Chiraag Kaushik

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Research Interests

- Robustness, explainability, and fairness in modern representation learning
- Effects of overparameterization and interpolation in statistical learning
- Design and application of ML systems to gain insight in natural sciences, imaging, and health

Education

Georgia Institute of Technology — Atlanta, GA
Ph.D. Electrical and Computer Engineering — August 2021 - May 2026 (expected)

- Advisors: Vidya Muthukumar and Justin Romberg
- Concentration: Digital Signal Processing and Machine Learning
- GPA: 4.00/4.00

Rice University — Houston, TX
B.S. Electrical and Computer Engineering, *summa cum laude, research distinction* — August 2017 - May 2021

- Concentration: Signal Processing and Data Science
- GPA: 4.11/4.00

Publications

Journal articles

1. Chi-Heng Lin, **C. Kaushik**, Eva L. Dyer and Vidya Muthukumar: "The good, bad and ugly sides of data augmentation: An implicit spectral regularization perspective," in *Journal of Machine Learning Research (JMLR)*, 2024.

2. **C. Kaushik**, Andrew McRae, Mark Davenport and Vidya Muthukumar: "New equivalences between interpolation and SVMs: Kernels and structured features," in *SIAM Journal on Mathematics of Data Science (SIMODS)*, 2024.

Conference articles and preprints

1. **C. Kaushik,** Justin Romberg, Vidya Muthukumar: "Precise asymptotics of reweighted least-squares algorithms for linear diagonal networks," preprint, under review

2. **C. Kaushik***, Ran Liu*, Chi-Heng Lin, Amrit Khera, Matthew Jin, Wenrui Ma, Vidya Muthukumar, Eva L. Dyer: "Balanced Data, Imbalanced Spectra: Unveiling Class Disparities with Spectral Imbalance," at *International Conference on Machine Learning (ICML)*, 2024.

3. **C. Kaushik,** T.M. Roddenberry, Santiago Segarra: "Network topology change-point detection from graph signals with prior spectral signatures," at *IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP)* 2021.

Research Experience

Georgia Institute of Technology

The effect of data augmentation on generalization and fairness in overparameterized models 2021-2023

- Developed generalization bounds for overparameterized models trained with various common stochastic data augmentations, including Gaussian noise injection and random mask.
- Used these insights to design interpretable augmentation procedures to help explain class imbalances and mitigate robustness failures during neural network training, including for vision-transformer and ResNet-based encoders.

Understanding class bias in modern pre-trained models 2023-2024

- Introduced the concept of "spectral imbalance" as an important contributor to performance gaps in classification models. Proved corresponding generalization bounds in the high-dimensional regime.
- Conducted empirical investigations of this phenomenon for 11 real-world encoders for vision data, and helped develop a metric to predict the bias of a given pre-trained model without any additional downstream training.

Recursive feature-learning in deep linear neural nets 2023-2024

- Analyzed an iterative algorithm motivated by deep neural networks architectures which can recover sparse and group-sparse signals efficiently. Proved guarantees using techniques from high-dimensional statistics and demonstrated favorable empirical performance compared to existing iterative methods.

Rice University

Network topology change-point detection from graph-supported data 2020-2021

- Developed a novel sequential change-point detection algorithm to predict changes in underlying graph topology by using spectral information obtained from data.
- Implemented algorithm on synthetic and real world (social network) datasets, demonstrating favorable performance in terms of average run length pre- and post- ground truth changes.

Early detection of cardiac electrical instability (with Texas Children's Hospital) 2020-2021

- Designed and implemented an online anomaly detection algorithm (based on a novel Wasserstein-CUSUM statistic derived from a personalized autoencoder model) for early detection of electrical instability from cardiac signals in post-operation pediatric patients.
- Voted 1st place at Rice Data Science Showcase by a panel of industry executives and professors

Professional Experience

Samsung Austin Semiconductor (Samsung Electronics) Austin, TX

Infrastructure Innovation Intern May 2019 - August 2019

- Led development of a new internal software application for tracking and data visualization during maintenance day in the semiconductor fab, leading to minimized downtime of the plant. Nominated by Samsung executives for a high-impact intern project award.

Scalable Health/Computational Imaging Labs Houston, TX

Undergraduate Researcher January 2018 - December 2019

- Implemented image processing methods based on the Scale-Invariant Feature Transform (SIFT) algorithm to improve the robustness of photoplethysmography (PPG) detection in wearable devices.

IronSolutions (Trimble Inc.) Franklin, TN

Testing and Automation Intern June 2018 - August 2018

Awards

- Herbert P. Haley Fellowship 2024-2025
- NSF Graduate Research Fellowship 2021-2026
- Georgia Tech President's Fellowship 2021-2026
- Simons Institute Deep Learning Theory Workshop travel award 2022
- 1st place - Rice Data Science Showcase 2021
- Rice Engineering Alumni Outstanding Senior Award 2021
- Phi Beta Kappa, member 2021 –present
- Eta Kappa Nu, member 2020 –present
- NUS Faculty of Engineering Annual Prize 2020
- Elizabeth D. Williams Fellowship for Study Abroad 2019
- President's Honor Roll 2018–2020
- Louis J. Walsh Engineering Scholarship 2018–2020

Leadership and Teaching

- **Innovation Ecosystem Coordinator** August 2019 - January 2020
  Student leader for the NSF PATHS-UP (Precise Advanced Technologies and Health Systems for Underserved Populations) Engineering Research Center
- **Teaching Assistant** Fall 2020
  Signals, Systems, and Learning (ELEC 301)

Posters and Presentations

1. **C. Kaushik**, Justin Romberg, and Vidya Muthukumar: "Precise asymptotics of reweighted least-squares algorithms for linear diagonal networks," poster presented at *IEEE Symposium on Information Theory (ISIT)*, Athens, Greece. July 2024.

2. Chi-Heng Lin, **C. Kaushik**, Eva L. Dyer, and Vidya Muthukumar: "The good, bad and ugly sides of data augmentation: An implicit spectral regularization perspective," poster presented at *DeepMath* conference, San Diego, CA. Nov. 2022.

3. **C. Kaushik**, B. Songong, V. Boominathan, A. Veeraraghavan, and A. Sabharwal, "Optical Design for Motion Compensation in Wearable Devices," poster presented at ECE Corporate Affiliates Day, Houston, TX. Apr. 2019.

4. B. Songong, **C. Kaushik**, V. Boominathan, A. Veeraraghavan, and A. Sabharwal, "Optical Design for Motion Compensation in Wearable Devices," poster presented at NSF Site Visit for PATHS-UP consortium, Texas A&M University, TX. Mar. 2019.

Skills

- **Technical skills:** Python, PyTorch, Numpy, Scikit-Learn, CVXPY, Matlab, C#, LaTeX
- **Languages:** Spanish, Brazilian Portuguese, Hindi