

Alexander Detkov

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Research Interests

AI Reasoning, Neuro-symbolic AI, Foundation Models, Trustworthy and Explainable AI, Convolutional and Graph Neural Networks, AI-Driven Scientific Discovery.

Publications

2023 **A. Detkov**, M. Salameh, M. Fetrat, J. Zhang, R. Luwei, S. Jui, D. Niu. "Reparameterization through Spatial Gradient Scaling." *International Conference on Learning Representations (ICLR)*, 2023.

Synopsis: Re-parameterization is a powerful technique used to improve CNN training (e.g. YOLOv7), yet its underlying mechanism remains unknown. We investigate how and why re-parameterization may positively affect model training, as well as propose a new analytical approach for finding high-performance re-parameterizations.

Education

Sep 2019 - Apr 2024 **B.S. in Engineering Physics, Minor in Mathematics**, University of Alberta, Canada.
GPA: 4.00/4.00

Research Experience

May 2023 - Current **Explainable Graph Neural Networks** | University of Alberta

Prof. Di Niu

Developing innovative methods to improve explainability in graph neural networks (GNNs), with a focus on extracting robust, global-level explanations reliable even for out-of-distribution data.

- Conducting research on integrating deep and symbolic learning within neuro-symbolic GNNs.
- Developing a closed loop system that converts between knowledge of the GNN and interpretable symbolic expressions.
- Employed methods of approximation and symbolic regression to generate faithful explanations.
- Currently exploring a gradient boosting-based method to reincorporate these symbolic explanations into GNN training, aiming to enhance model robustness.
- Worked in collaboration with a PhD student on leveraging reinforcement learning for enhancing GNN performance and explainability.
- Implemented a policy gradient approach to learn and apply graph augmentations that enrich model training.

Jan 2022 - Dec 2022 **Neural Architecture Search** | Huawei Research

Prof. Di Niu and Dr. Mohammad Salameh

Explored the integration of deep learning and symbolic methods to automate the architecture design of convolutional neural networks (CNNs) using neural architecture search (NAS).

- Initiated and led a research direction into understanding the learning dynamics of CNNs under re-parameterization.
- Proved equivalence between re-parameterization and modified gradient descent, resulting in a 2x speedup in training compared to other methods.
- Developed an information theoretic approach that consistently outperformed state-of-the-art re-parameterization methods at a fraction of their computational cost.
- Conducted extensive experiments across classification, semantic segmentation, and pose estimation tasks for a diverse set of vision models.
- Published "Reparameterization through Spatial Gradient Scaling" as first author at ICLR 2023.
- Worked on hardware-aware NAS for low-latency deep learning on mobile phones.
- Extended state-of-the-art graph level optimizers of convolutional and transformer-based architectures for use on neural processing units (NPUs).

- May 2021 - Dec 2021 **Computational Nanofluidics** | University of Alberta
Prof. Wylie Stroberg
Explored the dynamics of polymeric solution influx into nanotubes through computational means.
- Designed and programmed molecular dynamics simulations with dissipative particle dynamics techniques in LAMMPS.
 - Developed efficient Python and C++ scripts for the statistical analysis of simulation data.
 - Collaborated in creating a Langevin dynamics simulator in Julia to study polymer imbibition over time and length scales beyond the reach of molecular dynamics.
 - Employed stochastic process theory to identify a maximum mean first-passage time for polymer imbibition which has important engineering implications.
 - Presented research findings in an oral presentation at the CSME 2022.
- May 2021 - Aug 2021 **Experimental Particle Physics** | University of Alberta and IceCube Observatory
Prof. Juan Pablo Yáñez
Investigated the calibration of digital optical modules through analyzing Cherenkov radiation emitted by atmospheric minimum ionizing muons.
- Performed dataset cleaning for reconstructed muon tracks based on their stochastic losses using advanced statistical analysis techniques in Python.
 - Developed and documented a Python library specifically designed to facilitate and streamline future work in particle track filtering.

Presentations and Talks

2022 **A. Detkov**, W. Stroberg. "Imbibition of a Single Polymer into a Nanocapillary." *Canadian Society for Mechanical Engineering (CSME)*, 2022.

Fellowships and Awards

2023 NSERC Undergraduate Student Research Award (\$6,000)
2023 University of Alberta Undergraduate Scholarship (\$2,500)
2023 Louise McKinney Post-Secondary Scholarship (\$2,500)
2021 University of Alberta Dean's Research Award (\$500)
2021 Joseph and Edwina Charyk Scholarship in Engineering Physics (\$2,000)
2020 Louise McKinney Post-Secondary Scholarship (\$2,500)
2020 Enbridge Inc Dean of Engineering 2nd Year Scholarship (\$1,825)
2019 The Faculty of Engineering Entrance Scholarship (\$5,000)

Technical Skills

AI Libraries: PyTorch, PyTorch Geometric, Deep Graph Library, PyReason, TensorFlow, ONNX.
Languages: Python, C, C++, Java, Kotlin, Julia.