TECH SHEET 18

Exploring the Raw Digital Format

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The Evolution

A long time ago, way back in the early nineties I made photographic images with this stuff called film. I would reflect photons through a light gathering device to record images on this amazing media. If I was a little off on my exposure, say an f/stop over or under, I was still in good shape. I could go into my cave with chemicals and adjust the exposure on my photographic paper exposer to produce a photograph that had the tones I wanted. It was phenomenal what you could do with a little controlled processing after the initial exposure of the negative. My creatively exposed negative was not limited to the inferior results I would get from the "automated" drug store.

Time traveling to the current day, we find that photography has shifted away from those "romantic nineties." The act of recording light to a semi-conductor sensor, converting it to binary code and trusting the precious tone of an image to a processor programmed by someone far removed from the creative process can propose quite a challenge to a photographer. Do you feel the little gerbil inside the camera has more control over the TIFF or JPEG on the compact flash card than the photographer? If you have purchased into the digital realm, started the learning curve toward digital mastery, and found yourself wanting more, the RAW file format might be just for you.

Digital Negatives

To battle that gerbil, digital camera and software manufacturers have given us a useful tool that offers what Ansel Adams would metaphor as the score to the performance. A true digital negative that can be custom processed and interpreted after the time of exposure! Each camera manufacturer has their own name for their RAW file format, so it can get a little confusing. The camera tags each RAW file with a special file extension (see chart.)

RAW file Format Extensions

Canon	.CRW
Fuji	.RAF
Kodak	.DCR
Minolta	.MRW
Nikon	.NEF
Olympus	.ORF
Pentax	.PEF

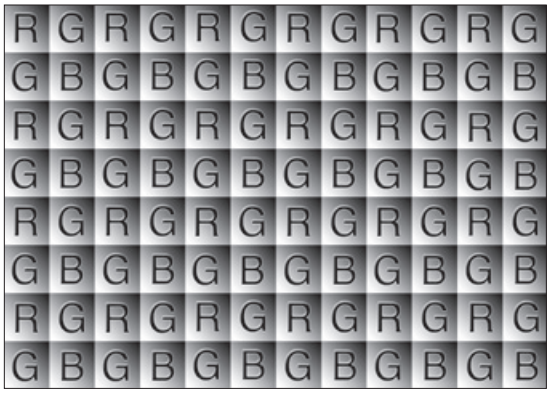
These RAW files are not universally supported like a TIFF or a JPEG. You can't just open them in your editing software and start working on them. Proprietary RAW format files need to be processed either by their own manufacturers software or another interpreter such as Adobe's RAW image converter built in Photoshop CS. This post-exposure processing offers the maximum amount of control in a digital camera workflow.

Dissecting The RAW

Let's review how the camera captures and processes the image first. The light sensitive chip inside the digital camera is divided up into a grid of units called photo sites or pixels. How many of these photo sites you have is the resolution of the chip (and directly related to how much you paid for the camera.) A six mega-pixel camera has six million photo sites on the sensor.

The photo sites are sensitive to light intensity not color, so on top of each pixel a microscopic colored filter is placed. Each filter is painted one of the primary colors of white light (Red, Green, or Blue). These dye painted filters follow an alternating four grid pattern across the sensor which is called the Bayer Pattern (see figure below). Color theory endorses if you have one red, one green, and one blue pixel and combine them together at different intensities you would be able to make an RGB pixel of any color. This is how that expensive little color-blind chip in your camera can make a color picture.

