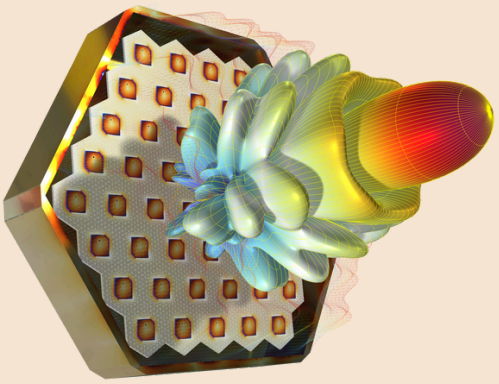
Design Robustness and Digital Twins for Antenna Engineering: Uncertainty Quantification and Surrogate Models with Deep Neural Networks



Abstract

In modern antenna engineering, addressing design uncertainties and achieving efficient performance evaluation is critical for robust and reliable solutions. This work explores two complementary methodologies: uncertainty quantification (UQ) and surrogate modeling using deep neural networks (DNNs). UQ is employed to evaluate the robustness of antenna designs by systematically assessing the impact of variations in material properties, fabrication tolerances, and environmental factors on key performance metrics, such as S-parameters and radiation patterns. As a result, it ensures the reliability and resilience of the designs under real-world conditions.

In parallel, DNN-based surrogate models provide fast and accurate approximations of computationally intensive electromagnetic simulations, facilitating real-time analysis and enabling digital twins for advanced antenna systems.

By combining these approaches, we demonstrate a powerful framework for improving the robustness of the design and the computational efficiency of antenna workflows. A case study on a microstrip patch antenna illustrates the application of UQ and surrogate models, highlighting their respective roles in modern antenna design and optimization.

Speakers

Jiyoun Munn is a senior technical product manager at COMSOL, where he has led the development of FEA-based electromagnetics simulation tools and applications since 2011. With over 20 years of experience in the RF industry, he has designed and developed more than 150 prototypes for antennas and microwave devices.

A senior member of IEEE, Munn holds patents for innovative antenna interrogation systems. He earned a Master's degree in Electrical Engineering from the University of Michigan.

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