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HD image capture: a welter of interacting choices

PBS has convened the Quality Group to improve the quality of the digital signals that public TV sends into viewers' homes. The group's yearlong Video Technical Quality Improvement Program, funded by CPB, goes where all broadcasters have had to go: into the chasms and wormholes of digital TV. Mark Schubin, engineering consultant on many PBS productions, is author of the series' second article.

By Mark Schubin

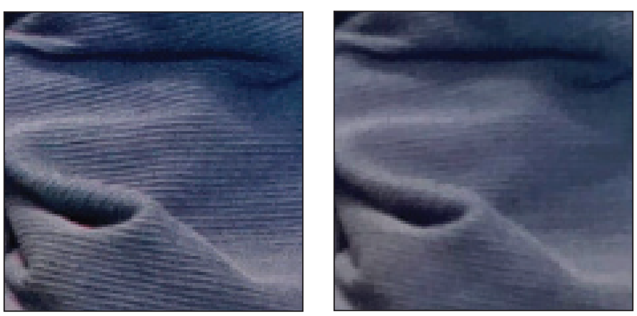
Part 2: Image acquisition

As recently as 15 years ago, the equivalent of an HDTV camcorder—a camera, lens, and recorder all capable of HD—could cost as much as $1 million. Today, despite inflation, HD camcorders are sold at prices as low as $100, and even the most expensive don't approach that 1995 price. But there's more to capturing quality high-definition images than just an HD camcorder.

Consider a loaf of bread. Its major component might be wheat flour, but other ingredients, how they are combined, and how the dough is baked can affect the taste, look and texture.

High-definition image acquisition is similar. It requires a camera, of course, but also an optical system consisting of lens, iris, perhaps some filters and, even before the images reach the lens, scene lighting.

In the first article in this series on digital television quality, a pair of images showed how a polarizing filter can remove unwanted reflections that might otherwise be nearly impossible (short of frame-by-frame "painting") to eliminate in postproduction. Here is another pair of images—blown-up pictures of corduroy fabric.



Images from www.cambridgeincolour.com, used with permission of Sean T. McHugh.

In the picture on the left, the detail of the fabric is clearly visible. On the right, much of the detail is lost. The two pictures were shot with the same camera and lens. The factor that makes the difference is the lens-iris setting.

As iris settings get smaller (higher *f* numbers), light diffraction reduces the contrast ratio available in fine detail. When the contrast ratio reaches zero, resolution is lost. It might seem, therefore, that it's always best to shoot at the widest possible iris setting.

Unfortunately, other sharpness-reducing factors, lens aberrations, tend to get worse the wider the setting. Maximum sharpness is achieved at iris settings between aberration limiting and diffraction limiting.

Suppose you've determined that, for your camera and lens, an iris setting of *f/4* offers maximum sharpness. How can you achieve that setting? One possibility is by adjusting lighting. Another (assuming there is enough light) is by using a neutral-density filter. Yet another (again assuming sufficient light) is by adjusting such camera settings as gain (video signal amplification) and shutter duration.

When we shot standard definition, there were aspects of acquisition we simply did not worry about, because the choices made little to no perceptible difference. With HD, however, we need to pay attention to those matters because we otherwise could lose the sharpness and detail and thus undercut the quality improvement we sought.

In these next images, the first pair shows the "Black Stretch" setting at +3 on the left and -3 on the right. The second pair shows "Master Gamma" at .35 on the left and .75 on the right. The third pair shows "Dynamic Level" at 200 on the left and 500 on the right.

Images from *Goodman's Guide to the Panasonic VariCam* by Robert Goodman, AMGMedia Publishers, used here with permission.

Those pictures were all shot with the same camera, lens and lighting; only the camera's image-processing settings were changed. But, based on those processing settings, lighting and iris settings—perhaps even makeup and clothing—might have been adjusted, too. There is interaction between camera settings, lens adjustments and lighting.

A broad range of processing settings is found on higher-end cameras and camcorders, but there are many other differences between models. One significant one is the size of the image sensor or sensors used.

The basic sensor size for studio HDTV cameras for the last 15 years has been the so-called "2/3-inch" format, even though nothing about it measures 2/3 of an inch (the designation is left over from the days of tube-based cameras, when a tube with an outside diameter of 2/3 of an inch had an image size matching that of today's 2/3-inch-format chips). Chips used in professional HD cameras and camcorders can be as small as 1/6-inch format (roughly a quarter of the width of a 2/3-inch format) and as large as "full-frame 35 mm format" (almost four times wider than the 2/3-inch format).

