A GENETIC-ALGORITHM BASED DECODER FOR LOW DENSITY PARITY CHECK CODES

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Abstract. **This paper presents a Genetic-Algorithm based decoder for a medium-sized Low Density Parity Check code (GAMD decoder). The main advantage of the proposed GAMD decoder is that no information on the noise level transmission channel is required, an essential condition for the well-known sum product algorithm. The proposed methodology combines a Genetic Algorithm stage with a meta-decision process. Genetic Algorithms were selected due to their capacity to solve this type of multiple minimum. Encouraging results were reached when comparing the Bit Error Rate (BER) performance of the proposed algorithm with that of the traditional sum-product decoding algorithm. The performance of the proposed decoder is very close to that of the optimal sum-product decoder, with the additional benefit of not requiring channel information (signal-to-noise ratio). In order to improve Bit Error Rate performance and/or reduce the complexity of the proposed decoder, the fitness function and parameters of the GA can be optimized.**

***Keywords*— LDPC codes, Genetic Algorithm, Sum-product Algorithm.**

I. INTRODUCTION

One of the main issues in communication theory is the design of a coding technique rendering reliable transmissions over noisy channels. Since Shannon's prediction (Shannon, 1948), there have been different approaches to accomplishing limit performance for a reliable transmission over a non-reliable channel. Low Density Parity Check (LDPC) codes appeared as a very suitable coding technique that, under some conditions, can yield a Bit Error Rate (BER) performance close to the Shannon's limit by fractions of a dB. LDPC codes were invented by Gallager (1963) and later rediscovered by MacKay and Neal (1997), becoming one of the most powerful error correction techniques known in these days.

A LDPC code is a linear block code defined by a very sparse parity check matrix $\boldsymbol{H}$. The decoding algorithm is easily understood by means of a graphic representation called bipartite graph. In this graphic representation, the decoding procedure is seen as the interchange of probabilistic information between symbol (or bit) nodes and parity check nodes. The relationship between the bits of a code vector is determined by the parity check matrix $\boldsymbol{H}$. A given code vector satisfies the whole set of parity check conditions described in the parity check matrix $\boldsymbol{H}$.

When these codes are decoded using Gallager's iterative probabilistic decoding method, also known as the sum-product algorithm or belief propagation algorithm, their empirical BER performances are found to be excellent (MacKay, 1999; Richardson and Urbanke, 2001). This is true when the length of the code vector is large enough. The decoding algorithm is an iterative decoding procedure that depends on the knowledge of the noise level in the channel. MacKay and Hesketh (2003) investigated the dependence of the performance of a LDPC code on both the assumed and actual noise levels of a binary symmetric channel and a Gaussian channel, respectively.

Genetic Algorithms (Goldberg, 1989) are search algorithms that apply operations from natural genetics to guide the trek through a search space. GAs have theoretically and empirically proven to provide robust search capability in complex spaces, offering a valid approach to a problem requiring efficient and effective search.

GAs have been previously applied to communication network design (Daijin and Sunha, 1999), VLSI layout (Valenzuela and Wang, 2002), maximal distance codes (Dontas and De Jong, 1990), to name a few examples.

In this work, we propose a new approach to a LDPC decoding algorithm based on a hybrid system that combines a Genetic Algorithm with a Meta-Decision Process (Bonissone, 2003). As the main advantage of the proposed decoding scheme, we emphasize that no knowledge of the signal to noise ratio present in the channel is necessary.

II. GENERAL CONSIDERATIONS

A. LDPC codes

LDPC codes (McKay, 1999) are a powerful class of linear block codes characterized equivalently by a generator matrix $\boldsymbol{G}$ (k x n dimension) used to encode a message vector $\boldsymbol{m}$ (k x 1 dimension) into a code vector $\boldsymbol{x}$ (n x 1 dimension), or by its corresponding parity check matrix $\boldsymbol{H}$ ($(n\text{-}k)$ x n dimension), which is such that any code vector satisfies the syndrome condition $\boldsymbol{H} \circ \boldsymbol{x} = \boldsymbol{0}$.