

Bo Liu

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EDUCATION

2010 -2015 **Ph.D.** Computer Science, University of Massachusetts Amherst
Advisor: Sridhar Mahadevan
2008 -2010 **M.S.** Computer Engineering, Stevens Institute of Technology
2005 -2008 **M.S.** Control Engineering, University of Science and Technology of China

INDUSTRY EXPERIENCE

07/2016 - present	Assistant Professor	Auburn University, Auburn, AL
09/2015 - 04/2016	Research Staff Member	Philips Research, Cambridge, MA
06/2015 - 08/2015	Research Scientist Intern	Amazon Research, Seattle, WA
06/2013 - 09/2013	Machine Learning Scientist Intern	Amazon Research, Seattle, WA
06/2011 - 09/2011	Applied Research Intern	eBay Search Science, San Jose, CA

HONORS AND AWARDS

2018 [Amazon Research Award, Amazon Inc.](#)
2017 [Tencent Rhino-Bird Award, Tencent AI Lab](#)
2016 ACM Doctoral Dissertation Award Nomination, by UMass Amherst
2015 [Facebook Best Student Paper Award of UAI-2015](#)
2013 Google Fellowship Nomination, by UMass Amherst
2012 Spotlight paper at NIPS 2012 (rate $\approx 4\%$)
2012 NIPS and UAI Student Award
2010 [Best Paper Runner-up of ICNSC-2010](#)
2010 ICNSC Doctoral Consortium Grant
2009 ICCNS Student Fellowship

RESEARCH INTEREST

Interactive Machine Learning

Reinforcement learning, Active learning, Online learning, and multi-armed bandit with application to online recommendation and spoken dialog system

Large-Scale Efficient Optimization

Online/stochastic optimization with application to time-series problems including demand forecasting and transaction risk management

Power and Control Systems

Adaptive control and robust control system design with applications to power systems

SELECTED PUBLICATIONS

My Google Scholar (click) ([Students advised in blue](#))

Stats: NIPS(3), JAIR(1), IEEE-TNN(3), UAI(3), IJCAI(2), AAAI(3), ACM-TECS(1), AAMAS(1), ICLP(1).

* denotes co-primary authors with equal contribution.

Topics: Machine learning, Control, Robotics, Optimization.

Conference Publications

- C1 Daoming Lyu, Fangkai Yang, **Bo Liu**, Steven Gustafson. A Human-Centered Data-Driven Planner-Actor-Critic Architecture via Logic Programming. *35th International Conference on Logic Programming (ICLP)*, Las Cruces, NM, 2019.
- C2 Fan Yang, **Bo Liu**, Wen Dong. Optimal Control of Complex Systems through Variational Inference with a Discrete Event Decision Process. *Autonomous Agents and Multi-agent Systems (AAMAS)*, Montreal, Canada, 2019.
Acceptance rate: 24%(189/781).
- C3 Daoming Lyu, Fangkai Yang, **Bo Liu**, Steven Gustafson. SDRL: Interpretable and Data-efficient Deep Reinforcement Learning Leveraging Symbolic Planning. *Thirty-Third AAAI Conference on Artificial Intelligence (AAAI)*, Honolulu, HI, 2019.
Acceptance rate: 16.2%(1150/7095).
- C4 Shangdong Zhang, Borislav Mavrin, Linglong Kong, **Bo Liu**, Hengshuai Yao. QUOTA: The Quantile Option Architecture for Reinforcement Learning. *Thirty-Third AAAI Conference on Artificial Intelligence (AAAI)*, Honolulu, HI, 2019.
Acceptance rate: 16.2%(1150/7095).
- C5 **Bo Liu***, Tengyang Xie* (* equal contribution), Yangyang Xu, Mohammad Ghavamzadeh, Yinlam Chow, Daoming Lyu, Daesub Yoon. A Block Coordinate Ascent Algorithm for Mean-Variance Optimization. *32nd Conference on Neural Information Processing Systems (NIPS)*, Montreal, Canada, 2018.
Acceptance rate: 20%(1011/4856).
- C6 Fangkai Yang, Daoming Lyu, **Bo Liu**, Steve Gustafson. PEORL: Integrating Symbolic Planning and Hierarchical Reinforcement Learning for Robust Decision-Making. *International Joint Conferences on Artificial Intelligence (IJCAI)*, 2018.
Acceptance rate: 20%(710/3470).
- C7 **Bo Liu**, Ji Liu, Luwan Zhang. Dantzig Selector with an Approximately Optimal Denoising Matrix. *Proceedings of the Conference on Uncertainty in AI (UAI)*, 2016.
Acceptance rate: 31%(85/275).
- C8 **Bo Liu**, Ji Liu, Mohammad Ghavamzadeh, Sridhar Mahadevan, Marek Petrik. A Proximal Gradient Framework for Robust TD Learning. *International Joint Conferences on Artificial Intelligence (IJCAI)*, 2016.
Acceptance rate: 24%(551/2294).
- C9 Deguang Kong, Ji Liu, **Bo Liu**, Xuan Bao. Uncorrelated Group Lasso. *Association for the Advancement of Artificial Intelligence (AAAI)*, 2016.
Acceptance rate: 26%(549/2132).
- C10 **Bo Liu**, Ji Liu, Mohammad Ghavamzadeh, Sridhar Mahadevan, Marek Petrik. Finite-Sample Analysis of Proximal Gradient Algorithms. *Proceedings of the Conference on Uncertainty in AI (UAI)*, 2015, **Facebook Best Student Paper Award**.
Acceptance rate: 1%(3/291) (Best paper award rate).
- C11 **Bo Liu**, Sridhar Mahadevan, Ji Liu. Regularized Off-Policy TD-Learning. *26th Annual Conference on Neural Information Processing Systems (NIPS)*, Lake Tahoe, Nevada, 2012, December 3-6, **Spotlight**.
Acceptance rate: 4%(72/1467) (Oral presentation rate).

