Guan-Horng Liu

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RESEARCH INTERESTS

Deep learning optimization, 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 ICLR2021 Spotlight, ICML2021 Oral, and NeurIPS2021 Spotlight

- **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

[1] **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)

[2] **G.-H. Liu**, T. Chen, and E. A. Theodorou, "Dynamic Game Theoretic Neural Optimizer," in *International Conference on Machine Learning (ICML)*, 2021 (Oral presentation)

[3] **G.-H. Liu**, T. Chen, and E. A. Theodorou, "Differential Dynamic Programming Neural Optimizer," in *International Conference on Learning Representations (ICLR)*, 2021 (Spotlight presentation)

[4] 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

[5] **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

[6] **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

[7] **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

  [8] **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 (*Equal contribution)

  [9] T. Chen*, **G.-H. Liu***, and E. A. Theodorou, "Likelihood Training of Schrödinger Bridge using Forward-Backward SDEs Theory," *arXiv preprint arXiv:2110.11291*, 2021

  [10] E. N. Evans, O. So, A. P Kendall, **G.-H. Liu**, and E. A. Theodorou, "Spatio-Temporal Differential Dynamic Programming for Control of Fields," *arXiv preprint arXiv:2104.04044*, 2021

  [11] **G.-H. Liu** and E. A. Theodorou, "Deep Learning Theory Review: An Optimal Control and Dynamical Systems Perspective," *arXiv preprint arXiv:1908.10920*, 2019

- Workshop Papers & Technical Reports

  [12] 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

  [13] **G.-H. Liu**, T. Chen, and E. A. Theodorou, "Differential Dynamic Programming Neural Optimizer," in *NeurIPS Wrokshop: Optimization for Machine Learning*, 2020 (Spotlight presentation)

  [14] **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

  [15] **G.-H. Liu**, "High Dimensional Planning and Learning for Off-Road Driving," *CMU Robotics Institute Master Thesis,* 2017

HONERS & AWARDS

- **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*
- **Best Paper Award**, IEEE/SICE International Symposium on System Integration *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

- **Higher-Order Optimization of Neural ODEs via Optimal Control Principle** *12/2021*
  DataSig: Rough Path Interest Group, invited talk
- **Likelihood Training of Schrödinger Bridge using Forward-Backward SDEs Theory** *11/2021*
  Dr. Molei Tao's Reading Group, invited talk
- **Optimal Control Theoretic Neural Optimizer** *10/2021*
  GaTech ML PhD Seminar, contributed talk

RESEARCH EXPERIENCES

- **Georgia Institute of Technology** Atlanta, GA
  Graduate Research Assistant from 08/2019
  Advisor: Evangelos A. Theodorou
  - Aligned existing deep learning theory through optimal control principle [11]
  - Presented a new DNN optimizer with control-theoretic (*i.e.* Bellman) optimality [3]
  - Proposed a new game-theoretic optimizer for cooperative (*i.e.* Nash) training [2]
  - Derived a new higher-order computation framework for training Neural ODEs [1]
  - Generalized score-based generative models with Schrödinger bridge [9]
  - Constructed connection between statistical inference and model-predictive control [4]
  - Facilitated optimal control algorithms for field PDE dynamics, *e.g.* fluid [10]

- **Uber Advanced Technology Group** Pittsburgh, PA
  Robotics Research Engineer 09/2017 – 12/2018
  Mentors: Mike Phillips, 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 [5]
  - Improved performance in noisy environments from 50% to 10% on simulation of racing car [14]
  - Constructed an off-road terrain traversability by learning human preference from demonstration [15]
  - 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 [6]

- **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 [7]
  - Derived dynamic robot leg movement based on reduced-order dynamic model [8]