Universität Rostock
Traditio et Innovatio

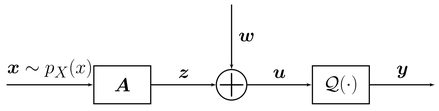
Institute of Communications Engineering

VECTOR APPROXIMATE MESSAGE PASSING FOR QUANTIZED COMPRESSED SENSING

Motivation

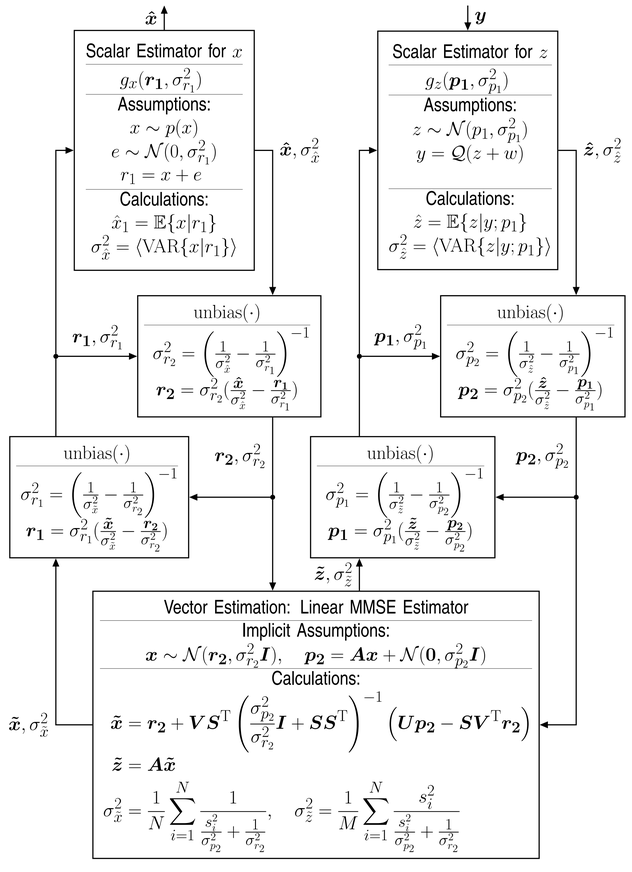
- Compressed sensing (CS) has various applications in imaging and communications
- Measurements always quantized, sometimes low resolution preferred
- Approximate Message Passing (AMP) [1] efficient algorithm to solve CS problems
- AMP only works well for (sub-)Gaussian measurement matrices with AWGN output channels
- Extensions to arbitrary output channels [2] or broader range of measurement matrices [3] possible
- Vector AMP for generalized linear models (GLM) [4] combines both features
- VAMP described from estimation theory perspective and adapted to quantized CS (QCS)

System Model



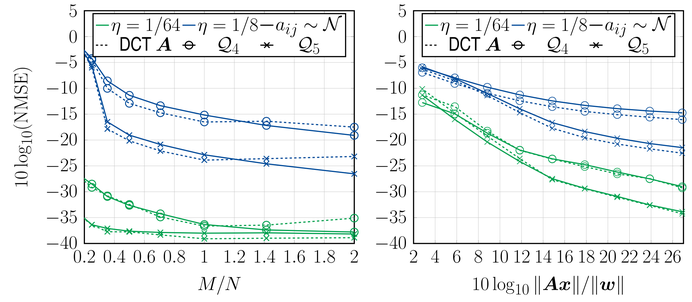
- System model: $\boldsymbol{y} = \mathcal{Q}(\boldsymbol{A}\boldsymbol{x} + \boldsymbol{w})$ with
  - Signal of interest $\boldsymbol{x} \in \mathbb{R}^N$ with known prior distribution $p_{\boldsymbol{x}}(\boldsymbol{x}) = \prod_{n=1}^{N} p_x(x_n)$ and $p_x(x_n) = (1-\eta)\delta(x_n) + \eta\mathcal{N}(0, \sigma_x^2)$ with sparsity rate $\eta \in [0, 1]$
  - Measurement matrix $\boldsymbol{A} \in \mathbb{R}^{M \times N}$ with SVD $\boldsymbol{A} = \boldsymbol{U}\boldsymbol{S}\boldsymbol{V}^{\mathrm{T}}$
  - Noise $\boldsymbol{w} \sim \mathcal{N}(\boldsymbol{0}, \sigma_w^2\boldsymbol{I})$
  - Scalar quantizer $\mathcal{Q} : \mathbb{R} \to \mathbb{Y}$ maps real values onto a finite set of codewords $\mathbb{Y}$ with cardinality $\|\mathbb{Y}\| = V$ such that $\mathcal{Q}(u) = v_i \quad b_i < u \leq b_{i+1}\ \forall\, i \in [1, ..., V]$
  - Measurements $\boldsymbol{y} \in \mathbb{Y}^M$

VAMP for QCS



Numerical Results

- Performance evaluation in terms of normalized mean squared error for $N = 2048$
- a) varied M for fixed $\sigma_w^2 = 10^{-3}$
- b) varied the noise power σ_w^2 for fixed $M = 2048$
- Set $\eta \in \{1/64, 1/8\}$, cardinality of the quantizer $V \in \{2^4, 2^5\}$ and measurement matrix Gaussian or partial DCT



References

[1] D. L. Donoho, A. Maleki, and A. Montanari, "Message Passing Algorithms for Compressed Sensing," p. 6, 2009. [Online]. Available: http://arxiv.org/abs/0907.3574

[2] S. Rangan, "Generalized approximate message passing for estimation with random linear mixing," in *2011 IEEE International Symposium on Information Theory Proceedings*, July 2011, pp. 2168–2172.

[3] S. Rangan, P. Schniter, and A. K. Fletcher, "Vector approximate message passing," in *Proc. IEEE Int. Symp. Information Theory (ISIT)*, Jun. 2017, pp. 1588–1592.

[4] P. Schniter, S. Rangan, and A. K. Fletcher, "Vector approximate message passing for the generalized linear model," in *Proc. Systems and Computers 2016 50th Asilomar Conf. Signals*, Nov. 2016, pp. 1525–1529.

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