V-BLAST 시스템에서의 Log-Likelihood Ratio를 이용한 효율적인 신호 검출 방식 연구

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Efficient Signal Detection using Log-Likelihood Ratio in V-BLAST Systems

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요 약

In this paper, we propose a new detection algorithm for the layered space-time (LST) codes. This algorithm utilizes the sorted QR decomposition (SQRD) based on the Log-Likelihood Ratio (LLR) ordering method. The motivation of this paper is to reduce computational efforts using SQR decomposition of channel matrix and to obtain reliable data decision based on LLR. Unlike a conventional SQRD method using the SNR-based sorting, the proposed scheme utilizes the LLR of the modified signals in a sorting process of QR decomposition. The proposed algorithm outperforms the conventional SQRD algorithm with small amount of additional computations.

I. Introduction

Using multiple antennas at transmitter and receiver, we can obtain high spectral efficiencies by using the layered space-time (LST) codes [1]. The simplified version of BLAST (Bell Lab. Layered Space-Time) was proposed in [2], known as V-BLAST (Vertical BLAST). For detecting the LST codes at the receiver, we require some signal processing such as Fig. 1. The detection scheme that was proposed in [2] uses the pseudo-inverse solution of channel matrix, and first detects the sub-stream of transmitted signal that has the maximum post detection signal-to-noise ratio (SNR) and then cancels the effect of the detected sub-stream from the received signal. The same process is repeated for the remaining substeams. Unlike [2], the detection order is determined by the LLR in [3]. In case of the equi-energy signaling, it requires just a little additional complexity. It provides the higher reliability of data decision using SNR as well as the instantaneous noise. But this algorithm also requires the pseudo-inverse processes in detecting each sub-stream. To reduce the computational efforts, [6] proposed the efficient algorithm using the sorted QR decomposition (SQRD) by sorting the detection sequence based on the SNR followed by exchanging the columns of the channel matrix. Although this algorithm has the performance degradation compared to Zero-forcing ordered successive interference cancellation (ZF-OSIC) algorithm, the computational efforts can be reduced by using QR decomposition of the channel matrix [6].

In this paper, we propose the new detection algorithm for VBLAST that utilizes the LLR-based SQRD. For this algorithm, we employ the modified Gram-Schmidt algorithm to obtain the factorization, and utilize the SNR as well as the instantaneous noise in sorting processes. Like LLR-based ZF-OSIC of [3], the proposed algorithm outperforms the conventional SQRD algorithm with small amount of additional computations. The remainder of this paper is organized as follows. In Section II, the system model is described. Section III reviews traditional detection algorithms. And in Section IV, a new detection algorithm is introduced. Section V provides the simulation results and some discussions. Finally, we present conclusion in Section VI.

II. System Model

We consider the multiple antenna systems with n_T transmit antennas and $n_R \geq n_T$ receive antennas. The data stream is de-multiplexed into n_T sub-streams. Each sub-stream is encoded into *M*-PSK symbols. The $n_T \times 1$ transmit signal vector $\mathbf{x} = [x_1, \ldots, x_{n_T}]^T$ are sent through each transmit antenna over a rich-scattering wireless channel $\mathbf{H}$. At each time slot, the $n_R \times 1$ received vector can be represented as

$$\mathbf{r} = \mathbf{H}\mathbf{x} + \mathbf{n} \tag{1}$$

where $\mathbf{H}$ is the $n_R \times n_T$ channel matrix which contains i.i.d complex Gaussian gains with mean zero and unit variance. And each element $h_{j,i}$ of $\mathbf{H}$ describes the tap gain between transmitter i and receiver j, and it is assumed to be perfectly known by each receiver. The $n_R \times 1$ noise vector $\mathbf{n}$ is assumed to be i.i.d. complex white Gaussian with mean zero and variance $N_0/2$ per dimension.