Journal Watch

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K Mohan Babu

SPC Lab
Department of Electrical Communication Engineering
Indian Institute of Science

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1.Group Sparse Bayesian Learning Via Exact and Fast Marginal Likelihood Maximization

Authors: Zeqiang Ma, Wei Dai, Yimin Liu and Xiqin Wang

Goal: Direct computation of optimal values of the unknown variance of signal coefficients by using FMLM.

$\boldsymbol{y} = \boldsymbol{\Phi x} + \boldsymbol{n}$, $x \in \mathbb{R}^N$, $y \in \mathbb{R}^M$ and $\phi \in \mathbb{R}^{M \times N}$

SBL frame work,

$$p(\boldsymbol{x}|\boldsymbol{\alpha}) = \mathcal{N}(\boldsymbol{0}, \boldsymbol{\Sigma}_0), \quad \text{where } \boldsymbol{\Sigma}_0 = \left(\text{diag}(\boldsymbol{\alpha})\right)^{-1}$$

Posterior distribution,

$$p(\boldsymbol{x}|\boldsymbol{y}, \boldsymbol{\alpha}, \beta) = \mathcal{N}(\boldsymbol{\mu}, \boldsymbol{\Sigma})$$

Solution of SBL problem:

- EM
- fast marginal likelihood maximization (FMLM).

Logarithmic likelihood to solve for α_i

$$\begin{aligned}\mathcal{L}(\boldsymbol{\alpha}) &= \log p(\boldsymbol{y}|\boldsymbol{\alpha}, \beta) \\ &= -\frac{1}{2}\Big[N \log(2\pi) + \log|\boldsymbol{C}| + \boldsymbol{y}^T \boldsymbol{C}^{-1} \boldsymbol{y}\Big].\end{aligned}$$

where $C = \frac{1}{\beta} I + \mathbf{\Phi \Sigma_0 \Phi^T}$. To find the optimal α_i,
FMLM : Decompose the matrix C into two parts

$$\boldsymbol{C} = \boldsymbol{C}_{-i} + \alpha_i^{-1} \phi_i \phi_i^T$$

$$\mathcal{L}(\boldsymbol{\alpha}) = \mathcal{L}(\boldsymbol{\alpha}_{-i}) + \frac{1}{2}\ell(\alpha_i)$$

$$\ell(\alpha_i) = \log \alpha_i - \log(\alpha_i + s_i) + \frac{q_i^2}{\alpha_i + s_i}$$

$$\alpha_i = \begin{cases} \frac{s_i^2}{q_i^2 - s_i}, & \text{if } q_i^2 > s_i, \\ \infty, & \text{if } q_i^2 \leq s_i \end{cases}$$

Where as,EM methods iteratively updates α_i

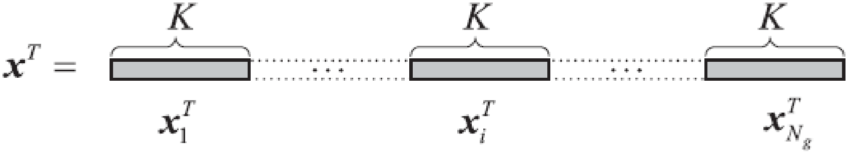


Figure: Group sparse signal

Similarly FMLM algo is derived for Group Sparse case

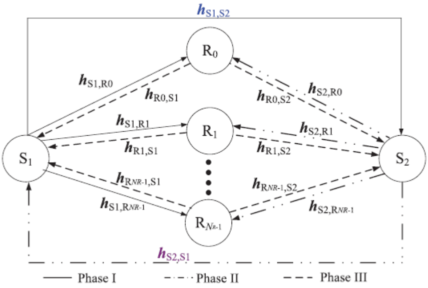
Contributions

- Derivation of an FMLM method for general group sparse signal recovery, termed as group FMLM (g-FMLM).
- Shown that the MLM problem can be solved by finding the roots of a polynomial. Hence the maximum of marginal likelihood can be found efficiently.

