Multispectral Photometric Stereo for Spatially-Varying Spectral Reflectances: IPR Course Project

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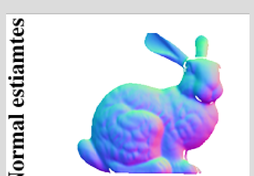
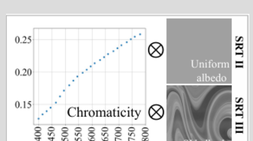
Motivation

- Traditional photometric stereo methods typically involve an assumption of uniform reflectance, which doesn't apply for spatially inhomogeneous materials.
- Reflectance of any material varies very complexly in spectral values across on their surface.
- Multispectral photometric stereo captures both the geometry and spectral properties correctly.

Goal

- Develop a well posed multispectral photometric stereo method that can handle spatially varying spectral reflectances.
- Full reconstruction of both geometry and spectral reflectance without needing prior knowledge of the materials.

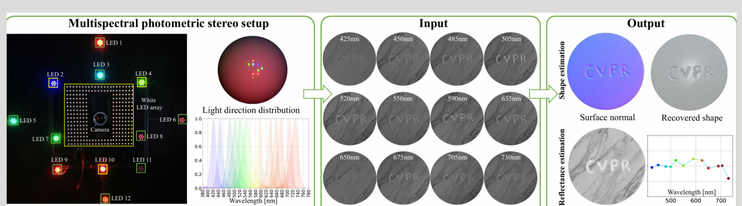




(c) Spectral reflectance

Method

- Proposed a multispectral photometric stereo model with variation in spectral reflectance.
- Uses a combination of lighting and multispectral imaging to capture rich spectral information.
- The approach is divided into three key stages:
  1. Spectral Image Acquisition
  2. Reflectance Modeling
  3. Surface Normal Estimation
- Additional Details:
  - Original Thresholding Method: It uses the SVD approach with a thresholding method to handle noise while also separating signal components. It results in an improvement of the robustness against noise by zeroing out small singular values but loses some spectral details.
  - Improved IRLS Approach: The Iteratively Reweighted Least Squares method improves the estimation by minimizing the impact of outliers. In IRLS, iterative refinement of weights reduces noisy pixels' influence, further improving the estimation of a surface normal and retaining finer details in noisier scenarios.

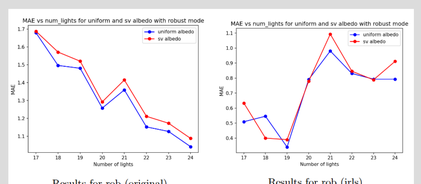


Results

- Surface normals estimated with high accuracy over a range of generated 3D objects.
- Spectral reflectance properties reconstructed with little/no artifacts.

Mode	num_lights	MAE
norm	4	9.91
norm	24	1.98
rob	24	1.08

Mode	num_lights	MAE
rob (original)	24	1.08
rob (irls)	24	0.91



Conclusion and Future Work

- Our method is designed so that it provides a solid foundation for multispectral photometric stereo with spatially-varying reflectances.
- Future work includes extending the model to dynamic scenes and real-time applications.