

Yuheng Bu

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RESEARCH INTERESTS

My research interests lie in the intersection of *information theory*, *signal processing* and *machine learning*. I have recently leveraged tools from information theory and signal processing to develop *theoretically justified* learning algorithms for diverse applications, including model compression, anomaly detection, and fair/trustworthy machine learning. More broadly, the primary goal of my research is to lay information-theoretic foundations for the learning algorithms with limited labeled data, including transfer learning and federated learning, particularly with privacy, fairness, and communication constraints.

EDUCATION

- Ph.D. in Electrical and Computer Engineering
University of Illinois at Urbana-Champaign, USA Jan. 2017 - Aug. 2019
Advisor: Venugopal V. Veeravalli
Thesis: “Information-theoretic Bounds in Learning Algorithms”
- Master in Electrical and Computer Engineering
University of Illinois at Urbana-Champaign, USA Aug. 2014 - Dec. 2016
Advisor: Venugopal V. Veeravalli
Thesis: “Estimation of KL Divergence: Optimal Minimax Rate”
- B.E. (**with honors**) in Electronic Engineering
Tsinghua University, Beijing, China Aug. 2010 - Jul. 2014
Ranking **7** among 240 students
Double Major in **Economics**

ACADEMIC APPOINTMENTS

- Postdoctoral Research Associate, **Massachusetts Institute of Technology** Sep. 2019 - present
Advisor: Gregory W. Wornell
- Research Assistant, **University of Illinois at Urbana-Champaign** Aug. 2014 - Jan. 2019
Advisor: Venugopal V. Veeravalli
- UGVR (Undergraduate Visiting Research), **Stanford University** Jun. 2013 - Sep. 2013
Only 18 students chosen from mainland China and Taiwan
Advisor: Tsachy Weissman
Project: Time-series forecaster based on Online Aggregation

RESEARCH PROJECTS

- **Exact Characterization of Generalization Errors using Information Measures**
Massachusetts Institute of Technology Sep. 2020 - present
 - Exact characterizations of generalization errors for Gibbs algorithms (randomized ERM) in both supervised/transfer learning settings using symmetrized Kullback-Leibler (KL) information

- Information-theoretical framework that guides the selection of different transfer learning algorithms
- **Fair selective classification/regression**
Massachusetts Institute of Technology Sep. 2019 - present
 - Theoretical guarantees on using *sufficiency criterion* to mitigate disparities across groups
 - Fair selective classification/regression algorithms by minimizing mutual information
- **Information-theoretical Generalization bounds of Supervised Learning**
University of Illinois at Urbana-Champaign Jan. 2018 - Aug. 2019
 - Tighter generalization error bound for supervised learning algorithm with mutual information
 - Novel model compression algorithm that improves generalization performance by minimizing mutual information based upper bound
- **Minimax Optimal Estimation of Information Measures**
University of Illinois at Urbana-Champaign Aug. 2015 - Jan. 2017
 - Kullback-Leibler divergence estimation between large-alphabet distributions
 - Minimax optimal estimator based on plug-in approach and polynomial approximation
 - Superior performance in applications such as data-driven anomaly detection
- **Data-Driven Outlying Sequence Detection**
University of Illinois at Urbana-Champaign May 2014 - Jan. 2017
 - Data-driven approaches for unstructured/structured outlying sequence detection
 - Computationally efficient and (exponentially) consistent algorithms

PUBLICATIONS

Selected Publications

- G. Aminian*, **Y. Bu***, L. Toni, M. R. D. Rodrigues, G. W. Wornell. “An Exact Characterization of the Generalization Error for the Gibbs Algorithm,” (* equal contribution), in *Proc. Conference on Neural Information Processing Systems (NeurIPS)*, Dec. 2021.
- **Y. Bu***, J. K. Lee*, D. Rajan, P. Sattigeri, R. Panda, S. Das, G. W. Wornell. “Fair Selective Classification via Sufficiency,” (* equal contribution), in *Proc. International Conference on Machine Learning (ICML)*, Jul. 2021. (**Long talk, Top 3%**)
- **Y. Bu**, S. Zou, V. V. Veeravalli. “Tightening Mutual Information Based Bounds on Generalization Error,” *IEEE Journal on Selected Areas in Information Theory*, vol. 1, no. 1, pp. 121-130, May 2020.
- **Y. Bu**, S. Zou, V. V. Veeravalli. “Linear-Complexity Exponentially-Consistent Tests for Universal Outlying Sequence Detection,” *IEEE Transactions on Signal Processing*, vol. 67, no. 8, pp. 2115-2128, Apr. 2019.
- **Y. Bu***, S. Zou*, Y. Liang, V. V. Veeravalli. “Estimation of KL Divergence: Optimal Minimax Rate,” (* equal contribution), *IEEE Transactions on Information Theory*, vol. 64, no. 4, pp. 2648-2674, Apr. 2018.

