ACMS Applied Math Seminar

Ming Zhong

Illinois Institute of Technology

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154 Hurley Hall

3:30 PM – 4:30 PM

Computational Discovery of Collective Behaviors from Observation

Collective Behaviors occurs naturally in bird flocking, cell aggregation, ant raiding, locust swarm, etc. It is challenging and intriguing to understand such behaviors from the mathematical point of view. We offer a data-driven approach to model collective behaviors from observation data; moreover, our approach can aid in validating and improving the modeling of collective behaviors.

We develop a learning framework to derive physically meaningful dynamical systems to explain collective behaviors from high-dimensional observation data [1]. We also investigate the steady state properties of our learned estimators [2]. We also extend the learning approach for dynamical models constrained on Riemannian manifolds [3]. We further improve our learning capability to infer interaction variables as well as interaction kernels [4]. We even study the effectiveness of our learning method on the NASA Jet Propulsion Laboratory's modern Ephemerides [5]. Upon careful inspection of our model, we discover that it even captures potion of the general relativity effects. A complete learning theory on second-order systems is presented [6], as well as two new models on emergence of social hierarchy [7] and multi-mode emergence [8].

[1]: Lu, Zhong, Tang, Maggioni, Nonparametric inference of interaction laws in systems of agents from trajectory data, PNAS, 2019.
[2]: Zhong, Miller, Maggioni, Data-driven discovery of emergent behaviors in collective dynamics, Physica D, 2020.
[3]: Maggioni, Miller, Qiu, Zhong, Learning Interaction Kernels for Agent Systems on Riemannian Manifolds, PMLR, 2021.
[4]: Feng, Maggioni, Martin, Zhong, Learning Interaction Variables and Kernels from Observations of Agent-Based Systems, IFAC-PapersOnLine, 2022.
[5]: Zhong, Miller, Maggioni, Machine Learning for Discovering Effective Interaction Kernels between Celestial Bodies from Ephemerides, under revision, 2023.
[6]: Miller, Tang, Zhong, Maggioni, Learning Theory for Inferring Interaction Kernels in Second-Order Interacting Agent Systems, submitted, 2022.
[7]: Greene, Tadmor, Zhong, The Emergence of Social Hierarchy in Collective Motion of Living Matters, submitted to Physical Biology, 2023.
[8]: Gerew, Zhong, Concurrent Emergence of Clustering, Flocking and Synchronization in Systems of Interacting Agents, submitted, 2023.