DETERMINISTIC ANNEALING BASED DESIGN OF ERROR RESILIENT PREDICTIVE COMPRESSION SYSTEM

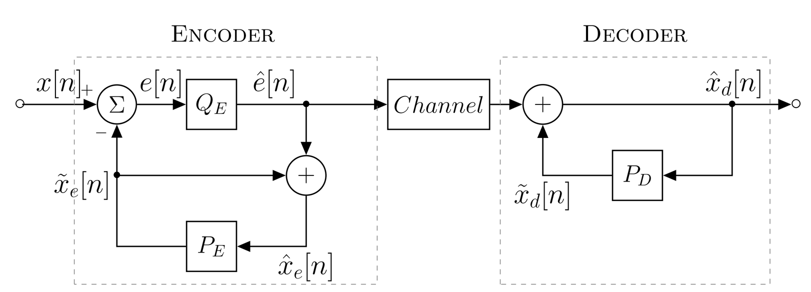
Bharath Vishwanath, Tejaswi Nanjundaswamy, Sina Zamani and Kenneth Rose

Signal Compression Lab, Department of ECE, University of California Santa Barbara

Predictive coding system design

- **Objective : Design optimal quantizers and predictors (P_E, Q_E and P_D) to minimize the expected distortion at the decoder to account for packet losses**

$$D = \sum_{n=0}^{N-1} E\{(x[n] - \hat{x}_d[n])^2\}$$
$$= \sum_{n=0}^{N-1} x^2[n] - 2x[n]E\{\hat{x}_d[n]\} + E\{\hat{x}_d^2[n]\}.$$



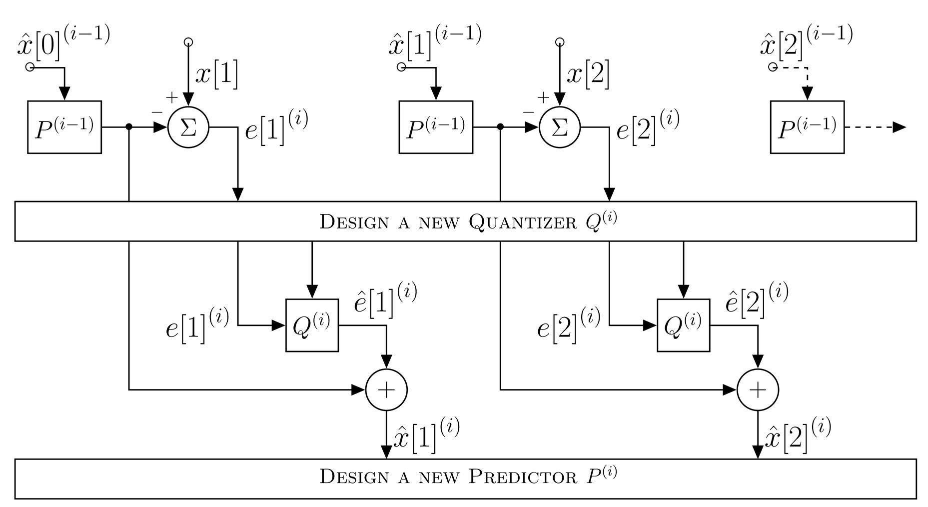
End to End distortion estimation

- **First order predictor with prediction coefficient α**
- **For simplicity, we assume each sample is lost independently of other samples, with probability of p.**
- **Moments can be updated recursively**

$$E\{\hat{x}_d[n]\} = (1-p)E\{\hat{e}[n] + \alpha\hat{x}_d[n-1] + pE\{\alpha\hat{x}_d[n-1]\}$$
$$E\{\hat{x}_d^2[n]\} = (1-p)E\{(\hat{e}[n] + \alpha\hat{x}_d[n-1])^2\} + pE\{\alpha^2\hat{x}_d^2[n-1]\}$$

Asymptotic Closed-Loop Design

- **Design predictor and quantizer in open-loop fashion, while ultimately optimizing the system for closed-loop operation**



- **Overcomes the major well documented instability problems of iterative closed loop design**

