Analysis and Application of Stochastic Decoding of LDPC Codes

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Stochastic decoding has been proposed as an alternative to the Sum-Product Algorithm (SPA) due to its low hardware complexity. We analyze the performance of stochastic decoding of binary LDPC codes over AWGN and ISI channels. Noise Dependent Scaling (NDS) has been suggested in the literature as a method to improve the convergence rate for stochastic decoding. We investigate the sensitivity of the scaling factor used in NDS. The effectiveness of Edge Memories and Tracking Forecast Memories in reducing the ill-effects of latching is demonstrated through simulation. Apart from these existing techniques, we propose redecoding as an effective approach to reduce the error floors observed using stochastic decoding.

While stochastic decoding has been found in practice to have performance close to that of the SPA, an analytical explanation of this empirical observation has been lacking. We present our attempts to develop analytical tools to assess the performance of stochastic decoding for LDPC codes. Techniques similar to density evolution were employed to determine the asymptotic performance of stochastic decoding in the limit of increasing block-length and number of decoding cycles. Since evolving the densities of statistics of the bit-streams in a stochastic decoder analytically is difficult and using Monte Carlo simulations is computationally challenging, we propose, instead, to evolve moments of these densities. This simplification allows us to evolve approximately the moments, which are one-dimensional real numbers unlike the densities, using a simple analytical recursion. Analysis of the fixed-points of this approximate moment evolution algorithm allows us to calculate rough thresholds for various LDPC code ensembles with regular degree distributions. Since this analysis is based on an incorrect assumption about independence of certain messages, we discuss a possible approach that might be useful in determining bounds on the thresholds.