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Investigation of impacting factors on camera calibration for spectral sensitivity estimation

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1 | BACKGROUND

Background

- The camera spectral sensitivity plays an fundamental role in image processing and color reproduction.
- The acquisition of the camera spectral sensitivity is a hot issue.

Background

- Traditional method: measure it with monochromator.
- Algebraic method: estimate it according to image response formation model.

Background

- The simplest image response formation model:

$$r^{(k)} = g \int_{\Omega} L(\lambda) S^{(k)}(\lambda) d\lambda$$

- Combine three channels and in matrix form:

$$\boldsymbol{r} = g\Delta\lambda \cdot \boldsymbol{L} \cdot \boldsymbol{S}^{\mathrm{T}}$$

$\boldsymbol{r}$: $N \times 3$; $\boldsymbol{L}$: $N \times m$; $\boldsymbol{S}^{\mathrm{T}}$: $m \times 3$

Background

- Goal: find the spectral sensitivity $\boldsymbol{S}$ to minimize the cost function

$$\mathcal{F} = \frac{\sum_{i=1}^{N} \Delta E_{00}(\rho_i, \hat{\rho}_i)}{N} + \max_i \{\Delta E_{00}(\rho_i, \hat{\rho}_i)\}$$

- The colorimetric characterization was performed using the root polynomial color correction (RPCC) regression.*

* Finlayson, *et al*. *Color Correction Using Root-Polynomial Regression*

2 | SAMPLE SELETION

Sample Selection

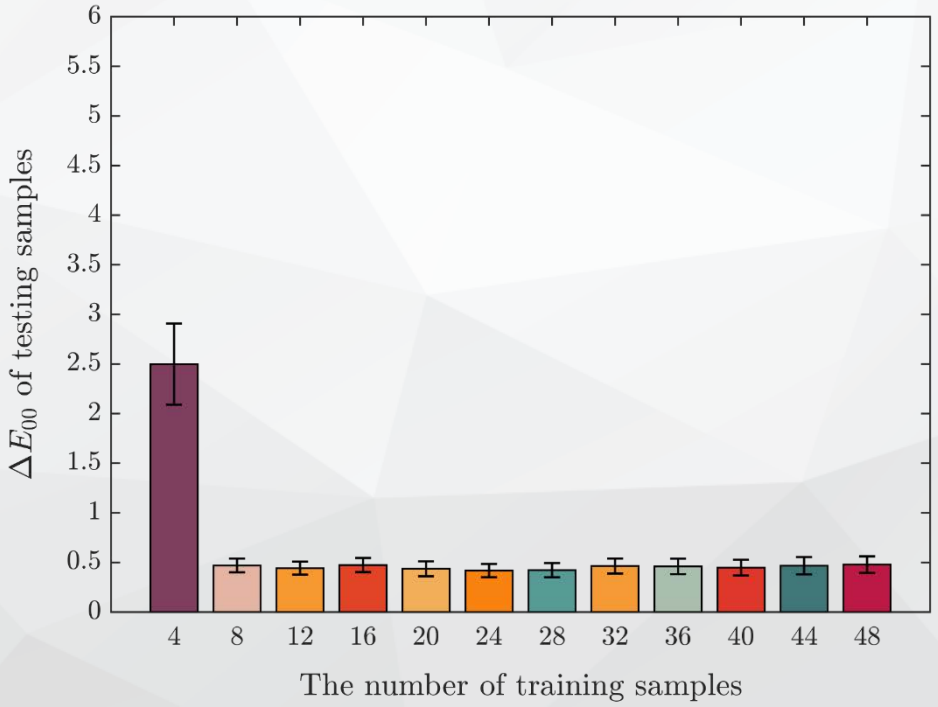
- Total 96 color patches in ColorChecker DSG.
- Illuminated by D65.
- Leave-one-out cross-validation (LOOCV).

