An Unequal Error Protection Trellis Coding Scheme for Still Image Communication[1]

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The source and channel coding functions of a communication system are usually designed independently of one another. This is justified by Shannon's separation principle [1], which indicates that no performance loss is suffered if the two functions are thus partitioned. However, Shannon's theorem is an asymptotic result that permits unlimited delay and complexity; given a constraint on complexity/delay, joint source-channel coding may outperform separately designed pairs [2]-[7].

In this work, we consider the problem of the reliable communication of compressed still grey-level images over very noisy channels. An unequal error protection (UEP) joint-source channel coding scheme is proposed for transmitting discrete-cosine transform (DCT) encoded images over an additive white Gaussian noise (AWGN) channel used in conjunction with coherent M-ary phase shift keying (MPSK) modulation. More specifically, it consists of a sequence maximum a posteriori (MAP) detection scheme that exploits both the channel soft decision information and the statistical image characteristics.

The image is first compressed as follows. It is subdivided in 8 by 8 blocks, and for each of these blocks the discrete cosine transform (DCT) is computed. These are quantized [8] and then encoded via a folded binary code (FBC). Three soft decision MAP schemes that offer different levels of protection to the DCT bitstream are suggested:

- *MAP-SD-UNC:* Since source coding schemes are not ideal, they always leave some residual redundancy in their output bitstream that can be exploited by a sequence MAP detector at the receiver [5]-[6]. In this scheme, no channel coding is performed. For each block, the FBC bitstream is modeled as an iid non-uniform source; it is then modulated and sent over the AWGN channel. The channel soft decision information and the residual redundancy due to the non-uniform distribution of the FBC data are utilized by the MAP detector in combating channel noise.
- *MAP-SD-UEP I:* In DCT coding, most of the signal information is concentrated in the lower spatial frequencies. The DC coefficient (the coefficient with zero frequency) is the most important DCT coefficient since it measures the average value of each block. In this scheme, we provide additional protection to all of the image DC coefficients. More specifically, the DC bitstream is modeled as an iid source and channel encoded via a trellis coded modulation scheme (TCM). As for the AC coefficients, they are processed without channel coding as in the MAP-SD-UNC scheme.
- *MAP-SD-UEP II:* This scheme is the same as the previous one with the exception that a third level of protection is added to the first AC coefficient of each DCT block. The resulting bitstream is trellis encoded along with the DC coefficients as described in MAP-SD-UEP I; the remaining AC coefficients are processed as in the MAP-SD-UNC scheme.

Experimental results on the transmission of typical images using the above schemes demonstrate substantial objective and subjective performance improvements over systems that do not exploit the image residual redundancy or the channel soft decision information.

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