

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 \rightarrow scalar quantization + 1-D binning
- Memoryless Gaussian sources:
 - Periodic quantizer \rightarrow 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 \rightarrow high complexity & coordination

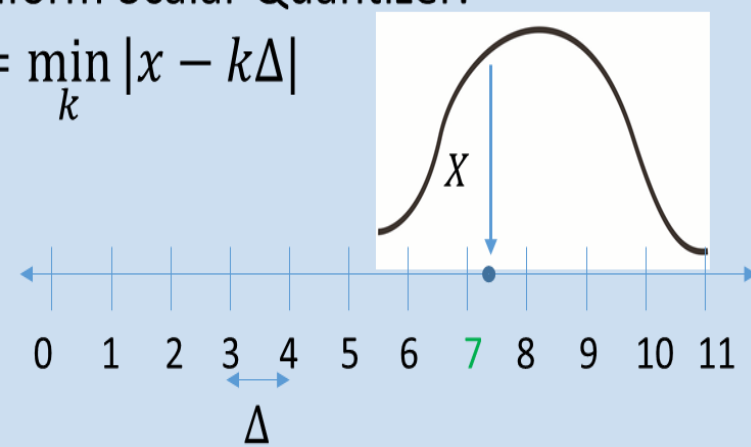
Zero-delay (scalar) Wyner-Ziv coding

- Zamir, Erez, Shamai '02:

Encoding:

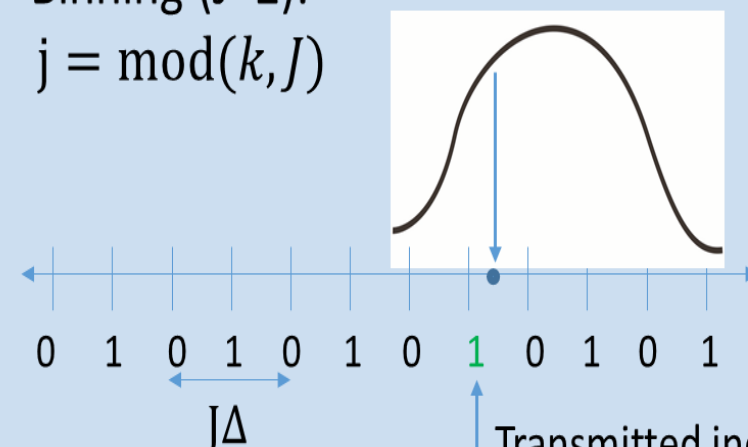
Uniform Scalar Quantizer:

$$k = \min_k |x - k\Delta|$$

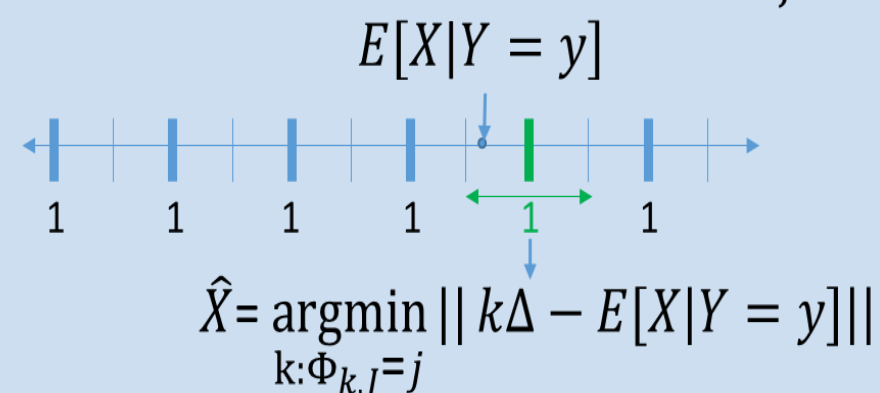


Binning (J=2):

