Distributed source coding: comparison of two methods close to the Wyner-Ziv bound

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I. Introduction

This paper deals with the practical performance of distributed source coding, *i.e.* the compression of correlated sources that are coded independently but decoded jointly. According to the Slepian and Wolf theorem two correlated discrete-alphabet sources can be compressed *independently* to the rate of $H(X,Y)$, if they are decoded *jointly* at the decoder. This theorem has been extended by Wyner and Ziv to the case of correlated Gaussian random variables. One of the first work in this area is the one of Pradhan and Ramchandran [1]. In their DISCUS method, the syndrome of an error correction code is used to compress the data. Later, methods that puncture the output of a turbo code to achieve the desired compression rate have been proposed. Another approach considers, for a pair of finite alphabet memoryless sources, a practical code design based on VLCs. This paper proposes to compare, in a global distortion sense, for the Gaussian continuous sources, DISCUS with another method that can be seen as an application of the Al Jabri and Al-Issa technique [2].

II. A VLC-based distributed source coding scheme

As in [1] we assume that X and Z are two Gaussian random variables with zero mean and variances of 1 and σ_Z^2, respectively. X and Z are independent. We assume that Y, $Y = X + Z$, is perfectly known at the decoder and we want to transmit X. X_q, the index of the quantized version of X is encoded in X_b and transmitted on an error free channel. In reference [1] the error correction code syndrome realizes this encoding. Here we use a VLC table defined offline. Y_q is the index of the quantized version of Y. Then, at the decoding stage, an estimate of X_q, is found by using X_b, Y_q and the VLC table. At last, an estimate of X, is computed with the reconstruction function of [1]. To build the VLC table, the technique details in [2] is used. It is applied to the density probability function obtained with two training sets of X and Y. Some probabilities need to be set to zero, then a threshold is fixed. The VLC table is designed for a given correlation, the one of the training data, and threshold. By changing these two parameters, the VLC rate can be adapted. As an example, Tab. 1 gives the probabilities found with training sets of 100000 samples, an 8-level Llyod-Max quantizer, a Correlation-SNR defined by $CSNR = 1/\sigma_Z^2$ fixed to 15.2 dB and a threshold set to 0. Tab. 2 shows the corresponding VLC table. Then the average compression rate, the entropy of X_q and the conditional entropy are $L = 1.65$, $H(X_q) = 2.41$ and $H(X_q|Y_q) = 0.9398$ bit/symbol, respectively.

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$Y_q \backslash X_q$	1	2	3	4	5	6	7	8
8	0	0	0	0	0	0	0.0029	0.0071
7	0	0	0	0	0	0.0128	0.0378	0.0015
6	0	0	0	0	0.0281	0.1213	0.0082	0
5	0	0	0	0.0340	0.2224	0.0228	0	0
4	0	0	0.0229	0.2232	0.0346	0	0	0
3	0	0.0083	0.1218	0.0279	0	0	0	0
2	0.0014	0.0389	0.0125	0	0	0	0	0
1	0.0067	0.0028	0	0	0	0	0	0

Tab. 1: Statistics found with $CSNR = 15.2$ dB.

Group	2, 5, 8	1, 4, 7	3, 6
Probability	0.3437	0.3421	0.3141
Codeword	0	10	11

Tab. 2: Groups of symbols found for training sets used in Tab 1.

III. Comparison between the two methods

Our comparison aims to show the evolution of the global distortion (SNR) (on the left in Fig. 1) and of the quantized symbol error rate (SER) (on the right in Fig. 1) as a function of the $CSNR$, under the two compression schemes, namely, DISCUS and VLC. The method that uses the VLC is derived for 3 compression rates: 2 bit/symbol, 1.65 bit/symbol and 1 bit/symbol. Codes for 2 and 1 bit/symbol compression have been found using training sets with a $CSNR = 13$ dB, threshold set to 0 and $CSNR = 15.2$ dB, threshold of 0.0128, respectively. Curves named " Wyner Ziv" and "Without error" represent the theoretical bound and the distortion coming only from the quantizer, respectively. The curve that uses a VLC with a rate of 1 bit/symbol gives very poor results for all the correlation. This comes from the very high threshold. In most cases the DISCUS method gives better results, however the difference in performance is not so large. Furthermore the technique using VLCs is very interesting for its rate flexibility.

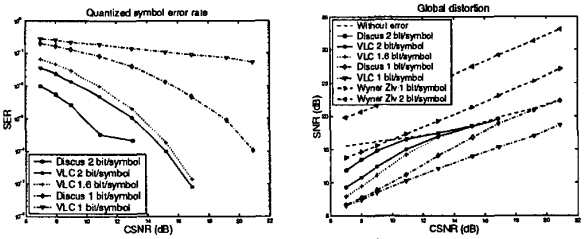

Fig. 1: Performance of the two methods for an 8-level quantizer.

References

[1] S. S. Pradhan and K. Ramchandran, "Distributed source coding using syndromes (discus): Design and construction," in *Proceedings of DCC*, Snowbird, USA, Mar. 1999, pp. 158–167.

[2] A. Kh. Al Jabri and S. Al-Issa, "Zero-error codes for correlated information sources," in *Proceedings of Cryptography*, Cirencester, UK, Dec. 1997, pp. 17–22.

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