# Performance Analysis of the Iterative Turbo Decoding Stopping Criteria in AWGN Channel

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***Abstract*—The variances in the channel estimates errors is the factor that affected the channel reliability factor in iterative turbo decoding, due to the flawed in the estimates of the signal-to-noise ratio (SNR). However, most of the stopping criteria approaches in turbo decoding assumed the channel reliability at the receiver is known with respect to the threshold. Under additive white Gaussian noise (AWGN) channel, three stopping criteria for iterative decoding are analyzed in this paper. The Cross-entropy (CE), Hard Decision Aided (HDA) and Sign-Change Ratio (SCR) are utilized for the simulation process by comparing the reliability channel stopping criteria. It is further enhanced by expanding puncturing method the rate of the system for AIN. At high SNR, the scaled received data results in the stopping criteria to stop iteration sooner while keeping up the BER performance, however more regrettable at certain frame size. Consequently, the different frame size does not influence the BER performance either in unscaled or scale condition.**

***Keywords—turbo codes; iterative decoding; stopping criterion; channel reliability***

## I. INTRODUCTION

These days, digital communication systems are winding up more appealing in light of the fact that digital transmission offers data processing options and the adaptabilities are not accessible with analogue transmission and furthermore, it regularly developing interest for data communication. There are a few kinds of digital signals, for example, information, broadcast, television and telephone can be dealt with as identical signals in transmission and exchanging where a bit is a bit. One of the error correcting codes used in coding theory is Turbo codes in which messages are passed iteratively between two concatenated decoders. Turbo codes are utilized as a part of 3G/4G mobile communications where it has been abused in the freshest and most advanced systems, for example, Digital Video Broadcasting (DVB) and the Universal Mobile Telecommunication System (UMTS) for the Third Generation Partnership Project (3GPP) [1][2]. The Maximum A-Posteriori Probability (MAP), Logarithmic MAP (Log-MAP) and the Maximum Log-MAP (Max Log-MAP) are prominent algorithms that been used for the Turbo decoding [3].

Iterative Turbo decoding make used the information generated from the conventional forward error correction codes (FEC); for instance the revised FEC version called Reed-Solomon, despite the fact that these systems are excessively unpredictable for practical implementations of iterative decoders [4]. The extrinsic information generated by two constituent decoders of the Turbo decoder are passed to each other in an iterative manner. This outward data traded between these decoders is the reasons to its outstanding performance[2]. The performance is increased when its iterate more, as expected in most cases. However, this will increase the computational latency as well as its power consumption. A design trade-off, in which, once the decoder converged, the iteration is stopped even before reaching the maximum iterations cycle ($k_{max}$) [2]. Numerous stopping criteria presented by researchers aim to stop the iteration in the decoding process to reduce the computational complexity and hardware resources so that the power consumption is kept at minimum.

This paper investigates the performance analysis of the channel reliability factor in iterative turbo decoding under the additive white Gaussian noise (AWGN) channel. Its performance for different code rate is investigate, then analyse the performance of the threshold CE stopping criterion for various frame size and finally compare its performance in terms of bit error rate (BER) and average iteration number (AIN). Cross-entropy (CE), Hard Decision Aided (HDA) and Sign-Change Ratio (SCR) are selected for the iterative Turbo stopping criteria. A fixed-iteration stopping criteria is used as the benchmark. The rest of this paper is sorted out as follows. Section II provides an overview of Turbo codes and its stopping criteria. Section III discusses the overall process for simulation of CE, SCR and HDA stopping criteria. The performance analysis of stopping criteria is analysed and compared in Section IV. Section V concluded the works.

## II. TURBO CODES

### A. Iterative Turbo Decoding

In 1993, Berrou, Glavieux and Thitimajshima [2] presented Turbo Codes, which has shown a remarkable error correction capability. For instance, the codes accomplished performances just 0.7 dB off the Shannon's channel capacity on AWGN channel. The iterative behavior made the Turbo decoding shown significant improvement on bit error rate (BER) in AWGN. The turbo iterative decoding estimates its output, by utilizing the two constituent decoders that produced mutual information, at each iteration, as shown in Figure 1. Let the received signal at the receiver as $y = (y_1, y_2,\ldots y_N)$ that undergo the AWGN, $v$ [6], then, $y = u + v$, and $u$ is the information bits. The extrinsic information, $Le$, of the two decoder is exchanged at i-$^{th}$ iteration. Let $\hat{u}_t$ is the estimate of the data bit, $u_t$, at time $t$, hence, the log-likelihood ratio ($Lr$) is related to the output of $y_t = (y_{t,1}, y_{t,2}, \ldots, y_{t,n})$ at every decoder, as follows: