Systematic feed-forward convolutional encoders are as good as other encoders with an M-algorithm decoder

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SYSTEMATIC FEED-FORWARD CONVOLUTIONAL ENCODERS ARE AS GOOD AS OTHER ENCODERS WITH AN M-ALGORITHM DECODER

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Summary—In this paper we show that systematic convolutional encoders perform as well as nonsystematic ones when they are used together with M-algorithm decoders [1]. We describe the algorithm and give a brief historical review. The following curves show simulation results for the event error probability of the M-algorithm. We compare an optimum distance profile nonsystematic encoder ($d_{free} = 22$) and a quick-look-in encoder ($d_{free} = 18$) with a systematic encoder ($d_{free} = 13$). All encoders have memory $m = 20$ and in the decoder 32 states are extended at every time instant ($M = 32$).

Error Event Probability
memory 20, M=32
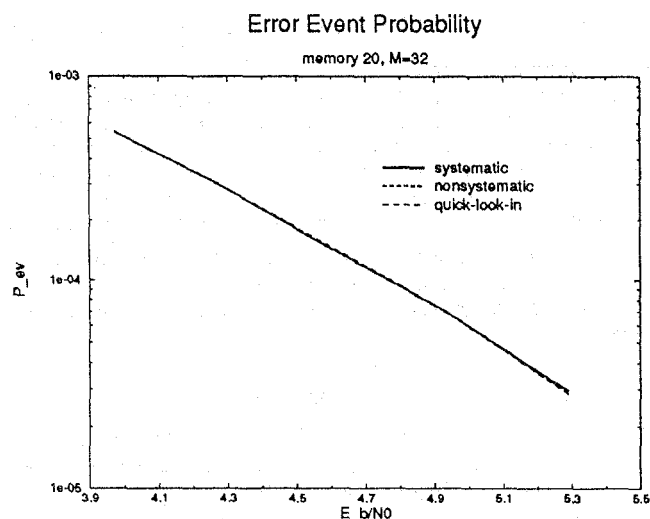
All curves show the same event error probability performance.

Using criteria for the encoder quality like the optimum distance profile and the optimum profile spectrum [2] any encoder is equivalent to a systematic one over the encoder memory. As long as these distance criteria support the decoder performance, the event error probability of the M-algorithm depends only on M. Therefore, in a range of interesting values of M, systematic encoders should behave like nonsystematic encoders in terms of error event probability as our simulations show. The decoder complexity is independent of the memory of the encoder. The free distance does not matter as long it is big enough to correct all paths within the set of extended decoder states. Hence, for M-algorithm decoders, in contrast to the Viterbi decoder, code quality cannot be expressed in

terms of the free distance and the distance spectrum. A rapid growth of the column distances is more important than a large free distance.

As a bonus when used together with the M-algorithm, systematic encoders outperform nonsystematic encoders in terms of bit error probability as shown in the next picture (framelength $= 1024$). The reason is that systematic encoders are superior from a correct path loss point of view.

Bit Error Probability
memory 20, M=32
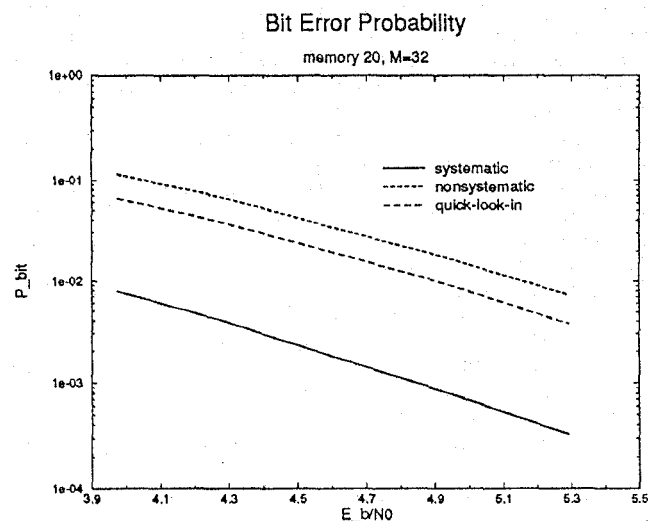
References

[1] J. B. Anderson, "Limited Search Trellis Decoding of Convolutional Codes", IEEE Trans. Information Theory, IT-35, pp. 944-956, Sep. 1989.

[2] H. Osthoff, R. Johannesson, B. Smeets and H. Vinck, "On the Linear M-Algorithm", Proceedings IEEE Information Theory Symposium, San Diego, Jan. 1990, pp.85.