Rob Brekelmans

Contact Information	rob.brekelmans@vectorinstitute.ai Google Scholar Personal Webpage Twitter

Research Background

- ❑ Unified view of guidance or controlled generation in language models (RLHF) and diffusion processes (generative models, AI for science) via soft RL & optimal control.
- ❑ Breadth of contributions in sampling, generative modeling, optimal transport, variational inference, reinforcement learning, representation learning, information theory
- ❑ Geometric structures and gradient flows on the space of probability distributions via optimal transport and information geometry.

Current

Vector Institute, Toronto, Ontario, CA

Postdoctoral Fellow   Jul 2022 - Present

- Hosts: Alireza Makhzani, Roger Grosse

Education

University of Southern California, Los Angeles, CA, USA
Information Sciences Institute / Department of Computer Science

Doctor of Philosophy (Ph.D), Computer Science   Aug 2016 - May 2022
Advisors: Greg Ver Steeg, Aram Galstyan   GPA: 3.87 / 4.0

Imperial College London, London, UK

M.Sc Computing Science (with Distinction)   Oct 2014 - Oct 2015

University of Pennsylvania, Philadelphia, PA, USA
B.A. Mathematics   GPA: 3.81 / 4.0,   Summa Cum Laude   2006 - 2010

Internship

DeepMind, London, UK (Virtual)   Summer 2021
Research Scientist Intern: AI Safety Analysis Team
- Adversarial interpretation of regularized RL policies using convex duality
- Host: Tim Genewein,   Team Lead: Pedro Ortega

Additional Experience

Susquehanna International Group, Philadelphia, PA
Stock Options Trader   August 2010 - March 2014

- Education program involving training in probability, behavioral economics, poker
- Responsible for firm's market making in natural gas and treasury ETF options
- Actively monitored trades, took proprietary positions, managed distribution risk

PhD Thesis

Information Geometry of Annealing Paths for Inference and Estimation.
Committee Members: Greg Ver Steeg, Aram Galstyan, Aiichiro Nakano, Assad Oberai, Shang-hua Teng (thesis proposal)

Publications

(★) Stephen Zhao*, Rob Brekelmans*, Alireza Makhzani, Roger Grosse. *"Probabilistic Inference in Language Models using Twisted Sequential Monte Carlo"*. International Conference on Machine Learning (ICML), 2024.

- **Best Paper Award ICML 2024** (10 awards out of 2610 accepted papers)
- Oral Presentation (top 5% of accepted papers)

Yuanqi Du*, Michael Plainer*, Rob Brekelmans*, Chenru Duan, Frank Noe, Carla Gomes, Alan Aspuru-Guzik, Kirill Neklyudov. *"Doob's Lagrangian: A Sample-Efficient Variational Approach to Transition Path Sampling"*. Neural Information Processing Systems (NeurIPS), 2024.

- Spotlight (NeurIPS 2024)
- Spotlight (ICML 2024 Workshop on AI4Science)

($\star$) Kirill Neklyudov*, Rob Brekelmans*, Alexander Tong, Lazar Atanackovic, Qiang Liu, Alireza Makhzani. *"A Computational Framework for Solving Wasserstein Lagrangian Flows"*. International Conference on Machine Learning (ICML), 2024.

Rob Brekelmans, Kirill Neklyudov. *"On Schrödinger Bridge Matching and Expectation Maximization"*. NeurIPS Workshop on Optimal Transport & Machine Learning, 2023.

($\star$) Kirill Neklyudov, Rob Brekelmans, Daniel Severo, Alireza Makhzani. *"Action Matching: Learning Stochastic Dynamics from Samples"*. International Conference on Machine Learning (ICML), 2023.

Xianghao Kong, Rob Brekelmans, Greg Ver Steeg. *"Information Theoretic Diffusion"*. International Conference on Learning Representations (ICLR), 2023.

($\star$) Rob Brekelmans, Tim Genewein, Jordi Grau-Moya, Gregoire Deletang, Markus Kunesch, Shane Legg, Pedro Ortega. *"Your Policy Regularizer is Secretly an Adversary"*. Transactions on Machine Learning Research, 2022.
- DeepMind internship project

Grégoire Delétang, Jordi Grau-Moya, Markus Kunesch, Tim Genewein, Rob Brekelmans, Shane Legg, Pedro A Ortega. *"Model-Free Risk-Sensitive Reinforcement Learning"*. arXiv, 2022.

Rob Brekelmans and Frank Nielsen. *"Variational Representations of Annealing Paths : Bregman Information under Monotonic Embedding"*. Information Geometry, 2022.

($\star$) Rob Brekelmans*, Sicong Huang*, Marzyeh Ghassemi, Greg Ver Steeg, Roger Grosse, Alireza Makzhani. *"Improving Mutual Information Estimation with Annealed and Energy-Based Bounds"*. International Conference on Learning Representations, 2022.

