TABLES FOR PRACTICAL WYNER-ZIV CODING OF LAPLACIAN SOURCES

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ABSTRACT

Many practical coding scenarios deal with sources with transform coefficients that are well modeled as Laplacians. For the Wyner-Ziv coding problem for such sources when correlated side-information is available at the decoder, the side-information is modeled as obtained by independent additive Laplacian or Gaussian innovation on the source. This paper deals with the optimal choice of encoding parameters for practical Wyner-Ziv coding in such scenarios, using the same quantizer family as in the regular codec to cover a range of rate-distortion trade-offs, given the variances of the source and innovation. Using our prior analysis of a general encoding model based on multi-level coset codes combining source and channel coding, we present comprehensive tables with optimal encoding parameters. These tables can be readily incorporated into a practical codec to read off the encoding parameters.

Index Terms − Wyner-Ziv coding, source-channel coding, Laplacian sources, entropy, conditional entropy

1. INTRODUCTION

Inspired by the foundation of Slepian-Wolf [1] and Wyner-Ziv [2] theorems, in recent years immense attention has been devoted to practical source coding with side-information problems [3]-[12]. Most such work emphasizes channel coding to convey a source, requiring the decoder to perform suitable channel decoding based on correlated side-information. However, achieving error-free transmission under practical block-length and complexity constraints always requires a non-trivial premium in the transmitted rate over the ideal channel coding rate given by the conditional entropy. Furthermore, in many realistic scenarios with finite block-lengths, the actual correlation statistics are non-stationary and cannot be reliably estimated without a large enough margin for channel mismatch. This challenges the practice of solely using channel codes for source coding with side-information problems. Our prior work [8][9] addressed quantitatively the problem of finding the optimum balance between various feasible source and channel coding combinations under a non-ideal channel coding model, for a Laplacian source and additive Laplacian or Gaussian innovation. Specifically, the source and correlation model was assumed to be: $Y = X + Z$, where X is a Laplacian source with variance σ_X^2, Y is the side-information available only at the decoder, and innovation Z is independent of X and either *i.i.d.* Gaussian or *i.i.d.* Laplacian with variance σ_Z^2. Note that this model trivially generalizes to the $Y = \rho X + Z$ model with $0 \le \rho \le 1$, by replacing Y with Y/ρ, and σ_Z by σ_Z/ρ.

In this work, we provide comprehensive tables with optimal coding parameters for the above model, for use in practical codecs. Because most transform coefficients used in practical codecs are well modeled as Laplacians, we believe these tables will be critical for many practical Wyner-Ziv codecs. We have used these tables in our codecs [10][11].

2. CODING FRAMEWORK

In a regular codec, X is quantized with a quantizer ϕ to yield a quantization index $Q = \phi(X, QP)$ that is subsequently entropy coded. QP parameterizes a family of quantizers that yield progressively fine to coarse quantization over a wide enough range. In this work, we consider the uniform deadzone quantizer commonly used in today's codecs:

$$Q = \phi(X, QP) = sign(X) \times \lfloor |X| / QP \rfloor \qquad (1)$$

In principle QP is continuous, but in practice it takes values from a discrete set Ω_{QP}. For Wyner-Ziv coding, the problem is broadly stated as follows: Given a target upper-limit D_t on the overall expected distortion, and variances $\{\sigma_X^2, \sigma_z^2\}$ for Laplacian X and Laplacian/Gaussian Z respectively, what is the optimal manner in which should X be coded based on a given quantizer family ϕ . D_t is expressed in terms of a target quantization parameter QP_t assuming regular coding and decoding *without* side-information.

For the source coding with side-information problem in our coding model, X is first quantized to Q based on QP; and then circular cosets $C = \psi(Q, M)$, are computed based on a coset modulus parameter M using:

$$C = \psi(Q, M) = Q - M\{\lfloor Q / M \rfloor\} \qquad (2)$$

where $C \in \Omega_C = \{0, 1, ..., M-1\}$. The decoder on receiving C, would perform an optimal reconstruction $E(X / Y = y, C = c)$ of a sample X based on the corresponding side-information $Y=y$, and the transmitted coset modulus $C=c$.

For actually transmitting C, it is decomposed into S symbol planes $\{C_0, C_1, \ldots, C_{S-1}\}$ where C_i, $i = 0, 1, \ldots, S-1$ is the $(i+1)^{\text{th}}$ least significant symbol associated with a finite l_i-ary alphabet. Given an alphabet-size parameter vector $L=\{l_0, l_1, \ldots, l_{S-1}\}$, we can compute $C = \psi(Q, M)$ with $M = l_0 l_1 \ldots l_{S-1}$ being the overall modulus. The symbol planes C_i are obtained from C (or Q directly), given L using:

$$\begin{aligned} &\textit{Initialize} \ : C'_0 = C \ or \ Q; \\ &\textit{Compute} \ : C_i = \psi(C'_i, l_i), \ C'_{i+1} = \lfloor C'_i / l_i \rfloor, \text{ for } i = 0, 1, ..., S-1 \end{aligned} \qquad (3)$$

Thus $C_i \in \Omega_{C_i} = \{0, 1, ..., l_i - 1\}$ for $i = 0, 1, ..., S-1$. C may be from $\{C_0, C_1, \ldots, C_{S-1}\}$ using: $C = (C_0 + l_0 C_1 + l_0 l_1 C_2 + ... + l_0 l_1 ... l_{S-2} C_{S-1})$.

