



UAV Classification using Radars, AI, and Digital Twins



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ABSTRACT

Illicit use of drones poses a critical threat, necessitating robust systems for drone detection and classification. Radar offers all-weather, day/night capability for drone sensing at a distance. However, generating comprehensive radar drone datasets via field measurements is prohibitively expensive and constrained. To address this, we have demonstrated the potential use of full-wave electromagnetic computer-aided design (EM CAD) tools to create radar-drone digital twins. This approach enables the synthesis of multi-parameter drone and radar models to generate tailored datasets for advancing drone classification research. We have modeled diverse radar systems (X/Ku/Ka-band) and drone types, including a COTS quadcopter carrying an explosive payload. The digital twins have empowered critical innovations. First, we have showcased that novel artificial intelligence methods can leverage the physics-based radar signatures and achieve over 90% classification accuracy, even amidst avian clutter. Second, our approach enables examination of radars spanning disparate bands to uncover operating regimes ideal for classification. Third, the flexibility of the digital twins allows us to systematically vary radar/target parameters and generate the diversity and volume of data needed to train deep neural networks empowering unprecedented classification capabilities.

BIO



Prof. George Shaker (Senior Member, IEEE) is an adjunct and research associate professor at the Department of Electrical and Computer Engineering at the University of Waterloo, Canada, where he is the director of the Wireless Sensors & Devices Lab. He is a research scientist at the UW-Schlegel Research Institute for Aging where he is the founder and director of “THE MIRADA - Technology for Health Empowerment: Monitoring, Intervention, and Response for Aging Demonstration Apartment”. He is the Chief Scientist at Spark Technology Labs (STL) which he helped launch in 2011. Prior to his current roles, George was with Research in Motion (BlackBerry) and Georgia Institute of Technology. Dr. Shaker has authored/coauthored more than 150 publications and has more than 35 patents/patent applications (11 of which are assigned to Google) in the broad area of applied electromagnetics. He has received multiple recognitions and awards, including the IEEE Antennas and Propagation Society (AP-S) Best Paper Award, the IEEE AP-S Honorable Mention Best Paper Award (three times as student and three as supervisor), the IEEE Antennas and Propagation Graduate Research Award, the IEEE Microwave Theory and Technology Society (MTT-S) Graduate Fellowship, the Electronic Components and Technology Best of Session Paper Award, and the IEEE Sensors Most Popular Paper Award. He coauthored three papers in IEEE journals that were among the top 25 downloaded papers on IEEEExplore for several consecutive months. He also co-authored a paper that was the top accessed article in Wiley Engineering Reports in 2022. He was the supervisor of the 5-member student team winning the Third Best Design Contest at IEEE AP-S 2016, the co-author of the Association for Computing Machinery (ACM) MobileHCI 2017 Best Workshop Paper Award, and the 2018 Computer Vision Conference Imaging Best Paper Award. He co-received with his students’ several research recognitions, including the Natural Sciences and Engineering Research Council of Canada (NSERC) Top Science Research Award in 2019, the Biotech Top Demo Award in 2019, the arXiv Top Downloaded Paper (medical device category) in 2019, the Velocity Fund in 2020, the National Aeronautics and Space Administration (NASA) Tech Briefs HM Award (medical device category) in 2020, the University of Waterloo (UW) Concept Winner in 2021, the U.K. Dragons Canadian Competition Winner in 2021, the Canadian Microelectronics Corporation (CMC) Nano Winner in 2021, the COIL CoLab Award in 2022, the 2023 Canadian Space Agency Satellite Competition (90+ student members), and the Engineer the Future Award (2024).