

Can Digital Cameras be Calibrated?

How to Apply Color Management to Digitally Captured Files

By Andrew Rodney

Anyone who has read *PEI* for any length of time knows I am critical about color matching and working with various color management solutions. *PEI* asked me to investigate color management in digital cameras and the resulting files. The questions I was asked were: "Can digital cameras be color managed?" and "Can the digital photography process be calibrated and characterized?"

Calibration vs. Characterization

Before we get started, it's very important to make the distinction between calibrating and characterizing a device. In most cases, we want to accomplish both tasks, but this is not always possible. Calibration is the process by which a device is adjusted so it mimics a

known or expected standard or condition. One example would be a hardware colorimeter that reads spectral data from a color monitor and adjusts that monitor to a known standard, such as D50, Gamma 1.8 (a print standard). Since few monitors are set to such a known state, the process of calibration ensures that what we see is based on known values.

Characterization is a process by which, once a device is in a known state, the actual values can be described by some type of color lookup table (CLUT), commonly known as a profile. One example of this workflow is the new Adobe Gamma utility supplied with Photoshop 5.0. This software first asks the user to calibrate the monitor (using a visual approach), then creates an ICC or ICM profile that reflects this known state for the color management system used by Photoshop and other ICC-savvy applications. As we will see, it's often impossible to calibrate or characterize a device.

The closest relative to a digital camera is a scanner, and calibrating and characterizing such a device is usually not difficult. Yet scanners remain in a known state for the tasks they need to accomplish, while digital cameras are not quite as easy to peg. For one thing, cameras are used in all kinds of lighting conditions, which can change by the minute. The differences in variable f/stops and lighting conditions play a huge role in the capture of digital data. In addition, many cameras invoke some sort of "automatic" exposure and color balancing that may be impossible to disable. These kinds of cameras are nearly

impossible to calibrate or characterize, as they are moving targets, unable to be placed in a consistent mode of operation. This doesn't mean we can't try to calibrate the final captured image, but the degree to which these devices can be color managed is minimal.

More expensive digital cameras (\$5,000 and more) do provide the necessary manual settings we need to control the calibration process.

Nonetheless, the calibration and profiling must be done under tightly controlled studio conditions. I was able to calibrate and characterize one digital camera in a studio setup for copy work. Large banks of high frequency Fluorescent daylight bulbs were set on a rail system, as was the 4x5 camera, which had a Phase One PowerPhase digital scanning back. In this setup, there was virtually no deviation between captures. Using Kodak's ColorFlow Profile Editor, I simply photographed a standard Macbeth color chart after gray-balancing the prescan, and made a custom ICC profile for the Phase One.

Creating the actual profile is an easy process; after photographing a 3MB file of the Macbeth chart, I simply imported the file into Kodak's ColorFlow Profile Editor software and followed the step-by-step "Wizards" that automate the process of creating a custom ICC profile. The ColorFlow software reads the color patches on the Macbeth color chart and analyzes the values in the file. It examines the captured colors, compares them to the known color values, and can then create a custom ICC

profile that is loaded into the Phase One driver software, thus ensuring that the camera produces the desired color rendering. However, this type of photography is not typical.

High-Bit Corrections

Assuming we can calibrate and characterize a camera, where do we apply the resulting ICC/ICM profile? Ideally, this is done either at the capture stage (with a

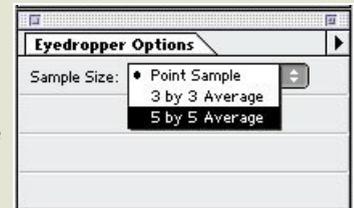
scanning camera hooked up to a computer) or after the capture stage, with the camera software. Ideally, this “correction” should be applied to high-bit data, a file containing more than 8 bits per

Color Correction as Easy as 1-2-3

Here is a before-and-after example of correcting images by the numbers. Using only Photoshop Levels controls, I cleaned up this poor-quality image. I assigned the White Eyedropper tool a clipping of 240/240/240 (double click on one of the Eyedroppers to change the setting of the tool numerically). By clicking on the white portion of Grant's hat, I not only cleaned up a good deal of the color cast, but also assigned the highlight end of my tone scale. I set the Black Eyedropper to 12/12/12, and then clicked in the darkest area I could find under the sweater. This also helped clean up the color cast in the dark regions of the image and set the opposite end of the tone curve.

