# A database of polarimetric and multispectral images in the visible and NIR regions

PIERRE-JEAN LAPRAY, LUC GENDRE, ALBAN FOULONNEAU, AND LAURENT BIGUÉ
IRIMAS, UNIVERSITÉ DE HAUTE-ALSACE, MULHOUSE, FRANCE

## INTRODUCTION

Multi-band polarization imaging, by mean of analyzing spectral and polarimetric data simultaneously, is a good way to improve the the information recovered from a scene.

This work presents a database of polarimetric and multispectral images that combine visible and near-infrared (NIR) information. An experimental setup is built around a dual-sensor camera.

## CONTRIBUTIONS

1. **A practical imaging pipeline**, including a calibration procedure, for recovering spatial, spectral and polarimetric data from a set of photographs,
2. **A database of multispectral and polarimetric images** of various materials in the visible and near- infrared part of the spectrum.

## EXPERIMENTAL SETUP

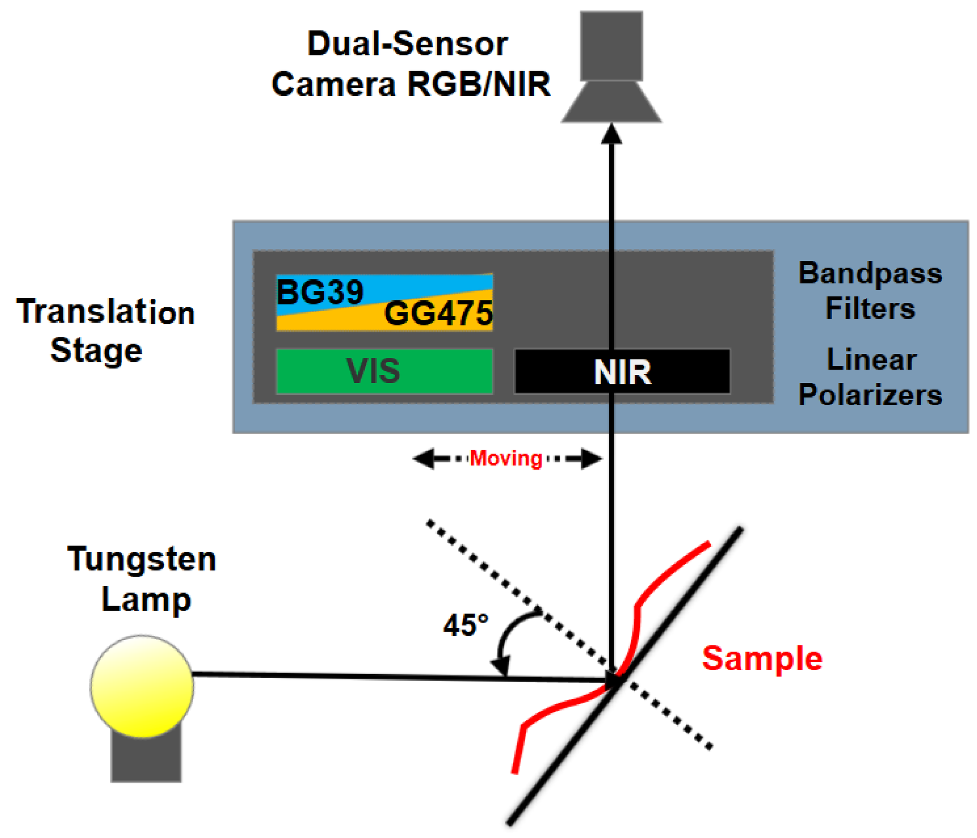



**Figure 1:** Experimental setup and optical path.

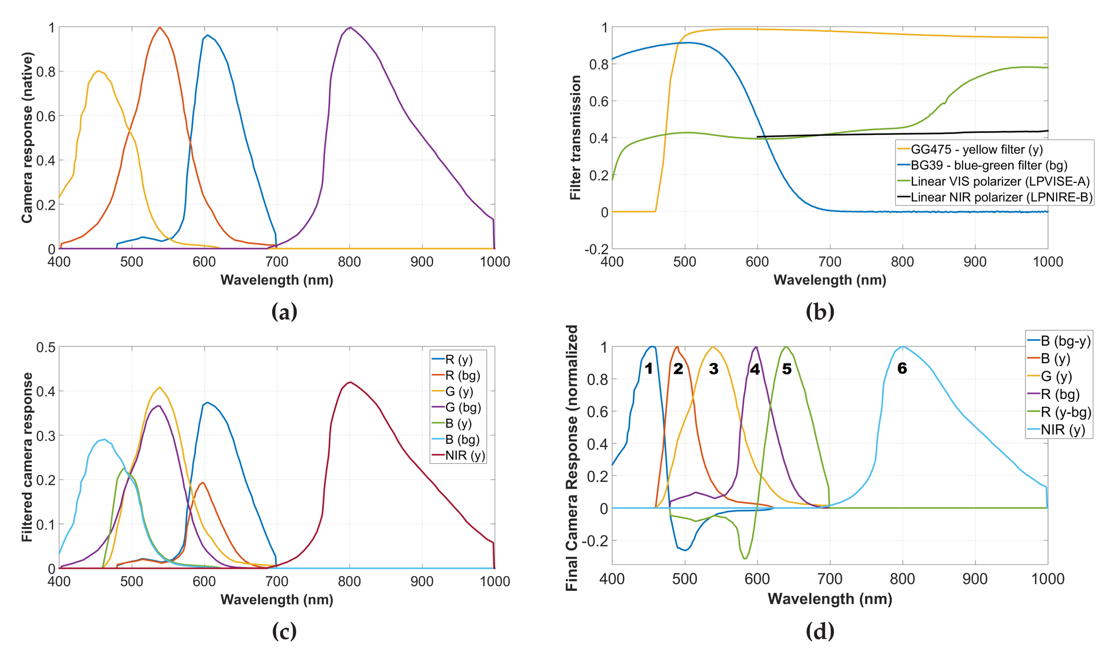
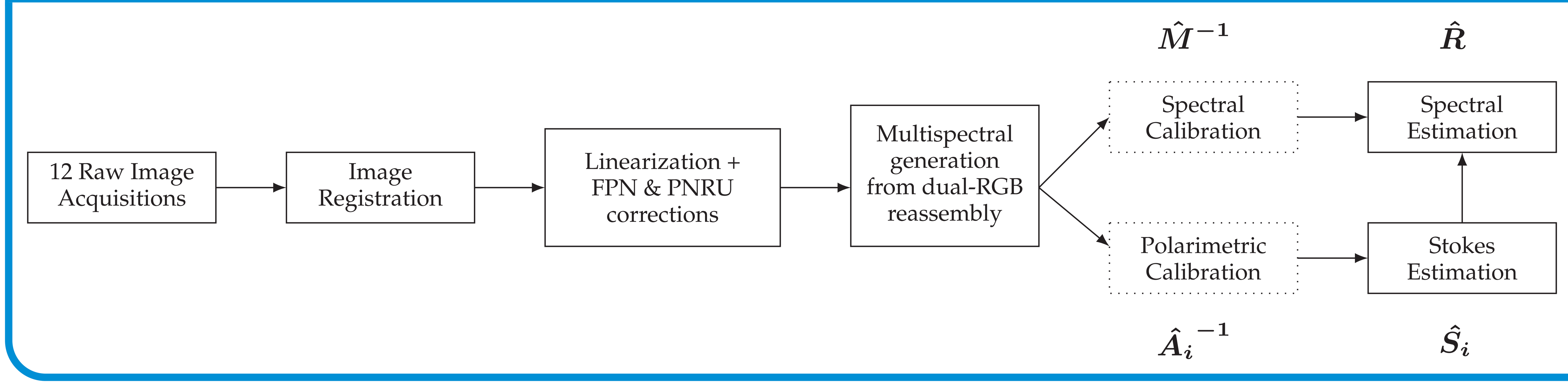


**Figure 2:** (a) RGB/NIR camera sensitivities. (b) Transmittance of the bandpass filters. (c) RGB reassembly using blue-green (bg) and yellow (y) filters. (d) Final camera responses.