The planes $\{C_0, C_1, \ldots, C_{S-1}\}$ may be transmitted using a combination of source and channel coding and in any order. We assume a model where the m-ary least significant symbol plane C_0 is source coded, while the remaining more significant bitplanes $C_1, C_2, \ldots$ are channel coded. Thus, the alphabet-size vector $L=\{m, 2, 2, \ldots, 2\}$, with $l_0=m$, and $l_i=2$ for $i=1,2,\ldots,S-1$, and $M=2^{S-1}m$. The S symbol planes are coded in order from C_0 to C_{S-1}. The rationale for this model has been discussed in [8][9]. Fig. 2 illustrates the above model, and the parameter selection problem. Given a target quantization parameter QP_t, and the source and correlation statistics σ_X and σ_Z, optimum parameter choice for Wyner-Ziv coding essentially involves obtaining: the optimum quantization parameter QP, the number of symbol planes $S \ge 1$, the alphabet-size of the source coded least significant plane $m \ge 1$, and the rates for the $S-1$ channel coded bit-planes $r_1, r_2, \ldots, r_{S-1}$. The additional input parameters γ, ε are explained in Section 3.

Note the above model is considerably generic, and covers all special cases of interest. For instance, S=1 corresponds to using only memoryless source coding (and no channel coding) used and may be preferred in many cases because of their simplicity. The case m=1 and S>1, corresponds to not using any source coding bits since the least significant symbol plane is trivial, and corresponds to only using channel coded bit-planes as is generally used in vast majority of literature. The case m=1, S=1 corresponds to the zero-rate coding case when the samples are not coded at all, but optimal reconstruction based on Y can still be conducted at the decoder. Finally, $m=\infty$ corresponds to the case when no coset computation is conducted on the quantized samples, and also S must be 1 in this case. In other words, regular source (entropy) coding of quantized samples is used ($C_0=Q$), but the

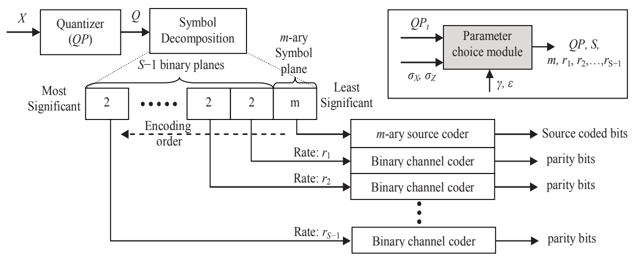

Fig. 2. Model for Wyner-Ziv coding with source-channel combination codes

decoder still optimally reconstructs within the quantization bin.

3. NON-IDEAL CHANNEL CODING MODEL

The ideal channel coding rate for a binary coset symbol C_i, $i > 0$ is given by $h = H(C_i/C_0, C_1, \ldots, C_{i-1}, Y)$, and it is realized ideally by use of a binary channel coder of *code-rate* $1/(1+h)$, from which only the parity (or syndrome) bits at rate h per input bit are transmitted. Had a very low probability of error been achievable at this ideal rate at practical block-lengths, pure channel coding would indeed have been optimal for Wyner-Ziv problems. However, under practical block size and complexity limitations, a non-trivial premium must be paid over the ideal transmitted rate h to achieve near error-free recovery of the symbol plane. The rate required is given by a function $\lambda(h)$ referred to as the *non-ideal binary channel coding rate function.* Even though $\lambda(h)$ can be quite involved to characterize accurately for a given family of codes, it is useful to consider an *approximate* model to gain an understanding of the parameter choice considerations. We note that practical channel coding is less efficient at lower values of conditional entropy h (higher channel code-rates), but become progressively more efficient with increasing h, until at h=1 we have $\lambda(h) = 1$. In other words, $\lambda(h)$ must be a non-decreasing function with non-increasing derivative over the range (0, 1), such that $\lambda(0) = 0$ and $\lambda(1) = 1$. A model (see Fig. 1) capturing this behavior is one where the derivative decays by *inverse square* law: $\lambda'(h) = (1+\gamma)/(1+\gamma h)^2$, so that:

$$\lambda(h) = h(1+\gamma)/(1+\gamma h) \tag{4}$$

The parameter γ is the *overprovision factor*. In [12] curves were presented that closely approximate this model. Even with the above model, at very high code-rates (very low values of h), most channel codes become very inefficient and even break down completely. Therefore, we establish a lower bound ε on the allowable rate transmitted from a channel coder, so that the $\lambda(h)$ function becomes: $\lambda(h) = \max(\varepsilon, h(1+\gamma)/(1+\gamma h))$.

