Quality Assurance Methods for Online Image Representations

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Abstract

The success of any cultural imaging program is measured by the ability to deliver quality visual representations of original objects to a wider and increasingly global online audience. Any phase in the artwork reproduction cycle, from the initial digitization procedure to the ingest process used in the end user viewing device can introduce distortions that if left unchecked can result in a less than optimal audience experience.

A growing number of institutions worldwide have adopted Metamorfoze and FADGI imaging protocols to create more consistent and measurably accurate representations of original artworks. Unfortunately, the range of this improved image quality does not always extend to the desktops and devices used by the typical internal or external user. A number of factors contribute to the loss of image quality as images typically pass through multiple digital systems and devices with varying levels of standards support.

The focus of this paper is to illustrate potential methods for objective image analysis and quality assurance that extends the process control from the initial digitization all the way through to the most important experience—that of the end user.

History/background

As is the case with most challenges facing today's digital imaging community, solving one problem tends to reveal new challenges. A real world experience of a breakdown in the artwork reproduction cycle triggered a personal search for answers and ultimately a method to help identify and resolve issues related to online image representations.
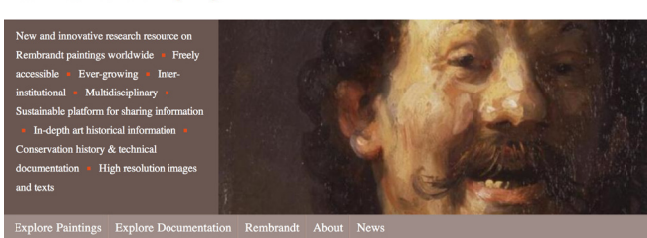

Figure 1.

Upon joining the staff of the Metropolitan Museum of Art last June, a paintings conservator contacted me about an issue with renderings of Rembrandt paintings submitted to the Rembrandt online database (Beta) project. The issue was that images submitted appeared dull and de-saturated when viewed via the beta version of the online database.

Figure 2. *Original Image / Image rendered via the Rembrandt Database*

After reaching out to Sytske Weidema, Andrew W. Mellon Fellow for The Rembrandt Database: www.rembrandtdatabase.org RKD (Rijksbureau voor Kunsthistorische Documentatie / Netherlands Institute for Art History), we were able to get to the bottom of the problem. The issue was an all too common breakdown in the artwork reproduction cycle where an embedded ICC color profile was stripped away and ignored by a downstream rendering process used to create the thumbnails and zoom views within the Rembrandt database. Ultimately the color bars embedded in the Metropolitan Museum's assets provided the essential information that resolved the issue in a readily identified way: when the color bars are rendered as dark and de-saturated, we know that the image source ICC wide Gamut ProPhotoRGB encoded master image file was ignored upon ingestion to the system, and the sRGB color space was assigned (or assumed) by default.
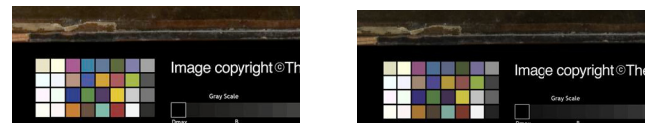

Figure 3. *Original Color Bars vs Color Bars as rendered in the Rembrandt Database*

Interestingly, the Met Museum's Media Bin asset management system has download tasks that correctly convert master image file color space to sRGB for online usage, but in this particular case, the Master image file was specifically requested and delivered in its original wide gamut color space. As an aside, the master image file is measurably accurate to the original predominantly dark painting.

This is not the first time that the color bars embedded in Met Museum image assets have helped resolve downstream reproduction problems, but this experience underscores just how easy it is for the correct imaging path to be broken.

Digging Deeper

While trying to give Sytske a summary of my findings and suggest a resolution to the problem that she could pass to Rembrandt Database software engineering team, I was struck by the fact that aside from a visual assessment of the color bars, there was no way to easily quantify and convey the image quality losses we were observing online.

During the same time period that marked the Rembrandt database challenge, I had been using Image Engineering IQ Analyzer software and renditions of the X Rite DCSG color chart to illustrate the fact that many common working color spaces, including AdobeRGB 1998, clip source DCSG chart colors. This finding was a follow up to an Image Muse discussion thread about color and encoding for digital capture.

It dawned on me that these DCSG chart renditions would be the ideal link between the source and ultimate destination results. The experience boils down to a very simple question: can the DCSG chart values survive the trip through a complex online external use scenario intact?

