Kaiyuan Tan

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Computer Science Ph.D. candidate at Vanderbilt University (expected DEC 2027) building generative world models for physical AI. Develops diffusion models in Python and PyTorch to forecast motion from sparse observations and uses Gaussian processes for Bayesian uncertainty quantification (UQ).

Industry Experience

Shanghai Kelai Mechatronics Engineering Co., Ltd. | Shanghai, China

Software Engineering Intern, Robotics Automation | Jun 2018 – Aug 2018

- Wrote control code that automated debugging steps during commissioning of a tobacco-packaging robot.

Hongta Securities Co., Ltd. | Kunming, Yunnan, China

Client Relationship Manager Intern | Jun 2017 – Aug 2017

- Participated in branch research meetings to learn how analysts evaluate investments.

Research Experience

Vanderbilt University | Research Associate Student | Aug 2023 – Present

- **PHDME | Physics-informed diffusion.** Designed a diffusion model to forecast physically consistent trajectories from sparse observations without requiring the full governing equations.
- Implemented the model in PyTorch and reduced forecast mean squared error by 28% on string dynamics and 11% on shallow water versus standard diffusion (DDPM). Fit a Gaussian process to 20 observed trajectories per benchmark to generate 10,000 synthetic training trajectories.
- Generated 10,000 trajectories in 33 min 23 s using batched GPU inference on Linux. Built a SQL database of high-speed spring video measurements and plotted observed and predicted trajectories in Python to check how closely the model tracked the spring over time.
- **PyGpPHs | C++ / Python integration.** Wrote and compiled the C++ covariance kernel for Gaussian process models of physical dynamics. Python calls the kernel via ctypes. github.com/Beckers-Lab/PyGpPhs
- **NAPI-MPC | Model predictive control.** Co-developed a neural controller using offline MPC solutions from the GP-dPHS dynamics model developed in prior first-author work. In a nonlinear string simulation, mean inference time was 0.75 ms versus 65 s for the scenario MPC solver.
- **CIPHER | Representation learning.** Evaluated forecasts on 10 clean and noisy datasets, including position traces and video. The team's model uses contrastive learning and a neural ODE to infer dynamics from partial observations, then fits a port-Hamiltonian model.
- **PnP-PIML | Few-shot learning for robotics.** Built a model to forecast deformable obstacle motion from a short video of a real spring. Used conformal prediction for out-of-distribution (OOD) detection and Gaussian processes for Bayesian learning of the spring's energy function and uncertainty quantification.
- Extracted trajectories from 226-fps spring video. Switched models when LSTM errors crossed a calibrated threshold, reducing mean squared error on held-out frames relative to a retrained LSTM and a standard Gaussian process. Tracked changes through Git pull requests. github.com/Beckers-Lab/PnP-PIML
- **GP-dPHS | Dynamics simulation.** Reconstructed motion at 400 spatial locations from observations at 8 by fitting a physics-constrained Gaussian process and simulating its dynamics.

Robotics research with Prof. Yiannis Kantaros, Washington University in St. Louis

Research collaborator | Both papers published in 2025

- **Mission-driven exploration | Deep reinforcement learning (RL).** Sampled robot trajectories in ROS to evaluate deep Q-learning guided by linear temporal logic (LTL). On a four-region navigation task in unseen environments, the policy achieved 62.5% success versus 22.5% for standard DQN.
- **HERACLEs | Formal methods for LLM planning.** Used LTL to order mission subtasks for an LLM and conformal prediction to flag when it needed help. At a 95% success target, the Llama 2-13B planner achieved 97.2% mission success with a 12% help rate, versus 96.7% success and 78% help for KnowNo.

Washington University in St. Louis | Research Associate Intern | May 2023 – Jul 2023

- Built Python workflows for model evaluation and shared robustness results with the research team.

Washington University in St. Louis | Research Associate Student | Jun 2022 – May 2023

- **TA4TP | Trajectory predictor robustness.** Designed and implemented a constrained optimization benchmark for GRIP++ and Trajectron++ on nuScenes and Apolloscape. Switching from gradient descent to Adam cut mean optimization time by 42–75% across four model/dataset pairs at a 100-iteration cap.

Technical Skills

Languages and tools: Python (primary), C++, C, SQL, PyTorch (CUDA), Linux, ROS, Git and pull requests.

AI-assisted development: Use Codex and Claude to develop code and check changes against specifications.

Education

Vanderbilt University | Ph.D., Computer Science | Expected DEC 2027

Washington University in St. Louis | M.S., Electrical Engineering | May 2023

Sun Yat-sen University | B.Eng., Information Engineering | May 2021

Honors & Awards

Sun Yat-sen University, 2019. Selected as one of 18 students for the inaugural Information Engineering Experimental Program, a university-wide selection by the School of Systems Science and Engineering.

Publications and Preprints

Peer-reviewed publications

[1] **K. Tan**, P. Li, J. Wang, and T. Beckers. Plug-and-Play Physics-Informed Learning Using Uncertainty Quantified Port-Hamiltonian Models. IEEE ICRA, 2025.

[2] J. Wang, H. Hasanbeig, **K. Tan**, Z. Sun, and Y. Kantaros. Mission-driven Exploration for Accelerated Deep Reinforcement Learning with Temporal Logic Task Specifications. L4DC, PMLR 283:763–776, 2025.

[3] J. Wang, J. Tong, **K. Tan**, Y. Vorobeychik, and Y. Kantaros. Conformal Temporal Logic Planning using Large Language Models. ACM Transactions on Cyber-Physical Systems, 2025.

[4] P. Li, **K. Tan**, and T. Beckers. NAPI-MPC: Neural Accelerated Physics-Informed MPC for Nonlinear PDE Systems. L4DC, PMLR 283:1230–1242, 2025.

[5] **K. Tan**, P. Li, and T. Beckers. Physics-constrained learning of PDE systems with uncertainty quantified port-Hamiltonian models. L4DC, PMLR 242:1753–1764, 2024.

[6] P. Li, **K. Tan**, and T. Beckers. PyGpPHs: A Python Package for Bayesian Modeling of Port-Hamiltonian Systems. IFAC-PapersOnLine 58(6):54–59, 2024.

[7] **K. Tan**, J. Wang, and Y. Kantaros. Targeted Adversarial Attacks against Neural Network Trajectory Predictors. L4DC, PMLR 211:431–444, 2023.

[8] **K. Tan**, Z. Wang, Z. Liu, and L. Sun. Research on Full-Space Spectrum-Sharing Strategy for Massive MIMO Cognitive Radio Systems. IEEE ICCECE, 639–644, 2021.

Preprints and manuscripts under review

[9] **K. Tan**, K. Givens, P. Li, and T. Beckers. PHDME: Physics-Informed Diffusion Models without Explicit Governing Equations. arXiv:2601.21234, 2026. Under review at TMLR.

[10] P. Li, **K. Tan**, D. Moyer, and T. Beckers. Identify then Realize: Contrastive Learning of Latent Port-Hamiltonian Dynamics from Partial Observations. arXiv:2605.16682, 2026. Under review at ICLR 2027.

Google Scholar: scholar.google.com/citations?user=t4VwC_oAAAAJ