Guest Editorial Special Issue on Integrated Sensing and Communications for Future Green Networks

I. Summary of This Special Issue

WITH the recent advances of wireless communications and signal processing techniques, the capability of wireless sensing would be integrated with communications, which benefits from dedicated communications and sensing hardware and enables new waveform design, transmission strategies, and resource allocation. In particular, a radio emission could simultaneously be used for conveying communication data as well as extracting environmental information from the scattered echoes. It is expected that this emerging paradigm can significantly improve the energy and hardware efficiencies of next generation cellular network and can enable a greener network. In practice, the integration may happen on different levels, via the same hardware architecture, the same spectrum resources, or via a unified signal processing framework such that different kinds of resource efficiency are achieved. This type of research is normally referred to as Integrated Sensing and Communications (ISAC).

Compared to current separate communication and radar systems, the reduction of cost and power consumption by adopting an integrated device has shown the 'green' nature of ISAC. We highlight that ISAC would bring considerable benefits in terms of spectral, energy, hardware, and cost efficiencies, which trigger a paradigm shift paving the way for the development of green networks. As a key enabler for the future green networks, various research problems related to ISAC need to be addressed that cover a wide range of disciplines, including resource optimization, green network architecture, waveform design, transceiver protocol, etc. The main objective of this special issue is to exploit the new opportunities and address the unique challenges of ISAC design for enabling green communications and networking by bringing this promising vision closer to reality. We have received 41 high-quality submissions in total. After a rigirous review process, only 16 papers were accepted for publication in this special issue.

II. Overview of the Accepted Papers

In [A1], Valiulahi et al. consider the mutual interference in the coexistence of sensing and communication functions. The ratio of the total transmitting data rate and the total power consumption is regarded as the optimization objection for energy-efficient interference cancellation.

In [A2], Mu et al. propose beamforming designs for net zero energy multi-input multi-output (MIMO) dual-functional radar-communication (DFRC) systems. An iterative algorithm is developed to obtain the beamforming matrices for the reference scenario when full channel state information (CSI) and energy arrival information (EAI) are available.

In [A3], Zhao et al. leverages the reference signal (RS) in 5G vehicle-to-everything (V2X) communications for radar sensing, which is designed under the constraints of radar sensing ambiguity functions. The RS spacing and power allocation for RS and each data subcarrier are further jointly optimized to minimize the transmission power, while satisfying the requirements ISAC.

In [A4], Qi et al. consider the Wi-Fi sensing problem with indoor sensing privacy and ubiquitous sensing ability concerns based on federated transfer learning framework. The proposed framework is implemented with Widar3.0 datasets for experiment conduction and performance evaluation.

In [A5], Wei et al. consider both ISAC signal design and signal processing. The phase coding is applied to ISAC signal to enhance the performance of anti-noise. An iterative ISAC signal processing method is proposed to improve the sensing accuracy with low computational complexity.

In [A6], Liu et al. propose a joint computation offloading and resource allocation strategy to unleash the potential of ISAC for building greener V2X networks. Several advanced optimization schemes are adopted to obtain the optimal computation offloading and resource allocation decision, achieving the energy efficiency target.

In [A7], Huang et al. propose a lightweight and efficient three-stage stereo disparity prediction network named HRSNet for real-time stereo matching on energy-efficient edge devices with limited resource, reducing energy consumption and requirement on high-performance computing resources.

In [A8], Zou et al. focuses on the beamforming algorithm for UAV-to-vehicle communications. To address the high-mobility of vehicles and UAV, a vision-assisted beamforming framework is developed, which detects and tracks the vehicles using deep learning networks.

In [A9], Wang et al. propose an environmental awareness ISAC network association architecture considering both the reward and cost of nodes' sensing range and transmission strategy. Graph theory is used to reduce the complexity of the resource allocation for the proposed architecture.

In [A10], Zhang et al. propose to accelerate edge intelligence via ISAC, where the sensing and communication stages are merged for the dual purpose of dataset generation and uploading. The ISAC acceleration gain over the conventional edge intelligence system is further analyzed.

In [A11], Zhong et al. study the energy efficiency maximization problem in an IRS-assisted DFRC system. Both the perfect CSI and the imperfect CSI cases are considered. In particular, the S-Procedure is applied to tackle the semi-infinite inequality in the imperfect CSI case.

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In [A12], Du et al. optimize the transmit waveform for MIMO-DFRC system. The multi-fold tradeoffs between communication and radar sensing are chracterized by defining an achievable performance region and the optimal waveform is designed by solving a fairness profile optimization problem.

In [A13], Wang et al. propose a quality-of-service (QoS)-oriented sensing-communication-control (SCC) co-design scheme for UAV-enabled positioning systems. The influence of sensing scheduling, transmission failure on the stability of UAV, and performance of positioning services is analyzed.

In [A14], Zhao et al. builds a novel UAV-aided integrated platooning vehicular network for energy consumption minimization-based resource management. The solution consists of dynamic parameter server selection and federated resource management.

In [A15], Ashraf et al. study the beamforming design that maximizes the radar received signal-to-clutter-plus-noise-ratio and satisfies the minimum data rate requirements of the individual users. Efficient algorithms are developed to overcome the non-convex problem.