Most common manufactured sensors commit to the RGBG color fil-

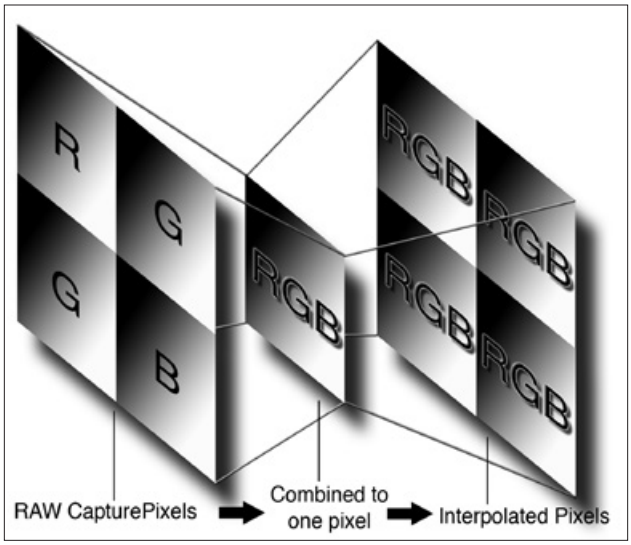


The Bayer Pattern, is an alternating four grid pattern.

ter array repeated across the sensor. Be aware that some older sensors are painted CYGM (Cyan, Yellow, Green, Magenta). New sensors made by Sony are adopting the RGBE (E representing an 'emerald' painted pixel filter) color filter array. These newly colored pixels are said to have an expanded gamut of color sensitivity.

The RAW image file of the 'color' image recorded is an unprocessed mosaic pattern of these colored pixels. What the camera truly saw behind the pixel's colored filters.

Through the magic of algorithmic mathematics (the gerbil in the camera), software reads each raw pattern of four pixels and averages them together to make 1 full color pixel in the digital photograph produced by the camera (see diagram). Wait a second, 6 million pixels divided by 4 turns my 6 mega pixel camera into a 2.5 meg camera! The mathematics then interpolate the 2.5 million pixels back up to 6 million and save it on the storage card in the camera as a JPEG or TIFF file format. Now, some algorithms can get very complex, and this is where different software programmers compete for better image quality.



The Internal Camera Processing of a TIFF file formatt.

This powerful processing of the image by the camera's internal brain slows down the writing time to the storage media and locks out the trigger from making another exposure. If you choose the non interpolated RAW file format, the camera will not process the file to a TIFF and save the smaller RAW image for custom processing later.

Because the image is RAW, none of the camera's internal settings (White balance, contrast, sharpness, etc) are applied to the image. This means if you screwed up and had the camera set to tungsten color balance while outdoors in open shade, no problem! The file can be processed correctly later on. If you used a JPEG or TIFF you would have to correct your image in Photoshop sacrificing image quality and possibly introducing banding and noise to the image.

Some scanners and drivers support raw file formats in a similar way. Simply save the raw format of the scan (what the RGB sensor in the scanner captured), then custom process the raw scan later in a software that supports the scanner's Raw format.

Processing the RAW Format

When opening a RAW file in Photoshop CS you will get the RAW Image Converter window (see image). Within here lies the controls to offer many different interpretations of the captured file. Most all of the processing controls of the camera including some additional features can be set, corrected, or adjusted. Starting in the lower left area there are four pop up windows. First you can choose a color space that you would like to map the data into. Set this to your preferred RGB working space in Photoshop. Next is bit depth, choose 16 or 8 bits per channel. Next you can set the Size (total resolution) of the processed image, and how you would like the that resolution sampled in pixels per inch. The Right hand side is where the real fun starts. The Adjust tab offers many ways to improve an inferior image. Color way off? Choose a different White Balance or adjust the Color Temperature and Tint. Exposure look a little dark? Go ahead, open up a third or half a stop. Can't do that if you photographed in TIFF Mode. Adjust how black the shadows are (set

The Image Converter window of a RAW image opened in Photoshop CS.

a black point). Forgot to check that histogram on that once in a lifetime image? You even get a live histogram that shows you real time adjustments to the file as you work. Tucked away behind the rest of the tabs are many other tools including Sharpening and Noise Reduction. Behind the Lens tab, there's a neat new feature that allows you to simulate a vignette either dark or light that will 'burn in' or 'dodge' the edges of the image.