Sample Selection

- 95 patches for training, remaining 1 patch for testing. (not the final training and testing phase)
- Repeat this operation for every patch.
- Rank (the better testing result, the more generalized that spectrum is)

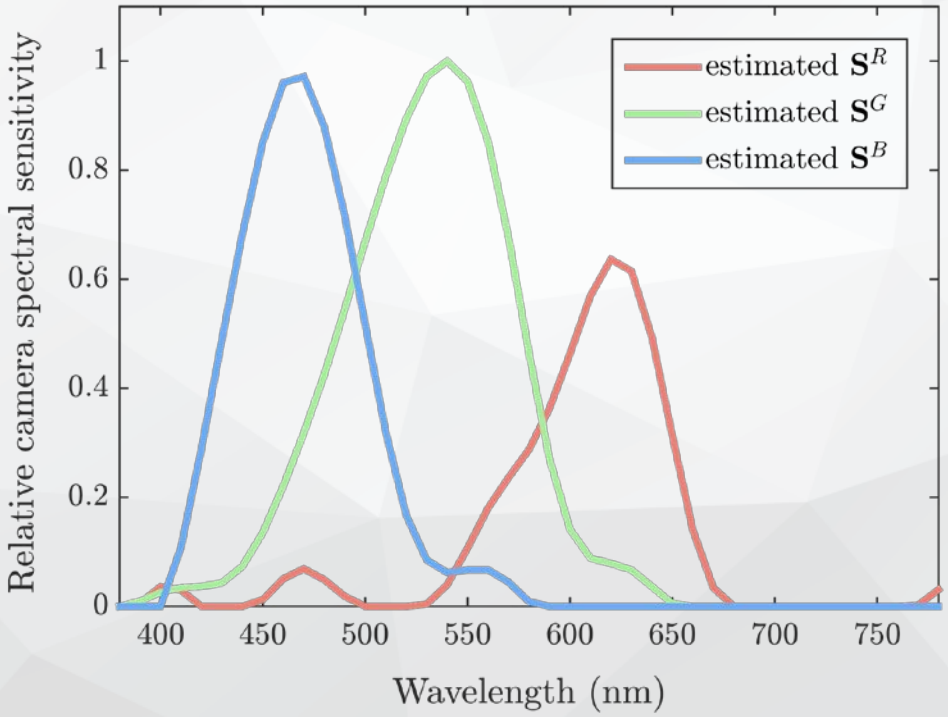
Sample Selection

- Using best 4, 8, 12,…,48 patches as training samples, to test the prediction accuracy on the remaining patches:



Sample Selection

- The estimated camera spectral sensitivity for D3x, using the optimal 16 training samples under D65:



