# Getting the Colour Right: An Introduction to Colour Management

These are companion notes for the slides of a presentation first presented to the Ladysmith Camera Club on February 28, 2012.

## What we'll be discussing

- What problem does it solve?
- What is it?
- How do I do it?

## Has this ever happened to you?

Let say you've been asked to take a portrait of your brother and his family. Here is how the scene looks, properly exposed. Good colour and contrast.

But when you display the image on your computer, it looks too bright and some of the colours are quite like you remember them. So you make some adjustments on your computer and print out the image.

But the output from your printer is too dark and skin tones and blues are all wrong.

## So what's going on?

What we have here is a "Failure to Communicate" Colour

Essentially, the colour information your camera recorded (assuming your camera correct recorded the original scene) was not properly communicated through your computer to your monitor and to your printer. Because of this, you were led to make incorrect or perhaps unnecessary adjustments that likely made matters worse.

In other words, there is no Colour Management to ensure consistent colour from camera to monitor to print.

## So what is Colour Management?

Colour Management is some steps you can take to ensure the colour information received from your camera is properly understood and interpreted by your monitor and your printer.

Colour Management involves profiles and colour spaces.

In this presentation, I'll first explain the basics of why this happens and give you a few colour management steps you can take to get your colours rights and make your digital life easier.

## It all starts with numbers

In the digital world, colours are represented by numbers. Each pixel in your image is a actually number that represents a Red value, a Green value and a Blue value. You probably know them as RGB numbers.

For example, here is a shade of red. R=226, G=47, B=47.

(Adobe RGB)

Or is it this one?

(sRGB)

Or this one?

(Color Match)

Each of the colour patches you've just seen have the same RGB numbers. But they were in different Colour Spaces.

## Colour Spaces

An RGB number can represent a total of 256 x 256 x 256 = 16,777,216 different colours.*

That might seem like a lot of colours, but it is really a very small number compared to the number of different shades the eye can perceive. You have only 16 million distinct numbers to work with, so which colours do you represent? The answer to that question is your "Colour Space".

* using an 8-bit file format such as JPEG.

## Think of a Colour Space like pins on a map.

Suppose you have a map of the world and 16 million pins and the problem is to use your 16 million pins to adequately represent the world. Do you try to arrange the pins to provide uniform area coverage? Or uniform population coverage? You could have lots of pins in North America, but then perhaps no pins in Antartica. Where pins are closely spaced, you have a lot of precision in that particular region, but you will have much less precision in other areas. Remember, you have only 16 million pins.

Now image the world map is replaced by a universal map of colours. Again, you have only 16 million pins and each pin can represent only one place on the map. What is a good way to arrange your pins? Should you pack the pins more densely in the green area (human eyes are more sensitive to green than other colours) and less densely packed in the red area?

The specific arrangement of pins you choose becomes your colour palette, which we call a "Color Space". It is simply a way of indicating that the pin with the RGB value of R=226, G=47, B=47 represents "this" particular shade of red.

The two most commonly used colour spaces in digital photography are sRGB and Adobe RGB. Your camera will certainly offer sRGB, probably also Adobe RGB and possibly other colour spaces (such as ProPhoto). You can change the colour space through your camera's setup menu.

## There are two important things to keep in mind about colour spaces.

First, there are "holes" inside the colour space. These are colours that fall between the "pins". These are colours that cannot be named by the colour space, and the best you can do is choose the closest

matching colour that does have a “pin”. The more “pins” you have (i.e. the more bits your RGB numbers have), the smaller the holes will be.

Second, there are colours “outside” the colour space. These are colours that could be quite far from any available “pin”. Again, the best you can do is choose the closest matching colour that does have a “pin” and hope for the best. It doesn’t matter how many “pins” you have, the region outside the colour space doesn’t get any smaller.

Colours that cannot be named by a colour space (either they are outside or in a “hole”) are called “out of gamut” colours.

