Guest Editorial Special Issue on Integrated Sensing and Communication—Part II

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I. On the Special Issue

THIS is Part II of the double-part Special Issue (SI) on Integrated Sensing and Communication (ISAC). This SI aims at bringing together contributions from both academia and industry to highlight the recent progress of ISAC, where sensing and communication (S&C) functionalities are jointly designed to utilize wireless/hardware resources efficiently and to assist each other for mutual benefits. The 32 accepted articles of this SI are arranged into six groups, namely, 1) Fundamental Performance Bounds and Optimization, 2) Time-Frequency Signal Processing, 3) Spatial Signal Processing, 4) Networking and Resource Allocation, 5) ISAC With Emerging Communications Technologies, and 6) ISAC Applications. We kindly refer readers to Part I of this SI for a comprehensive overview written by the Guest Editorial Team, which provides both a bird's eye view and technical details regarding state-of-the-art ISAC innovations. The contributions made by the papers in Part II are summarized as follows, which correspond to paper groups 4), 5), and 6).

II. Networking and Resource Allocation

In [A1], Wang *et al.* investigate the fundamental limits of reconfigurable intelligent surface (RIS)-aided ISAC systems, specifically, RIS-aided wireless communication and localization networks. A general signal model for RIS-aided communication and localization valid for both near- and far-field scenarios is established, followed by an analysis on the theoretical limits for both communication and localization, in terms of the spectral efficiency and Cramér–Rao Bound (CRB).

In [A2], Wu *et al.* study a distributed system comprising heterogeneous radars and multi-tier communication systems, where a resource allocation design in the context of multi-target tracking (MTT) is proposed to simultaneously allocate available power, dwell time, and shared bandwidth within the network, such that the Bayesian CRB is improved with guaranteed quality-of-service (QoS) for communication systems.

In [A3], Pucci *et al.* provide a system-level analysis and simulation for ISAC based on multi-input multi-output (MIMO) 5G new radio (NR) networks, where a base station (BS) acts as a monostatic radar, estimating the range, speed, and direction of arrival (DoA) of multiple targets through beam scanning. An in-depth investigation of the dominant factors that affect the system performance is finally given.

III. ISAC With Emerging Communications Technologies

In [A4], Liu *et al.* propose a RIS-aided ISAC system operating in the terahertz (THz) band. In particular, ISAC transmit beamforming and phase-shift designs are formulated into a universal optimization problem with ergodic constraints. This problem is solved via a gradient-based primal-dual proximal policy optimization (PPO) algorithm for a multi-user multiple-input single-output (MU-MISO) scenario, which is then extended to the MU-MIMO case using a distributed PPO framework.

In [A5], by Shao *et al.* study the application of RIS for sensing and localizing targets in wireless networks, where a multiple signal classification (MUSIC) algorithm was applied to estimate the DoA of the target in the RIS's vicinity with high accuracy, without the involvement of either the BS or any mobile device. The passive reflection matrix is designed for maximizing the total average received signal power at the RIS sensors, which leads to the minimum mean squared error (MSE).

In [A6], Ding *et al.* develop an integrated communication, radar sensing, and mobile-edge computing (CRMEC) architecture, where user terminals (UTs) perform radar sensing and computation offloading simultaneously at the same spectrum using MIMO arrays and ISAC techniques. A multi-objective optimization problem is formulated to optimize both the performance of multi-UT MIMO radar beampattern design and the computation offloading energy consumption.

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In [A7], Chang *et al.* propose a new integrated scheduling method for sensing, communication, and control in millimeter-wave (mmWave)/THz UAV networks connected with cellular. This scheme enables efficient data transmission of the backhaul from UAV to the ground BS, as well as robust motion control performance.

In [A8], Zhang *et al.* address the challenge of ISAC design for holographic beamforming with a unique amplitude-controlled structure based on a well-designed iterative algorithm. Moreover, a lower bound for the maximum beampattern gain is provided through theoretical analysis, which reveals the potential performance gain that is obtained by densely deploying several elements in a metamaterial antenna.

