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Universal Decoding for Arbitrary Channels Relative to a Given Class of Decoding Metrics

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Abstract

We consider the problem of universal decoding for arbitrary unknown channels in the random coding regime. For a given random coding distribution and a given class of metric decoders, we propose a generic universal decoder whose average error probability is, within a sub–exponential multiplicative factor, no larger than that of the best decoder within this class of decoders. Since the optimum, maximum likelihood (ML) decoder of the underlying channel is not necessarily assumed to belong to the given class of decoders, this setting suggests a common generalized framework for: (i) mismatched decoding, (ii) universal decoding for a given family of channels, and (iii) universal coding and decoding for deterministic channels using the individual–sequence approach. The proof of our universality result is fairly simple, and it is demonstrated how some earlier results on universal decoding are obtained as special cases. We also demonstrate how our method extends to more complicated scenarios, like incorporation of noiseless feedback, and the multiple access channel.

Index Terms: Universal decoding, mismatched decoding, error exponents, finite–state machines, Lempel–Ziv algorithm, feedback, multiple access channel.