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Designing Cognitive Coded Metasurfaces for Next-Generation Radar and Communications

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Reconfigurable metasurface (RMTS) has recently received significant attention in wireless communications as building blocks for smart radio environments (SRE) and adaptable wireless channels [1]. By altering the spatially and time varying electromagnetic (EM) properties of the suffer, RMTS transforms the inherently stochastic nature of the wireless environment into a programmable propagation channel. In particular, cognitive coded MTS (CC-MTS) – wherein meta-atoms are embedded with active components – lead to systems that produce programmable radiation patterns. perform multiple functions, and reduce the hardware complexity-size-weight-cost compared to conventional large arrays [2].

Despite the promise, physical implementations of CC-MTS are limited. The hardware realization of an CC-MTS comprises a two-dimensional array of subwavelength scattering elements, known as meta-atoms. The CC-MTS design is non-trivial and typically required an experienced engineering practitioner to perform hundreds or thousands of full-wave electromagnetic (EM) simulation iterations to optimize the design for specific performance requirements. Due to the challenges and inherit complexities of EM design, computational optimization techniques, such as genetic algorithms (GA), particle swarm optimization (PSO), and simulated annealing (SA), have been the focus of research for many years.

However, these stochastic optimization techniques are computational expensive and typically start from scratch with each new design. Recently, there is increased interest in using deep learning (DL) techniques [3] for modeling and design of metasurfaces following the rapid rise of artificial intelligence and machine learning across disciplines. In addition to predicting the EM response of a candidate CC-MTS particle design, there is also significant interest in using DL techniques to perform inverse design. In this manner, DL is used to intelligently discover or synthesize a meta-atom design from a specific response. Very recently, generative adversarial networks have been used to synthesize new MTS designs not previously seen in literature. This talk provides a synopsis of our research contributions, which apply deep learning-based techniques for tackling inverse design challenges in CC-MTS wireless networks.

References

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[3] J. A. Hodge, K. V. Mishra, and A. I. Zaghloul, "Deep inverse design of reconfigurable metasurfaces for future communications," arXiv preprint arXiv:2101.09131, 2021.