2.Semiblind Channel Estimation and Precoding Scheme in Two-Way Multirelay Networks

Authors: Ming-Li Wang, Chih-Peng Li and Wan-Jen Huang

Goal: Design of a new low-complexity precoding scheme and semi-blind channel estimation method for multirelay AF-TWRNs.



- Two source nodes (S1 and S2) and N_R AF relays.

- Nodes have half-duplex transceivers.
- Direct link between them is not obstructed.
- Frequency selective fading channel.
- Transmission b/n S_1 and S_2 is done in three phases.

Channel estimation :

- Training based - extra bandwidth reduces the spectral efficiency.
- Blind - requires a large amount of received signals
- Semi-blind methods - combine the blind method with few pilot symbols

- In Phases I and II, S_1 and S_2 take turns in transmitting N_t training blocks and N_d data blocks
- These blocks are first modulated by OFDM with N subcarriers.
- To avoid interblock interference, the sources append a cyclic prefix, the channel matrices are circulant.
- After receiving the signals in Phases I and II, the relays remove the training symbol blocks and then forward the data blocks during Phase III following multiplication with a precodingmatrix.

Blocks received at source-2 and q^{th} relay in phase - I,

$$\mathbf{y}_{21}[m] = \sqrt{P_s}\mathbf{H}_{S_1 S_2}\mathbf{s}_1[m] + \mathbf{z}_{\mathbf{S}_2}^{(1)}[m]$$
$$\mathbf{y}_q^{(1)}[m] = \sqrt{P_s}\mathbf{H}_{S_1 R_q}\mathbf{s}_1[m] + \mathbf{z}_q^{(1)}[m]$$

Blocks received at source-1 and q^{th} relay in phase - II,

$$\mathbf{y}_{12}[m] = \sqrt{P_s}\mathbf{H}_{S_2 S_1}\mathbf{s}_2[m] + \mathbf{z}_{S_1}^{(2)}[m]$$
$$\mathbf{y}_q^{(2)}[m] = \sqrt{P_s}\mathbf{H}_{S_2 R_q}\mathbf{s}_2[m] + \mathbf{z}_q^{(2)}[m].$$

The data blocks pre-coded at relay R_q (Phase-III),

$$\mathbf{t}_q[m] = \alpha_q \left(\mathbf{C}_q^{(1)}\mathbf{y}_q^{(1)}[m] + \mathbf{C}_q^{(2)}\mathbf{y}_q^{(2)}[m]\right)$$

Received signal at source node S_k

$$\mathbf{y}_{k3}[m] = \sum_{q=0}^{N_R-1} \mathbf{H}_{R_q S_k}\mathbf{t}_q[m] + \mathbf{z}_{S_k}^{(3)}[m]$$
$$= \sum_{k'=1}^{2} \sqrt{P_s}\mathcal{G}_{k'k}\mathbf{s}_{k'}[m] + \tilde{\mathbf{z}}_{S_k}^{(3)}[m]$$

Equivalent channel matrix,

$$\mathcal{G}_{k'k} = \sum_{q=0}^{N_R-1} \alpha_q \mathbf{H}_{R_q S_k}\mathbf{C}_q^{(k')}\mathbf{H}_{S_{k'} R_q}$$

Semi-Blind channel estimation(CE)

CE is symmetric and CE at S_2 is considered here.

$$\mathbf{y}_{21}[m] = \sqrt{P_s}\mathbf{S}_1[m]\mathbf{h}_{S_1 S_2} + \mathbf{z}_{S_2}^{(1)}[m]$$

$$\widehat{\mathbf{h}}_{S_1 S_2} = \frac{1}{N_t\sqrt{P_s}} \sum_{m=0}^{N_t-1} \left(\mathbf{S}_1^H[m]\mathbf{S}_1[m]\right)^{-1} \mathbf{S}_1^H[m]\mathbf{y}_{21}[m].$$

