Zhengmeng Zhai

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Summary

Zheng-Meng Zhai is a Ph.D. candidate in Electrical Engineering at Arizona State University, under the supervision of Prof. Ying-Cheng Lai. His background is in physics and electrical engineering and he is interested in nonlinear dynamics and chaos (e.g. symbolic regression, tipping points), machine learning (e.g., Transformer, RNNs, LLMs, Generative models).

Education

Arizona State University **Sep. 2021 – Now**
Ph.D. of Electrical, Computer and Energy Engineering *Arizona, USA*

Research Focus: Nonlinear dynamics and machine learning

East China Normal University **Sep. 2019 – June 2022**
Master of Theoretical Physics *Shanghai, China*

Research Focus: Epidemic spreading and complex networks

Southwest Jiaotong University **Sep. 2015 – May 2019**
Bachelor of Electronic Information Science and Technology *Sichuan, China*

Publications

[15] **Zheng-Meng Zhai**, Jun-Yin Huang, Benjamin D. Stern, and Ying-Cheng Lai. "Reconstructing dynamics from sparse observations with no training on target system," *ArXiv*, (2024).

[14] **Zheng-Meng Zhai**, Bryan Glaz, Mulugeta Haile, and Ying-Cheng Lai. "Learning to learn ecosystems from limited data - a meta-learning approach," *ArXiv, submitted to PRX Life*, (2024).

[13] **Zheng-Meng Zhai**, Mohammadamin Moradi, and Ying-Cheng Lai. "Detecting attacks and estimating states of power grids from partial observations with machine learning," *Preprint, submitted to PRX Energy*, (2024).

[12] Mohammadamin Moradi, **Zheng-Meng Zhai**, Shirin Panahi, and Ying-Cheng Lai. "Adaptive network approach to exploration-exploitation trade-off in reinforcement learning," *Chaos*, **34**, 123120, 1-14, (2024).

[11] Shirin Panah, Ling-Wei Kong, Mohammadamin Moradi, **Zheng-Meng Zhai**, Bryan Glaz, Mulugeta Haile, and Ying-Cheng Lai. "Machine learning prediction of tipping in complex dynamical systems," *Physical Review Research*, **6**, 043194, 1-18, (2024).

[10] **Zheng-Meng Zhai**, Mohammadamin Moradi, Shirin Panah, Zhi-Hua Wang, and Ying-Cheng Lai. "Machine-learning nowcasting of the Atlantic Meridional Overturning Circulation," *APL Machine Learning*, **2**, 036103, (2024).

[9] Mohammadamin Moradi, Shirin Panah, **Zheng-Meng Zhai**,Yang Weng, John Dirkman, and Ying-Cheng Lai. "Heterogeneous reinforcement learning for defending power grids against attacks," *APL Machine Learning*, **2**, 026121, (2024).

[8] Mohammadamin Moradi, **Zheng-Meng Zhai**,Aaron Nielsen, and Ying-Cheng Lai. "Random forests for detecting weak signals and extracting physical information: A case study of magnetic navigation," *APL Machine Learning*, **2**, 016118, (2024).

[7] **Zheng-Meng Zhai**, Mohammadamin Moradi, Bryan Glaz, Mulugeta Haile, and Ying-Cheng Lai. "Machine-learning parameter tracking with partial state observation," *Physical Review Research*, **6**, 013196, 1-19 (2024).

[6] **Zheng-Meng Zhai**, Mohammadamin Moradi, Ling-Wei Kong, Bryan Glaz, Mulugeta Haile, and Ying-Cheng Lai. "Model-free tracking control of complex dynamical trajectories with machine learning," *Nature Communications*, **14**, 5968, 1-11 (2023). Highlighted as a Featured Article

[5] **Zheng-Meng Zhai**, Ling-Wei Kong, and Ying-Cheng Lai. "Emergence of a resonance in machine learning," *Physical Review Research*, **5**, 033127, 1-12 (2023).

