

Ching-An Cheng

Senior Researcher
Microsoft Research

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Research Interests

Theory, algorithms, and applications of learning and control in sequential decision making and robotics.

Reinforcement Learning · Imitation Learning · Online Learning · Meta Learning · Gaussian Processes · Variational Inference · Kernel Methods · Stochastic Optimal Control · System Identification · Force/Impedance Control · Humanoid · Exoskeleton · Manipulation · Grasping

Education

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|-----------|--|
| 2015–2019 | Ph.D. in Robotics, Georgia Institute of Technology, USA
Thesis: <i>Efficient and Principled Robot Learning: Theory and Algorithms</i>
Advisor: Byron Boots
Committee: Seth Hutchinson, Geoff Gordon, Evangelos A. Theodorou, Karen Liu |
| 2011–2013 | M.S. in Mechanical Engineering, National Taiwan University, Taiwan
Thesis: <i>Robot Dynamics Learning and Human-Robot Interaction</i>
Advisor: Han-Pang Huang |
| 2007–2011 | B.S. in Mechanical Engineering, National Taiwan University, Taiwan
B.S. in Electrical Engineering, National Taiwan University, Taiwan |

Awards and Honors

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| 2022 | Outstanding Paper Award (Runner-Up), ICML 2022 |
| 2019 | Best Paper Award, OptRL Workshop @ NeurIPS 2019 |
| 2019 | Best Student Paper Award, RSS 2019 |
| 2019 | Best Systems Paper Award (Finalist), RSS 2019 |
| 2019 | Google PhD Fellowship, Machine Learning (declined) |
| 2019 | Nvidia PhD Fellowship |
| 2018 | Best Systems Paper Award (Finalist), RSS 2018 |
| 2018 | Best Paper Award, AISTATS 2018 |
| 2015 | Government Scholarship to Study Abroad, Ministry of Education, Taiwan |
| 2014 | Excellent Project, Industrial Technology Research Institute, Taiwan |
| 2012 | Third place, HIWIN National Intelligent Robot Arm Contest, Taiwan |
| 2010 | Cheng-Tai Scholarship, Taiwan |

Publications

Journal

- 2021 C.-A. Cheng, M. Mukadam, J. Issac, S. Birchfield, D. Fox, B. Boots, and N. Ratliff. RMPflow: A geometric framework for generation of multitask motion policies. *IEEE Transactions on Automation Science and Engineering*, 18(3):968–987, 2021
- 2019 Y. Pan, C.-A. Cheng, K. Saigol, K. Lee, X. Yan, E. A. Theodorou, and B. Boots. Imitation learning for agile autonomous driving. *The International Journal of Robotics Research*, 39(2-3):286–302, 2020
- 2019 Z.-H. Kang, C.-A. Cheng, and H.-P. Huang. A singularity handling algorithm based on operational space control for six-degree-of-freedom anthropomorphic manipulators. *International Journal of Advanced Robotic Systems*, 16(3), 2019
- 2016 C.-A. Cheng and H.-P. Huang. Learn the Lagrangian: A vector-valued RKHS approach to identifying Lagrangian systems. *IEEE Transactions on Cybernetics*, 46(12):3247–3258, 2016
- 2016 S.-Y. Lo, C.-A. Cheng, and H.-P. Huang. Virtual impedance control for safe human-robot interaction. *Journal of Intelligent & Robotic Systems*, 82(1):3, 2016
- 2016 C.-A. Cheng, H.-P. Huang, H.-K. Hsu, W.-Z. Lai, and C.-C. Cheng. Learning the inverse dynamics of robotic manipulators in structured reproducing kernel Hilbert space. *IEEE Transactions on Cybernetics*, 46(7):1691–1703, 2016
- 2015 H.-P. Huang, Y.-H. Liu, W.-Z. Lin, Z.-H. Kang, C.-A. Cheng, and T.-H. Huang. Development of a p300 bci and design of an elastic mechanism for a rehabilitation robot. *International Journal of Automation and Smart Technology*, 5(2):91–100, 2015

