

BWT Based Universal Lossless Source Controlled Channel Decoding with Low Density Parity Check Codes

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In many channel decoding applications, redundancy is left in the channel coded data. A new method for utilizing this redundancy in channel decoding is proposed. The method is based on the Burrows-Wheeler Transform (BWT) [1] and on universal compression techniques for piecewise stationary memoryless sources (PSMS's), and is applied to regular *low-density parity-check* (LDPC) codes. The method utilizes redundancy in i.i.d. data sequences as well as in sequences generated by sources with memory to improve channel decoding even if the redundancy is in an unknown form. This is done by extracting the source model context out of the data between channel decoding iterations, and then using this input as *a-priori* statistics of the code bits. In particular, between LDPC decoding iterations, the data is rearranged with the BWT. The rearranged data is then segmented using PSMS segmentation methods [2], and the i.i.d. statistics within each segment are estimated and passed to the LDPC decoder as *a-priori* information on each of the bits. Two settings are proposed. In the first the BWT-PSMS loop is in the decoder, while in the second, the rearrangement of the data is performed with the BWT before channel encoding, and then the decoder is designed for extracting statistics in a PSMS. After the last iteration, the data is reassembled with the inverse BWT. The second setting is slightly better in terms of block error rates (because source statistics are easier to learn in a PSMS than a source with memory). Simulations show that the bit error rate performance of the new method (in either setting) is almost as good as genie-aided decoding with perfect knowledge of the statistics of each data bit, and naturally improves on codes that do not utilize redundancy in the data if such redundancy exists, and also on methods that only utilize the marginal memoryless distribution redundancy. Unlike context approaches that assume a fixed length context, the BWT-PSMS approach allows adaptation to statistics of sources with various models, including context tree models. If the source context model is known to be bounded, shorter context sorting techniques can replace the BWT.

References

- [1] M. Burrows and D. J. Wheeler, *A block-sorting lossless data compression algorithm*, Digital Systems Research Center, Palo Alto, CA, May 10, 1994.
- [2] G. I. Shamir, D. J. Costello, Jr., "Asymptotically optimal low complexity sequential lossless coding for piecewise stationary memoryless sources - Part I: The regular case," *IEEE Trans. Inform. Theory*, Vol. 46, No. 7, pp. 2444-2467, Nov. 2000.

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