Dynamic Dual Reconfigurable Intelligent Surfaces for Integrated Sensing and Communication

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Abstract

This study proposes the optimization of base station (BS) antenna beamforming to the dynamic dual reconfigurable intelligent surfaces (DDRIS)-assisted integrated sensing and communication (ISAC) in dense urban environment scenario. The transmit antenna in the BS and DDRIS can be utilized to increase the performance of both sensing and communication part of the system. In this study, the main consideration is the user equipment (UE) rate. From the simulation results, it can be seen that the proposed system offers higher UE rate than the conventional static dual RIS without the optimization.

Ⅰ. Introduction

Since it enables unified waveforms to perform communication and radar sensing tasks simultaneously, integrated sensing and communication (ISAC) has evolved into a modernization of the earlier separate sensing and communication system [1]. ISAC is regarded as a supporting technology for next-generation wireless networks, which can be used in automotive networks, smart homes and factories, and other applications that require both high-accuracy sensing and high-quality wireless communications. Researchers from academia and business have studied ISAC extensively up to this point, both theoretically and practically [2].

One of the most impressive innovations for the sixth generation (6G) is the reconfigurable intelligent surface (RIS), a low-cost, low-power device composed of passive reflecting components that may alter channel realization to increase signal quality [3]. RIS is appropriate for dense urban environments because it may be affixed to building facades, interior space ceilings, etc. Dual RISs (DRIS) are used in [4] to improve spectral efficiency in a difficult ISAC system with significant pilot overhead. They use the single RIS in [5] to connect with consumers and identify targets while simultaneously optimizing the sensing SNR. Furthermore, several RISs are simultaneously used to enhance the communication performance in ISAC system [6]

However, the previous work did not utilize dynamic dual RIS to enhance the radar SNR of the ISAC system. In this study, we try to enhance the previous existing works by optimizing the transmit beamforming of the BS antenna to enhance the performance matrix of in a ISAC with dynamic DRIS (DDRIS) system.

Ⅱ. System Models

Our proposed system in Fig. 1 depicts that the transmitter sends the downlink signals to the RIS. After being modified in RIS, the phase shift signals are reflected to the receiver. The communication beamforming matrix and symbol are denoted by $\mathbf{W}_c$ and $\mathbf{s}_c$, respectively, and the transmitted signal from the BS is represented as

$$\mathbf{x} = \mathbf{W}_c\,\mathbf{s}_c + \mathbf{W}_r \boldsymbol{s}_r, \qquad (1),$$

and radar beamforming matrix and symbol vector are indicated by $\mathbf{W}_r$ and $\mathbf{s}_r$, respectively. The overall beamforming matrix is defined by $\mathbf{W} = [\mathbf{W}_c\,\mathbf{W}_r]$.

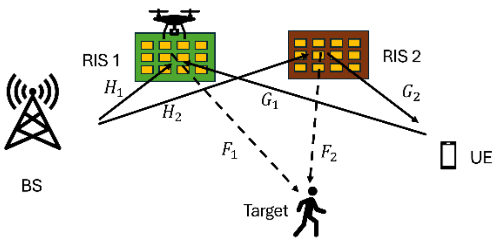

Figure 1. System model of the DDRIS-ISAC .

H_t is the radar channel matrix and can be expressed more detail as below

$$H_t = H_1\varphi_1F_1 + H_2\varphi_2F_2$$

where $H_i, \varphi_{i,}$ and F_i the channel from BS to the i-th RIS, reflection matrix of the i -th RIS, and channel from the i -th RIS to the user, respectively. The doppler correlation for the dynamic RIS using the 0-th order Bessel function of the can be written as $\rho = J_0(2\pi f_d T_s)$, where f_d is the doppler frequency and T_s is the time step.

III. Optimal Beamforming Matrix

In this study, the majorization-minimization algorithm is used, with the objective function can be expressed as follows

$$\max_{\mathbf{W}} \ (1+\Gamma_c^{-1})\mathbf{h}_c^T\mathbf{w}_c\mathbf{w}_c^H\mathbf{h}_c^*$$
$$\text{s.t.} \ \ \|\mathbf{W}\|_F^2 \le P$$

where Γ_c is the communication SINR. this problem is a non-convex quadratically constrained quadratic programming (QCQP) problem that can be solved using semi-definite relaxation (SDR) strategy.

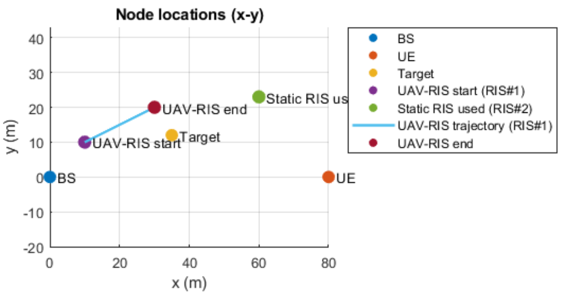

Figure 2. Node Locations of DDRIS-ISAC.

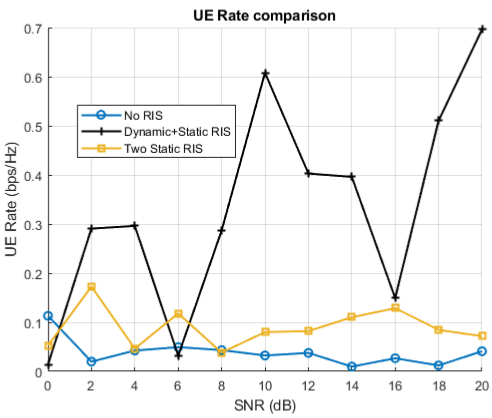

Figure 3. UE Rate of DDRIS-ISAC.

In Fig. 2, the comparison of DDRIS-ISAC which BS beamforming matrix is shown and compared to the conventional system that does not consider the beamforming optimization. The optimization using SDR can leverage the radar SNR value. In Fig. 3, the UE rate of 2 RIS with 1 dynamic and 1 static RIS outperforms other scheme.

IV. Conclusion

In this study, the comparison of DDRIS-ISAC with the conventional DRIS is shown. Because the RIS can change the location, if placed in the suitable location it can outperform other schemes.

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