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TATA INSTITUTE OF FUNDAMENTAL RESEARCH

ICTS Biophysics Seminar

Title : Biological Data Science From the Perspective of Dynamical Systems

Speaker : Tosif Ahamed (HHMI, Janelia Research Campus, USA)

Date : Monday, 27 January 2025

Time : 2:00 PM (IST)

Abstract : Biology is experiencing a data revolution, fueled by high-resolution measurements of spatiotemporal dynamics in complex systems. Of particular interest are simultaneous recordings of neural activity and behavior, now possible in several key model organisms. However, the complexity of these spatiotemporal datasets challenges traditional time-series analysis methods. My research explores how dynamical systems theory, combined with modern AI/ML, offers a powerful approach for building interpretable, data-driven models of these complex biological phenomena. I'll illustrate this with examples from my work, focusing on a data-driven theory of C. elegans locomotion. By analyzing the spectrum of Lyapunov exponents estimated from experimental data, we identified damped-driven Hamiltonian systems as the appropriate model class for worm locomotion. Like many animals, C. elegans locomotion spans multiple timescales, from rapid neuromuscular activity to slower behaviors like navigation and foraging. To bridge these timescales, we build methods for developing data-driven approximations of the Perron-Frobenius operator, which moves phase-space probability densities forward in time. Interestingly, the nontrivial eigenfunctions of the estimated operator correspond to "run and tumble" like behaviors, which are essential for C. elegans navigation in 2D environments. Finally, I'll discuss how I am “scaling up” such analyses to very high-dimensional datasets, such as recordings from ~10,000 neurons spanning hours. Inspired by ideas of reduction in dynamical systems, I developed an efficient dimensionality reduction algorithm to capture the longest predictable timescales. The algorithm, formulated as a generalized eigenvalue problem, is highly scalable enabling rapid extraction of the dominant dynamical modes in very high dimensional recordings. I'll demonstrate its application to a new experimental paradigm designed to study neural encoding of complex visual dynamics in head-fixed mice.

Venue : Feynman Lecture Hall
Zoom Link: https://icts-res-in.zoom.us/j/93523917949?pwd=zQRWn9B3NCCYsc52vbNFYjRsgGu2KV.1
Meeting ID: 935 2391 7949
Passcode: 272728