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A Novel Matrix Optimization for Compressive Sampling based Sub-Nyquist OFDM Receiver in Cognitive Radio

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1 Extended Abstract

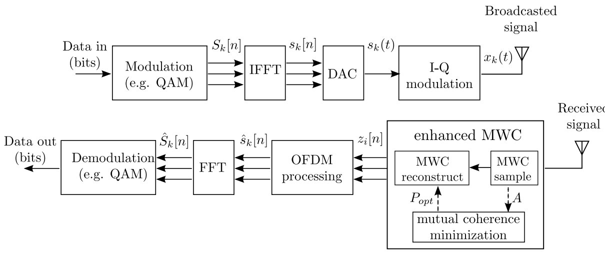
Cognitive radio (CR) has been proposed as a promising solution to enhance the spectrum usage efficiency by exploiting underutilized spectral resources in an opportunistic manner [1]. However, a crucial factor in CRs' implementation lies in the spectrum sensing (SS) procedure [2]. During the SS, a CR typically needs to rapidly monitor multiple frequency bands, which demenads very high sampling rate that is beyond many current commercially available analog-to-digital converters (ADCs) due to their limited front-end bandwidths [3]. One promising solution to overcome the sampling rate bottleneck in SS is the compressive sampling (CS) [4] technique, which is based on the observation that typically, only a small portion of (sparse) frequency bands are utilized while others are rarely occupied at any instance of time [5]. As such, several sub-Nyquist implementations [6, 7] have been proposed based on the CS framework. On the other hand, due to its high robustness to noise, the modulated wideband converter (MWC) [7] has become the favorite design for CR receivers [8, 9] to alleviate both the analog and digital processing requirements.

It has been shown that reducing mutual coherence is one of the most effective ways to improve the performance of CS based systems [10]. One way to minimize the mutual coherence is through the use of conventional matrix optimization algorithms [11, 12] by updating the parameters in measurement matrices. However, to the best of our knowledge, the issue of mutual coherence has always been largely ignored in MWC-CR designs [3, 13, 14]. These works mainly focus on incorporating the MWC to OFDM or MIMO frameworks, rather than improving the MWC's performance. A likely reason is the mentioned conventional algorithms [11, 12] cannot be directly embedded in the MWC. This is because with the pre-designed (i.e. fixed) architecture, the hardware parameters that affect the mutual coherence cannot be easily updated during the MWC's sampling operation.

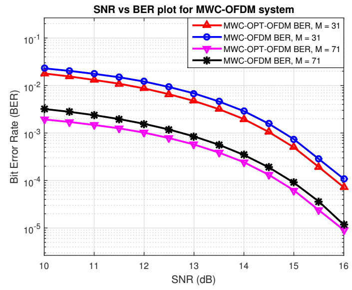
This paper hence proposes a novel matrix optimization algorithm that minimizes the mutual coherence of MWC-CR receiver using OFDM based standard. The proposed algorithm can be pre-calculated and easily implemented using a digital signal processor, and is hence compatible with typical digital based OFDM receiver. The block diagram of the proposed enhanced MWC-OFDM system is shown in Figure (a) in Appendix. It first describes an OFDM system that incorporates MWC to sample a wide-band signal, which composed of several OFDM transmissions with unknown carriers. It then presents the proposed matrix optimization as a digital signal processing approach that interacts with MWC to minimize the mutual coherence in the MWC's sensing matrix. The MWC then outputs the enhanced spectrum information for subsequent OFDM demodulation processes.

Figure (b) in Appendix compares the bit error rate (BER) of MWC-OFDM systems with and without the proposed optimization algorithm operating under different received signal-to-noise ratio (SNR) conditions. Compared to the original system without the proposed optimization, our enhanced system is able to reduce the BER under all levels of SNR indicated. (For example, it reduces the BER by 9% when the number of sampling channels = 31 and SNR = 14dB.) This result shows that our proposed optimization algorithm has made the enhanced MWC-OFDM system consistently better which leads to lower CS reconstruction error.

Appendix



(a) High level architecture of MWC-OFDM system with the proposed mutual coherence minimization (novel matrix optimization) embedded.



(b) BER performance under different SNR when number of channels equals to 31 and 71.

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