ALEX MOREHEAD

Machine Learning & Computational Biology Researcher

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"Machine Learning & Computational Biology Researcher with over 4 years of experience developing cutting-edge deep learning algorithms for geometric (e.g., structural biology) data. Track record of bringing new ideas to life and implementing them using AI-standard programming languages/frameworks. Experienced leading research teams, fostering collaborations, and presenting research findings at top conferences."

SKILLS

Python | PyTorch | PyG | PyTorch Lightning | W&B | Hydra | Slurm | Git | LaTeX | Pandas | Java

Geometric deep learning | Generative modeling | Graph neural networks | AI4Science | CompBio/Chem

EXPERIENCE

Graduate Research Assistant (Supervisor: Dr. Jianlin Cheng)

University of Missouri | Bioinformatics & Machine Learning Lab

Aug 2020 – Ongoing | Missouri, USA

Awarded two competitive first-year PhD fellowships for graduate studies in computer science.

- Research geometric and generative modeling methods for bioinformatics, to date yielding **20+ academic works**.
- Developed two state-of-the-art protein representation learning methods along with the first geometric diffusion model to successfully generate large, stable 3D molecules. Published results at top-tier machine learning conferences (**ICLR**) and scientific journals (**Bioinformatics** & **Nature Communications Chemistry**).
- Introduced the first deep learning benchmark for **practical** protein-ligand docking, yielding insights for future work.
- Orchestrated several **large-scale** deep learning experiments on HPC clusters, documented code (Sphinx), and contributed to **open-source code**.

Deep learning | Geometric & graph representation learning | Generative models | Structural bioinformatics

Research Intern

Profluent Bio | AI Research Lab

May 2023 – Aug 2023 | California, USA

- Created **MMDiff**, the first SE(3) diffusion model for joint sequence-structure generation of DNA, RNA, and proteins, which achieved a **9% nucleic acid design success rate**. Presented at NeurIPS 2023 MLSB. **Paper** and **Code**.

Diffusion models | Structure generation | Sequence generation | Differential geometry | Google Cloud

Research Intern

Absci | AI Research Lab

Jun 2022 – Apr 2023 | New York, USA

- Collaboratively attained a **0.1%** *de novo* antibody binder design success rate using deep learning, **a first-of-its-kind result**. **Paper** and **Data**.

Protein design | Generative AI | Data science | Model prototyping & benchmarking | Kubernetes

Undergraduate Research Assistant

IUPUI | NSF REU on the Data Science of Risk and Human Activity

Jun 2019 – Aug 2019 | Indiana, USA

- Invented and deployed a convolutional neural network pipeline that yielded a **98% F-1 score** for gunshot sound detection.
- **Published** and orally presented one corresponding manuscript **at IEEE Big Data (2019)**. **Paper** and **Code**.

Artificial intelligence | Machine learning | Data mining | Signal processing | Edge computing

MY LIFE PHILOSOPHY

"The cure to boredom is curiosity.
There is no cure for curiosity." - Dorothy Parker

ACHIEVEMENTS

LoG Top-10 Reviewer
• Awarded large monetary prize for being a *top-3%* reviewer for the 2023 Learning on Graphs (LoG) conference.

Dean's Engineering Excellence and O'Neill Graduate Fellowships
• Won *two* competitive graduate fellowships for first-year PhD students.

Region IV Scholarship and Floyd Tesmer/Strayer University Prize in Computer Science and Engineering
• Earned *two* awards for innovative computer science research.

Public outreach
• Research featured in *two* public-facing venues including HPCwire and Marktechpost.

INVITED TALKS

- RNA-FrameFlow for *de novo* 3D RNA backbone design, SPIGM workshop @ ICML, Jul 2024, Vienna, AT
- A Gated Graph Transformer for Protein Complex Structure Quality Assessment, 3DSIG @ ISMB, Jul 2023, Lyon, FR
- Geometry-Complete Perceptron Networks for 3D Molecular Graphs, AI2ASE workshop @ AAAI, Feb 2023, Washington D.C., USA
- Neural Diffusion Models: Next-Generation Generative Deep Learning, Advanced topics in deep learning course @ the University of Missouri, Nov 2022, Columbia, Missouri, USA
- Geometric Transformers for Protein Interface Contact Prediction, Xuefeng Cui Lab @ Shandong University, May 2022, Remote

EDUCATION

M.S. & Ph.D. in Machine Learning & Computational Biology

University of Missouri | O'Neill and College of Engineering Dean's Graduate Fellow

Aug 2020 - Ongoing

PhD Topic:
- Geometric Deep Learning & Generative Modeling of 3D Biomolecules

Collaborations:
- University of Cambridge, Research Labs of Prof. Pietro Lió & Prof. Sir Tom Blundell

Coursework:
- Highest distinction (GPA=4.0/4.0)

B.S. in Computer Science

Missouri Western State University | General Studies and Outstanding Graduate Honors

Aug 2016 - May 2020

- Graduated **top of class** among all 2020 graduates in computer science, mathematics, and physics (GPA=4.0/4.0)

REFERENCES

Dr. Jianlin Cheng
@ University of Missouri
chengji@missouri.edu

Dr. George Mohler
@ Boston College
mohlerg@bc.edu

REVIEWING

- **Conferences:**
  - Neural Information Processing Systems (NeurIPS), also reviewed for the AI4Science, AI4D3, & GenBio workshops
  - International Conference on Machine Learning (ICML) AI4Science, CB, AccMLBio, ML4LMS, & SPIGM workshops
  - International Conference on Learning Representations (ICLR) GEM workshop
  - Learning on Graphs Conference (LoG) of the Proceedings of Machine Learning Research (PMLR)
    - Also served on the LoG 2024-2025 organizing committee
  - ACM Conference on Bioinformatics, Computational Biology, & Health Informatics (ACM BCB)
- **Journals:**
  - Nature Machine Intelligence & Nature Methods
  - Bioinformatics, Briefings in Bioinformatics, BMC Bioinformatics, & Computational & Structural Biotechnology (CSB)
  - IEEE Transactions on Neural Networks & Learning Systems (TNNLS) & Transactions on Emerging Topics in Computational Intelligence (TETCI)

