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On Hierarchical Joint Source–Channel Coding

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Abstract

We extend the setting of two–stage lossy source coding with successive refinement structures into a joint source–channel coding setting. In particular, we consider a problem where two descriptions of a memoryless source are to be transmitted across two independent memoryless channels and where the output of the channel corresponding to the first (coarse) description is also available to the decoder of the second (refinement) decoder. Side information, correlated to the source, may also be available to the decoders. Our first result is a separation theorem asserting that in the limit of long blocks, no optimality is lost by first applying lossy successive–refinement source coding, regardless of the channels, and then applying good channel codes to each one of the resulting bitstreams, regardess of the source and the side information. It is also shown that (even noiseless) feedback from the output of the first channel to the input of the second encoder cannot improve performance, but may sometimes facilitate the implementation of optimum codes significantly: In certain situations, even single–letter codes (of unit block length) may achieve optimum performance. Necessary and sufficient conditions are furnished for the optimality of single–letter codes with and without feedback.

Index terms — Hierarchical coding, joint source–channel coding, side information, successive refinement, systematic coding, Wyner-Ziv problem.

1 Introduction

The problem of lossy source coding in two or more stages of successive refinement has received quite considerable attention throughout the last few decades (see, e.g., [2], [5], [6], [8], [9], [10], [11],