- C12 Sridhar Mahadevan, **Bo Liu**. Sparse Q-learning with Mirror Descent. *Proceedings of the Conference on Uncertainty in AI (UAI)*, 2012.
Acceptance rate: 31%(95/304).
- C13 Sridhar Mahadevan, **Bo Liu**. Basis Construction from Power Series Expansions of Value Functions. *24th Annual Conference on Neural Information Processing Systems (NIPS)*, Vancouver, B.C., Canada, 2010, December 6-8.
Acceptance rate: 24%(293/1219).
- C14 Haibo He, **Bo Liu**. A Hierarchical Learning Architecture with Multiple-Goal Representations Based on Adaptive Dynamic Programming *IEEE International Conference on Networking, Sensing and Control (ICNSC'10)*, Chicago, 2010.
- C15 **Bo Liu**, Haibo He, Daniel.Repperger. Two-Time-Scale Online Actor-Critic Paradigm Driven by POMDP. *IEEE International Conference on Networking, Sensing and Control (ICNSC'10)*, Chicago, 2010.
- C16 **Bo Liu**, Haibo He, Sheng Chen. A Dual-System Learning and Control Method for Machine Intelligence. *Proc. Int. Conf. on Cognitive and Neural Systems (ICCNS'09)*, Boston, May 27-30, 2009.

Journal Publications

- J1 Kangfu Mei, Aiwen Jiang, Juncheng Li, **Bo Liu**, Mingwen Wang, Deep Residual Refining based Pseudo Multi-frame Network for Effective Single Image Super Resolution. *IET Image Processing*, 2019.
Impact factor: 1.472.
- J2 Shuying Li, Zhanwen Liu, Tao Gao, Fanjie Kong, Ziheng Jiao, Aodong Yang, **Bo Liu**. A Novel Restoration Algorithm for Noisy Complex Illumination. *IET Computer Vision*, 2018.
Impact factor: 1.132.
- J3 **Bo Liu**, Ian Gemp, Mohammad Ghavamzadeh, Ji Liu, Sridhar Mahadevan, Marek Petrik. Proximal Gradient Temporal Difference Learning: Stable Reinforcement Learning with Polynomial Sample Complexity. *Journal of Artificial Intelligence Research (JAIR)*, 2018.
Impact factor: 8.78.
- J4 [Daoming Lyu](#), **Bo Liu**, Matthieu Geist, Wen Dong, Saad Biaz, and Qi Wang. Stable and Efficient Policy Evaluation *IEEE Transactions on Neural Networks and Learning Systems (IEEE TNN)*, 2018.
Impact factor: 7.982.
- J5 Qi Wang, Jia Wan, Feiping Nie, **Bo Liu**, Chenggang Yan, Li, Xuelong Li. Hierarchical Feature Selection for Random Projection. *IEEE Transactions on Neural Networks and Learning Systems (IEEE TNN)*, 2018.
Impact factor: 7.982.
- J6 Ai-Wen Jiang, **Bo Liu**, Ming-Wen Wang. Deep Multimodal Reinforcement Network with Contextually Guided Recurrent Attention for Image Question Answering *Journal of Computer Science and Technology*, 32(4), 738-748, 2017.
Impact factor: 0.956.

