Ruminations on Digital Imaging

I am old enough and have been taking photographs long enough (since the early 1970s) to be firmly in the silver halide film generation. You might think that I might be one of those lamenting the rise digital imaging. On the contrary, I am typing here to laude the suitability of digital imaging in capturing the world as our eyes comprehend it.

One good thing about coming out of the era of photography that I did is that you had to be able to use a hand-held light meter but I must admit I had one camera with an in-built light meter (a Nikkorex with a non-interchangeable zoom lens no less!) and it was just so much more convenient to use.

However, the really good thing about using the hand-held meter was that you learned to appreciate Exposure Value (EV).

Using your light meter, EV was a sort of average exposure for the scene. (Your digital cameras do exactly the same thing today). However, with the hand-held meter, you read your EV and then set your dial to give a range of apertures and shutter speeds that will fit with that EV. (ISO was fixed from the type of film you loaded in your camera – now ISO is a third variable you can juggle along with aperture and shutter speed.)

What is EV? For a long time I thought of it as just some sort of linear measure of scene brightness, but I was completely wrong.

Look at the way we adjust shutter speed:
1/1000 second, 1/500, 1/250, 1/125, 1/60, 1/30, etc. >>>> all factors of 2

Look at ISO:
50, 100, 200, 400, 800, 1600, 3200, 6400, etc. >>>> factors of 2 again

What about aperture?
f/2, f/2.8, f/4, f/5.6, f/8, f/11, f/16, f/22, etc.

Surely this isn’t varying by a factor of each time the change by one f-stop? Well, we are. To adjust for the amount of light hitting our camera’s sensor for different lenses with different focal lengths, we express aperture as the focal length (f) divided by the actual size of the aperture. Hence, for f/2 in a 50mm lens, the diameter of (approximately circular) aperture would be 25mm. However, the amount of light reaching the sensor is in proportion not to the <u>diameter</u> of the aperture but to the <u>area</u> of the aperture and area of a circle equals *pi multiplied by the radius squared*.

The square root of 2 is 1.414 or let’s just call it 1.4. To double the area of a circle, the radius (and the diameter since radius is just half the diameter) just has to increase by 1.4 (approximately). This is why <u>number in the f-stop series varies by a factor of 1.4</u>. Hence one EV difference from f/2 is f/2.8, etc.

So whenever we vary our image exposure by one EV, whether it is by varying shutter speed, aperture or ISO, we are increasing (or decreasing) the amount of light hitting our camera's sensor by a factor of 2.

To reiterate, to take a correct exposure, we need to balance shutter speed, aperture, and ISO (sensitivity of the sensor). Using the camera's sensor as with a hand-held light meter, there is an appropriate exposure value (EV) for any given scene we want to capture. If Scene A had an EV of 8 and Scene B had an EV of 9, the light in Scene B would be twice as bright as Scene A.

Each increment in EV means a factor of 2 in brightness. A difference in EV of 2 means a factor of 4 in brightness and EV difference of 3 is a brightness factor of 8 and an EV difference of 4 is a brightness factor of 16.

EVs approximate to the way our eyes and brain see variations in brightness. What about digital cameras?

When we pick up our cameras, we are holding in our hands more raw computing power than the whole of NASA when they put a man on the moon.

All of that computing power is there just for us to capture our images, the good images, the bad images, and even the ugly. As a portable computer, our cameras, like all modern computers, uses the binary number system. To capture an image, each point within the image is represented by a group of binary numbers.

What is a binary number? For computers to count, they either see zero voltage (corresponding to binary zero) or they see a voltage (one in binary). So the numbers used by computers are made up of ones and zeros only.

In the decimal number system we are used to in our daily lives, we have ten numerals (0, 1, 2, 3, 4, 5, 6, 7, 8 and 9) but we are not limited to counting up to 9. In the same way, computers can count beyond 1.

In the same way we go back to using 1 again once we are past 10 in the decimal system (e.g. 8, 9, 10, 11 …… etc.), to count in binary like a computer, the sequence is like this:
0, 1, 10, 11, 100, 101, 110, 111, 1000, 1001, (etc.)

Converting binary to the decimal system, the conversion can be expressed like this:

Binary	**Decimal**	**Decimal as power of 2**
10	2	2^1
100	4	2^2 (e.g. 2 squared)
1000	8	2^3
10000	16	2^4
100000	32	2^5
1000000	64	2^6
10000000	128	2^7
100000000	256	2^8

Now, the last of these numbers, 100000000 should be very familiar to you. It is the maximum number used in describing any value in a JPG image. This is why JPG is called an 8 bit format (two to the power of eight) and why there can only ever be 256 (in decimal) level of grey, etc, in a JPG image.

However, the actual light sensors in our camera capture 12 or even 14 bit images. 2 to the power of 12 in decimal is 4096 so, when we shoot in JPG, we are potentially keeping only one sixteenth of our original image data.

Well, so what?

The scary part of “so what” is that the way we actually see is just like binary arithmetic. Also, from the beginnings of photography, cameras have been working in a binary model even when they used silver halide emulsion as the light sensor because the very essence of photographic exposure is the Exposure Value (EV), and EVs work, as described above, as factors of decimal 2 (binary 10).

This is why there is such a good match between binary numbers and EVs. An image with a range of light intensities across it (from the deep shadows to the bright highlights) of, say 8 EVs, will fit nicely in the middle of the histogram of an image capture with a 12 bit sensor, leaving room of 2 EVs at either end.

This also illustrates why we should shoot in RAW rather than JPG – using JPG strips away the information RAW provides us in the highlights and shadows in our images.

What is the moral of all this? Principally, we need to realise that digital imaging, rather than being an alien interloper into the wonderful world of photography, is a natural fit to EVs and that EVs represent the way we actually see light. So the next time you fire up your computer, whether it is a mainframe, a desktop, a laptop, a tablet or a camera, have a thought for how you have a lot more in common with it than you might have thought.

NOTE: Any errors in fact are all mine.

David Woodcock, 23/12/2014