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A New Transmission Target for Cultural Heritage Imaging

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Abstract

The accurate digitization of film using high-resolution digital cameras, especially historic positive and negative film, presents a difficult challenge for cultural-heritage imaging. Approaches used for reflecting materials—e.g., profiling using color targets—are difficult to apply to transparent materials due to a paucity of film-specific targets, measurement challenges of small patch sizes, and the inadequacy of these targets for historical films and negatives. Research was carried out to design, construct, and verify a new transmission target. Simulation was used to select 80 filters, optimized from a 476-filter set of absorption filters with criteria including colorimetric performance for the 80 filters and four validation spectral datasets, color gamut, and spectral diversity. A prototype target was constructed, measured, and imaged. All criteria were met. Future research will refine the target and validate its performance using independent targets and color-challenging photographs.

Introduction

Color accuracy in cultural-heritage digitization continues to be a challenge. The imaging of reflective materials, although still not perfect, has been well addressed using profiling targets and software, usually resulting in a multi-dimensional look-up table (MLUT) that transforms non-linear camera signals to CIELAB. In principle, the process can be applied to the imaging of transmissive materials, but currently available targets are limited to Fujichrome and Ektachrome. There are two primary issues with these and similar targets. First, measuring these small patch sizes, particularly 35mm, is difficult and expensive. Second, different film types have different spectral characteristics. As a result, a profile for one film type may not be effective for a different film type. When imaging historical materials, targets do not exist. This is also true for negative film. The goal of this research was to design a transmissive target that address these issues.

Filter Selection

Absorption filter materials are gel or glass. Any target using glass filters would be cost prohibitive. Accordingly, Rosco [1] and Lee [2] gel filters were used as candidate target filters, 476 in total. Their spectral transmittance factor and CIELAB coordinates (D50, 1931 standard observer) are shown in Figures 1 and 2, respectively. They have a large range of spectral shapes and large color gamut. Conversely, Kodak Ektachrome is plotted in Figures 3 and 4. Its spectral shapes are limited by the absorption characteristics of its cyan, magenta, and yellow. Its color gamut is considerably smaller than the candidate filters.

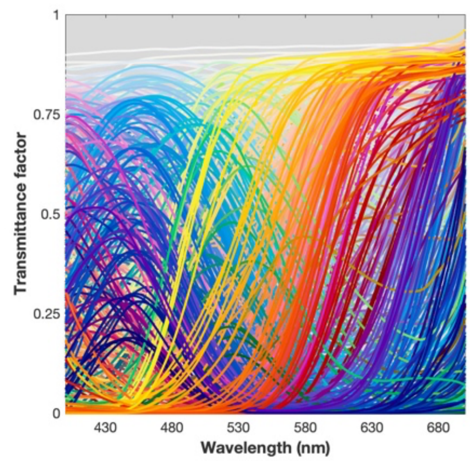

***Figure 1**. Transmittance data for the candidate gel filters. (All colored figures in this paper are encoded in sRGB.)*

