Nonuniform Dithered Quantization *

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Dithered quantization has useful properties such as producing quantization noise independent of the source and continous reconstruction at the decoder side. Dithered quantizers have traditionally been considered within their natural setting of uniform quantization framework. A uniformly distributed (with step size matched to the quantization interval) dither signal is added before quantization and the same dither signal is subtracted from the quantized value at the decoder side (only subtractive dithering is considered in this paper). The quantized values are entropy coded conditioned on the dither signal. This work proposes and analyzes optimal (non-uniform) dithered quantization. One immediate problem with nonuniform dithered quantization is how to apply dithering for unequal quantization intervals. This problem is circumvented by performing dithering in the companded domain. After appropriate companding, uniform dither can be applied. The quantization problem is defined as finding the optimal compander mapping that minimizes the mean square error. To solve the problem, some approximations of rate and distortion expressions and to the compander mapping are used. First, we only consider the piecewise linear compander which is also used in deterministic quantizers. Also, we assume the error in each half quantization interval (the interval between the decision boundary and the reconstruction) is constant and only a function of the intervals length, i.e., identical to the case where for each interval a uniform dithered quantizer is applied. We also assume that rate can be approximated by the rate of the deterministic quantizer which uses the same compander. We derive the necessary conditions for optimality and design the compander by iterating between the necessary conditions.

A deterministic quantizer cannot render the quantization noise independent of the source or white but can make it uncorrelated with the source. An alternative deterministic quantizer that is constrained to provide quantization error uncorrelated with the source is also analysed.

The proposed nonuniform dithered quantizer is experimentally compared to the traditional dithered quantizer and the deterministic quantizer that generates quantization error uncorrelated with the source. The nonuniform dithered quantizer outperforms the uniform dithered quantizer and the constrained deterministic quantizer. The proposed quantizers can be used in compression system optimizations where quantization noise uncorrelated with the source is required for especially low rates.

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