Optimal Quantizer for Distributed Source Coding

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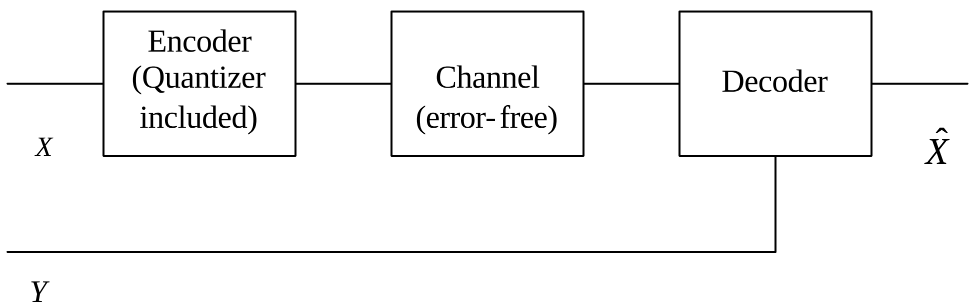
In this project, we address the problem of designing an optimal quantizer for distributed source coding, i.e., separate coding of correlated sources knowing only partly the information of the other sources, for instance the joint statistical distribution of the sources. We are interested in the particular case shown in the following block diagram.



Precisely, we have a signal *X* that we want to send to a decoder which has Y as side information. *X* and *Y* are correlated. We wish to achieve the highest compression ratio for *X* for a particular distortion. In the lossless case, the result is $R(X) \geq H(X \mid Y)$, and the Slepian-Wolf coding theorem tells us that this bound can be approached asymptotically.
A possible application of this problem would be an array of independent sensors sending correlated information to a central unit. Another example is discussed in [1], where the authors present an efficient way to use analog signals as side information to improve digital video data compression.

However, the scheme proposed by the authors of [1] is not feasible in practice. A more practical approach has been adopted in [2], where a lossy compression scheme of *X* with significant rate-distortion improvement is proposed. However in their scheme, the quantizer used for *X* does not depend on the joint statistics of X and *Y* because the authors suppose that the sources cannot communicate, which is reasonable in most cases. We address the problem in which the joint pdf of X and Y is known by the encoder, but not the actual value of Y. For instance, we could imagine some feedback scheme where the decoder sends the statistics of *Y*, or assume that a training set of values of X and Y is available. In this case, a quantizing process taking into account the joint pdf may achieve better performance. The purpose of our project is to design an optimal scalar quantizing scheme for *X taking into account the joint statistics with the side information Y*, and compare its performance with other methods.

The first part of our work will consist to design an algorithm to calculate the optimal quantizer for *X*, when we know the joint pdf of *X and Y*, and in the case when we have only training sets. We will first try to solve the case of constant length coding, then the case of variable length coding, if we have enough time. We will try to extend the ideas of

the Max-Lloyd algorithm for quantizer design, as described in [3], and the variation for the entropy-constrained case.
The second part of the work will be performance comparisons of our scheme with other schemes proposed in different papers: we will study in particular the effect of correlation between X and Y on the rate-distortion performance.

Our study will be limited to the scalar quantizer design. A possible future extension for the work is of course the case of vector quantization, which should be much more challenging.

References

[1] Enhancing Analog Transmission Systems Using Digital Side Information: A New Wavelet-based Image Coding Paradigm, by Sandeep Pradhan and Kannan Ramachandran, IEEE Data Compression Conference, March 2001.

[2] S. Sandeep Pradhan and Kannan Ramchandran in their paper: Distributed Source Coding Using Syndromes (DISCUS): Design and Construction.

[3] Allen Gersho, Robert M. Gray: Vector Quantization and Signal Compression. Kluwer Acedemic Publishers, 2nd edition, 1993.