A Study on Transmit Precoder Designs for Spatial Modulation and Deep Learning-Based Beam Allocation

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Thesis Abstract

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In this dissertation, I investigate the transmit precoder designs for spatial modulation (SM) and deep learning-based high-resolution beam-quality prediction for guaranteeing high-quality and low-latency communications. Notably, the system performances degrade significantly caused by the correlated fading channels. To tackle this challenge, I first introduce an orthogonality structure design (OSD) for the generalized precoding aided spatial modulation (GPSM) to overcome the performance degradation. To facilitate a better trade-off between performance and computational complexity, I study the peculiarities of the Hermitian matrix which provides an important insight for conceiving orthogonality conditions to the channel matrix of GPSM system. Next, I observe that the system performances degrade distinctly when employing the current existing transmit precoding (TPC) approaches into the multiple-access spatial modulation (MASM) in multiple-input multiple-output (MIMO) systems. To address this challenge, I next investigate the dual-ascent inspired TPC algorithms for MASM-MIMO systems. In addition, I study the peculiarities of the convex optimization methods that take the dual-ascent method into account to find a global optimum against the non-convex maximum minimum Euclidean distance (MMD) and quadratically constrained quadratic program (QCQP) problems, as well as to enlarge the energy-efficiency. Numerical results show the benefits of our proposals under different kinds of performance metrics. On the other hand, due to the challenges in mmWave networks that: (i) existing deep-learning based approaches predict the beamforming matrix that in practice can not be well-suited to the underlying channel distribution as the beamforming dimension at BS is large; (ii) user equipments (UEs) who are geographically co-located together may render the serve beam conflicts, thus deteriorating the system performance. In this context, to make fast beamforming available at BS, this dissertation focuses on investigating the deep learning-based beam and power allocation by exploiting the image super-resolution technology. More explicitly, this dissertation develops a deep learning-based beam and power resource allocation approach which can accurately allocate the desired beam and power for UEs with low-overhead. Numerical results verify the effectiveness of our approach.

The reminder of this dissertation will be structured as follows:

Chapter 1 introduces the concept of transmit precoding, and its applications into the MASM-MIMO systems. Besides, high resolution beam quality prediction in the downlink mmWave communication and

its challenges are also introduced in this chapter. Several related works in reference to the above two research topics are also introduced.

Chapter 2 introduces non-convex precoding optimization problem as well as the analysis of the non-convex problem solver and its challenges. In particular, this dissertation focuses on investigating two non-convex optimization problems, i.e., the transmit-precoding optimization problem and the joint precoding weight optimization and power allocation problem.

Chapter 3 develops a low-complexity solution to the non-convex precoding optimization problem. In addition, this dissertation introduces an OSD for the GPSM to overcome the performance degradation.

Chapter 4 studies the challenging non-convex MMD problem and the non-convex QCQP problem. To develop an efficient solution to the above problems as well as to keep low hardware realization cost, this dissertation presents a dual-ascent inspired transmit precoding approach by exploiting the primal-dual optimality theory.

Chapter 5 introduces a low-overhead beam and power allocation solution as a solver to the non-convex joint beamforming (precoding) weight optimization and power allocation problem. By exploiting the deep learning technology and the super resolution technology, high-resolution beam-quality prediction with high accuracy can be realized with a low-overhead.

Finally, Chapter 6 concludes this dissertation by making remark on the key technologies proposed by Chapter 3, Chapter 4, and Chapter 5 as well as stating their technical contributions. Besides, Chapter 6 presents possible venues for future research topic on developing low overhead beamforming (precoding) weight prediction and applications.