

Bo Liu

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Biography: Bo Liu is a tenure-track assistant professor in the Dept. of Computer Science and Software Engineering at Auburn University. He obtained his Ph.D. from Autonomous Learning Lab at University of Massachusetts Amherst, 2015, co-led by Drs. Sridhar Mahadevan and Andrew Barto. His primary research area covers decision-making under uncertainty, human-aided machine learning, symbolic AI, trustworthiness and interpretability in machine learning, and their numerous applications to BIGDATA, autonomous driving, and healthcare informatics. In his current research, he has more than 30 publications on several notable venues, such as NIPS/NeurIPS, ICML, UAI, AAI, IJCAI, AAMAS, JAIR, IEEE-TNN, ACM TECS, etc. His research is funded by NSF, Amazon, Tencent (China), Adobe, and ETRI (South Korea). He is the recipient of NIPS'2012 Spotlight recognition, **UAI'2015 Facebook Best Student Paper Award**, and the Amazon (Faculty) Research Award in 2018. His research results have been covered by many prestigious venues, including the classical textbook "Reinforcement Learning: An Introduction" (2nd edition), NIPS'2015/IJCAI'2016/AAAI'2019 tutorials. He is an **Associate Editor** of IEEE Transactions on Neural Networks and Learning Systems (**IEEE-TNN**), a senior member of IEEE, and a member of AAI, ACM, and INFORMS.

RESEARCH INTEREST

Statistical machine learning, Reinforcement learning, Knowledge representation, Deep learning, Adversarial learning, Trustworthy AI, Explainable AI, and other data-driven applications.

EDUCATION

2010 -2015 **Ph.D.** Computer Science, University of Massachusetts Amherst
Advisors: Sridhar Mahadevan (Chair), Andrew Barto, Shlomo Zilberstein, Weibo Gong
2008 -2010 **M.S.** Computer Engineering, Stevens Institute of Technology
2005 -2008 **M.S.** Control Engineering, University of Science and Technology of China

EMPLOYMENT

07/2016 - present Assistant Professor Auburn University, Auburn, AL
09/2015 - 04/2016 Research Staff Member Philips Research, Cambridge, MA

MAJOR HONORS AND AWARDS

2019,20 Junior Research Award for Excellence Award Nomination (1 per department)
2018 **Amazon Research Award, Amazon Inc.**
2017 **Tencent Rhino-Bird Award, Tencent AI Lab**
2016 ACM Doctoral Dissertation Award Nomination, by UMass Amherst (2 per university)
2015 **Facebook Best Student Paper Award of UAI'2015**
2013 Google Fellowship Nomination, by UMass Amherst
2012 **Spotlight paper at NIPS 2012 (acceptance ratio \approx 4%)**
2010 Best Paper Award Nomination of ICNSC'2010

FUNDINGS

My current research is generously funded by: **NSF**, **Amazon**, **Tencent**, **Adobe**, **ETRI**.

Single PI: the only PI with other Co-PIs. Sole PI: the only PI without any Co-PIs.

As PI

- NSF IIS-core (1910794), “*RI: Small: **TIDES: Trustworthy Interactive DEcision-making Using Symbolic Planning***”, **NSF**, single PI (Co-PI: Dr. Levent Yilmaz), \$420K.
- Amazon Research Award (Class of 2018), “*Sequential Transaction Risk Management with Deep Reinforcement Learning*”, **Amazon**, sole PI, \$100K. Acceptance rate: 12%(82/674)
- Adobe Research gift money, 2019, **Adobe**, sole PI, \$10K.
- Tencent Rhino-Bird Faculty Research Award, “*ETA:Energy-efficient, Transferable, and Accurate Reinforcement Learning*”, **Tencent**, 2017, sole PI, \$50K.
- Transition-based Reinforcement Learning, sole PI, Auburn IGP, **Auburn University**, \$20K.
- Deep Reinforcement Learning for Cyber-Security, sole PI, Mccarary Institute, 2017, **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), \$180K.
- A Prototype Framework of Climate Services for Decision Making, Co-PI (PI: Dr. Di Tian), PAIR program, **Auburn University**, \$300K.
- Data-Enabled Engineering Projects for Undergraduate Data Science and Engineering Education, Senior Personnel (PI: Dr. Qinghua He), **NSF**, \$300k.

ACADEMIC SERVICES

Associate Editor:

IEEE Trans. on Neural Networks (IEEE-TNN) (2021-present); IEEE Geoscience and Remote Sensing Letters (2016-2019); IET Image Processing (2020-present)

Area Chair/Senior PC:

IJCAI 2017-present, UAI 2021

Conference Reviewing:

ICML, NIPS, COLT, UAI, AISTATS, AAAI, IJCAI, ICLR, etc.

Journal Reviewing:

JMLR, JAIR, MLJ, AIJ, Neural Computation, Neural Networks, IEEE-TNN, etc.

Workshop Organization:

INFORMS’2020 Workshop on Primal Dual Optimization and Reinforcement Learning.

Proposal Panel Review:

NSF panels 2016-present, Swiss NSF panels 2020.

SELECTED PUBLICATIONS

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

While at Auburn (2016-present): JAIR(1), IEEE-TNN(2), NIPS(1), ICML(2), UAI(1), IJCAI(1), AAAI(3), AAMAS(1), ICLP(1).