Conference

- 2022 C.-A. Cheng*, T. Xie*, N. Jiang, and A. Agarwal. Adversarially trained actor critic for offline reinforcement learning. *International Conference on Machine Learning*, 2022 (**Outstanding Paper Award, Runner-Up**) (*equal contribution)
- 2021 T. Xie, C.-A. Cheng, N. Jiang, P. Mineiro, and A. Agarwal. Bellman-consistent pessimism for offline reinforcement learning. *Advances in neural information processing systems*, 34:6683–6694, 2021 (**Oral Presentation (<1%)**) (*equal contribution)
- 2021 C.-A. Cheng, A. Kolobov, and A. Swaminathan. Heuristic-guided reinforcement learning. *Advances in Neural Information Processing Systems*, 34:13550–13563, 2021
- 2021 N. C. Wagener, B. Boots, and C.-A. Cheng. Safe reinforcement learning using advantage-based intervention. In *International Conference on Machine Learning*, pages 10630–10640. PMLR, 2021
- 2021 A. Zanette, C.-A. Cheng, and A. Agarwal. Cautiously optimistic policy optimization and exploration with linear function approximation. In *Conference on Learning Theory*, pages 4473–4525. PMLR, 2021
- 2021 A. Li*, C.-A. Cheng*, M. A. Rana, M. Xie, K. Van Wyk, N. Ratliff, and B. Boots. RMP²: A structured composable policy class for robot learning. *Robotics: Science and Systems*, 2021 (*equal contribution)
- 2021 X. Yan, B. Boots, and C.-A. Cheng. Explaining fast improvement in online imitation learning. In *Uncertainty in Artificial Intelligence*, pages 1874–1884. PMLR, 2021
- 2020 C.-A. Cheng, A. Kolobov, and A. Agarwal. Policy improvement via imitation of multiple oracles. *Advances in Neural Information Processing Systems*, 33:5587–5598, 2020 (**Spotlight Talk (3%)**)
- 2020 A. Rahimi*, A. Shaban*, C.-A. Cheng*, B. Boots, and R. Hartley. Intra order-preserving functions for calibration of multi-class neural networks. *Advances in Neural Information Processing Systems*, 33:13456–13467, 2020 (*equal contribution)

- 2020 C.-A. Cheng, R. T. Combes, B. Boots, and G. Gordon. A reduction from reinforcement learning to no-regret online learning. In *International Conference on Artificial Intelligence and Statistics*, pages 3514–3524. PMLR, 2020
- 2020 C.-A. Cheng*, J. Lee*, K. Goldberg, and B. Boots. Online learning with continuous variations: Dynamic regret and reductions. In *International Conference on Artificial Intelligence and Statistics*, pages 2218–2228. PMLR, 2020 (*equal contribution)
- 2020 B. Wingo, C.-A. Cheng, M. Murtaza, M. Zafar, and S. Hutchinson. Extending Riemannian motion policies to a class of underactuated wheeled-inverted-pendulum robots. In *2020 IEEE International Conference on Robotics and Automation (ICRA)*, pages 3967–3973. IEEE, 2020
- 2019 C.-A. Cheng, X. Yan, and B. Boots. Trajectory-wise control variates for variance reduction in policy gradient methods. In *Conference on Robot Learning*, pages 1379–1394. PMLR, 2020 (*equal contribution)
- 2019 M. Mukadam, C.-A. Cheng, D. Fox, B. Boots, and N. Ratliff. Riemannian motion policy fusion through learnable lyapunov function reshaping. In *Conference on robot learning*, pages 204–219. PMLR, 2020
- 2019 A. Li, C.-A. Cheng, B. Boots, and M. Egerstedt. Stable, concurrent controller composition for multi-objective robotic tasks. In *2019 IEEE 58th Conference on Decision and Control (CDC)*, pages 1144–1151. IEEE, 2019
- 2019 N. Wagener*, C.-A. Cheng*, J. Sacks, and B. Boots. An online learning approach to model predictive control. *Robotics: Science and Systems*, 2019 (*equal contribution) **Best Student Paper Award; Best Systems Paper Award, Finalist**
- 2019 C.-A. Cheng, X. Yan, N. Ratliff, and B. Boots. Predictor-corrector policy optimization. In *International Conference on Machine Learning*, pages 1151–1161. PMLR, 2019 **(Long Talk (5%))**
- 2019 C.-A. Cheng, X. Yan, E. Theodorou, and B. Boots. Accelerating imitation learning with predictive models. In *The 22nd International Conference on Artificial Intelligence and Statistics*, pages 3187–3196. PMLR, 2019
- 2019 A. Shaban*, C.-A. Cheng*, N. Hatch, and B. Boots. Truncated back-propagation for bilevel optimization. In *The 22nd International Conference on Artificial Intelligence and Statistics*, pages 1723–1732. PMLR, 2019 (*equal contribution)
- 2018 C.-A. Cheng, M. Mukadam, J. Issac, S. Birchfield, D. Fox, B. Boots, and N. Ratliff. RMPflow: A computational graph for automatic motion policy generation. In *International Workshop on the Algorithmic Foundations of Robotics*, pages 441–457. Springer, 2018
- 2018 H. Salimbeni*, C.-A. Cheng*, B. Boots, and M. Deisenroth. Orthogonally decoupled variational Gaussian processes. *Conference on Neural Information Processing Systems*, 2018 (*equal contribution)
- 2018 C.-A. Cheng, X. Yan, N. Wagener, and B. Boots. Fast policy learning using imitation and reinforcement. *Conference on Uncertainty in Artificial Intelligence*, 2018 **(Plenary Presentation (9%))**
- 2018 Y. Pan, C.-A. Cheng, K. Saigol, K. Lee, X. Yan, E. Theodorou, and B. Boots. Agile off-road autonomous driving using end-to-end deep imitation learning. *Robotics: Science and Systems*, 2018 **Best Systems Paper Award, Finalist**
- 2018 C.-A. Cheng and B. Boots. Convergence of value aggregation for imitation learning. In *International Conference on Artificial Intelligence and Statistics*, volume 84, pages 1801–1809, 2018 **Best Paper Award**
- 2018 J. L. Molnar, C.-A. Cheng, L. O. Tiziani, B. Boots, and F. L. Hammond. Optical sensing and control methods for soft pneumatically actuated robotic manipulators. In *2018 IEEE International Conference on Robotics and Automation (ICRA)*, pages 3355–3362. IEEE, 2018
- 2017 C.-A. Cheng and B. Boots. Variational inference for Gaussian process models with linear complexity. In *Advances in Neural Information Processing Systems*, 2017

