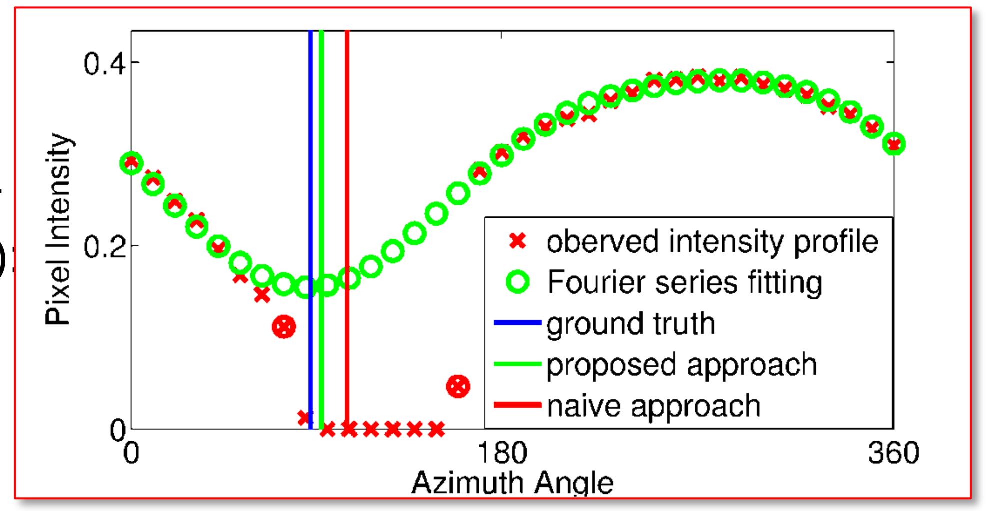
Technical Details

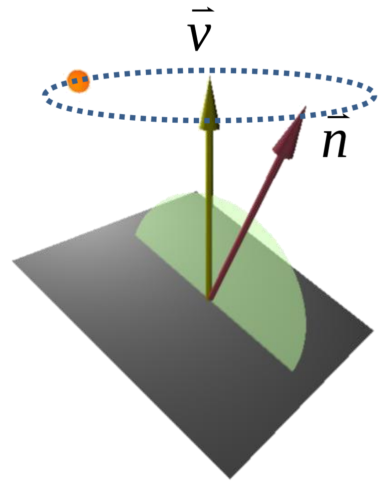
Iso-depth contour estimation

- The symmetry axis of an intensity profile provides the azimuth angle [3];
- An intensity profile can be fit to a truncated Fourier series (to be robust to shadow, inter-reflection, etc)

$$A_0 + \sum_{k=1}^{2} A_k\cos(k\theta) + \sum_{k=1}^{2} B_k\sin(k\theta)$$

- Recover iso-depth contours from azimuth angles.





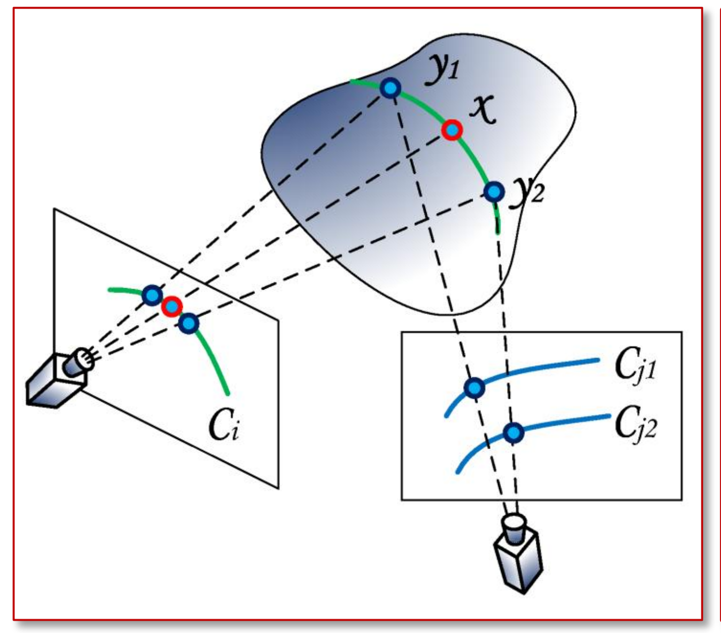
Shape capture

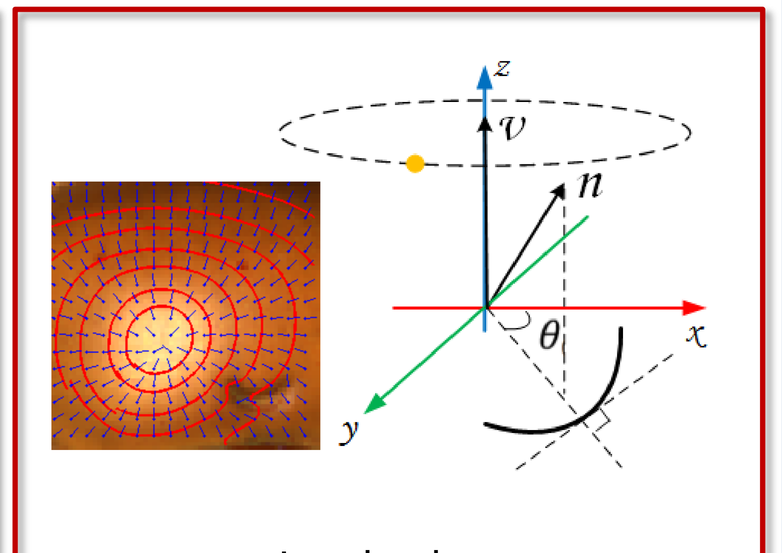
Depth propagation

1. Begin with sparse SfM points.
2. Project a 3D point to one view;
3. Assign its depth to the iso-depth contour passing through its projection to generate new 3D points;
4. Iterate 1-3 with a different 3D point and view.

Shape refinement

Jointly optimize normals and 3D positions[5].





Iso-depth contour

Reflectance capture

Fix the shape, and apply the ACLS algorithm [4] to estimate BRDFs.

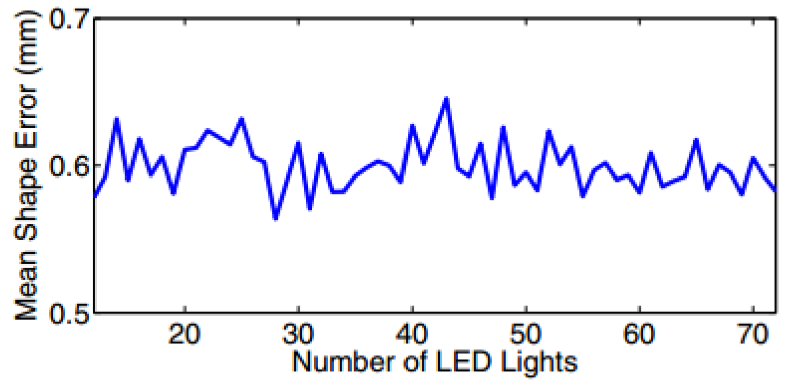
Experiments (more in the paper)

Two Capture systems

Ringlight system

Handheld system

Shape Errors



An input image | Final shape | Shape Error (mm) | Basis BRDFs & weights | A reference photograph | A rendered image

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