Joint Source Channel Matching for a Wireless Communications Link

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With the rapid growth of wireless communications systems there is an increasing demand for efficient image and video transmission. Significant performance gains can be obtained from joint source channel matching where system resources are assigned based on the tradeoff between data and redundancy. Application of joint-source channel matching in heterogeneous, multi-media environments will demand general source-channel optimization schemes suitable for a wide variety of source coding standars, channel coders, and variable channel conditions. In a typical situation, system designers will choose prefabricated components for the source coder and the channel coder and must obtain the best performance within these constraints. There has been significant work in the past on joint source channel coding for specific source and channel coders. In some work, the rates of the source code and the channel code are adjusted for specific coders to minimize mean squared error. Other researchers consider channel optimized quantization in which source coding accuracy is traded for resistance against channel noise.

We develop a more general approach for joint source channel matching based on a parametric distortion model that incorporates the flexibility and constraints of both the source and the channel. We use parametric models describing source and channel characteristics that can be accurately applied to most classes of source and channel coders. The source coder is described by a sensitivity curve that determines the source distortion as a function of bit error probability (BEP) and source rate (i.e., $D(BEP, R_s)$). The channel coder is described by BEP as a function of power and channel rate (i.e., $BEP(Power, R_{tot} - R_s)$). By using BEP as the common parameter between the source and the channel, the source and channel characteristics can be combined to obtain a distortion vs BEP curve, simplifying the joint optimization to the choice of the optimal BEP to minimize distortion. Ideally, an optimal BEP would be chosen for each bit; however, due to flexibility constraints we consider packets of source bits having the same BEP. The expected distortion is then expressed as $E(D) = \sum_{packet} D(packet) BEP(packet)$. Gradient projection based methods can be used to solve for the optimal BEP in each packet subject to power or bandwidth constraints.

To show the generality of our approach, we applied it to the familiar Said-Pearlman progressive image coder with two types of channel coders, a coder with orthogonal symbols of different power (system 1), and fixed-rate BPSK modulation overlayed with Reed Solomon Codes (system 2). At low bit error rates system 2 performed better than system 1 according to the limitations of the individual systems. The analytical results (of the best of the two systems) are nearly identical to results found in current literature on fully joint source channel optimizations such as the one by Sherwood and Zeger. It may thus be possible to obtain in practice nearly all of the benefits of joint source-channel optimization by matching existing source and channel coding standards using the simple and general method proposed here.