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Iterative decoding of low-density parity check codes over compound channels

Ilan Sutskover and Shlomo Shamai (Shitz)

Abstract

We present a setting for decoding of LDPC codes jointly with channel estimation, suitable for transmission over memoryless compound channels. We show that the performance of the combined scheme can be rigorously evaluated by means of density evolution, and focus on density evolution as a tool for designing a channel estimator that matches not only to the channel, but also to the LDPC ensemble as well.

I. Introduction

Low-density parity-check (LDPC) codes have proven themselves extremely useful for error protection in a memoryless noisy channel when the channel statistics are known [1]. Iterative decoding, either of LDPC codes or of Turbo codes, has been considered also in conjunction with certain unknown channel parameters, e.g., [2], [3], [4] that address iterative decoding and channel estimation for Turbo codes and Rayleigh fading channels, [5] that deals with blind turbo equalization, [6] that examines Turbo codes over an AWGN channel with unknown phase rotation and [7], [8], [9], [10] that investigate LDPC decoding at the same channel conditions.

In this paper, decoding of LDPC codes over compound channels [11] is considered. Examples for such channels are: complex AWGN with phase uncertainty or frequency uncertainty (or both), block fading AWGN channel, BSC with unknown transition probability etc.

In the literature, several strategies are taken when parameters uncertainty exists. Among these strategies we can find the following non-exhaustive list: Schemes that improve their estimation from one coded-block to the next [6], [12], systems that patch SISO channel estimators to SISO decoders [6], [13], [14] and frameworks that use factor graphs to represent the channel parameter [8], [9], [10]. Numerical analysis of complete systems (joint decoding and estimation/equalization) appears to the best of our knowledge only in [8], [15], [16]. All other methods are analyzed via Monte-Carlo simulations.

The work most close in nature to the one presented in this paper is perhaps the work of Nuriyev and Anastasopoulos [8]. The authors of [8] present results for joint decoding and phase estimation when LDPC codes are used. Their setting, unlike the setting used in this paper, is Bayesian. In an AWGN, a constant phase, uniformly distributed over $[0, 2\pi]$, is assumed to govern short sub-blocks of the coded block (where BPSK transmission is regarded). Several message-passing decoders are proposed and analyzed via density evolution. However, where [8] puts its emphasis on the gain from pilot bits and its results are averaged with respect to a uniform distribution over the phase rotation, our work addresses a single unknown parameter (which can be, for example, an unknown phase rotation) and puts its emphasis on proper channel estimators design and the theoretical support for the analysis of the complete system by density evolution (which is somewhat more complicated than in the setting of [8]). Moreover, the setting of [8] is specialized to

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