Master's Thesis

Applications of bilevel optimization in robust beamforming techniques

Guidance

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February 2025

Abstract

In wireless communications, communication resources are limited and must be managed efficiently. Numerous studies have been conducted on resource allocation based on perfect channel state information (CSI) at the base station. However, obtaining perfect CSI is challenging in practice, requiring calculations based on CSI that includes channel estimation errors. For robust beamforming problems, the few methods that had been investigated in the literature are based on semidefinite optimization, which are computational inefficient.

In this work, we analyze and propose methods that solve the beamforming problem while considering CSI errors. Specifically, we consider the problem of maximizing the weighted sum-rate subject to power constraints, with imperfect CSI. We use the robust optimization idea of maximizing its worst-case scenario, formulating the problem as a bilevel optimization. Since the problem is non-convex, it is difficult to obtain global optimal solutions, and thus we aim to find suboptimal solutions. This research discusses solutions for this bilevel optimization problem using the cutting plane method. We also propose the augmented Lagrangian-based method, the Karush-Kuhn-Tucker-based method and the quasi-Newton method with Broyden–Fletcher–Goldfarb–Shanno (BFGS) update. We analyze all these methods, discussing their pros and cons. Finally, numerical experiments for the augmented Lagrangian-based method and the Karush-Kuhn-Tucker-based method are summarized, and the validity of the resulting solutions is verified.