A Fast Trellis-Based Rate-Allocation Algorithm for Robust Transmission of Progressively Coded Images over Noisy Channels

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We propose a fast trellis-based rate-allocation algorithm for robust transmission of progressively coded images over noisy channels. The algorithm, which is an improved version of a similar algorithm in [1], is based on the application of the Viterbi algorithm to a search trellis. The proposed algorithm is applied to images encoded by set partitioning in hierarchical trees (SPIHT) and JPEG2000 for the transmission over binary symmetric channels. For different total bit budgets and channel parameters, speed-up factors of up to about three orders of magnitude are achieved.

First, we demonstrate that only the candidate (final) nodes in a small number of trellis levels need to be tested to obtain the path with the minimum distortion. Suppose that for a particular instance of the rate-allocation problem we know the optimal ratio (α) of the number of source bits (kN) to the total bit budget (B). Assuming that αB is divisible by k, we can then calculate the optimal number of packets by $N^* = \alpha B/k$, thereby limiting the search to only the candidate nodes at a single level of the trellis. In this work, we obtain an empirical estimate for α which is only a function of the channel parameter and is independent of the image and the total bit budget. Knowing the channel parameter ε, we can thus easily obtain this estimate, $\widehat{\alpha}(\varepsilon)$, and then use the following inequality

$$\frac{(\widehat{\alpha}(\varepsilon)-\eta_l)B}{k} < N^* < \frac{(\widehat{\alpha}(\varepsilon)+\eta_u)B}{k} \qquad (1)$$

to limit the search for the candidate nodes. In inequality (1), parameters η_l and η_u represent the estimation error, and are determined empirically. We subsequently show that only few trellis levels satisfy inequality (1) and need to be checked.

The next step in trimming the trellis involves removing some of the branches that have no chance of being part of the survivor path. For this, we use the following lemma.

Lemma 1: Consider two paths on the trellis starting from a common node U and ending at final nodes V_{i1} and V_{i2}, both at level i of the trellis. If the rates for all the branches of the path between U and V_{i1} are less than or equal to the corresponding rates of the path between U and V_{i2}, then the latter path cannot be part of the final survivor path.

In addition to the foregoing two simplifications, we may further reduce the complexity of the search trellis by noticing that for a given channel parameter only a small number of the available channel codes are useful in an optimal rate-allocation scheme.

Finally, assuming that the optimal channel coding rates for the transmission of successive source packets are non-decreasing, we can further simplify the trellis by trimming all the emanating branches of every node that have rates smaller than the minimum rate of the incoming branches to the node.

It should be noted that all the aforementioned simplifications to the search trellis are applied only once and off-line.

Reference

[1] B. A. Banister, B. Belzer, and T. R. Fischer, "Robust image transmission using JPEG2000 and turbo-codes," *IEEE Signal Processing Letters*, vol. 9, no. 4, pp. 117-119, Apr. 2002.

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