Color Management and ICC Profile

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What is Color Management?

In digital imaging systems, color management is the controlled conversion between the color representations of various devices, such as image scanners, digital cameras, monitors, TV screens, film printers, computer printers, offset presses, and corresponding media.
For example, you have two different monitors. The most saturated red on the two monitors are both \((255, 0, 0)\). Yet they might look different. Because \((255, 0, 0)\) are the values in the device space, not in the color space. Only when the values in the color space are identical, the red on both monitors will appear equal.

Monitor A ≠ Monitor B ?
Device Independent Color Encoding
These devices can be grouped into two categories:
- input device, such as scanner, digital camera;
- output device, such as monitor, printer;

Sometimes, the output device can be regarded as the input device. For example, when you design an image on your monitor and hope to reproduce your image with the printer, the monitor here is the INPUT device.
When you have the profile for this industrial printer, you can predict its color output. When you want to simulate that output with a desktop printer, the desktop printer is the OUTPUT device and the industrial printer is the INPUT device.
ICC Profile

- file specification for the color profile data;
- born in 1993;
- vendor neutral, cross platform color management architecture;
- the latest version is ver. 4, but the most popular version is ver. 2;

Website: http://www.color.org/icc_specs2.xalter
Normal Procedure to Calibrate the Monitor

- place the spectrometer on the monitor;
- the software changes the color of the monitor;
- measure the color for calculation;
Normal Procedure to Calibrate the Printer

- Use your software to process a given test chart and print it;
- Measure the reproduction with the spectrometer;
- Calculate;
Procedure to Calibrate DC or Scanner

- Put the standard test chart into the scanner or in front of the DC;
- Capture its image for analysis;
Difference between the Input Device Calibration and Output Device Calibration:

- to the output device, the device value is given and we need to measure its tri-stimulus value;
- to the input device, the exact tri-stimulus values are given and we need to know the correlated device value.

Notice:
Printer calibration is a complicated process, which is dependant on the software and has a lot of parameter settings. So, this requires education and experience.
Gamut Mapping

Gamut Mapping is translation between devices with different color gamuts. For example, the color gamut for the monitor is normally bigger than the color gamut for the printer. So, the color outside of the printer gamut cannot be reproduced accurately. Some of them might be clipped to the gamut boundary of the printer, while others will be mapped inside of the printer gamut, according to the different gamut mapping algorithm.

Reference:
Jan Morovic, Color Gamut Mapping, Wiley, Hoboken, NJ
The left is the original image, while the right is the image reproduced by the printer. Because of the difference between the color gamut of the printer and that of the monitor, the green cannot be reproduced.
Rendering Intents

Each time a gamut mismatch occurs, the color management module uses the rendering intent to decide what qualities of the image it should prioritize.

There are four intents.
- Perceptual: balance;
- Relative: colorimetric;
- Saturation: least used;
- Absolute: accurate plus white point;

Notice:
Perceptual & saturation intents are vendor specified.
Relative vs. Absolute

- In the relative intent, all the colors inside the gamut should be reproduced accurately.
- In the absolute intent, all the colors inside the gamut, including the difference of the media whiteness, should be reproduced accurately.

Notice:

Relative & Absolute intents share the same data in the ICC Profile.

One interesting phenomenon about absolute intent is that there are often colors in the white background.
As we can see, there are more details in the perceptual intent while the colors in the relative intent are more accurate.
Color Profilers

- ProfileMaker;
- Monaco;
- Fujifilm ColourKit;
- ICS basIICCColor;

Comparison of the color profilers:
http://www.wmich.edu/pci/staff/downloads/index.html
Digital Textile Printing

Digital textile printing is more flexible if compared with the digital paper printing.

- CMYK, supported by almost all the digital printers;
- HIFI, color channels that are involved in the color management beyond CMYK, such as hexachroma, which can greatly enlarge the color gamut;
- Spot color, color channels that are not involved in the color management;