Based on this model for the channel coding rate, the practical rate-distortion points for each set of allowable coding parameters can be readily computed using the equations in [8][9]. From this set, only the Pareto-frontier points are optimal in a rate-distortion sense. For a given target distortion specified by QP_t, the Pareto-optimal point that yields the closest distortion to the target, should chosen as the optimal [8][9].

4. TABLES AND USAGE

In this section, we present a set of tables for varying values of σ_Z, normalized for σ_X=1, providing the optimal encoding parameters obtained using the above method. QP and QP_t is restricted to lie within a finite set Ω_{QP}, where QP is discretized in fine steps. m takes values in $\{1, 2,\ldots, m_{\max}, \infty\}$. S can have values in $\{1, 2,\ldots, S_{\max}\}$ where $S_{\max}$ is a design parameter. Note $S_{\max}$=1 corresponds to the memoryless codes case with no channel coding.

Because closed form solutions do not exist for the seed functions [8][9] needed to find the optimum, it will be at best tedious and time-consuming for a codec developer to duplicate the parameter selection procedure for an arbitrary input parameter set. In all the normalized tables presented below, we fixed γ and ε at reasonable values suitable for most applications. Each table further fixes σ_Z and provides optimum coding parameters for varying values of S_{max} and QP_t. To find the coding parameters for an arbitrary $\{\sigma_X, \sigma_Z\}$ combination, first compute the ratio σ_Z/σ_X, and then look up the normalized table corresponding to the closest $\sigma_Z^{(table)}$ value to the ratio. Within that table, look up the line corresponding to the closest $QP_t^{(table)} = QP_t/\sigma_X$. Finally, the optimal value of QP read from the table, $QP^{(table)}$ is scaled to $QP^{(table)}.\ \sigma_X$ to obtain the final parameter QP.

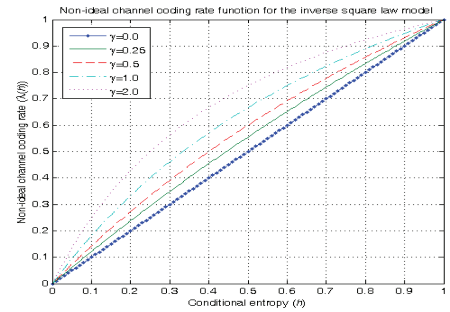

Fig. 1. Inverse Square-Law model

The tables below map QP_t to optimal WZ coding parameters based on the Pareto Optimal set, for design parameter S_{max} = 1, 2, 3, with Ω_{QP}={0.05,0.1,…,2.95,3.0}, m_{max}=31, $\gamma = 0.5$ and ε = 0.04. Both Laplacian and Gaussian innovations are considered. r_i is the channel coded transmission rate for the symbol plane C_i.

TABLE I. PARAMETERS FOR σ_Z=0.2 (LAPLACIAN), γ=0.5, ε=0.04

	S_{max}=1			S_{max}=2				S_{max}=3				
QP_t	QP	S	m	QP	S	m	r_1	QP	S	m	r_1	r_2
0.05	0.05	1	∞	0.05	1	∞	0	0.05	1	∞	0	0
0.10	0.10	1	30	0.10	2	15	0.040	0.10	3	8	0.265	0.040
0.15	0.10	1	19	0.10	2	10	0.133	0.15	3	7	0.131	0.040
0.20	0.20	1	10	0.20	2	5	0.125	0.20	3	3	0.470	0.059
0.25	0.30	1	8	0.30	2	4	0.058	0.30	3	2	0.480	0.058
0.30	0.35	1	5	0.40	2	3	0.062	0.40	3	2	0.274	0.040
0.35	0.55	1	4	0.55	2	2	0.111	0.55	3	1	0.640	0.111
0.40	0.80	1	3	0.80	2	2	0.040	0.80	3	1	0.433	0.040
0.45	1.75	1	2	1.75	2	1	0.099	1.75	2	1	0.099	0
0.50	∞	0	1	∞	0	1	0	∞	0	1	0	0
…	∞	0	1	∞	0	1	0	∞	0	1	0	0

