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A frequency domain subspace blind channel estimation method for trailing zero OFDM systems

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ABSTRACT

The technique of orthogonal frequency division multiplexing (OFDM) is widely used for high-speed data transmission in indoor and outdoor communication networks. Trailing zero (TZ) OFDM systems possess some favorable features compared to conventional cyclic prefixed OFDM systems. In this paper, we propose a blind channel estimation method for TZ-OFDM systems in the frequency domain. The significance of the proposed method is threefold. First, it gives an insight into the characteristics of TZ-OFDM systems from a frequency domain perspective. The characteristics revealed are not clearly manifest in the time domain. Second, by exploiting the desirable property brought by the trailing zeros and making use of the frequency domain samples available at the TZ-OFDM receiver, the frequency domain subspace based blind channel estimator is straightforward in concept and algorithm derivation as opposed to a time domain formulation. Third, the proposed method explicitly addresses the issue of unknown channel length. The new method is theoretically proven and numerically shown to work effectively for channels of unknown length. Simulation results demonstrate the satisfactory performance of the proposed method as compared to the existing methods and its robustness to channel overestimation.

1. Introduction

Orthogonal frequency division multiplexing (OFDM) is an attractive multicarrier transmission technique for combating frequency-selective distortion and narrowband interference (Sklar, 2001; Prasad, 2004) in indoor and outdoor communication networks (Thompson et al., 2006). Conventional OFDM systems apply a cyclic prefix (CP) to eliminating inter-block interference (IBI). However, CP-OFDM systems fail to recover transmitted symbols if there is a channel spectral null located on a subcarrier (Wang and Giannakis, 2001). To address this issue, the CP is replaced by trailing zeros (TZ), added to each transmitted block. As an appealing alternative to CP-OFDM, not only are TZ-OFDM systems insensitive to channel spectral nulls, but they also enjoy maximum diversity gain (Wang and Giannakis, 2001). Despite the seeming relationship between CP- and TZ-OFDM systems, the results obtained for the former cannot be carried over directly to the latter.

To detect transmitted data correctly, reliable estimation of time-dispersive channels is important for CP- and TZ-OFDM systems. There are two classes of channel estimation methods, training-based and blind. In the former, training sequences (also called pilots) are transmitted to enable channel estimation at the receiver. However, training sequences consume system bandwidth, thus reducing network spectral efficiency. In addition, to track channel variations in wireless applications, pilot symbols have to be transmitted periodically, causing further loss in system throughput. Compared to training-based schemes, blind channel estimation methods do not suffer from these drawbacks. Indeed, blind identification techniques have been recognized as a bandwidth efficient means (Giannakis et al., 2001) for increasing network capacity. Since the celebrated work of Moulines et al. (1995), the subspace (SS) based estimation framework has played a critical role in blind channel identification for single-carrier systems (e.g., Giannakis et al., 2001; Tsai and Tseng, 2008) and for OFDM systems (e.g., Muquet et al., 2002a,b). It is also useful in remotely continuous monitoring of medical patients where fast and accurate estimation of large volume of medical images such as ECG is critical (e.g., Hu and Han, 2009).

In this paper, we propose a frequency domain subspace approach to blind channel estimation for TZ-OFDM systems. Although the frequency domain is particularly suitable for analyzing TZ-OFDM systems (Manton, 2002), due to the fact that

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