A New Trellis Vector Residual Quantizer with Applications to Speech and Image Coding

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Abstract

Quantization is the process of approximating a continuous-amplitude signal by a digital (discrete-amplitude) signal, while minimizing a given distortion measure (or error). Vector Quantizers (or VQ) have the property of achieving asymptotically the best theoretical performance. Unfortunately, conventional optimal VQ are extremely demanding in terms of both storage and memory requirements, and it was recently demonstrated that the design of an optimal VQ is an NP-complete problem. Therefore, the design of sub-optimal vector quantizers is now an interesting alternative to scalar quantization for applications that require good quality performance when a limited amount of computing resources is available.

In this paper, we present a new Trellis Coded Vector Residual Quantizer (or TCVRQ) that combines trellis coding and vector residual quantization. Our TCVRQ is a general-purpose sub-optimal Vector Quantizer with low computational costs and small memory requirements that permits high memory savings when compared to traditional quantizers. Our experiments confirm that TCVRQ is a good compromise between memory/speed requirements and quality and that it is not sensitive to codebook design errors. We propose a method for computing quantization levels and experimentally analyze the performance of our TCVRQ when applied to speech coding at very low bit rates and to direct image coding.

We employed our TCVRQ in a Linear Prediction based speech codec for the quantization of the LP parameters. Several experiments were performed using both SNR and a perceptive measure of distortion known as Cepstral Distance. The results obtained and some informal listening tests show that nearly transparent quantization can be performed at a rate of 1.9 bits per parameter.

The experiments in image coding were performed encoding some 256 gray levels, 512 x 512 pixel images using blocks of 3 x 3 pixels. Our TCVRQ were compared, on the same training and test sets, to an Exhaustive Search Vector Quantizer (built using Generalized Lloyd Algorithm) and to a Tree Quantizer for different coding rates ranging from 3 to 10 bits per block. The performance comparison of our TCVRQ with these classical Vector Quantizers shows that in Low Bit-Rate image coding, our TCVRQ outperforms the standard algorithms in terms of memory and computational complexity and emerges as an interesting compromise between performance and requirements.

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