In [A9], He *et al.* propose a double-RIS-assisted radar-communication coexisting system, with two RISs equipped near the transmitter and receiver, respectively. The communication signal-to-interference-plus-noise ratio (SINR) is maximized by properly designing the active and passive beamforming matrices, under the radar detection constraints.

IV. ISAC Applications

In [A10], Cheng *et al.* develop a hybrid simultaneous localization and mapping (SLAM) mechanism that combines active and passive sensing, in which mutual enhancement between two sensing modes is realized in communication systems. A common feature associated with the reflective surface is established to bridge active and passive sensing, based on which physical anchor initialization is attained through multipath component (MPC) with the assistance of active sensing. Finally, the classical probability data association SLAM approach is extended to enhance the SLAM performance.

In [A11], Niu *et al.* rigorously analyze the effects of target location and heading on velocity estimation errors for WiFi sensing. In particular, a dynamic receiver selection scheme is proposed to achieve accurate velocity estimation in non-contact sensing systems utilizing existing WiFi infrastructures, followed by a theoretical derivation and experimental verification of a closed-form solution for velocity estimation.

In [A12], Ge *et al.* propose a novel low-complexity SLAM filter, based on the Poisson multi-Bernoulli mixture (PMBM) approach. It utilizes the extended Kalman (EK) first-order Taylor series-based Gaussian approximation of the filtering distribution and applies the track-oriented marginal multi-Bernoulli/Poisson (TOMB/P) algorithm to approximate the resulting PMBM as a Poisson multi-Bernoulli (PMB). The proposed method is proven to be able to account for different landmark types in radio SLAM and multiple data association hypotheses.

In [A13], Zhang *et al.* develop a system named WiGesID based on WiFi sensing, which realizes joint gesture recognition and human identification (JGRHI). The basic idea is to identify personalized spatiotemporal dynamic patterns from the gestures of different users. Moreover, an effective approach is proposed to recognize new categories of gestures and users by computing relation scores between the features of the new category samples and the support samples.

In [A14], Zhang *et al.* design a cooperation algorithm for raw sensory data sharing in the context of mmWave-enabled connected automated vehicles, based on a time-division ISAC (TD-ISAC) framework. A closed-form solution to the vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) cooperative communication mode selection is theoretically achieved based on the response delay analysis to guarantee the timeliness of raw sensing data sharing. The age of information-based system status update algorithm is proposed for the V2V/V2I collaborative communication mode.

In [A15], Kong *et al.* design and implement WheelLoc, a novel WiFi-based localization system leveraging the rotation of wheels, with specifically designed cost-effective and self-powered WheelLoc hardware with the composition of three commercial antennas and a solar cell, which is also easy to be installed on wheels. A hybrid WheelLoc algorithm is further proposed to realize accurate localization in diverse environments, whether the wheel of targets is static or mobile, indoor or outdoor, on flat or bumpy ground.

In [A16], Gao *et al.* develop a data generation method named multilevel feature synthesis method (multilevel-FSM) to obtain positioning features based on data collected using standard-compatible signals, namely, the 3GPP Rel 16 standards. Subsequently, a deep-learning-based positioning method, multipath res-inception (MPRI), is designed, which is then trained on the proposed dataset to enhance positioning accuracy.

Acknowledgment

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Appendix: Related Articles

[A1] Z. Wang, Z. Liu, Y. Shen, A. Conti, and M. Z. Win, "Location awareness in beyond 5G networks via reconfigurable intelligent surfaces," *IEEE J. Sel. Areas Commun.*, early access, Mar. 8, 2022, doi: 10.1109/JSAC.2022.3155542.

[A2] L. Wu, K. V. Mishra, M. R. B. Shankar, and B. Ottersten, "Resource allocation in heterogeneously-distributed joint radar-communications under asynchronous Bayesian tracking framework," *IEEE J. Sel. Areas Commun.*, early access, Mar. 8, 2022, doi: 10.1109/JSAC.2022.3157371.

[A3] L. Pucci, E. Paolini, and A. Giorgetti, "System-level analysis of joint sensing and communication based on 5G new radio," *IEEE J. Sel. Areas Commun.*, early access, Mar. 2, 2022, doi: 10.1109/JSAC.2022.3155522.