The channel matrices G_{12} and G_{22} can be estimated at S_2 as

$$\begin{aligned}
\widehat{\mathcal{G}}_{12} &= \frac{1}{P_s}\widehat{\mathbf{R}}_{\mathbf{y}_{23}\mathbf{y}_{21}}\widehat{\mathbf{H}}_{S_1 S_2}^{-H}\mathbf{R}_{\mathbf{s}_1\mathbf{s}_1}^{-1} = \frac{1}{P_s}\widehat{\mathbf{R}}_{\mathbf{y}_{23}\mathbf{y}_{21}}\widehat{\mathbf{H}}_{S_1 S_2}^{-H}, \\
\widehat{\mathcal{G}}_{22} &= \frac{1}{\sqrt{P_s}}\widehat{\mathbf{R}}_{\mathbf{y}_{23}\mathbf{s}_2}\widehat{\mathbf{R}}_{\mathbf{s}_2\mathbf{s}_2}^{-1}
\end{aligned} \tag{1}$$

where

$$\widehat{\mathbf{R}}_{\mathbf{xy}} \triangleq \frac{1}{N_s}\sum_{m=0}^{N_s-1} \mathbf{x}[m]\mathbf{y}^H[m].$$

- Precoding is performed using a rotation-based matrix, no matrix multiplication is actually required in the proposed precoding scheme.
- The semi-blind estimation process has low complexity due to the elegant algebraic relation between the circulant channel matrix and the precoding rotation matrix.

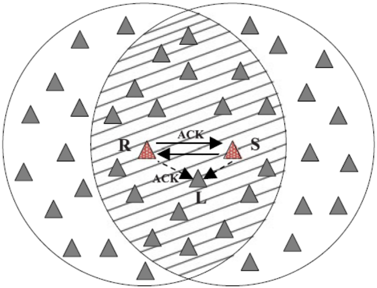
Contributions

- Proposed a rotation matrix-based precoding scheme and a semi-blind channel estimation method for AF TWRNs with multiple relays.

3. Maximum Likelihood Estimation of Clock Skew in Wireless Sensor Networks With Periodical Clock Correction Under Exponential Delays

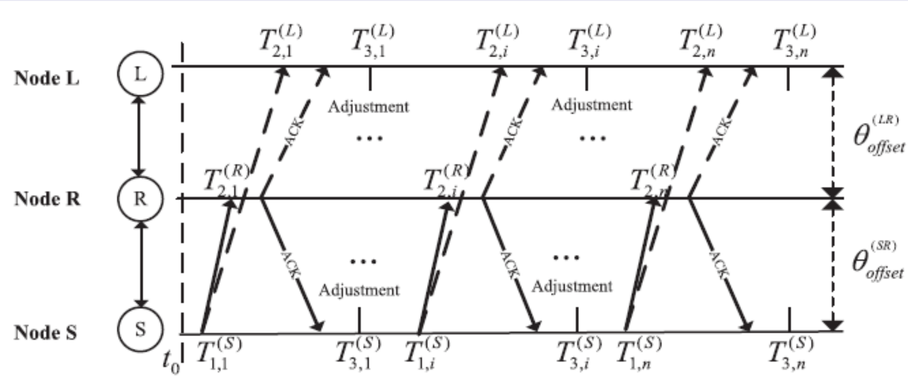
Authors: Heng Wang, Haiyong Zeng, Baoguo Wang and Ping Wang

Goal: Analyzing the time synchronization scheme of active and overhearing nodes based on ACK mechanism under exponential random delays, with clock correction at every synchronization.



- S - Sender, R - Receiver and L - Overhearing node.
- The node adjusts its local clock by an estimated offset at every cycle
- Node R serving as the reference clock node - time synchronization.

