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Data-driven Optimization for Zero-delay Lossy Source Coding with Side Information

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Introduction

- Lossy source coding with side-information: Wyner-Ziv (WZ)
  - Infinite block length
  - Joint distribution known
- Many applications require minimal delay: zero delay -> scalar quantization + 1-D binning
- Memoryless Gaussian sources:
  - Periodic quantizer->optimize a single parameter
- General sources, data-driven approach?
  - Chen & Tuncel '11: AR(1) Gaussian Sources
    - DPCM, exhaustive search, three parameters
    - ~10 dB from (infinite delay) WZ
  - Fleming, Zhao, Effros '04, Sexana & Rose '09:
    - Update each block while keeping others fixed -> high complexity & coordination

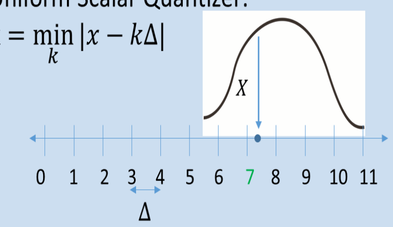
Zero-delay (scalar) Wyner-Zin coding

- Zamir, Erez, Shamai '02:

Encoding:

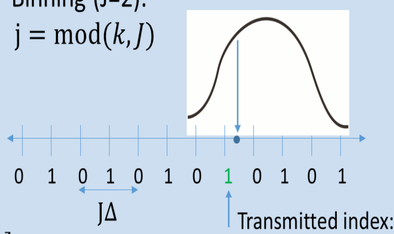
Uniform Scalar Quantizer:

$\mathrm{k} = \min_k |x - k\Delta|$

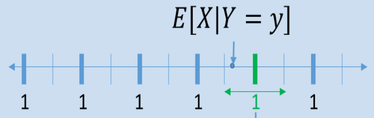


Binning (J=2):

$\mathrm{j} = \mathrm{mod}(k, J)$



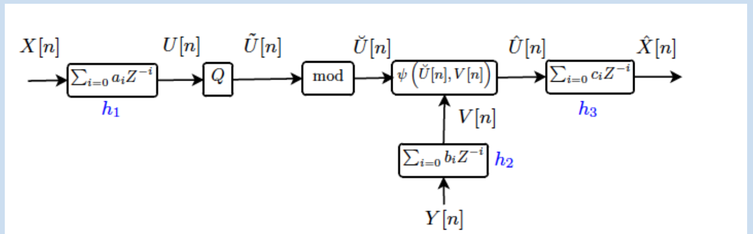
Decoding:



$\hat{X} = \underset{\mathrm{k}:\Phi_{k,J}=j}{\mathrm{argmin}} || k\Delta - E[X|Y=y] ||$

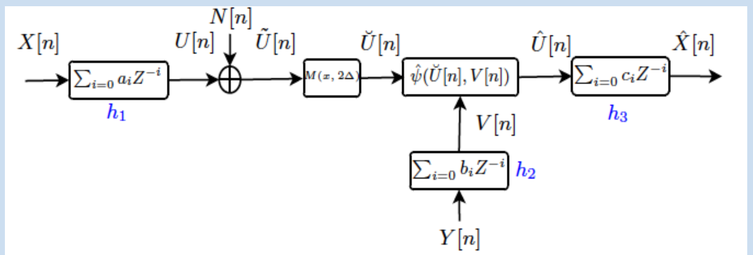
Proposed architecture

Proposed (testing) architecture:



- Filter choice:
  - h_1=feed-forward filter (predictive in prior art)
  - h_3=optimized individually (h_1^{-1} in prior art)
- Decoder: $\hat{X}[n] = \underset{l \in \mathbb{Z}}{\mathrm{argmin}} |(j + l \cdot J)\Delta - V[n]|$
  - Replace $E[X|Y=y]$ in prior art with $V[n]$

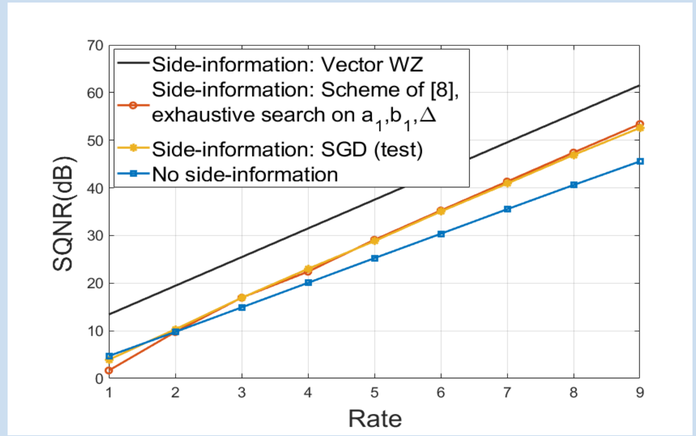
Training architecture:



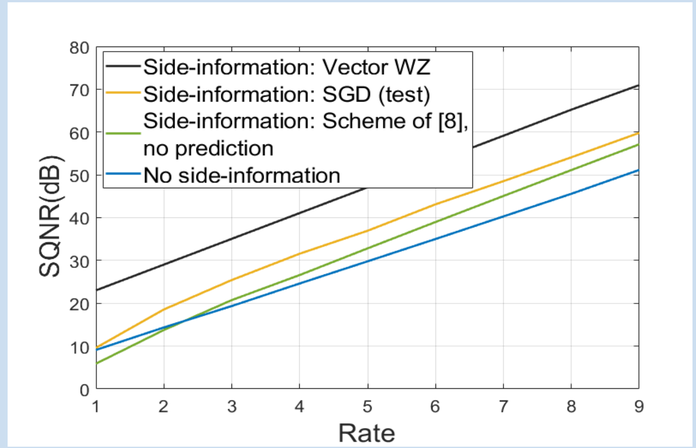
- Quantization ⇒ additive test channel
- Modulo
  - Not differentiable
  - Optimization with respect to modulo size
  - ⇒ Approximtion
- Decoder:
  - Not differentiable ⇒ soft minimization
- Training algorithm: SGD

Experimental results

First order Gauss Markov processes:



Source=AR(3), SI=AR(2):



Conclusions

- ✓ Data driven approach for zero-delay lossy source coding with side information
- ✓ Updates all blocks simultaneously
- ✓ Consistently ~10dB loss from WZ