Digital: So Good, It's "Perfect"

Just because it's digital, doesn't mean it's faultless—as some may lead you to believe

▪ By C.R. Caillouet

Who told you that digital signals equal perfect video? Probably no one used those exact words, but the implication exists in advertising for everything from professional video equipment all the way down to cell phones—and that pretty much spans the range of video today.

Digital signals are just repackaged analog signals, and the quality of the output depends on many factors. That's the whole story about digital; it's just a string of numbers that represents the size of some physical property. In our business, the most common things that we digitize are audio and video.

Audio is an electrical representation (an analog) of the amplitude of the sound pressure level as it presses against a sound-sensitive sensor, like a diaphragm in a microphone. If we grab a sample of the sound pressure level (sample it) at consistent time intervals and measure the level (quantize it), we have thus digitized it.

The smaller the increment of time and the more accurate the measurement, the better the representation can be—if we're careful. In audio, we measure the sample time in thousands of samples per second.

Video is digitized in a similar way, but because there's much more information in a video signal, it must be sampled much faster, way up in the millions of samples per second. Scanning an analog video sensor (camera tube) produces a vertical sampling effect even before the signal is digitized.

The result of scanning plus digitization is a grid of blocks (pixels) representing the image. The size of the pixels, compared to the size of the entire image, limits the quality of the digitized image because all information inside each pixel has been averaged together.

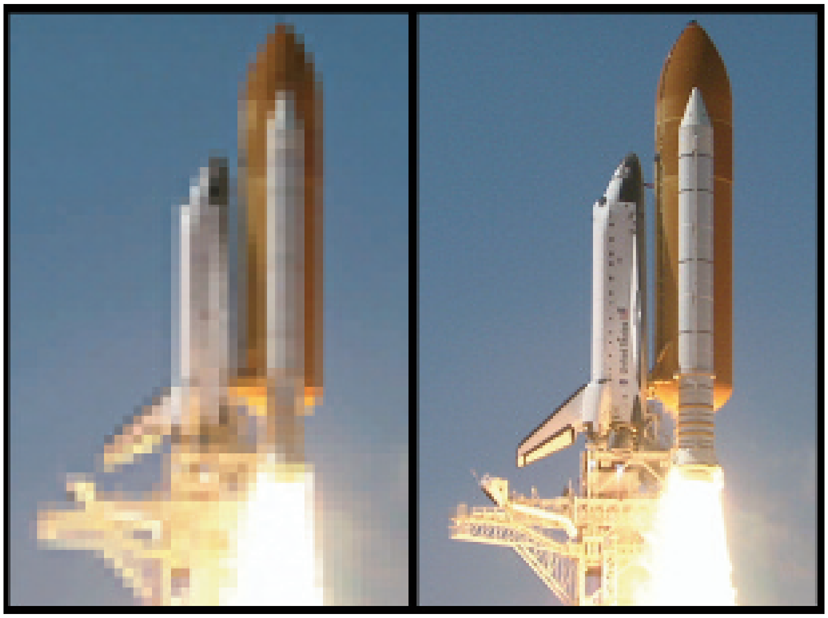

Photo courtesy NASA MSFC

Both images are digital and contain the same amount of data. The image on the right came from an HD frame, was reduced to 1⁄16 scale and then was reconstituted to the original size and 300 dpi to create the one on the left. The right image obviously contains more information.

The goal of digitization is to create a representation of a signal that can more easily be worked with by any number of digital processors and then reconstructed at a display into a replica of the original captured image.

You've probably figured out that the analog capture process, the accuracy of the digitization, the amount of information carried digitally and the reconstruction process all affect the quality of that final image.

If that weren't enough, I've only described the digitization and reconstruction of native image data. In the real world, there are seldom enough resources to move native image data around, so we're quickly tempted to try to eliminate any image data that doesn't contribute to the viewed image. One technique is subsampling, or simply reducing the amount of detail in one of the components of the image. To perform the reduction, we often transform the image into a

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different form that better accommodates the reduction.

For example, we might change (transcode) an image created from separate red, blue and green sensors into one with separate brightness (luma) and color (chroma) components. If we can create color components that contain no brightness information, we can then treat the luma and chroma separately. Because human vision gets most of its detail information from the brightness and not the color, we can throw away much of the color detail and reduce the amount of data needed to reconstruct the image for human viewing.

If the viewed product is destined for small screens, we might even be able to throw away some of the detail in the brightness component. Tricks like this one can be applied to analog signals, but they're much easier once the image data has been digitized.

If we want to carry even less information about the image, we have additional tools that are often referred to as digital video compression. These tools also change the nature of the image into a form that's easier to break apart—then analysis of the image components identifies more unneeded information that can be discarded.

The techniques described above require assumptions about how the final product will be used. What works for television broadcast and small to medium displays may not work for image compositing or delivery to a large cinema screen. If the assumptions aren't correct, then the product may not be satisfactory after it's decompressed, transcoded and reconstructed into a viewable image.

So, being digital has very little to do with being perfect and a lot to do with being manageable. And the next time someone tries to convince you that something is better simply because it's digital, you should hang on to your wallet. Going digital may be better in the long run, but it might not be because of improved image quality. **HDVP**