

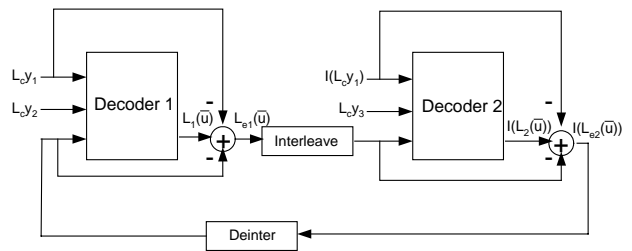
KAIST

Simple and Efficient Stopping Criteria for W-CDMA Turbo Decoding

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Abstract

In this paper, we propose new simple and efficient stopping criteria for W-CDMA turbo decoding. The new criteria are based on the sum of logarithm of absolute extrinsic information values and the count of one-estimations calculated after each component decoder. The calculation of the proposed criteria can be made simpler by summing one of ten values without any penalty. This proposed method can be implemented with negligible overhead and no extra memory. Simulation results on W-CDMA standard shows that the number of iterations required is reduced compared to the existing stopping criteria without degrading the BER performance. Reduced iterations and simple operations make the proposed criteria desirable for low-power turbo decoder.



1. Turbo Decoder

가 latency
가 SNR
가
frame
hard
decision 가
[2], decoder priori information extrinsic
information sign [3]
가
BER performance
W-
CDMA

I.

1993 Berrou
Shannon limit 가
[1], W-CDMA
1
priori information
가

II. Stopping Criteria

2.1 Turbo Decoder

Turbo decoder BPSK modulation
noise 가 가 LLR(log likelihood ratio)
Time index k

$$u_k = \text{sign}[L(u_k)] \quad (1)$$

$$L(u_k) = \log[P(u_k=+1/y)/P(u_k=-1/y)] \quad (2)$$

Channel information bit parity bit 2
 y_1, y_2, y_3 channel reliability L_c
positive feedback extrinsic information

LLR L_{cy1} priori information
extrinsic information interleaver
deinterleaver decoder priori information
estimation

decoding $L_e(\text{extrinsic information})$ 가
가 가 ,
confidence 가

LLR L_e
가

throughput 가
가
[5]

LLR estimation reliability sign
hard-decision magnitude soft-
decision 2 가 가
reliability

가
stopping criteria

2.2 HDA(Hard-Decision Aided) Stopping Criteria

HDA(Hard-Decision Aided) [2] iteration
hard decision iteration

가
(K frame)

$$\text{for } i = 2, \text{ if } \text{sign}[L(u_k)^{2,i}] = \text{sign}[L(u_k)^{2,i-1}] \quad k \in \{1 \dots K\} \quad (3)$$

(3) $L(u_k)^{2,i}$ i iteration 2
LLR
frame iteration

2.3 Sign-Difference Ratio (SDR)

SDR(Sign-Difference Ratio) [3] decoder
priori information extrinsic information sign
frame 0.01

HDA
가
0.5 iteration

CE(Cross Entropy) [4], SCR(Sign-Change Ratio), Min(Minimum LLR) . Stopping Criteria

III. Stopping Criteria

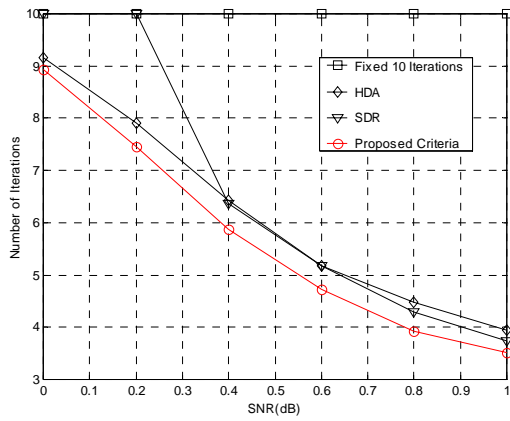
L_e
bit 가 가
error 가 L_e
magnitude 가 sign
error

가

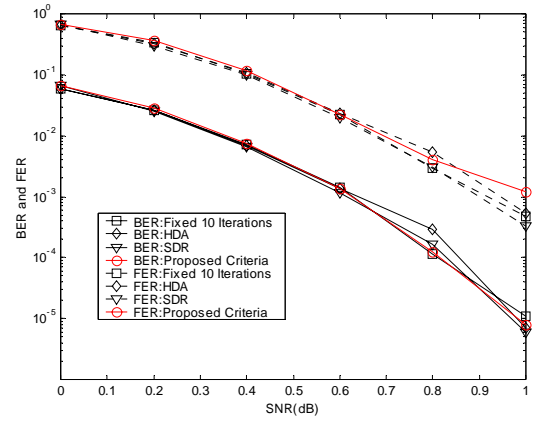
stopping criterion , L_e
log 가

(threshold)

$$\{\log(|L_e(u_k)|)\} > \text{ , } k \in \{1 \dots K\} \quad (4)$$



2. Average number of iterations



3. BER and FER Performance

가 .
 - Decoding |Le|가 가
 |Le| range 가 log
 range
 - 1 Le
 error 가 measurement
 negative 가
 - Summation 가
 SNR threshold

