ON ERROR RESILIENT DESIGN OF PREDICTIVE SCALABLE CODING SYSTEMS
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Scalable Coder Architecture and Problem Statement

- Scalable coding framework considers hierarchical bitstream layers.
- Lower information bitstream is embedded into a higher information bitstream in a way that minimizes redundancy.
- Without loss of generality, we consider a two-layer predictive scalable coder.

Base Layer Operation

- First order linear predictor with prediction coefficient \( \alpha_b \).
- The base layer predictions are based on expected decoder reconstructions, \( \hat{x}_n = \alpha_b \hat{x}_{n-1} \).
- End-to-end distortion (EED) estimation can be expressed as, \( \mathbb{E} (d_b) = \sum_{n=0}^{N-1} x_n^2 - 2 \alpha_b \mathbb{E} (\hat{x}_n^2) + \mathbb{E} (\hat{x}_n^2) \).
- The base layers packets are assumed to be lost independently with probability \( p_b \).
- EED moments can be recursively updated as, \( \mathbb{E} \left( \hat{x}_n^2 \right) = (1 - p_b) \mathbb{E} \left( \hat{x}_{n-1}^2 \right) + \alpha_b^2 \mathbb{E} \left( \hat{x}_{n-1}^2 \right) \).

Enhancement Layer Operation

- The enhancement layer predictor combines current sample base layer information as well as previous enhancement layer information, \( \hat{x}_n = \mathbb{E} \left( x_n | x_{n-1}, \hat{x}_{n-1} \right) \).
- The intersection between base layer and enhancement layer quantizer intervals is then obtained as, \( \mathbb{E} (d_e) = \max \left( \hat{x}_n + A_e, \hat{x}_n + C_e \right) - \min \left( \hat{x}_n + A_e, \hat{x}_n + C_e \right) \).
- The enhancement layer packets are dropped independently with probability \( p_e \).
- Given the current channel event, the reconstruction at the decoder can be obtained as, \( \hat{x}_n = \mathbb{E} \left( x_n | x_{n-1}, \hat{x}_{n-1} \right) \).
- The EED moments at the enhancement layer can be updated recursively as, \( \mathbb{E} \left( \hat{x}_n^2 \right) = \frac{1}{\alpha_e^2} \mathbb{E} \left( \hat{x}_{n-1}^2 \right) + \frac{1}{\alpha_e^2} \mathbb{E} \left( \hat{x}_{n-1}^2 \right) \).
- Therefore, the optimal prediction coefficient at enhancement layer, that minimizes EED, is given by, \( \alpha^*_e = \frac{N-1}{\sum_{n=0}^{N-1} \mathbb{E} \left( \hat{x}_n^2 \right) - \mathbb{E} \left( \hat{x}_{n-1}^2 \right)} \).

Proposed Scalable Coder Architecture

- The enhancement block computes the enhancement layer EED moments according to (9).
- The PRE block computes the \( \hat{k}^{(L)} \), where \( (L, R) \) depends on the current channel event.

Evaluations

- We compare our proposed coder (C3) with two competing coders:
  - Coder (C1) ignores packet losses. At enhancement layers, it directly quantizes the base layers reconstruction errors.
  - Coder (C2) ignores packet losses as well. However, the enhancement layer utilizes all the available information by employing estimation-theoretics approach similar to (6).
- The proposed approach consistently outperforms its competitors, offering up to 2.2 dB and 3.3 dB gains in SNR over C2 and C1, respectively.

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