Product Code and Recurrent Alternative Decoding for Wireless Image Transmission

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We developed a novel channel coding scheme for image transmission over wireless channels. A key component is the construction of the product code using convolutional code and recursive systematic code (RSC) in horizontal and vertical directions, respectively. High performance transmission has been achieved through an innovative recurrent alternative decoding scheme based on constrained Viterbi decoding.

We choose RSC because of its systematic structure so that we need not transmit the original data portion of the RSC coding outcome since this portion can be obtained from the other direction of channel decoding. Such a RSC reduces the transmission burden as well as the channel coding rate. At the receiving end, the data will at first be decoded along the horizontal direction. After decoding, the position of correctly decoded row will be assigned a positive sign and be preserved. When we decode along the vertical direction, the positive signs after horizontal decoding will be used as constraints in the Viterbi decoding algorithm to force the survival paths passing through these known positions of correctly decoded bits. The constrained Viterbi algorithm using known correct bits enables us to derive likely correct value for other bits. For example, at a certain stage, if we know the previous input bit is 1 (or 0) and correct, then all the branches represented by input bit of 0 (or 1) can therefore be dropped directly. This will reduce greatly possible paths along the trellis diagram even though some of the paths dropped may have smaller path cost due to channel noise corruption and would otherwise be preserved by unconstrained Viterbi algorithm. Moreover, This also reduces significantly the comparisons between the branches and the received symbols. Similarly, the positions of the correctly decoded columns are also preserved and used again to refine the next round of horizontal decoding. Such recurrent decoding will alternate between horizontal and vertical directions until all data are correctly decoded or until there is no more improvement in both directions.

We investigated the performance of the proposed scheme for both BSC and GEC channels. In our initial study, RSC code with generators in octal form (133, 171) was used in both directions. Input data is grouped into 200×200 bits. The channel coding rate is 1/3.708. For BSC channels, the BER is set to 0.1. For GEC channels, we need four parameters: \( (E_G, E_B, P, Q) \), denoting error probabilities for Good state \( (E_G) \) and Bad state \( (E_B) \), Transition probabilities from Good to Bad \( (P) \) and from Bad to Good \( (Q) \), respectively. Four different GEC channels are studied: \( (0.001, 0.111, 9/100, 1/100), (0.01, 0.11, 9/100, 1/100), (0.068, 0.12, 8/100, 5/100) \) and \( (0.001, 0.12, 0.005, 0.0031) \), each with different burst length. The BERs of the first three channels are 0.1, and the BER of the 4th channel is 0.0742. Experiments show that the scheme can fully decode the corrupted data within several iterations. The proposed scheme can be directly applied to image transmission with equal error protection. For a 200×200 array of bits, we can transmit a 512×512 image compressed to 0.1526 bpp using SPIHT source coding. This translates into a high PSNR of 31.97 dB for Lena image over either BSC or bursty GEC channels with BER = 0.1. When unequal error protection is desired, RCPC can be adopted. This is currently under investigation.

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