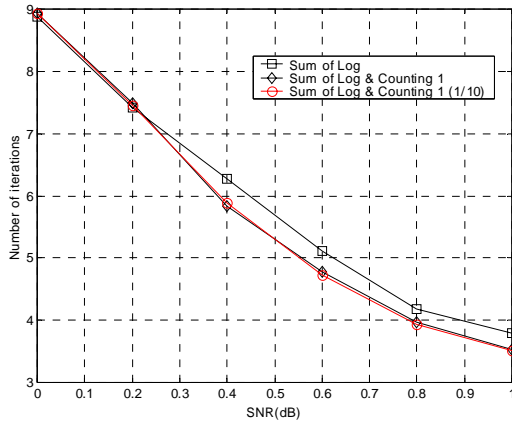
Error 가 bit estimation sign
 error
 bit (4)
 10 summation
 threshold 1/10
 3 가
 가

Threshold BER performance
 iteration performance trade-off
 Le magnitude
 가 (4)
 Error measurement
 SNR iteration
 (4)
 threshold
 hard-decision
 , 1 decoding estimation
 iteration
 counter 가
 Threshold

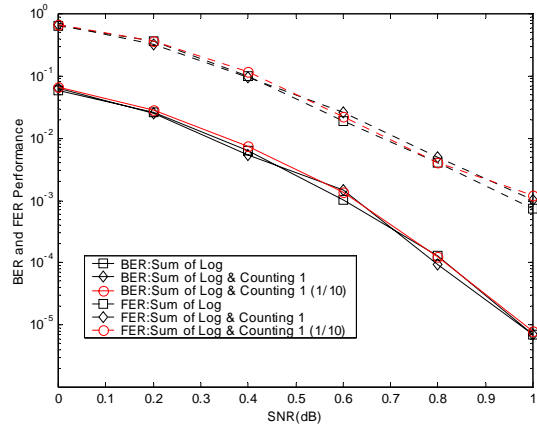
IV.
 W-CDMA standard encoder
 interleaver C 1024
 frame 가 AWGN 가
 stopping criteria HDA, SDR average iteration
 , performance 10 iteration
 10 fixed iteration
 2 3
 BER(bit error rate), FER(frame error rate)
 Threshold SNR
 360 500
 stopping criteria 10% BER
 performance 10 fixed iteration
 가

1. SNR=0.6 threshold

SNR = 0.6dB , Sum of Log & Counting 1 (1/10)			
Threshold	Iteration	BER	FER
430	4.4545	0.001453	0.03053
450	4.5890	0.001320	0.02805
460	4.6256	0.001220	0.02655
470	4.7303	0.001071	0.02251
480	4.8136	0.001072	0.02261
490	4.9150	0.001024	0.02321



4. Average number of iterations



5. BER and FER Performance

iteration stopping criteria
 output extrinsic
 information log threshold , 1
 1/10
 10 fixed iteration
 1dB 66% iteration low-power turbo decoder

4 5 3 가
 . 1
 performance iteration
 . 10
 bit
 가 .
 1 3 가 trade-off
 threshold .
 threshold iteration 가
 . SNR=0.6dB 470
 threshold 4.73 iteration
 .
 1 counting threshold
 error frame .
 threshold 7~10% .

V.

가
 10%

[1] C. Berrou, A. Glavieux, and P. Thitimajshima, "Near Shannon Limit Error-Correcting Coding and Decoding: Turbo-Codes" in *ICC '93*. Geneva, Switzerland, pp. 1064-1070, May 1993.

[2] R. Y. Shao, S. Lin, and M. C. P. Fossorier, "Two Simple Stopping Criteria for Turbo Decoding" *IEEE Transactions on Communications*, Vol. 47, no. 8, pp. 1117-1120, Aug. 1999.

[3] Y. Wu, B. D. Woerner, and W. J. Ebel, "A Simple Stopping Criterion for Turbo Decoding." *IEEE Communications Letters*, vol. 4, pp. 258-260, Aug. 2000.

[4] J. Hagenauer, E. Offer, and L. Papke, "Iterative Decoding of Binary Block and Convolutional Codes", *IEEE Transactions on Information Theory*, vol. 42, no. 2, pp. 429-445. Mar. 1996.

[5] F. Gilbert, F. Kienle, and N. Wehn, "Low Complexity Stopping Criteria for UMTS Turbo-Decoders", in *VTC 2003- Spring*, vol. 4, pp. 2376-2380, April. 2003.