Raghav **Kansal**

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Education

UC San Diego/CERN/Fermilab — *La Jolla, USA; Geneva, Switzerland; and Chicago, USA*

PhD in Physics, **GPA: 3.97/4.00** — *2019 -*

Topic: Machine Learning and Particle Physics 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

Publications

[1] R. Kansal et al. "Particle Cloud Generation with Message Passing Generative Adversarial Networks". In: *NeurIPS*. 2021. arXiv: 2106.11535.

[2] F. Mokhtar, R. Kansal, et al. "Explaining machine-learned particle-flow reconstruction". In: *4th Machine Learning and the Physical Sciences Workshop at NeurIPS*. 2021. arXiv: 2111.12840.

[3] S. Tsan, R. Kansal, et al. "Particle Graph Autoencoders and Differentiable, Learned Energy Mover's Distance". In: *4th Machine Learning and the Physical Sciences Workshop at NeurIPS*. 2021. arXiv: 2111.12849.

[4] R. Kansal et al. "Graph Generative Adversarial Networks for Sparse Data Generation in High Energy Physics". In: *3rd Machine Learning and the Physical Sciences Workshop at NeurIPS*. 2020. arXiv: 2012.00173.

Honors and Awards

Nov 2021 **2020-21 Carol and George Lattimer Graduate Award for Excellence** — *UCSD Division of Physical Sciences*

One of two recipients of this award, which 'honors outstanding graduate students in the Division of Physical Sciences who seek interdisciplinary approaches to problem solving and have a strong commitment to education, mentorship, and service.'

2021-2022 **Fermilab LPC Artificial Intelligence Fellowship** — *Fermilab*

For ML-based fast simulation software, ML techniques for reconstruction, compression, and anomaly detection tasks, and a boosted Higgs to WW tagger for precision measurements. Full description.

Aug 2019 **CERN Openlab Summer Students Lightning Talks Award Runner-Up** — *CERN*

For the talk 'Deep Graph Neural Networks for Fast HGCAL Simulation'

Jun 2019 **2019 IRIS-HEP Fellowship** — *IRIS-HEP*

For the project 'HGCAL Fast Simulation with Graph Networks'

Jun 2019 **2019 John Holmes Malmberg Prize** — *UCSD Department of Physics*

Sole recipient of this prize, which is 'presented annually at commencement to a graduating physics student who is recognized for potential for a career in physics and a measure of experimental inquisitiveness.'

May 2019 **2018-2019 Physical Sciences Dean's Undergraduate Award for Excellence** — *UCSD Division of Physical Sciences*

One of 33 students from the departments of Mathematics, Physics and Chemistry 'recognized for excellence in academics and fundamental research'.

Jul 2018 **2018 William A. Lee Undergraduate Research Award** — *UCSD Division of Physical Sciences*

For the project 'Arbitrary ultra-cold atomic lattices using holographic optical tweezers'

Projects

MPGAN — **paper** **slides** **github** — *Jun 2019 -*

- Leading the effort on developing a graph-based generative adversarial network, which we call MPGAN, which has proven effective at generating sparse data with irregular underlying geometry.
- Our latest work on this has been accepted to the 2021 NeurIPS main conference.
- We're now experimenting with a conditional GAN version and variable-sized graphs, as well as applications to other datasets such as 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).
- Developing a new graph neural network to classify between H→VV particle clouds and backgrounds.

JetNet Library github website *Sep 2021 -*

- Developing a library and website for convenient access to jet datasets, in particle cloud representations, along with several useful utilities for jet-based machine learning development.
- Has been used so far for our group's MPGAN and LGAE projects, and continues to be expanded.

Machine Learning for Particle Flow github *May 2021 -*

- Developing graph neural networks to perform event reconstruction in the CMS experiment at CERN.
- Interpreting results using the Layerwise Relevance Propagation (LRP) method; latest work on this has been submitted to the Machine Learning for Physical Science workshop at NeurIPS 21.

Lorentz Group Equivariant Autoencoder review github *Dec 2020 -*

- Wrote a review of deep learning models that are equivariant to physics-relevant group transformations for Prof. John McGreevy's fantastic group theory course.
- Led to our group developing a graph-based autoencoder equivariant to Lorentz group transformations (LGAE)
- Our latest work has been submitted to the Machine Learning for Physical Sciences workshop at NeurIPS 2021.

