The Video Compression Problem

Products for the Broadcast Industry

- **HD, SD Format Conversion**
- **Subjective Quality Monitor**
- **Time Compression**
- **Video Compression**

Overview

Conventional compression technology is based on one of three technologies:

- Motion Estimation. This technology reduces the redundancy between frames of motion video by representing a match of an object between the frames as a vector to the object. This technology is limited in the compression ratios it may attain without degrading picture quality, and is computationally prohibitively expensive.

- Function matching (fractals). This technique attempts to describe a region of video as a mathematical formula. This technique has also been unsuccessful in obtaining large compression ratios without visual artifact.

- Subband (wavelet). This technique is limited in its practical utility because quantization in subbands have side effects in other bands.

Futureware's ZPEG™ compression technology is based upon its Visibel™ Human Visual Model. This model statistically guarantees that all information not visible to the human eye is removed, or alternatively, that the highest compression ratios are reached with the minimum of visible artifact.

Lossless Compression

The value of a given pixel in typical video data (figure 1) may be used to predict the value of the next pixel with a probability of .96 and above (over .99 in the time dimension for SD video). This property is known as correlation between pixels, and is modeled with the Markov probability model.

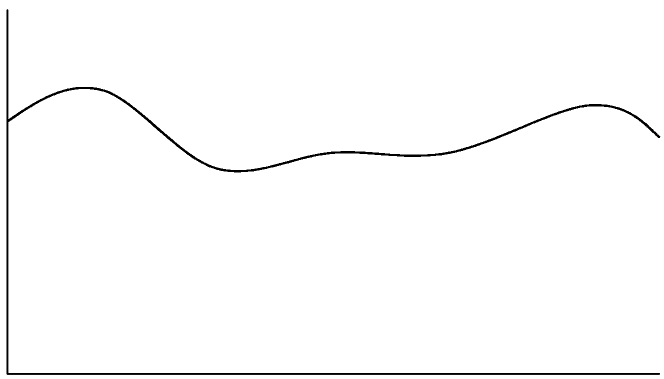

Figure 1.PCM (Pixel) Representation of Video Sequence.

The optimal representation of video data, in the sense of maximal concentration of energy into the minimal number of coefficients, is the representation in decorrelated K-L space (figure 2). The statistics for the video sequence are used determine the properties of this transform, which is invertible and can be undone when received.

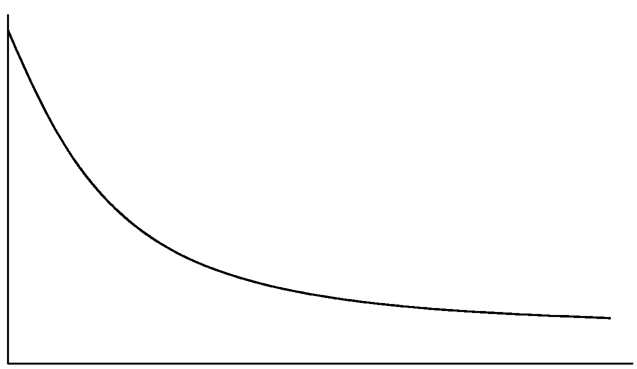

Figure 2.Decorrelated (K-L) Representation of Video Sequence.

After the maximal length of the sequence has been determined (through a technique invented by Futureware), entropy encoding of this representation will give lossless compression ratios of 10:1.

Quantization

Quantization is the process of introduction of error into a representation of a video sequence for the purpose of increasing compression, hopefully without visible artifacts. A transform representation of video data may be independently quantizable (figure 3, DCT or similar transform) or retain some correlation between the representational basis (all other transforms, wavelet in this case).

