Dhruva Karkada

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Deep learning is a theoretically- and experimentally-accessible playground for understanding learning as a general, emergent phenomenon. My research goal is to probe deep learning systems to elucidate and characterize the general properties of systems that learn. To this end, I use techniques from statistical physics, applied math, and numerics to bridge the gap between the theory and empirics of deep learning.

Education.

2021– **University of California, Berkeley.** PhD Physics.

2017–2021 **University of Texas at Austin.** BS Physics Honors, BS Computer Science Honors, BS Astronomy Honors
Dean's Scholar. Turing Scholar. GPA 3.93/4.00.

Research.

2023 More is Better in Modern Machine Learning: when Infinite Overparameterization is Optimal and Overfitting is Obligatory. J. B. Simon, **D. Karkada**, N. Ghosh, M. Belkin

Accepted, ICLR '24. We theoretically give sufficient conditions under which a general kernel learner achieves optimal performance at zero regularization. This resolves a long-standing question regarding the statistical soundness of overfitting wide neural networks. I developed new measurement techniques and used them to devise experiments that convincingly validate our theory for a wide class of realistic task-model pairs, e.g., random feature models and convolutional neural networks learning CIFAR10.

2022 The Eigenlearning Framework: A conservation law perspective on kernel regression and wide neural networks. J. B. Simon, M. Dickens, **D. Karkada,** M. R. DeWeese

Accepted, TMLR. We provide an interpretable closed-form estimate for the test error of wide neural networks. I implemented a suite of experiments which validate the theory and provide the first convincing theoretical explanation for the so-called deep bootstrap phenomenon (Nakkiran et al '20).

2021 Automatically Quantifying Protostellar Outflows in Star Formation Simulations. **D. Karkada.**

Best Honors Thesis Runner-up, UT Computer Science 2021. I developed a novel algorithm to track substructures in protostellar gas outflows during star formation. I used it to quantitatively characterize the energy/momentum feedback effects of protostellar outflows on star formation dynamics.

2020 Geometric Quantum Thermodynamics.

NSF REU. I developed numerical software to visualize and demonstrate a novel geometric formalism for open quantum systems. I rederived Larmor precession for a time-independent single-qubit Hamiltonian. My contributions were acknowledged in a series of papers by F. Anza and J. Crutchfield.

2020 Holographic Variational Quantum Eigensolvers.

I wrote high-performance parallelized software to simulate quantum circuits and tensor networks. This classically simulates a new class of "holographic" eigensolvers, in which a D-dimensional qubit system is fully simulated by a (D-1)-dimensional system. My contributions show that the holographic ansatz quickly finds ground states (within 0.5% of the theoretical value) of 1D spin chains subject to the transverse-field Ising Hamiltonian, a result which has since been extended into publications.

2019 Using deep neural networks to identify and classify disturbances in seagrass meadows observed in side-scan sonar images. **D. Karkada**, M.S. Ballard, K.M. Lee, A.F. Rahman, P.S. Wilson.

I developed a deep learning model for accurate image segmentation of noisy sonar images of shallow-water seagrass meadows with 98% pixel accuracy, outperforming previous approaches. I presented these results at the 2020 Ocean Sciences conference.

Honors and awards.

2023	**Honorable mention:** NSF GRFP
2022	**Winner:** Teaching Effectiveness Award (university-wide accolade)
2022	**Winner:** Outstanding Graduate Student Instructor Award (department accolade)
2021	**Runner-up:** Best Honors Thesis, UT Computer Science
2021	**Honorable mention:** NSF GRFP
2017–2021	**Winner:** College of Natural Sciences Departmental Scholarship
2020	**Winner:** Darrell W. Moffitt Jr. Memorial Physics Endowed Presidential Scholarship
2019	Finalist: Best New Tutor at UT Austin Sanger Learning Center
2018, 2019	Finalist: UT Austin's Visualizing Science outreach competition
2017	**Winner:** National Merit Scholarship award

Work experience.

2021–	**Graduate Student Instructor.** I taught introductory mechanics and electromagnetism to physics and engineering majors. Students evaluated me as a very effective, knowledgeable, and approachable TA. This led to me winning department-wide and university-wide teaching awards.
2019–2020	**Research assistant, Applied Research Laboratories.** I was employed under a DoE grant to characterize the geological and ecological dynamics of shallow-water sediment and flora.
2019–2020	**Tutor, Sanger Learning Center.** I tutored at the campus tutoring center for classes such as introductory physics, calculus, discrete mathematics, and astronomy.

Mentorship and outreach.

2022–	**Mentor, POWER Bay Area.** I support community college students from underrepresented backgrounds and help them build their science career. I provide concrete guidance to help navigate undergraduate science
2017–	**Outreach leader, National Science Olympiad Astronomy.** With NASA's Universe of Learning initiative, I developed official educational resources for high school students studying astrophysics for the National Science Olympiad. I designed highly-rated online educational content (such as webinars and tutorial guides) specifically aimed to help students who are underexposed to science. I led multiple workshops for K12 teachers about how to effectively communicate astronomy concepts to students. I lead and coordinate teams of volunteers to run high school science tournaments at university campuses including MIT, UT, and Princeton. These tournaments are popular and frequently rated as highly engaging by competitors.
2022	**Writer for the Berkeley Science Review,** a graduate student run science publication.
2019–2021	**Lead event supervisor and outreach, Texas Science Olympiad Data Science.** I designed a new computer science event for Texas Science Olympiad focused on programming fundamentals, scientific data analysis, and statistical analysis. I prepared educational materials and led workshops to help students gain exposure to computer science topics, especially students who didn't have access to CS classes at their high school. Student competitors consistently gave very positive feedback, and it was a popular competition event.

Skills.

Proficient	Python (incl. numpy, jax, pytorch, plotly), LaTeX, Git, Java, Vector graphics, Audio processing
Intermediate	Linux/Bash, Mathematica, parallel computing, React, C++,
Exposure	Matlab, C, Rust