Vaden Masrani*, Rob Brekelmans*, Thang Bui, Frank Nielsen, Aram Galstyan, Greg Ver Steeg, Frank Wood. *"q-Paths: Generalizing the Geometric Annealing Path using Power Means"*. Uncertainty in Artificial Intelligence (UAI), 2021.

- Rob Brekelmans, Vaden Masrani, Thang Bui, Frank Wood, Aram Galstyan, Greg Ver Steeg, Frank Nielsen. *"Annealed Importance Sampling using q-Paths"*. NeurIPS Workshop on Deep Learning through Information Geometry, 2020.
  - Best Paper Award (NeurIPS Workshop)
  - 15-Minute Oral Presentation

Rob Brekelmans, Frank Nielsen, Alireza Makhzani, Aram Galstyan, Greg Ver Steeg. *"Likelihood Ratio Exponential Families"*. NeurIPS Workshop on Deep Learning through Information Geometry, 2020.

Rob Brekelmans*, Vaden Masrani*, Frank Wood, Greg Ver Steeg, Aram Galstyan. *"All in the Exponential Family: Bregman Duality in Thermodynamic Variational Inference"*. International Conference on Machine Learning (ICML), 2020.

---

*Denotes joint first authorship / equal contribution. ($\star$) : Highlighted work

Rob Brekelmans, Aram Galstyan, Greg Ver Steeg. *"Understanding Thermodynamic Variational Inference"*. NeurIPS Workshop on Information Theory in Machine Learning, 2019.

– 15-Minute Oral Presentation

Rob Brekelmans, Daniel Moyer, Aram Galstyan, Greg Ver Steeg. *"Exact Rate-Distortion in Autoencoders via Echo Noise"*. Neural Information Processing Systems, 2019.

($\star$) Daniel Moyer, Shuyang Gao, Rob Brekelmans, Greg Ver Steeg, Aram Galstyan. *"Invariant Representations without Adversarial Training"*. Neural Information Processing Systems (NeurIPS), 2018.

ADDITIONAL PUBLICATIONS
Vu Nguyen, Vaden Masrani, Rob Brekelmans, Michael Osborne, Frank Wood. *"Gaussian Process Optimization of the Thermodynamic Variational Objective."* Neural Information Processing Systems (NeurIPS), 2020.

Ayush Jaiswal, Rob Brekelmans, et al. *"Discovery and Separation of Features for Invariant Representation Learning"*. arXiv, 2019.

Shuyang Gao, Rob Brekelmans, Greg Ver Steeg, and Aram Galstyan. *"Auto-encoding Total Correlation Explanation"*. AIStats, 2018.

Yolanda Gil, et al. *"P4ML: A Phased Performance-based Pipeline Planner for Automated Machine Learning"*. ICML AutoML Workshop. 2018.

Greg Ver Steeg, Rob Brekelmans, Hrayr Harutyunyan, Aram Galstyan. *"Disentangled Representations Via Synergy Minimization"*, 55th Annual Allerton Conference on Communication, Control, and Computing, 2017.

INVITED TALKS
MIT Learning on Graphs Reading Group	September 2024
Information Geometry for Data Science Conference	September 2022
Guest Lecture, USC CSCI699: "Dynamics of Representation Learning"	March 2022
Vector Institute: Thursday Seminar Series	January 2022
Google Brain: "Shannon's Bandwagon" Reading Group	Summer 2021

REVIEWING
Conferences:
    NeurIPS: 2023, 2021, ICLR: 2022, AIStats: 2021

Journals:
Journal of Computational and Graphical Statistics	*(Invited)*	2023
Information Geometry	*(Invited)*	2022
Machine Learning: Science and Technology	*(Invited)*	2021
IEEE Transactions on Communications	*(Invited)*	2020

ACADEMIC EXPERIENCE
University of Southern California, Los Angeles, CA
Teaching Assistant

• CSCI467: Introduction to Machine Learning	Spring 2022
• CSCI109: Introduction to Computer Science	2016-2017

Information Sciences Institute, *DARPA Data Driven Discovery Project*
Graduate Research Assistant   May 2017 - Dec 2021

- Project automating the search over machine learning pipelines for prediction tasks across diverse data settings (AutoML)
- Implemented ML methods to be used by the planning system, including semi-supervised dimensionality reduction and graph convolutional networks

Los Alamos National Laboratory, Los Alamos, NM   Summer 2018
  Applied Machine Learning Fellowship
  - Learning tree-structured graphical models with latent variables
  - Host: Marc Vuffray, Andrey Lokhov, Sidhant Misra

COURSEWORK   Advanced Topics in Statistical Machine Learning, Advanced Analysis of Algorithms, Information Theory, Convex & Combinatorial Optimization, Algebraic Combinatorics, High Dimensional Statistics & Big Data Problems

Best Project Award: "Backpropagating Importance of Training Examples"
  Advanced Topics in Statistical Machine Learning   Nov 2018

Deep Reinforcement Learning Bootcamp, *UC Berkeley*   Aug 2017

NATIONALITY   Dual Citizen: USA, Netherlands