

Raghav Kansal

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Education

UC San Diego, CERN, and Fermilab (Artificial Intelligence Fellow)

La Jolla, USA; Geneva, Switzerland; and Chicago, USA

PHD IN PHYSICS, GPA: 3.97/4.00

2019 - 2024 (Tentative)

Topic: Particle Physics and Machine Learning Advisor: [Javier Duarte](#)

UC San Diego

La Jolla, USA

BS IN PHYSICS & COMPUTER ENGINEERING, GPA: 3.98/4.00, *summa cum laude*

2015 - 2019

Divisional and Departmental Highest Honors

Selected Publications

Primary Contribution

- [1] [R. Kansal](#) et al. "On the Evaluation of Generative Models in High Energy Physics". In: *Accepted to Phys. Rev. D* (Mar. 2023). arXiv: 2211.10295.
- [2] [R. Kansal](#) et al. "Particle Cloud Generation with Message Passing Generative Adversarial Networks". In: *NeurIPS*. 2021. arXiv: 2106.11535.
- [3] [R. Kansal](#) et al. "Graph Generative Adversarial Networks for Sparse Data Generation in High Energy Physics". In: *NeurIPS ML4PS Workshop*. 2020. arXiv: 2012.00173.

Secondary Contributions

- [4] Z. Hao, [R. Kansal](#), et al. "Lorentz Group Equivariant Autoencoders". In: *Submitted to Eur. Phys. J. C* (Dec. 2022). arXiv: 2212.07347.
- [5] F. Mokhtar, [R. Kansal](#), and J. Duarte. "Do graph neural networks learn traditional jet substructure?" In: *NeurIPS ML4PS Workshop*. 2022. arXiv: 2211.09912.
- [6] CMS Collaboration. "Search for nonresonant pair production of highly energetic Higgs bosons decaying to bottom quarks". In: *Phys. Rev. Lett.* (July 2022). arXiv: 2205.06667.
- [7] M. Touranakou et al. "Particle-based fast jet simulation at the LHC with variational autoencoders". In: *Machine Learning: Science and Technology* 3.3 (July 2022), p. 035003. arXiv: 2203.00520.
- [8] F. Mokhtar, [R. Kansal](#), et al. "Explaining machine-learned particle-flow reconstruction". In: *NeurIPS ML4PS Workshop*. 2021. arXiv: 2111.12840.
- [9] S. Tsan, [R. Kansal](#), et al. "Particle Graph Autoencoders and Differentiable, Learned Energy Mover's Distance". In: *NeurIPS ML4PS Workshop*. 2021. arXiv: 2111.12849.

Honors and Awards

- | | | |
|-----------|--|---|
| 2023 | Fermilab LPC Graduate Scholarship | <i>Fermilab</i> |
| | For point cloud generative modelling of particle collisions, self-supervised learning for jet classification, and an ML-based search for flavour changing neutral currents. | |
| Nov 2021 | 2020-21 Carol and George Lattimer Graduate Award for Excellence | <i>UCSD Division of Physical Sciences</i> |
| 2021-2022 | Fermilab LPC Artificial Intelligence Fellowship | <i>Fermilab</i> |
| | For graph-based fast simulation models, ML techniques for reconstruction, compression, and anomaly detection tasks, and a boosted Higgs boson graph classifier for precision measurements. Full description. | |
| Aug 2019 | CERN Openlab Summer Students Lightning Talks Award Runner-Up | <i>CERN</i> |
| | For the talk 'Deep Graph Neural Networks for Fast HGCal Simulation' | |
| Jun 2019 | 2019 IRIS-HEP Fellowship | <i>IRIS-HEP</i> |
| | For the project 'HGCal Fast Simulation with Graph Networks' | |
| Jun 2019 | 2019 John Holmes Malmberg Prize | <i>UCSD Department of Physics</i> |
| | Presented annually at commencement to a graduating physics student for excellence in experimental physics. | |
| May 2019 | 2018-2019 Physical Sciences Dean's Undergraduate Award for Excellence | <i>UCSD Division of Physical Sciences</i> |
| Jul 2018 | 2018 William A. Lee Undergraduate Research Award | <i>UCSD Division of Physical Sciences</i> |
| | For the project 'Arbitrary ultra-cold atomic lattices using holographic optical tweezers' | |

Selected Talks and Posters

A complete list, as well as links, slides, posters, and videos are available at raghavkansal.com/event.