Journal Papers and Preprints

- [1] **Y. Bu***, G. Aminian*, L. Toni, M. R. D. Rodrigues, G. W. Wornell. “An Exact Characterization of the Generalization Error for the Gibbs Algorithm,” (* equal contribution), submitted to *IEEE Transactions on Information Theory*, Jan. 2022, preliminary version appeared in NeurIPS 2021.
- [2] **Y. Bu**, W. Gao, S. Zou, V. V. Veeravalli. “Population Risk Improvement with Model Compression: An Information-Theoretic Approach,” *Entropy* 23, no. 10, pp. 1255, Sept. 2021.

- [3] **Y. Bu**, S. Zou, V. V. Veeravalli. “Tightening Mutual Information Based Bounds on Generalization Error,” *IEEE Journal on Selected Areas in Information Theory*, vol. 1, no. 1, pp. 121-130, May 2020.
- [4] C. Wilson, **Y. Bu**, V. V. Veeravalli. “Adaptive Sequential Machine Learning,” *Sequential Analysis*, 38(4), pp. 545-568, Jan. 2020.
- [5] **Y. Bu**, S. Zou, V. V. Veeravalli. “Linear-Complexity Exponentially-Consistent Tests for Universal Outlying Sequence Detection,” *IEEE Transactions on Signal Processing*, vol. 67, no. 8, pp. 2115-2128, Apr. 2019.
- [6] **Y. Bu***, S. Zou*, Y. Liang, V. V. Veeravalli. “Estimation of KL Divergence: Optimal Minimax Rate,” (* equal contribution), *IEEE Transactions on Information Theory*, vol. 64, no. 4, pp. 2648-2674, Apr. 2018.

Conference Papers

- [1] A. Shah*, **Y. Bu***, J. K. Lee, P. Sattigeri, R. Panda, S. Das, G. W. Wornell. “Selective Regression under Fairness Criteria,” (* equal contribution), submitted to *International Conference Machine Learning (ICML 2022)*, Jan. 2022, available at [arXiv:2110.15403](https://arxiv.org/abs/2110.15403).
- [2] J. K. Lee*, **Y. Bu***, P. Sattigeri, R. Panda, G. W. Wornell, L. Karlinsky, R. Feris. “A Maximal Correlation Approach to Imposing Fairness in Machine Learning,” (* equal contribution), to appear in *Proc. IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, May 2022, available at [arXiv:2012.15259](https://arxiv.org/abs/2012.15259).
- [3] **Y. Bu***, G. Aminian*, L. Toni, M. R. D. Rodrigues, G. W. Wornell. “Characterizing and Understanding the Generalization Error of Transfer Learning with Gibbs Algorithm,” (* equal contribution), to appear in *Proc. International Conference on Artificial Intelligence and Statistics (AISTATS)*, Mar. 2022, available at [arXiv:2111.01635](https://arxiv.org/abs/2111.01635).
- [4] G. Aminian*, **Y. Bu***, L. Toni, M. R. D. Rodrigues, G. W. Wornell. “An Exact Characterization of the Generalization Error for the Gibbs Algorithm,” (* equal contribution), in *Proc. Conference on Neural Information Processing Systems (NeurIPS)*, Dec. 2021.
- [5] **Y. Bu***, J. K. Lee*, D. Rajan, P. Sattigeri, R. Panda, S. Das, G. W. Wornell. “Fair Selective Classification via Sufficiency,” (* equal contribution), in *Proc. International Conference on Machine Learning (ICML)*, Jul. 2021. (**Long talk, Top 3%**)
- [6] G. Aminian*, **Y. Bu***, L. Toni, M. R. D. Rodrigues, G. W. Wornell. “Characterizing the Generalization Error of Gibbs Algorithm with Symmetrized KL information,” (* equal contribution), *ICML Workshop on Information-Theoretic Methods for Rigorous, Responsible, and Reliable Machine Learning*, 2021.
- [7] **Y. Bu**, T. Wang, G. W. Wornell. “SDP Methods for Sensitivity-Constrained Privacy Funnel and Information Bottleneck Problems,” in *Proc. IEEE International Symposium on Information Theory (ISIT)*, Melbourne, Australia, Jul. 2021.
- [8] **Y. Bu**, W. Gao, S. Zou, V. V. Veeravalli. “Information-theoretic Understanding of Population Risk Improvement with Model Compression,” in *Proc. AAAI Conference on Artificial Intelligence (AAAI)*, New York, Feb. 2020.
- [9] **Y. Bu**, K. Small. “Active Learning in Recommendation Systems with Multi-level User Preferences,” *AAAI Workshop on Interactive and Conversational Recommendation Systems (WICRS)*, New York, Feb. 2020.
- [10] **Y. Bu**, J. Lu, V. V. Veeravalli. “Active and Adaptive Sequential learning,” in *Proc. IEEE Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, Nov. 2019.
- [11] **Y. Bu**, S. Zou, V. V. Veeravalli. “Tightening Mutual Information Based Bounds on Generalization Error,” in *Proc. IEEE International Symposium on Information Theory (ISIT)*, Paris, France, Jul. 2019.