- 2017 M. Mukadam, C.-A. Cheng, X. Yan, and B. Boots. Approximately optimal continuous-time motion planning and control via probabilistic inference. In *IEEE International Conference on Robotics and Automation*, pages 664–671, 2017
- 2016 C.-A. Cheng and B. Boots. Incremental variational sparse Gaussian process regression. In *Advances in Neural Information Processing Systems*, pages 4410–4418, 2016
- 2015 C.-H. Chang, H.-P. Huang, H.-K. Hsu, and C.-A. Cheng. Humanoid robot push-recovery strategy based on cmp criterion and angular momentum regulation. In *IEEE International Conference on Advanced Intelligent Mechatronics*, pages 761–766. IEEE, 2015
- 2015 M.-B. Huang, H.-P. Huang, C.-C. Cheng, and C.-A. Cheng. Efficient grasp synthesis and control strategy for robot hand-arm system. In *IEEE International Conference on Automation Science and Engineering*, pages 1256–1257. IEEE, 2015
- 2013 C.-A. Cheng, H.-P. Huang, H.-K. Hsu, W.-Z. Lai, C.-C. Cheng, and Y.-C. Li. Identification of the inverse dynamics of robot manipulators with the structured kernel. In *International Automatic Control Conference*, pages 266–271. IEEE, 2013
- 2013 T.-H. Huang, C.-A. Cheng, and H.-P. Huang. Self-learning assistive exoskeleton with sliding mode admittance control. In *IEEE/RSJ International Conference on Intelligent Robots and Systems*, pages 698–703. IEEE, 2013
- 2013 C.-A. Cheng, T.-H. Huang, and H.-P. Huang. Bayesian human intention estimator for exoskeleton system. In *IEEE/ASME International Conference on Advanced Intelligent Mechatronics*, pages 465–470. IEEE, 2013
- 2012 T.-H. Huang, H.-P. Huang, C.-A. Cheng, J.-Y. Kuan, P.-T. Lee, and S.-Y. Huang. Design of a new hybrid control and knee orthosis for human walking and rehabilitation. In *IEEE/RSJ International Conference on Intelligent Robots and Systems*, pages 3653–3658. IEEE, 2012
- 2012 H.-P. Huang, Y.-H. Liu, T.-H. Huang, Z.-H. Kang, W.-Z. Lin, W. Ching-Ping, and C.-A. Cheng. Development of a brain-machine interface for motor imagination task. In *International Conference on Automation Technology*, 2012
- 2011 Y.-H. Liu, C.-A. Cheng, and H.-P. Huang. Novel feature of the EEG based motor imagery BCI system: Degree of imagery. In *International Conference on System Science and Engineering*, pages 515–520. IEEE, 2011
- 2010 C.-A. Cheng, Y.-H. Liu, and H.-P. Huang. Motor imagery recognition for brain-computer interfaces using Hilbert-Huang transform and effective event-related-desynchronization features. In *CSME National Conference*, 2010