Feb 2023	Inter-experimental Machine Learning Meeting Generative transformers and how to evaluate them	CERN (Talk)
Nov 2022	Foundation Models and Detector Simulation Workshop Generative transformers and how to evaluate them	CERN (Invited Talk)
Nov 2022	ML4Jets Evaluating Generative Models in High Energy Physics	Virtual (Talk)
Sep 2022	PyHEP 2022 JetNet library for machine learning in high energy physics	Virtual (Talk)
Sep 2022	Machine Learning at the Galileo Galilei Institute Workshop Generative Modelling for Physics	Florence (Discussion)
Sep 2022	Machine Learning at the Galileo Galilei Institute Workshop Particle Cloud Generation with Message Passing GANs	Florence (Invited Talk)
Jul 2022	CMS Machine Learning Townhall 2022 Overview and Outlook: Machine Learning for Simulation	CERN (Invited Talk)
Jul 2022	LPC Physics Forum Machine Learning for LHC Simulation	Fermilab (Invited Talk)
Dec 2021	NeurIPS 21 Main Poster Session Particle Cloud Generation with Message Passing GANs	Virtual (Poster)
Nov 2021	University of Washington EPE Machine Learning Seminar Particle Cloud Generation with Message Passing GANs	Virtual (Invited Talk)
Nov 2021	LPCC FastSim Workshop Validation Techniques for Machine-Learned FastSim	Virtual (Invited Talk)
Jun 2021	Mainz Institute for Theoretical Physics Machine Learning for Particle Physics Workshop Particle Cloud Generation with Message Passing GANs	Virtual (Invited Talk)
Mar 2021	James Madison University Artificial Intelligence and Machine Learning Seminar Graph Generative Adversarial Networks for High Energy Physics Data Generation	Virtual (Invited Talk)
Mar 2021	Berkeley Institute for Data Science Deep Generative Models for Fundamental Physics Meeting Graph Generative Adversarial Networks for High Energy Physics Data Generation	Virtual (Invited Talk)
Feb 2021	Imperial College London DataLearning Seminar Graph Generative Adversarial Networks for High Energy Physics Data Generation	Virtual (Invited Talk)
Aug 2019	CERN Openlab Lightning Talks Deep Graph Neural Networks for Fast HGCal Simulation, Runner-Up Award	CERN (Talk)
Aug 2018	William A. Lee Undergraduate Research Award Poster Presentations Arbitrary Positioning and Manipulation of Ultra-Cold Atoms with Optical Tweezers	UCSD (Poster)

Projects

MPGAN & GAPT

[GAPT](#) [MPGAN](#) [slides](#) [github](#)

Jun 2019 -

- Leading effort on developing a graph-based generative adversarial network, MPGAN, which has proven effective at simulating particle collisions.
- Developed as well the attention-based generative adversarial particle transformer (GAPT), using set transformers.
- Developed validation metrics and techniques for real applications to LHC simulations.
- Working now on conditional generation and application to CERN detector data.

HH→bbVV

[github](#)

Jun 2019 -

- Leading the analysis of 2016-2018 data collected at CERN looking for two Higgs bosons (H) decaying to beauty quarks (b) and vector bosons (V).
- Developed a state-of-the-art graph neural network to classify between H→VV particle clouds and backgrounds.

JetNet Library and Dataset

[github](#) [website](#)

Sep 2021 -

- Developed a library for convenient access to jet datasets, and other utilities, to increase accessibility and reproducibility in ML in particle physics.
- >25,000 downloads as of March 2023, used in several ML and particle physics projects.

Lorentz Group Equivariant Autoencoders

[paper](#) [review](#) [github](#)

Dec 2020 - April 2023

- Wrote a review of deep learning models that are equivariant to physics-relevant group transformations for my group theory course.
- Led to our group developing a graph-based autoencoder equivariant to Lorentz group transformations (LGAE).
- Outperforms CNN and GNN autoencoders for compression and anomaly detection tasks.

Particle Graph Autoencoders

[paper](#) [github](#)

Dec 2020 - Dec 2021

- Developed a graph-based autoencoder for compression of and anomaly detection in Large Hadron Collider data.

Machine Learning for Particle Flow

[paper](#) [github](#)

May 2021 - Dec 2021

- Developing graph neural networks to perform event reconstruction in the CMS experiment at CERN.
- Interpreted results using the Layerwise Relevance Propagation (LRP) method.