While at UMass (2010-2015): IEEE-TNN(1), NIPS(2), UAI(2), IJCAI(1), AAAI(1), ACM-TECS(1).

* denotes co-primary authors with equal contribution.

Conference Publications

- C1 Shangdong Zhang, **Bo Liu**, Shimon Whiteson. Mean-Variance Policy Iteration for Risk-Averse Reinforcement Learning. *Thirty-Fifth AAAI Conference on Artificial Intelligence (AAAI)*, 2021.
Acceptance rate: 21%(1692/7911).
- C2 Shangdong Zhang, **Bo Liu**, Hengshuai Yao, Shimon Whiteson. Provably Convergent Two-Timescale Off-Policy Actor-Critic with Function Approximation. *International Conference on Machine Learning (ICML)*, 2020.
Acceptance rate: 21%(1088/4990).
- C3 Shangdong Zhang, **Bo Liu**, Shimon Whiteson. Gradientdice: Rethinking generalized offline estimation of stationary values. *International Conference on Machine Learning (ICML)*, 2020.
Acceptance rate: 21%(1088/4990).
- C4 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).
- C5 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.
- C6 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).
- C7 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).
- C8 **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).
- C9 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).
- C10 **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: 30%(85/275).
- C11 **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).

C12 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).

C13 **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).

C14 **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).

C15 Sridhar Mahadevan, **Bo Liu**. Sparse Q-learning with Mirror Descent. *Proceedings of the Conference on Uncertainty in AI (UAI)*, 2012.

Acceptance rate: 30%(95/304).

C16 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).

C17 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.

C18 **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.

C19 **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 Levent Yilmaz and **Bo Liu**. Model Credibility Revisited: Concepts and Considerations for Appropriate Trust. *Journal of Simulation*, 2020.

Impact factor: 1.214.

J2 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)*, 2019.

Impact factor: 8.793.

J3 Qi Wang, Jia Wan, Feiping Nie, **Bo Liu**, Chenggang Yan, Xuelong Li. Hierarchical Feature Selection for Random Projection. *IEEE Transactions on Neural Networks and Learning Systems (IEEE-TNN)*, 2019.

Impact factor: 8.793.

- J4 **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. **The arxiv preliminary version is “recommended to read” in the classical RL textbook *Introduction to Reinforcement Learning*.**
Impact factor: 8.78.
- J5 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: 8.793.
- J6 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: 2.004.
- J7 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*, 2019.
Impact factor: 1.648.
- J8 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.
- J9 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: 1.367.
- J10 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. **One of the most-cited Neurocomputing publications since 2012.**
Impact factor: 2.471.
- J11 **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.
- J12 Shuai Li, **Bo Liu**, Baogang Chen, and Yuesheng Lou. Neural Network-Based Mobile Phone Localization Using Bluetooth Connectivity. *Neural Computing and Applications*, 2012.
Impact factor: 1.569.
- J13 Shuai Li, Yangming Li, **Bo Liu**, Timmy Murray. Model-free Control of Lorenz Chaos Using an Approximate Optimal Control Strategy. *Communications in Nonlinear Science and Numerical Simulation*, 2012.
Impact factor: 4.270.
- J14 **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 Shangdong Zhang, **Bo Liu**, Shimon Whiteson. Mean-Variance Policy Iteration for Risk-Averse Reinforcement Learning. *NeurIPS Workshop on Offline Reinforcement Learning*, Vancouver, CA, 2020.
- W2 [Daoming Lyu](#), Qi Qi, Mohammad Ghavamzadeh, Hengshuai Yao, Tianbao Yang, and **Bo Liu**. Variance-Reduced Off-Policy Memory-Efficient Policy Search. *NeurIPS Workshop on Offline Reinforcement Learning*, Vancouver, CA, 2020.
- W3 Shangdong Zhang, **Bo Liu**, Hengshuai Yao, Shimon Whiteson. Provably Convergent Off-Policy Actor-Critic with Function Approximation. *NeurIPS Workshop on The Optimization Foundations of Reinforcement Learning*, Vancouver, CA, 2019.
- W4 [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)
- W5 **Bo Liu**, Ji Liu, Kenan Xiao. R^2 PG: Risk-Sensitive and Reliable Policy Gradient. *32nd AAAI Conference on Artificial Intelligence workshop on planning and inference*, New Orleans, LA, 2018. (oral presentation)
- W6 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.
- W7 Hasan, S. A., **Bo Liu**, Liu, J., et al. Neural Clinical Paraphrase Generation with Attention. *ClinicalNLP*, Osaka, Japan, 2016.
- W8 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.

INVITED TALKS

- Towards Trustworthy Decision-Making and AI: Explainability and Safety (virtual), Tencent AI Lab, September, 2020
- Legendre-Fenchel Dualities In Reinforcement Learning: Successes, Challenges & Opportunities, INFORMS 2020 Annual Meeting, November, 2020
- 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. WSU, Pullman, WA, 2013
- First-Order Sparse Reinforcement Learning. Adobe Research, CA, 2012

STUDENT ACHIEVEMENT

- Daoming Lyu is nominated for Google PhD Fellowship in 2020.
- Nimit Patel (M.S. student) is a recipient of the *Outstanding Master Student Award* 2019.