## So what?

The important thing is this: every image file (e.g. JPEG, TIFF, PSD, etc.) needs to indicate which colour space it is using. We say such files contain a “colour tag” or they are “colour tagged” or they are “colour managed”.

An image file without a colour tag is just a bunch of numbers that could mean almost anything colourwise.

The good news is your digital camera assigns the colour tag for you.

The bad news is the software in your computer can remove the colour tag if you’re not careful. Files you receive from others might not contain colour tags. Files on the web often don’t. Scan files, even from commercial shops, sometimes do not contain colour tags.

## How to keep your colour tags

<Screen shot of saving a JPEG, TIFF or PSD>

<Screen shot opening a RAW file and how to assign the colour space>

## So then what are profiles?

Even though your camera or software produces a colour managed file, how do you know that the colour values are right? The fact is every piece of equipment responds to or produces colours somewhat differently.

Suppose your aim your camera at this particular shade of red R=226, G=47, B=47. Quite possibly the camera might actually "see" that shade of red as R=227, G=88, B=47 (green shifted). Your camera would output R=227, G=88, B=47 when it should have output R=226, G=47, B=47.

This shift could be a combination of factors including the behaviour of the camera sensor, the nature of the light source and the pigments in the subject itself. They all contribute to what your camera "sees" as the colour and then it records a number in the image file according to the colour space.

In other words, a camera can be fooled and not record colours as you see them or as another camera might see them. A camera will see colours based on its own personality.

You might even be aware that some particular camera always made peoples' faces look slightly redder than they should be. Other cameras might make grass look a little bluer than it should be. Etc. We certainly knew this to be the case with different types of film (well, that's if you're old enough!).

## Monitors can only display certain colours

Monitors do their best to output true colours, based on the numbers given to them. Even so, every monitor produces light within its own unique palette of colours. Different factors can affect this including:

- the type of monitor (LCD vs. CRT)
- the age of the monitor
- the brightness and contrast settings

You might give a monitor this value R=227, G=47, B=47 and what it actually displays could be R=227, G=47, B=67.

**NOTE**: A typical problem with monitors is to have them set too bright for colour critical work. Then the user tends to darker their images to compensate and therefore their images tend to print too dark.

## Printers can only print certain colours

Printers are especially prone to producing their own peculiar palette of colours because so many different physical factors are involved in creating a printed image, including:

- The colour, brightness and quality of the paper you print on
- The number of available colours
- The type (dye vs. pigment) and quality of the inks
- The number and size of the ink dots the printer uses to try to replicate all the intermediate colours (lighter colours depend on allowing the paper to show through)
- The software that converts image files into the combination of ink colours needed to reproduce the original image (i.e. the printer driver, the printer firmware or RIP)

So even though your properly tagged image file might contain this value R=227, G=47, B=47, it is possible that your printer/paper/ink/software combination simply cannot reproduce that shade and instead produces something like R=220, G=100, B=100.

## Profiles to the rescue!

A profile is a file in your computer that describes the colour behaviour of a specific piece of equipment under specific conditions.

A camera profile describes the colour response of a particular camera under specific lighting conditions. It would tell your computer that when the camera says R=227, G=88, B=47, it really means R=226, G=47, B=47, so adjust the camera files accordingly.

A monitor profile describes the colour response of a particular monitor under a specific set of brightness and contrast settings. It would tell your computer that when the monitor is given R=226, G=47, B=47, it actually displays R=227, G=47, B=67, so adjust the image values to compensate.

SImilarly, a printer profile describes the colour response of a particular printer/ink/paper combination. It would tell you computer that when you send R=226, G=47, B=47 to the printer with that ink and paper, it actually prints R=220, G=100, B=100, so adjust the image values to compensate.

Profiles attempt to translate all your devices between a standard independent colour standard. For example, the profiles will translate the R=226, G=47, B=47 shade of red to the appropriate values for your monitor and printer so that they will produce as accurate a rendering of that shade of red as possible.