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

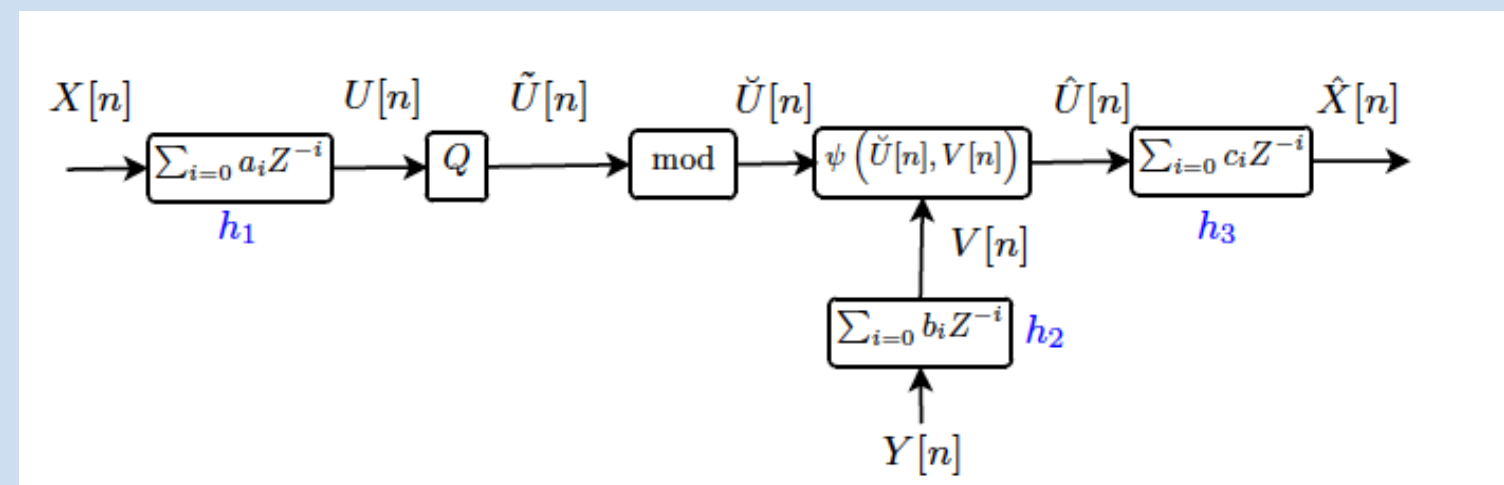


Decoding:



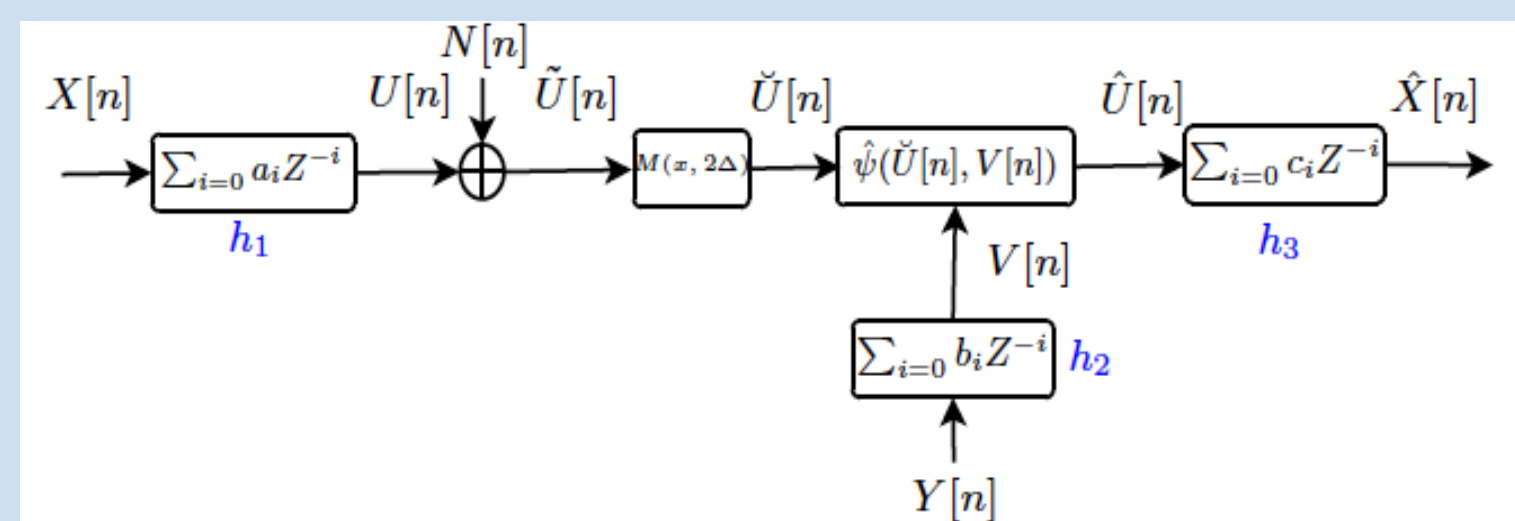
Proposed architecture

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: $\hat{X}[n] = \arg\min_{l \in \mathbb{Z}} |(j + l \cdot J)\Delta - V[n]|$
 - Replace $E[X|Y = y]$ in prior art with $V[n]$

