PERFORMANCE OF A SIMPLIFIED SOFT-DISTANCE DECODING ALGORITHM FOR LDPC CODES OVER THE RAYLEIGH FADING CHANNEL

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***Abstract*— In this paper, we investigate the performance of a Soft-Input soft-Output decoding algorithm for LDPC codes that uses Euclidean distance as its metric, in the Rayleigh fading channel. It is found that its Bit Error Rate performance is close to that of traditional decoding algorithms like the Sum-Product algorithm and its logarithmic version. Main characteristics of the proposed algorithm and its modification to perform over the Rayleigh channel are described. This algorithm uses squared Euclidean distance as the metric, does not require knowledge of the signal-to-noise ratio of the received signal, and is less complex to implement than other soft-input, soft-output algorithms.**

***Keywords*— LDPC codes, Rayleigh Channel, Soft Distance decoding.**

I. INTRODUCTION

Low-density parity-check (LDPC) codes (MacKay and Neal, 1997; MacKay, 1999) have become one of the most interesting options among block error-correcting codes when a high Bit Error Rate (BER) performance is desired. It is known that by using message passing decoding algorithms, like the classic Sum-product (SP) or its logarithmic version, called LogSP, or the proposed Simplified Soft Distance (SSD) decoding algorithm, which is based on Euclidean Distance metric (Farrell and Castiñeira Moreira, 2009; Castiñeira Moreira and Farrell, 2008) irregular (LDPC) codes can achieve reliable transmission at signal-to-noise ratios (SNR) extremely close to the Shannon limit, on the additive white Gaussian noise (AWGN) channel. They outperform turbo codes of the same block size and code rate (MacKay and Neal, 1997; MacKay, 1999; How *et al.*, 2001). LDPC codes have certain advantages, such as simple descriptions of their code structure and fully parallelizable decoding implementations (How *et al.*, 2001).

However, their potential as capacity achieving codes for other channels, has not been completely established yet. Preliminary results are available which suggest that they can achieve capacity for a wide range of channels.

In How *et al.* (2001) irregular LDPC codes of large lengths were analyzed in a flat uncorrelated Rayleigh fading channel. The channel model assumed in How *et al.* (2001), was a slow (large coherence time) frequency non-selective (flat) Rayleigh fading channel. It is shown that LDPC codes have also an excellent BER performance over the Rayleigh Channel.

We want to study the performance of a decoding algorithm for LDPC codes that operates with iterative interchange of information like the SP algorithm, but utilizes soft distance as its metric. The proposed algorithm uses an antilog-sum as its main operation for performing the interchange of information characteristic of an iterative Soft-Input Soft-Output (SISO) decoding algorithm for LDPC codes. We adopt the Rayleigh channel model used in How *et al.* (2001), that is, a slow memory-less frequency non-selective (flat) Rayleigh fading channel with channel state information (CSI). The channel dynamics are explicitly taken into account by considering a block-independent fading model.

II. BINARY LDPC CODES

LDPC codes belong to a very efficient class of linear block codes. They are constructed by designing a sparse (few nonzero elements scattered among rows and columns) parity check matrix related to a generator matrix $\boldsymbol{G}$, which is used to encode a message vector $\boldsymbol{m}$ with k elements in a code word $\boldsymbol{c}=\boldsymbol{G}.\boldsymbol{m}$, with n elements.

Any word belonging to the code satisfies the syndrome condition: $\boldsymbol{H}.\boldsymbol{c}=\boldsymbol{0}$. This matrix satisfies certain conditions that provide optimum performance in terms of BER (MacKay and Neal, 1997; MacKay, 1999).

Binary LDPC codes operate with message and codeword vectors defined over the binary field, so that their components belong to the discrete alphabet {0,1}.

Digital transmission has the best performance if polar format is adopted, i.e. bits are transmitted by sending signals from the discrete alphabet {-1,1}. Then, codeword $\boldsymbol{c}$ is sent through the channel as a signal $\boldsymbol{s}$, where it is affected by the presence of noise and by multipath fading. The aim of the decoding algorithm is to find the vector $\boldsymbol{d}$, considered as an estimation of the transmitted vector, able to satisfy the condition $\boldsymbol{H}.\boldsymbol{d}=\boldsymbol{0}$.

The LDPC SP decoding algorithm described in MacKay and Neal (1997) and MacKay (1999) operates