TABLE II. PARAMETERS FOR σ_Z=0.4 (LAPLACIAN), γ=0.5, ε=0.04

	S_{max}=1			S_{max}=2				S_{max}=3				
QP_t	QP	S	m	QP	S	m	r_1	QP	S	m	r_1	r_2
0.05	0.05	1	∞	0.05	1	∞	0	0.05	1	∞	0	0
0.10	0.10	1	∞	0.10	1	∞	0	0.10	3	17	0.172	0.040
0.15	0.10	1	∞	0.10	2	21	0.076	0.10	3	11	0.488	0.062
0.20	0.20	1	24	0.20	2	12	0.040	0.20	3	6	0.391	0.040
0.25	0.25	1	21	0.20	2	9	0.128	0.25	3	6	0.225	0.040
0.30	0.30	1	13	0.30	2	7	0.063	0.30	3	4	0.371	0.040
0.35	0.35	1	11	0.35	2	6	0.066	0.35	3	3	0.458	0.066
0.40	0.45	1	10	0.40	2	4	0.169	0.45	3	3	0.271	0.040
0.45	0.50	1	7	0.50	2	4	0.071	0.50	3	2	0.487	0.071
0.50	0.60	1	6	0.60	2	3	0.107	0.60	3	2	0.351	0.040
0.55	0.70	1	5	0.70	2	3	0.056	0.70	3	2	0.244	0.040
0.60	0.80	1	4	0.80	2	2	0.167	0.80	3	1	0.651	0.167
0.65	0.85	1	3	1.00	2	2	0.075	1.00	3	1	0.520	0.075
0.70	1.20	1	3	1.20	2	2	0.040	1.20	3	1	0.406	0.040
0.75	1.30	1	2	1.30	2	1	0.356	1.55	3	1	0.255	0.040
0.80	2.05	0	2	2.05	2	1	0.127	2.05	2	1	0.127	0
0.85	∞	0	1	∞	0	1	0	∞	0	1	0	0
…	∞	0	1	∞	0	1	0	∞	0	1	0	0

TABLE III. PARAMETERS FOR σ_Z=0.6 (LAPLACIAN), γ=0.5, ε=0.04

	S_{max}=1			S_{max}=2				S_{max}=3				
QP_t	QP	S	m	QP	S	m	r_1	QP	S	m	r_1	r_2
0.05	0.05	1	∞	0.05	1	∞	0	0.05	1	∞	0	0
0.10	0.10	1	∞	0.10	1	∞	0	0.10	3	28	0.083	0.040
0.15	0.10	1	∞	0.10	2	30	0.061	0.10	3	15	0.491	0.061
0.20	0.20	1	∞	0.20	2	19	0.040	0.20	3	10	0.245	0.040
0.25	0.25	1	∞	0.25	2	22	0.040	0.25	3	11	0.086	0.040
0.30	0.30	1	21	0.30	2	11	0.040	0.30	3	6	0.298	0.040
0.35	0.35	1	18	0.35	2	9	0.041	0.35	3	5	0.306	0.040
0.40	0.40	1	14	0.40	2	7	0.063	0.40	3	4	0.364	0.040
0.45	0.45	1	12	0.45	2	6	0.074	0.45	3	3	0.473	0.074
0.50	0.55	1	12	0.50	2	5	0.095	0.55	3	3	0.320	0.040
0.55	0.60	1	9	0.55	2	4	0.148	0.60	3	3	0.258	0.040
0.60	0.70	1	9	0.65	2	4	0.077	0.65	3	2	0.476	0.077
0.65	0.75	1	7	0.70	2	3	0.162	0.75	3	2	0.369	0.040
0.70	0.85	1	6	0.85	2	3	0.078	0.85	3	2	0.280	0.040
0.75	0.95	1	6	0.95	2	3	0.047	0.95	3	2	0.209	0.040
0.80	1.05	1	5	0.95	2	2	0.209	0.95	3	1	0.657	0.209
0.85	1.15	1	4	1.15	2	2	0.112	1.15	3	1	0.543	0.112
0.90	1.30	1	4	1.30	2	2	0.069	1.30	3	1	0.464	0.069
0.95	1.50	1	4	1.50	2	2	0.040	1.50	3	1	0.370	0.040
1.00	1.65	1	3	1.70	2	2	0.040	1.70	3	1	0.291	0.040
1.05	1.95	1	4	1.60	2	1	0.329	1.95	3	1	0.213	0.040
1.10	2.15	1	2	2.15	2	1	0.164	2.15	2	1	0.164	0
1.15	2.80	1	2	2.80	2	1	0.068	2.80	2	1	0.068	0
1.20	∞	0	1	∞	1	1	0	∞	0	1	0	0
…	∞	0	1	∞	0	1	0	∞	0	1	0	0