- [12] **Y. Bu**, J. Lu, V. V. Veeravalli. “Model Change Detection with Application to Machine Learning,” in *Proc. IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, Brighton, UK, May 2019.
- [13] **Y. Bu**, S. Zou, V. V. Veeravalli, “Linear-Complexity Exponentially-Consistent Tests for Universal Outlying Sequence Detection,” in *Proc. IEEE International Symposium on Information Theory (ISIT)*, Aachen, Germany, Jun. 2017.
- [14] **Y. Bu***, S. Zou*, Y. Liang, V. V. Veeravalli. “Estimation of KL Divergence Between Large-Alphabet Distributions,” (* equal contribution), in *Proc. IEEE International Symposium on Information Theory (ISIT)*, Barcelona, Spain, Jul. 2016.
- [15] **Y. Bu**, S. Zou, Y. Liang, V. V. Veeravalli. “Universal Outlying Sequence Detection for Continuous Observations,” in *Proc. IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, Shanghai, China, Mar. 2016.

PROFESSIONAL EXPERIENCES

- Amazon.com Inc., Core machine learning group Jun. 2017 - Dec. 2017
(Currently known as **Amazon AI Lab**)
Title: Applied scientist intern
 - Built a conversational agent that can actively learn users’ interests to make recommendations.
 - Conducted extensive research on customer purchase history with Yelp data.

TEACHING AND MENTORSHIP

- Mentoring graduate students:

Joshua Ka-Wing Lee, Ph.D. at MIT EECS,	Fall 2019 - Summer 2021
Tony T. Wang, MEng at MIT EECS,	Summer 2020 - Spring 2021
Gary Lee, Ph.D. candidate at MIT EECS,	Summer 2020 - present
Abhin Shah, Ph.D. candidate at MIT EECS,	Spring 2021 - present
Maohao Shen, Ph.D. candidate at MIT EECS,	Fall 2021 - present
- Teaching and developing contents for **MIT IDSS MicroMaster** program:

14.310x Data Analysis for Social Scientists (live recitation and video recording)	Fall 2019, MIT
6.86x Machine Learning with Python–From Linear Models to Deep Learning	Spring 2020, MIT
- Teaching assistant:

ECE 365: Data Science and Engineering	Spring 2019, UIUC
ECE 398: Making Sense of Big Data	Fall 2018, UIUC
- Grader:

ECE 398: Making Sense of Big Data	Spring 2017, UIUC
ECE 598: Computational Inference and Learning	Fall 2016, UIUC

HONORS & AWARDS

- Outstanding Reviewer Award, **NeurIPS** 2021
- **Yi-Min Wang and Pi-Yu Chung** Research Award, UIUC 2019
- Nominee for Graduation Day at **IEEE ITA Workshop** 2019
- Student Travel Grant, **IEEE ISIT** 2016, 2017
- Student Travel Grant, **IEEE ICASSP** 2016

- **Outstanding graduate**, Tsinghua University 2014
- **National Scholarship** Granted by Ministry of Education of China (**top 2%**), 2012 and 2013
- **Third prize**, "Challenge Cup" the Tsinghua University
Student extra-curricular academic science and technology competitions 2012
- **Second prize**, Shing-Tung Yau secondary school mathematics competition 2009

SERVICE & PROFESSIONAL ACTIVITIES

- **Membership:** IEEE, IEEE Information Theory Society, IEEE Signal Processing Society
- **Reviewer:**
Journals: IEEE Transactions on Information Theory (TIT), IEEE Journal on Selected Areas in Information Theory (JSAIT), IEEE Transactions on Signal Processing (TSP), IEEE Transactions on Pattern Analysis and Machine Intelligence (TPAMI), Transactions on Information Forensics & Security (TIFS), IEEE Transactions on Vehicular Technology (TVT),
Conferences: NeurIPS, ICML, ICLR, AAAI, IJCAI, AISTATS, ISIT, ICASSP
- **Vice President**, Student Association for Science and Technology,
EE Department, Tsinghua University 2012-2014