Guest Editorial: Advances in AI-assisted radar sensing applications

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GUEST EDITORIAL

Advances in AI-assisted radar sensing applications

1 | INTRODUCTION

Recent developments in Artificial Intelligence (AI) and the accessibility of cost-effective radar hardware have transformed various sectors, including e-healthcare, smart cities, and critical infrastructures. AI holds immense potential for enhancing radar technology. However, there are significant challenges hindering its adoption in this domain. These challenges encompass **Radar Data Accessibility**, which involves limited access to radar data for training AI models due to low sample availability. **Data Labelling**, requiring domain-specific expertise, and **Data Preprocessing**, aimed at selecting the best radar data representation for AI applications, are complex and vital steps. Additionally, **integrating an AI framework into radar hardware**, whether using pre-trained or custom models, presents a major obstacle. This special issue focuses on research, articles, and experiments that bridge the gap between radar hardware and AI frameworks, addressing these critical challenges.

2 | PAPERS IN THE SPECIAL ISSUE

The special issue has garnered significant interest, with a total of 13 paper submissions. After rigorous peer review, nine papers that met high publication standards were accepted. These papers collectively address crucial challenges in AI-assisted radar technology, offering innovative ideas, insightful analyses, and experimental results that bridge the gap between radar hardware and AI frameworks. Most notably, these papers include real-world validation and demonstrate innovative system designs and processing solutions. They advance current knowledge and pave the way for future innovations in the field.

Among the featured papers, Zhou et al. focus on the application of millimetre-wave radar, specifically 4D TDM MIMO FMCW radar, for health monitoring and human activity recognition [1]. Their comprehensive simulation model achieves an impressive 90% average classification accuracy, offering valuable insights for radar configuration and activity testing. Zhenghui Li et al. introduce an innovative approach to radar-based human activity recognition across six domains, with adaptive thresholding and holistic optimisation, significantly improving classification accuracy [2]. Li et al. propose a groundbreaking voice identification method using Ultra-Wideband technology, leveraging micro-Doppler shifts during speech production to achieve close to 90% accuracy in healthcare applications [3].

Yu et al. explore radar-based human activity recognition for elderly care health monitoring, addressing noisy radar signals. They introduce wavelet denoising and the Double Phase Cascaded Denoising and Classification Network, improving accuracy and robust activity monitoring [4]. Xiong et al. tackle track-to-track association (T2TA) challenges by using homography estimation to address radar bias, enhancing association credibility and reducing manual labelling [5]. Perďoch et al. utilise a simple Neural Network (NN) for signal preprocessing, effectively reducing clutter and enhancing processing speed in radar systems [6].

Yang et al. discuss the use of millimetre-wave radar technology to alleviate traffic congestion, achieving a 20% reduction through radar sensors and advanced traffic state discrimination algorithms [7]. Rehman et al. contribute to millimetre-wave radar systems for marine autonomy by distinguishing maritime targets from sea clutter using experimental data from field trials [8]. Wu et al. develop a hybrid NN model for target recognition against reflector jamming, outperforming other methods in recognition performance and robustness [9].

These papers collectively advance the field of radar technology and signal processing, offering practical solutions to real-world challenges.

KEYWORDS

artificial intelligence, convolutional neural nets, radar signal processing, radar target recognition

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In this Special Issue of IET Radar, Sonar & Navigation, we extend our heartfelt gratitude and congratulations to the authors of the featured papers. Their submissions have significantly enriched this edition with their exceptional quality and innovative approaches. We are equally thankful to the diligent reviewers who played a pivotal role in the selection and enhancement of these articles. Their expertise and insights were invaluable in shaping the content of this issue. We believe that the research presented in this Special Issue will inspire and motivate continued exploration and innovation in this dynamic field, both in academic and industrial settings. Our appreciation also goes out to the Editor-in-Chief of IET Radar, Sonar & Navigation, and the entire editorial team. Their unwavering support and guidance have been instrumental throughout the entire editorial process.

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DATA AVAILABILITY STATEMENT

Data sharing not applicable.

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Shelly Vishwakarma received her PhD degree in electrical engineering from the Indraprastha Institute of Information Technology, Delhi, India, in January 2020. From February 2020 to July 2022, she worked as a Research Fellow on an EPSRC-funded project, OPERA Opportunistic Passive RADAR for Non-Cooperative Contextual Sensing, at University College London where she developed an animation data-driven human radio frequency (RF) scattering simulator, SimHumaLator, to generate realistic RADAR signatures associated with activities relevant to healthcare, including sitting and standing to fall over (https://uwsl.co.uk/). Since August 2022, she has joined as a Lecturer in Digital Health & Biomedical Engineering Group at the University of Southampton, UK. Her current research focuses on designing and developing hardware and software frameworks to advance state-of-the-art radar sensing that prioritise privacy and offer remarkable versatility across various fields including contextual sensing for home based healthcare, sign language recognition and translation. Dr Vishwakarma won the best student paper at the IEEE International Radar Conference 2020 and the radar challenge at the IEEE Radar Conference 2022 for her AI-assisted radar signal processing framework and hardware prototype. She has been a reviewer for a number of high-esteem journals including: IET Radar, Sonar and Navigation; IEEE Geoscience & Remote Sensing; and IEEE TAES.