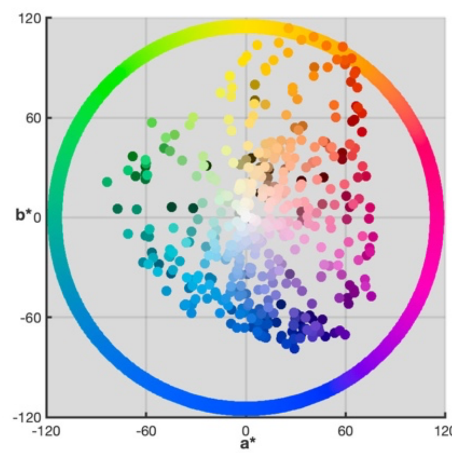

***Figure 2**. Candidate gel filters plotted in CIELAB looking down the L* axis.*

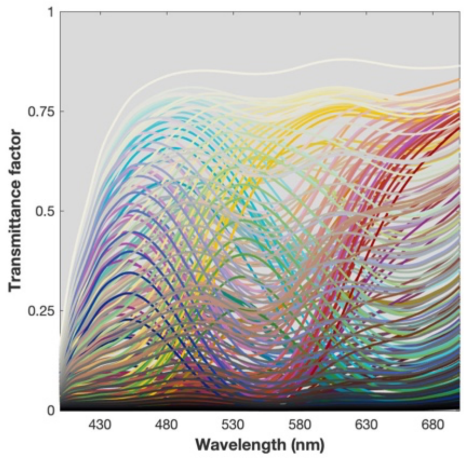

Figure 3. *Transmittance data for Kodak Ektachrome.*

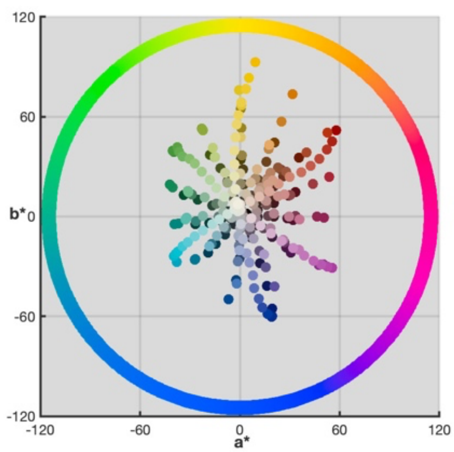

Figure 4. *Kodak Ektachrome plotted in CIELAB looking down the L* axis.*

We decided that the target would have 80 filters. Camera signals were calculated using the spectral radiance of a light source, the spectral sensitivities of a sensor and lens, and the spectral transmittance of the candidate filters. The goal was to select 80 filters that had spectral diversity, a wide color gamut, and resulted in excellent color accuracy when evaluating independent validation data. These data were a Kodak Ektachrome target—similar to an IT8.7/1—produced using a film recorder (plotted in Figures 3 and 4), a FujiClear target of CMYKRGB ramps produced using a Durst Lambda printer, the complete set of glass absorption filters manufactured by Schott,[3] and the complete set of glass absorption filters manufactured by Hoya.[4] We used a combination of optimization and selection. The profile and validation colorimetric statistics are listed in Table 1.

Prototype Target

A prototype target of the 80 filters was constructed, shown in Figure 5, referred to as the GSI-T target (Gray Sky Imaging-Transmittance) in this paper. Its size is 165 mm by 135 mm. The 10 mm filters were measured with a Photo Research PR740 and converted to spectral transmittance, shown in Figure 6. These filters have the intended spectral diversity. The CIELAB data are plotted in Figure 7. The large color gamut of the entire set of filters are maintained.

Table 1. CIELAB CIEDE2000 total-color-difference average, 90th percentile, and maximum statistics for each listed dataset.

Dataset	Average	90th percentile	Maximum
GSI-T (profile target)	0.4	0.9	1.7
Kodak Ektachrome	0.3	0.6	0.9
FujiClear	0.3	0.6	1.1
Schott	0.7	0.8	7.3
Hoya	0.6	1.4	2.2

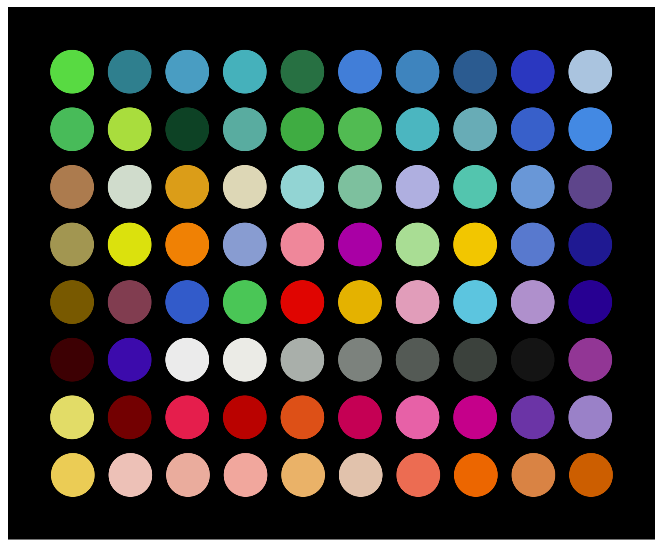

Figure 5. *Rendering of the 80-filter prototype target.*

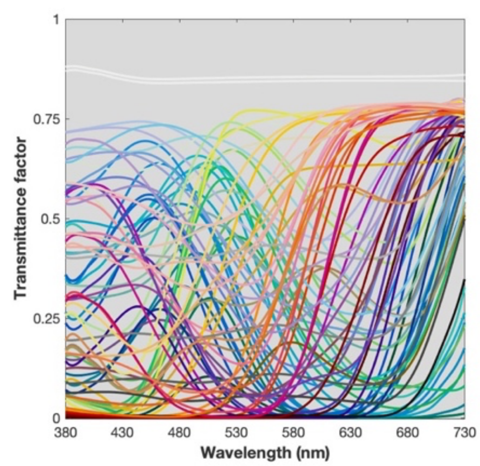

Figure 6. *Transmittance data for the profiling target. These patches represent a more general class of transmittance samples, and are not connected to any particular set of film dyes.*