## How do you "profile" a device?

To profile a camera, monitor or printer, you need an accurate and reliable way to measure each device, plus software that produces the corresponding profile file.

## How to profile a camera?

There are several methods that will measure and adjust your camera output to produce more accurate colours.

- Custom white balance is a feature of many cameras, even entry-level cameras. Instead of using one of the built-in white balances for the type of lighting (e.g. sunlight, flash, fluorescent, cloudy, etc.), you use the camera to take a shot of a reference neutral object (e.g. a commercial gray card) and your camera creates a camera-internal "profile" (or custom white balance).
- Commercial multi-coloured targets and software, e.g. ColorChecker Passport, US$99. Especially if you are shooting RAW, you take a shot of the ColorChecker Passport target. You then convert the RAW file to DNG format and process that DNG file with the supplied software which produces a profile in your computer. You select that profile for all the RAW files shot under the same lighting conditions.

## How to profile a monitor?

One way is to produce a profile with your eyes using a utility provided with your operating system.

For Macintosh, the utility is called the **Display Calibrator Assistant Utility**. The following link provides a description of how to use it:

http://www.computer-darkroom.com/colorsync-display/colorsync_1.htm

For Windows 7, the utility is called **Display Color Calibration**. The following link provides a description of how to use it:

http://windows.microsoft.com/en-CA/windows7/Calibrate-your-display

Since these methods rely on your eyes to perceive various colours, contrasts and geometrical effects on your monitor, they are only as good as your eyes and your state of being at the time you do it. Try to be fully awake, not drunk, not sick and in a good mood when you do this!

**NOTE AGAIN**: a common situation is for users to have their monitor set too bright for colour critical work, which leads to the user darkening their images so they look "right" on screen, but then they appear too dark when printed.

### A better way to profile a monitor

The better way is to use a commercial measurement device such as:

- X-Rite ColorMunki Photo
- Pantone Huey
- Datacolor Spyder

The supplied software will walk you through the procedure. The basic steps are:

- Use the device to measure the ambient room brightness
- Use the device to measure your monitor brightness and adjust it to the proper level for colour critical work for the current ambient light level
- Use the device to measure and adjust the monitor contrast
- Display and measure a series of colours on the monitor, usually a series of pure Red, Green, Blue values and a series of neutral gray values
- The software creates and saves the monitor profile and tells the operating system to associate the profile with that monitor.

Some of these devices are also capable of profiling a printer.

### Using the monitor profile

Just because the monitor profile exists on your computer, it doesn't mean your applications use it!

Photoshop and Photoshop Elements automatically use the monitor profile defined in the operating system by the software that created it.

In other applications, you might need to enable colour management and choose the appropriate profile through Preferences or Options.

### There is no need to profile your printer if...

Printer manufacturers include a set of high-quality factory-generated profiles for their printer's original ink and the manufacturers brand of papers. You can usually select these in the printer driver. If you stick to the manufacturers ink and choose the correct paper type in the printer driver, you are very likely going to get the best colour accuracy your printer is capable of producing on that paper.

**NOTE**: If you use a different brand or type of paper than the one selected in the printer driver, you should NOT expect the built-in profiles to necessarily produce the same or even good results. You might

get lucky, but don't count on it. Even minor variations in the paper density, coating formula, etc. can change the colour response, sometimes dramatically. That does NOT mean the paper you are using isn't good. The paper could be awesome and you just need to use the proper profile to get those awesome results.

**NOTE 2**: Ditto if you change brands of ink. A particular profile is only valid with a particular type of paper and ink and should not be expected to produce consistent or even good results when those factors are changed.

**ADVICE**: if you are not getting acceptable results from your printer, you are advised to first use a manufacturer recommended paper with the original ink before drawing any conclusions about your printer's ability to produce good prints. The savings in time and frustration, plus the benefit of predictability and the reduction of wasted ink and paper will often offset the savings by using third-party paper and ink.

