Chris Pedersen

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RESEARCH INTERESTS

I am a research scientist in deep learning. My expertise is in the construction of bespoke machine learning models to solve problems across science, including cosmology, bioinformatics, and turbulence modelling in fluid dynamics.

EXPERIENCE

Courant Institute of Mathematical Sciences, New York University September 2022 - present
Postdoctoral Associate
Topics: Developing new ML approaches to improve the accuracy and robustness of climate models

Center for Cosmology and Particle Physics, New York University September 2021 - August 2022
Postdoctoral Associate
Topics: Applications of statistical techniques and deep learning to challenges in astrophysics.

Center for Computational Astrophysics, Flatiron Institute September 2021 - present
Guest Researcher

EDUCATION

University College London September 2017 - August 2021
Ph.D. in Astrophysics

- Primarily responsible for a 4.5M CPU hour allocation on a Tier 1 machine (code performance evaluation, running simulations, data management, postprocessing, scientific analysis and publications.)
- Development of simulation code in C/C++, construction of Bayesian inference and Gaussian process modelling pipelines in Python.

Cardiff University September 2012 - July 2017
MPhys in Physics with Astronomy, First class honours

- Bayesian inference using Markov chain Monte Carlo simulations in Python, in the context of gravitational wave astronomy.

ML PROJECTS LED

Diffusion modelling for turbulent flows (2023 - present):

- Novel application of diffusion model framework to stabilise the neural emulation of turbulent fluid flows (project ongoing)

Neural emulation for improved turbulence modelling (2023):

- Responsible for model design and implementation, construction of hybrid MLops and simulation analysis pipeline (PyTorch, Weights and Biases).
- Led to a workshop paper at ICML 2023 improving the stability and computational cost of turbulence simulations.

Cancer-net (2022 - 2023):

- Using graph neural networks to model the progression of prostate and brain cancer based on the genetic mutations within the tumor.
- Responsible for model design and implementation in PyTorch, model optimisation, and performance validation (submitted to Nature Machine Intelligence, and publicly available code).

Wavelet scattering for cosmological inference (2022):

- Created a new wavelet based CNN to extract information from cosmological data, significantly outperforming a standard CNN in the low-data regime.
- Led to a workshop paper at ICML 2022 and publicly available code.

Cosmology emulator (2020-2021):

- Built a surrogate model (or *emulator*) using Gaussian processes, enabling accurate Bayesian parameter inference of observational data from just 30 training simulations.
- Led to a publication and publicly available code.

TECHNICAL SKILLS

Computational skills	Python, Linux/Bash, git, LaTeX, High Performance Computing, PyTorch, TensorFlow, Jax, SciPy, scikit-learn, numerical methods
Statistical & ML techniques	Bayesian inference, Markov chain Monte Carlo simulations, linear regression, logistic regression, SVM, PCA, Gaussian processes, convolutional neural networks, graph neural networks, autoencoders, wavelet scattering networks diffusion models, data parallelism (DDP), model parallelism (Deepspeed)
Software development	cancer-net, torch-qg, LearnableWavelets, LaCE, cup1d, MP-Gadget (Contributor), fake_spectra (Contributor)

SELECTED PUBLICATIONS

Complete list available at available here

- **C. Pedersen**, T. Tesileanu, T. Wu, S. Golkar, M. Cranmer, Z. Zhang, S. Ho
  Reusability report: Prostate cancer stratification with diverse biologically-informed neural architectures, Submitted to Nature Machine Intelligence
- **C. Pedersen**, L. Zanna, J. Bruna, P. Perezhogin
  Reliable coarse-grained turbulent simulations through combined offline learning and neural emulation, ICML 2023 Synergy of Scientific and Machine Learning Modeling Workshop
- **C. Pedersen**, A. Font-Ribera, N. Y. Gnedin
  Compressing the cosmological information in one-dimensional correlations of the Lyman-α forest, *Astrophysical Journal* (2023)
- **C. Pedersen**, M. Eickenberg, S. Ho
  Learnable wavelet neural networks for cosmological inference, ICML 2022 Machine Learning for Astrophysics Workshop
- **C. Pedersen**, A. Font-Ribera, K. K. Rogers, P. McDonald, H. V. Peiris, A. Pontzen, A. Slosar
  An emulator for the Lyman-α forest in beyond-ΛCDM cosmologies, JCAP (2021)
- **C. Pedersen**, A. Font-Ribera, T. D. Kitching, P. McDonald, S. Bird, A. Slosar, K. K. Rogers, A. Pontzen
  Massive neutrinos and degeneracies in Lyman-alpha forest simulations, JCAP (2020)