Kevin Chetty is an Associate Professor at University College London. His research expertise lies in the field of radiofrequency (RF) sensing, and radar signal processing using machine learning. Major achievements in RF sensing include demonstrating the first detections of personnel targets using passive Wi-Fi radar and proving the ability of these systems to perform through-the-wall sensing at standoff distances. In the signal processing domain Kevin's work has focused on classifying people's actions based on their radar micro-Doppler signatures for applications in both security and e-healthcare. His work in this area also covers indoor mapping, target tracking, and high-throughput data processing. Kevin is author to over fifty peer reviewed publications and has been an investigator on grants in passive wireless sensing and FMCW radar for micro-Doppler target classification funded by EPSRC, EU Joint Research Centre, UK Ministry of Defence/Dstl and the UK Maritime & Coastguard Agency. He also sits on the Technical and Organising Committees for the International Security & Crime Science conference and is a member of the IEEE and IET, and reviewer for a number of high-esteem journals including: IET Radar, Sonar and Navigation; IEEE Geoscience & Remote Sensing; and IEEE Communications magazine.

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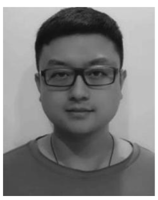

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Sevgi Zubeyde Gurbuz received the B. S. degree in electrical engineering with minor in mechanical engineering and the M.Eng. degree in electrical engineering and computer science from the Massachusetts Institute of Technology, Cambridge, MA, USA, in 1998 and 2000, respectively, and the Ph.D. degree in electrical and computer engineering from Georgia Institute of Technology, Atlanta, GA, USA, in 2009. She is currently an Assistant Professor in the University of Alabama at Tuscaloosa, Department of Electrical and Computer Engineering. Her current research interests include physics-aware machine learning, RF sensor-enabled cyber-physical systems, radar signal processing, sensor networks, human motion recognition for biomedical, automotive autonomy, and human-computer interaction (HCI) applications. Dr. Gurbuz's recent achievements include a patent for radar-based American Sign Language recognition (2022) and several prestigious awards like the 2022 American Association of University Women Research Publication Grant, the IEEE Harry Rowe Mimno Award (2019), the SPIE Rising Researcher Award (2020), an EU Marie Curie Fellowship, and the 2010 IEEE Radar Conference Best Student Paper Award. She contributes as a member of the IEEE Radar Systems Panel and Associate Editor for various IEEE and IET publications.

Wenda Li is currently an assistant professor of telecommunication at the Institute of Sensors, Signals and Systems, Heriot Watt University. He was a lecturer in the Department of Biomedical Engineering, School of Science and Engineering, University of Dundee between 2022 and 2023. He obtained his PhD at the University of Bristol in 2018 with research focused on remote sensing techniques. After that, he joined the University of Birmingham as a Research Fellow and moved to the University College London in 2019 also as a Research Fellow. His research focuses on the signal processing for passive radar and high-speed digital system design for wireless sensing applications in healthcare, security, and positioning. His research in passive WiFi radar has led to a number of IEEE conference and journal publications.

Shobha Sundar Ram received the B.Tech. degree in electronics and communications engineering from the University of Madras, Chennai, India, in 2004, and the M.S. and Ph.D. degrees in electrical engineering from the University of Texas at Austin, Austin, TX, USA, in 2006 and 2009, respectively.,She is currently an Associate Professor with the Department of Electronics and Communications Engineering, Indraprastha Institute of Information Technology Delhi (IIIT Delhi), New Delhi, India. Before joining IIIT Delhi, she was a Research and Development Electrical Engineer with Baker Hughes Inc., Houston, TX. Her research interests include radar signal processing and electromagnetic sensor design and modelling., Dr Ram was a recipient of student paper awards at IEEE Radar Conference in 2008 and 2009 and best paper awards for coauthored papers at 2016 International Workshop on Nonintrusive Load Monitoring, 2019 IEEE International Microwave and RF Conference, and 2020 IEEE Radar Conference. She is an Associate Editor for IEEE Transactions on Aerospace and Electronics Systems, a Member of IEEE Radar Systems Panel for IEEE Aerospace and Electronic Systems Society, a Member of the Synthetic Aperture Technical Working Group for IEEE Signal Processing Society, a Guest Editor for IET Radar Sonar and Navigation, and a Topic Editor for Frontiers on Signal Processing.

Francesco Fioranelli received the Laurea (B.Eng.) and Laurea Specialistica (M.Eng.) degrees (cum laude) in telecommunication engineering from Universitã Politecnica delle Marche, Ancona, Italy, in 2007 and 2010, respectively, and the Ph.D. degree from Durham University, U.K., in 2014., He was an Assistant Professor with the University of Glasgow from 2016 to 2019 and a Research Associate with University College London from 2014 to 2016. He is currently an Associate Professor with TU Delft, The Netherlands. He has authored over 160 publications between book chapters, journals and conference papers, and edited the book on Micro-Doppler Radar and Its Applications (IET-Scitech, 2020). His research interests include the development of radar systems and automatic classification for human signatures analysis in healthcare and security, drone and UAV detection and classification, automotive radar, wind farms, and sea clutter. He received four best paper awards.