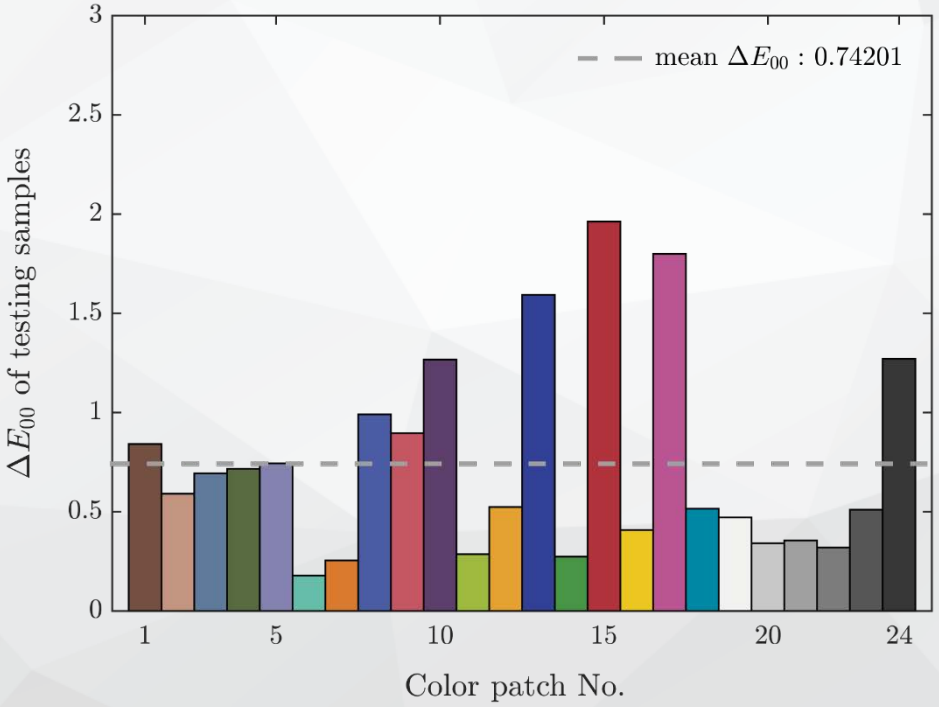
3 | ILLUMINANT SELECTION

Illuminant Selection

- Investigate how the spectral radiances of training samples would influence the performance of the spectral characterization.
- Cross-illuminant validation: a) D65 as training, A as testing; b) A as training, D65 as testing

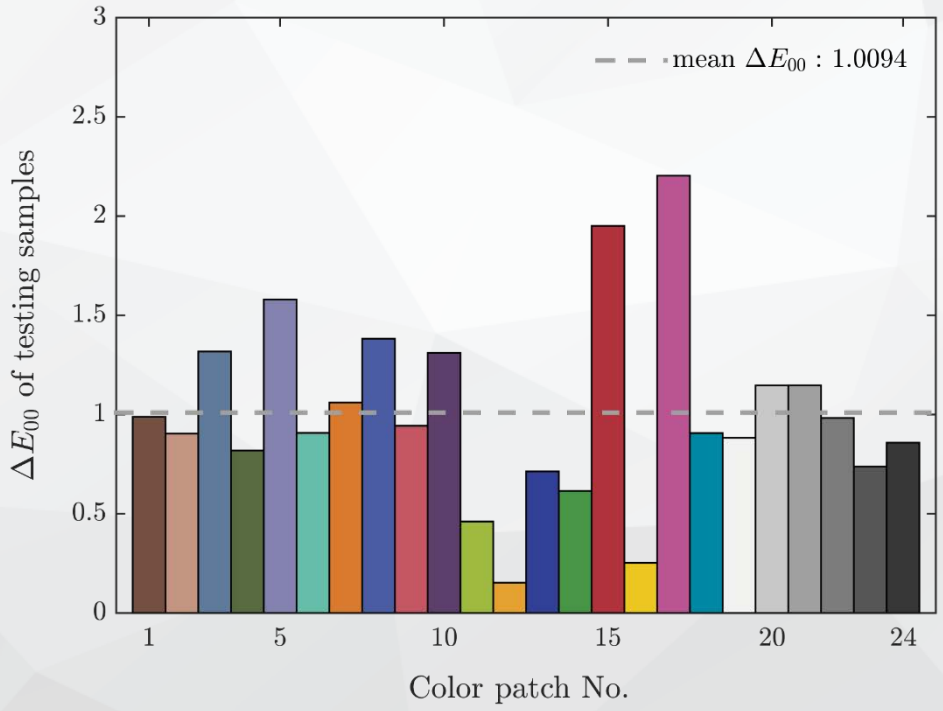
Illuminant Selection

- a) Using D65 as training illuminant, A as testing illuminant:



Illuminant Selection

- b) Using A as training illuminant, D65 as testing illuminant:



4 | CONCLUSION

Conclusion

- The selections of the training color samples as well as the illuminant are the critical factors for a reliable and accurate camera characterization.
- High-fidelity color reproduction could be achieved using less than 10 training samples.
- The SPD of the illuminant should be as flat as possible over the visible spectrum.

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Thanks for your attention!