Ching-An Cheng

Senior Researcher
Microsoft Research AI

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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

2015–2019 **Ph.D. in Robotics, Georgia Institute of Technology, USA**
Thesis: *Efficient and Principled Robot Learning: Theory and Algorithms*
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: *Robot Dynamics Learning and Human-Robot Interaction*
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

2019 **Best Paper Award, OptRL Workshop @ NeurIPS 2019**
2019 DeepMind Student Travel Award, OptRL Workshop @ NeurIPS 2019
2019 **Best Student Paper Award, RSS 2019**
2019 Finalist to Best Systems Paper Award, RSS 2019
2019 **Google PhD Fellowship, Machine Learning** (declined)
2019 **Nvidia PhD Fellowship**
2018 Finalist to Best Systems Paper Award, RSS 2018
2018 **Best Paper Award, AISTATS 2018**
2018 Student Travel Grant, Georgia Institute of Technology, USA
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
2011–2013 Research Assistantship, National Taiwan University, Taiwan
2010 Cheng-Tai Scholarship, Taiwan

Publications

Journal

2019 Y. Pan, **C.-A. Cheng**, K. Saigol, K. Lee, X. Yan, E. Theodorou, and B. Boots. Imitation learning for agile autonomous driving. *The International Journal of Robotics Research*, 2019

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 brain–machine interface and design of an elastic mechanism for a rehabilitation robot. *International Journal of Automation and Smart Technology*, 5(2):91–100, 2015

Conference

2021 N. Wagener, B. Boots, and **C.-A. Cheng**. Safe reinforcement learning using advantage-based intervention. *International Conference on Machine Learning*, 2021

2021 A. Zanette, **C.-A. Cheng**, and A. Agarwal. Cautiously optimistic policy optimization and exploration with linear function approximation. *Conference on Learning Theory*, 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. *Conference on Uncertainty in Artificial Intelligence*, 2021

2020 **C.-A. Cheng***, A. Kolobov, and A. Agarwal. Policy improvement from multiple experts. *Conference on Neural Information Processing Systems*, 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. *Conference on Neural Information Processing Systems*, 2020 (*equal contribution)

2020 **C.-A. Cheng**, R. Tachet des Combes, B. Boots, and G. Gordon. A reduction from reinforcement learning to no-regret online learning. *International Conference on Artificial Intelligence and Statistics*, 2020

2020 **C.-A. Cheng***, J. Lee*, K. Goldberg, and B. Boots. Online learning with continuous variations: Dynamic regret and reductions. *International Conference on Artificial Intelligence and Statistics*, 2020 (*equal contribution)

2020 B. Wingo, **C.-A. Cheng**, M. A. Murtaza, M. Zafar, and S. Hutchinson. Extending Riemmanian motion policies to a class of underactuated wheeled-inverted-pendulum robots. *International Conference on Robotics and Automation*, 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 methods. *Conference on Robot Learning*, 2019 (*equal contribution)

2019 M. Mukadam, **C.-A. Cheng**, D. Fox, B. Boots, and N. Ratliff. Riemannian motion policy fusion through learnable hierarchical energy reshaping. *Conference on Robot Learning*, 2019

2019 A. Li, **C.-A. Cheng**, B. Boots, and M. Egerstedt. Stable, concurrent controller composition for multi-objective robotic tasks. *IEEE Conference on Decision and Control*, 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; Finalist for Best Systems Paper Award**

2019 **C.-A. Cheng**, X. Yan, N. Ratliff, and B. Boots. Predictor-corrector policy optimization. *International Conference on Machine Learning*, 2019 **(Long Talk (5%))**

2019 **C.-A. Cheng**, X. Yan, E. Theodorou, and B. Boots. Model-based imitation learning with accelerated convergence. *International Conference on Artificial Intelligence and Statistics*, 2019

2019 A. Shaban*, **C.-A. Cheng***, N. Hatch, and B. Boots. Truncated back propagation for bilevel optimization. *International Conference on Artificial Intelligence and Statistics*, 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 *The 13th International Workshop on the Algorithmic Foundations of Robotics*, 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 **Finalist for Best Systems Paper Award**

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. Molnar, **C.-A. Cheng**, L. Tiziani, B. Boots, and F. Hammond III. Optical sensing and control methods for soft pneumatically actuated robotic manipulators. *Accepted to IEEE International Conference on Robotics and Automation*, 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

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)

Research Experience

2015–2019 PhD Student, Georgia Tech Robot Learning Lab, Atlanta, USA

- Policy optimization: developed algorithms with theoretical foundation that combine model-free and model-based learning using online learning techniques
- Online learning: established a new setup of online learning, called Continuous Online Learning, which better captures regularity appearing in online learning problems faced in practice
- Imitation learning: proved the non-asymptotic convergence and performance of value aggregation, and developed an agile autonomous driving platform using deep imitation learning
- Robot control: developed theoretical foundation and computationally efficient algorithms for policy synthesis based on differential geometry
- Gaussian process models: identified the dual RKHS representation of variational Gaussian processes, and proposed a linear-complexity framework for learning complext large-scale models from big data with general likelihoods
- Stochastic optimal control: proposed a framework for solving control problems using approximate probabilistic inference

2019 Summer | Research Intern, Microsoft Research, Redmond, USA

- Optimistic policy improvement: developed a unified framework of reinforcement learning and imitating learning for efficient policy optimization

2018 Summer | Research Intern, Nvidia Research, Seattle, USA

- PicCoLO: a unified framework for model-free and model-based policy learning: proposed a new framework to leverage model information to accelerate policy learning yet without suffering from performance bias due to imperfect model
- Structured reactive policy: proposed a computational graph, RMPflow, that can combine local policies into a expressive global policy with geometric consistency

2013, 2015 | Research Assistant, NTU Robotics Laboratory, Taiwan

- Geometric operational space control: developed a geometric framework towards operational space control with maximal dexterity
- Integration of planning and control for humanoid robot NINO: integrated planning and control for whole-body locomotion and developed force control for grasping and real-time stabilizer for biped robots

2011–2013 | Master Student, NTU Robotics Laboratory, Taipei, Taiwan

- Identification of robot dynamics: proposed a unified theory of Lagrangian systems and RKHS, and designed a semi-parametric multi-kernel learning framework to identify robot dynamics
- Exoskeleton in rehabilitation and power augmentation: designed a Bayesian intention estimator and a robust assistive controller for powered exoskeletons, and designed a back-drivable torsion spring actuator for intrinsically safe exoskeleton
- Safe human-robot interaction: designed a reactive controller using virtual impedance for consistent collision avoidance, and implemented the system with Kinect for safe human-robot assembly
- Brain-controlled rehabilitation robot: designed a P300-BCI with wavelet and compressive sampling

2010–2011 Undergraduate Student, NTU Robotics Laboratory, Taipei, Taiwan

- Brain-controlled rehabilitation robot: designed a motor-imagery-BCI with STFT, wavelet, HHT, and SVM

Service

- Reviewer:
  JMLR · 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:
  MSR Reinforcement Learning Day 2021
  ICML 2019 Workshop: Real-World Sequential Decision Making: Reinforcement Learning and Beyond

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, LaTeX

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