Deterministic Annealing

- **Prevalence of poor local minima of the cost function, and the piecewise constant quantization function, pose a significant challenge to joint optimization of predictor and quantizer**
- **DA introduces controlled randomness in the optimization procedure, governed by its annealing schedule, to avoid many poor local minima**
- **Probabilistic cost function for entropy constrained quantizer design**

$$J = \sum_n \sum_j P_n^i P_{j|n}^i \left\{(e_n^i - y_j^i)^2 - \lambda \log(P_j^i)\right\}$$

- **Randomness is measured by Shannon's entropy**

$$H = -\sum_n \sum_j P_{nj}^i \log(P_{nj}^i)$$

- **Lagrangian cost function to be minimized**

$$F = J - TH$$

- **Minimization of the Lagrangian cost function with respect to association probability leads to Gibb's distribution,**

$$P_{j|n}^i = \frac{e^{-\{(e_n^i - y_j^i)^2 - \lambda\log(P_j^i)\}}}{\sum_k e^{-\{(e_n^i - y_k^i)^2 - \lambda\log(P_k^i)\}}}.$$

Proposed Approach: DA-ACL-EED

- **Optimal predictor which minimizes EED**

$$\alpha^i = \frac{\sum_{n=0}^{N} E\{\hat{x}_{d,n-1}^{i-1}\}(x_n - (1-p)\sum_j P_{j|n}^i y_j^i)}{\sum_{n=0}^{N} E\{(\hat{x}_{d,n-1}^{i-1})^2\}}.$$

- **Optimal quantizer**

$$y_j^i = \frac{\sum_n P_{j|n}^i e_n^i}{\sum_n P_{j|n}^i}$$

- **Recursive calculation of decoder moments in probabilistic framework**

$$E\{\hat{x}_{d,n}^i\} = \alpha^i E\{\hat{x}_{d,n-1}^{i-1}\} + (1-p)\sum_j P_{j|n}^i y_j^i$$
$$E\{(\hat{x}_{d,n}^i)^2\} = (\alpha^i)^2 E\{(\hat{x}_{d,n-1}^{i-1})^2\} + (1-p)\sum_j P_{j|n}^i\{(y_j^i)^2 + 2\alpha E\{\hat{x}_{d,n-1}^{i-1}\}y_j^i\}.$$

