Dhruva Karkada

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Deep learning is a theoretically- and experimentally-accessible playground for understanding learning as a general, emergent phenomenon. The overarching goal of my research 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–'21 **University of Texas at Austin**. BS Physics Honors, BS Computer Science Honors, BS Astronomy Honors
Dean's Scholars Honors Program and Turing Scholars Honors Program. GPA 3.93/4.00

Research

2022 **The Eigenlearning Framework: A conservation law perspective on kernel regression and wide NNs**
J. B. Simon, M. Dickens, **D. Karkada**, M. R. DeWeese
- ICLR 2023 submission (acceptance pending)
- I performed a suite of experiments demonstrating that our theory explains the deep bootstrap phenomenon highlighted by Nakkiran et al. 2020 (*The Deep Bootstrap Framework...)*

2019–'21 **Automatically Quantifying Protostellar Outflows in Star Formation Simulations**
with Prof. Stella Offner, UT Austin
- Runner-up for Best Honors Thesis, UT Computer Science 2021
- I developed a novel algorithm to track substructures in protostellar gas outflows during star formation
- I used this technique to quantify the feedback effects of protostellar outflows on star formation dynamics by analyzing data from star formation fluid simulations
- Further applications: use algorithm on observational data to make quantitative statements about the effects of mass/energy dynamics in protostellar systems

2020 **Geometric Quantum Mechanics**
with Prof. James Crutchfield, UC Davis (Summer NSF REU)
- **D. Karkada** acknowledged in *Beyond Density Matrices: Geometric Quantum States*, F. Anza, J. P. Crutchfield and *Geometric Quantum Thermodynamics*, F. Anza, J. P. Crutchfield
- During NSF REU, I developed numerical software and visualizations to demonstrate the power of a new geometric formalism for open quantum systems
- I used these tools to demonstrate benchmark cases for the new formalism (e.g. reproducing Larmor precession for a time-independent single-qubit Hamiltonian)
- My work demonstrated that the geometric formalism encodes more information about entanglement dynamics than the traditional density matrix approach

2020 **Holographic Variational Quantum Eigensolvers**
with Prof. Andrew Potter, UT Austin
- I wrote high-performance parallelized software to efficiently simulate quantum circuits and tensor networks, allowing us to classically simulate "holographic" eigensolvers. In this new class of eigensolvers, a system with D spatial dimensions can be simulated with a $(D-1)$-dimensional subset of qubits
- I then showed that our new holographic ansatz is able to quickly find ground states (within 0.5% of the theoretical value) of infinite 1D spin chains subject to the transverse-field Ising Hamiltonian
- This preliminary work has since been extended into multiple publications exploring on the holographic ansatz

2019–'20 **Deep Neural Networks for Quantifying Disturbances to Seagrass Ecosystems**
with Dr. Megan Ballard, Appied Research Laboratories (Summer research internship)
- **D. Karkada**, M.S. Ballard, K.M. Lee, A.F. Rahman, P.S. Wilson. *Using deep neural networks to identify and classify disturbances in seagrass meadows observed in side-scan sonar images.* Ocean Sciences conference, San Diego, 2020.
- 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 developed auxiliary software tools to read and process raw sonar data as part of a data preprocessing pipeline

Outreach

2022– Mentor for POWER (mentorship program for students across the Bay Area)
- Each semester I support community college students from underrepresented backgrounds and help them build their science career
- I provide concrete guidance and advice about navigating undergraduate science

2022 Writer for the Berkeley Science Review (graduate student run science publication)

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've designed highly-rated online educational content (such as webinars and tutorial guides) specifically aimed to help students who are underexposed to science
- I've led workshops for high school 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 rated as highly engaging by competitors

2019–'21 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

Advanced 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

Honors and Awards

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

2017–'21 **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 National Merit Scholar