With Sytske's assistance, four sample chart file images encoded in sRGB, AdobeRGB1998, eciRGBv2 and ProPhotoRGB color spaces were ingested into the Rembrandt Database for evaluation. The results not only helped verify the initial problem, but identified multiple problems with browsers and operating systems that impact every museum publishing content to the web.

The Method In Detail

Step 1: Create synthetic DCSG TIFF files.

Using the published X Rite DCSG Color Chart reference data set (Original Greatag Spectrolino) the source color values were converted directly to a Tiff format image in L*A*B* color. This process was completed using software called Patch Tool from Babelcolor. This L*A*B* image file was then converted to the individual RGB color spaces: sRGB, AdobeRGB1998, eciRGBv2, and ProPhotoRGB using Adobe® Photoshop™.
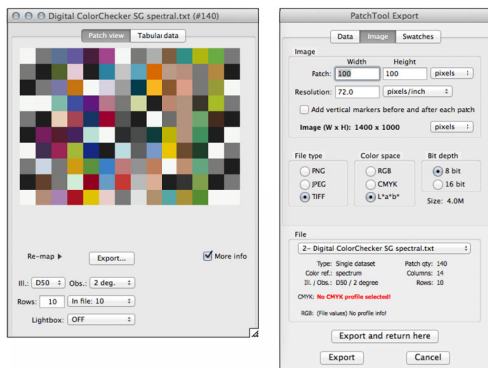
Figure 4. *X Rite DCSG color chart reference data is converted to a L*A*B* Tiff file using Babelcolor Patch Tool. The Tiff is then converted to the various RGB spaces using Adobe® Photoshop™*

Step 2: Establish a baseline reference data for each encoding.

As I have mentioned in earlier papers, the DCSG chart colors extend beyond the gamut of all but the ProPhotoRGB color space. This explains why users of eciRGBv2 and ProPhoto RGB often experience lower DeltaE values when verifying results for Metamorfoze or FADGI protocols.
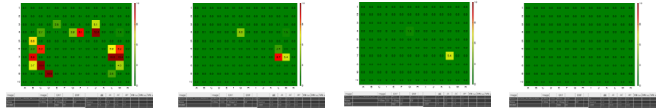
Figure 5. *Color gamut clipping from DCSG chart to sRGB, AdobeRGB 1998, eciRGBv2, and ProPhotoRGB (DeltaE 1976)*

In order to validate to the files encoded in spaces with color gamuts smaller than the source values, the Image Engineering IQA5 Color Module "write Cref" function was used to create a custom reference data for each color space encoding. By creating a custom Cref for each encoding, the analysis of each tiff file will result in a perfect match result.
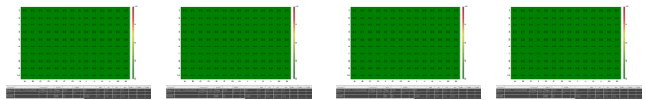
Figure 6. *Baseline reference file validation results: Created using custom "Cref" data for each color space encoding using Image Engineering IQA5 Color Module*

Step 3: Ingest the four color-space encoded Tiff files into the workflow you wish to evaluate (in this case, the Rembrandt Database)

Figure 7.

Step 4: Calibrate the end user display to "true" sRGB.

The World Wide Web Consortium (W3C) currently identifies sRGB as the preferred web color space and it is generally known as the most ubiquitous color space. sRGB has a unique gamma gradation that should be strictly adhered to. Using BasICColor Display 5 and its validation functions the state of the host computer display can be calibrated and verified to conform to this specification.
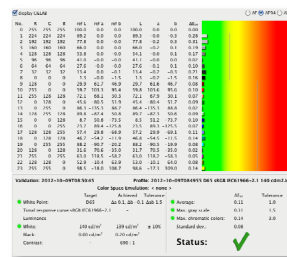
Figure 8. *sRGB display calibration validation report (BasICColor Display)*

*It is critically important to note that the web and web standards are in constant flux and the current concept of defining a single static color space (sRGB) to represent any and all possible devices is not likely to satisfy the demands of the community moving forward. Rapid advances in display technology used in desktops, laptops, and mobile devices capable of wide gamut color are literally being held back by an outdated definition of yesterday's CRT technology. If recent history serves as a guide, the W3C will ultimately mandate full dynamic ICC support.

Step 5: Navigate to the online content via a device web browser and capture the screen display.
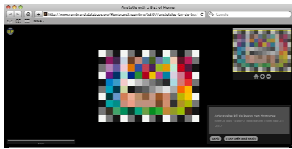

Figure 9.

Step 6: Analyze the resulting image file in Image Engineering IQA 5 color module using the appropriate "Cref" data for the source image file to compare the source to the data as displayed on the device. Repeat the process across different web browsers and devices.

