Yifan (Rico) Zhu

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RESEARCH INTERESTS

Interpretable machine learning, group symmetric models, deep learning theory, AI for science.

EDUCATION

B.S. in Computer Science, **AI & ML Concentration** — **Duke University**
B.S. in Mathematics — **August 2021 - May 2025**

- **GPA:** 3.87/4.0, Dean's List x3.
- **Graduation with Highest Distinction, Computer Science Department.**
  Thesis: *A Lorentz-Equivariant Diffusion Model for High-Energy Physics.* Advisor: Simon Mak.
- **Relevant Coursework:** Graduate – Machine Learning, Deep Learning, Advanced Deep Learning, NLP, Theory of Deep Learning, Advanced Algorithms, Geometric Algorithms. Undergraduate – Topological Data Analysis, Abstract Algebra, Real Analysis, Topology.

PUBLICATIONS

Conference

Ni-Hahn, S., Xu, W., Yin, J., **Zhu, R.,** Mak, S., Jiang, Y., Rudin, C. (2024). A New Dataset, Notation Software, and Representation for Computational Schenkerian Analysis. In *Proceedings of the 24th International Society for Music Information Retrieval Conference.*

Hahn, S., Yin, J., **Zhu, R.,** Xu, W., Mak, S., Jiang, Y., Rudin, C. (2024). SentHYMNent: An Interpretable and Sentiment-Driven Model for Algorithmic Melody Harmonization. In *Proceedings of the 30th ACM SIGKDD Conference on Knowledge Discovery and Data Mining* (pp. 5050-5060).

Hahn, S., **Zhu, R.**, Mak, S., Rudin C., Jiang, Y. (2023). An Interpretable, Flexible, and Interactive Probabilistic Framework for Melody Generation. In *Proceedings of the 29th ACM SIGKDD Conference on Knowledge Discovery and Data Mining* (pp. 4089-4099).

Demos

Hahn, S., **Zhu, R.,** Yin, J., Jiang, Y., Mak, S., Rudin, C. (2023) "New Orleans: An Adventure In Music." *NeurIPS, Creative AI Track.* [Demo of sentiment-driven music generative model, integrated into the backend engine of a video game set in New Orleans to create dynamic background music].

Competitions

Robosub 2023: *Oogway: Designing, Implementing, and Testing an AUV for Robosub 2023.* **Placed 2nd out of 34 teams on Technical Design Report.**

Robosub 2022: *CTHULHU: The Design and Implementation of the Duke Robotics Club's 2022 RoboSub Competition Entry.* **Best Report Award at competition.**

RESEARCH EXPERIENCE

Theory of In-Context Learning — **Research Assistant**
Supervisor: Rong Ge — May 2024 - Present

- Theoretical analysis on the emergence of in-context and in-weights learning in a two-layer transformer network; analysis includes in-depth derivations of the model training dynamics in a synthetic setting, as well as conjectures and proofs for the optimal model weights.

JETSCAPE Collaboration, **Research Assistant**
Lawrence Berkeley National Lab January 2024 - May 2025
Supervisors: Simon Mak (Duke), Peter Jacobs (LBNL)

- High-energy physics collaboration for developing emulators of relativistic heavy-ion collisions using Bayesian methods and machine learning.
- Developing symmetry-aware diffusion models to emulate e^+e^- collision events with relativistic constraints.

Interpretable Machine Learning Lab **Research Assistant**
Supervisors: Cynthia Rudin, Simon Mak, Yue Jiang December 2022 - May 2025

- Developed a group theoretic formulation of music theory and corresponding graphical representation of musical domain knowledge.
- Designed: (1) graph neural networks to generate musical analyses with architectural guarantees for transposition-invariance, (2) interpretable generative models for composition which incorporate other forms of music-theoretic inductive biases.

ATLAS Collaboration, CERN **Research Internship**
Supervisor: Ayana Arce May 2022 - September 2022

- Investigated the application of graph neural networks for particle-flow reconstruction as an efficient alternative to the Particle Flow algorithm.

TEACHING EXPERIENCE

Data Structures & Algorithms **Head Teaching Assistant**
CS 201, Duke University January 2024 - May 2025
Developed back-end course infrastructure (autograders, gradescope server, Slack bots) and advised project designs for Duke University's largest undergraduate computer science course. Held weekly office hours sessions and recitations with 30+ students.

Design & Analysis of Algorithms **Teaching Assistant**
CS 330, Duke University January 2024 - May 2025

Mathematics of Machine Learning **Homework Grader**
Math 466, Duke University January 2025 - May 2025

High Dimensional Data Analysis **Homework Grader**
Math 465, Duke University August 2024 - December 2024

Data Structures & Algorithms **Teaching Assistant**
CS 201, Duke University August 2022 - December 2023

TECHNICAL SKILLS

Languages: Python, Java, C++, C, Bash, SQL, HTML, CSS, Javascript.
Frameworks: Pytorch, Pytorch Geometric, Jax, Keras, Scikit-learn, Giotto TDA, Matplotlib, ROS, ROOT, Vue.js.
Platforms: Linux, Docker, Slurm.