Abstract of Ph.D. thesis titled

Waveform Design and Parameter Estimation Techniques for OFDM-based Joint Radar-Communication Systems

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In this thesis, waveform design and parameter estimation techniques are developed for orthogonal frequency-division multiplexing (OFDM)-based joint radar-communication (JRC) systems. OFDM is a multicarrier modulation technique in which information symbols are transmitted over multiple orthogonal subcarriers, making it suitable for both communication and sensing. In this thesis, we address the design of transmit- and receive-side signal processing techniques for monostatic OFDM-based JRC systems to improve the radar sensing performance while maintaining reliable communication data transmission.

On the transmitter side, the thesis considers three waveform-design problems for OFDM-based JRC systems using reserved subcarriers. In all three problems, the data symbols on the communication subcarriers remain fixed, while the magnitude and phase of the reserved subcarriers are optimized to enhance the transmit waveform characteristics. The first problem considers peak-to-average power ratio (PAPR) minimization for quadrature amplitude modulation orthogonal frequency-division multiplexing (QAM-OFDM)-based JRC waveforms to reduce distortion caused by the nonlinear nature of the power amplifier used in the transmitter. The resulting problem is fractional and nonconvex and is solved using Dinkelbach's approach combined with the majorization-minimization (MM) principle. Although the proposed approach achieves effective PAPR reduction, its computational complexity limits its suitability for real-time implementation. Motivated by this, the second problem considers low-complexity PAPR minimization, in which the PAPR minimization approach is improved and made suitable for real-time implementation. Since radar sensing performance is determined by the ambiguity-function sidelobes of the transmitted waveform, in the third problem, we consider the joint minimization of the ambiguity-function sidelobes and PAPR for the QAM-OFDM-based JRC system, which results in a transmitted waveform with lower delay-Doppler sidelobes and PAPR.

On the receiver side, we addressed the problem of Doppler spectral estimation under nonuniform frame transmission in OFDM-based JRC systems. In packet-based OFDM systems, such as Wi-Fi, frame transmission can become nonuniform due to factors including medium access, traffic scheduling, and channel conditions, producing nonuniform slow-time samples. This violates the uniform-sampling assumption used by conventional FFT-based Doppler processing and degrades range-Doppler estimation. To address this problem, the received OFDM data are first transformed into the range domain, and a maximum-likelihood Doppler spectral estimation problem is formulated using the actual frame time instances. The resulting nonconvex problem is solved using the MM principle, leading to efficient iterative closed-form updates for Doppler spectrum estimation.

Overall, the contributions from this thesis provide signal-processing and optimization algorithms for practical OFDM-based JRC systems. The proposed methods improve transmit waveform design, reduce implementation complexity, and enhance Doppler spectral estimation under realistic nonuniform OFDM frame transmission.