Julian M. Urban, Ph.D.

Research Scientist, Machine Learning

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SUMMARY

Computational physicist with 7 years of experience designing and deploying machine learning models at scale to generate research insights from vast amounts of simulation data. Pioneering applications of cutting-edge data science to answer questions in elementary particle physics, with a focus on generative neural networks for probability density estimation and extracting clean signals from noisy observations via non-parametric regression. Deep understanding of stochastic sampling and numerical optimization algorithms for Bayesian inference and synthetic data generation. Proficient in MCMC methods and statistical analysis of correlated time series. Leading and contributing to collaborative projects in interdisciplinary teams of researchers across academia and industry, ranging from the development of software packages for probabilistic inference to the distributed training of large deep learning architectures on exascale HPC platforms with thousands of GPUs.

EXPERTISE

Conceptual	Probabilistic modeling, statistical inference, regression, Bayesian model selection, generative neural networks, representation & transfer learning, probability density estimation, time series, stochastic processes, MCMC, molecular dynamics, numerical optimization, distributed systems, data parallelism, equivariance, diffusion models, self-attention, ensemble methods, clustering
Programming	Proficient: Python (PyTorch, NumPy, SciPy, scikit-learn, statsmodels) Basics: C++, Bash, PHP, SQL, Mathematica
Software	Linux, Git, Slurm/PBS, Conda, Jupyter
Languages	English (fluent), German (native)

MAIN PROJECTS

Generative Modeling for Lattice QCD: Collaboration with *Google DeepMind* to build large neural network architectures for the generative modeling and stochastic sampling of complex multi-modal probability distributions central to lattice quantum chromodynamics research. Designing custom deep learning modules based on state-of-the-art computer vision and natural language processing methodology for large quantities of high-dimensional structured data. Engineering fully sharded data parallelism and distributed MCMC for massively parallel training and inference on the Aurora supercomputer at Argonne National Lab. Leading the team on development and maintenance of extensive code base integrating exploratory research with MLOps and HPC software stacks.

Bayesian Fredholm Inversion: Developing the *fredipy* package for solving heavily ill-conditioned continuous inverse problems probabilistically within a non-parametric Bayesian inference framework based on Gaussian process regression and numerical hyperparameter optimization. Extracting strongly suppressed signals from noisy data with sophisticated error quantification for high-precision downstream calculations. Exploring mathematical connections to other approaches in continuous inverse theory, such as the maximum entropy and Backus-Gilbert methods.

ACADEMIC POSITIONS

2022 - current	**Postdoctoral Associate**, Center for Theoretical Physics	**MIT**
2021 - 2022	**Research Affiliate**, Laboratory for Nuclear Sciences	**MIT**
2020 - 2022	**Research and Teaching Assistant**, Institute for Theoretical Physics	**U Heidelberg**

EDUCATION

2018 - 2022	**Ph.D.**, Machine learning for computational quantum field theory	**U Heidelberg**
2015 - 2018	**M.Sc.**, Machine learning for computational quantum field theory	**U Heidelberg**
2012 - 2015	**B.Sc.**, Detector physics for collider experiments	**U Heidelberg**

SELECTED PUBLICATIONS

arXiv:2203.01243	*Flow-based density of states for complex actions*	**Phys.Rev.D**
arXiv:2003.01504	*Towards novel insights in lattice field theory with explainable machine learning*	**Phys.Rev.D**
arXiv:1811.03533	*Reducing autocorrelation times in lattice simulations with generative adversarial networks*	**Mach.Learn.Sci.Tech.**

INVITED TALKS

11/2023	**Workshop**, Large-scale lattice QCD simulation and application of machine learning	**U Tsukuba**
9/2023	**Conference**, European network for particle physics, lattice field theory and extreme computing	**HU Berlin**
3/2023	**Seminar**, Applied Mathematics	**UC Berkeley**

MISCELLANEOUS

Contributor	Found and fixed a high priority issue in `torch.distributions.von_mises.VonMises`	**GitHub/PyTorch**
Organizer	Organized an interdisciplinary workshop on Machine Learning and the Renormalization Group	**ECT* Trento**