World Academy of Science, Engineering and Technology
International Journal of Information and Communication Engineering
Vol:11, No:04, 2017

Hybrid Precoder Design Based on Iterative Hard Thresholding Algorithm for Millimeter Wave Multiple-Input-Multiple-Output Systems

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Abstract : The technology advances have most lately made the millimeter wave (mmWave) communication possible. Due to the huge amount of spectrum that is available in MmWave frequency bands, this promising candidate is considered as a key technology for the deployment of 5G cellular networks. In order to enhance system capacity and achieve spectral efficiency, very large antenna arrays are employed at mmWave systems by exploiting array gain. However, it has been shown that conventional beamforming strategies are not suitable for mmWave hardware implementation. Therefore, new features are required for mmWave cellular applications. Unlike traditional multiple-input-multiple-output (MIMO) systems for which only digital precoders are essential to accomplish precoding, MIMO technology seems to be different at mmWave because of digital precoding limitations. Moreover, precoding implements a greater number of radio frequency (RF) chains supporting more signal mixers and analog-to-digital converters. As RF chain cost and power consumption is increasing, we need to resort to another alternative. Although the hybrid precoding architecture has been regarded as the best solution based on a combination between a baseband precoder and an RF precoder, we still do not get the optimal design of hybrid precoders. According to the mapping strategies from RF chains to the different antenna elements, there are two main categories of hybrid precoding architecture. Given as a hybrid precoding sub-array architecture, the partially-connected structure reduces hardware complexity by using a less number of phase shifters, whereas it sacrifices some beamforming gain. In this paper, we treat the hybrid precoder design in mmWave MIMO systems as a problem of matrix factorization. Thus, we adopt the alternating minimization principle in order to solve the design problem. Further, we present our proposed algorithm for the partially-connected structure, which is based on the iterative hard thresholding method. Through simulation results, we show that our hybrid precoding algorithm provides significant performance gains over existing algorithms. We also show that the proposed approach reduces significantly the computational complexity. Furthermore, valuable design insights are provided when we use the proposed algorithm to make simulation comparisons between the hybrid precoding partially-connected structure and the fully-connected structure.

Keywords : alternating minimization, hybrid precoding, iterative hard thresholding, low-complexity, millimeter wave communication, partially-connected structure
Conference Title : ICWITS 2017 : International Conference on Wireless Information Technology and Systems
Conference Location : Lisbon, Portugal
Conference Dates : April 16-17, 2017