- The spectral signature is recovered using an RGB/NIR camera plus a couple of bandpass filters. Multispectral images are constructed from the dual-RGB method [1].
- The polarimetric feature is achieved using rotating linear polarization filters in front of the camera at four different angles (0, 45, 90 and 135 degrees).

## IMAGING PIPELINE




## DATABASE

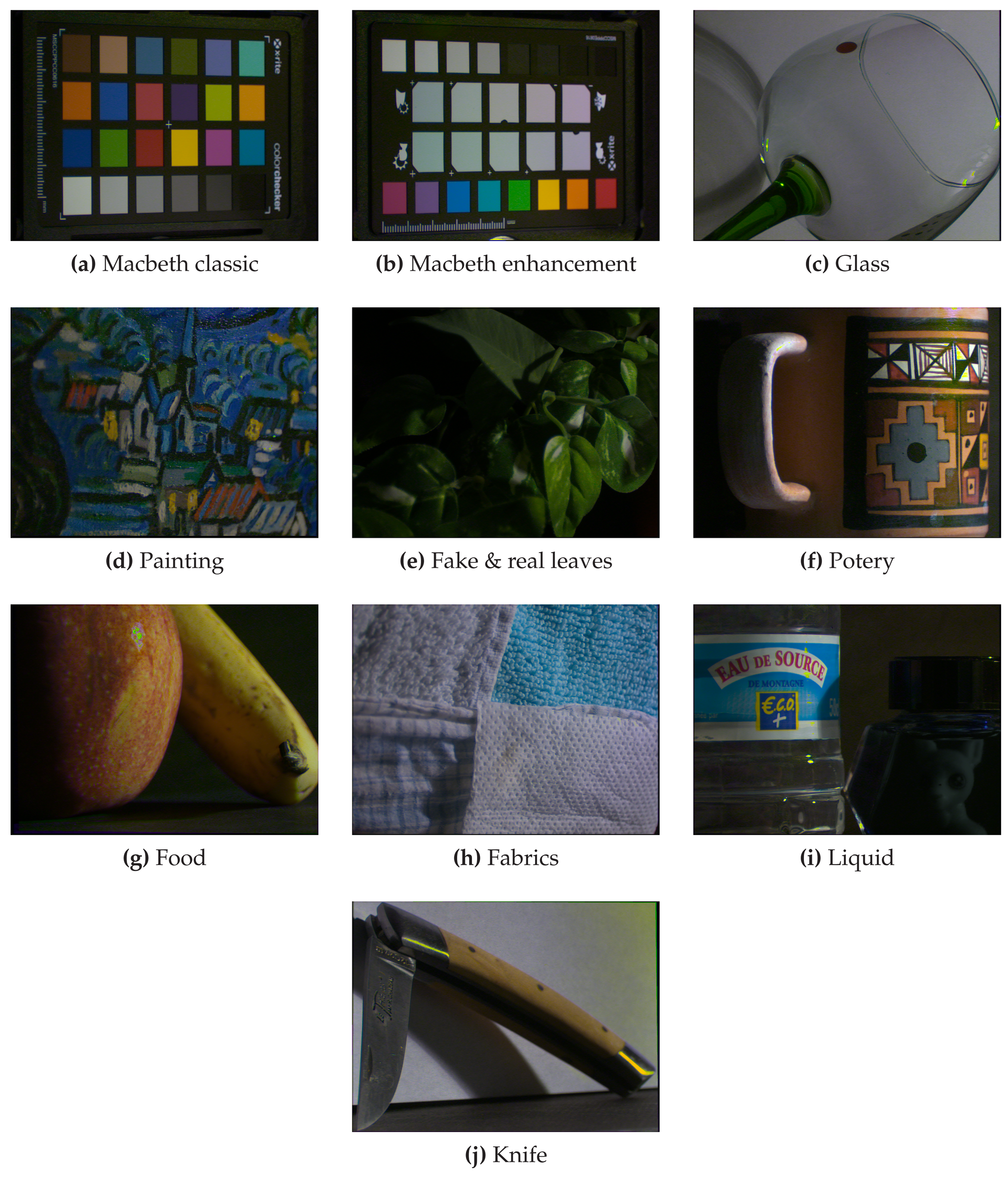



**Figure 3:** sRGB visualization of the scenes. sRGB are reconstructed from a linear transform of the 6-band multispectral images after polarization component removing.