The eyedropper tool in the upper left corner toolbox can make any tone sampled by it neutral. If you include a Kodak grey scale or grey card in one of your images of a given scene, the software has the capabilities to save the neutrality and apply it to another image. This can be very powerful for removing color casts and getting exact color temperature settings in tricky lighting situations.

Each of the camera manufacturers (Canon, Nikon, Fuji, etc) make interpreters for each of their proprietary RAW files. There isn't enough room here to show them all. Each actually calculates a slightly different algorithm when processing the image, so you can get different results depending on the software used. Several other independent software companies (Bibble, Photofirst Qimage, VueScan, PhaseOne, etc) sell multiple format interpreters. Some offer free trial downloads before purchasing. Be sure to check before buying that your format is supported. Many Nikon fans enjoy the control found in the purchased version of Nikon Capture RAW Image Converter. Adobe's all in one combo in the new Photoshop (and its built in File Browser) packs quite a digital punch that's hard to beat. Intuitively laid out with lots of adjustments, it's the choice of many photographers. No matter which Raw interpreter you choose, quite frankly its much more easy to apply camera settings to the images at home on a large monitor rather that a 2 inch LCD on the camera back in bright sunlight.

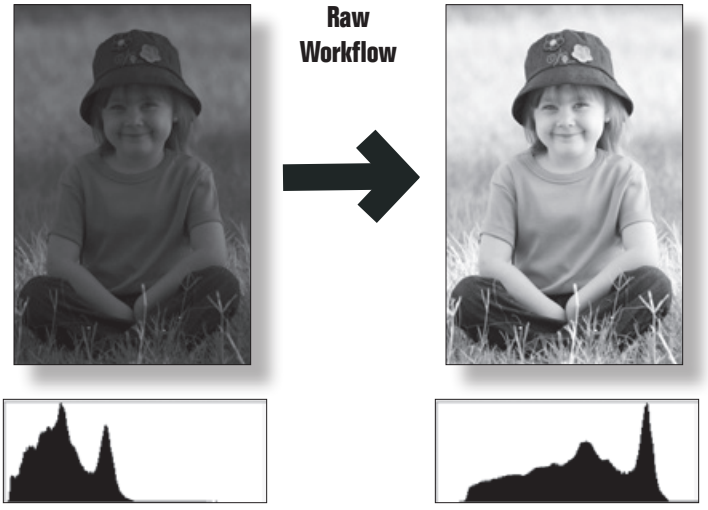
The Real Advantage: The proof is in the Histogram

As photographers we seek gradations of tone in our images. We desire separation in the shadows without noise or banding and subtle gradations in the highlights producing fidelity. We want smooth, even mid-tones with out artifacts or posterization. There is no better way to achieve this than using the RAW format. Opening into Photoshop custom processed with all the horsepower of 16 bit is the only way to do it (until we get 32 bit cameras)!

Compare the histograms of an under exposed 8 bit TIFF, opened and adjusted in Photoshop, to an underexposed RAW file processed in the RAW converter to a 16 bit TIFF. The stripes or broken up lines in the histogram reflect the breakdown in tonality gradation in the image after torquing the tones with adjustments. This is where subtle banding or posterization can ruin the smooth gradations of softer tones. The equivalent RAW image corrected and processed reveals a histogram with no gaps in it offering the smoothest gradations and highest quality of tones.

An Underexposed Original TIFF.

An 8 bit TIFF image corrected in Photoshop with resulting Histogram.



An Underexposed Original RAW File Format.

A 16 bit RAW Image corrected and saved as a TIFF.

Bit Depth Primer: Understanding why we desire more

Dynamic range, measured in bits per channel, determines how much detail gets recorded in highlights and shadows. Computers calculate digital images in binary codes, 0's and 1's. How many bits or slots the binary data is entered in reveals the amount of combinations that the data can render into tones.