Note: This outlines a specific method using very specific software tools. The same process can be replicated using the same source files and different analysis tools. However it is important that the display calibration is as accurate as possible.

Initial Results

The initial results reveal multiple layers of color management breakdowns both within the database web services and the operating system/ browser level. The files were evaluated across three separate systems and three web browsers:

System One: A Macbook Pro laptop (MacOS 10.8.2) with Retina Display Calibrated to true sRGB using BasICColor Display and the precision Discus Colorimeter. The browsers were Safari 6.0.2 and Firefox 16.0. Firefox has multiple color management configuration preferences so both the default and "Mode 1" were evaluated.

System Two: A Mac Pro desktop (MacOS 10.6.8) with an NEC Spectraview PA271W display calibrated to true sRGB using BasICColor Display and the precision Discus Colorimeter. The browsers were Safari 5.17 and Firefox 16.0. Firefox has multiple color management configuration preferences so both the default and "Mode 1" were evaluated.

System Three: A Dell Optiplex 9010 desktop (Windows 7 Enterprise SP1) with an NEC Spectraview PA271W display calibrated to true sRGB using BasICColor Display and the precision Discus Colorimeter. The browser was Internet Explorer 9.0.8112

I will let the reports speak for themselves. To help interpret the following results, the DeltaE (1976) values over 10 are highlighted in red and pure green is a perfect match. The exact same Metamorfoze tolerances many of us use for our digital captures are employed to maintain a consistent point of reference.
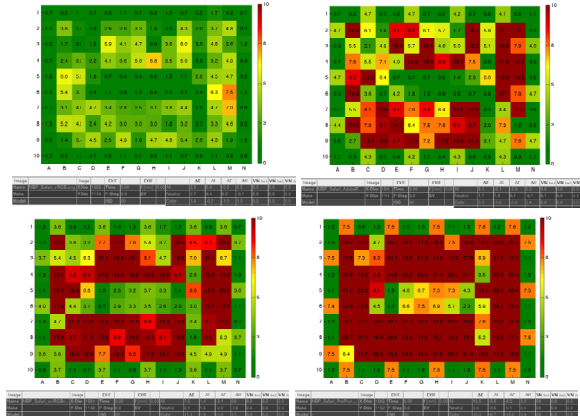
System One Results:

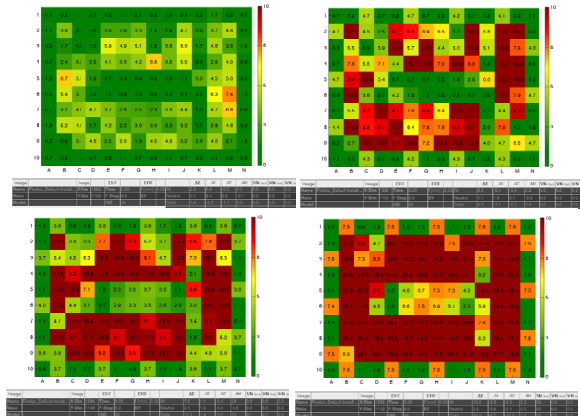**Figure 10**: Safari 6.0.2: sRGB, AdobeRGB1998, eciRGBv2, ProPhotoRGB

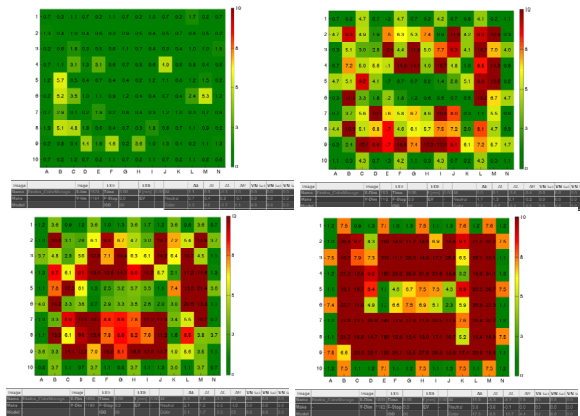**Figure 11.** Firefox 16.02: sRGB, AdobeRGB1998, eciRGBv2, ProPhotoRGB