**Figure 4:** Simple RGB visualizations without any spectral and polarization processing.

## FUTURE DIRECTIONS

1. **Improve pipeline and SNR using high dynamic range technique (HDR)**, and evaluate benefits of such technique on polarimetric and spectral estimations,
2. **Unify the polarimetric and spectral models using the dichromatic model**, to get better understanding of spectral and polarimetric behaviors of specular and diffuse components,
3. **Data correlation analysis**: could be investigated for spectral and polarization correlations among different materials.

## LINKS

The database and source code in Matlab are available at:

https://github.com/pjlapray

## RESULTS

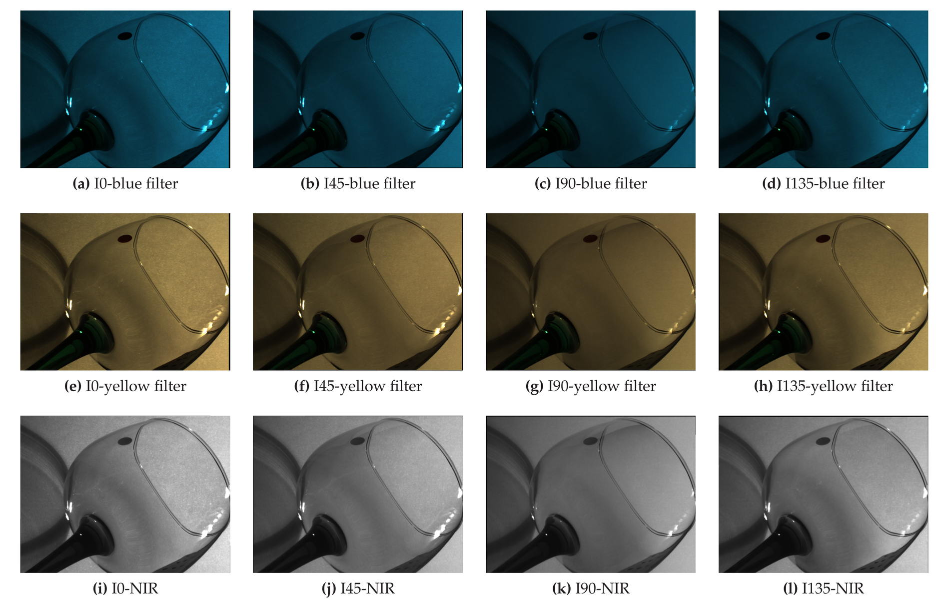


**Figure 5:** 12 raw images for the "Glass" scene after registration.

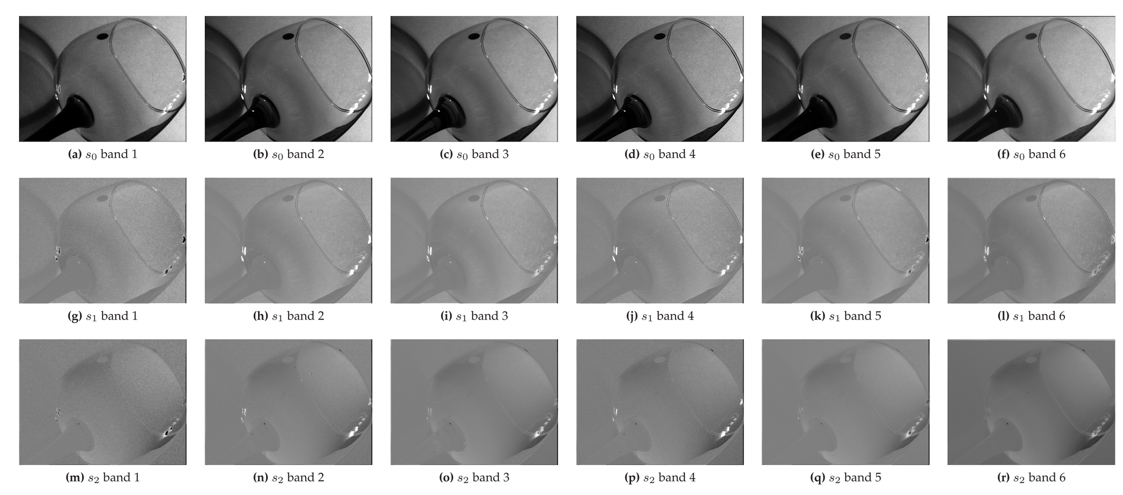


**Figure 6:** 6-band linear Stokes images $s_0$, $s_1$ and $s_2$.

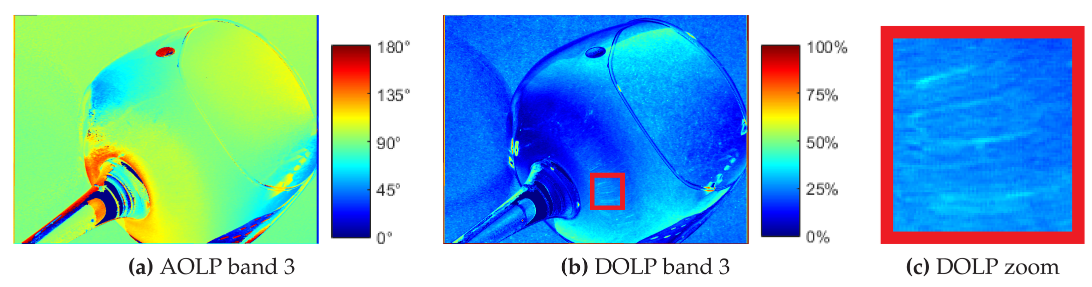



**Figure 7:** Glass scene: (a)-(b) Visualization of Angle and Degree Of Linear Polarization for band 3. (c) Potential defect detection application.

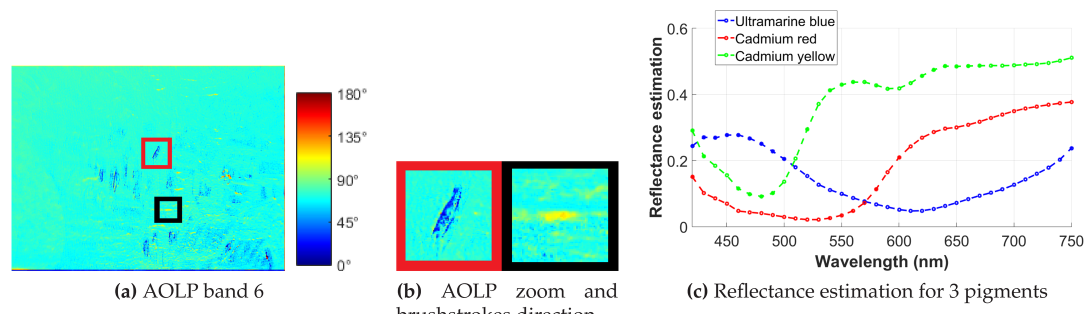



**Figure 8:** Painting scene: (a) Visualization of Angle Of Linear Polarization for band 3. (b) Angle of polarization reveals brushstrokes direction. (c) Shapes of spectral reflectance for 3 pigments used in the painting.

Identified drawbacks:

- Training for spectral reflectance reconstruction is done using the Xrite ColorChecker. But reflectance estimation highly depends on the training dataset.
- There is an energy balance disparity among all channels (see Figure 2d). Thus, all spectral bands don't share the same noise level for a single shot.

## REFERENCE

[1] R. S. Berns, L. A. Taplin, M. Nezamabadi, Y. Zhao, and M. Mohammadi. Practical spectral imaging using a color-filter array digital camera. *Studies in Conservation*, 2006.