Advancing Nano- and Quantum Photonics with Machine Learning

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Abstract: Discovering unconventional optical designs via machine-learning promises to advance on-chip circuitry, imaging, sensing, energy, and quantum information technology. In this talk, we discuss photonic design approaches and emerging material platforms for showcasing machine-learning-assisted topology optimization for optical metasurface designs with applications in thermophotovoltaics, reflective optics, and lightsail technology. We demonstrate the effectiveness of autoencoders for compressing the vast design space of metasurfaces into a smaller search space. By employing global optimization via adjoint methods or quantum annealing, one can find the optimal metasurface designs within the smaller space constructed by the autoencoder. The quantum-assisted machine learning framework, named bVAE-QUBO, presented in this work is the first demonstration of a generic machine learning framework that compresses an arbitrary continuous optimization problem into an Ising-model formalism for quantum sampling. When compared to other global optimization techniques, bVAE-QUBO has the potential for quantum speedups and achieving higher quality designs than traditional adjoint optimization methods. The techniques employed in this work extend well beyond the metasurface optimization space and into many inverse design problems for engineering and physics.

Biographical notes:

Alexandra Boltasseva is a Ron and Dotty Garvin Tonjes Professor of Electrical and Computer Engineering with courtesy appointment in Materials Engineering at Purdue University. She received her PhD in electrical engineering at Technical University of Denmark, DTU in 2004. Boltasseva specializes in nanophotonics, quantum photonics, and optical materials. She is the 2023 recipient of the R.W. Wood Prize (Optica, formerly Optical Society of America), 2022 Guggenheim Fellow, 2018 Blavatnik National Award for Young Scientists Finalist and received the 2013 Institute for Electrical and Electronics Engineers (IEEE) Photonics Society Young Investigator Award, 2013 Materials Research Society (MRS) Outstanding Young Investigator Award, the 2011 MIT Technology Review Top Young Innovator (TR35), the 2009 Young Researcher Award in Advanced Optical Technologies from the University of Erlangen-Nuremberg, Germany, and the Young Elite-Researcher Award from the Danish Council for Independent Research (2008). She is a Fellow of the National Academy of Inventors (NAI) (2020), MRS (2021), IEEE (2020), Optica (2017), and International Society for Optical Engineers (SPIE) (2015). She served on MRS Board of Directors (2014-2016) and is past Editor-in-Chief for Optical Materials Express journal, Optica Publishing group (2016-2021).