- J7 Shuai Li, Yuesheng Lou, **Bo Liu**. Bluetooth aided mobile phone localization: a nonlinear neural circuit approach. *ACM Transactions on Embedded Computing Systems (ACM TECS)*, 2014. Impact factor: 1.190.
- J8 Shuai Li, **Bo Liu**, Yangming Li. Selective Positive-negative Feedback Produces the Winner-take-all Competition in Recurrent Neural Networks. *IEEE Transactions on Neural Networks and Learning Systems (IEEE TNN)*, 2013. Impact factor: 7.982.
- J9 Shuai Li, Sanfeng Chen, **Bo Liu**, Yangming Li, Yongsheng Liang Decentralized Kinematic Control of A Class of Collaborative Redundant Manipulators via Recurrent Neural Networks, *Neurocomputing*, 2012. Impact factor: 2.471.
- J10 **Bo Liu**, Sanfeng Chen, Shuai Li, Yongsheng Liang Intelligent control of a sensor-actuator system via kernelized least-squares policy iteration. *Sensors* 12 (3), 2632-2653, 2012. Impact factor: 2.437.
- J11 Sanfeng Chen, Shuai Li, **Bo Liu**, Yuesheng Lou and Yongsheng Liang, Self-Learning Variable Structure Control for a Class of Sensor-Actuator Systems, *Sensors*, Vol.12, pp.6117-6128, 2012. Impact factor: 2.437.
- J12 **Bo Liu**, Haibo He, Sheng Chen. Adaptive Dual Network Design for a Class of SIMO Systems with Nonlinear Time-variant Uncertainties. *Acta Automatica Sinica*, Vol.36, pp.564-572, 2010. Impact factor: 1.290.

Workshop and Others

- W1 Daoming Lyu, Fangkai Yang, Steven Gustafson, **Bo Liu**. A Joint Planning and Learning Framework for Human-Aided Decision-Making. *AAAI Fall Symposium*, DC, 2019. (oral presentation)
- W2 **Bo Liu**, Ji Liu, Kenan Xiao. R²PG: Risk-Sensitive and Reliable Policy Gradient. *32nd AAAI Conference on Artificial Intelligence workshop on planning and inference*, New Orleans, LA, 2018. (oral presentation)
- W3 Fangkai Yang, Steven Gustafson, Alexander Elkholy, Daoming Lyu and **Bo Liu**. Program Search for Machine Learning Pipelines: Leveraging Symbolic Planning and Reinforcement Learning. *Genetic Programming Theory & Practice XVI*, Ann Arbor, MI, 2018.
- W4 Hasan, S. A., **Bo Liu**, Liu, J., et.al. Neural Clinical Paraphrase Generation with Attention. *ClinicalNLP*, Osaka, Japan, 2016.
- W5 Ian Gemp, Sridhar Mahadevan, **Bo Liu**. Solving Large-Scale Sustainable Supply Chain Networks using Variational Inequalities, *AAAI Workshop on Computational Sustainability*, Austin, Texas, 2015.

US Patents

- P1 Sadid Hasan. S., **Bo Liu**, O. Farri Farri, Junyi Liu, & Aaditya Prakash. (2019). Systems and methods for neural clinical paraphrase generation. U.S. Patent Application No. 16/072,128.

FUNDINGS

\$ amount denotes my share.

As PI

- NSF IIS-core (1910794), “*RI: Small: TIDES: Trustworthy Interactive DEcision-making Using Symbolic Planning*”, NSF, PI (Co-PI: Dr. Levent Yilmaz), \$420K.
- **Amazon Research Award** (Class of 2018), sole PI, \$100K. Acceptance rate: 12%(82/674)
- Adobe Research gift money, 2019, sole PI, \$10K.
- **Tencent Rhino-Bird Award**, Tencent AI Lab, sole PI, \$50K.
- Deep Reinforcement Learning for Cyber-Security, sole PI, Mccrary Institute, Auburn University, \$19K.

