Computational Research in Boston and Beyond Seminar

Optimizing physical systems using "unphysical" simulations

Friday, November 7, 2025

12:00 PM - 1:00 PM

Zoom: https://mit.zoom.us/j/91933017072

Steven Johnson

(MIT)

Abstract

"Inverse design" is the technique of using large-scale optimization (over thousands or even millions of parameters) to allow the computer to "discover" the best arrangement of materials for a given application, often leading to non-intuitive freeform geometries. In contrast to machine learning, this is typically model-driven optimization rather than data-driven. In particular, the most straightforward way to perform inverse design is to apply optimization to the result of an accurate physical model that directly simulates the desired effect: a "numerical experiment" mirroring (one hopes) the real-world performance. However, we argue that this is often too restrictive: sometimes, vastly better performance is attainable by allowing the computer to exploit "unphysical" models—inaccurate simulations, unphysical materials, and regimes inaccessible to realistic experiments—as long the eventual result (after optimization convergence) returns to the physical realm. We illustrate these ideas with several examples from photonics topology optimization, including incoherent emission, laser optimization, and the design of optical filters.