Iterative Decoding

Thesis by

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Abstract

Though coding theory suggests long error correcting codes chosen at random perform close to the optimum, the problem of designing good codes has traditionally been attacked by developing codes with a lot of structure, which lends itself to feasible decoders. The challenge to find practical decoders for long random codes has not been seriously considered until the recent introduction of turbo codes in 1993. This methodology of multi-stage iterative decoding with exchange of soft information, applied to codes with pseudo-random structure, has provided a whole new approach to construct good codes and to decode them with low complexity. This thesis examines the theoretical ground as well as the design and implementation details of these iterative decoding techniques. The methodology is first applied to parallel concatenated unit-memory convolutional codes and generalized concatenated convolutional codes to demonstrate its power and the general design principle. We then show that, by representing these coding systems with appropriate Bayesian belief networks, all the *ad hoc* algorithms can be derived from a general statistical inference belief propagation algorithm. A class of new binary codes based on low-density generator matrices is proposed to eliminate the arbitrariness and unnecessary constraints in turbo coding we have recognized from this Bayesian network viewpoint. Contrary to the turbo decoding paradigm where sequential processing is accomplished by very powerful central units, the decoding algorithm for the new code is highly parallel and distributive. We also apply these codes to M-ary modulations using multilevel coding techniques to achieve higher spectral efficiency. In all cases, we have constructed systems with flexible error protection capability and performance within 1 dB of the channel capacity.

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