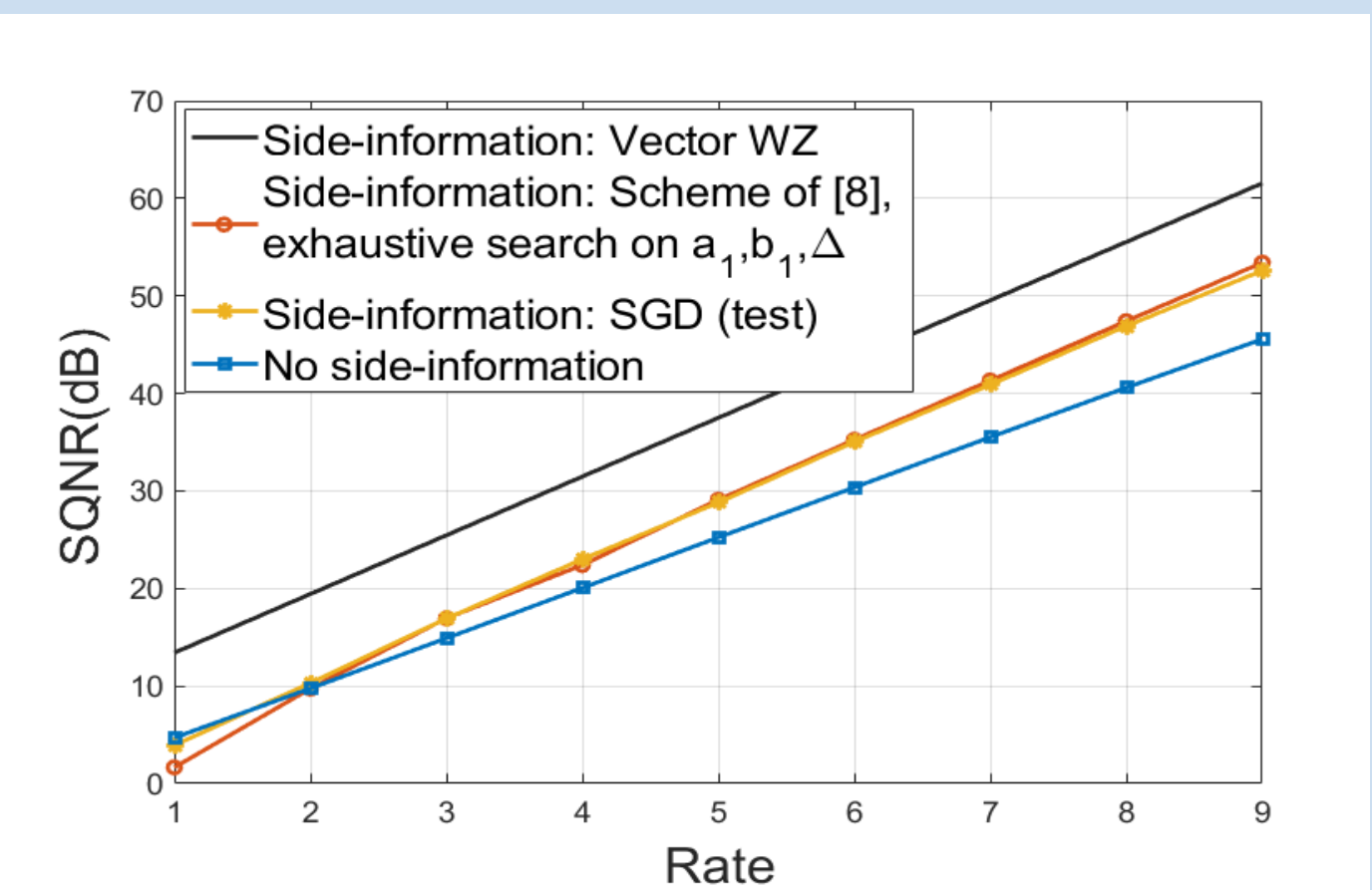
Training architecture:



