# Yuheng Bu

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## Research Interests

My research interests lie in the intersection of *information theory*, *machine learning*, and *signal processing*. 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, fair selective prediction, and uncertainty quantification. More broadly, the primary goal of my research is to lay information-theoretic foundations for trustworthy learning algorithms, particularly with generalization, fairness, and robustness guarantees.

## Academic Appointments

- Assistant Professor, Department of Electrical and Computer Engineering, Aug. 2022 - present
  Herbert Wertheim College of Engineering, **University of Florida**

- Postdoctoral Research Associate, **Massachusetts Institute of Technology**  Sep. 2019 - May 2022
  Advisor: Gregory W. Wornell

- Undergraduate Visiting Research (UGVR), **Stanford University**  Jun. 2013 - Sep. 2013
  Only 18 students chosen from mainland China and Taiwan
  Advisor: Tsachy Weissman

## 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
  Double Major in **Economics**

## Full Publication List

**Journal Papers**

[1] G. Aminian*, **Y. Bu***, L. Toni, M. R. Rodrigues, G. W. Wornell. "Information-theoretic Characterizations of Generalization Error for the Gibbs Algorithm," (* equal contribution), *IEEE Transactions on Information Theory*, vol. 70, no. 1, pp. 632-655, Nov. 2023.

[2] J. K. Lee\*, **Y. Bu\***, P. Sattigeri, R. Panda, G. W. Wornell, L. Karlinsky, R. S. Feris. "A Maximal Correlation Framework for Fair Machine Learning," (\* equal contribution), *Entropy 24*, no. 4, pp. 461, Mar. 2022.

[3] **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, Sep. 2021.

[4] **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.

[5] C. Wilson, **Y. Bu**, V. V. Veeravalli. "Adaptive Sequential Machine Learning," *Sequential Analysis*, 38(4), pp. 545-568, Jan. 2020. (**16th Abraham Wald Prize**)

[6] **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.

[7] **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.

## Preprints

[1] B. Hu, **Y. Bu**, J. C. Príncipe, "Feature Learning in Image Hierarchies using Functional Maximal Correlation," in preparation for, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Apr. 2024.

[2] D. Yu, D. Zhuang, **Y. Bu**, S. Wang, G. Wang, "UQGNN: Uncertainty Quantification of Heterogeneous Graph Neural Networks for Multimodal Urban Mobility Prediction," submitted to *ACM SIGKDD International Conference on Knowledge Discovery and Data Mining (KDD)* , Feb. 2024.

[3] D. Zhuang, **Y. Bu**, G. Wang, S. Wang, J. Zhao, "SAUC: Sparsity-Aware Uncertainty Calibration for Spatiotemporal Prediction with Graph Neural Networks," submitted to *ACM SIGKDD International Conference on Knowledge Discovery and Data Mining (KDD)* , Feb. 2024.

[4] B. Hu, **Y. Bu**, J. C. Príncipe, "Learning Orthonormal Features in Self-Supervised Learning using Functional Maximal Correlation," submitted to *IEEE International Conference on Image Processing (ICIP)*, Feb. 2024.

[5] Y. Liu, **Y. Bu**, "Adaptive Text Watermark for Large Language Models," submitted to *International Conference on Machine Learning (ICML)*, Jan. 2024.

[6] J. J. Ryu, X. Xu, H. SM Erol, **Y. Bu**, L. Zheng, G. W. Wornell, "Operator SVD with Neural Networks via Nested Low-Rank Approximation," submitted to *International Conference on Machine Learning (ICML)*, Jan. 2024.

[7] J. J. Ryu, M. Shen, S. Ghosh, **Y. Bu**, P. Sattigeri, S. Das, G. W. Wornell, "Improved Evidential Deep Learning via a Mixture of Dirichlet Distributions," submitted to *International Conference on Machine Learning (ICML)*, Jan. 2024.