The last job was to click on the wooden window frame in the background with the Set Neutral Eyedropper. A calibrated display helps immensely, because even subtle differences in areas picked with the Eyedropper tools can make a difference. Don't forget, Eyedroppers can be set to average a number of pixels

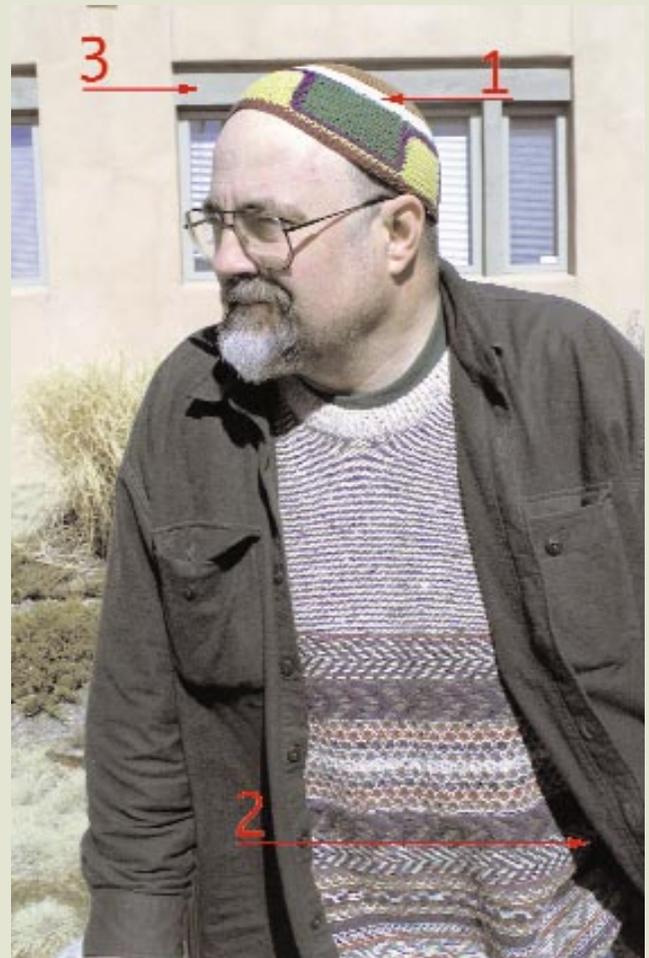
that you click on. The secret is to select the standard Eyedropper tool in Adobe Photoshop and examine the Tool Option (See Figure 5). Notice that I have highlighted a 5x5-pixel matrix so that Photoshop will set the Eyedropper tool to examine a 25-pixel sampling for reading the area I've selected. Another interesting feature of this tool is how a setting affects the sampling of the Magic Wand tool, as well as the other Eyedropper tools used throughout the program. Once the image is corrected to my satisfaction, I use Photoshop 5.0 to apply source and destination profiles to the file for outputting, thus continuing the CMS workflow.



The Photoshop Eyedropper Tool options.