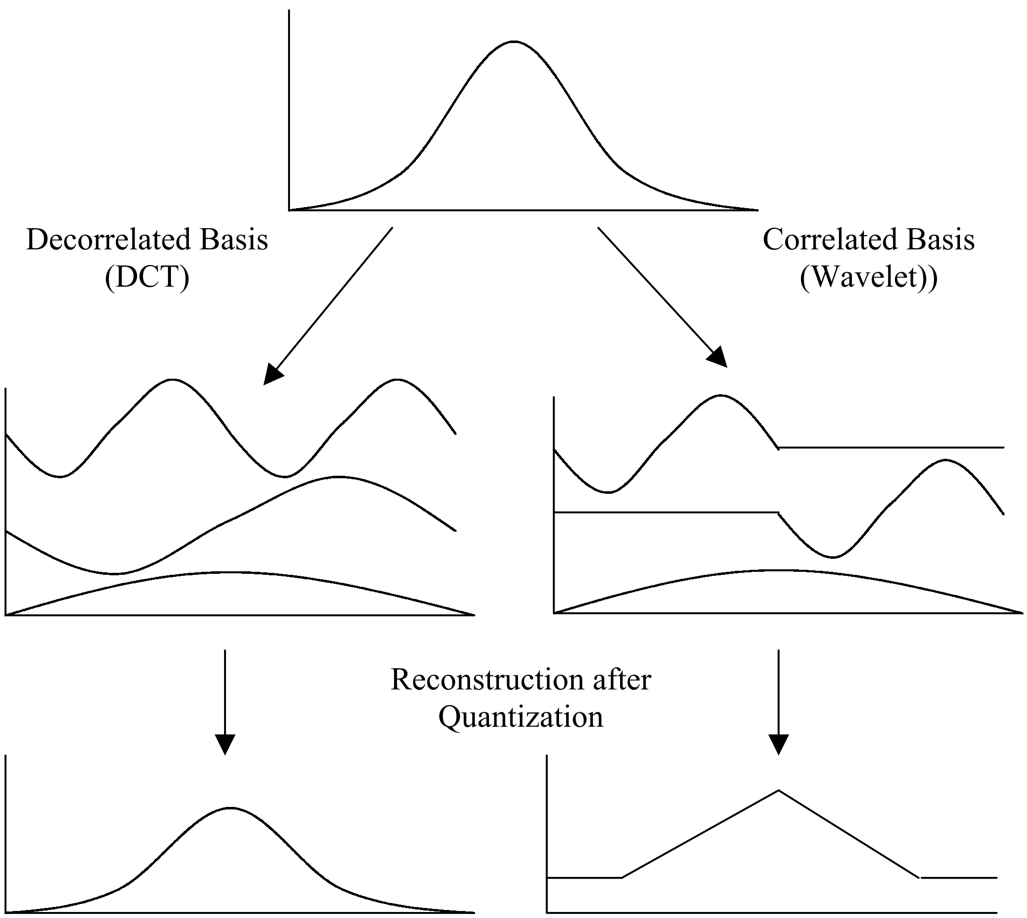

Figure 3. Quantization in decorrelated bases give similar reconstructions; those in correlated spaces show side-effects in the reconstruction.

The advantage of quantization in a decorrelated basis is that quantization of each basis element can be done without affecting other basis elements. An example of how important this property is can be seen in the recent unsuccessful efforts to harness the wavelet transform as a compression transform - the unpredictable effects of quantization made the technique unworkable.

Visually Lossless Quantization

Once an independently quantizable transform has been defined, the optimal visually lossless quantizer for each basis element may be define. This quantizer is a function of screen resolution, temporal resolution, and viewing distance.

The set of (largest) quantizer values which under the defined viewing conditions result in no visual loss is defined as 0 Visibels™, Vb) Every factor of two applied to each of the quantizers (i.e., each doubling of the viewing distance) is defined to add 6 to the Visibel value, so that the relationship between decibels and visibels is constant.

Visually lossless compression is obtained by quantizing video data at the 0 Vb level; and minimum-artifact error is obtained at higher compression rates by specifying a higher quantization level.

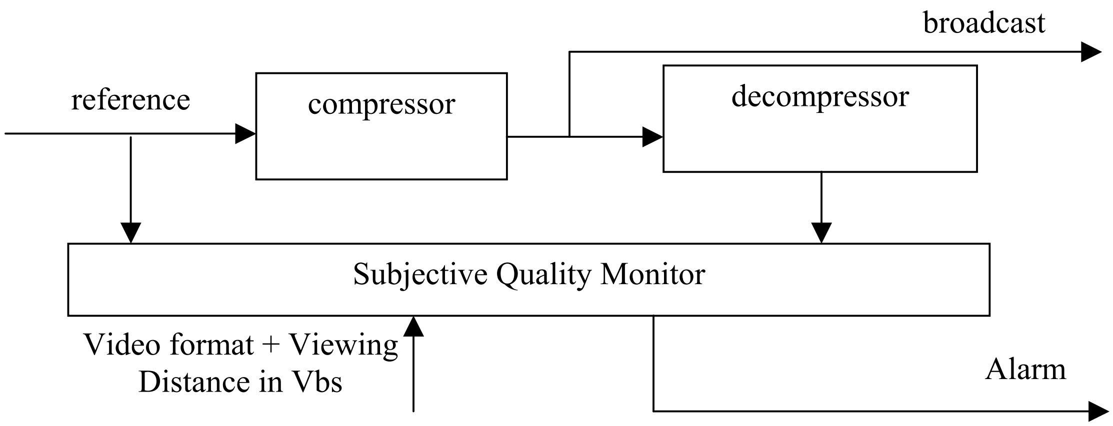

Figure 4. The Subjective Quality Monitor compares compressed and reference data streams and reports artifacts above a given Vb. threshold.

Subjective quality of a compressed data stream may now be measured against a reference stream (its source, figure 4). The reference and decompressed streams are continuously compared against one another, generating the error between them in Vbs. If the error exceeds a predefined threshold, a warning is signaled.

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