Calibrating the Digital Darkroom Environment

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As a color scientist, I am often asked, "Can you design a system that simply reproduces exactly what's in a scene?" I respond, "No." Quite perplexed, the inquisitor asks, "Why? This is supposed to be a science! It can be measured; there should be methods that can accomplish this." While there are many reasons, typically I have to explain the problem of dynamic range—the ratio of light to dark.

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An average exposure of a scene with a very high dynamic range.
The dynamic range is far greater than the camera's chip can record.

In a high-contrast scene, such as that depicted in this photo of a warehouse, a reflection off of a shiny object could emit almost the full power of the sun. The area under the roof that is in shadow may only reflect .00001 the power of that highlight. So it's quite possible this scene has a dynamic range of 100,000 to 1. A large problem arises when I want to capture and print this image. The dynamic range of even the very best printing methods—from the paper white to the darkest black—is around 500 to 1. In order to realize this image on my wall I have to reinterpret the original values in the scene.

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To capture a scene with a dynamic range this wide requires making several exposures.
The exposure on the left was made to capture detail in the shadows, while letting the highlights wash out. The exposure on the right was made to capture adequate detail in the highlights. The photo in the middle is a blend of several exposures, to create a true, high-dynamic range interpretation.

The art of photography is the reinterpretation of a scene to the printed page. As any accomplished photographer will tell you, a photograph is an interpretation of the scene. Photographers decide how to record the values and how the values that are recorded translate to the finished prints. Photographers may attempt to recreate how they remember the scene looking, or they may work with the values to create a completely different interpretation.

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The power of digital photography and tools like the Adobe® Camera Raw plug-in, is the interactive preview. This preview can give you an accurate representation of how your image will look when developed using the settings you choose. You can preview many versions of an image before making even one test print. When you are happy with your image preview, a simple press of a button develops the image. With these steps, you can create the artistic interpretation of the original scene into the lower dynamic range of the final print.

For this to work properly your computer's display must be calibrated and the ICC (International Color Consortium) display profile must be accurate. In addition to ICC calibration and profiling, you must also adjust and calibrate the dynamic range of the display and the environment in which you work.

A photograph is a translation from the scene's dynamic range to the print's dynamic range. Your display should match the dynamic range of your print. This is very important! If you only do ICC calibration and pay no attention to the dynamic range of your display, the prints will not come out as you expected. If you allow your displayed dynamic range to fluctuate, the result of your efforts will also fluctuate. What you see on-screen must match from day to day and year to year.

Display dynamic range

The dynamic range of a display, just like a scene, is the ratio of black to white. To adjust a display's dynamic range, you must be able to independently adjust white and black. On a cathode ray tube (CRT), you can make these adjustments by setting Brightness (black) and Picture or Contrast (white). You must make very accurate measurements for black; a very small change in the black setting can have a large effect on the ratio. You should calibrate these settings often (once a month) because the luminance of a CRT changes over time.

Liquid crystal displays (LCDs) pose a major problem. Most LCD displays cannot adjust black and white independently. LCDs use a backlight, so when you increase the brightness of the backlight, both black and white increase. The contrast ratio of the display is fixed for any given luminance. The half-life of most LCD backlights is two years. The best you can do with an LCD is to adjust it to half of the maximum luminance. Each time you calibrate your LCD, adjust the luminance to the same value that you started with. You will not be able to adjust the dynamic range, but at least this method will keep the dynamic range relatively stable.

You can forgo all adjustments by purchasing a monitor that can calibrate and set the dynamic range automatically. A monitor, such as Sony's Artisan Color Reference System, can automatically calibrate and set this range.

Environment and dynamic range

Calibrating the dynamic range of the display is only half the battle. Your perception of the image must stay as constant as the display itself. The environment in which you view an image has a big effect on the way you perceive it.

Black is the color of your display glass. When you turn off your display, you are looking at black. The display cannot produce a darker black than what the screen looks like when it is turned off. Ambient light in the room raises the luminance of black and thus changes the dynamic range.

If the light in your room is fluctuating, the product of your hard work will also fluctuate. Windows are bad things to have in the digital darkroom. To maintain a fixed dynamic range, you have to keep your working environment fairly dark and stable. Light and color that enters the eye from areas outside the display will affect your perception as well—bright yellow walls and a desk lamp next to your monitor are not good ideas.

The environment for soft-proofing

The environment in which you do your work also has a big impact on the final image. Here I will layout the optimal viewing conditions. While not everyone will be able to match these conditions exactly, the closer your environment comes to these conditions, the better and more consistent your results will be.

With the light output levels of current display technology, an ambient light level of 4 lux is an optimal compromise. While a lower light level would provide better results, it's impractical. You need to be able to walk around your environment. Above 16 lux, the room ambient will have a very significant effect on the dynamic range of the display. Whatever light level you pick, it is very important for it to be consistent. A blackout curtain over a window with a small light leak around the edge could make the room illumination vary by as much as 100 lux between day and night. Sunlight is very powerful.

It is best to provide the room illumination from a fixed, artificial source. The light source should be diffuse, indirect, and located outside the field of view. The monitor's face must be shielded from the light source to eliminate screen reflections. Ideally, the light source should be located directly above you and should reflect off the ceiling so that no incident light meets the monitor's face. The color of the light source should match the D50 standard prevalent in the graphic arts and printing industries. A single D50 fluorescent lamp, which is hung one foot from the ceiling, faces up, and is baffled to control the amount of light, works very well. Make sure the ceiling is painted with a pure white, titanium-dioxide pigment.

Colors in your field of view or surfaces off which the ambient light reflects need to be neutral. Other colors in your field of view affect the perception of color on your display. To eliminate this effect, all surfaces should ideally be painted Munsell 8 gray. Furniture should also be neutral. It is crucial that walls from which light is reflected, or fall within your field of view, be painted Munsell 8 gray.

You should also set the desktop background on the display to a neutral gray with a value of 50 L*. Ideally, you should wear black clothing when you are working with images; your image is often reflected in the display. The area the display faces should be as dark as possible; in fact, painting a black wall behind the operator is often used in professional color editing suites.

When making color-matching judgments on-screen, you can use a reference original—a swatch of fabric or paint chip. The viewing conditions for this reference must also meet strict criteria and be designed to have the least effect on the display. The intensity of the reference light source should be set such that paper white luminance is equal to the monitor's white luminance. The reference light box should be constructed so that the subject area is evenly illuminated and no light spills beyond the subject area into your field of view. Reflecting surfaces in the reference light box should be Munsell 8 gray.

The monitor's screen and the printed reference should be equidistant from you. Ideally, both the screen and the printed reference should fall within a 2° angle so that you can base all color judgments on light striking your eye's fovea, but this construction is impractical because it would require you to be positioned approximately 20 feet from the subjects. In practice, you can obtain significantly better perceptual matching when you are positioned so that the screen and the printed reference are not only equidistant, but they also are at the same viewing angle, rather than you being positioned directly in front of the monitor. You should have to move your head to view each subject separately. Because one subject is a transmission source and the other is a reflective source, both subjects should not both be in your field of view at the same time.

Digital photography is a revolution in the photographic art. In order for us to achieve the promise of this revolution, the display and the environment in which you work must be calibrated and constant. We no longer have to work in a darkroom—just a dim one.

Karl Lang

Karl Lang—product creator, scientist, artist and engineer—has worked to bring a long history of products and technologies to market. You may recognize some of them: The Radius System 100, Thunder Color, PressView, Artica, and The ColorMatch System. Recently Karl was the architect for the Sony Artisan Color Reference System.

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