Alex Xu

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Skills

Programming Languages: Python, Java, C/C++, Rust, PyTorch, Scikit-learn, Numpy, Pandas, Polars, SQL, LaTeX
Machine Learning: Variational Autoencoders, Diffusion Models, Transformers, Retrieval Augmented Generation, Low Rank Adaption
Math & Statistics: Bayesian Statistics, Variational Inference, Convex Optimization, Linear Regression, Partial Differential Equations, Differential Geometry, Riemannian Manifolds
Languages: English, Chinese

Education

- **Columbia University, PhD Mathematics** 20
  Advisor: Prof. Francesco Lin, Thesis: The Seiberg—Witten Equations and Asymptotically Hyperbolic Einstein Metrics
- **Columbia University, MA Mathematics** 2022
  Advisor: Prof. Francesco Lin
- **University of California Santa, Barbara, BS Mathematics** 2020
  Advisor: Prof. Xianzhe Dai, Thesis: Adiabatic Limits and Hodge Leray Theory

Experience

- **Columbia University** New York, NY
  Graduate Student Instructor *Sep. 2021 - Current*
  - Created course curriculum and taught biweekly classes for Calculus 1 as the Instructor of Record
  - Graduate TA for various classes including: Calculus and Optimization, Linear Algebra, Calculus 3, Calculus 2, Calculus 1, and Algebraic Topology
- **UC Santa Barbara** Santa Barbara, CA
  Undergraduate TA *Jan. 2018 - Jun. 2020*
  - Grader for graduate level Differential Geometry, Discrete Math, Linear Algebra, and Convex Optimization
- **Summer@ICERM** Providence, RI
  Undergraduate Researcher *Jun. 2018 - Aug. 2018*
  - Researched and made progress on longstanding conjectures in Teichmüller theory and the study of hyperbolic Riemann surfaces
  - Used Python to visualize and understand properties of hyperbolic surfaces and generate new conjectures

ML Projects

- **gpt_sae**: Implemented a sparse autoencoder (SAE) for dictionary learning of features learned by the GPT2 small model. Conducted ablation testing and benchmarking for various loss functions and SAE architectures to compare which methods had best feature generations.
- **localRAG**: Implemented retrieval augmented generation (RAG) for various statistics and machine learning textbooks using the Mixedbread AI model mxbai-embed-large-v1 to create a vector database and the Google gemma-2-2b-it model for LLM text generation.
- **mini-diffusion**: Implemented a 825k parameter U-net diffusion model in PyTorch for generation of self-portraits.
- **LoRA_gpt2**: Implemented low-rank adaption (LoRA) fine tuning on the GPT2 124M checkpoint in PyTorch.
- **nanoGPT**: Implemented a simple GPT and tokenizer from scratch in PyTorch
- **VAEs**: Implementation of a variational autoencoder (VAE) to learn the MNIST dataset

Publications and Preprints

- **Seiberg-Witten Equations and Einstein Metrics on Finite Volume 4-Manifolds with Asymptotically Hyperbolic Ends**: Preprint - arxiv.org/abs/2402.10366

Invited talks

MSU - Graduate Student Topology and Geometry Conference: 2024
SUNY Stony Brook - Symplectic Geometry, Gauge Theory, and Low-Dimensional Topology: 2024
MIT - Gauge Theory and Topology Seminar: 2024
Columbia - Symplectic Geometry and Gauge Theory Seminar: 2024