Lingwei Zhu

Postdoc fellow, Department of Computing Science
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Research Interests

Machine Learning, application of machine learning to real-world problems such as healthcare, automation, industrial control (using reinforcement learning).

Education

Postdoc Fellow — *supervisor: Martha White*
RLAI Lab, University of Alberta, Canada 2022-2024

Ph.D. with the Best Student Honor — *supervisor: Takamitsu Matsubara*
Robot Learning Lab, Nara Institute of Science and Technology, Japan 2019-2022
Thesis title: Entropy regularization for scalable, safe and robust reinforcement learning

Master of Engineering — *supervisor: Takamitsu Matsubara*
Robot Learning Lab, Nara Institute of Science and Technology, Japan 2017-2019
Thesis title: RL for Large-scale Process Control: application to vinyl acetate monomer process

Bachelor of Engineering
Tianjin Polytechnic University, China 2013-2017

Selected Publications

Reinforcement Learning

- **Cautious Policy Programming: Exploiting KL Regularization for Monotonic Policy Improvement in RL**, *Lingwei Zhu, T. Matsubara*, 2023, Machine Learning
- **Scalable reinforcement learning for plant-wide control of vinyl acetate monomer process**, *Lingwei Zhu, et al.*, 2020, Control Engineering Practice
- **Alleviating parameter-tuning burden in RL for large-scale process control**, *Lingwei Zhu, et al.*, 2022, Computers and Chemical Engineering
- **Dynamic actor-advisor programming for scalable safe reinforcement learning** (IEEE chapter award), *Lingwei Zhu, Y. Cui, T. Matsubara*, 2020, IEEE International Conference on Robotics and Automation (ICRA)
- **Cyclic policy distillation: Sample-efficient sim-to-real reinforcement learning with domain randomization**, *Y. Kadokawa, Lingwei Zhu, Y. Tsurumine, T. Matsubara,* 2023, Robotics and Autonomous Systems

AI for Science

(† indicates joint first authors)

- **Automated cancer subtyping via vector quantization mutual information maximization**, *Z. Chen†, Lingwei Zhu†, et al.*, 2022, European Conference on Machine Learning (ECML)
- **Multi-tier platform for cognizing massive electroencephalogram**, *Z. Chen†, Lingwei Zhu†, et al.*, 2022, International Joint Conference on Artificial Intelligence (IJCAI)
- **Hierarchical Categorical Generative Modeling for Multi-omics Cancer Subtyping**, *ZW. Yang†, Lingwei Zhu†, et al.*, 2022, International Conference on Bioinformatics and Biomedicine (BIBM)
- **Learning vector quantized representation for cancer subtypes identification**, *Z. Chen†, Z. Yang†, Lingwei Zhu†, et al.*, 2023, Computer Methods and Programs in Biomedicine
- **Automated sleep staging via parallel frequency-cut attention**, *Z. Chen, Z. Yang, Lingwei Zhu, et al.*, 2023, IEEE Transactions on Neural Systems and Rehabilitation Engineering

Patents

Inventor of apparatus, method, program and recording medium

- **United States patent Patent Number US20200057416A1**, *T Matsubara, Y. Cui, Lingwei Zhu, et al.*,
- **European patent; Patent Number EP3620868A1**, *T Matsubara, Y. Cui, Lingwei Zhu, et al.*,
- **Chinese patent; Patent Number CN110837893A**, *T Matsubara, Y. Cui, Lingwei Zhu, et al.*,
- **Japanese patent; Patent Number JP2020027556A**, *T Matsubara, Y. Cui, Lingwei Zhu, et al.*,

Awards and Honors

Best Ph.D. student honor, Nara Institute of Science and Technology, 2022

National Scholarships:

- Japanese Society for Promotion of Science - DC2, (83/416, $\sim$ 19.8%), 2021-2022
- Japanese Government Scholarship (MEXT), 2020-2021

IEEE Kansai Chapter Paper Award, 2020
Awarded to *Dynamic actor-advisor programming for scalable safe reinforcement learning*

Research Experience

Scalable, Safe and Robust Reinforcement Learning (2017 - Present)
My research focus in reinforcement learning has been on developing sample-efficient and safe algorithms that can be applied to complex real-world systems, such as robots or industrial plants. Currently there are still many obstacles blocking the deployment of RL algorithms to these real-world systems. Among them are (1) RL agents usually interact with the environment in a deterministic manner. However, the environment itself may be stochastic; (2) for the agent to learn we need to employ function approximators, which are guaranteed to bring errors and bias; (3) the trial-and-error learning inherent to RL can result in particularly bad performance at some points. Therefore, even at the end the agent could learn to interact with the environment optimally, its learning process happening on the real system can be detrimental to both the agent itself (e.g. robots) and its surroundings (e.g. the plant). My approach has been using developing **entropy regularization** monotonically improving algorithms to address the issues above. Theoretically, these algorithms have provably smoothed and safe behaviors, with the degree of smoothness and safety controlled by the choice of entropy regularizer. One of my current research direction lies in investigating more general entropy regularizers beyond the conventional Shannon entropy and Kullback-Leibler divergence. Entropy regularization has been the recurring theme of my published applications on plants and robotics.

Reinforcement Learning in Industry (2017 - Present)
As a postdoc in the RLAI lab, University of Alberta, I am focusing on using RL to automatically control a water plant located in Drayton valley, Alberta, responsible for producing daily household water. During my Ph.D. time, I researched entropy regularized RL algorithms for improving production and stability of a chemical (vinyl acetate monomer) manufacturing plant. My proposed algorithm successfully realized plant-wide control of the plant and improved production rate in a very sample-efficient manner. This success has been featured by multiple international patents and press releases, and the algorithm has been deployed to a recent product of the Yokogawa eletric corporation.

AI for Science (2021 - Present)
I have been cooperating with researchers in Osaka University focusing on leveraging machine learning to better understand medical problems such as cancer subtyping, brain activity cognition, etc. For the cooperation, I mostly contribute the technical part of machine learning algorithms. My past projects include analyzing EEG signals for sleep stages classification by spiking neural networks; identifying cancer subtypes by the use of unsupervised latent variable models to extract informative features from transcriptomics data. I am interested in pursuing further the direction of utilizing cutting-edge machine learning techniques for real-world problems.

Ongoing Projects

Heart disease as anormaly detection
We are researching using diffusion probabilistic models to automatically detect arrhythmia or irregular heart rhythms and diagnose heart disease. This project is in cooperation with the Osaka hospital.

Drug resistancy prediction from binary urinary tract infections records
We are researching effective machine learning methods to predict drug resistancy labels given completely binary data from massive electronic health record, which comprises urine cultures for antibiotic drug resistance testing from over 110,000 patients with urinary tract infections (UTI) treated at Massachusetts General Hospital.

Handling Missing Data
Real-world datasets often come with missingness. As an example, gene expression data that can be used to predict disease types frequently contain missing values. We are researching various deep learning techniques to handle high dimensional missing datasets such as those from The Cancer Genome Atlas Program (TCGA).

Personal Information

Languages: fluent English, semi-fluent Japanese, native Chinese
Citizenship: Chinese