

Guan-Horng Liu

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RESEARCH INTERESTS

Deep learning, stochastic optimal control theory, score-based/diffusion generative models, scalable higher-order optimization, Hamilton-Jacobi Bellman principle, forward-backward stochastic differential equations, information-theoretic control, differential geometry.

EDUCATION

- **Georgia Institute of Technology** Atlanta, GA
Ph.D. in Machine Learning (GPA: 4.0/4.0) from 08/2019
 - Research on Deep Learning and Stochastic Optimal Control Theory
 - Received ICLR'21 Spotlight, ICML'21 Oral, NeurIPS'21 Spotlight, and NeurIPS'22 Oral
- **Carnegie Mellon University** Pittsburgh, PA
M.S. in Robotics (GPA: 4.0/4.0) 05/2017
 - Thesis: High-dimensional planning and learning for off-road driving
- **Tokyo Institute of Technology** Tokyo, Japan
Research Exchange Program (GPA: 4.0/4.0) 06/2015
 - Tech report: Autonomous navigation of the unmanned surface vehicle
- **National Taiwan University** Taipei, Taiwan
B.S. in Mechanical Engineering (GPA: 3.99/4.0) 06/2014
 - Graduated Cum Laude; Best Paper Award in 2013 IEEE/SICE ISS.

PUBLICATIONS LIST

- Conference Papers (*Equal contribution)
- [1] **G.-H. Liu**, T. Chen*, O. So*, and E. A. Theodorou, “Deep Generalized Schrödinger Bridge,” in *Conference on Neural Information Processing Systems (NeurIPS)*, 2022 (**Oral presentation**)
 - [2] T. Chen*, **G.-H. Liu***, and E. A. Theodorou, “Likelihood Training of Schrödinger Bridge using Forward-Backward SDEs Theory,” in *International Conference on Learning Representations (ICLR)*, 2022
 - [3] **G.-H. Liu**, T. Chen, and E. A. Theodorou, “Second-Order Neural ODE Optimizer,” in *Conference on Neural Information Processing Systems (NeurIPS)*, 2021 (**Spotlight presentation**)
 - [4] **G.-H. Liu**, T. Chen, and E. A. Theodorou, “Dynamic Game Theoretic Neural Optimizer,” in *International Conference on Machine Learning (ICML)*, 2021 (**Oral presentation**)
 - [5] **G.-H. Liu**, T. Chen, and E. A. Theodorou, “Differential Dynamic Programming Neural Optimizer,” in *International Conference on Learning Representations (ICLR)*, 2021 (**Spotlight presentation**)
 - [6] Z. Wang*, O. So*, J. Gibson, B. Vlahov, M. S. Gandhi, **G.-H. Liu**, and E. A. Theodorou “Variational Inference MPC using Tsallis Divergence,” in *Robotics: Science and Systems (RSS)*, 2021
 - [7] **G.-H. Liu**, A. Siravuru, S. Prabhakar, M. Veloso, and G. Kantor, “Learning End-to-end Multimodal Sensor Policies for Autonomous Navigation,” in *Conference on Robot Learning (CoRL)*, 2017

- [8] **G.-H. Liu**, A. Y. Yasutomi, A. Holgado, and E. F. Fukushima, “Autonomous Control of the WAM-V Catamaran Type Unmanned Surface Vehicle: Propulsion System Design,” in *Annual Conference of the Robotics Society of Japan*, 2014
- [9] **G.-H. Liu**, H.-Y. Lin, H.-Y. Lin, S.-T. Chen, and P.-C. Lin, “Design of a kangaroo robot with dynamic jogging locomotion,” in *Proceedings of the 2013 IEEE/SICE International Symposium on System Integration (ISS)*, 2013 (**Best paper award**)
- Journal Papers
 - [10] **G.-H. Liu**, H.-Y. Lin, H.-Y. Lin, S.-T. Chen, and P.-C. Lin, “A bio-inspired hopping kangaroo robot with an active tail,” in *Journal of Bionic Engineering (JBE)*, 2014
- Preprints
 - [11] E. N. Evans, O. So, A. P. Kendall, **G.-H. Liu**, and E. A. Theodorou, “Spatio-Temporal Differential Dynamic Programming for Control of Fields,” *preprint arXiv:2104.04044*, 2021
 - [12] **G.-H. Liu**, T. Chen, and E. A. Theodorou, “A Differential Game Theoretic Neural Optimizer for Training Residual Networks,” *preprint arXiv:2007.08880*, 2020
 - [13] **G.-H. Liu** and E. A. Theodorou, “Deep Learning Theory Review: An Optimal Control and Dynamical Systems Perspective,” *preprint arXiv:1908.10920*, 2019
- Workshop Papers & Technical Reports
 - [14] T. Chen*, **G.-H. Liu***, and E. A. Theodorou, “Likelihood Training of Schrödinger Bridge using Forward-Backward SDEs Theory,” in *NeurIPS Wrokshop: Optimal Transport and Machine Learning*, 2021
 - [15] **G.-H. Liu**, T. Chen, and E. A. Theodorou, “Differential Dynamic Programming Neural Optimizer,” in *NeurIPS Wrokshop: Optimization for Machine Learning*, 2020 (**Spotlight presentation**)
 - [16] **G.-H. Liu**, A. Siravuru, S. Prabhakar, G. Kantor, and M. Veloso, “Multi-modal Deep Reinforcement Learning with a Novel Sensor-based Dropout,” in *Multi-disciplinary Conference on Reinforcement Learning and Decision Making*, 2017
 - [17] **G.-H. Liu**, “High Dimensional Planning and Learning for Off-Road Driving,” *CMU Robotics Institute Master Thesis*, 2017