[8] F. Laakom, **Y. Bu**, M. Gabbouj, "Class-Wise Generalization Error: An Information-Theoretic Analysis," submitted to *International Conference on Machine Learning (ICML)*, Jan. 2024.

[9] C. Shi, **Y. Bu**, J. Fu, "Information-Theoretic Opacity-Enforcement in Markov Decision Processes," submitted to *International Joint Conference on Artificial Intelligence (IJCAI)*, Jan. 2024.

## Conference and Workshop Publications

[1] **Y. Bu**, "Towards Optimal Inverse Temperature in the Gibbs Algorithm," to appear in, *Proc. IEEE International Symposium on Information Theory (ISIT)*, 2024.

[2] A. Shah, M. Shen, J. J. Ryu, S. Das, P. Sattigeri, **Y. Bu**, G. W. Wornell, "Group Fairness with Uncertainty in Sensitive Attributes," to appear in, *Proc. IEEE International Symposium on Information Theory (ISIT)*, 2024.

[3] H. Chen, **Y. Bu**, G. W. Wornell, "Gibbs-Based Information Criteria and the Over-Parameterized Regime," in *Proc. International Conference on Artificial Intelligence and Statistics (**AISTATS**)*, Valencia, Spain, May 2024.

[4] D. Zhuang, **Y. Bu**, G. Wang, S. Wang, J. Zhao, "SAUC: Sparsity-Aware Uncertainty Calibration for Spatiotemporal Prediction with Graph Neural Networks," *NeurIPS Workshop on Temporal Graph Learning (TGL)*, Dec. 2023. (**Spotlight talk**)

[5] B. Hu, **Y. Bu**, J. C. Príncipe, "Feature Learning in Image Hierarchies using Functional Maximal Correlation," *NeurIPS Workshop on Self-Supervised Learning - Theory and Practice*, Dec. 2023. (**Spotlight talk**)

[6] J. J. Ryu, X. Xu, H. SM Erol, **Y. Bu**, L. Zheng, G. W. Wornell, "Operator SVD with Neural Networks via Nested Low-Rank Approximation," *NeurIPS Workshop on Machine Learning and the Physical Sciences*, Dec. 2023.

[7] M. Shen, **Y. Bu**, G. W. Wornell. "On Balancing Bias and Variance in Unsupervised Multi-Source-Free Domain Adaptation," in *Proc. International Conference on Machine Learning (**ICML**)*, Jul. 2023.

[8] F. Laakom, **Y. Bu**, M. Gabbouj, "Information-Theoretic Generalization Bounds for the Subtask Problem," *ICML workshop on PAC-Bayes Meets Interactive Learning*, Jul. 2023.

[9] **Y. Bu**, H. V. Tetali, G. Aminian, M. R. Rodrigues, G. W. Wornell. "On the Generalization Error of Meta Learning for the Gibbs Algorithm," in *Proc. IEEE International Symposium on Information Theory (ISIT)*, Taipei, Jun. 2023.

[10] A. Weiss, A. Lancho, **Y. Bu**, G. W. Wornell. "A Bilateral Bound on the Mean Squared Error for Estimation in Model Mismatch," in *Proc. IEEE International Symposium on Information Theory (ISIT)*, Taipei, Jun. 2023.

[11] M. Shen, S. S. Ghosh, P. Sattigeri, S. Das, **Y. Bu**, G. W. Wornell. "Reliable Gradient-free and Likelihood-free Prompt Tuning," in *Proc. Conference of the European Chapter of the Association for Computational Linguistics (**EACL**)*, Dubrovnik, Croatia, May 2023.

[12] H. He, G. Aminian, **Y. Bu**, M. R. Rodrigues, V. YF Tan. "How Does Pseudo-Labeling Affect the Generalization Error of the Semi-Supervised Gibbs Algorithm?" in *Proc. International Conference on Artificial Intelligence and Statistics (**AISTATS**)*, Valencia, Spain, Apr. 2023.