In [A16], Dong et al. propose sophisticated beamforming designs for multi-user DFRC systems by additionally taking the physical layer security (PLS) into account. An optimization problem is formulated for striking a compelling trade- off amongst the conflicting design objectives.

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APPENDIX: RELATED ARTICLES

[A1] I. Valiulahi, C. Masouros, and A. Salem, "Net-zero energy dual-functional radar-communication systems," *IEEE Trans. Green Commun. Netw.*, vol. 7, no. 1, pp. 356–369, Mar. 2023.

[A2] J. Mu, W. Ouyang, Z. Jing, B. Li, and F. Zhang, "Energy-efficient interference cancellation in integrated sensing and communication," *IEEE Trans. Green Commun. Netw.*, vol. 7, no. 1, pp. 370–378, Mar. 2023.

[A3] Q. Zhao, A. Tang, and X. Wang, "Reference signal design and power optimization for energy-efficient 5G V2X integrated sensing and communications," *IEEE Trans. Green Commun. Netw.*, vol. 7, no. 1, pp. 379–392, Mar. 2023.

[A4] W. Qi, R. Zhang, J. Zhou, H. Zhang, Y. Xie, and X. Jing, "A resource-efficient cross-domain sensing method for device-free gesture recognition with adaptive federated transfer learning," *IEEE Trans. Green Commun. Netw.*, vol. 7, no. 1, pp. 393–400, Mar. 2023.

[A5] Z. Wei, H. Qu, W. Jiang, K. Han, H. Wu, and Z. Feng, "Iterative signal processing for integrated sensing and communication systems," *IEEE Trans. Green Commun. Netw.*, vol. 7, no. 1, pp. 401–412, Mar. 2023.

[A6] Q. Liu, R. Luo, H. Liang, and Q. Liu, "Energy-efficient joint computation offloading and resource allocation strategy for ISAC-aided 6G V2X networks," *IEEE Trans. Green Commun. Netw.*, vol. 7, no. 1, pp. 413–423, Mar. 2023.

[A7] J. Huang, B. Liang, C. Liu, W. Wei, W. Shang, and J. Li, "Real-time stereo disparity prediction based on patch-embedded extraction and depthwise hierarchical refinement for 3D sensing of autonomous vehicles on energy-efficient edge computing devices," *IEEE Trans. Green Commun. Netw.*, vol. 7, no. 1, pp. 424–433, Mar. 2023.

[A8] J. Zou, Y. Liu, C. Wang, Z. Zou, and S. Sun, "Vision-assisted 3-D predictive beamforming for green UAV-to-vehicle communications," *IEEE Trans. Green Commun. Netw.*, vol. 7, no. 1, pp. 434–443, Mar. 2023.

[A9] J. Wang, L. Bai, J. Chen, and J. Wang, "Starling flocks inspired resource allocation for ISAC aided green ad hoc networks," *IEEE Trans. Green Commun. Netw.*, vol. 7, no. 1, pp. 444–454, Mar. 2023.

[A10] T. Zhang, G. Li, S. Wang, G. Zhu, G. Chen, and R. Wang, "ISAC-accelerated edge intelligence: Framework, optimization, and analysis," *IEEE Trans. Green Commun. Netw.*, vol. 7, no. 1, pp. 455–468, Mar. 2023.

[A11] W. Zhong, Z. Yu, Y. Wu, F. Zhou, Q. Wu, and N. Al-Dhahir, "Resource allocation for an IRS-assisted dual-functional radar and communication system: Energy efficiency maximization," *IEEE Trans. Green Commun. Netw.*, vol. 7, no. 1, pp. 469–482, Mar. 2023.

[A12] Y. Du, Y. Liu, K. Han, J. Jiang, W. Wang, and L. Chen, "Multi-user and multi-target dual-function radar-communication waveform design: Multi-fold performance tradeoffs," *IEEE Trans. Green Commun. Netw.*, vol. 7, no. 1, pp. 483–496, Mar. 2023.

[A13] Z. Wang, R. Liu, Q. Liu, L. Han, Y. Wu, and J. S. Thompson, "QoS-oriented sensing-communication-control co-design for UAV-enabled positioning," *IEEE Trans. Green Commun. Netw.*, vol. 7, no. 1, pp. 497–511, Mar. 2023.

[A14] J. Zhao, Y. Nie, H. Zhang, and F. R. Yu, "A UAV-aided vehicular integrated platooning network for heterogeneous resource management," *IEEE Trans. Green Commun. Netw.*, vol. 7, no. 1, pp. 512–521, Mar. 2023.

[A15] M. Ashraf, B. Tan, D. Moltchanov, J. S. Thompson, and M. Valkama, "Joint optimization of radar and communications performance in 6G cellular systems," *IEEE Trans. Green Commun. Netw.*, vol. 7, no. 1, pp. 522–536, Mar. 2023.

[A16] F. Dong, W. Wang, X. Li, F. Liu, S. Chen, and L. Hanzo, "Joint beamforming design for dual-functional MIMO radar and communication systems guaranteeing physical layer security," *IEEE Trans. Green Commun. Netw.*, vol. 7, no. 1, pp. 537–549, Mar. 2023.

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