Kelvin Peng

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Education

University of Waterloo Sept 2023 – Present
Bachelor of Mathematics – Major in Combinatorics & Optimization (Expected 2027)

Relevant Coursework:
Number Theory, Quantum Info Processing, Applied Cryptography, Graph Theory, Convex Optimization, Linear Algebra.

Research & Technical Projects

TopoAdamW: TDA-Guided Meta-Optimizer *Python, PyTorch, Gudhi*
github.com/SVAH-X/topoadamw

- Designed **TopoAdamW**, a non-convex optimizer that integrates **Topological Data Analysis (TDA)** signals into gradient-based updates to better navigate sharp minima in complex loss landscapes.
- Implemented real-time **Persistent Homology** computation (Gudhi) to extract topological invariants (e.g., Betti numbers / connected components) from the loss surface and use persistence-based cues to trigger escape behavior.
- Ongoing work: analyzing the relationship between persistence profiles and the **flatness of minima** to better understand and improve neural network generalization.

Geometry Dash AI Verifier (DreamerV3) *RL, JAX*
github.com/SVAH-X/gd_agent

- Developed a **DreamerV3** world-model agent for *Geometry Dash*, a high-frequency physics platformer requiring frame-level control under strict collision constraints.
- Improved representation stability by mitigating **discrete latent space collapse** in stochastic regimes via symlog prediction tuning and discrete autoencoder bottleneck adjustments.
- Demonstrated long-horizon planning behavior in constrained environments, supporting automated verification of level completability.

Efficient Large Language Model Fine-Tuning *LLMs, DeepSpeed, RunPod*
Technical Implementation

- Built an efficient fine-tuning pipeline for **Dream-7B** and **GPT-OSS-20B** on mathematical datasets (e.g., OpenWebMath), targeting both single-GPU (16GB) and multi-GPU setups.
- Applied **QLoRA (4-bit)**, gradient checkpointing, and **DeepSpeed** optimizations to maximize throughput while reducing memory footprint.
- Achieved **20% improvement** in math reasoning benchmarks with over **60% VRAM reduction**, enabling cost-effective customization of large models.

Technical Skills

- **Languages:** Python, C/C++, Racket, SQL, Bash, LaTeX
- **AI Frameworks:** PyTorch, JAX, DeepSpeed, HuggingFace, BitsAndBytes
- **Research Tools:** Gudhi (TDA), Ripser, WandB, RunPod/Cloud Computing
- **Mathematics:** Combinatorial Optimization, Graph Theory, TDA, Bayesian Statistics, Cryptography

Awards

Euclid Mathematics Contest 2021 – 2022
School Champion (2x), Honour Roll, **Top 1 in BC Province**.

Canadian Senior Mathematics Contest (CSMC) 2022
School Champion, Honour Roll.