

Charlie Godfrey

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Skills

- **Research:** empirical science of foundation models, novel deep learning architecture components, interpretable and explainable AI, evaluating and understanding trustworthiness of machine learning systems.
- **Data modalities:** computer vision, reinforcement learning, natural language processing.
- **Tools:** Python (PyTorch, HuggingFace, DeepSpeed, NumPy, SciPy, Pandas, lightgbm, scikit-learn, Matplotlib, Seaborn, Jupyter Notebooks), Git, Bash, Linux, cluster computing (SLURM), AWS EC2, Azure VMs, Tensorboard, MLFlow.

Experience

Research Associate, Machine Learning, [Pacific Northwest National Laboratory](#) October 2021 - Present
National Security Directorate, Mathematics of Data Science Team

- Adapted high-efficiency MosaicBERT language model training to internal cluster computer environment, obtaining 50% improvement in throughput (tokens/second) and dramatically reducing cost of training; in situations where compute budget was fixed, this resulted in increased model accuracy.
- Improved performance of segmentation models for multispectral satellite images (5 % relative increase in Intersection-over-Union) by implementing multi-GPU distributed training, which facilitated learning for more epochs.
- Accelerated training of neural image compressors (from 3 minutes to 6 seconds per epoch) with a modernized data loading and preprocessing pipeline. This allowed for more rapid hyperparameter sweeps to optimize performance.
- Investigated safety and security of machine learning systems; constructed datasets to measure out-of-distribution performance of computer vision models.
- Presented results to senior leadership and project sponsors in the form of slide decks and technical reports — comfortable conveying research findings at appropriate level of technical detail.

Program Associate, [Mathematical Sciences Research Institute](#) March-May 2019

- Participated in the Birational Geometry and Moduli Spaces semester program.
- Presented research on logarithmic Chow-to-Hodge cycle maps at the institute's graduate student seminar.

Education

PhD in Mathematics, The University of Washington-Seattle June 2021

- Thesis: *Higher Direct Images of Ideal Sheaves, Correspondences in Log Hodge Cohomology and Globally F-Full Varieties*.
- Completed the [eScience Institute's Advanced Graduate Data Science Option](#) (PhD-level courses in machine learning, data visualization and statistical inference, implemented machine learning methods like LASSO, kernel regression and k-means clustering in raw NumPy and SciPy).
- Department of Mathematics Graduate Fellowship (2018-2019).

Student, [MSRI Mathematics of Machine Learning Summer Graduate School](#) July 29-August 9 2019

- Attended mini-courses and problem sessions on statistical learning, convex optimization, deep learning and reinforcement learning.
- Presented an expository account of recent work on linear stochastic bandits.

Mentoring

Industry Mentor, **Math-to-Industry Boot Camp**

July 2023-August 2023

- Mentored a team of math PhD students evaluating the usefulness of GPT-type large language models for scientific knowledge retrieval and the robustness of Segment Anything for person (e.g. pedestrian) detection.
- To facilitate this capstone project, implemented a Segment Anything inference endpoint using TorchServe and provided a notebook demonstrating inference using the HuggingFace API.

Graduate Mentor, **Washington Experimental Math Laboratory**

January 2019-December 2020

- Mentored undergraduate research projects on foundations of quantum mechanics and mathematical epidemiology.

Publications

Main Track

1. Davis Brown, **Charles Godfrey**, Nicholas Konz, Jonathan Tu and Henry Kvinge. **Understanding the Inner-workings of Language Models Through Representation Dissimilarity**. In *EMNLP 2023*.
2. Kelsey Lieberman, James Diffenderfer, **Charles Godfrey** and Bhavya Kailkhura. **Neural Image Compression: Generalization, Robustness, and Spectral Biases**. In *NeurIPS 2023* (was also selected for an oral presentation at the *ICML 2023 Workshop Neural Compression: From Information Theory to Applications*).
3. **Charles Godfrey**, Davis Brown (equal contribution), Tegan Emerson and Henry Kvinge. **On the Symmetries of Deep Learning Models and their Internal Representations**. In *NeurIPS 2022*. **Code available at github.com/pnnl/modelsym**.

Workshop

1. **Charles Godfrey**, Henry Kvinge, Elise Bishoff, Myles McKay, Davis Brown, Tim Doster and Eleanor Byler. **How many dimensions are required to find an adversarial example?**. In *The 3rd Workshop of Adversarial Machine Learning on Computer Vision at CVPR 2023*, **selected for oral presentation**.
2. **Charles Godfrey**, Michael Rawson, Henry Kvinge and Davis Brown. **Fast computation of permutation equivariant layers with the partition algebra**. In *ICLR 2023 Workshop on Physics for Machine Learning*.
3. Davis Brown, **Charles Godfrey** (equal contribution), Cody Nizinski, Jonathan Tu, Henry Kvinge. **Robustness of edited neural networks**. In *ICLR 2023 Workshop on Mathematical and Empirical Understanding of Foundation Models*.
4. Henry Kvinge, Davis Brown and **Charles Godfrey**. **Exploring the Representation Manifolds of Stable Diffusion Through the Lens of Intrinsic Dimension**. In *ICLR 2023 Workshop on Mathematical and Empirical Understanding of Foundation Models*, **featured in The Gradient**.
5. **Charles Godfrey**, Elise Bishoff, Myles McKay and Eleanor Byler. **Impact of architecture on robustness and interpretability of multispectral deep neural networks**. In *SPIE Defense + Commercial Sensing 2023*.
6. Elizabeth Coda, Nico Courts, Colby Wight, Loc Truong, WoongJo Choi, **Charles Godfrey**, Tegan Emerson, Keerti Kappagantula and Henry Kvinge. **Fiber bundle morphisms as a framework for modeling many-to-many maps**. In *ICLR 2022 Workshop on Geometrical and Topological Representation Learning*.

Preprints

1. **Correspondences in log Hodge cohomology** (2023).

2. Henry Kvinge, Grayson Jorgenson, Davis Brown, **Charles Godfrey** and Tegan Emerson. [Neural frames: A Tool for Studying the Tangent Bundles Underlying Image Datasets and How Deep Learning Models Process Them](#) (2022).
3. **Charles Godfrey**, Elise Bishoff, Myles Mckay, Davis Brown, Grayson Jorgenson, Henry Kvinge and Eleanor Byler. [Testing predictions of representation cost theory with CNNs](#) (2022). Code available at https://github.com/pnnl/frequency_sensitivity.
4. Takumi Murayama and **Charles Godfrey**. [Pure subrings of Du Bois singularities are Du Bois singularities](#) (2022).
5. [Higher direct images of ideal sheaves](#) (2022).

Invited Talks

1. June 2023 [ICERM Mathematical and Scientific Machine Learning Workshop](#).
2. February 2023 [Boston College Math and Machine Learning Seminar](#).
3. January 2023 [Joint Mathematics Meetings](#) (Boston, MA).
4. November 2022 [Purdue Algebraic Geometry Seminar](#).
5. October 2020 AMS Fall Eastern Sectional Special Session on Algebraic Singularities in Arbitrary Characteristic.