[A4] X. Liu, H. Zhang, K. Long, M. Zhou, Y. Li, and H. V. Poor, "Proximal policy optimization-based transmit beamforming and phase-shift design in an IRS-aided ISAC system for the THz band," *IEEE J. Sel. Areas Commun.*, early access, Mar. 11, doi: 10.1109/JSAC.2022.3158696.

[A5] X. Shao, C. You, W. Ma, X. Chen, and R. Zhang, "Target sensing with intelligent reflecting surface: Architecture and performance," *IEEE J. Sel. Areas Commun.*, early access, Mar. 2, 2022, doi: 10.1109/JSAC.2022.3155546.

[A6] C. Ding, J.-B. Wang, H. Zhang, M. Lin, and G. Y. Li, "Joint MIMO precoding and computation resource allocation for dual-function radar and communication systems with mobile edge computing," *IEEE J. Sel. Areas Commun.*, early access, Mar. 8, 2022, doi: 10.1109/JSAC.2022.3157389.

[A7] B. Chang, W. Tang, X. Yan, X. Tong, and Z. Chen, "Integrated scheduling of sensing, communication, and control for mmWave/THz communications in cellular connected UAV networks," *IEEE J. Sel. Areas Commun.*, early access, Mar. 8, 2022, doi: 10.1109/JSAC.2022.3157366.

[A8] H. Zhang *et al.*, "Holographic integrated sensing and communication," *IEEE J. Sel. Areas Commun.*, early access, Mar. 2, 2022, doi: 10.1109/JSAC.2022.3155548.

[A9] Y. He, Y. Cai, H. Mao, and G. Yu, "RIS-assisted communication radar coexistence: Joint beamforming design and analysis," *IEEE J. Sel. Areas Commun.*, early access, Mar. 8, 2022, doi: 10.1109/JSAC.2022.3155507.

[A10] J. Yang, C.-K. Wen, and S. Jin, "Hybrid active and passive sensing for SLAM in wireless communication systems," *IEEE J. Sel. Areas Commun.*, early access, Mar. 3, 2022, doi: 10.1109/JSAC.2022.3156630.

[A11] K. Niu, X. Wang, F. Zhang, R. Zheng, Z. Yao, and D. Zhang, "Rethinking Doppler effect for accurate velocity estimation with commodity WiFi devices," *IEEE J. Sel. Areas Commun.*, early access, Mar. 9, 2022, doi: 10.1109/JSAC.2022.3155523.

[A12] Y. Ge *et al.*, "A computationally efficient EK-PMBM filter for bistatic mmWave radio SLAM," *IEEE J. Sel. Areas Commun.*, early access, Mar. 2, 2022, doi: 10.1109/JSAC.2022.3155504.

[A13] R. Zhang, C. Jiang, S. Wu, Q. Zhou, X. Jing, and J. Mu, "Wi-Fi sensing for joint gesture recognition and human identification from few samples in human-computer interaction," *IEEE J. Sel. Areas Commun.*, early access, Mar. 2, 2022, doi: 10.1109/JSAC.2022.3155526.

[A14] Q. Zhang, H. Sun, X. Gao, X. Wang, and Z. Feng, "Time-division ISAC enabled connected automated vehicles cooperation algorithm design and performance evaluation," *IEEE J. Sel. Areas Commun.*, early access, Mar. 4, 2022, doi: 10.1109/JSAC.2022.3155506.

[A15] L. Kong, Y. Liu, Y. Liu, L. Zheng, M. Qiu, and G. Chen, "WheelLoc: Practical and accurate localization for wheeled mobile targets via integrated sensing and communication," *IEEE J. Sel. Areas Commun.*, early access, Mar. 2, 2022, doi: 10.1109/JSAC.2022.3155530.

[A16] K. Gao, H. Wang, H. Lv, and W. Liu, "Towards 5G NR high-precision indoor positioning via channel frequency response: A new paradigm and dataset generation method," *IEEE J. Sel. Areas Commun.*, early access, Mar. 8, 2022, doi: 10.1109/JSAC.2022.3157397.

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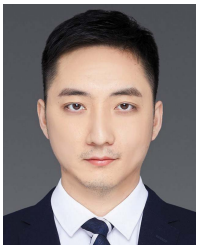

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