PUBLICATIONS

Conference Proceedings

[1] R. Anand*, C. K. Joshi*, **A. Morehead**, *et al.*, "Rna-frameflow for de novo 3d rna backbone design," in *ICML AI4Science & SPIGM Workshops*, selected as a SPIGM oral presentation and an AI4Science spotlight presentation (top 20% - 30/159), 2024.

[2] A. R. Jamasb*, **A. Morehead***, Z. Zhang*, *et al.*, "Evaluating representation learning on the protein structure universe," in *The Twelth International Conference on Learning Representations (ICLR)*, also presented at the NeurIPS 2023 MLSB workshop, 2024.

[3] **A. Morehead**, N. Giri, J. Liu, and J. Cheng, "Deep learning for protein-ligand docking: Are we there yet?" In *ICML AI4Science Workshop*, selected as a spotlight presentation (top 20% - 30/159), 2024.

[4] X. Chen*, **A. Morehead***, J. Liu, and J. Cheng, "A gated graph transformer for protein complex structure quality assessment and its performance in casp15," in *Intelligent Systems for Molecular Biology (ISMB)*, 2023.

[5] C. K. Joshi, A. R. Jamasb, R. Viñas, *et al.*, "Grnade: Geometric deep learning for 3d rna inverse design," in *ICML Computational Biology Workshop*, 2023.

[6] **A. Morehead**, A. Bhatnagar, J. A. Ruffolo, and A. Madani, "Towards joint sequence-structure generation of nucleic acid and protein complexes," in *NeurIPS Machine Learning in Structural Biology (MLSB) Workshop*, 2023.

[7] **A. Morehead**, W. Chantapakul, and J. Cheng, "Semi-supervised graph learning meets dimensionality reduction," in *IEEE International Conference on Machine Learning and Applications*, 2023.

[8] E. Soltanikazemi, R. S. Roy, F. Quadir, N. Giri, **A. Morehead**, and J. Cheng, "Drlcomplex: Reconstruction of protein quaternary structures using deep reinforcement learning," in *International Conference on Intelligent Biology and Medicine*, 2023.

[9] **A. Morehead**, C. Chen, and J. Cheng, "Geometric transformers for protein interface contact prediction," in *The Tenth International Conference on Learning Representations (ICLR)*, 2022.

[10] M. Shoman, A. Aboah, **A. Morehead**, Y. Duan, A. Daud, and Y. Adu-Gyamfi, "A region-based deep learning approach to automated retail checkout," in *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR) Workshops*, 2022.

[11] M. Gao, P. Lund-Andersen, **A. Morehead**, *et al.*, "High-performance deep learning toolbox for genome-scale prediction of protein structure and function," in *IEEE/ACM Machine Learning with Graphs in High Performance Computing Environments (MLHPC) Workshop*, 2021.

[12] **A. Morehead**, L. Ogden, G. Magee, R. Hosler, B. White, and G. Mohler, "Low cost gunshot detection using deep learning on the raspberry pi," in *IEEE International Conference on Big Data*, 2019.

Journal Articles

[13] **A. Morehead** and J. Cheng, "Geometry-complete diffusion for 3d molecule generation," *Nature Communications Chemistry*, 2024, also presented at the ICLR 2023 MLDD workshop.

[14] **A. Morehead** and J. Cheng, "Geometry-complete perceptron networks for 3d molecular graphs," *Bioinformatics*, 2024, also presented at the AAAI 2023 DLG (poster) and AI2ASE (oral presentation) workshops.

[15] C. Chen, X. Chen, **A. Morehead**, T. Wu, and J. Cheng, "3d-equivariant graph neural networks for protein model quality assessment," *Bioinformatics*, 2023.

[16] M. F. Lensink, G. Brysbaert, N. Raouraoua, *et al.*, "Impact of alphafold on structure prediction of protein complexes: The casp15-capri experiment," *Proteins: Structure, Function, and Bioinformatics*, 2023.

[17] S. Mahmud, **A. Morehead**, and J. Cheng, "Accurate prediction of protein tertiary structural changes induced by single-site mutations with equivariant graph neural networks," *bioRxiv*, 2023.

[18] **A. Morehead**, C. Chen, A. Sedova, and J. Cheng, "Dips-plus: The enhanced database of interacting protein structures for interface prediction," *Nature Scientific Data*, 2023.

[19] **A. Morehead** and J. Cheng, "Protein structure accuracy estimation using geometry-complete perceptron networks," *Protein Science*, 2023.

[20] A. Shanehsazzadeh, S. Bachas, M. McPartlon, *et al.*, "Unlocking de novo antibody design with generative artificial intelligence," *bioRxiv*, 2023, follow-up work presented at the NeurIPS 2023 MLSB workshop.

[21] **A. Morehead**, X. Chen, T. Wu, J. Liu, and J. Cheng, "Egr: Equivariant graph refinement and assessment of 3d protein complex structures," *arXiv*, 2022.

[22] O. Kouckya, J. Wagnerb, S. Aguilerab, *et al.*, "Synthetic biology bicistronic designs support gene expression equally well in vitro and in vivo," *AJUR*, 2020.