Guest Editorial >>>

Special Topic on Near-Field Communication and Sensing Towards 6G

Guest Editors

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6G wireless technologies involve dense device deployment, utilize large-scale antenna arrays, and operate in the millimeter-wave and terahertz bands. This will shift the challenges of communication and sensing from the far field to the radiative near field, where traditional models and algorithms may incur errors or even become obsolete due to mismatch. Therefore, there is an urgent need to discuss localization and communication issues in the near-field region. The near-field assumption allows us to capture more information in electromagnetic signals, unlocking new possibilities for improving communication quality and localization accuracy. It can be anticipated that research on the near-field will play an increasingly important role in 6G and future wireless networks.

In this special issue on near-field communication and sensing towards 6G, a series of articles are presented to summarize the opportunities and challenges of communication sensing in the near-field region and offer innovative solutions to some key issues. A comprehensive review of near-field communications for 6G is provided, and other research articles encompass a wide range of topics, including ambient Internet of Things (ambient IoT), channel estimation, degree of freedom (DoF) analysis, beam training, and Bessel beams. The call for papers for this special issue has attracted a series of high-quality submissions, indicating a high level of interest among researchers in the field of near-field region. After two rounds of rigorous review, the following six papers are presented in this special issue organized as follows.

DOI: 10.12142/ZTECOM.202401001
Citation: G. Wei, Y. J. Zhao, and L. Chen, "Editorial: near-field communication and sensing towards 6G," *ZTE Communications*, vol. 22, no. 1, pp. 1–2, Mar. 2024. doi: 10.12142/ZTECOM.202401001.

The first paper titled "Towards Near-Field Communications for 6G: Challenges and Opportunities" conducts a comprehensive survey on the challenges and opportunities in near-field communication. The key technologies in 6G mobile networks bring about a completely new near-field assumption. This review article formulates a general model for near-field channels and discusses the challenges in beam training, localization, and transmission scheme design within the near-field region. Finally, a series of promising research directions for near-field communication are proposed and summarized.

The second paper titled "Link Budget and Enhanced Communication Distance for Ambient Internet of Things" proposes a low-noise amplifier (LNA) module to increase the communication range of backscatter communication. Backscatter communication is a key technology for ambient IoT and plays a crucial role in connecting everything in B5G and 6G systems. By utilizing the LNA module before the envelope detection at the tag to enhance the strength of the incident signal, the downlink communication range is increased by nearly 20 m, which holds the potential to address the challenges of high losses and limited communication distance in backscatter communication.

The third paper titled "Impacts of Model Mismatch and Array Scale on Channel Estimation for XL-HRIS-Aided Systems" investigates the lower bound of the estimated parameters for the extremely large-scale hybrid reconfigurable intelligent surface (XL-HRIS) and discusses the impact of its near-field effects on estimation accuracy. XL-HRIS is an improved version of the reconfigurable intelligent surface (RIS), with the potential to further enhance communication performance. However, the increase in the size of RIS introduces near-field effects, where the phase variation of the signal becomes significant, and mismatched channel models may reduce the accuracy of the estimation. In this case, the paper meticulously studies the impact of the array scale, distance, and signal-to-noise ratio on the lower bound of parameter estimation for XL-HRIS in the near-field region.

The fourth paper titled "Degree of Freedom Analysis for Holographic MIMO Based on a Mutual-Coupling-Compliant Channel Model" utilizes a mutual-coupling-compliant circuit multiple-input multiple-output (MIMO) model to study the DoF of the holographic MIMO (HMIMO) channel. The DoF is a key indicator of the spatial multiplexing layers of a wireless channel. Recent studies indicate that in near-field communication, when considering strong mutual coupling, the effective DoF may be less than the number of antennas. This paper investigates the DoF in HMIMO systems, provides an upper bound on DOF under strong coupling conditions, and validates the results through numerical simulations.

The fifth paper titled "Near-Field Beam Training for Holographic MIMO Communications: Typical Methods, Challenges and Future Directions" conducts a comprehensive survey of near-field beam training methods in HMIMO systems. HMIMO is a promising technology in future wireless systems for achieving ultra-high frequency spectral efficiency and spatial resolution. Due to the increase in antenna aperture, the spherical wavefront effect in near-field communication becomes more pronounced in HMIMO systems, necessitating the use of new near-field beam training methods. The paper introduces, analyzes, and compares the performance of several typical near-field beam training methods, validating them on a hardware platform. Additionally, it addresses the challenges and outlines future research directions in near-field beam training.

The sixth paper titled "Near-Field Wireless Power Transfer, Sensing and Communication with Bessel Beams" conducts a comprehensive survey on the generation and application of Bessel beams in the near-field region. Bessel beams are a type of beam with limited propagation distance. Unlike traditional phased-array beamforming, Bessel beams exhibit unique non-diffracting characteristics, maintaining a stable beam intensity along the propagation direction without spreading. The paper introduces the concept and basic theory of Bessel beams, and categorizes and discusses research on their generation and applications, with particular emphasis on their application in near-field wireless power transfer and communication. Finally, the research challenges and opportunities associated with Bessel beams are discussed.

To conclude, it is hoped that this special issue serves as a solid foundation, helping researchers understand and address the upcoming near-field challenges in wireless networks. Additionally, we hope that this special issue sparks more research interest in near-field communication and sensing in 6G networks. Finally, we sincerely express our gratitude to all the authors and reviewers whose outstanding work contributes to the success of this special issue. We sincerely hope that the papers in this special issue provide both clarity and insight for all readers in the field.

Biographies

WEI Guo received his BS degree in electronic engineering from the University of Science and Technology of China (USTC) in 1983 and MS and PhD degrees in electronic engineering from the Chinese Academy of Sciences, China in 1986 and 1991, respectively. He is currently a professor with the School of Information Science and Technology, USTC. He has won the second prize of the National Science and Technology Progress Award and published more than 100 papers. He holds dozens of national invention patents. His current research interests include wireless and mobile communications, wireless multimedia communications, and wireless information networks.

ZHAO Yajun received his BE, MS, and PhD degrees. Since 2010, he has assumed the role of Chief Engineer at the Wireless and Computing Product R&D Institute, ZTE Corporation. Prior to this, he contributed to wireless technology research at the Wireless Research Department, Huawei. Currently, his primary focus centers on 5G standardization technology and the advancement of future mobile communication technology, particularly 6G. His research pursuits encompass a broad spectrum, including reconfigurable intelligent surfaces (RIS), spectrum sharing, flexible duplex, CoMP, and interference mitigation. He has played an instrumental role in founding the RIS Tech Alliance (RISTA) and currently holds the position of Deputy Secretary General within the organization. Additionally, he is a founding member of the RIS task group under the purview of the China IMT-2030 (6G) Promotion Group, where he serves as the deputy leader.

CHEN Li received his BE degree in electrical and information engineering from Harbin Institute of Technology, China in 2009 and PhD degree in electrical engineering from the University of Science and Technology of China (USTC) in 2014. He joined The University of Hong Kong, China as a postdoctor from 2016 to 2017. He is currently an associate professor with the Department of Electronic Engineering and Information Science, USTC. He has hosted a number of national projects and won the second prize of the Anhui Provincial Natural Science Award and the Anhui Provincial Outstanding Youth Fund. His research interests include integrated communication and computation and integrated communication and sensing.