On Successive Refinement for the Wyner–Ziv Problem

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Abstract

Achievable rates are characterized for successive refinement in the Wyner–Ziv scenario, namely, in the presence of correlated side information (SI) at the receiver. In this setting, the encoder is assumed to operate in two stages, where the first corresponds to relatively low rate and high distortion, and the second, comprising a refinement code on top of the first code, is aimed at reproduction at reduced distortion. Both decoders (for low-rate/high-distortion and for high-rate/low-distortion) are equipped with SI streams, correlated to the source, but unavailable to the encoder. Furthermore, it is assumed that the decoder that receives the higher rate bitstream, i.e., the additional refinement bits, accesses also SI of better quality (in a sense that will be defined later) than that of the lower resolution decoder. For a memoryless joint process (that includes the source to be encoded and its instantaneously correlated SI streams), necessary and sufficient conditions are furnished, in terms of single–letter formulas, for the achievability of a pair of rates, corresponding to two given distortion levels. Special attention is devoted to the degenerate, but important, case where the two SI streams, at the two decoders, are identical. For this case, conditions are provided for successive refinability in the sense of the existence of codes that asymptotically achieve the Wyner–Ziv rate–distortion function, simultaneously at both distortion levels. In this context, the doubly symmetric binary source (with the Hamming distortion measure) and the jointly Gaussian source (with the squared error distortion measure) are shown to be successively refinable in the Wyner–Ziv setting. It is also demonstrated that a source that is not successively refinable in the ordinary sense (i.e., without SI) may become successively refinable in the presence of SI at the decoders.

Index terms — Side information, successive refinement, scalable coding, progressive coding, multiple description, Wyner-Ziv problem.

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