Telairity Dives Deep Into 4K Technology – Part 5

The digital rendering technology used in contemporary HD television broadcasting requires moving millions of bits every second to support a display of about 2 million pixels at 30 frames a second. With the aid of advanced video compression technology, like H.264 (MPEG-4), this number can be pushed as low as 5 million bits per second (5Mbps), or even lower in some cases, but it cannot be pushed down to nothing—or even very close to nothing.

Broadly speaking, digital compression is simply a process of eliminating information in inverse order of importance.[3] Where the digital information being encoded is a picture, the first reductions are imperceptible. Image sensors capture color information the human eye is not able to discriminate, so the first step in video compression is simply to eliminate what we cannot discern. If the compression process stops here, there is absolutely no degradation of visual quality. Everything the human eye can actually see is still present in the remaining data.

If still more compression is needed, the next step is to eliminate what can be seen with perfect vision, but whose absence most people will not notice. From there, the process proceeds to losses that may be more widely seen, but will be generally viewed as insignificant, and so on.

Indeed, the rest of the story of declining bitrates should be familiar to anyone who has watched much streaming video. As the information being discarded becomes more and more important, the picture begins to soften up. Eventually, the edges of objects blur and run together. Finally, the objects themselves become unrecognizable, dissolving first into a mosaic of colored blocks, then into nothing at all.

The point here is simply that there are limits to even the best possible compression technology. Great video compression technology like H.264 may be able to eliminate 299 out of every 300 bits in the original image, with little or no perceptible loss in visual quality. Even better compression technology might be able to eliminate still more bits, leaving only 1 in 400 or 500. But no compression technology can eliminate all the bits, and no compression technology can eliminate bits from the hard residual core of important information (however large or small it may be) without significantly degrading the quality of what remains.

There is an important moral here about what can be expected from the next step in video compression technology: the move from H.264 (MPEG-4 or AVC, for Advanced Video Coding) to H.265 (MPEG-5 or HEVC, for High Efficiency Video Coding). We will return to this issue later. For now, however, the point is simply that, since UHD has 4X the pixel count of HD, and pixels are nothing but 24-bit bundles of color data, the starting point for any discussion of upgrading HD to UHD *without* degrading picture quality (cutting more of the *significant* information from the bit stream) is how to move 4 times as many bits across our broadcast networks.

In truth, shifting from HD to UHD at the cost of moving just 4X the amount of information would be the good news. The bad news is that the amount of additional data to be moved for UHD is likely to be far higher. We will take up that problem in the next part of this series.

[3]More exactly, digital compression reduces to two logical tasks. The first and most straightforward task is simply to eliminate everything redundant in the data being transmitted, i.e., to find the smallest number of bits that can be used to encode any given amount of data with no loss of information. Technically, this is called *entropy* encoding.

The second task begins with a ranking exercise, where the non-redundant or meaningful data is sorted in order of its interest or importance. Data is then eliminated starting at the bottom, with the least significant (most uninteresting), and working up through the ranks of data in order of increasing significance. This second type of compression stops either when a set size target or a specified level of importance (quality standard) is reached.

The first type of compression, which retains all information and eliminates only redundancies, is known as "lossless" compression; the second type of compression, which also eliminates the least important or most uninteresting parts of the original data, is known as "lossy" compression. For images, lossless compression alone is generally inadequate; i.e., unable to achieve the kinds of very substantial reductions needed to cope with the overwhelming number of bits generated by digital imaging technology. For this reason, all standard image compression technologies (JPEG, MPEG, etc.) are lossy.

In brief, image compression is very much like floating a boat that threatens to sink in heavy seas under the weight of too much cargo. You begin by throwing overboard everything extra, and follow by throwing overboard everything dispensable, until a critical core of functionality is reached past which the boat ceases to be viable. Nothing in this process of lightening the load, however, is able to change the size of the boat. If you leave port on the UHD supertanker, you must arrive on a supertanker, not aboard some trim little yacht.