# Alexander Detkov

Email: detkov@ualberta.ca Website: alexanderdetkov.github.io

## 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.