A PDF Estimation-Based Iterative MIMO Signal Detection With Unknown Interference

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***Abstract*—The equivalent diversity order of iterative minimum mean squared error (MMSE) multiuser detectors for multiple input multiple output (MIMO) channels is decreased if they aim at suppressing unknown cochannel interference (UCCI) while detecting multiple users' signals. In this letter, we propose a new MIMO signal detection scheme with the aim to preserve the detector's diversity order by estimating the probability density function of the UCCI plus background noise. It is shown that the proposed detector significantly outperforms the conventional detector based on UCCI's covariance matrix estimation.**

***Index Terms*—Channel estimation, cochannel interference, equalization, multiple input multiple output (MIMO), minimum mean squared error (MMSE), probability density function (PDF) estimation, turbo multiuser detection.**

I. Introduction

ITERATIVE low-complexity multiuser detection, equalization and decoding principle based on soft cancellation and minimum-mean squared-error filtering (SC/MMSE) [1] has attracted a considerable attention in recent years. It is a suboptimal solution to the prohibitively complex optimal joint multiuser detection, equalization and decoding problems.

The SC/MMSE equalizer is robust against unknown cochannel interference (UCCI) if the covariance matrix of the UCCI is properly estimated [2] or subspace estimation [3] is performed. To suppress UCCI, however, the both methods unavoidably consume the degrees-of-freedom (DOF) supported by the multiple antennas for MIMO signal detection, resulting in decreased diversity order [3]. In fact, the available DOF are used both for UCCI suppression and multipath combining. The loss tends to be more severe in lower memory length frequency selective channels, due to the lack of multipath diversity.

In this letter, we propose a new iterative receiver that can preserve the diversity gain by estimating the probability density function (PDF) of the UCCI plus noise. It is shown through simulations that the proposed receiver significantly outperforms the conventional detector of [2] in relatively low memory length channels.

The letter is organized as follows. Section II describes system model. Section III presents the proposed receiver. Sections IV and V present the simulation results and conclusions, respectively.

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II. System Model

The system model is shown in Fig. 1. The notations follow closely those in [1]. Each of $N+N_I$ users encodes information sequence $c_n(i)$, $n=1,\ldots,N+N_I$, $i=1,\ldots,BR$ with R and B being the code rate and frame length in symbols, respectively. Users indexed by $n=1,\ldots,N$ are desired users, and those indexed by $n=N+1,\ldots,N+N_I$ are assumed to be UCCI. The encoded sequences $b_n(k)$, $k=1,\ldots,B$ are interleaved, and headed by the user-specific training sequences of length T. The entire frame is then BPSK modulated and transmitted through frequency selective channel with L paths.

After coherent demodulation in the receiver, the signals from each of the M receive antennas are sampled in time domain to capture the multipath components. The space-time representation of the received signal at time instant k is given in the vector form by [1]

$$\mathbf{y}(k)=\mathbf{H}\mathbf{u}(k)+\mathbf{H}_I\mathbf{u}_I(k)+\mathbf{n}(k),\quad k=1,\ldots,T+B \quad (1)$$

where $\mathbf{y}(k)\in\mathbb{C}^{LM}$ is the space-time sampled received signal vector and $\mathbf{H}$ is the channel matrix of the form

$$\mathbf{H}=\begin{bmatrix}\mathbf{H}(0) & \ldots & \mathbf{H}(L-1) & \ldots & \mathbf{0}\\ \vdots & \ddots & & \ddots & \vdots\\ \mathbf{0} & \ldots & \mathbf{H}(0) & \ldots & \mathbf{H}(L-1)\end{bmatrix}\in\mathbb{C}^{LM\times N(2L-1)}$$

with $[\mathbf{H}(l)]_{m,n}$ being the l-th path complex gain between the n-th user and mth receive antenna. $\mathbf{H}_I\in\mathbb{C}^{LM\times N_I(2L-1)}$ is channel matrix of the UCCI defined similarly to $\mathbf{H}$, and $\mathbf{u}(k)\in\mathbb{C}^{N(2L-1)}$, $\mathbf{u}_I(k)\in\mathbb{C}^{N_I(2L-1)}$ and $\mathbf{n}(k)\in\mathbb{C}^{LM}$ are vectors containing desired users' signals, UCCI signals and additive white Gaussian noise (AWGN) with covariance $E\{\mathbf{n}(k)\mathbf{n}^H(k)\}=\sigma^2\mathbf{I}$, respectively [1].

III. Iterative Receiver With PDF Estimation

First iteration: In the first iteration the proposed receiver is exactly the same as conventional receiver from [2]. Let $\mathbf{x}(k)=\mathbf{H}_I\mathbf{u}_I(k)+\mathbf{n}(k)$. Let $\tilde{\mathbf{u}}(k)$, $k=1,\ldots,T$ denote the vector containing training sequences of N desired users [1]. The samples $\tilde{\mathbf{u}}(k)$, $k=1,\ldots,T$ are first fed to the channel estimator to obtain the estimate $\hat{\mathbf{H}}$ of $\mathbf{H}$. After that the samples $\hat{\mathbf{x}}(k)=\mathbf{y}(k)-\hat{\mathbf{H}}\tilde{\mathbf{u}}(k)$, $k=1,\ldots,T$ are used to estimate the covariance matrix of the UCCI-plus-noise using sample average given by

$$\mathbf{R}_{\mathbf{xx}}=\mathbf{H}_I\mathbf{H}_I^H+\sigma^2\mathbf{I}\approx\frac{\sum_{k=1}^{T}\hat{\mathbf{x}}(k)\hat{\mathbf{x}}^H(k)}{T}=\hat{\mathbf{R}}_{\mathbf{xx}}. \quad (2)$$