New Turbo-Like Codes

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Abstract — **Unlike the usual turbo codes, "unifilar turbo codes" are based on only one underlying trellis code. If terminated (i.e., as block codes), they perform as well as (ordinary) turbo codes; if not terminated (i.e., as convolutional codes), they are attractive for continuous transmission under tight delay constraints.**

One way of looking at turbo codes [1] is as two trellis codes with the contraint that the information bits are coupled in pairs, one bit from each trellis, and that any two coupled bits must be identical. Of course, only one bit of each pair is transmitted.

A general class of turbo-like codes is obtained by varying the number of trellises and the rules of coupling. Note that this class includes also *serially* concatenated codes [2], where the output bits of one code are coupled with the input bits of the other code.

This general class contains many interesting codes beyond serial or parallel concatenation. Of particular interest are constructions with only one trellis, as schematically shown in Fig. 1.

We describe one example. The construction is based on a systematic rate 2/3 binary convolutional encoder. As shown in Fig. 2, the two inputs are fed with the same information bits, but with an interleaver between them. The overall rate is 1/2.

If the overall code is to be a block code, the trellis is best made tail-biting. With tail-biting, it is not always possible to choose the u-bit pairs as the information bits of the overall code. A sufficient condition is that the matrix $A^N - I$ has full rank, where A is the state transition matrix (for zero input) of the encoder and N is the number of trellis sections. If the feedback polynomial is irreducible, this condition is always met if $\gcd(N, 2^m\text{-}1) = 1$, where m is the number of memory cells.

Decoding proceeds according to the well-known principles of turbo decoding. In particular, the canonical "min-sum" algorithm and "sum-product" algorithm [3] [4] can be applied to any such code. (Figure 1 is a simplified version of a Tanner graph.) For "random" interleavers, the simulated performance of such codes is essentially identical with that of ordinary turbo codes with the same parameters.

However, such codes can also be used without termination, i.e., as convolutional codes. In this case, the coupling pattern (Fig. 1) should be periodic. A number of "optimal" such connection patterns (with the shortest cycle as large as possible, for the given period) have been found by computer search. Such codes are expected to outperform block turbo codes under tight delay constraints.

References

[1] C. Berrou, A. Glavieux, and P. Thitimajshima, "Near Shannon-limit error-correcting coding and decoding: turbo codes", *Proc. ICC'93,* pp. 1064–1070, Geneva, May 1993.

[2] S. Benedetto and G. Montorsi, "Iterative decoding of serially concatenated convolutional codes", *Electr. Lett.,* vol. 32, pp. 1186–1188, June 1996.

[3] G. D. Forney, Jr., "The forward-backward algorithm", *Proc. 34th Allerton Conf. on Comm., Contr., and Comp.,* Oct. 2–4, 1996.

[4] N. Wiberg, H.-A. Loeliger, and R. Kötter, "Codes and iterative decoding on general graphs", *Europ. Trans. Telecomm.,* vol. 6, pp. 513–525, Sept/Oct. 1995.

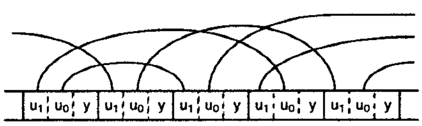

Figure 1: Trellis with coupled bits.

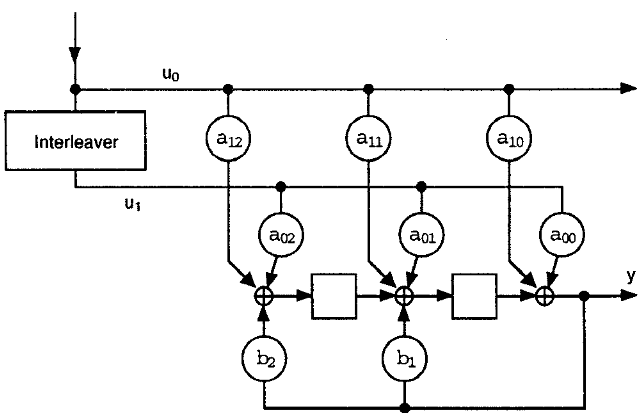

Figure 2: Encoder.