

Kai-Chieh Hsu

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I work on combining game-theoretic counterfactual reasoning and machine learning techniques for safe human-centered robotic systems.

Research Interests

Machine Learning

Safe reinforcement learning (RL), adversarial RL and safe Sim2Real transfer

Human-Robot Interaction

Generative models and inverse RL for strategy and intent inference

Multi-Agent Planning

Game-theoretic counterfactual reasoning for imaginary gameplays

Education

Princeton University (PU)

Ph.D. Candidate in Electrical and Computer Engineering

M.A. in Electrical and Computer Engineering

Princeton, NJ, USA

Sept. 2021 - June 2024 (EXPECTED)

Sept. 2019 - May 2021

- Concentration: Machine learning and Robotics
- Achieved 4.0/4.0 GPA
- Thesis Advisor: Prof. Jaime Fernández Fisac

National Taiwan University (NTU)

B.S. in Electrical Engineering

Taipei, Taiwan

Sept. 2014 - Jan. 2019

- Concentration: Signal processing and Digital IC design
- Achieved 4.19/4.30 overall GPA and ranked in **top 5%**
- Research Advisors: Prof. An-Yeu (Andy) Wu and Prof. Jean-Fu Kiang

Work Experience

Research Scientist Intern

Remote

NVIDIA Corporation (Manager: Prof. Marco Pavone, Mentor: Prof. Karen Leung, Yuxiao Chen)

May 2022 - PRESENT

- Formalize **responsibility** by safety margin decrease and policy shift with **counterfactual reasoning**
- Estimate the responsibility level online with **hidden Markov model**
- Incorporate the estimated responsibility into the **trajectory prediction** models

Research Projects

Adversarial Safety Game

PU, NJ, USA

Safe Robotics Laboratory, Prof. Jaime Fernández Fisac, Duy Phuong Nguyen

Feb. 2022 - PRESENT

- Robustify the **reachability-based RL** by jointly training an adversarial agent under the self-play spirit
- Apply a novel shielding scheme to combine both the **model-based counterfactual rollout** and model-free safety value function

Inverse Specification

PU, NJ, USA

Safe Robotics Laboratory, Prof. Jaime Fernández Fisac

July 2020 - PRESENT

- Use Bayesian optimization to infer constraints **interactively with humans** by asking for ranking feedback
- **Select queries actively** to speed up the convergence to the true preference based on information-theoretic metrics
- Survey in **inverse optimal control** and **imitation learning**

Safe Sim2Real Transfer (Sim-to-Lab-to-Real) [P1]

PU, NJ, USA

Safe Robotics Laboratory, Prof. Jaime Fernández Fisac, Duy Phuong Nguyen

Intelligent Robot Motion Lab, Prof. Anirudha Majumdar, Allen Z. Ren

May 2021 - Jan. 2022

- Use **Reachability-Based RL** and a **supervisory control** scheme to allow the least-restrictive safe exploration
- Combine with **PAC-Bayes control** to provide a tight performance lower bound to unseen environments

Reach-Avoid Reinforcement Learning [C1] [P1]

PU, NJ, USA

Safe Robotics Laboratory, Prof. Jaime Fernández Fisac

Hybrid Systems Laboratory, Prof. Claire J. Tomlin, Vicenç Rubies-Royo

July 2020 - Mar. 2021

- Derive a time-discounted formulation of the reach-avoid optimal control problem that lends itself to **(deep) RL**
- Deploy our reach-avoid Q-Learning in a range of nonlinear systems, including an **attack-defense game**
- Reach-avoid reinforcement learning allows learning from near defeat and fits in **safe reinforcement learning**

ECG Real-Time Telemonitoring [J1] [C2]

NTU, Taiwan

Access IC Lab, Prof. An-Yeu (Andy) Wu

Aug. 2017 - Mar. 2019

- **Edge Classification:** Incorporate **compressed sensing**, task-driven dictionary learning (predictive sparse coding) and PCA to render light-weighted classifier and overcome limited labeled data challenge
- **On-Demand Recovery:** Design a two-stage algorithm that classifies and reconstructs only problematic signals. This algorithm utilizes the information from classification stage to speed up the reconstruction algorithm
- **Hardware Design and Chip Implementation:** Propose a hardware architecture for on-demand recovery to allow hardware sharing between classification and reconstruction algorithms