HONERS & AWARDS

- **NeurIPS 2022 Oral**, acceptance rate 1.9% 10/2022
- **Graduate Research Fellowship**, Aerospace Engineering, Georgia Tech 08/2022 – 06/2023
- **NeurIPS 2021 Spotlight**, acceptance rate 3% 09/2021
- **ICML 2021 Oral**, acceptance rate 3% 05/2021
- **ICLR 2021 Spotlight**, acceptance rate 3.8% 01/2021
- **Graduate Scholarship**, Ministry of Education, Taiwan 08/2019 – 07/2021
- **ISS 2013 Best Paper Award**, acceptance rate < 0.8% 12/2013
- **Third Prize**, Chuian-Yan Technical Thesis Paper Competition, Taipei, Taiwan 10/2013
- **Third Prize**, NTU Robot Design Competition, Taipei, Taiwan 04/2012
- **Japan Student Service Organization Scholarship**, government scholarship 11/2013
- **Presidential Awards (Received 4 times)**, Top 5% in class, NTU 09/2009 – 06/2014

SEMINAR TALKS & LECTURES

- **Generalized Schrödinger Bridge: from Generative Models to Mean-Field Games**
NeurIPS 2022 Score-Based Methods Workshop, invited talk 12/2022
The Alan Turing Institute (Rough Path Interest Group), invited talk 11/2022
IBM Research Seminar, invited talk 11/2022
- **Likelihood Training of Schrödinger Bridge using FBSDEs Theory**
Learning on Graphs and Geometry Reading Group, invited talk 02/2023
Molei Tao Reading Group (Georgia Tech Math), invited talk 11/2021
- **Higher-Order Optimization of Neural ODEs via Optimal Control Principle**
The Alan Turing Institute (Rough Path Interest Group), invited talk 12/2021
- **Optimal Control Theoretic Neural Optimizer**
Georgia Tech Machine Learning PhD Seminar, contributed talk 10/2021
- **Differential Dynamic Programming Neural Optimizer**
AE4803 Robotic Systems and Autonomy, guest lecture 10/2022
Neural 2020 Optimization for Machine Learning Wrokshop, contributed talk 12/2020

RESEARCH EXPERIENCES

- **Georgia Institute of Technology** Atlanta, GA
Graduate Research Assistant from 08/2019
Advisor: Evangelos A. Theodorou
 - Developed scalable numerical solvers grounded on Schrödinger bridge for mean-field games [1]
 - Generalized score-based generative models with Schrödinger bridge [2]
 - Derived a new higher-order computation framework for training Neural ODEs [3]
 - Proposed a new game-theoretic optimizer for cooperative (*i.e.* Nash) training [4]
 - Presented a new DNN optimizer with control-theoretic (*i.e.* Bellman) optimality [5]
 - Aligned existing deep learning theory through optimal control principle [13]
- **NVIDIA Research** remote
Research Intern 05/2022 – 08/2022
Mentors: Weili Nei, Arash Vahdat, De-An Huang, and Anima Anandkumar
 - Robst diffusion models based on Schrödinger Bridge.
- **Uber Advanced Technology Group** Pittsburgh, PA
Robotics Research Engineer 09/2017 – 12/2018
Mentors: Mike Phillips and Tony Stentz
 - Developed motion planning algorithm and software libraries for self-driving vehicles
 - Designed modules that quantify safe and comfortable autonomous lane changing behavior
 - Modeled human preference and generated motion primitives for trajectory optimization
- **Carnegie Mellon University** Pittsburgh, PA
Graduate Research Assistant 09/2015 – 07/2017
Advisor: George Kantor
 - Proposed a stochastic technique for sensor fusion in multimodal deep reinforcement learning [7]
 - Improved performance in noisy environments from 50% to 10% on simulation of racing car [16]
 - Constructed an off-road terrain traversability by learning human preference from demonstration [17]
 - Built off-road high-speed maneuvering planner on a full-size all-terrain vehicle

- **Aptiv Mobility Group** Pittsburgh, PA
Robotics Research Intern 06/2016 – 08/2016
Mentor: Wenda Xu
 - Developed a parking planner using strategy-guided finite state machine as searching template
 - Developed an advanced planner interface for exhaustive testing and drag-and-drop reconfiguration
 - Researched human-like driving strategies using inverse reinforcement learning algorithm

- **Tokyo Institute of Technology** Tokyo, Japan
Graduate Research Assistant 09/2013 – 06/2014
Advisor: Edwardo F. Fukushima
 - Developed autonomous navigation algorithms to compete in Maritime Robotx Challenge
 - Designed wave-adaptive propulsion system and power configuration [8]

- **National Taiwan University** Taipei, Taiwan
Undergraduate Research Assistant 01/2012 – 10/2013
Advisor: Pei-Chun Lin
 - Built independently-designed kangaroo robot with dynamic jogging characteristic [9]
 - Derived dynamic robot leg movement based on reduced-order dynamic model [10]