APS Scientific Computation Seminar Series

Speaker: George Barbastathis
Massachusetts Institute of Technology

Title: Embedding Physics in Machine Learning for Computational Imaging

Date: Monday, February 1, 2021

Time: 1:00 p.m. (Central Time)

Location: https://bluejeans.com/598169198

Hosts: Nicholas Schwarz and Mathew Cherukara

Abstract:

Machine learning has been proven to be especially effective for numerous tasks in computational optimization and function approximation. During the past five years, that has included computational imaging, where training examples are used to mix, to some degree, the physical models of imaging systems (forward operators) with regularization priors for relatively restricted classes of objects. Restricting the objects is especially productive under extremely adverse conditions, such as highly noisy or highly diffuse.

In this talk, I will review the various machine learning architectures that have been proposed so far, and then describe in some detail ongoing work in our group on two problems relating to scattering, both utilizing recurrent neural nets. The first is a forward scattering problem, where we embed the null space projection of the Lippmann-Schwinger operator into the recurrence. The second is an inverse scattering problem, where the recurrence operates on successive inputs from scanning a three-dimensional object—e.g., lateral can, as in ptychography or laminography; or angular scan, as in tomography. In all instances of the 3D inverse problem, we embed knowledge of the scattering operator into the recurrence as an Approximant, and we also employ a form of spatial attention to reward scan positions that are found to be of special significance.

In addition to this ongoing work, I will speculate about two major challenges in all these approaches: first, image evaluation metrics. It is well known in computational imaging that most often algorithms' performance is not monotonic between different metrics; and neither is it consistent with human perception of image quality. The second problem is quantifying reconstruction confidence, including uncertainty in the forward operator. Progress in these challenges will be necessary toward wider adoption of these promising methods to practice, e.g., in medical imaging and manufacturing inspection.