Publications

Preprint

[P1] **K.-C. Hsu***, Allen Z. Ren*, Duy Phuong Nguyen, Anirudha Majumdar⁺, and Jaime F. Fisac⁺, **Sim-to-Lab-to-Real: Safe Reinforcement Learning with Shielding and Generalization Guarantees**, in *arXiv (preprint)*, Jan 2022. | Spotlight in **ICLR Workshop**, submitted to *Artificial Intelligence Journal*

Journal Papers

[J1] C.-Y. Chou, **K.-C. Hsu**, B.-H. Cho, K.-C. Chen and A.-Y. (Andy) Wu, **Low-Complexity On-demand Reconstruction for Compressively Sensed Problematic Signals**, in *IEEE Trans. Signal Process.*, vol. 68, pp. 4094-4107, July 2020.

[J2] **K.-C. Hsu** and J.-F. Kiang, **Joint Estimation of DOA and Frequency From A Mixture of Frequency Known and Unknown Sources with Orthogonal Coprime Arrays**, in *Sensors*, 19(2), 335, Jan. 2019.

Conference Papers

[C1] **K.-C. Hsu***, V. Rubies-Royo*, C. J. Tomlin and J. F. Fisac, **Safety and Liveness Guarantees through Reach-Avoid Reinforcement Learning**, in *Proceedings of Robotics: Science and Systems (RSS)*, Held Virtually, July 2021.

[C2] **K.-C. Hsu***, B.-H. Cho*, C.-Y. Chou and A.-Y. (Andy) Wu, **Low-Complexity Compressed Analysis in Eigenspace with Limited Labeled Data for Real-Time Electrocardiography Telemonitoring**, in *IEEE GlobalSIP*, Anaheim, USA, Nov. 2018.

Honors & Awards

2021–2022 Teaching Assistant Award

Dept. of ECE, PU, NJ, USA

- For the new *Intelligent Robotic Systems* course

Sept. 2022

3rd Prize

in Integrated Circuit Design Contest

Ministry of Education, Taiwan


- Out of about 300 teams

July 2018

2nd Prize

in Taiwan Creative Electromagnetic Implementation Competition

High-speed RF and mm-Wave Tech. Center, Taiwan

- Under the supervision of Prof. Tzong-Lin Wu | 

Aug. 2017

8th place

in Data Structure and Programming Contest

Cadence, Taiwan

- Out of about 250 students

Mar. 2017

Graduate Representative

in NTUEE graduate ceremony

Dept. of EE, NTU, Taiwan

- Given to top ten students of four years

June 2018

Professor Chun-Hsiung Chen Scholarship

Electromagnetic Industry-Academia Consortium, Taiwan

- Rewarded outstanding performances in electromagnetic fields

Jan. 2018

Presidential Awards

Dept. of EE, NTU, Taiwan

- Given to top ten students of that semester

second semester of 2014 and 2016

Research & Teaching Experiences

Teaching Assistant

ECE346/566: Intelligent Robotic Systems, Prof. Jaime Fernández Fisac
ELE364: Machine Learning for Predictive Data Analytics, Prof. Niraj Jha

PU, NJ, USA
Jan. 2022 - May 2022
Sept. 2020 - Dec. 2020

Research Assistant

Access IC Lab, Prof. An-Yeu (Andy) Wu
Group of Electromagnetic Applications, Prof. Jean-Fu Kiang

NTU, Taiwan
Feb. 2018 - Mar. 2019
Feb. 2017 - Mar. 2019

Teaching Assistant

Digital System Design

NTU, Taiwan
Feb. 2018 - June 2018

Professional Activities

Reviewer Artificial Intelligence, IEEE Open Journal of Control Systems, IEEE Transactions on Vehicular Technology, IETE Technical Review, IEEE Transactions on Signal Processing, Conference on Information Sciences and Systems

Skills

- **Program Languages** Python, MATLAB, Verilog, C++
- **Others** PyTorch, Git, SLURM, NumPyro, CVX, \LaTeX