Title: Performance Enhancement of Next Generation Wireless Technology using Reconfigurable Intelligent Surfaces

With the rapid growth of wireless communication and the increasing demand for high-speed data transmission, next-generation wireless technologies are required to address the limitations of existing infrastructure. Reconfigurable intelligent surfaces (RISs) have emerged as a promising solution to enhance wireless communications by intelligently manipulating the propagation environment. RISs are passive surfaces embedded with a large number of sub-wavelength elements that can reflect and control the propagation of wireless signals. By adaptively adjusting the reflection properties of incident signals, RISs can mitigate the effects of blockages and optimize resource allocation. This dissertation explores the potential of RISs in next-generation wireless communication systems. RISs offer numerous benefits, including overcoming network blockage, improving signal directionality, enhancing system performance, and enabling resource allocation optimizations. The dissertation contributes to the field of wireless communications by providing novel solutions for blockage prediction, resource allocation in unmanned aerial vehicle (UAV)-assisted networks, energy harvesting in Internet of Things (IoT) systems, efficient control of RIS elements, adaptive signal strength maintenance, and resource allocation in small cell networks (ScNs). We investigate using RISs to counter the blockage effect in wireless communication caused by network blockage conditions. A novel RIS-aided wireless communication problem is formulated, considering signal propagation through multiple paths and the Doppler spread for mobile user equipment (UE). Combining RGB camera sensing at the base station (BS) and RIS-assisted gain, a deep neural learning model is employed to maximize the probability of UE communication blockage detection. Simulation results demonstrate the effectiveness of the proposed RIS-assisted model in improving blockage prediction accuracy. We focus on resource allocation challenges in UAV-assisted wireless networks. The concept of actively simultaneously transmitting and reflecting (ASTAR)-RISs is introduced to amplify incident signals, enhancing signal-to-noise ratio (SNR) in remote areas. A path-planning problem is formulated, and iterative algorithms are used to find the optimal UAV trajectory. Simulation results highlight the potential of ASTAR-RISs in improving network performance and resource allocation in UAV-assisted wireless networks. We investigate integrating active and passive elements in RISs for batteryless IoT (b-IoT) systems. The trade-off between the number of RIS elements and system performance is analyzed. An optimization problem is formulated to minimize RIS energy consumption and maximize bits transmission, considering energy harvesting and device-to-device (D2D) communications. Iterative algorithms are employed to solve the problem, showcasing significant performance enhancements compared to benchmark models. The focus is on efficiently controlling the programmable passive and active elements of RISs. The proposed solution introduces the concept of "Module," where each module consists of an optimal number of active or passive elements controlled by a microcontroller. An optimization problem is formulated to minimize RIS energy consumption while satisfying energy harvesting and information causality constraints. Iterative algorithms solve the non-convex problem, leading to substantial performance improvements in IoT systems. We present a paradigm-shifting innovation called the RIS dynamic element, which transitions between active and passive modes to adapt to incoming signals' strength. The dynamic element is integrated into mobile edge computing IoT systems to maintain a desired SNR value. A non-convex maximization problem is formulated and solved using an iterative algorithm, demonstrating the advantage of RIS dynamic element-assisted systems in enhancing computational capacity. We propose a novel approach using ASTAR-RISs to address resource allocation limitations and limited reflection space in ScNs. The optimization problem is formulated to maximize SNR and minimize power consumption, considering the ON/OFF status, phase shift, and power budget of ASTAR-RISs. Simulation results reveal significant performance improvements compared to traditional RIS schemes. This future work entails the distributed RIS-assisted blockage prediction for mobile UEs and the security challenges of RISs. For blockage prediction, the aim is to develop a distributed framework utilizing machine learning algorithms and the distributed nature of RIS to dynamically adjust the reflection and transmission properties of RIS elements. Regarding security challenges, the focus lies on covert communications, such as eavesdropping and injection of false information, potential malicious exploitation, RIS malfunctioning, lack of standardized security protocols, physical attacks, absence of authentication mechanisms, and timely security updates. Addressing these challenges will bolster the overall security of RIS-enabled communication systems.