URSI AP-RASC 2019, New Delhi, India, 09 - 15 March 2019

Mixed Gibbs Sampling Iterative MIMO Detection and Decoding with Maximum Ratio Combining

Y. Kobayashi and Y. Sanada
Keio University, Yokohama, Japan; e-mail: yu.kobayashi@snd.elec.keio.ac.jp; sanada@elec.keio.ac.jp

This research presents the performance of Gibbs sampling iterative MIMO detection and decoding scheme with maximum ratio combining (MRC).

In conventional Gibbs sampling schemes, a Gibbs sampling algorithm is directly applied to received signals. When it is applied to signals with higher order modulation symbols, a stalling problem occurs [1]. In [2], Gibbs sampling MIMO detection scheme with MRC was proposed. In the proposed scheme, each candidate symbol is updated with a metric calculated by multiplying corresponding MRC coefficients to the received signal vector. In this case, the convergence speed of the metric for the received signals even with higher order modulation symbols improves and the computational complexity for the update of a transmit candidate symbol vector can be reduced.

In the Gibbs sampling MIMO detection, the n_tth symbol in a candidate transmit symbol vector is renewed as

$$X_{n_t}^{(t+1)} \sim p\left(\hat{X}_{n_t} \middle| X_1^{(t+1)}, \cdots, X_{n_t-1}^{(t+1)}, X_{n_t+1}^{(t)}, \cdots, X_{N_T}^{(t)}, \mathbf{R}, \mathbf{H}\right)$$
$$\propto (1-Q)\varphi\left(\alpha, \hat{\mathbf{X}}^{n_t}\right) p\left(\gamma_{n_t}^k\right) + Q\varphi\left(\infty, \hat{\mathbf{X}}^{n_t}\right)$$

where $X_{n_t}^{(t)}$ is the n_tth transmit symbol candidate, N_T and N_R are the numbers of transmit and receive antennas, $\mathbf{R}$ is the $N_R \times 1$ received signal vector, $\mathbf{H}$ is the $N_R \times N_T$ channel response vector, $Q$is the mixing ratio that is set to $1/2N_T$, $\alpha = 1.5$ is the temperature parameter, $\gamma_{n_t}^k$ is the log likelihood ratio (LLR) for the kth of the n_tth symbol, and $\hat{\mathbf{X}}^{n_t} = \left[X_1^{(t+1)} \cdots X_{n_t-1}^{(t+1)}\ \hat{X}_{n_t}\ X_{n_t+1}^{(t)} \cdots X_{N_T}^{(t)}\right]^T$ where $[\cdot]^T$ represents transpose. To further improve the convergence performance, the LLR output from a turbo decoder is used to calculate the following probability as,

$$p\left(\gamma_{n_t}^k\right) = \begin{cases} 1/\left(1+e^{-\gamma_{n_t}^k}\right) & \text{if the } k\text{th bit that consisits the } n_t\text{th candidate symbol is } +1 \\ e^{-\gamma_{n_t}^k}/\left(1+e^{-\gamma_{n_t}^k}\right) & \text{if the } k\text{th bit that consists the } n_t\text{th candidate symbol is } -1 \end{cases}.$$

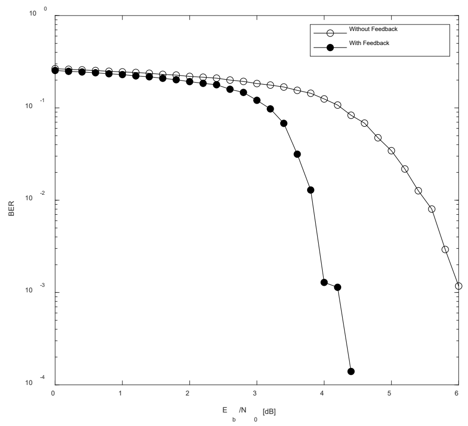

Figure 1. Bit Error Rate Performance

Figure 1 shows the bit error rate performance of the mixed Gibbs sampling MIMO detection with and without LLR feedback from a turbo decoder. Numbers of transmit and receive antennas are 2×2, a coding rate is 1/3, QPSK modulation is used. The number of Gibbs sampling iterations is 2, the number of turbo decoding iterations is 7, and the LLR feedback is applied after the 3rd iteration. As it is clear that iterative detection and decoding improves the performance significantly.

1. B. Farhang-Boroujeny, H. Zhu, and Z. Shi, “Markov Chain Monte Carlo Algorithms for CDMA and MIMO Communication Systems,” IEEE Trans. Signal Process., vol. 54, no. 5, pp. 1896-1909, May 2006.
2. Y. Sanada, "Gibbs Sampling MIMO Detection with Maximum Ratio Combining," IEEE International Symposium on Personal, Indoor, and Mobile Radio Communications 2017, Oct. 2017.