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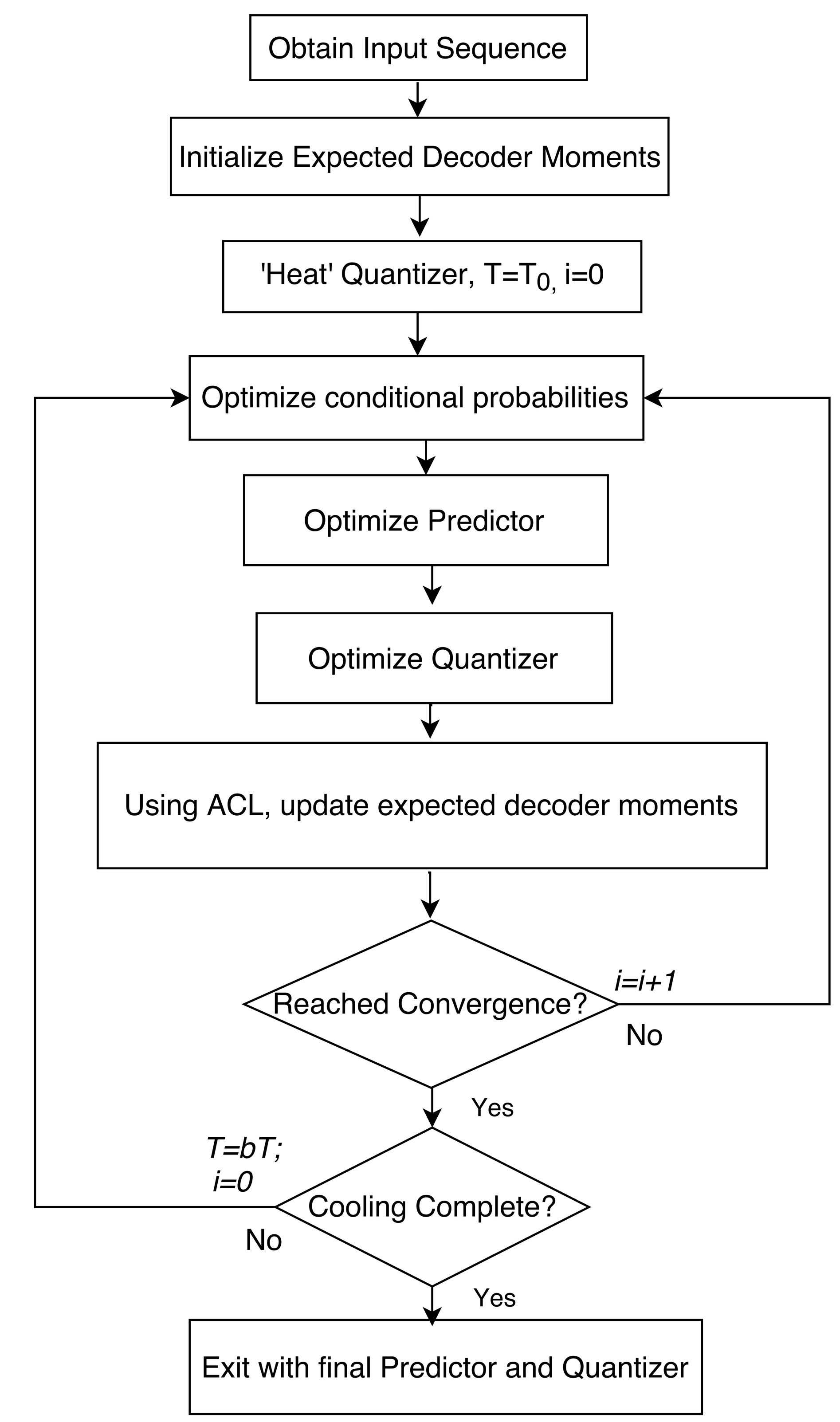
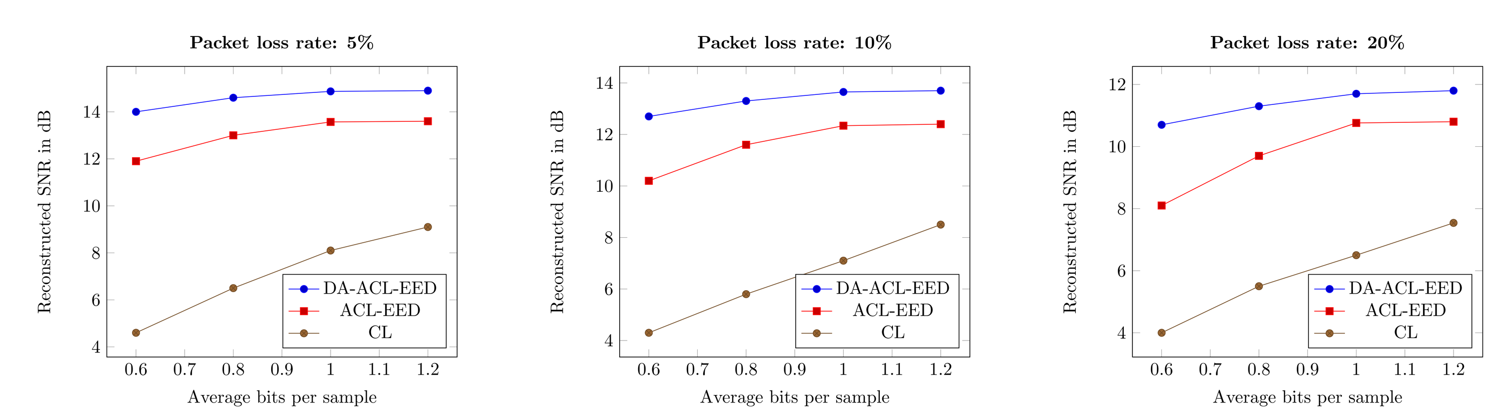


Evaluations

- **We compare CL, ACL-EED and DA-ACL-EED design techniques for a system with first order linear prediction and an entropy constrained scalar quantizer**
- **Testing Data: 6 speech files in the EBU SQAM database, first half of each file used as training set and the second half as test data**



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{bharathv, tejaswi, sinazmn, rose}@ece.ucsb.edu