Physical Mathematics Seminar

Model selection of chaotic systems from data with hidden variables using sparse data assimilation

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ABSTRACT:

Many natural systems exhibit chaotic behavior, including the weather, hydrology, neuroscience, and population dynamics. Although many chaotic systems can be described by relatively simple dynamical equations, characterizing these systems can be challenging due to sensitivity to initial conditions and difficulties in differentiating chaotic behavior from noise. Ideally, one wishes to find a parsimonious set of equations that describe a dynamical system. However, model selection is more challenging when only a subset of the variables are experimentally accessible. Manifold learning methods using time-delay embeddings can successfully reconstruct the underlying structure of the system from data with hidden variables, but not the equations. Recent work in sparse-optimization based model selection has enabled model discovery given a library of possible terms, but regression-based methods require measurements of all state variables. We present a method combining variational annealing—a technique previously used for parameter estimation in chaotic systems with hidden variables—with sparse-optimization methods to perform model identification for chaotic systems with unmeasured variables. We applied the method to ground-truth time-series simulated from the classic Lorenz system and experimental data from an electrical circuit with Lorenz-system like behavior. In both cases, we successfully recover the expected equations with two measured and one hidden variable. Application to simulated data from the Colpitts oscillator demonstrates successful model selection of terms within nonlinear functions. This work was recently published: Chaos 32, 063101(2022); https://doi.org/10.1063/5.0066066

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2:30 PM – 3:30 PM
Building 2, Room 449

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