Vision and Contrast
Part 1

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In traditional/silver-based photography, the ratio between the brightest and darkest parts of a subject the film exposing/processing protocol of choice can record is directly proportional to the brightness range (inherent contrast) of the subject. The contrast of the finished representation of the subject, if everything in the photographic process is done properly, will also be directly proportional to the subject brightness range.

In digital photography contrast is referred to as dynamic range (D.R.). The D.R. capability of the camera sensor is the ratio between the maximum record-able signal strength (highest brightness) and the camera (visual) noise of a captured image. (This relationship is referred to as the signal to noise ratio, S/N.) Signal strength is limited by the maximum sensing capacity of the individual pixel. Noise, in this case, is the sum of the dark and read noises. (Visual noise is most easily seen as a flat darkening with no detail, often found in parts of the darkest areas of a digital image.) Dark noise is the image degradation caused by the image sensor's inability to discern contrast detail in low light situations. As the light level decreases, dark noise increases. This is not due to inherent sensor difficulty with low light situations, but instead to the time duration necessary to capture the image. Longer exposures result in more noise. Noise also increases proportionally with higher sensor temperature and longer exposures raise the temperature of the sensor due to the duration of work. Read noise is the image degradation arising from the limitations of the individual pixel amplifiers during signal processing. Again, the longer it takes to process the image, the more the read noise. A subject, and proportionally its representation, that vary from brightly lit to deep shadows are said to have a high dynamic range, while indoor, dimly lit or other low contrast subjects will have a low dynamic range.

As noise decreases, dynamic range increases. As dynamic range increases, the ability of the device to differentiate between the light and dark areas of the subject increases. The digital image when viewed on a monitor or reproduced in printed form will contain and reproduce the captured light to dark image information within the capabilities of the capture device and within the ultimate capabilities of the display/printing output. As in human vision, the lower the inherent contrast of the subject or scene, the harder it will be for the camera/sensor of choice to resolve the differences in the captured features. Therefore, the higher the dynamic range or contrast of the subject, the better the perceived sharpness/resolution of the resultant image. Obviously, the camera makes internal trade-offs to maximize both dynamic range and image resolution. Many camera manufacturers install image-optimizing software in their cameras for processing the captured images while converting them to jpegs or tiffs. In-camera sharpening software could diminish dynamic range because it may amplify noise. When considering the purchase of a digital camera, be sure to consider your quality needs and compare them to the equipment's quality capabilities

The ship on the left has lost detail in the shadows. The one on the right has shadow detail restored.

In traditional photography, there are several techniques useful to photographers for optimizing the subject brightness range thereby minimizing the difficulties a wide range of subject contrast may cause in image capture and reproduction. When the subject brightness range is very broad, it is often necessary to make compromises at one end of the brightness scale or the other, in order to produce an image with differentiated tones in the areas the photographer feels are important. The production of either flat highlights or blocked shadows is possible and

probable when exposing film on very sunny days.

When working digitally, the existing subject contrast, any physical techniques used to minimize the subject contrast, and any possible adjustments made to the programming of the camera, may or may not make it possible to capture the entire existing dynamic range of the subject. In recording subjects with very high dynamic range, digital cameras will of necessity make compromises for the user, allowing the capture of only the parts of the subject range the camera computer decides are most important or the parts of the range the operator has set by choice for the camera's capture parameters. These compromises are necessary because no camera or output device (including even the un-adapted human eye) can reproduce in one instant, the very broad dynamic range (contrast) existing for many subjects. Sources show the most acute human eye, belonging to a person of the optimum (young) age, has an absolute sensitivity range (contrast capability) of more than 1,000,000:1 between fully adapted (dilated), and viewing subjects ranging from near total darkness to the brightest possible conditions existing at noon daylight in the snow. Taken a slice (any current reality) at a time, the normal, and not too old human eye is able to discern a dynamic range or contrast ratio somewhere between 10,000:1 and 30,000:1, at any one time, under regular adapted working conditions. Therefore, the adapted range of vision, is at minimum when compared to a photographic reproduction, of about 13 ½ camera f-stops.

The necessity for compromise in image capture, when using either traditional or digital photographic hardware, becomes understandable when considering both of their limitations when compared to what truly exists in nature or to what we can truly see. Traditional black and white camera film, exposed and processed under the most exacting conditions is capable of a contrast capture ratio of about 256:1 or 7 f-stops. (Or a bit more in the case of sheet film, that can be exposed and processed individually and maximized for a particular situation.) When the negative is converted to a reflective print, the ratio falls to about 100:1 or 5 ½ f-stops. Color glossies from color negatives will yield a maximum of about 50:1 or 4 ½ f-stops. Some of the best digital cameras set at ISO 80-100 have a dynamic range capture capability of about 700:1. That means the camera is capable of handling all the detail in an image comprised of about 8 ½ f-stops of brightness. Monitor images reduce that ratio to anywhere from 150:1 to 300:1, depending upon technology, and digitally produced hard copy is a match with the color negative glossies. No digital capture device or method, film, monitor or print could possibly reproduce the range of illumination existing in most normally lit subjects. It is important to note that, as in conventional photography when using slow speed films, the light sensitivity (ISO) of the digital camera, in order to capture the broadest sampling of the subject brightness/dynamic/contrast range of the subject, should be set at the lowest possible practical level.

Of course, there are mechanical and software solutions for adjusting the finished contrast of digital images. Professional cameras and image processing software are able to represent the finished digital image as a graph or histogram, where the concentrations of tone values of an image are represented quantitatively. Stretching the image histogram will increase the details discernable in both the highlights and shadows of a finished image. It may also be possible to enhance detail in either the highlights or shadows of an image individually, or by using combined layers of multiple images of the same subject. If using multiple images, the images need to be captured specifically to contain brightness information elements from the light, normal and dark parts of the subject brightness (dynamic ranges), while not otherwise changing the content of the image.

The next column in this series will explain methods to mechanically maximize the contrast or dynamic range of the subject before creating the image exposure.

Highlight detail lost

Highlight detail restored