DRL in IRS-assisted ISAC Systems: Applications and Current Trends

Mubasher Ahmed Khan and Yun Hee Kim
Dept. of Electronics and Information Convergence Engineering, Kyung Hee University
{mubasher, yheekim}@khu.ac.kr

Abstract

This paper aims to provide a survey on the applications of deep reinforcement learning (DRL) to improve performance in intelligent reflecting surface (IRS) aided integrated sensing and communication (ISAC) systems. This integration of IRS and ISAC increases the system optimization complexity so that DRL can provide promising solutions by resolving the complexity issues in these systems.

Ⅰ. Introduction

In recent years, integrated sensing and communication (ISAC) has gained significant attention as a key technique for beyond 5G communications by enabling the simultaneous execution of communication and sensing functions using a single transmitter [1]. Intelligent reflecting surface (IRS) is another promising technology that can help improve coverage without any significant increase in power consumption [2]. Integrating IRS into an ISAC system can improve the performance significantly but this also increases the complexity of the system. To tackle the increased complexity, deep reinforcement learning (DRL) is now being explored as an effective low complexity optimization method. This paper reviews the application and effectiveness of DRL for the above mentioned systems.

Ⅱ. DRL for IRS-assisted ISAC

In [3], the authors considered an IRS aided ISAC system for the THz band. The THz band can provide a higher transmission rate to keep up with but also suffers from increased attenuation due to obstacles. The addition of IRS mitigates the problem of significant path loss by establishing a favorable transmission environment. To achieve maximum system capacity, the study jointly optimizes the transmit beamforming and phase-shifts of the IRS. The authors consider a multi-user multiple-input single-output model comprising an M-antenna base station (BS) and K single-antenna users. For optimization a primal dual proximal policy optimization (PPO) algorithm is considered. The results obtained show that the primal-dual PPO algorithm outperforms the traditional zero forcing and maximum ratio transmit beamforming algorithms.

The study in [4] seeks to maximize the sum rate of the users by optimizing the sub-channel assignment and power allocation in a downlink multi-cell orthogonal frequency division multiple access (OFDMA) ISAC system. Each BS in the system has the capability using a single trasmitted signal for both user data and target detection. Sub-channel allocation is achieved through a dueling double Q network (DDQN), while power allocation is accomplished using the DDPG algorithm. Both networks are used in conjunction to achieve the maximum sum rate.

A STAR-IRS assisted ISAC secure system is considered in [5]. A multi-antenna BS is considered with a ULA, and STAR-IRS is divided into sensing and communication spaces. In the communication space a single Eve (eavesdropper) and legitimate user (LU) reside, and a single target in the sensing space. STAR-IRS is operated in energy splitting (ES) mode to simultaneously serve communication user and sensing target. To achieve maximum average long-term security rate for the learning user (LU) the system jointly optimizes receive and transmit beamforming of the BS, along with the transmission and reflection coffeicients of the STAR-IRS, while guranteeing a lower-bound on echo SNR and meeting the achievable rate constraints for the LU. Two DRL algorithms are used for optimization i.e., deep deterministic policy gradient (DDPG) and soft actor-critic (SAC) algorithm.

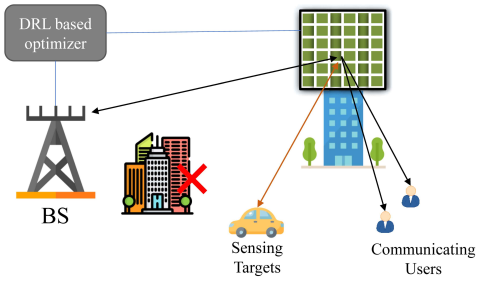

Fig. 1. IRS-assisted ISAC sytem

The authors in [6] considered the physical layer security of an IRS assisted ISAC system that serves multiple communication users and senses a radar target which is also the eavesdropper. Artificial noise (AN) is introduced at the BS to distort the eavesdropper signal. A downlink IRS assisted ISAC system with multi-antenna BS and single-antenna users, and a target is considered. The maximization of the achievable secrecy rate for all users is performed through optimizing the transmit beamforming, the AN signal and the phase-shift of IRS simultaneously using the SAC algorithm.

Ⅲ. Conclusion

This survey outlines several application in which DRL can help enhance the performance of IRS-assisted ISAC systems. While significant progress has been made to address the challenges associated with these systems, ongoing innovation and research are crucial to fully realize their potential. Continued efforts in research and collaboration are essential to solidify the place of IRS-based ISAC systems in future of wireless communication networks.

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