Transmission of Two-tone Images over Noisy Channels with Memory

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Extended Abstract

We consider an alternate approach to coding information bearing data for the reliable transmission of two-tone images over noisy communication channels with memory. This consists of jointly designing the source and channel codes (a technique referred to as joint source-channel coding).

Source and channel coding are two problems that have traditionally been implemented separately, forming what is known as a tandem source-channel coding system. The separation of channel and source coding is only optimal in an asymptotic sense, i.e., when no constraints exist on the coding block lengths (delay) and on the complexity of the encoder/decoder [1]. Joint source-channel coding, however, has recently received increased attention. It has been shown that if delay and complexity are constrained, performance can be increased if the source and channel codes are jointly designed, as opposed to being treated independently [2, 3].

In this work, we propose joint source-channel coding schemes for the reliable transmission of two-tone images over a binary channel with additive Markov noise. Applications of this work are in the transmission of facsimile documents over land mobile radio channels.

We model the image as a one-dimensional non-uniform binary iid, a Markov process or as a two-dimensional causal Markov process. We then investigate the problem of the maximum a posteriori probability (MAP) detection of binary images directly transmitted over the Markov channel. The objective is to design a MAP detector that fully exploits the redundancy of binary images to combat channel noise. It will also exploit the larger capacity of the channel with memory as opposed to the interleaved (memoryless) channel. Since this is a model-based decoding algorithm, we assume that the image parameters are provided to the decoder (this can be achieved by transmitting them over the channel using a forward error-control code). We next address the problem of MAP detection of compressed binary images directly transmitted over the Markov channel. Comparisons of the performance of the above coding schemes with traditional tandem schemes (that use Run-length and Huffman coding for source coding, and convolutional codes and interleaving for channel coding), are also presented.

Simulation results for the transmission and detection of an uncompressed two-tone image of Lena are displayed in Figures 1 and 2. In this experiment, the Markov channel bit error rate is $Pr(Z_n = 1) = \epsilon = 0.1$ and the noise correlation parameter is $\delta = 10.0$ (the corresponding noise correlation coefficient is $\frac{\delta}{1+\delta}$). These parameters correspond to a very noisy channel with high noise correlation. The resulting average decoding bit error probability is 0.02. This result is very promising given the low complexity of the system (which primarily resides in the MAP decoder). The decoder is implemented using a modified version of the Viterbi algorithm.

Figure 1. Received two-tone Lena

Figure 2. Decoded two-tone Lena

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