Particle Graph Autoencoders github *Dec 2020 -*

- Developing graph-based autoencoders for compression of and anomaly detection in particle cloud representations of Large Hadron Collider data.
- Our latest work has been submitted to the Machine Learning for Physical Sciences workshop at NeurIPS 2021.

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 soccer 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

Selected Talks and Posters

See raghavkansal.com/event for a complete list, as well as links, slides, posters, and videos.

Dec 2021 **NeurIPS 21 Main Poster Session** *Virtual (Poster)*
Particle Cloud Generation with Message Passing GANs

Nov 2021 **University of Washington EPE Machine Learning Seminar** *Virtual (Talk)*
Particle Cloud Generation with Message Passing GANs

Nov 2021 **ACAT Poster Session** *Virtual (Poster)*
Particle Cloud Generation with Message Passing GANs

Nov 2021 **LPCC FastSim Workshop** *Virtual (Talk)*
Validation Techniques for Machine-Learned FastSim

Jul 2021 **ML4Jets Workshop** *Virtual (Talk)*
Particle Cloud Generation with Message Passing GANs

Jun 2021 **Mainz Institute for Theoretical Physics Machine Learning for Particle Physics Workshop** *Virtual (Talk)*
Particle Cloud Generation with Message Passing GANs

May 2021 **CMS ML Forum** *Virtual (Talk)*
Sparse Data Generation

Mar 2021 **James Madison University Artificial Intelligence and Machine Learning Seminar** *Virtual (Talk)*
Graph Generative Adversarial Networks for High Energy Physics Data Generation

Mar 2021 **Berkeley Institute for Data Science Deep Generative Models for Fundamental Physics Meeting** *Virtual (Talk)*
Graph Generative Adversarial Networks for High Energy Physics Data Generation

Feb 2021 **Imperial College London DataLearning Working Group Meeting** *Virtual (Talk)*
Graph Generative Adversarial Networks for High Energy Physics Data Generation

Dec 2020 **NeurIPS 2020, Machine Learning and the Physical Sciences Workshop** *Virtual (Poster)*
Graph Generative Adversarial Networks for Sparse Data Generation in High Energy Physics

Nov 2020 **Inter-Experimental LHC Machine Learning Working Group Meeting** *Virtual (Talk)*
Sparse Data Generation with Graph GANs

Feb 2020 **Princeton IRIS-HEP Review Meeting** *Princeton (Poster)*
Deep Graph Neural Networks for Fast HGCAL Simulation

Aug 2019 **CERN Openlab Lightning Talks** *CERN (Talk)*
Deep Graph Neural Networks for Fast HGCAL Simulation, Runner-Up Award

Aug 2018 **William A. Lee Undergraduate Research Award Poster Presentations** *UCSD (Poster)*
Arbitrary Positioning and Manipulation of Ultra-Cold Atoms with Optical Tweezers

Experience

Duarte Lab, UC San Diego *UCSD/CERN*

Machine Learning and Particle Physics Researcher *Sep 2019 -*

- Developing new graph generative models for sparse and irregular data like that prevalent in particle physics
- Graph neural network (GNN) autoencoders for compression and anomaly detection, machine learning for particle flow reconstruction, Lorentz-group equivariant autoencoders, JetNet library for convenience and reproducibility in machine learning development in high energy physics
- Developing and applying state-of-the-art GNN classifiers to set the most stringent constraints to date on double-Higgs production, allowing insight into the metastability of the universe

Machine Learning for Particle Physics Group, CERN *CERN*

CERN Openlab Intern *Jun - Aug 2019*

- Started our project on graph generative models for particle physics simulations, motivated primarily by the CMS experiment's new High Granularity Calorimeter (HGCAL)

Kleinfeld Lab, UC San Diego *UCSD*

Neurophysics Researcher *Sep 2018 – Jun 2019*

- Used two-photon microscopy to measure pO2 in the mouse somatosensory cortex
- Imaged the cortex to measure vasomotion relative to pO2

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 dynamic, arbitrarily arranged, sub-micron optical tweezers, integrated with the QGM, via two methods, using: 1) a Digital Micromirror Device (i.e. holography), and 2) an acousto-optic deflector
- Characterized a high (0.8) Numerical Aperture objective for the QGM using OSLO optical simulations and point-spread function image analysis in Python
- Using an FPGA device, outputted RF waveforms that modulate laser beams with parabolic spatial intensity in order to produce a Bose-Einstein Condensate
- 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*

- Interned at a software startup which has since been bought by Moka
- 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, along with web panels for easy viewing of the data (using said APIs)