Source Optimized Channel Codes (SOCCs) for Parameter Protection

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Abstract — **We present a new class of channel codes, which we call *Source Optimized Channel Codes* (SOCCs). These non-linear codes are designed to maximize a given analogue quality measure in consideration of source and channel statistics.**

I. Introduction

Unlike conventional channel coding which usually minimizes the residual bit or sequence error rate, we design a new class of non-linear block codes which minimizes a given quality measure in the domain of continuous-valued source encoder symbols, e.g. parameters of a speech encoder. These codes are called *Source Optimized Channel Codes* (SOCCs) [1, 2]. At the receiver, we do not exploit the code redundancy for error correction, but for parameter estimation [3]. The performance of SOCCs is compared to that of a reference system which was developed at the Institute for Communications Engineering at Munich University of Technology [6] This reference employs rate compatible convolutional codes [4] for *Unequal Error Protection* (UEP) and *Source Controlled Channel Decoding* (SCCD) [5].

II. Communication Model

By the model shown in Figure 1, we simulate a block-oriented speech transmission. The source encoder is represented by a vector source producing L-dimensional real valued parameter vectors $\mathbf{u} = (u_1, .., u_L)$. To mimic residual inter-frame correlation each component u_i is independently modeled by a Gaussian low-pass source with $\varphi_{u_i u_i}(1) = \rho$. Each vector component is quantized independently. Instead of conventional linear channel encoding as used e.g. in mobile telecommunications, we apply non-linear *Source Optimized Channel Codes* (SOCCs) to encode the quantized parameter vectors $\bar{\mathbf{u}}$ to a binary channel sequence $\mathbf{x}$. At the receiver, parameter estimates $\hat{\mathbf{u}}$ are extracted from the observed soft bit sequence $\hat{\mathbf{y}}$ by *Softbit Source Decoding* (SBSD) [3].

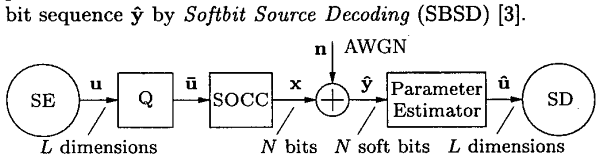

Fig. 1: Communication model
SE: parameter source (model of the source encoder),
Q: quantizer, SD: parameter sink (source decoder)

III. Source Optimized Channel Codes

We assume a given quality measure $\mathcal{D}(\bar{\mathbf{u}}, \hat{\mathbf{u}})$ and a statistical model of the transmission channel $\hat{\mathbf{y}} \mp t(\mathbf{x})$ which is described by $p_{\hat{\mathbf{y}}|\mathbf{x}}(\hat{\mathbf{y}}|\mathbf{x})$. The optimal decoder (estimator) with respect to $\mathcal{D}$ and t is denoted by $\hat{\mathbf{u}} = f_{\mathcal{D},t}(\hat{\mathbf{y}})$. Then we define a SOCC as a set of channel symbols

$$\mathbb{C} = \{\, \mathbf{x} \,|\, \mathbf{x} = \Phi[\bar{\mathbf{u}}],\ \bar{\mathbf{u}} \in \mathbb{U} \,\} , \tag{1}$$

which results from solving the optimization problem

$$\mathbf{E}\,\{\mathcal{D}(\bar{\mathbf{u}}, f_{\mathcal{D},t}(\ t(\Phi[\bar{\mathbf{u}}])\ ))\} = \min_{\Phi} , \tag{2}$$

where $\mathbf{E}\{\cdot\}$ denotes expectation. Hence, SOCCs minimize the mean distortion $\mathcal{D}(\bar{\mathbf{u}}, \hat{\mathbf{u}})$ measured between quantized and estimated parameter vectors.

IV. SOCC Performance

Figure 2 depicts a performance comparison between SOCC/SBSD and UEP/SCCD at a transmission rate of 4 bits per vector dimension. Three values of residual inter-frame correlation are considered: $\rho = 0$, 0.75 and 0.9. SOCC/SBSD outperforms UEP/SCCD for all channel conditions if $\rho \geq 0.75$. For $\rho = 0.9$, a gain in parameter SNR of at least 1 dB and up to 3 dB can be observed. In addition, the SOCC/SBSD system exhibits a graceful analogue-type degradation, whereas UEP/SCCD shows the well known threshold effect.

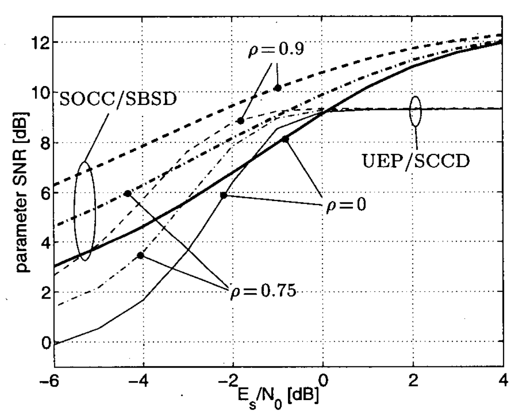

Fig. 2: SOCC/SBSD vs. UEP/SCCD, 4 bits per dim.

References

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