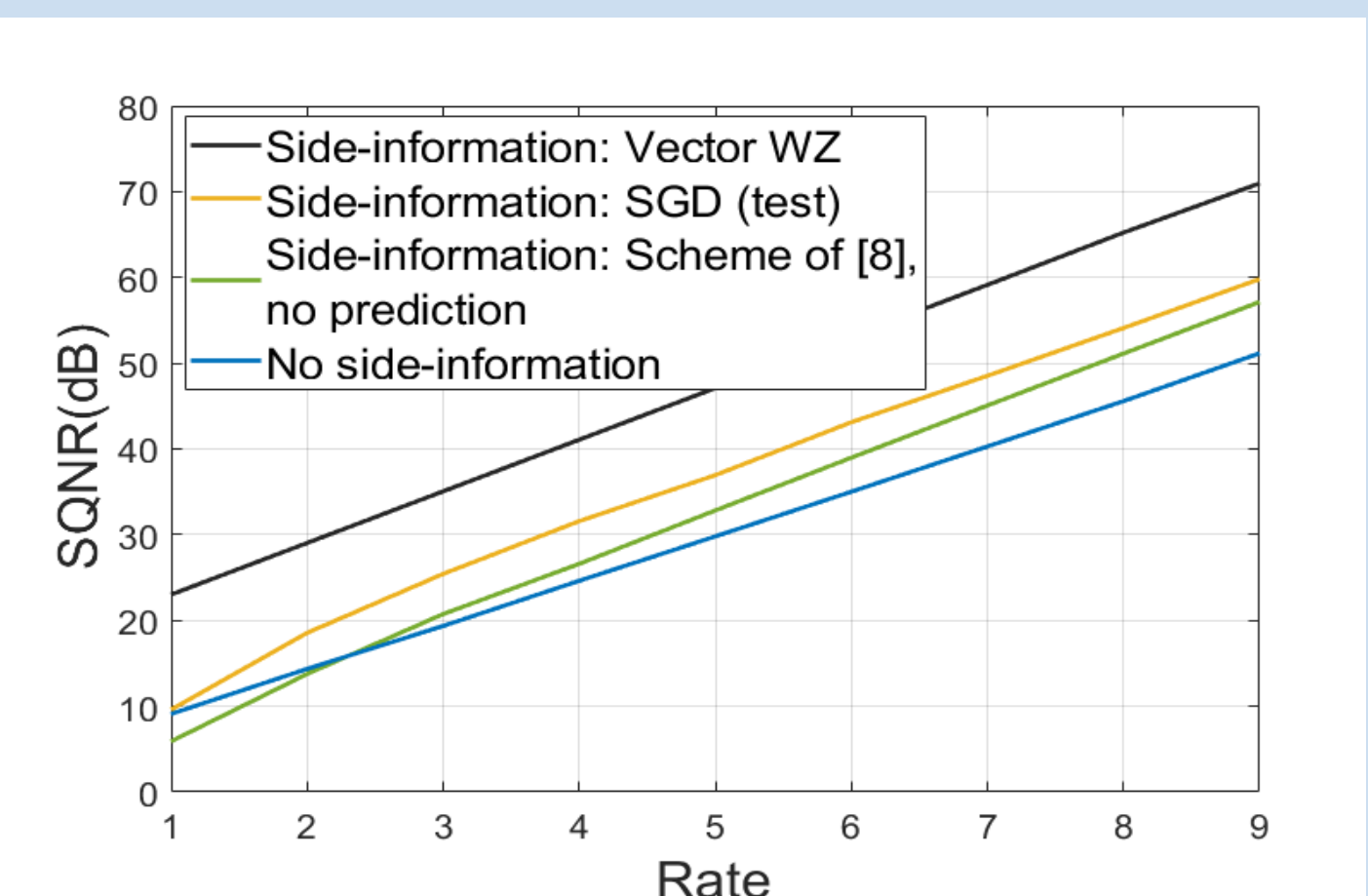
- Quantization \Rightarrow additive test channel
- Modulo
 - Not differentiable
 - Optimization with respect to modulo size
 - \Rightarrow Approximation
- Decoder:
 - Not differentiable \Rightarrow soft minimization
- Training algorithm: SGD

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 ~ 10 dB loss from WZ