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Bidirectional Fano Algorithm for High Throughput Sequential Decoding

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Abstract

➢In this paper, a bidirectional Fano algorithm (BFA) is proposed, in which a forward decoder (FD) and a backward decoder (BD) search in the opposite direction simultaneously.

➢It is shown that the proposed BFA can reduce the average decoding delay by at least 50% compared to the unidirectional Fano algorithm (UFA). Due to the reduction in the variability of computational effort by using bidirectional search, there is even higher decoding throughput improvement at low signal-to-noise-ratio (SNR). For example at Eb/No=3dB, there is 300% throughput improvement by using the BFA decoding compared to the conventional UFA decoding.

➢The proposed BFA decoding technique can be employed in very high throughput wireless communication systems with low hardware complexity and power consumption.

Introduction

➢There is a forward decoder (FD) and a backward decoder (BD) in the bidirectional Fano algorithm. Both of them start decoding from the known state zero and perform decoding in the forward and backward direction in parallel. The decoding will finish if the FD and the BD merge somewhere in the code tree. Otherwise, if the FD and the BD cannot merge, the decoding will finish when either of them reaches the other end of the code tree in its own direction.

➢Both of the FD and the BD decode the same codeword in the opposite direction according to the flow chart in Fig. 3, which is similar to the conventional unidirectional Fano algorithm (UFA)[1][2], except that a merging check is carried out after a forward movement is made.

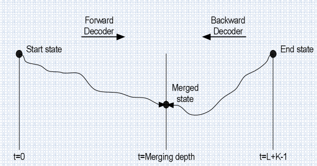

Figure 1. Illustration of bidirectional Fano decoding, where L is the information length and K is the constraint length of the convolutional code

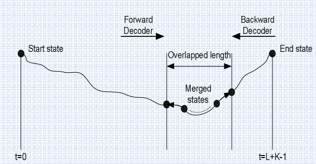

Figure 2. Illustration of the more rigorous merging check in the proposed BFA, in which there are more than one merged states and the overlapped length should be not less than 1

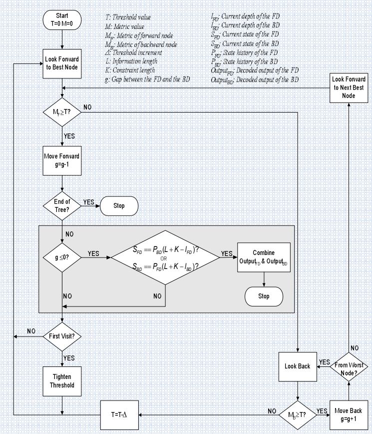

Figure 3. Flow chart of the FD or the BD with a bidirectional Fano algorithm

Results

➢Simulation setup
-Code rate is R=1/3
-Generator polynomials are $g_0=\{133\}_8$, $g_1=\{171\}_8$ and $g_2=\{165\}_8$
-Constraint length is K=7
-Threshold increment value in the Fano algorithm is Δ=2
-Metric calculation is based on the Fano metric which is considered to be optimal for sequential decoding
-Output of the demodulator is 1-bit hard decision
-Modulation is BPSK
-AWGN channel

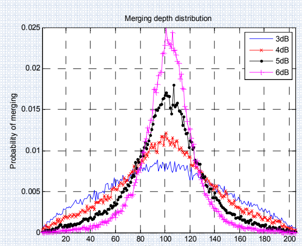

Figure 4. Merging depth distribution of the BFA

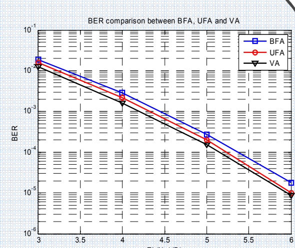

Figure 5. BER performance comparison between the VA, the UFA and the BFA

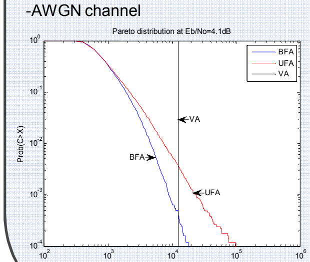

Figure 6. Pareto distribution of the BFA, the UFA and the VA

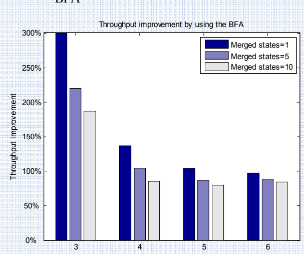

Figure 7. Throughput improvement by using the BFA with respect to the UFA for different number of merged states

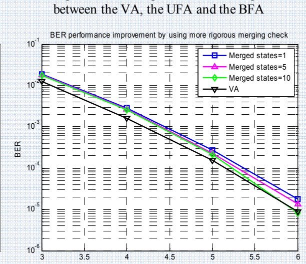

Figure 8. BER performance improvement by using more rigorous merging check

Conclusions

➢In this paper, a bidirectional Fano decoding algorithm for convolutional codes was proposed.

➢The proposed BFA can reduce the decoding delay by applying a forward decoder and a backward decoder to search in the opposite direction simultaneously. The average decoding delay can be reduced by at least 50% compared to the unidirectional Fano decoding and there is higher throughput improvement at low SNR.

➢More rigorous merging check condition can be applied to make a trade-off between error rate performance and decoding throughput.

➢Alternative decoding techniques for convolutional codes are of interest in high throughput systems due to the high power consumption and large silicon area of Viterbi decoders. The proposed bidirectional Fano decoding technique is very attractive for high throughput wireless communication systems, such as the WirelessHD system[3][4], due to its low hardware complexity, low power consumption and ability to decode very long constraint length convolutional codes[5][6].

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