Multispectral Image Capture Using Two RGB Cameras

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Abstract: The development of faster and more cost effective acquisition systems is very important for the widespread use of multispectral imaging. This paper studies the feasibility of using two commercially available RGB cameras, each equipped with an optical filter, as a six channel multispectral image capture system. The main idea is to pick the best pair of filters from among readily available filters that modifies the sensitivities of the two cameras in such a way that the spectral reonstruction would be optimal. Simulations with a reasonably large number of available filters show encouraging result, clearly indicating the feasibility of using such systems.

Simulation Setup:

* ***Cameras***: The spectral sensitivities of commercial SLR cameras: Nikon D70, and Canon 20D (Fig. 1). Camera simulation model with 2% random Gaussian noise and 12-bit quantization noise.
* ***Filters***: 265 optical filters of three different types:exciter, dichroic, and emitter from Omega.
* ***Test Targets***: The Gretag Macbeth Color Checker DC as the training target and the classic Macbeth Color Checker as the test target.

Filter Selection: Two filters that produce minimum reconstruction error spectrally or colorimetrically are selected through an exhaustive search algorithm. In order to reduce the computational complexity, infeasible filter pairs are excluded based on some secondary criteria.

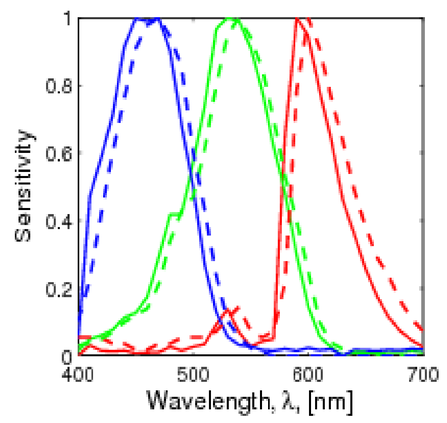


Fig.1 Camera Sensitivities of
Nikon D70 (solid) and Canon 20D (dotted)

Evaluation: The reconstructed reflectances are obtained from different spectral reconstruction methods, and the system is evaluated using spectral as well as colorimetric metrics.

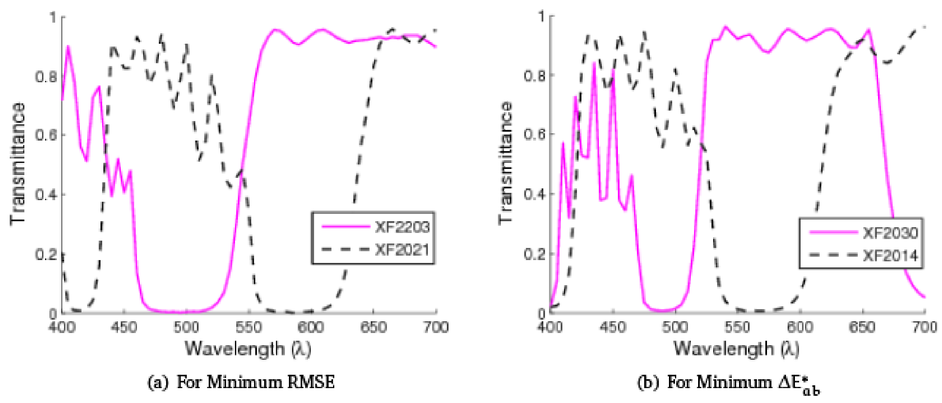
Results: Different optimal filter combinations are picked for different camera sensitivities and for different selection criteria. As an example, results for a pair of Nikon D70 cameras are given in Tables 1 and 2. Fig. 2 shows the filters selected in these two cases, and Fig. 3 the resulting channel sensitivities. All the estimation methods show that the proposed six channel multispectral system outperforms the 3 channel RGB systems in all cases of camera combinations (see paper for complete results).

Table 1: Estimation errors (3-channel system: Nikon D70)

Method	RMS%		ΔE^*_{ab}	
	Max	Mean	Max	Mean
Maloney and Wandell	9.92	3.35	6.15	1.95
Imai and Berns	10.51	3.30	8.82	2.49
Wiener	10.96	3.22	5.70	1.90

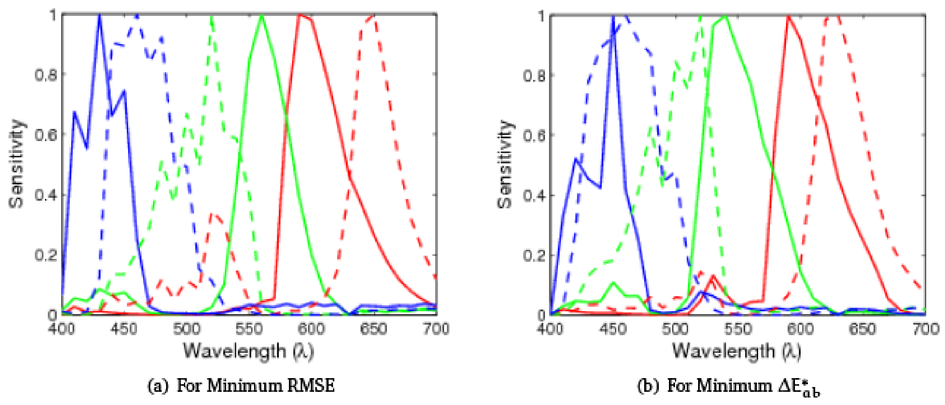
Table 2: Estimation errors (6-channel system: Two Nikon D70)

Method	For min. RMS				For min. ΔE^*_{ab}			
	RMS%		ΔE^*_{ab}		RMS%		ΔE^*_{ab}	
	Max	Mean	Max	Mean	Max	Mean	Max	Mean
Maloney & Wandell	2.34	1.08	1.06	0.41	2.55	1.13	1.22	0.37
Imai & Berns	2.45	1.08	1.18	0.43	2.70	1.14	1.35	0.41
Wiener	2.53	1.07	1.60	0.52	2.70	1.13	1.21	0.37



(a) For Minimum RMSE (b) For Minimum ΔE^*_{ab}

Fig. 2 Selected Filters



(a) For Minimum RMSE (b) For Minimum ΔE^*_{ab}

Fig. 3 Multispectral 6-channel sensitivities (Two Nikon 70D)

Conclusion: Two commercially available RGB cameras with the proper selection of a filter pair can be a practical and cheaper solution for fast multispectral image capture. By setting up the two cameras in a stereoscopic configuration, the problem of aligning the images from two cameras can be solved through stereo matching.

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