Before



After

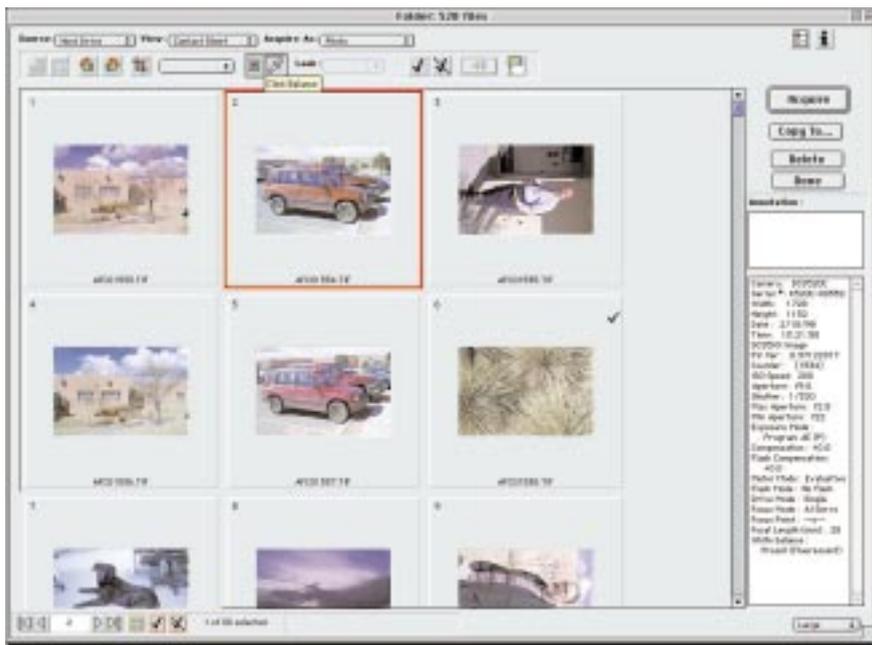


Figure 1. The Kodak DCS Acquire Module. The Index Print view provides the user with the ability to select one or more images to correct or acquire. Notice that the "Click" Eyedropper is active and that I have applied it to Image 2. It is possible to enlarge the preview of that image alone to full screen to simplify selecting an area to correct.

color. Many high-end cameras—like the Phase One scanning models—allow the user to load an ICC profile and apply these corrections to 42-bit files at the capture stage. In these cases, the ability to calibrate/characterize and apply the corrections with high-bit data is quite beneficial. The ICC profile places the scanning camera in a known state and accounts for abnormalities in the CCD, lens, and other conditions in the shooting environment, such as lighting. With a well-calibrated monitor, the software allows the photographer to use all the tools in the scanning interface to produce the best looking prescan. As with a scanner, once the corrections are made and applied to the high-bit data, the resulting file will contain the most accurate data.

Many higher-end digital cameras, such as the instantaneous capture models from Kodak, do capture 12 bits per color (a 36-bit file). The Kodak DCS Photoshop acquire module allows the user to bring in this high-bit data and apply some corrections to the file (see Figure 1). The software doesn't support

ICC/ICM profiles, but it does allow the user to color balance the files for various lighting situations within the 36-bit file. The advantage is improved image quality. Applying these corrections to a 24-bit file can lead to some data loss.

The Kodak Module allows the user to view all the captured files in an "Index Print" view. The user can apply a correction from one file to several or all of the selected files. For example, a photographer on site could photograph an 18-percent gray card in just the first shot. Once all the images for that lighting situation are brought into the Acquire module, the user can pick a setting in the software (called "Click") that can apply

a gray balance to the image by clicking on that picture of the 18-percent gray card. The user can apply this gray balance correction to all the other images in the session.

Like other professional cameras, both the Kodak and the Phase One camera software allow files to be saved as high-bit files, which means the other necessary corrections can be executed in Photoshop. Photoshop 5.0 has far more high-bit editing capabilities than earlier versions. Of course, if a 24-bit camera file needs a correction, it has to be carried out even if some data loss is inevitable. I have some tips for accomplishing this.

Consumer Cameras

Let's say you have a camera with an auto exposure system, and you can only work with a 24-bit file. This doesn't mean you can't attempt to achieve "calibrated" color from your images. The trick is understanding the importance of gray balancing. Try to work numerically using Photoshop's Info palette as your guide. Realize that $R=B=G=neutral$. That is, if you get a reading where R, G, and B are equal in value (e.g., $R=50, G=50, B=50$), then the area is neutral. It

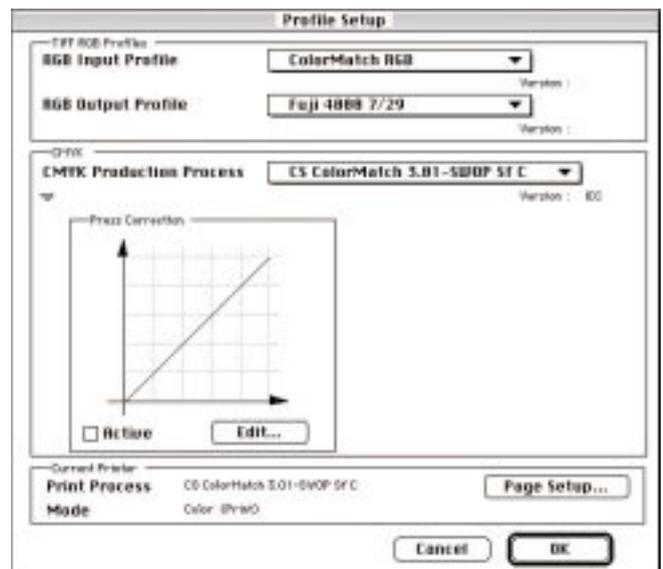


Figure 2. D-Cam allows the user to load input (Monitor) RGB output or CMYK output profiles in the Profile Set Up. This allows very accurate on-screen soft proofing of the files while editing, even in CMYK.

has no color. If you happen to have some item in your image you know is a neutral gray, you can easily color correct the image by using a gray balance tool, such as the Photoshop gray balance Eyedropper (found both in the Levels and the Curves dialog boxes). Simply click on the neutral area of your image (such as the 18-percent gray card) with one of these tools, and it will set the values of the area to neutral.