As Co-PI

- Development of cognitive architecture for estimating drivers’ status in automated driving mode, ETRI, Korea, Co-PI (PI: Dr. Hari Narayanan), Total \$180K, My share \$162K.
- A Prototype Framework of Climate Services for Decision Making, Co-PI (PI: Dr. Di Tian), PAIR program, Auburn University, Total \$300K, My share \$20K.

INVITED TALKS

A Joint Planning and Learning Framework for Human-Aided Decision-Making, AAAI Fall Symposium, DC, November, 2019

A Human-Centered Data-Driven Planner-Actor-Critic Architecture via Logic Programming, ICLP, NM, September, 2019

SDRL: Symbolic Deep Reinforcement Learning, KAIST, South Korea, August, 2019

SDRL: Symbolic Deep Reinforcement Learning, ETRI, South Korea, August, 2019

Reinforcement Learning at Scale, Amazon Research, Seattle, April, 2019

SDRL: Symbolic Deep Reinforcement Learning, AAAI, Honolulu, HI, January, 2019

Efficient Mean-Variance Optimization, Rensselaer Polytechnic Institute, November, 2018

Efficient Mean-Variance Optimization, University of Alberta, July, 2018

Symbolic Deep Reinforcement Learning, RBC Borealis AI, June, 2018

Symbolic Deep Reinforcement Learning, University of Alberta, June, 2018

Duality in TD Learning and Risk Control, Huawei (Futurewei) RLAD Lab, Edmonton, May, 2018

Gradient, Semi-gradient and Pseudo-gradient Reinforcement Learning, SIAM Conference on Optimization, Vancouver, July, 2017

Proximal Gradient Temporal Difference Learning Algorithms. IJCAI, NYC, NY, 2016

Proximal Reinforcement Learning. SUNY Buffalo, Buffalo, NY, 2016

Proximal Reinforcement Learning. Auburn University, AL, 2016

Proximal Reinforcement Learning. Washington State University, Pullman, WA, 2015

Efficient Transfer Decision-making. Amazon Research, Seattle, WA, 2015

Efficient Transfer Decision-making. Philips Research, Briarcliff, NY, 2015

Sequential Decision Making Meets Big Data. Washington State University, Pullman, WA, 2013

First-Order Sparse Reinforcement Learning. Adobe Research, CA, 2012

Student Activities

Current Graduate Students

- Daoming Lyu. Ph.D. candidate: Daoming is developing a general interpretable sequential decision-making framework using symbolic planning and reinforcement learning. He has published in IJCAI, AAAI, NIPS, and IEEE-TNN.
- Hugh Kwon.
- Zheng Zhang.

Past Graduate Students

- Xinning Wang. Ph.D. Thesis: Android Malware Detection through Machine Learning on Kernel Task Structure. Year graduated: 2017.
- Nirmal Patel. M.S. Project: Driver behavior identification model for autonomous vehicles. Year graduated: 2018. He is a recipient of the *Outstanding Master Student Award 2019*.
- Zheng Zhang. M.S. Project: Development of inference architecture for estimating drivers' status in Automated Driving Mode. Year graduated: 2019.

Student Achievement

- Nirmal Patel (M.S. student) is a recipient of the *Outstanding Master Student Award 2019*.

ACADEMIC SERVICES

Associate Editor:

IEEE Geoscience and Remote Sensing Letters, ACM Transactions on Interactive Intelligent Systems (Senior Reviewer)

Program Committee:

AAAI 2017. IJCAI 2015, 2016, 2018, 2019 (SPC). ICTAI 2017. KDH 2018. IEEE MIPR 2018.

Journal Review:

Journal of Machine Learning Research (JMLR), Machine Learning (MLJ), Artificial Intelligence (AIJ), IEEE Transactions on Neural Networks and Learning Systems (TNN), IEEE Signal Processing Letters, IEEE Transactions on Circuits and Systems for Video Technology (TCSVT), IEEE Transactions on Transactions on Autonomous Mental Development (TAMD), IET Image Processing, ACM Transactions on Interactive Intelligent Systems, Neurocomputing, Knowledge-Based Systems, Applied Soft Computing, Artificial Intelligence Review, Evolving Systems, Expert Systems with Applications, Journal of Classification, Pattern Analysis and Applications

Conference Review:

UbiComp 2015. AAAI 2016-present. IJCAI 2015-present. NIPS 2013-present. AISTATS 2017-present. ICLR 2018-present. COLING 2018. COLT 2018. IJCNN 2009,2010. ICML 2019.