TABLE IV. PARAMETERS FOR σ_Z=0.8 (LAPLACIAN), γ=0.5, ε=0.04

	S_{max}=1			S_{max}=2				S_{max}=3				
QP_t	QP	S	m	QP	S	m	r_1	QP	S	m	r_1	r_2
0.05	0.05	1	∞	0.05	1	∞	0	0.05	1	∞	0	0
0.10	0.10	1	∞	0.10	1	∞	0	0.10	1	∞	0	0
0.15	0.10	1	∞	0.10	1	∞	0.061	0.10	3	20	0.412	0.040
0.20	0.20	1	∞	0.20	2	24	0.040	0.20	3	12	0.250	0.040
0.25	0.20	1	∞	0.20	2	17	0.073	0.20	3	9	0.464	0.056
0.30	0.30	1	27	0.30	2	14	0.040	0.30	3	7	0.323	0.040
0.35	0.35	1	25	0.35	2	13	0.040	0.35	3	7	0.211	0.040
0.40	0.40	1	18	0.40	2	9	0.047	0.40	3	5	0.337	0.040
0.45	0.45	1	16	0.45	2	8	0.047	0.45	3	4	0.398	0.047
0.50	0.50	1	13	0.50	2	7	0.049	0.50	3	4	0.320	0.040
0.55	0.55	1	12	0.55	2	6	0.064	0.55	3	3	0.442	0.064
0.60	0.65	1	12	0.65	2	6	0.040	0.65	3	3	0.314	0.040
0.65	0.70	1	9	0.70	2	5	0.044	0.70	3	3	0.262	0.040
0.70	0.75	1	8	0.75	2	4	0.084	0.75	3	2	0.478	0.084
0.75	0.85	1	8	0.85	2	4	0.047	0.85	3	2	0.385	0.047
0.80	0.90	1	7	0.85	2	3	0.144	0.90	3	2	0.343	0.040
0.85	1.00	1	6	1.00	2	3	0.076	1.00	3	2	0.269	0.040
0.90	1.10	1	6	1.10	2	3	0.049	1.10	3	2	0.208	0.040
0.95	1.20	1	6	1.20	2	3	0.040	1.20	3	2	0.159	0.040
1.00	1.30	1	6	1.20	2	2	0.159	1.30	3	2	0.121	0.040
1.05	1.40	1	5	1.35	2	2	0.105	1.35	3	1	0.507	0.105
1.10	1.50	1	4	1.50	2	2	0.069	1.50	3	1	0.437	0.069
1.15	1.65	1	4	1.65	2	2	0.045	1.65	3	1	0.373	0.045
1.20	1.80	1	4	1.80	2	2	0.040	1.80	3	1	0.316	0.040
1.25	1.95	1	4	1.95	2	2	0.040	1.95	3	1	0.266	0.040
1.30	2.15	1	3	2.15	2	2	0.040	2.15	3	1	0.209	0.040
1.35	2.40	1	3	2.15	2	1	0.209	2.40	3	1	0.153	0.040
1.40	2.60	1	2	2.60	2	1	0.119	2.60	2	1	0.119	0
1.45	3.00	1	2	3.00	2	1	0.070	3.00	2	1	0.070	0
1.50	3.00	1	2	3.00	2	1	0.070	3.00	2	1	0.070	0
1.55	∞	0	1	∞	0	1	0	∞	0	1	0	0
…	∞	0	1	∞	0	1	0	∞	0	1	0	0

TABLE V. PARAMETERS FOR σ_Z=1.0 (LAPLACIAN), γ=0.5, ε=0.04

	S_{max}=1			S_{max}=2				S_{max}=3				
QP_t	QP	S	m	QP	S	m	r_1	QP	S	m	r_1	r_2
0.05	0.05	1	∞	0.05	1	∞	0	0.05	1	∞	0	0
0.10	0.10	1	∞	0.10	1	∞	0	0.10	1	∞	0	0
0.15	0.10	1	∞	0.10	1	∞	0	0.10	3	22	0.435	0.042
0.20	0.20	1	∞	0.20	2	29	0.040	0.20	3	15	0.187	0.040
0.25	0.20	1	∞	0.20	2	20	0.061	0.20	3	10	0.478	0.061
0.30	0.30	1	∞	0.30	2	17	0.040	0.30	3	9	0.236	0.040
0.35	0.35	1	∞	0.35	2	16	0.040	0.35	3	8	0.205	0.040
0.40	0.40	1	22	0.40	2	11	0.040	0.40	3	6	0.296	0.040
0.45	0.45	1	20	0.45	2	10	0.040	0.45	3	5	0.328	0.040
0.50	0.50	1	16	0.50	2	8	0.047	0.50	3	4	0.404	0.047
0.55	0.55	1	14	0.55	2	7	0.056	0.55	3	4	0.327	0.040
0.60	0.60	1	12	0.60	2	6	0.071	0.60	3	3	0.457	0.071
0.65	0.65	1	11	0.65	2	6	0.049	0.65	3	3	0.392	0.049
0.70	0.75	1	12	0.75	2	6	0.040	0.75	3	3	0.285	0.040
0.75	0.80	1	9	0.80	2	5	0.040	0.80	3	3	0.241	0.040
0.80	0.85	1	8	0.85	2	4	0.078	0.85	3	2	0.454	0.078
0.85	0.95	1	9	0.90	2	4	0.059	0.90	3	2	0.413	0.059
0.90	1.00	1	7	1.00	2	4	0.040	1.00	3	2	0.334	0.040
0.95	1.10	1	8	1.05	2	3	0.095	1.10	3	2	0.267	0.040
1.00	1.15	1	6	1.15	2	3	0.064	1.15	3	2	0.238	0.040
1.05	1.25	1	6	1.25	2	3	0.043	1.25	3	2	0.187	0.040
1.10	1.35	1	7	1.30	2	3	0.040	1.35	3	2	0.146	0.040
1.15	1.40	1	5	1.30	2	2	0.165	1.40	3	2	0.129	0.040
1.20	1.50	1	5	1.45	2	2	0.113	1.45	3	1	0.503	0.113
1.25	1.60	1	4	1.60	2	2	0.077	1.60	3	1	0.437	0.077
1.30	1.75	1	5	1.70	2	2	0.059	1.70	3	1	0.396	0.059
1.35	1.85	1	4	1.85	2	2	0.040	1.85	3	1	0.339	0.040
1.40	2.00	1	5	1.95	2	2	0.040	1.95	3	1	0.305	0.040
1.45	2.10	1	3	2.10	2	2	0.040	2.10	3	1	0.258	0.040
1.50	2.30	1	4	2.30	2	2	0.040	2.30	3	1	0.205	0.040
1.55	2.45	1	3	2.45	1	3	0	2.45	3	1	0.172	0.040
1.60	2.65	1	3	2.45	2	1	0.172	2.45	2	1	0.172	0
1.65	2.80	1	2	2.80	2	1	0.112	2.80	2	1	0.112	0
1.70	3.00	1	2	3.00	2	1	0.087	3.00	2	1	0.087	0
1.75	3.00	1	2	3.00	2	1	0.087	3.00	2	1	0.087	0
1.80	3.00	1	2	3.00	2	1	0.087	3.00	2	1	0.087	0
1.85	∞	0	1	∞	0	1	0	∞	0	1	0	0
…	∞	0	1	∞	0	1	0	∞	0	1	0	0

