Modeling and Simulation for Defense Applications

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ABSTRACT

Electromagnetic modeling and simulation have become essential tools for modern defense applications, enabling accurate analysis of propagation, scattering, and detection in complex operational environments. Applications such as over-the-horizon radar, surveillance, and stealth technology demand accurate numerical tools for predicting electromagnetic behavior in the presence of atmospheric effects, terrain, and engineered structures.

The Parabolic Wave Equation (PWE) provides an efficient framework for modeling long-range radio wave propagation in the presence of atmospheric refraction, terrain variations, and sea surface effects. It is particularly effective in simulating tropospheric ducting, shadow zones, and terrain-induced multipath phenomena relevant to low-altitude radar and coastal surveillance systems.

For electrically large and geometrically complex scenarios, high-frequency methods such as Geometrical Optics (GO), Uniform Theory of Diffraction (UTD), and Physical Theory of Diffraction (PTD) are essential. Within this context, the Shooting and Bouncing Ray (SBR) method effectively models multiple reflections and diffractions in complex environments. Meanwhile, the Incremental Length Diffraction Coefficient (ILDC) approach enhances the modeling of creeping waves and edge diffractions by accounting for the gradual accumulation of diffracted fields along finite paths. These techniques are widely employed in Radar Cross Section (RCS) analysis and Inverse Synthetic Aperture Radar (ISAR) imaging—key tools for target detection, classification, and electromagnetic signature analysis.

This talk will present practical simulation examples and hybrid modeling strategies that integrate full-wave, asymptotic, and environmental models, offering a comprehensive framework for electromagnetic analysis in defense-oriented applications.

BIO

Dr. Özlem Özgün is currently a Full Professor in the Department of Electrical and Electronics Engineering and Vice Dean of the Faculty of Engineering at Hacettepe University, Ankara, Turkey. She received her B.Sc. and M.Sc. degrees from Bilkent University and her Ph.D. from Middle East Technical University (METU), all in Electrical and Electronics Engineering. She was a postdoctoral researcher at Penn State University, US; and previously worked at TÜBİTAK, Aselsan, METU, and TED University in Turkey.

Her research focuses on computational electromagnetics and radiowave propagation, including numerical methods, domain decomposition, transformation electromagnetics, and stochastic electromagnetic problems. She has authored over 130 refereed publications, including a book on finite element programming in electromagnetics (CRC Press, 2018).

Dr. Özgün is a Senior Member of IEEE and URSI and a past chair of the URSI Turkey steering committee. Her awards include the METU Best Ph.D. Thesis Award (2007), the Felsen Fund Excellence in Electromagnetics Award (2009), and the IEEE AP-S Outstanding Reviewer Award (2023-2024). She was recognized among the world's top 2% most influential scientists (Stanford University & Elsevier, 2023–2024); and received the Hacettepe University 2024 Science Award.