Report to

LIBRARY OF CONGRESS

FADGI Color Consultation services
Task 3.3
Report on creation of new metrics and processes for applying spectral analysis to the FADGI conformance program

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Executive Summary

In support of the digitization efforts of the Library of Congress, a contract, *FADGI Color Consultation services*, was awarded to Avian Rochester, LLC for research, reporting, and improvement of the spectral imaging capabilities of the Library.

This report fulfills the requirements of Task 3.3 of the contract for the project, which is to report on the creation of new metrics and processes for applying spectral analysis to the FADGI conformance program..

The focus here is to determine a method of improving the color accuracy of the Metis large format flatbed scanner in use within the Prints and Photographs area of the Library of Congress. After reviewing the technical details of the Metis scanner and its current shortfalls, general techniques for spectral imaging are mentioned. Finally, one simple technique is proposed which should provide immediate improvement while more involved solutions are expored.

This report fulfils the contract LCLST17P0006 *FADGI Color Consultation services*.

Introduction

This report will serve to complete a few final questions regarding the use of spectral information to improve the capture and rendering of culturally significant materials. Much of the relevant information for this report is taken from reference 1. Consult that document for additional details. In general this report provides information that can be applied to imaging systems across the library and archiving community. However some of the specific details are intended for application only to the Metis flatbed scanner in current use at the Library of Congress (LC).

This report also makes specific reference to the content of the previous report written under this contract, "Report on research into spectral imaging prior art and best practice." [2]

Improvement of Metis Scanner

Previous effort with LC quantified the spectral sensitivities of several digitization systems. The details of this procedure are in reference 1. The resulting data describe how the system reacts to each individual wavelength in the visible spectrum. Figure 1 compared the relative sensitivities of the Metis flatbed scanner to the color matching functions of the typical human observer.

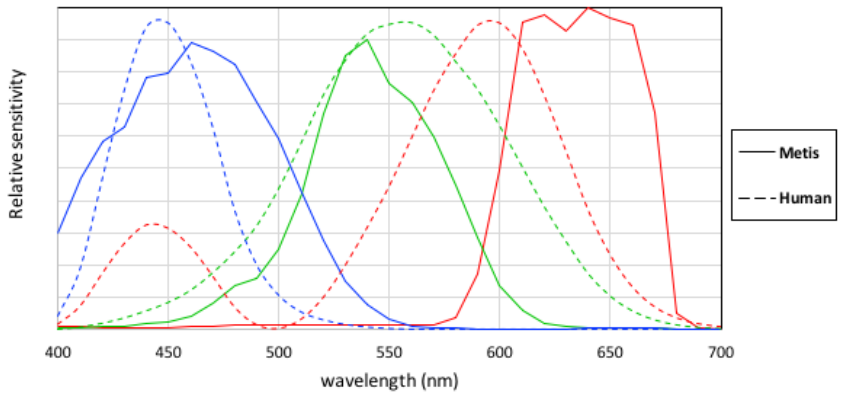

Figure 1.Spectral sensitivities of the Metis flatbed scanner (solid lines) and the CIE 1964 Color Matching Functions (dashed).

Reports from LC personnel responsible for the scanning of Prints and Photographs indicate a particular problem reproducing certain color common in cultural heritage materials, namely yellowish browns and light tan. The region of color space occupied by these colors has been quantified, [3,4] but an analysis has not yet been completed to address the specific shortfall of the Metis system.

It is known that the non-overlapping sensitivity curves, as seen in Figure 1, do not facilitate high-accuracy colorimetric reproduction. A technique was developed [5] whereby a greenish-blue filter is inserted into the light path, effectively tuning the red channel to have more overlap with the green channel. This technique was modeled and reported in reference 1. The results were promising; additional physical experimentation will be needed for verification as outlined in *Improvements for Colorimetric Imaging*, below.

Implementation of Spectral Imaging Techniques

Several techniques were described in reference 2. Many of these are not realistic for immediate implementation at LC. One way to easily separate the options is: 1) Those that are candidates for upgrading current systems; and 2) those that are all new or "clean sheet" installations.

Reference 6 provides an excellent overview of a reasonable entry point for a new installation. The system described is a seven position filter wheel with a monochrome detector. There are several options that will allow customization for LC applications:

- Selection of the filters
- Selection of the lens(es)
- Selection of the monochrome detector (with respect to resolution)

This solution, or similar solutions, should be considered for the applications for which spectral imaging of the best quality is required. Also, note that this solution is one of many that requires several individual image captures. The potential difficulties with multi-capture techniques are focusing, and registration. For most static samples these will not be issues, but if they are, single-capture abridged spectral imaging technologies are available. For one example see reference 7.

The advantages presented in reference 6 do not all require the installation of a completely new imaging system. Filters wheels are available, or can be customized, to fit most modern cameras. There will obviously be workflow and software changes required, but many of the current (and familiar) hardware and software can remain.

Improvements for Colorimetric Imaging

Given the problems described by the Prints and Photographs personnel at LC, a straightforward technique could be as simple as applying the NGT [4] as a calibration target. This was recommended [2] and should be tried before more involved and expensive solutions are tried. This does not move the P&P scanning any closer to spectral imaging, but it could help the current issues with no expense and very little effort.

Other techniques were described in reference 2. Some of these (e.g.: changing Bayer interpolation techniques) might require changes to the work process that are unattainable within the current software provided by the scanner manufacturers. Therefore the recommendation specifically for the Metis scanner is:

1. Use of the NGT as a characterization target
2. Use of the 1mm BG60 blue-green filter.

Conclusions

It is difficult to conclude anything other than the need for spectral imaging for at least some of the digitization systems in current use at the Library of Congress. There are significant challenges, many of which are related to the operators of these systems, many of whom have been practicing RGB imaging workflows for many years. Much of this valuable experience will translate to new systems, but it is likely that spectral imaging require some new skills for which the old training will simply not apply. Good training and preparation can alleviate these potential pitfalls.

The rest of the imaging community is already moving in the direction of spectral imaging. Besides the largely academic work cited in this document, note that the popular color image processing software basICColor [8] has implemented the ability to process multi-plane spectral image data. In addition to being a good indicator of the direction of the technology, basICColor is in common use at LC and other

library and archiving facilities, and by implementing spectral image processing the users at these facilities will have one fewer new software packages to learn.

References

[1] David R Wyble, "Spectral Implications for Camera Characterization Target." *IS&T Archiving 2018*, Washington DC (2018).

[2] David R. Wyble, "Report on research into spectral imaging prior art and best practice." Initial report submitted to Library of Congress towards the fulfilment of LCLST17P0006 *FADGI Color Consultation services* (January 2018).

[3] David R. Wyble, "Define the coordinates for cultural heritage materials by logical category." Report to Library of Congress, February 2015.

[4] David R. Wyble, "Next Generation Camera Calibration Target for Archiving." *IS&T Archiving 2017*, Riga, Latvia (2017).

[5] Roy S. Berns, Stanley Smith, "Analysis of Color Management Default Camera Profiles for Museum Imaging Applications." *IS&T Archiving 2012*, Copenhagen, Denmark (2012).

[6] Roy S. Berns, "Practical UV-VIS-NIR Multispectral Imaging." *IS&T Archiving 2018*, Washington DC (2018).

[7] FluxData Inc produces a three detector co-registered imaging system, with each detector configured with a custom filter. Refer to: `<fluxdata.com/fd-1665-multispectral-cameras>`

[8] basICColor Input 5 software is provided by basICColor GMBH. Refer to `<basiccolor.de/en/>`.