TABLE VI. PARAMETERS FOR σ_Z=0.2 (GAUSSIAN), γ=0.5, ε=0.04

	S_{max}=1			S_{max}=2				S_{max}=3				
QP_t	QP	S	m	QP	S	m	r_1	QP	S	m	r_1	r_2
0.05	0.05	1	∞	0.05	1	∞	0	0.05	1	∞	0	0
0.10	0.10	1	17	0.10	2	9	0.099	0.10	3	5	0.678	0.050
0.15	0.10	1	13	0.10	2	7	0.311	0.10	3	4	0.850	0.183
0.20	0.20	1	7	0.20	2	4	0.183	0.20	3	2	0.827	0.183
0.25	0.25	1	6	0.25	2	3	0.267	0.25	3	2	0.646	0.079
0.30	0.35	1	4	0.35	2	2	0.355	0.35	3	1	0.874	0.355
0.35	0.50	1	3	0.50	2	2	0.107	0.50	3	1	0.724	0.107
0.40	0.65	1	2	0.65	2	1	0.570	0.75	3	1	0.483	0.040
0.45	1.70	1	2	1.70	2	1	0.106	1.70	2	1	0.106	0
0.50	∞	0	1	∞	0	1	0	∞	0	1	0	0
…	∞	0	1	∞	0	1	0	∞	0	1	0	0

TABLE VII. PARAMETERS FOR σ_Z=0.4 (GAUSSIAN), γ=0.5, ε=0.04

	S_{max}=1			S_{max}=2				S_{max}=3				
QP_t	QP	S	m	QP	S	m	r_1	QP	S	m	r_1	r_2
0.05	0.05	1	∞	0.05	1	∞	0.000	0.05	1	∞	0	0
0.10	0.10	1	∞	0.10	2	18	0.069	0.10	3	9	0.703	0.069
0.15	0.10	1	27	0.10	2	14	0.246	0.10	3	7	0.872	0.246
0.20	0.20	1	15	0.20	2	8	0.121	0.20	3	4	0.755	0.121
0.25	0.20	1	12	0.25	2	8	0.046	0.25	3	4	0.529	0.046
0.30	0.30	1	9	0.30	2	5	0.155	0.30	3	3	0.632	0.057
0.35	0.35	1	8	0.35	2	4	0.212	0.35	3	2	0.782	0.212
0.40	0.40	1	6	0.40	2	3	0.340	0.40	3	2	0.704	0.111
0.45	0.50	1	5	0.50	2	3	0.153	0.50	3	2	0.510	0.040
0.50	0.60	1	5	0.60	2	3	0.062	0.60	3	2	0.342	0.040
0.55	0.65	1	4	0.65	2	2	0.275	0.65	3	1	0.791	0.275
0.60	0.70	1	3	0.80	2	2	0.134	0.80	3	1	0.684	0.134
0.65	0.90	1	3	0.95	2	2	0.064	0.95	3	1	0.574	0.064
0.70	1.15	1	3	1.15	2	2	0.040	1.15	3	1	0.444	0.040
0.75	1.35	1	2	1.35	2	1	0.338	1.45	3	1	0.294	0.040
0.80	2.05	0	2	2.05	2	1	0.125	2.05	2	1	0.125	0
0.85	∞	0	1	∞	0	1	0	∞	0	1	0	0
…	∞	0	1	∞	0	1	0	∞	0	1	0	0