Sequential Modeling for Soccer Predictions

[github](#)

Mar 2018 - Mar 2019

- Fun project mostly to gain experience with RNNs and Attention
- I achieved a 71% testing accuracy in predicting the outcome of European football matches

Optical Tweezers and a Quantum Gas Microscope

[poster](#)

Jun 2017 - Jun 2019

- Created dynamic, sub-micron holographic optical tweezers and a Quantum Gas Microscope with sub-micron resolution in order to manipulate individual atoms (or qubits) for quantum computing and quantum information science experiments
- This work won a William A. Lee Research award, and will be published soon

GRAD: An interactive graph-based degree planning app

[github](#)

Jan 2017 - Mar 2017

- Created an app for visualizing course requirements with a user-friendly UI
- I was the Back-end and Algorithms Lead for a team of 10, and personally wrote the server, scraping, and graphing algorithms for the app
- We were one of 8 finalists out of 60 projects in the UCSD 2018 software engineering course

Open Source Software Contributions

- Lead developer of the popular [JetNet](#) Python package for ML in particle physics, >25,000 downloads as of March 2023
- Contributed to [PyTorch](#) CUDA kernels for linear algebra
- Maintainer of [fastjet](#) Python package and interface for C++ jet algorithms
- Contributed statistical methods to the [rhalphalib](#) library for limit setting in particle physics

Students Mentored

Zhaoyu (Tina) Zhang (Undergrad, UCSD)

[github](#)

Aug 2022 -

- MPGAN for detector simulations

Anni Li (Undergrad / IRIS-HEP Fellow, UCSD)

[paper](#) [github](#)

Jan 2022 -

- Generative adversarial particle transformers (GAPT)

Carlos Pareja (Undergrad, UCSD)

[EXPAND program](#) [github](#)

Jan 2022 -

- JetNet library and website

Zichun Hao (Undergrad, UCSD)

[github](#)

Jan 2021 -

- Lorentz-equivariant autoencoder for anomaly detection. Paper in prep.
- H→VV graph neural network classifier. (Completed) Paper in prep.

Steven Tsan (Undergrad, UCSD)

[paper](#) [github](#)

Jan 2021 -

- Graph neural network autoencoder for anomaly detection.

Ish Kaul (Undergrad, Princeton)

[github](#)

Jul - Sep 2021

- Graph neural network regression for the mass of Higgs Boson jets. Paper in prep.

ENLACE Students (5 undergrads, San Diego and Mexico)

[ENLACE program](#) [project](#)

Jul - Sep 2021

- JetNet library and website

Saloni Agarwal (Undergrad, UCSD)

[EXPAND program](#) [github](#)

Jan - Aug 2022

- JetNet library and website

Experience

Duarte Lab, UC San Diego

UCSD/CERN

MACHINE LEARNING AND PARTICLE PHYSICS RESEARCHER

Sep 2019 -

- Developing graph- and attention-based **generative models and metrics** for simulating high energy collisions
- Developed and applying graph neural network (GNN) classifiers to **set the most stringent constraints** to date on double-Higgs production
- Lorentz-group equivariant and **GNN auto-encoders** for compression and anomaly detection
- **JetNet library** and **dataset** for accessibility and reproducibility in machine learning and high energy physics
- **Interpretable GNNs** for particle reconstruction

Machine Learning for Particle Physics Group, CERN

CERN

CERN OPENLAB INTERN

Jun - Aug 2019

- Deep learning and generative models for high energy particle collisions

Kleinfeld Lab, UC San Diego

UCSD

NEUROPHYSICS RESEARCHER

Sep 2018 – Jun 2019

- Two-photon microscopy to measure vasomotion dependence on pO₂ in the mouse somatosensory cortex

Barreiro Lab, UC San Diego

UCSD

EXPERIMENTAL QUANTUM INFORMATION SCIENCE RESEARCHER

Jun 2017 – Jun 2019

- Designed and implemented a setup for a quantum gas microscope (QGM) to image with single-site resolution
- Generated 2D holographic, dynamic, arbitrarily arranged, sub-micron optical tweezers, integrated with the QGM
- Programmed FPGA and C electronic devices, and created and (3D) printed mechanical mounts and electronics circuits for experimental use

Focus Analytics

Mumbai, India

SOFTWARE INTERN

Jul 2016 – Sep 2016

- Developed and deployed a location prediction SparkJava server with Cassandra and Redis databases
- Implemented ML k-means clustering and SVM linear classification algorithms on location data
- Wrote NodeJS servers and pages for receiving users' predicted locations and displaying the live data on maps
- Designed Cassandra and MySQL databases storing user tracking data, and wrote server APIs for accessing/updating)