### OK, so you want to use third-party paper and ink

First, you need to understand that probably none of the built-in profiles will produce the best results with the third-party paper and ink. To get the best, consistent results, you need to install the correct custom profile or create a custom profile of your own using a commercial measurement device and software such as:

- X-Rite ColorMunki Photo
- Datacolor SpyderPRINT
- DDI Software Profile Prism (you must supply a scanner)

The supplied software will walk you through the procedure. The basic steps are:

- Use the software to print out a set of colour patches. Be sure to use the ink, paper and print settings you intend to use later with the profile. Follow the software instructions closely.
- With the supplied device (or your scanner in some cases), scan the patches back into the software.
- The software creates and saves a printer profile into the operating system.
    - Mac OSX: Macintosh HD > Library > ColorSync > Profiles
    - Windows: \Windows\system32\spool\drivers\color

### How to use a custom printer profile

A printer profile can be handled by the printing application (e.g. Photoshop) or by the printer driver. In the former case, we say "the application manages colour" and the latter case we say "the printer manages colour". One or the other is OK, but you don't want both the application and the driver to manage colours when you're printing.

<See screenshots from Photoshop>

**NOTE**: Some printer drivers don't recognize custom profiles, only the ones that are built-in by the manufacturer. Similarly, these built-in profiles might not be available outside the driver or be in the standard format. This is more common with low-end printers such as HP Deskjet and Officejet printers.

To use a custom profile with one of these printers, you need to ensure that your printing application is set to manage colours and you have selected the correct profile. Then ensure that the printer is set to not manage colours. This might be referred to as "ICM Disabled". Check the advanced settings in your printer driver.

### What are these rendering intents?

Whenever colours are converted from one colour space to another (e.g. from Adobe RGB as an internal working space to a printer profile), you need a rule for how to handle the "out of gamut" colours. These rules are called "rending intents". Most profiles will contain four rules, but only two of them are commonly used for photographic images:

- Perceptual (sometimes called Photographic or Pictures). When correcting an out of gamut colour, Perceptual will shift other colours to try to maintain colour relationships that are natural to human vision. This can even alter some colours that were not out of gamut to begin with.
- Relative Colorimetric (sometimes called Proof). Tries to map the white point of the output relative to that of the input. Will only alter colours that are out of gamut by bringing them into the closest in-gamut value.
- Black Point Compensation (available option for both Perceptual and Relative Colorimetric). Automatically maps the black point of the input profile to the output profile.

### Which rendering intent is right?

Each image has a unique palette of colours that works differently with different printer profiles. Therefore there is no one right answer for all cases. You either need to do test prints or used the "Soft Proofing" feature of your printing application.

However, here are some general tips:

- If you have a lot of dark shadow areas in your image and Black Point Compensation is not used, the shadow areas could be filled in and lose detail. Enable Black Point Compensation in that case.
- If the image has a very limited number of colours, Relative Colorimetric will generally be more accurate.
- When testing (or soft proofing), look for large areas of highly saturated colours such as painted objects, deep blue skies, green fields, etc. and choose the rendering intent that provides the most accurate rendering of those areas.

### So what can I really expect?

If you apply some colour management procedures to your workflow, you should expect:

- Generally more accurate colours on screen and in print.

- More consistent and predictable results. What you got last week or last month, you should get today and next week.
- Less waste of ink, paper and time.
- More consistent results if you send your files out for printing.

But it's not a perfect world and there will always be colours your camera can't capture, or your monitor can't display or your printer can produce. But with colour management working for you, you will maximize the potential of your equipment and be a happier photographer.

## Resources

This is a well-written and comprehensive four-part primer on colour management for photographers using Adobe Photoshop and Lightroom.

http://photo.net/learn/digital-photography-workflow/color-management/

http://photo.net/learn/digital-photography-workflow/color-management/monitor-profiling/

http://photo.net/learn/digital-photography-workflow/color-management/color-settings/

http://photo.net/learn/digital-photography-workflow/color-management/printer-profiling/

## Thank You

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