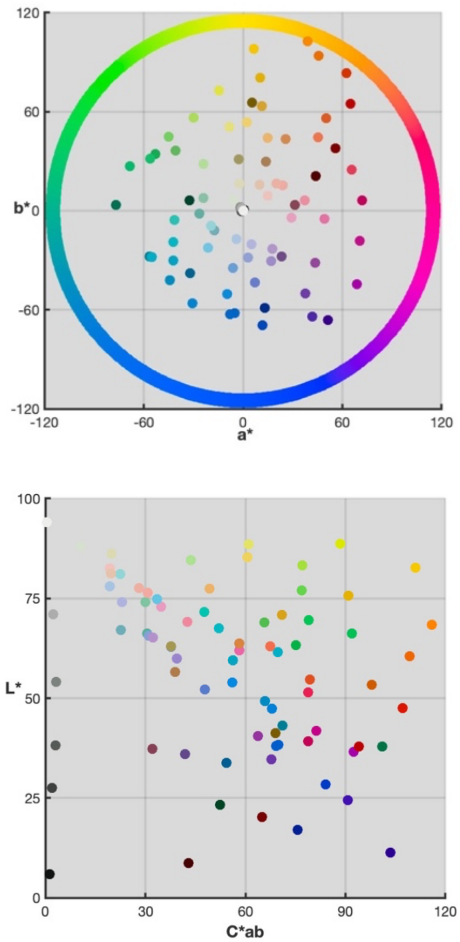

Figure 7. GSI-T target plotted in CIELAB looking down the L axis(above) and L*C_{ab}* (below).*

Experimental

Thus far, we have not obtained validation targets and photographs. A simple imaging experiment was performed using the GSI-T and comparing RGB and Dual-RGB.

The target was imaged using a Digital Transitions (DT) imaging system. A Phase One IXH150 was affixed to a DT Atom. The light source was a prototype DT Stellar, placed below the platen. The DT Stellar contains a high color-rendering white light and a sapphire light designed by Berns and Wyble [5]. Diffuse glass was mounted on the Atom, insuring color uniformity of the prototype light source. CaptureOne controlled the camera and was used for flat fielding (LCC). The aperture was f/8. The ISO was 50. Exposure time and white balance were set using the white light. The tone reproduction was "Linear Scientific." A color space was not assigned. Images were exported as 16-bit tiff with a camera embedded profile.

Shaper-matrix profiles were made using white light and white and sapphire lights. The colorimetric statistics are listed in Table 2. Color difference vector plots are shown in Figure 8. These results are typical when Dual-RGB is compared with RGB. This occurred because the Dual-RGB method results in a camera that better approximates color-matching functions [6].

Table 2 CIELAB CIEDE2000 total-color-difference average, 90th percentile, and maximum statistics for each listed dataset.

Profile	Average	90th percentile	Maximum
RGB	1.6	3.6	8.1
Dual-RGB	0.6	1.2	2.0

Conclusions and Future Work

The prototype target is promising, meeting all of our design criteria. We anticipate designing a new the 7 x 9 gridded target with 63 colored filters, a slanted edge target, an opaque sample, a clear sample and a UPC code. This target will be 4" by 5".

Once the target is manufactured, we will test its effectiveness with independent validation targets and color-challenging photographs.

References

[1] Roscoe gel filters are available from <us.rosco.com>.

[2] Lee gel filters are available from <leefilters.com>.

[3] An Excel spreadsheet containing a transmittance database is available from Schott USA at <us.schott.com>.

[4] Transmittance data for Hoya glass filters are available from <hoyaoptics.com>.

