URSI GASS 2020, Rome, Italy, 29 August - 5 September 2020

Recent Advances in Radar and Communications Co-Design

Kumar Vijay Mishra
United States Army Research Laboratory, Adelphi, MD 20783 USA
E-mail: kumarvijay-mishra@uiowa.edu

Synergistic design of communications and radar systems with common spectral and hardware resources is heralding a new era of efficiently utilizing a limited radio-frequency (RF) spectrum. Such joint radar communications (JRC) model has advantages of low cost, compact size, less power consumption, spectrum sharing, improved performance, and safety due to enhanced information sharing [1]. In this talk, we present my research on two broad approaches for designing radar systems to address the spectral crowding problem.

In the "spectral coexistence" approach [2], we employ a novel approach to radar signal processing which allows the radar signal detection and parameter estimation using a much smaller number of measurements than required by Nyquist sampling. These systems exploit the fact that the target scene is sparse facilitating the use of recent advances in compressed sensing methods. In this segment, we introduce recent developments in reduced-rate sampling, present state-of-the-art hardware prototypes and examine extensions to diverse applications such as cognition, spectral coexistence, matrix completion, autonomous driving, ground penetration radar, multiple-input-multiple-output, and synthetic aperture radars.

In the spectral co-design approach [3], we focus on millimeter-wave JRC for autonomous vehicles where we address the major challenges of joint waveform design and performance criteria that would optimally trade-off between communications and radar functionalities. We propose a joint spectrum co-design for a statistical multiple-input-multiple-output (MIMO) radar and a full-duplex (FD) multi-user MIMO (MU-MIMO) communications system in the presence of a moving target. The proposed scheme exploits the connection between the achievable rate and the weighted minimum mean square error (WMMSE) thereby enabling us to at once co-design the waveform matrix of the MIMO radar, the precoders of the FD MU-MIMO and the linear receive filters of the two systems, subjected to power and quality of service (QoS) constraints. Numerical experiments show that our proposed WMMSE-based method achieves monotonic convergence within finite steps and the performances of both radar and communications functions are guaranteed due to the co-design approach [4]. We conclude the talk by connecting some of these works with deep learning approaches. In particular, we discuss the antenna selection and hybrid beamforming in the context of radar and communications.

References

[1] K. V. Mishra, M. R. Bhavani Shankar, V. Koivunen, B. Ottersten and S. A. Vorobyov, “Toward millimeter wave joint radar-communications: A signal processing perspective,” *IEEE Signal Processing Magazine*, vol. **36**, 5, 2019, pp. 100-114.
[2] D. Cohen, K. V. Mishra and Yonina C. Eldar, “Spectrum sharing radar: Coexistence via Xampling,” *IEEE Transactions on Aerospace and Electronic Systems*, vol. 54, **3**, 2018, pp. 1279-1296.
[3] S. H. Dokhanchi, M. R. Bhavani Shankar, K. V. Mishra and B. Ottersten, “A mmWave automotive joint radar-communications system,” *IEEE Transactions on Aerospace and Electronic Systems*, vol. 55, **3**, 2019, pp. 1241-1260.
[4] G. Duggal, S. Vishwakarma, K. V. Mishra and S. S. Ram, “Doppler-resilient 802.11ad-based ultra-short range automotive radar,” *IEEE Transactions on Aerospace and Electronic Systems*, 2019, to appear.