Channel Estimation using Adaptive Compressive Sensing

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1 Signal Model and problem formulation

Many wireless channels could be modeled as sparse vectors (with most taps being zero, and with the location of the nonzero taps random and unknown). A simple model could be

$$h(t,\tau) = \sum_{i=1}^{I} \eta_i \delta(\tau - \tau_i) e^{j2\pi v_i t}$$

where most of the η_i are zero. Although standard compressive sensing techniques could be used to estimate such channels from incomplete information, more efficient modifications over standard compressive sensing should be used. The reason is that wireless channels vary smoothly with time. Hence the channel at times t_i and $t_i + \epsilon$ should not be estimated as independent pieces of information since we could improve the estimate from the knowledge of the autocorrelation of the channel, $E[h_t^* h_{t+\epsilon}]$.

Unfortunately, most compressive sensing results consider block-wise data and considers each block (i.e. each sparse vector) independently [1]. Another inefficient approach would be to re-estimate the entire incoming vector of measurements every time we receive new data, the complexity of this system grows quite rapidly in time since matrix manipulations are involved. A better approach would thus be to take advantage of the correlation information to adaptively track the variation of the sparse channel in time.

2 Objective

After familiarizing yourself with compressive sensing (refer to [2],[3], and the tutorials in [4] if you're completely new to the field of compressive sensing), a good start would be [5] where the authors deal with channel estimation using a standard compressive sensing approach. [1] is also a good starting point for the general adaptive compressive sensing problem.

Once you're comfortable with the channel model and the basic concepts of compressive sensing and its adaptive form, you could move on to the adaptive compressive sensing channel estimation methods such as [6]. Many other references also exist. Please refer to the course instructor to specify your task. Good luck!

References

[1] Daniele Angelosante, Georgios B. Giannakis, "RLS-weighted lasso for adaptive estimation of sparse signals," IEEE Int. Conf. on Acoustics, Speech, and Signal Processing (ICASSP), Taipei, Taiwan, April 2009.

[2] E. J. Candes, J. Romberg and T. Tao. "Robust uncertainty principles: exact signal reconstruction from highly incomplete frequency information". IEEE Trans. Inform. Theory, 52 489-509, 2004.

[3] D. Donoho, "Compressed sensing," IEEE Trans. on Information Theory, 52(4), pp. 1289 - 1306, April 2006.

[4] dsp.rice.edu/cs

[5] Georg Taubock and Franz Hlawatsch, "A compressed sensing technique for OFDM channel estimation in mobile environments: Exploiting channel sparsity for reducing pilots," IEEE Int. Conf. on Acoustics, Speech, and Signal Processing (ICASSP), Las Vegas, Nevada, April 2008.

[6] H. Zayyani, M. Babaie-Zadeh, and C. Jutten, "Compressed Sensing Block Map-Lms Adaptive Filter For Sparse Channel Estimation And A Bayesian Cramer-Rao Bound," IEEE 2009