动力系统与神经科学前沿研讨会

Frontier Workshop on Dynamical Systems and Neuroscience (Online)

—Celebrating Manfred Denker's 80th Birthday

https://www.gbu.edu.cn/detail/article/991

September 20, 2024

Great Bay University

Dongguan, China

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Notes: This frontier workshop focuses on dynamical systems and neuroscience, including :

- Nonlinear and Stochastic dynamics
- Neuroscience and Biological dynamics
- Related topics

This workshop will celebrate Manfred Denker's 80th birthday.

Workshop Date: Friday, September 20

Workshop Time: 14:30-17:30&19:00-20:00(China time)

8:30-11:30&13:00-14:00(Germany time)

Venue:

Zoom ID: 506 635 6571 Password: 123456

Organizers:

Jinqiao Duan(Chair), Great Bay University, China

Ting Gao(co-Chair), Huazhong University of Science and Technology, China

Xiaoli Chen, China University of Geosciences (Wuhan), China

Jianyu Chen, Huazhong University of Science and Technology, China

Shan Jiang, Great Bay University, China

Time	Program
Chair: Jianyu Chen	
14:20-14:30	Sign in
14:30-15:00	Jinqiao Duan (Great Bay University, China) Opening speech
15:00-15:30	Manfred Denker (Gottingen University, Germany)
15:30-16:00	Anna Levina (Universität Tübingen, Germany)
16:00-16:30	Douglas Zhou (Shanghai Jiaotong University, China)
Break	
Chair: Xiaoli Chen	
16:30-17:00	Michael Denker (Forschungszentrum Jülich at the Helmholz Center, Germany)
17:00-17:30	Yu Hu (Hong Kong University of Science and Technology, China)
19:00-19:30	Ting Gao (Huazhong University of Science and Technology, Wuhan, China)
19:30-20:00	Xuan Zhang (Universidade Federal Fluminense, Brazil)

学术报告信息

Academic report information

1、**Speaker:** Jinqiao Duan

Title: Research areas at the Guangdong Provincial Key Lab of Mathematical and Neural Dynamical Systems

Abstract: The speaker will outline the current research areas at the Lab of Mathematical and Neural Dynamical Systems.

2、**Speaker:** Manfred Denker

Title: Challenges originating in neural dynamics

Abstract: The talk discusses rectangle exchange transformations and generalized Bernoulli distributions. Both objects are connected to neural dynamics. Only few results are known, so the talk focuses on open problems and some of the easy facts for these notions.

3、**Speaker:** Anna Levina

Title: Modeling neuronal cultures: adaptation and parameter invariance

Abstract: Neuronal cultures are a versatile system for studying the fundamental properties of individual neurons and neuronal networks. We designed a simple biophysically inspired dynamical system and used Bayesian inference to fit it to a large number of recordings of population activity. Even with a small number of parameters, the model showed strong inter-parameter dependencies leading to invariant bursting dynamics for many parameter combinations. I will discuss how our simplified models provide insights into the modifications of excitation-inhibition balance under chronic experimental manipulations. Additionally, I will demonstrate how different types of cultures across development can be effectively mapped, enabling discrimination between various experimental conditions in an informative manner.

4、Speaker: Douglas Zhou

Title: Brain-inspired artificial neural network models and their applications

Abstract: Research on brain-inspired intelligence is not only at the forefront of science but also a core element of the National Brain Project and AI development plans. As the fundamental unit of brain information processing, the dynamical modeling of single neurons is the first step toward quantitatively understanding brain computation and developing brain-inspired artificial intelligence. However, existing point neuron models fall short in capturing the complex dendritic effects that are critical for neural information processing, thus failing to reflect the powerful dendritic computational abilities of real neurons. By establishing an asymptotic analytical framework based on cable theory, which includes dendritic structures, we reduce a partial differential equation (PDE)-based cable neuron model to an ordinary differential equation (ODE)-based point neuron model. Our biophysical model introduces an additional synaptic integration current, which arises from nonlinear interactions between synaptic currents on spatial dendrites. Additionally, our model effectively characterizes the voltage response of the soma in neurons with complex dendritic structures, enabling it to achieve intricate dendritic computation. Through this asymptotic analysis framework, we also derive a bilinear integration rule and establish a simple and efficient mapping between real neurons and artificial neurons. This mapping significantly outperforms existing models in terms of accuracy in simulating real neuron somatic dynamics, training complexity, parameter size, and dynamic temporal data

processing. Our work provides a systematic theoretical and computational framework for studying the dynamics and functions of neurons with spatial dendritic structures, offering new insights for designing brain-inspired artificial neural networks.

5、**Speaker:** Michael Denker

Title: Validation and Knowledge Transfer for Analysis Workflows in Electrophysiology

Abstract: Efforts to digitize scientific processes have led to standardized tools supporting all stages of the research data life cycle. In neuroscience, the use of standardized software tools, model descriptions and data representations for neural network modelling and data analysis provides researchers access to a wide range of methodological approaches. Besides reducing the time-to-result by providing readily available components project, such tools are bound to spark creativity with researchers by putting a diversity of prior research outputs (codes, data, and models) at their fingertips. Moreover, these research outputs typically arise from the combined efforts and knowledge of a large base of authors and contributors, with the promise of optimized and thoroughly checked content. Despite these advantages, many researchers still exhibit skepticism in sharing and re-using research outputs due to the fact that researchers lack the trust in prior work due to the non-availability of explicit validation data and an incomplete knowledge transfer about the existing code, data, or models. Here, we present various efforts and hands-on examples of our group to strengthen rigor of produced research artifacts in neuroscience through

processes of validation and provenance capture.

6、Speaker: Yu Hu

Title: How dimension and geometry of neuron population activity are shaped by random connectivity and motifs

Abstract: Multi-dimensional structures of neural population activity have received much interest thanks to advances in simultaneous recordings of a large number of neurons. A key question is how these dynamic features emerge mechanistically and their relation to circuit connectivity. In this work we characterize the dynamics through the covariance spectrum, which is closely related to linear dimension and PCA. By considering the linearized dynamics fluctuating around a steady state, analytical results can be obtained to explicitly show the impact of connectivity statistics including motifs. In particular, the theoretical spectrum has a long tail of large eigenvalues that matches the low-dimensional activity and power-law spectra observed across various experimental data. The theory provides a local circuit mechanism for these phenomena and a quantitative benchmark to fit the data robustly.

7、Speaker: Ting Gao

Title: Learning stochastic models with applications in brain transition dynamics

Abstract: Recently, deep learning has helped to improve first principle-based methods for stochastic dynamical systems, including the identification of governing laws, effective dynamics, and complex phenomena such as critical transition and tipping. We will present our recent findings on learning

governing laws from various data-driven problems and tipping indicators based on the Schrödinger bridge. To validate our framework, we apply our methodology to some neural models as well as real brain image data.

8、Speaker: Xuan Zhang

Title: Benford's law for sequence of ergdic sums

Abstract: We establish a necessary and sufficient condition for a sequence of ergodic sums to be almost surely uniformly distributed mod 1, and hence to exhibit Benford's law, which somehow also appeared in the study of Neuroscience.