This feature is useful for many, but not all, images. For example, say you photograph a subject holding a gray card at sunset, and you do not want to remove the lovely golden glow we expect to see in such an image. Using a gray balance adjustment in this situation would produce an image that is neutral (no color cast), but it would also ruin the glow. Some images should have a color cast, so keep this in mind when you try gray balancing your images.

Also keep in mind that Photoshop's White and Black Eyedroppers can be used at each end of the tonal range. Like the Gray Eyedropper, these tools allow you to set either shadows or highlights numerically. Double click on the Eyedropper tools to set exact numeric values. For example, the default setting for the White Eyedropper tool is 255R, 255G, 255B, which would be a pure white. You may find that a value like 250/250/250 would work better, so enter that value and click on an area of the image you want to assign that value. The trick with all the Eyedropper tools is to carefully click on the correct area of the image. Picking the wrong area of the image could ruin a file. If you do click on the wrong area in Levels or Curves, hold down the Option/Alt key, and the Cancel button will change to a "Reset" button. (For an example of how I corrected a severely off-color and density file, see the sidebar.)

Once a file is corrected to your satisfaction, it is still possible to pass it through the rest of the Color Management System (CMS). The key is to have a calibrated and profiled monitor. Nearly all CMSs allow the user to pass this data to a color managed output device, specifying the monitor as the source. What this tells the CMS is "I like what I see on

screen, so match it in the output." An example of this workflow in Adobe Photoshop 5.0 would be to tag the file with the RGB Working Space and output that file using the proper ICC profile for the printer. (For more information on ICC workflows in Photoshop 5.0 see "Color Management," *PEI* August 1998.)

For this CMS to work properly, the monitor and output device must be calibrated and profiled, and the user must understand that not all colors displayed on screen may be printable on the selected output device. When set up properly, print-to-screen matches can be very close. While it's ideal to capture the raw data using an ICC profile on high-bit data, this workflow is the best compromise in cases where the camera simply can't deal with this method of capture and processing.

D-CAM

Another option for working with camera files, especially for cameras that can supply high-bit data, is the Linotype CPS D-Cam, a

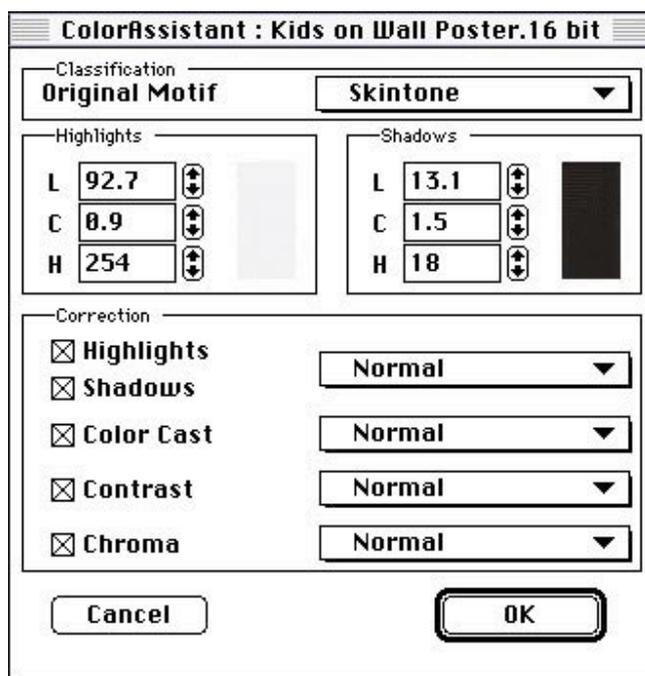


Figure 3. The ColorAssistant dialog is set here for Skintone. I can further manipulate the highlight and shadow settings by entering values for L (Luminance, or tonality), C (Chroma, or saturation) or H (Hue, or actual color). The pop-down menus allow additional corrections with this one ColorAssistant.

new software package modeled after LinoColor scanning software. Likewise robust and sophisticated, in the right hands, D-Cam can produce exceptional results. It is fully ICC-savvy and comes with a number of ICC profiles for different cameras and lighting conditions. With a package called ScanOpen D-Cam, a user can produce custom ICC profiles for various lighting and shooting conditions. A variety of these profiles are provided in the D-Cam package for all the Kodak DCS professional cameras (See Figure 2).

