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Reinforcement Learning for Reconfigurable Intelligent Surfaces

Assisted Wireless Communication Systems

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Preface

As the wireless communication networks are advancing toward their sixth generation, the key enabling technologies need to be thoroughly investigated. Recently, reconfigurable intelligent surfaces (RISs) have emerged as a promising solution to realize the demands of future wireless communication systems. They consist of low-cost passive reflecting elements that can be independently tuned to boost the received signal quality. RISs have the ability to control, amongst others, the phase of the electromagnetic waves that are reflected, refracted, and scattered. This feature enables RISs to effectively control the randomness of the propagation environment, leading to enhanced signal quality and strength, enhanced security, increased data rates, reduced error rates, and improved coverage. Furthermore, since the RIS elements are passive (i.e., they do not require a direct power source), the RISs can be deployed at low-cost, which makes them efficient in large-scale wireless systems. The RIS reflection coefficients can be optimized along with different parameters to maximize key performance metrics, such as the sum rate, secrecy rate, energy efficiency, signal coverage, etc. These features make RISs a critical component for future wireless communication systems.

Optimizing RIS-assisted wireless systems requires powerful algorithms to cope with the dynamic propagation environment and time-frequency-space varying channel conditions. Most of the current work on optimizing the RISs relies on alternating optimization techniques. Although such approaches can provide near-optimal solutions, they rely on well-established mathematical relaxations that change depending on the wireless communication system and objective function. Furthermore, they are not scalable. Future wireless systems will be characterized by massive number of connected devices, base stations, and sensors. Designing and controlling such large-scale wireless systems under dynamic environments will be infeasible given the considered relaxations for deriving explicit and solvable mathematical formulations of the wireless systems. Therefore, developing adaptive approaches through sensing and learning is needed to efficiently optimize the RIS reflection coefficients.

Deep reinforcement learning (DRL) is envisioned as one of the key enabling techniques to exploit the full potential of dynamic RIS-assisted wireless commu-