Figure 12. Firefox 16.02: Color Mode 1
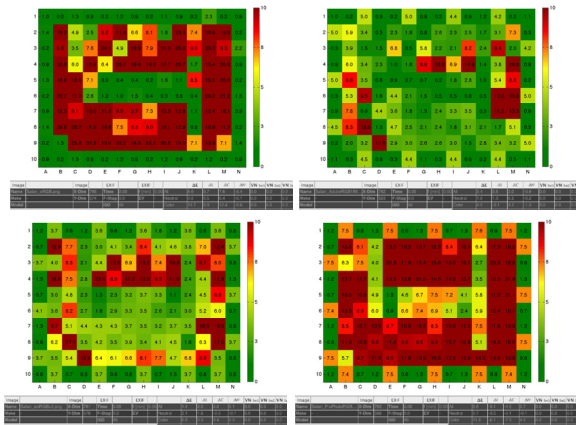sRGB, AdobeRGB1998, eciRGBv2, ProPhotoRGB

System Two Results:

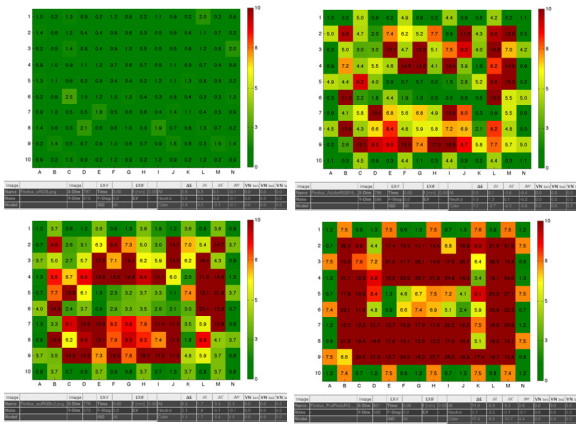**Figure 13.** *Safari 6.02: sRGB, AdobeRGB1998, eciRGBv2, ProPhotoRGB*

Figure 14. *Firefox 16.02: Color Mode 1*
sRGB, AdobeRGB1998, eciRGBv2, ProPhotoRGB
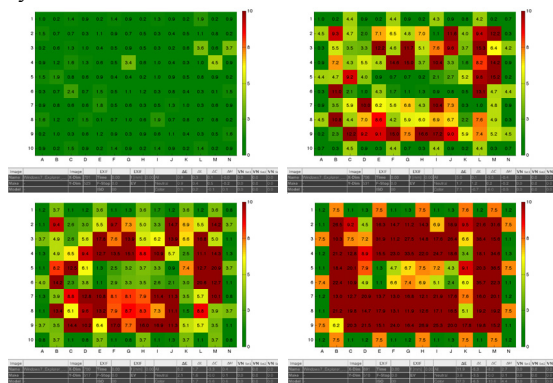
System Three Results:

Figure 15. *Internet Explorer 9.0.8112*
sRGB, AdobeRGB1998, eciRGBv2, ProPhotoRGB

Summary

The results presented in this paper are an initial review of a single web based database and three computer systems. The Rembrandt Database was in a beta stage of development during the time of the testing and it is important to note that the majority of web-based imaging systems suffer from a lack of ICC support.

The findings indicate that there are severe problems with the rendering of images that begins with the host database (stripping of ICC profiles) and is compounded by the operating system and browser's ability to properly render the untagged images. This is especially apparent on System 2 running an older Mac OS where even the source sRGB image was rendered incorrectly. One thing is clear: if the host database did not strip away the source ICC profiles, the browsers that generally support ICC profiles would have had a much higher success rate. With no color roadmap embedded in individual image files, downstream display and print rendering tasks are severely compromised. The practice of stripping ICC profiles and assuming sRGB began in the early "dialup modem" days of the internet because the 40k or so size of the ICC tag was seen as a performance drain. For today's rich dynamic web experience this practice has negative impact on image quality.

The state of web based image presentation is frail at best. Ideally the WC3 can do a better job of encouraging the proper use of ICC protocols across all web-enabled systems and devices. As color management at the browser and operating system level is becoming more prevalent, and advanced wide gamut displays and printers are moving to the mainstream, web developers and system administrators need to make sure that all systems that touch image assets can provide full end to end support for ICC protocols. The modern web can and should be fully color managed.

I am hoping that this method of evaluating online image representations will be useful for imaging and digital media program managers as well as for web and application developers. This quality assurance method based upon leveraging existing tools, targets, and tolerance models can be easily incorporated into acceptance testing of web-based systems. Clearly the best time to resolve color rendering performance is when web based systems are being evaluated and specified. This method of objective evaluation can be used for ongoing quality assurance and quality control across virtually any device category.

Future reports will incorporate actual image samples to help correlate the color distortions indicated in the reports to a more typical end user experience.

Author Biography

Scott Geffert is currently Senior Imaging Systems Manager at The Metropolitan Museum of Art,NYC. Scott is an active IS&T member as well as a Member of ISO and is President of ImagingEtc Inc.
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