D-Cam has virtually all the correction tools found in LinoColor, and more, including three selective color tools, ColorAssistants, sharpening filters, curves, saturation curves, and the ability to do conversions to CMYK or RGB using ICC profiles. The ColorAssistants in LinoColor and D-Cam make corrections based on analysis of the image, along with preset auto corrections such as Landscape, Skin Tones, Jewels, and Sunset. Simply open a file, pick one of the preset ColorAssistants, and

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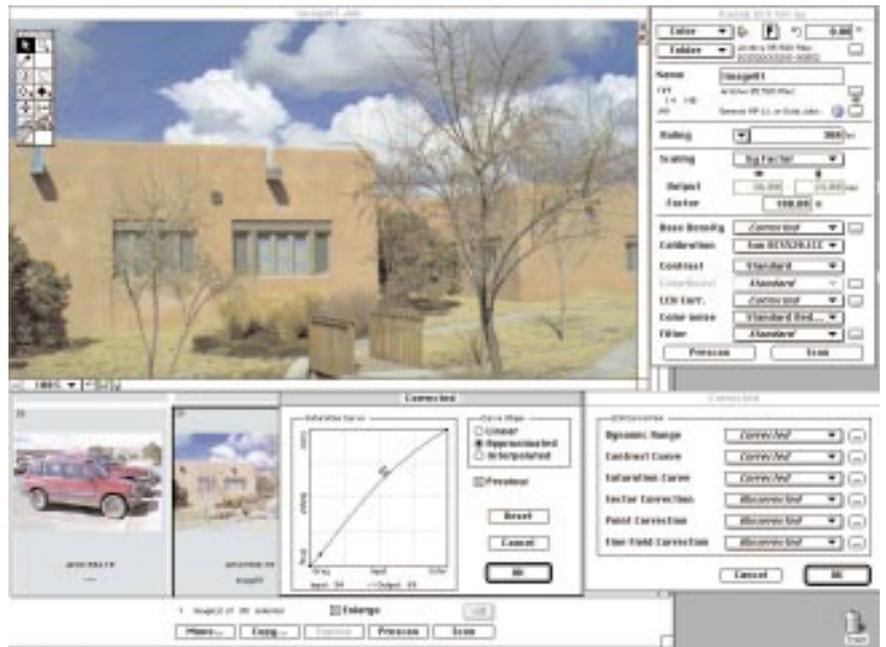


Figure 4. The main D-Cam interface contains a large preview of the file being worked on. The main control window allows such options as noise reduction and sharpening, as well as setting the ColorAssistant and other color controls. Notice the pull-down menu called "Calibration," where a supplied DCS-520 ICC profile for sunlit photos has been selected. The Saturation Curve window is open below the main preview window; behind that window is the Index Window, which displays all the images on the camera.

D-Cam will analyze the image and apply a correction. The ColorAssistants do an amazing job.

Notice in Figure 3 that you can further tweak the chosen ColorAssistant numerically using the LCH (Luminance, Chroma, and Hue) adjustments for both highlight and shadow, as well as specify (via a series of pull-down menus) the degree of correction to Highlight, Shadow, Color Cast, Contrast, and Chroma. If further corrections are needed, users can summon a standard Curve dialog and a Saturation dialog. D-Cam's post-processing control on high-bit camera files actually surpasses that of Photoshop.

D-Cam can be used to tethered Kodak DCS cameras as well, allowing the user to apply corrections at the capture stage. Many common camera controls, such as setting the internal date and time of the camera, formatting the PC cards, or updating the firmware, can be accomplished in the software. The software has some special features designed for

digital camera files, such as a Color Noise Reduction filter and the ability to import Kodak DCS raw files into an image index page for simple selection (Figure 4). D-Cam is a fine piece of software for correcting camera files for output, even when using an ICC workflow. If you have experience with LinoColor, D-Cam is a snap to learn. If not, expect a steep learning curve much like LinoColor, as these software packages are very sophisticated and powerful.

More info? Circle Reader Service No.:
Adobe Systems Inc. (180)
Eastman Kodak Company (181)
Phase One (182)

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