

RESEARCH INTERESTS

Understanding how models perform under different circumstances is essential. My work explores two important questions in evaluating a learnt model: (1) how well it generalizes to new data, and (2) how robust it is to corrupt data. Despite overparameterization, state-of-the-art models often exhibit implicit low-dimensionality and parsimony. Leveraging parsimonious structure in models/data (eg. sparsity, low rank) often leads to tighter theoretical guarantees and efficient algorithms.

EDUCATION & RESEARCH EXPERIENCE

Johns Hopkins University Ph.D Student, Department of Computer Science <i>Advisors</i> : Jeremias Sulam	JULY 2019 - PRESENT
Cornell University Research Assistant, Department of Operations Research and Information Engineering <i>Advisors</i> : Madeleine Udell, Drew Kouri (Sandia National Lab.)	JULY 2017 - MAY 2019
Birla Institute of Technology and Science Pilani, Goa Campus Master of Science in MATHEMATICS, Bachelor of Engineering in COMPUTER SCIENCE	JULY 2013 - MAY 2018

JOURNAL PUBLICATIONS

- **R. Muthukumar**, J. Sulam. [Adversarial robustness of sparse local Lipschitz predictors](#). SIAM Journal on Mathematics of Data Science (SIMODS), 2023
 - Input-specific pruning of neural networks helps provides tighter estimation of local Lipschitz constant.
 - Provides tighter robustness certificates leveraging the sparse activation patterns of ReLU feedforward networks.
 - Improved robust generalization bound that scale favourably with depth.
- **R. Muthukumar**, D. P. Kouri, and M. Udell. [Randomized sketching algorithms for low-memory dynamic optimization](#). SIAM Journal on Optimization (SIOPT), 31(2):1242– 1275, 2021
 - Builds on cutting edge randomized sketching algorithms to perform low memory PDE optimization
 - Provably convergent optimization algorithms based on Inexact Trust Region methods.

CONFERENCE PUBLICATIONS

- **R. Muthukumar**, J.Sulam. [Sparsity-aware generalization theory for deep neural networks](#). In Proceedings of the 34th Annual Conference on Learning Theory (COLT), 2023
 - Novel generalization bounds that account for sparsity in intermediate layer activations of deep neural networks.
 - Demonstrates fundamental trade-offs between sparsity and generalization.
 - Data-dependent priors enable meaningful bounds on generalization errors in over-parameterized scenarios.
- J. Sulam, **R. Muthukumar**, R. Arora. [Adversarial Robustness of Supervised Sparse Coding](#). In Advances in Neural Information Processing Systems (NeurIPS), 2020
 - Demonstrates bounds on robust generalization error for supervised dictionary learning
 - Provides tighter deterministic robustness certificates leveraging sparse structure.

AWARDS AND FELLOWSHIPS

SUMMER 2021	MINDS Summer Fellowship in Data Science
SPRING 2022	MINDS Spring Fellowship in Data Science

TALKS AND POSTERS

NOVEMBER 2023	Sparsity-aware generalization theory for deep neural networks, Poster @ Conference on the Mathematical Theory of Deep Neural Networks (DEPMATH), 2023
JULY 2023	Sparsity-aware generalization theory for deep neural networks, Poster @ 36th Annual Conference on Learning Theory (COLT), 2023
JUNE 2023	Sparsity-aware generalization theory for deep neural networks, Poster @ Computational Complexity of Statistical Problems Workshop
JANUARY 2023	Adversarial Robustness of sparse local Lipschitz predictors, Poster @ Third Workshop on Seeking Low Dimensionality in Deep Neural Networks 2023
NOVEMBER 2022	Adversarial Robustness of sparse local Lipschitz predictors, Poster @ Conference on the Mathematical Theory of Deep Neural Networks (DEPMATH), 2022
JULY 2022	Adversarial Robustness of sparse local Lipschitz predictors, Poster @ Sparsity in Neural Networks Workshop 2022
MARCH 2022	Adversarial Robustness of sparse local Lipschitz predictors, Invited Talk @ MINDS Retreat 2022
DECEMBER 2020	Adversarial Robustness of Supervised Sparse Coding, Poster @ Conference on Neural Information Processing Systems (NeurIPS), 2020
FEBRUARY 2020	Randomized Sketching Algorithms for Low Memory Dynamic Optimization, Invited Student Guest speaker @ CSL Student Conference, UIUC
JULY 2019	Sketching Algorithms for Approximate Gradients @ JuliaCon 2019
JUNE 2016	Presolving Algorithms for Optimization @ JuliaCon 2016

EXPERIENCE

- PRESOLVE ROUTINES FOR LP AND SDP @ [Google Summer of Code 2016](#)
Mentor - Dr. Madeleine Udell
 - Implemented fast Presolving algorithms to speed up LP optimization in scientific computing language - Julia
 - Benchmarked against existing solvers for speed and efficiency

TEACHING ASSISTANTSHIP

FALL 2021 @ JHU	EN.580.709 : Sparse Representations in Computer Vision and Machine Learning
FALL 2020 @ JHU	EN.580.709 : Sparse Representations in Computer Vision and Machine Learning
FALL 2016 @ BITS	F464 : Machine Learning

REFERENCES

[Jeremias Sulam](#), [Rene Vidal](#), [Madeleine Udell](#), [Drew Kouri](#)