An Iterative Decision Directed Channel Estimation for Multi-user MIMO Systems

Guilherme Gaspar[(1)], Afonso Ferreira[(1,2)], Paulo Montezuma[(1,2,3)], Mario Marques da Silva[(2,4)] and Rui Dinis[(1,2)]

[(1)] DEE, FCT Universidade Nova de Lisboa, Portugal
[(2)] IT, Instituto de Telecomunicações, Av. Rovisco Pais, Lisboa, Portugal.
[(3)] Uninova, Instituto de Desenvolvimento de Novas Tecnologias, Quinta da Torre, Caparica, Portugal.
[(4)] DCT, Universidade Autonoma de Lisboa, Portugal.

Abstract - The massive use of transmit and receive antennas with perfect channel state information (CSI) in massive MIMO systems (Multiple Input Multiple Output) can lead array power gain increments proportional to the number of antennas. For CSI estimation pilots can be used, but in multi-user scenarios pilot contamination may occur which may compromise estimation, even when are used orthogonal sequences such as Chu sequences. In such conditions even a precoding does not cancel interference among users and the system performance can be compromised. It is shown that a decision directed scheme based on a iterative block frequency domain equalizer can be used to compensate the pilot contamination impact on channel estimation without sacrificing the complexity. Moreover, when the coherence time spans multiple data blocks, these most accurate channel estimates can be used to precod the subsequent blocks and thereby improve system performance. It is also presented a set of performance results that sustain our assumption.

Index Terms: massive MIMO, Channel state information, decision directed channel estimation, pilot contamination.

I. Introduction

Multiple-input multiple-output (MIMO) channels arising from the use of multiple antennas at both the transmitter and at the receiver provide an important increase in capacity over single-input single-output (SISO) channels under some uncorrelation conditions [1], [2]. For that reason massive MIMO (m-MIMO) has attracted considerable attention as a possible key technologies for 5G [3]. Given perfect channel state information (CSI), the signals received at all antenna elements can be combined coherently and the array gain grows without bound with the number of antennas at the access point [4]. Therefore, massive use of antennas elements can overcome both multiuser interference and thermal noise for any given number of users and any given powers of the interfering users. In such conditions a large array gain can be attained by a massive use of antenna elements [3]. Note that this requires CSI available at both ends of the link. Thus channel estimation has a relevant role in the system capacity.

The use of training sequences should achieve uncorrelation conditions and avoid pilot contamination, which can be granted by orthogonal sequences [5], [6], [7]. For that purpose sequences with periodic auto-correlation function which is 0 except for the period multiple shift terms such as Zadoff-Chu (ZC) sequences can be used [7], without the need of any precoding which may reduce complexity. However, the very high number of users and transmit channels associated to each user can lead to situations where pilot contamination occurs due to the use of same orthogonal sequences or due to imperfect time synchronization between transmitter and receivers. The reuse of training sequences in neighboring cells imposes a limitation on the achievable rate in a m-MIMO system, due to pilot contamination. The number of distinct training sequences should be higher than the number of users that are being served in the system. Moreover, the number of mutually orthogonal training sequences that can be generated is lower bounded by the length of those sequences. Thus, there is a tradeoff between the length of the training sequences and the data transmission payload. The tradeoff worsens as the channel coherence interval becomes smaller.

In order to mitigate pilot contamination and reduce the bandwidth usage by training sequences, an iterative channel estimation technique based on the outputs of an iterative block decision feedback equalizer (IB-DFE) can be employed [8], [9], [10], [11]. In comparison to traditional pilot-based channel estimation techniques, this technique requires fewer, or even none, pilots to estimate the CSI, relieving the effect of pilot contamination and increasing spectral efficiency. The proposed iterative channel estimation technique consists in an adaptation of the IB-DFE. By taking advantage of the iterative process, CSI can also be, iteratively, estimated.

This paper analyzes how channel estimation aided by a decision directed scheme can be applied to multi user m-MIMO (MU-m-MIMO) systems in scenarios with interference among pilots. In these scenarios the decision directed channel estimation can be used to cope with pilot contamination in order to obtain a better channel estimation after the coarse estimate provided by the pilots. After this introductory part the rest of the paper is organized as follows: systems characterization is presented in section II, where it is also introduced the problem to be analyzed. Section III, characterizes the proposed technique. Simulation results regarding scenarios without and with pilot contamination are presented and discussed in section IV. Finally, Section V concludes the paper.