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Joint RHS and RIS-Aided Sensing and Communications

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Reconfigurable Intelligent Surfaces (RISs) have recently emerged as a transformative technology for manipulating electromagnetic (EM) waves by dynamically altering surface boundary conditions. These ultra-thin surfaces are composed of sub-wavelength scattering elements, known as meta-atoms, which can be precisely engineered to shape incident EM waves into customized transmitted or reflected wavefronts. The rapid advancements in RIS technology have unlocked new possibilities in antenna design, wireless communications, and radar systems [1,2].

To overcome the challenges of non-line-of-sight (NLoS) sensing and communications, recent dual-function radar-communications (DFRC) systems have explored the use of RIS as passive reflectors [3]. However, in dense environments and at higher frequencies, severe propagation losses and attenuation hinder the effectiveness of RIS-aided DFRC systems, particularly for wideband processing. This limitation can be addressed by integrating a reconfigurable holographic surface (RHS) at the transceiver [4]. Unlike RIS, an RHS is an active metasurface with an embedded connected feed, enabling fine control over radiation amplitude. This feature is essential for compact, cost-effective wideband systems, where ultra-massive antenna arrays are required to counteract losses due to diffraction and attenuation.

We consider a wideband DFRC system where the transmitter is equipped with an RHS, and an RIS serves as a reflector in the wireless channel. Our approach jointly optimizes the receive filter, digital beamforming, holographic beamforming, and passive RIS beamforming to maximize the worst-case radar signal-to-interference-plus-noise ratio (SINR) while ensuring a minimum communications SINR across all users. We develop an alternating maximization framework to solve the resulting nonconvex problem. Numerical evaluations show that our proposed design outperforms conventional DFRC systems without RIS, as well as those with randomly configured RIS and RHS, in terms of radar performance.

References

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