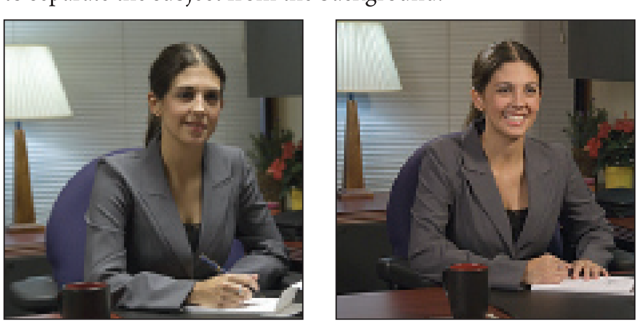
All else being equal, the larger the sensor, the more sensitive the camera (the less light it needs), the greater the dynamic range (the ratio between brightest part of the image and darkest shadow detail), and the *shallower* the depth of field (the range of distances from the lens that appear to be in focus at the same time).

For some applications, such as shooting a landscape or even a news story, more depth of field can be desirable. For others, such as shooting a "talking head" and separating the subject from the background, less depth of field can be desirable. The version on the left below might be desirable when a foreground reporter (or Gromit) is discussing an incident in the background. The version on the right in the pair might be better to direct attention to the foreground character.

Images from a website about depth-of-field, toothwalker.org/optics/dof.html, used here with permission from Paul van Walree.

Thanks to sufficient light and camera sensitivity, both pictures could be shot with the same camera and lens. The difference in depth of field, in this case, is based on iris setting. In general, larger-format image sensors can deliver greater depth of field when their lens irises are set to small apertures. Small-format image sensors, however, might not be able to deliver shallow depth of field.

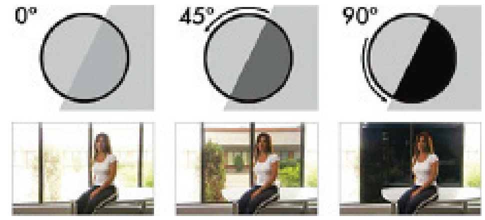
When it's not possible to control depth of field, it may still be possible to separate the subject from the background through the use of lighting. In the first of these photos of an interview in an office, there is sufficient ambient light to make a picture, but the second adds lighting to separate the subject from the background.



Images from the lighting-education website of Lowel-Light Manufacturing Inc.

Sometimes improving the lighting involves reducing rather than adding light. Note the closed blinds behind the subject above. If it were desirable to see what was outside the window, it might have been necessary to cover it with a filter of some sort.

One filter used in such situations is Rosco View, a two-part window-filter system that uses a polarizing gel on the window instead of a simple neutral-density filter. As shown here, a second polarizing filter in front of the lens can then be rotated to admit the desired amount of outside light.



Given their increased sensitivity and dynamic range and their ability to offer shallow depth of field, larger image sensors might seem best, but they can mean larger cameras. Pocket-sized camcorders usually have small-format image sensors but can be desirable for other reasons. Not only are they readily available for use, but they also don't look like traditional TV cameras. As a result, fewer subjects will feel they should "perform" for TV news.

A new HD camera option is a class of devices that don't look like TV cameras at all. They are digital single-lens reflex (DSLR) cameras, capable of shooting HDTV as well as still images. Their sensors tend to be very large—the *smallest* is a so-called "4/3" format, roughly twice as wide as 2/3-inch sensors; the largest is the size of a 35 mm still-camera frame, roughly twice as wide as the 4/3 format, with twice the area of a 35 mm motion-picture frame.

The large-sensor format offers high sensitivity (often sufficient for shooting at night without added lighting) and shallow depth of field. The cameras usually offer a broad range of lenses. And, although a DSLR looks like the sort of camera a photojournalist might use, it does *not* look like a TV camera. Unfortunately, HD-shooting DSLRs lack many features desirable in TV cameras, such as time-code inputs and outputs and connections for live, multicamera shooting.

Accessories are available to convert a DSLR to a cinematography camera, though with mixed results. On the left is Canon's EOS 5D Mark II, a DSLR that can shoot HDTV. On the right is the same model camera (almost invisible behind the large white focus disk) after the addition of nine accessories from Cavision.

Even after accessorizing a DSLR, it would be a poor candidate to be a studio camera. Different applications require different cameras. But new technology helps expand applications.

Consider lens aberrations. Among the worst are various forms of chromatic aberration, in which not all colors appear in focus together on the image plane. Lens manufacturers have used multiple types of glass to help compensate for chromatic aberrations, making lenses larger, heavier and costlier. Today, however, some lens-camera combinations use digital processing to compensate for chromatic aberrations.

Similarly, steady tracking shots once required dollies. Today, shooters can add lighter-weight stabilizing mounts, and optical image stabilization built into some lenses. And using digital image-stabilizing software in postproduction can sometimes turn jerky handheld shots into smooth motion.

There is definitely a trend towards more digital processing to deal with some of the problems of image acquisition. But remember those unwanted reflections eliminated with a polarizing filter during image acquisition. Even when it's *possible* to fix problems in postproduction, it isn't always desirable. ■

You'll find lots more information and tidbits at the Schubin Café at schubincafe.com. The Quality Group can be found at pbsconnect.org/qualitygroup.