Workshop

- 2020 A. Li*, C.-A. Cheng*, M. A. Rana, N. Ratliff, and B. Boots. RMP²: A differentiable policy class for robotic systems with control-theoretic guarantees. *NeurIPS 2020 3rd Robot Learning Workshop*, 2020
- 2019 J. Lee*, C.-A. Cheng*, K. Goldberg, and B. Boots. Continuous online learning and new insights to online imitation learning. *NeurIPS 2019 Optimization Foundations of Reinforcement Learning Workshop*, 2019 (*equal contribution) **Best Paper Award**
- 2019 C.-A. Cheng*, X. Yan*, and B. Boots. Trajectory-wise control variates for variance reduction in policy gradient method. *NeurIPS 2019 Optimization Foundations of Reinforcement Learning Workshop*, 2019
- 2018 C.-A. Cheng, X. Yan, N. Ratliff, and B. Boots. Predictor-corrector policy optimization. *Deep Reinforcement Learning Workshop NeurIPS*, 2018
- 2017 Y. Pan, C.-A. Cheng, K. Saigol, K. Lee, X. Yan, E. Theodorou, and B. Boots. Learning deep neural network control policies for agile off-road autonomous driving. *The NIPS Deep Reinforcement Learning Symposium*, 2017
- 2017 C.-A. Cheng and B. Boots. Convergence of value aggregation for imitation learning. In *The NIPS Deep Reinforcement Learning Symposium*, 2017

- 2016 C.-A. Cheng and B. Boots. Incremental variational sparse Gaussian process regression. In *NIPS Workshop on Adaptive and Scalable Nonparametric Methods in Machine Learning*, 2016

Invited Talks

- 2020 “Efficient Policy Optimization by Online Imitation Learning,” MSR AI Seminar, Microsoft Research, USA
- 2020 “Trajectory-wise Control Variates for Policy Gradient Methods,” GTC, Nvidia, USA
- 2019 “RMPflow: A Geometric Framework for Policy Fusion,” Fanuc, USA (host: Hsien-Chung Lin)
- 2019 “Learning from Past Mistakes and Future Predictions for Sequential Decision Making,” RIKEN, Osaka, Japan (host: Yoshinobu Kawahara)
- 2019 “Learning to Optimize,” NTU, Taipei, Taiwan (host: Han-Pang Huang)
- 2018 “Policy Optimization as Predictable Online Learning Problems,” Microsoft Research, Montreal, Canada (host: Geoffrey Gordon)
- 2018 “Policy Optimization as Predictable Online Learning Problems: Imitation Learning and Beyond,” Microsoft Research, Redmond, USA (host: Andrey Kolobov)

Service

- Reviewer:
JMLR · NATURE · JAIR · IEEE RA-L · IEEE TPAMI · IEEE SPL · JINT · MACH · IEEE Trans SMC Systems · NeurIPS · ICML · COLT · ICLR · AAAI · RSS · ICRA · AIM · IROS · WAFR
- Organizer:
Microsoft Research Summit (RL track) 2021
MSR Reinforcement Learning Day 2021
ICML 2019 Workshop: Real-World Sequential Decision Making: Reinforcement Learning and Beyond

Mentorship

- Interns: Ying Fan (PhD Student, UW-Madison) Sinong Geng (PhD Student, Princeton) Hoai-An Nguyen (Undergraduate Student, Rutgers) Garrett Thomas (PhD Student, Stanford) Sean Sinclair (PhD Student, Cornell) Nolan Wagener (PhD Student, Georgia Tech) Tengyang Xie (PhD Student, UIUC) Andrea Zanette (PhD Student, Stanford)
- Collaborators: Sanae Amani (PhD Student, UCLA) Mohak Bhardwaj (PhD Student, UW) Jonathan Lee (Undergraduate Student, UC Berkeley) Bruce Wingo (PhD Student, Georgia Tech)

Teaching Experience

- 2018 Teaching Assistant in Statistical Techniques in Robotics (CS8803, Byron Boots), Georgia Institute of Technology, USA (lectured “Gaussian Process Regression”)
- 2017 Teaching Assistant in Statistical Techniques in Robotics (CS8803, Byron Boots), Georgia Institute of Technology, USA (lectured “Inference of Graphical Model”)
- 2013 Lectured “Introduction to Machine Learning” in Intelligent Control (ME7144, Han-Pang Huang), National Taiwan University, Taiwan
- 2012 & 2013 Lectured induction training of Robotics Laboratory in linear algebra, matrix theory, convex optimization, machine learning, Matlab, and C++, National Taiwan University, Taiwan

Skills

Python, C/C++, Matlab/Simulink, Tensorflow, L^AT_EX

Languages

Chinese (native), English (fluent), Japanese (basic)

Musicianship

2007–2015	Principal flute and cofounder of Viator Philharmonic
2010–2011	Conductor and cofounder of EP Chamber Wind Orchestra
2009	Flute/piccolo player of NCCU Wind Symphony
2007–2009	Flute/piccolo player of NTU Wind Orchestra