[5] Roy S. Berns, David R. Wyble, "Improving Color Accuracy When Imaging Cultural Heritage Using a Bi-color LED Source" in Archiving Conference, 2023, pp 57–61, https://doi.org/10.2352/issn.2168-3204.2023.20.1.11

[6] Roy S. Berns, "Predicting Camera Color Quality" in Archiving Conference, 2021, pp 61–64, https://doi.org/10.2352/issn.2168-3204.2021.1.0.14

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Author Biography

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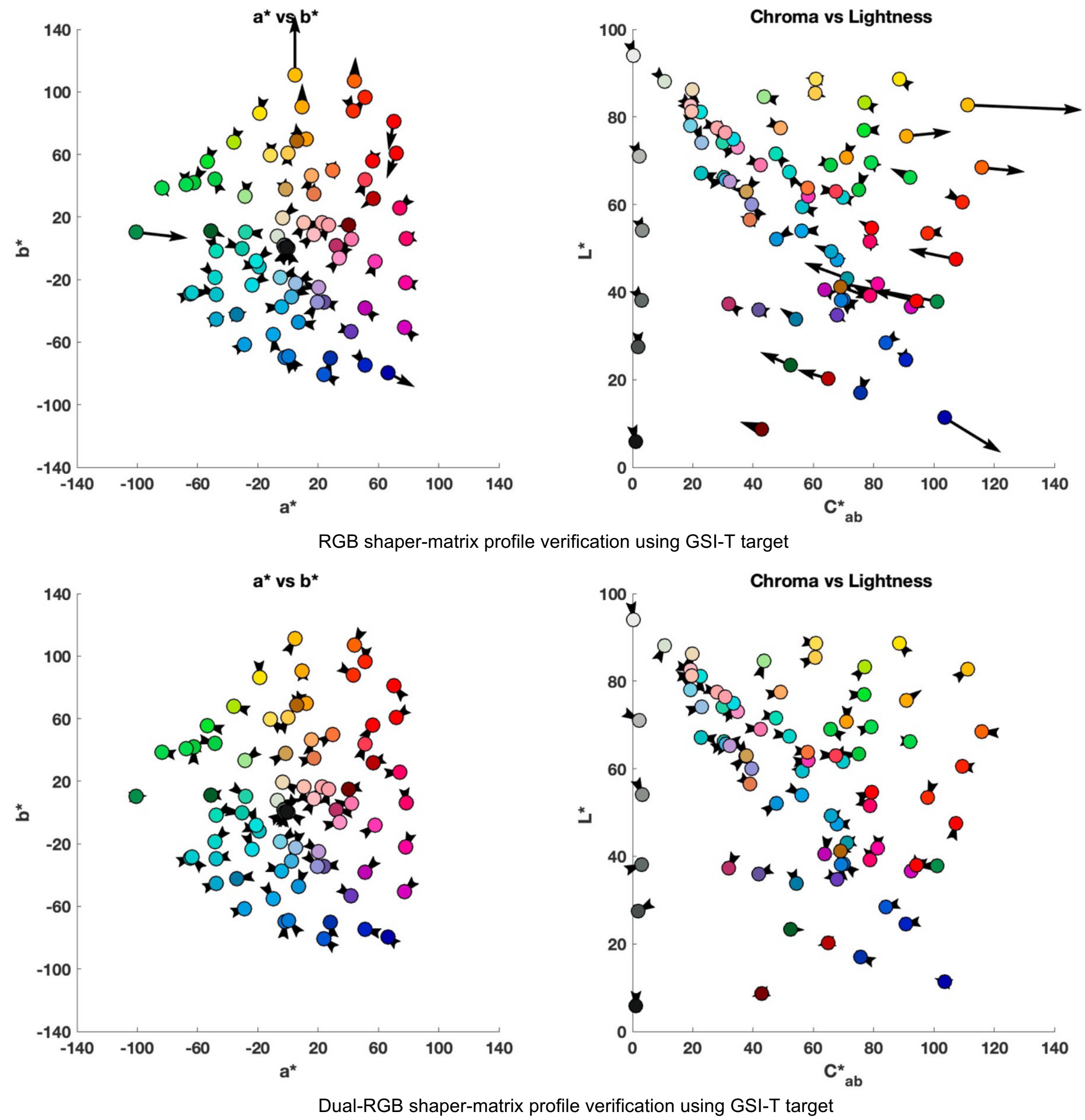

***Figure 8**. CIELAB coordinates of the RGB and Dual-RGB profiles where the color dots are measured values and the arrowheads are camera signals following profiling.*