[4] **Zheng-Meng Zhai**, Mohammadamin Moradi, Ling-Wei Kong, and Ying-Cheng Lai. "Detecting Weak Physical Signal from Noise: A Machine-Learning Approach with Applications to Magnetic-Anomaly-Guided Navigation," *Physical Review Applied*, **19**, 034030, 1-18 (2023).

[3] Yong-Shang Long, **Zheng-Meng Zhai**, Ming Tang, Ying Liu, and Ying-Cheng Lai. "Structural position vectors andsymmetries in complex networks," *Chaos*, **32**, 093132, 1-24 (2022). Featured in Scilight

[2] Yong-Shang Long, **Zheng-Meng Zhai**, Ming Tang, and Ying-Cheng Lai. "Metamorphoses and explosively remote synchronization in dynamical networks ," *Chaos*, **32**, 043110, 1-10 (2022).

[1] **Zheng-Meng Zhai**, Yong-Shang Long, Ming Tang, Zonghua Liu, and Ying-Cheng Lai. "Optimal inference of the start of COVID-19," *Physical Review Research*, **3**, 013155, 1-12 (2021).

Research

Meta-learning in ecological systems with limited data

- A fundamental challenge in developing data-driven approaches to ecological systems is the paucity of observational or measurement data. We develop a meta-learning based framework to reconstruct the "dynamical climate" of the ecological system with only limited data. Three benchmark population models in ecology, namely the Hastings-Powell model, food chain, and Lotka-Volterra system, and two benchmark real-world ecological datasets, namely the gut microbial dataset and global population dynamics database are used to demonstrate the performance of the meta-learning based prediction framework.

Trajectories tracking control with machine learning

- We develop a model-free, machine-learning framework to control a two-arm robotic manipulator using only partially observed states, where the controller is realized by reservoir computing. Stochastic input is exploited for training. By so doing, the model trained on "random-walk" like signals can then effectively track a variety of periodic and chaotic signals in the testing phase.

Dynamics reconstruction with no training data on target system

- We develop a hybrid transformer and reservoir-computing machine-learning scheme. A number of known chaotic systems are used to train the transformer, during which the target systems are never exposed to it. In testing, random and sparse observations from the target system are provided to the well-trained transformer to recover its dynamics. In experiments on unseen target systems, the reconstruction accuracy is even high with the available data only 20%.

Talks

APS March Meeting 2024 **March 2024**
Tracking parameter in nonlinear dynamical systems using machine learning *Minneapolis, Minnesota, USA*

APS March Meeting 2023 **March 2023**
Model-free tracking control of regular and chaotic trajectories with machine learning *Las Vegas, Nevada, USA*

The 16th Chinese Conference on Complex Networks **October 2020**
When did COVID-19 start? - Time zero inference *Anqing, Anhui, China*

Service

Journal Reviewer: Nature Communications, Physical Review X, Physical Review X Energy, Physical Review Applied, IEEE Transactions on Neural Networks and Learning Systems, IEEE Transactions on Artificial Intelligence, Neurocomputing, etc.

News and Media Coverage

- Helping robots follow a new path, *Nanowerk* (Oct. 2023)
- Helping robots follow a new path, *ASU News* (Oct. 2023)
- Machine learning research enables Robots to traverse flexible, complex trajectories, *Wisdom of Science* (Oct. 2023)
- Nat. Commun. Express: Model-free tracking control of complex dynamic trajectories based on machine learning, *Swarma Club* (Oct. 2023)
- Nat. Commun. Express: Model-free tracking control of complex dynamic trajectories based on machine learning, *The Paper* (Oct. 2023)
- Nature Communications: Model-free tracking control of complex dynamic trajectories based on machine learning, *AI Energy* (Sept. 2023)
- 'Time Zero' tool adds dimension to COVID-19 arrival, spread and mutations, *ASU News* (Feb. 2021)

References

- Prof. Ying-Cheng Lai, Arizona State University (Ph.D. Advisor).
- Prof. Ming Tang, East China Normal University (Master Advisor).