Georgia Tech
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Distinguished Lecture Series

The Role of Electronically Reconfigurable, Reflectarrays, Transmitarrays, and Metasurfaces in Future Phased-Array Antenna Applications

FEATURING

Nader Behdad

McFarland-Bascom Professor
Department of ECE
University of Wisconsin-Madison

Date: Thursday, March 2, 2023
Seminar: 11:00 a.m. - 12:00 p.m.
Student-Speaker Session: 12:00 p.m. - 12:30 p.m.
Location: TSRB 118 Auditorium
Pizza and Soda Provided Post Session

Abstract: Phased-array antennas are widely used in various communications, radar, and electronic warfare systems. Compared to mechanically beam-steerable antennas, they provide significantly faster beam steering and more functionalities albeit at the expense of added cost and complexity of design. Phased-array antennas can be categorized into active and passive electronically steered arrays (AESAs and PESAs). In an AESA architecture, each array element is backed by a transmit/receive (T/R) module that includes a complete RF transceiver chain. AESAs are capable of performing sophisticated beamforming and spatial filtering using digital beamforming techniques. In contrast, a PESA architecture is characterized by having one or a few RF transceiver chains that feed the array elements using a passive feed network. Each array element uses a phase shifter and possibly an amplitude control mechanism to perform beam steering. PESAs are generally less capable than AESAs but offer a comparatively simpler system architecture. With the development and proliferation of low-cost microwave and millimeter-wave silicon-based T/R modules, however, the cost of developing AESAs has significantly decreased and they are being deployed at an ever-increasing rate, particularly in consumer wireless communications applications. It is likely that AESAs will dominate the future of phased-array antenna market, at least in terms of the number of units deployed. One method of developing PESAs that has received a significant attention in recent years is the use of reconfigurable metasurfaces and sub-wavelength periodic structures to perform beam steering. These devices consist of periodic or quasi-periodic electromagnetic structures whose responses can be electronically tuned using electronic switches, varactor diodes, or numerous other means. Developing phased-array antennas at microwave and millimeter-wave frequency bands is one of the application areas that has motivated the development of these structures. In light of the significant growth in the development of silicon-based T/R modules, an interesting question arises: What is the future role of reconfigurable metasurfaces in phased-array antenna development? In this presentation, I answer this question based on our team's experiences working on developing electronically reconfigurable electromagnetic periodic structures for phased-array applications at the University of Wisconsin-Madison (UW). I will first present an overview of the state-of-the-art in passive and active phased-array antenna design and provide a brief description of electromagnetic wave front manipulation with EM periodic structures. Then I will discuss the characteristics of the applications where PESAs can compete well with AESAs. I will then present two specific applications that have motivated our work in this area in recent years. These include very-high-power radar, electronic warfare, and wireless communications on the move applications. In conclusion, I will briefly discuss potential future applications where PESAs based on electronically-reconfigurable metasurfaces can compete well against silicon-based AESAs.

Beam Steering with Reconfigurable Reflectarrays

Biography:

Nader Behdad received the B.S. degree in Electrical Engineering from Sharif University of Technology in 2000 and the M.S. and Ph.D. degrees in Electrical Engineering from University of Michigan - Ann Arbor in 2003 and 2006, respectively. Currently, he is the McFarland-Bascom Professor in the Department of Electrical and Computer Engineering of the University of Wisconsin-Madison. Dr. Behdad's research expertise is in the area of applied electromagnetics with particular focus on electrically small antennas, phased-array antennas, bio-electromagnetics, microwave ablation, microwave periodic structures, and high-power microwaves. He has 23 issued or pending U.S. patents in these areas. Dr. Behdad has served as a consultant on topics related to designing antennas and phased arrays to industry. He has also served as a consultant and an expert witness for different U.S. law firms on topics related to intellectual property disputes as well as cell phone record analysis and historical cell site analysis. Over the years, Dr. Behdad's research has been sponsored by various U.S. Federal agencies including the U.S. Navy, U.S. Air Force, U.S. Army, National Science Foundation, and the Defense Health Agency. Dr. Behdad has graduated 28 Ph.D. and 11 M.S. students so far and served as the research advisor of 27 other post-doctoral research fellows and visiting scholars. He received the Harvey D. Spangler Faculty Scholar Award, the H. I. Romnes Faculty Award, and the Vilas Associates Award from the University of Wisconsin-Madison. Dr. Behdad is also the recipient of the 2021 H. A. Wheeler Prize Paper Award, the 2014 R. W. P. King Prize Paper Award, and the 2012 Piergiorgio L. E. Uslenghi Letters Prize Paper Award of the IEEE Antennas and Propagation Society. In 2011, he received the CAREER award from the U.S. National Science Foundation, the Young Investigator Award from the United States Air Force Office of Scientific Research, and the Young Investigator Award from the United States Office of Naval Research. Dr. Behdad served as the 2020 chair of the paper awards committee of the IEEE Antennas and Propagation Society. He also served as an Associate Editor for IEEE Antennas and Wireless Propagation Letters (2011-2015) and as the co-chair of the technical program committee of the 2012 IEEE International Symposium on Antennas and Propagation and USNC/URSI National Radio Science Meeting.

Host: Nima Ghalichechian