TABLE VIII. PARAMETERS FOR σ_Z=0.6 (GAUSSIAN), γ=0.5, ε=0.04

	S_{max}=1			S_{max}=2				S_{max}=3				

QP_t	QP	S	m	QP	S	m	r_1	QP	S	m	r_1	r_2
0.05	0.05	1	∞	0.05	1	∞	0	0.05	1	∞	0	0
0.10	0.10	1	∞	0.10	2	28	0.040	0.10	3	14	0.585	0.040
0.15	0.10	1	∞	0.10	2	20	0.224	0.10	3	10	0.841	0.224
0.20	0.20	1	24	0.20	2	12	0.083	0.20	3	6	0.680	0.083
0.25	0.20	1	19	0.20	2	10	0.200	0.20	3	5	0.803	0.200
0.30	0.30	1	14	0.30	2	7	0.148	0.30	3	4	0.645	0.074
0.35	0.35	1	13	0.35	2	7	0.073	0.35	3	4	0.485	0.040
0.40	0.40	1	10	0.40	2	5	0.170	0.40	3	3	0.616	0.069
0.45	0.45	1	9	0.45	2	5	0.101	0.45	3	3	0.498	0.040
0.50	0.50	1	7	0.50	2	4	0.161	0.50	3	2	0.718	0.161
0.55	0.60	1	7	0.60	2	4	0.063	0.60	3	2	0.575	0.063
0.60	0.65	1	6	0.65	2	3	0.172	0.65	3	2	0.502	0.040
0.65	0.70	1	5	0.70	2	3	0.124	0.70	3	2	0.437	0.040
0.70	0.70	1	4	0.80	2	3	0.063	0.80	3	2	0.318	0.040
0.75	0.90	1	4	0.90	2	2	0.224	0.90	3	1	0.720	0.224
0.80	1.00	1	4	1.00	2	2	0.154	1.00	3	1	0.659	0.154
0.85	1.05	1	3	1.10	2	2	0.105	1.10	3	1	0.598	0.105
0.90	1.20	1	3	1.25	2	2	0.058	1.25	3	1	0.509	0.058
0.95	1.40	1	3	1.40	2	2	0.040	1.40	3	1	0.428	0.040
1.00	1.40	1	2	1.40	2	1	0.428	1.55	3	1	0.356	0.040
1.05	1.75	1	2	1.75	2	1	0.275	1.75	2	1	0.275	0.000
1.10	2.15	1	2	2.15	2	1	0.160	2.15	2	1	0.160	0.000
1.15	3.00	1	2	3.00	2	1	0.049	3.00	2	1	0.049	0.000
1.20	∞	0	1	∞	1	1	0	∞	0	1	0	0
…	∞	0	1	∞	0	1	0	∞	0	1	0	0

TABLE IX. PARAMETERS FOR σ_Z=0.8 (LAPLACIAN), γ=0.5, ε=0.04

	S_{max}=1			S_{max}=2				S_{max}=3				
QP_t	QP	S	m	QP	S	m	r_1	QP	S	m	r_1	r_2
0.05	0.05	1	∞	0.05	1	∞	0	0.05	1	∞	0	0
0.10	0.10	1	∞	0.10	1	∞	0	0.10	3	25	0.212	0.040
0.15	0.10	1	∞	0.10	2	27	0.154	0.10	3	14	0.743	0.130
0.20	0.20	1	∞	0.20	2	16	0.054	0.20	3	8	0.597	0.054
0.25	0.20	1	25	0.20	2	13	0.162	0.20	3	7	0.703	0.115
0.30	0.30	1	19	0.30	2	10	0.071	0.30	3	5	0.615	0.071
0.35	0.35	1	19	0.35	2	10	0.040	0.35	3	5	0.458	0.040
0.40	0.40	1	13	0.40	2	7	0.094	0.40	3	4	0.532	0.044
0.45	0.45	1	12	0.45	2	6	0.113	0.45	3	3	0.639	0.113
0.50	0.50	1	10	0.50	2	5	0.148	0.50	3	3	0.558	0.060
0.55	0.55	1	9	0.55	2	5	0.095	0.55	3	3	0.465	0.040
0.60	0.60	1	8	0.60	2	4	0.164	0.60	3	2	0.686	0.164
0.65	0.70	1	9	0.65	2	4	0.116	0.70	3	3	0.249	0.040
0.70	0.75	1	7	0.75	2	4	0.054	0.75	3	2	0.507	0.054
0.75	0.80	1	6	0.80	2	3	0.151	0.80	3	2	0.453	0.040
0.80	0.90	1	6	0.90	2	3	0.087	0.90	3	2	0.350	0.040
0.85	0.95	1	5	0.95	2	3	0.067	0.95	3	2	0.304	0.040
0.90	1.00	1	4	1.00	2	2	0.263	1.05	3	2	0.226	0.040
0.95	1.10	1	4	1.10	2	2	0.193	1.10	3	1	0.663	0.193
1.00	1.20	1	4	1.20	2	2	0.140	1.20	3	1	0.609	0.140
1.05	1.20	1	3	1.30	2	2	0.100	1.30	3	1	0.555	0.100
1.10	1.40	1	3	1.40	2	2	0.071	1.40	3	1	0.502	0.071
1.15	1.50	1	3	1.55	2	2	0.042	1.55	3	1	0.428	0.042
1.20	1.65	1	3	1.70	2	2	0.040	1.70	3	1	0.361	0.040
1.25	1.85	1	3	1.85	2	2	0.040	1.85	3	1	0.302	0.040
1.30	1.95	1	2	1.95	2	1	0.267	1.95	2	1	0.267	0
1.35	2.20	1	2	2.20	2	1	0.194	2.20	2	1	0.194	0
1.40	2.60	1	2	2.60	2	1	0.114	2.60	2	1	0.114	0
1.45	3.00	1	2	3.00	2	1	0.066	3.00	2	1	0.066	0
1.50	∞	0	1	∞	0	1	0	∞	0	1	0	0
…	∞	0	1	∞	0	1	0	∞	0	1	0	0

