Nature-Inspired Designs: How Darwin, Bees, and Humans Drive Smarter Optimization (GA, PSO, BSO)

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Abstract:
Advances in computational power have opened the door to solving increasingly complex engineering design problems. Traditional brute-force optimization methods are giving way to state-of-the-art evolutionary approaches that mimic the adaptive power of nature and human intelligence. Among these, three stand out: **Genetic Algorithms (GA)**, inspired by Darwin's principles of evolution and survival; **Particle Swarm Optimization (PSO)**, modeled after the collective foraging behavior and social intelligence of swarms such as bees; and **Brain Storm Optimization (BSO)**, drawing on the creativity and problem-solving abilities of human groups. This presentation offers an accessible introduction to these algorithms, highlighting their concepts, strengths, and recent advances for both newcomers and experienced practitioners. Real-world applications will be showcased, from space and planetary mission systems to wireless and medical devices, adaptive antennas, metamaterials, and nanoscale structures. Finally, we will assess the opportunities and limitations of these nature- and human-inspired techniques, showing how they can lead to smarter, more efficient designs.

Bio:
DR. Yahya Rahmat-Samii is a Distinguished Professor and the Former Chairman of the Electrical and Computer Engineering Department, University of California at Los Angeles (UCLA), Los Angeles, CA, USA. He was a Senior Research Scientist with Caltech/NASA's JPL, Pasadena, CA, USA. He received his B.S. from the University of Tehran, Iran, with highest honor and his M.S. and Ph.D. for the University of Illinois, Urbana-Champaign, USA. He has authored or coauthored more than 1100 technical journal and conference papers and has written over 40 book chapters and seven books. He has more than 20 cover-page IEEE publication articles. His research contributions cover diverse areas of modern electromagnetics and antennas, spanning from small medical antennas to large space deployable antennas. His research interests include electromagnetics, antennas, measurements and diagnostics techniques, numerical and asymptotic

methods, satellite and personal communications, human/antenna interactions and medical applications, metamaterials and periodic structures, and nature-inspired optimization algorithms. Dr. Rahmat-Samii is a fellow of IEEE, AMTA, ACES, EMA, and URSI. He was a recipient of the Henry Booker Award from URSI, in 1984, which is given triennially to the most outstanding young radio scientist in North America, the Best Application Paper Prize Award (Wheeler Award) of the IEEE AP-S in 1992 and 1995, the University of Illinois ECE Distinguished Alumni Award in 1999, the IEEE Third Millennium Medal and the AMTA Distinguished Achievement Award in 2000. In 2001, he received an Honorary Doctorate Causa from the University of Santiago de Compostela, Spain. He received the 2002 Technical Excellence Award from JPL, the 2005 URSI Booker Gold Medal presented at the URSI General Assembly, the 2007 IEEE Chen-To Tai Distinguished Educator Award, the 2009 Distinguished Achievement Award of the IEEE AP-S, the 2010 UCLA School of Engineering Lockheed Martin Excellence in Teaching Award, and the 2011 campus-wide UCLA Distinguished Teaching Award. He was the winner of the 2011 IEEE Electromagnetics Field Award. He was also a recipient of the Distinguished Engineering Educator Award from The Engineers Council in 2015, the John Kraus Antenna Field Award of the IEEE AP-S and the NASA Group Achievement Award in 2016, the ACES Computational Electromagnetics Award and the IEEE AP-S S. A. Schelkunoff Best Transactions Prize Paper Award in 2017, and the prestigious Ellis Island Medal of Honor in 2019. He is also the winner of the 2011 IEEE Electromagnetics Field Award. He received the Harrington–Mittra Computational Electromagnetics Award in 2022 and he is the recipient of the 2023 USNC-URSI Outstanding Educator Award. He is the Designer of the original IEEE AP-S logo. He is a holder of the Northrop-Grumman Chair in electromagnetics at UCLA, a member of the U.S. National Academy of Engineering (NAE), a Foreign Member of the Chinese Academy of Engineering (CAE), and the Royal Flemish Academy of Belgium for Science and the Arts. He was the 1995 President of the IEEE AP-S and the 2009–2011 President of the United States National Committee (USNC-URSI). He has also served as an IEEE Distinguished Lecturer, presenting lectures internationally. In 2023, he was designated as a "Legend of Electromagnetics" by the IEEE AP-S, with the YouTube link for his interview available at https://www.youtube.com/watch?v=HO2-nrC2rCM