System Model



- Packet delays : send time, channel access time, transmission time, propagation time, reception time and receive time.
  - Fixed delays - unknown but maintain constant
  - Random delays - independent exponential Random Variables.

Timestamp made by node R :

$$T_{2,1}{}^{(R)} = T_{1,1}{}^{(S)} + \theta_{t_0}{}^{(SR)} + \rho^{(SR)}(T_{1,1}{}^{(S)} - t_0) + d^{(SR)} + X_1{}^{(SR)} + \rho^{(SR)}(d^{(SR)} + X_1{}^{(SR)})$$

Pairwise Sender-Receiver Time Synchronization

Periods (N)	**1**	**2**	**3**	$\cdots$	i
Initial Phase Offset	$\theta_{t_0}{}^{(SR)}$	$\theta_{t_1}{}^{(SR)}$	$\theta_{t_2}{}^{(SR)}$	$\cdots$	$\theta_{t_{i-1}}{}^{(SR)}$
Time of Adjustment	$T_{3,1}{}^{(S)}$	$T_{3,2}{}^{(S)}$	$T_{3,3}{}^{(S)}$	$\cdots$	$T_{3,i}{}^{(S)}$
Adjustment of Node S	$(T_{2,1}{}^{(R)} - T_{1,1}{}^{(S)})$	$(T_{2,2}{}^{(R)} - T_{1,2}{}^{(S)})$	$(T_{2,3}{}^{(R)} - T_{1,3}{}^{(S)})$	$\cdots$	$(T_{2,i}{}^{(R)} - T_{1,i}{}^{(S)})$

Time Synchronization based on Overhearing Mechanism

Periods (N)	**1**	**2**	**3**	$\cdots$	i
Initial Phase Offset	$\theta_{t_0}{}^{(LR)}$	$\theta_{t_1}{}^{(LR)}$	$\theta_{t_2}{}^{(LR)}$	$\cdots$	$\theta_{t_{i-1}}{}^{(LR)}$
Adjustments	$T_{3,1}{}^{(L)}$	$T_{3,2}{}^{(L)}$	$T_{3,3}{}^{(L)}$	$\cdots$	$T_{3,i}{}^{(L)}$
Adjustment of Node L	$(T_{2,1}{}^{(R)} - T_{2,1}{}^{(L)})$	$(T_{2,2}{}^{(R)} - T_{2,2}{}^{(L)})$	$(T_{2,3}{}^{(R)} - T_{2,3}{}^{(L)})$	$\cdots$	$(T_{2,i}{}^{(R)} - T_{2,i}{}^{(L)})$

Contributions

- Derivation of the exponential MLE of clock skew.
- Since the corresponding Cramer-Rao lower bound (CRLB) does not exist, a mild approximate CRLB is proposed.
- The exponential MLE and corresponding approximate CRLB of clock skew for the overhearing nodes are developed.

For Further Interesting Papers

- Sparse Signal Approximation via Nonseparable Regularization.
  I. Selesnick and M. Farshchian
- Direct Localization for Massive MIMO.
  N. Garcia, H. Wymeersch, E. G. Larsson, A. M. Haimovich, and M. Coulon .
- Bandwidth Estimation From Multiple Level-Crossings of Stochastic Signals.
  D. Rzepka, M. Pawlak, D. Koscielnik, and M. Miskowicz
- A Distributed Algorithm for Resource Allocation Over Dynamic Digraphs.
  Y. Xu, T. Han, K. Cai, Z. Lin, G. Yan, andM. Fu

Channel estimations :

training-based, blind and semi-blind methods.

The training-based method requires extra bandwidth to accommodate the periodic known symbols and thus reduces the spectral efficiency.

The blind method saves the spectral efficiency by utilizing the statistics of received signals.

But, this method requires a large amount of received signals to obtain accurate statistics.

Semi-blind methods, on the other hand, combine the blind method with few pilot symbols to solve the ambiguity problem occurred in blind methods.