VBI-based Uplink Channel Estimation for Massive MIMO Systems

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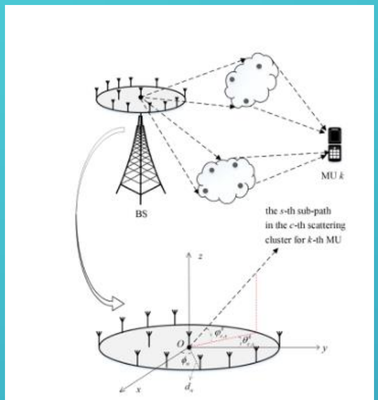
Key words

Massive multiple-input multiple-output (MIMO), uplink channel estimation, sparse Bayesian learning (SBL),variational Bayesian inference (VBI)

Abstract

Uplink channel estimation is a classical and important issue for massive multiple-input multiple-output (MIMO) communication systems. The existing methods usually adopt a prior least squares (LS) estimator to decouple the pilot matrix. Another solution is to utilize the expectation propagation approximation (EPA) instead to decouple the pilot matrix. In this regard, we try to propose a new sparse Bayesian learning (SBL) uplink channel estimation method, which decouples the sparse signals-of-interest automatically using the independent variational Bayesian inference (VBI) factorization.

Our method



Assume that in a massive MIMO system, the BS is equipped with M antennas, and the BS serves K single antenna mobile users (MUs). Therefore, the signal received at the BS can be expressed as follows:

$$\mathbf{Y} = \mathbf{H}\mathbf{S}^{\mathrm{T}} + \mathbf{N}, \qquad (1)$$

The off grid model is as follows:

$$\begin{aligned}\mathbf{Y} &= \left[\boldsymbol{\Phi}(\boldsymbol{\beta}_1)\mathbf{x}_1, \boldsymbol{\Phi}(\boldsymbol{\beta}_2)\mathbf{x}_2, \ldots, \boldsymbol{\Phi}(\boldsymbol{\beta}_K)\mathbf{x}_K\right]\mathbf{S}^{\mathrm{T}} + \mathbf{N} \\ &= \sum_{k=1}^{K} \boldsymbol{\Phi}(\boldsymbol{\beta}_k)\mathbf{x}_k\mathbf{s}_k^{\mathrm{T}} + \mathbf{N}. \qquad (6)\end{aligned}$$

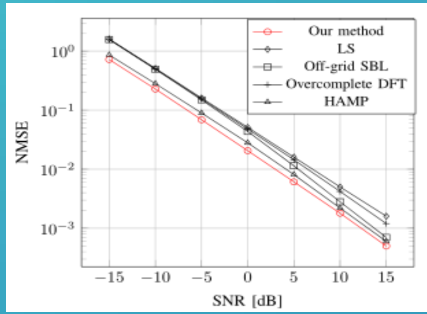
Using SBL knowledge, we can get what we need. The specific algorithm flow chart is as follows:

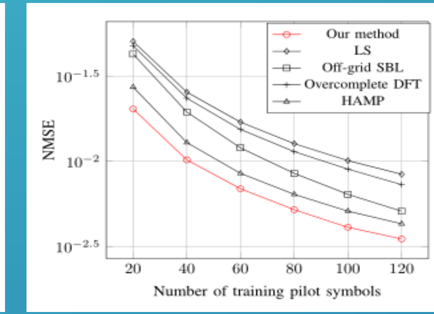
Algorithm 1 Proposed VBI-based Algorithm

1: Input: $\mathbf{Y}$.
2: Initialization: $\hat{\alpha} = 1$, $\hat{\mathbf{x}}_k = \mathbf{0}$, $\hat{\gamma}_{k,l} = 1$ and $\boldsymbol{\beta}_k = \mathbf{0}, \forall k, l$.
3: Proceed the following operations until convergence:
   a) Update $q(\mathbf{x}_k)$s with (20) and calculate $\hat{\mathbf{x}}_k$s and $\boldsymbol{\Sigma}_k^x$s.
   b) Update $q(\gamma_{k,l})$s with (21) and calculate $\hat{\gamma}_{k,l}$s.
   c) Update $q(\alpha)$ with (22) and calculate $\hat{\alpha}$.
   d) Update $\boldsymbol{\beta}_k$s with (25) and calculate $\boldsymbol{\beta}_k^{\text{new}}$s.
4: Output: $\boldsymbol{\Phi}(\boldsymbol{\beta}_k)\hat{\mathbf{x}}_k$s.

Simulation

In this section, we compare our proposed method with DFT, LS, HAMP and off-grid SBL and give simulation results to demonstrate the effectiveness of our method.





Conclusion

We propose a novel channel estimation method based on VBI for massive MIMO uplink channels. We employing an independent VBI decomposition to separate the sparse signal-of-interest, and incorporating an additional column-independent decomposition.

Reference

[1] E. G. Larsson, O. Edfors, F. Tufvesson, and T. L. Marzetta, “Massive MIMO for next generation wireless systems,” IEEE Commun. Mag., vol. 52, no. 2, pp. 186–195, Feb. 2014.