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, AAAI, 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 AAAI, ACM, and INFORMS.

RESEARCH INTEREST
Statistical machine learning, Reinforcement learning, Knowledge representation, Deep learning, AI safety, 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	AU's 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 ≈ 4%)
2010	Best Paper Award Nomination of ICNSC'2010

EXTERNAL FUNDINGS
My current research is generously funded by: **NSF, Amazon, Tencent, Adobe, ETRI**.
<u>Single PI</u>: the only PI with other Co-PIs. <u>Sole PI</u>: the only PI without any Co-PIs.

As PI
- NSF IIS-core (1910794), "*RI: Small: **TIDES**: **T**rustworthy **I**nteractive **DE**cision-making Using **S**ymbolic Planning*", **NSF**, single PI, $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.

As Co-PI
- Development of cognitive architecture for estimating drivers' status in automated driving mode, **ETRI** (Korea), Co-PI (PI: Dr. Hari Narayanan), $180K.
- Data-Enabled Engineering Projects for Undergraduate Data Science and Engineering Education, Senior Personnel (PI: Dr. Qinghua He), **NSF**, $300K.

INTERNAL FUNDINGS
- 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.
- A Prototype Framework of Climate Services for Decision Making, Co-PI (PI: Dr. Di Tian), PAIR program, **Auburn University**, $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/NeurIPS, 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)
Stats: JAIR(1), IEEE-TNN(3), IEEE-TETCI(1), NIPS(3), ICML(2), UAI(3), IJCAI(2), AAAI(3), AAMAS(1), ICLP(1), ACM-TECS(1).

∗ denotes co-primary authors with equal contribution.

Conference Publications

C1 Shangtong 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 Shangtong 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 Shangtong 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 Shangtong 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 Daoming Lyu, Fangkai Yang, Hugh Kwon, Wen Dong, Levent Yilmaz, and **Bo Liu**. TDM: Trustworthy Decision-Making via Interpretability Enhancement. *IEEE Transactions on Emerging Topics in Computational Intelligence* (**IEEE-TETCI**), 2021.
Impact factor: 4.62.

J2 **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.

J3 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.

J4 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.

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 Zhaokun Li, Xueliang Liu, Ye Zhao, **Bo Liu**, Zhen Huang, Richang Hong. A Lightweight Multi-scale Aggregated Model for Detecting Aerial Images Captured by UAVs. *Journal of Visual Communication and Image Representation*, 2021.
Impact factor: 2.259.

J7 Levent Yilmaz and **Bo Liu**. Model Credibility Revisited: Concepts and Considerations for Appropriate Trust. *Journal of Simulation*, 2020.
Impact factor: 1.214.

J8 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.

J9 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.

J10 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.

J11 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.

J12 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.

J13 **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.

J14 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.

J15 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.

J16 **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 Shangtong 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 Shangtong 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

- Explainable and Safety-Critical Decision-Making (virtual), Eli Lilly, Indiana, January 2021; Nanyang Technological University, Singapore, November 2020; Tencent AI Lab, September 2020

- Legendre-Fenchel Dualities In Reinforcement Learning: Successes, Challenges & Opportunities (virtual), 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; ETRI, South Korea, August 2019; AAAI, Honolulu, HI, January 2019; RBC Borealis AI, June 2018; University of Alberta, June 2018
- Reinforcement Learning at Scale, Amazon Research, Seattle, April 2019
- Efficient Mean-Variance Optimization, Rensselaer Polytechnic Institute, November 2018; University of Alberta, July 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. Job talk at SUNY Buffalo, NY, Auburn University, AL, and U Wyoming, WY, 2016 (Got offers from all)
- Proximal Reinforcement Learning. Washington State University, Pullman, WA, 2015
- Efficient Transfer Decision-making. Amazon Research, Seattle, WA, 2015; 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.
- Nirmit Patel (M.S. student) is a recipient of the *Outstanding Master Student Award* 2019.

REFERENCES
Sridhar Mahadevan
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