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Cognitive Coded Metasurfaces for Radar and Communications

John A. Hodge [(1)], Kumar Vijay Mishra* [(2)], and Amir I. Zaghloul[(1)(2)]
(1) Virginia Tech, Falls Church, VA 22043, USA
(2) United States CCDC Army Research Laboratory (ARL), Adelphi, MD, 20783, USA

In recent years, metasurfaces (MTSs) have shown promising abilities to control and manipulate electromagnetic (EM) waves through modified surface boundary conditions. These surfaces are electrically thin and comprise an array of spatially-varying sub-wavelength scattering elements (or meta-atoms). Through careful engineering of each meta-atom, MTSs can transform an incident EM wave into an arbitrarily tailored transmitted or reflected wavefront. Recent developments in MTSs have opened exciting new opportunities in antenna design, as well as communications and radar systems [1].

In particular, cognitive coded MTSs (CC-MTSs) – wherein meta-atoms are embedded with active components – lead to the development of low-cost, lightweight, and compact systems that are capable of producing programmable radiation patterns, jointly perform multi-function communications, and enable advanced radars for next-generation military platforms. This talk will introduce the concept of CC-MTS and their various applications in designing simplified communications and radar systems, wherein the RF aperture and transceiver are integrated within the MTS. In particular cognitive operation enables dynamic reconfiguration of the MTS aperture in a wireless communications transmitter facilitates beam steering, frequency agility, and phase modulation without conventional front-end devices such as phase-shifters, mixers, and switches. In a synthetic aperture radar (SAR), MTSs have potential to achieve directive beams for traditional stripmap and spotlight SAR imaging modes using a low-cost compact aperture without mechanical gimbles or conventional phase-shifters.

Additionally, MTSs are able to generate diverse radiation patterns for innovative holographic computational imaging modes, such as diverse pattern stripmap SAR. Recent work on coding MTSs has shown reduction in broadband scattering radar cross-section. Further, space-time coding of MTS has potential to realize frequency translation to achieve Doppler spoofing of reflected radar signals. Other applications of MTSs that are currently under investigation include cognitive radar, multiple-input multiple-output (MIMO) imaging, adaptive beamforming, orbital angular momentum (OAM) beam generation, low-profile beam scanning, and polarization switching. Finally, we will present our recent work on CC-MTS control, MTS-enabled direct signal modulation, and deep learning-based MTS design.

References

[1] J. A. Hodge, K. V. Mishra, and A. I. Zaghloul, “Reconfigurable metasurfaces for index modulation in 5G wireless communications,” in IEEE International Applied Computational Electromagnetics Society Symposium, 2019, pp. 1–2.