[13] M. Shen, **Y. Bu**, P. Sattigeri, S. S. Ghosh, S. Das, G. W. Wornell. "Post-hoc Uncertainty Learning using a Dirichlet Meta-Model," in *Proc. AAAI Conference on Artificial Intelligence (**AAAI**)*, Washington DC, Feb. 2023.

[14] A. Lancho, A. Weiss, G. C. Lee, J. Tang, **Y. Bu**, Y. Polyanskiy, G. W. Wornell. "Data-Driven Blind Synchronization and Interference Rejection for Digital Communication Signals," in *Proc. IEEE Global Communications Conference*, Rio de Janeiro, Brazil, Dec. 2022.

[15] G. C. Lee, A. Weiss, A. Lancho, J. Tang, **Y. Bu**, Y. Polyanskiy, G. W. Wornell. "Exploiting Temporal Structures of Cyclostationary Signals for Data-Driven Single-Channel Source Separation," in *Proc. IEEE International Workshop on Machine Learning for Signal Processing*, Xi'an, China, Aug. 2022. (**Best Student Paper Award**)

[16] A. Shah*, **Y. Bu***, J. K. Lee, P. Sattigeri, R. Panda, S. Das, G. W. Wornell. "Selective Regression under Fairness Criteria," (* equal contribution), in *Proc. International Conference Machine Learning (**ICML**)*, Baltimore, MD, Jul. 2022.

[17] G. Aminian*, **Y. Bu***, G. W. Wornell, M. R. Rodrigues. "Tighter Expected Generalization Error Bounds via Convexity of Information Measures," (* equal contribution), in *Proc. IEEE International Symposium on Information Theory (ISIT)*, Espoo, Finland, Jun. 2022.

[18] J. K. Lee\*, **Y. Bu\***, P. Sattigeri, R. Panda, G. W. Wornell, L. Karlinsky, R. S. Feris. "A Maximal Correlation Approach to Imposing Fairness in Machine Learning," (\* equal contribution), in *Proc. IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, Singapore, May 2022.

[19] **Y. Bu\***, G. Aminian\*, L. Toni, M. R. Rodrigues, G. W. Wornell. "Characterizing and Understanding the Generalization Error of Transfer Learning with Gibbs Algorithm," (\* equal contribution), in *Proc. International Conference on Artificial Intelligence and Statistics (**AISTATS**)*, Mar. 2022.

[20] G. Aminian\*, **Y. Bu\***, L. Toni, M. R. 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.

[21] **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. (**Oral**, **Top 3%**)

[22] G. Aminian\*, **Y. Bu\***, L. Toni, M. R. 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.

[23] **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.

[24] **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.

[25] **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.

[26] **Y. Bu**, J. Lu, V. V. Veeravalli. "Active and Adaptive Sequential Learning with Per Time-step Excess Risk Guarantees," in *Proc. IEEE Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, Nov. 2019.

[27] **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.

[28] **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.

[29] **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.

[30] **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.

[31] **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.

**Patents**

[1] J. K. Lee, **Y. Bu**, D. Rajan, P. Sattigeri, S. Das, R. Panda, and G. W. Wornell. "Fair selective classification via a variational mutual information upper bound for imposing sufficiency." U.S. 17/565,411, Jun. 2023.