TABLE X. PARAMETERS FOR σ_Z=1.0 (GAUSSIAN), γ=0.5, ε=0.04

	S_{max}=1			S_{max}=2				S_{max}=3				
QP_t	QP	S	m	QP	S	m	r_1	QP	S	m	r_1	r_2
0.05	0.05	1	∞	0.05	1	∞	0	0.05	1	∞	0	0
0.10	0.10	1	∞	0.10	1	∞	0	0.10	1	∞	0	0
0.15	0.10	1	∞	0.10	1	∞	0	0.10	3	17	0.687	0.102
0.20	0.20	1	∞	0.20	2	20	0.040	0.20	3	10	0.512	0.040
0.25	0.20	1	30	0.20	2	15	0.163	0.20	3	8	0.692	0.123
0.30	0.30	1	24	0.30	2	12	0.060	0.30	3	6	0.568	0.060
0.35	0.30	1	19	0.30	2	10	0.148	0.30	3	6	0.568	0.060
0.40	0.40	1	17	0.40	2	9	0.054	0.40	3	5	0.450	0.040
0.45	0.45	1	16	0.45	2	8	0.056	0.45	3	4	0.516	0.056
0.50	0.50	1	12	0.50	2	6	0.125	0.50	3	3	0.641	0.125
0.55	0.55	1	11	0.55	2	6	0.079	0.55	3	3	0.558	0.079
0.60	0.60	1	10	0.60	2	5	0.116	0.60	3	3	0.487	0.045
0.65	0.65	1	9	0.65	2	5	0.079	0.65	3	3	0.412	0.040
0.70	0.70	1	8	0.70	2	4	0.145	0.70	3	2	0.637	0.145
0.75	0.80	1	9	0.80	2	5	0.040	0.80	3	3	0.234	0.040
0.80	0.85	1	7	0.85	2	4	0.055	0.85	3	2	0.482	0.055
0.85	0.90	1	6	0.90	2	3	0.152	0.90	3	2	0.435	0.040
0.90	0.95	1	6	0.95	2	3	0.121	0.95	3	2	0.388	0.040
0.95	1.05	1	6	1.05	2	3	0.075	1.05	3	2	0.305	0.040
1.00	1.10	1	5	1.10	2	3	0.058	1.10	3	2	0.268	0.040
1.05	1.20	1	5	1.20	2	3	0.040	1.20	3	2	0.205	0.040
1.10	1.25	1	4	1.25	2	2	0.178	1.25	2	2	0.178	0.000
1.15	1.35	1	4	1.35	2	2	0.133	1.35	2	2	0.133	0.000
1.20	1.45	1	4	1.45	2	2	0.099	1.45	2	2	0.099	0.000
1.25	1.55	1	4	1.55	2	2	0.072	1.55	2	2	0.072	0.000
1.30	1.60	1	3	1.65	2	2	0.053	1.65	2	2	0.053	0.000
1.35	1.70	1	3	1.75	2	2	0.040	1.75	3	1	0.388	0.040
1.40	1.85	1	3	1.85	2	2	0.040	1.85	3	1	0.348	0.040
1.45	2.00	1	3	2.00	2	2	0.040	2.00	3	1	0.293	0.040
1.50	2.15	1	3	2.15	2	2	0.040	2.15	3	1	0.246	0.040
1.55	2.20	1	2	2.20	2	1	0.231	2.20	2	1	0.231	0
1.60	2.45	1	2	2.45	2	1	0.169	2.45	2	1	0.169	0
1.65	2.75	1	2	2.75	2	1	0.114	2.75	2	1	0.114	0
1.70	3.00	1	2	3.00	2	1	0.082	3.00	2	1	0.082	0
1.75	3.00	1	2	3.00	2	1	0.082	3.00	2	1	0.082	0
1.80	∞	0	1	∞	0	1	0	∞	0	1	0	0
…	∞	0	1	∞	0	1	0	∞	0	1	0	0

5. CONCLUSION

We have presented a set of optimal tables for use in a variety of Wyner-Ziv coding applications involving Laplacian distributed transform coefficients and additive Laplacian or Gaussian innovation. If the source/correlation statistics are known or can be reliably estimated, the coding parameters can be readily read off from these tables.

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