Numerical Analysis and Scientific Computing Seminar

Predicting Complex Spatiotemporal Cardiac Voltage Dynamics Using Reservoir Computing

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Abstract: Disruptions to the electrical behavior of the heart caused by cardiac arrhythmias can result in complex dynamics, from period-2 rhythms in single cells to spatiotemporally complex spiral and scroll waves of electrical activity, which can inhibit contraction and may be lethal if untreated. Accurate forecasts of cardiac voltage behavior could allow new opportunities for intervention and control, but predicting complex nonlinear time series is a challenging task. In this talk, we discuss our recent work using machine-learning approaches based on reservoir computing to forecast cardiac voltage dynamics.
First, we show that a novel method combining an echo state network with automated feature extraction via an autoencoder can successfully and efficiently predict time series of synthetic and experimental datasets of cardiac voltage in one cell with 20-30 action potentials in advance. Building on this work, we then demonstrate a novel method for predicting the complex spatiotemporal electrical dynamics of cardiac tissue using an echo state network integrated with a convolutional autoencoder. We show that our approach can forecast complex spiral-wave behavior, including breakup several periods in advance for time series ranging from model-derived synthetic datasets to optical-mapping recordings of explanted human hearts.

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