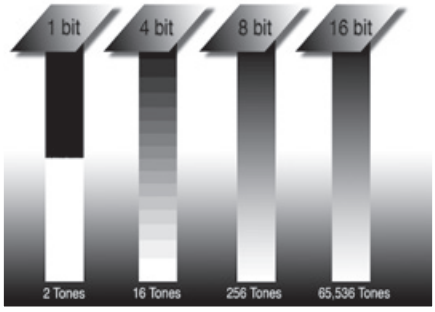
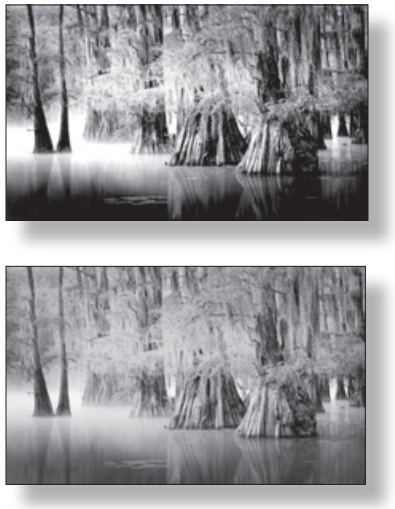


Image Bit Depth is measured by a pixel's capability to distinguish one tone from another. The larger the bit range, the smoother gradations will be reproduced.

1 bit images can contain only 2 (2x1=2) tones:
0,1
2 bit images can contain 4 (2x2=4) tones:
00, 01, 10, 11
3 bit images can produce 8 (2x2x2=8) tones:
000, 001, 011, 111, 110, 100, 010, 101
4 bit = 16 tones
8 bit = 256 tones
10 bit = 1024 tone
12 bit = 4096 tones
16 bit = 65,536 tones

The RAW image file format extracts the full bit depth of the camera's capability. The true bit depth of a chip in a digital camera is difficult to find out, and many argue the numbers given by manufacturers are not reliable. Another confusing aspect of bit depth is that Photoshop 'rounds up' any image that is greater than 8 bits per channel to 16 bits per channel. Even though a camera has a sensitivity of 10 bit (1024 tones) or 12 bit (4096 tones), the processed image opens in Photoshop's expanded 16 bit (65,536) mode.

Total bit depth is calculated by multiplying bit depth times the number of color channels (RGB=3) in an image. An 8 bit RGB image has a total bit depth of 24. A 16 bit RGB file has a total bit depth of 48. Scanners follow this exact same formula.



Top: A Low Dynamic Range Image compared, bottom, to an Image with Higher Dynamic Range.

Is It For Me?

Living in the land of ORFs and NEFs can be a little intimidating for the non-geek. It does require more work on the photographer and less on the camera's gerbil. Some will try it and not see much of a difference. Others will not use anything else. If you are photographing for high quality print, not the Internet, the difference in quality of using the RAW file format can be jaw dropping. Once you get used to it, it's hard to go back.

The RAW image format eats away storage memory quicker than a JPEG, offering lower images counts per card. This seems to be a big issue for some photographers. That same RAW file takes up to 60% less room than an uncompressed TIFF. Also, the RAW file writes to the storage card quicker than a TIFF, freeing up crucial time in between exposures.

If processing the RAW sounds like it would take too much of your time, try becoming more familiar with Photoshop's powerful batch processing tools and the recording of actions for repetitive tasks.

Unless you consistently nail the exposure, color balance and every other menu setting on the camera for every photograph you make, the RAW file format will always be a better choice for the ultimate in image quality and versatility.

About the Author: Scott Campbell

Scott Campbell is a photographer living and working in East Texas. Graduating with top honors from Kilgore College in 1983, he received an Associate of Applied Arts in Commercial Photography Degree under the direction of O. Rufus Lovett. Working at one of the largest digital photography studios in East Texas, Scott developed and implemented many successful digital processes for Dynamic Resource Group the company he works for. His work has been exhibited throughout the country and is included in many permanent collections. Scott's Web Site is: www.easttexasphotographer.com.

Scott Campbell
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