## Invited Talks

- Adaptive Text Watermark for Large Language Models
    - Annual Conference on Information Sciences and Systems, Princeton University  Mar. 2024
- Group Fairness with Uncertainty in Sensitive Attributes
    - Allerton Conference on Communication, Control, and Computing, UIUC  Oct. 2023
- From Sensitivity-constrained Information Bottleneck to Fair Selective Prediction
    - Information Theory and Data Science Workshop (Virtual), NUS  Jan. 2023
- Post-hoc Uncertainty Learning using a Dirichlet Meta-Model
    - Allerton Conference on Communication, Control, and Computing, UIUC  Oct. 2022
- Can Information Theory Characterize Learning Algorithms?
    - ECE department, The Ohio State University (OSU)  Mar. 2024
    - Information Theory and Applications Workshop (ITA), UCSD  Feb. 2023
    - CS Colloquium, University of California, Santa Barbara (UCSB)  Oct. 2022
    - ECE department, University of Florida (UF)  Mar. 2022
    - ECE department, National University of Singapore (NUS)  Jan. 2022
    - ECE department, Hong Kong University of Science and Technology (HKUST)  Jan. 2022
    - EEE department, Hong Kong University (HKU)  Dec. 2021

## Honors & Awards

- 16th **Abraham Wald Prize**, *Sequential Analysis*  2023
- **MLSP** 2022 Best Student Paper Award  2022
- 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, 2013

## Industrial Experiences

- Amazon.com Inc., Core machine learning group  Jun. 2017 - Dec. 2017
  (Currently known as **Amazon AI Lab**)
  Title: Applied Scientist Intern

# Teaching Experience

- **University of Florida**:
  EEL 3850: Data Science for ECE                                                                      Fall 2023
  EEL 6935: Information-Theoretic Methods in Machine Learning                   Spring 2023 and 2024
- Teaching and developing contents for **MIT IDSS MicroMaster** online program:
  6.86x Machine Learning with Python–From Linear Models to Deep Learning                Spring 2020
  14.310x Data Analysis for Social Scientists (live recitation and video recording)            Fall 2019
- Teaching assistant at **UIUC**
  ECE 365: Data Science and Engineering                                                             Spring 2019
  ECE 398: Making Sense of Big Data                                                          Spring 2017, Fall 2018
  ECE 598: Computational Inference and Learning                                                      Fall 2016

# Students Mentoring

- Mentoring Ph.D. students at UF ECE:
  Yepeng Liu, topic: Watermarking techniques for large language model              Fall 2023 - present
  Haobo Chen, topic: Over-parameterized models and Gibbs algorithm             Spring 2023 - present
- Serving in Ph.D. supervisory committee at UF ECE:
  Hongming Li, Haoxiang Ma, Bo Hu, Charlie Tran
- Serving in Ph.D. supervisory committee at UF CS:
  Yuchen Sun, Jingzhou Hu
- Undergraduates Senior Design projects at UF ECE:
  Cody Hutcheson, topic: Towards better domain adaptation via uncertainty quantification,   Fall 2023
- Graduate students at MIT EECS:
  Maohao Shen, Ph.D. candidate at MIT EECS,                                           Fall 2021 - present
  Abhin Shah, Ph.D. candidate at MIT EECS,                                          Spring 2021 - present
  Gary Lee, Ph.D. candidate at MIT EECS,                                     Summer 2020 - Summer 2022
  Tony T. Wang, MEng at MIT EECS,                                              Summer 2020 - Spring 2021
  Joshua Ka-Wing Lee, Ph.D. at MIT EECS,                                        Fall 2019 - Summer 2021

# Professional Activities

- **Panelist:** NSF CISE: CIF
- **Guest Editors:** Entropy Special Issue "Fairness in Machine Learning: Information Theoretic Perspectives," 2022-2023.
- **Organizer:** 6th and 7th Annual Workshop on Cognition & Control at University of Florida, 2023-2024
- **Reviewer:** Journal of Machine Learning Research (JMLR), Transactions on Machine Learning Research (TMLR), 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), IEEE Transactions on Neural Networks and Learning Systems (TNNLS), Transactions on Information Forensics & Security (TIFS), IEEE Transactions on Vehicular Technology (TVT), IEEE Journal on Selected Areas in Communications (JSAC)
  Conferences: NeurIPS, ICML, ICLR, AAAI, AISTATS, IJCAI, ISIT, ITW, ICASSP