Isaac Reid

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Research interests

I am interested in problems at the interface of ML, statistical physics and applied mathematics, especially where theoretical results have proved elusive and applications are high impact. Recently, I've focussed on efficient Transformers for graph-structured data. I hold a Google PhD Fellowship in Algorithms and Theory.

Education

Machine Learning Group, University of Cambridge *Oct 2022 - present*
PhD in Engineering
Supervisors: Dr Adrian Weller and Prof. Rich Turner
Advisor: Prof. Carl Rasmussen
Subject: Scalable and data-efficient machine learning. Ongoing collaboration with Prof. Krzysztof Choromanski (Google DeepMind and Columbia University, New York).

Physics, University of Oxford *Oct 2017 - Jun 2021*
Master of Physics, MPhys
Grade: First class, 92%, top of Oxford cohort (out of ~ 150)
Research project: Quantum entanglement barriers in dual-unitary circuits
Supervisor: Dr Bruno Bertini

Publications and select preprints

Linear Transformer Topological Masking with Graph Random Features
Preprint, under review
Isaac Reid, Avi Dubey, Deepali Jain, Will Whitney, Amr Ahmed, Joshua Ainslie, Alex Bewley, Mithun Jacob, Aranyak Mehta, David Rendleman, Connor Schenck, Richard E. Turner, René Wagner, Adrian Weller, Krzysztof Choromanski
Synopsis: Efficiently incorporating structural information into Transformer attention using graph random walks, for applications in computer vision and robotics
https://arxiv.org/abs/2410.03462

Optimal Time-Complexity Algorithms for Computing General Random Walk Kernels on Sparse Graphs
Preprint, under review
Krzysztof Choromanski*, **Isaac Reid***, Arijit Sehanobish, Avi Dubey
Synopsis: By simulating correlated random walks on an ensemble of graphs, you can estimate the graph kernel between any given pair in linear time
https://arxiv.org/abs/2410.10368

Variance-Reducing Couplings for Random Features
Preprint, under review
Isaac Reid, Stratis Markou, Krzysztof Choromanski, Richard E. Turner, Adrian Weller
Synopsis: Variance reduction in Monte Carlo is really a multi-marginal optimal transport problem, and treating it as such gives us tools to sample more efficiently in Euclidean and discrete space
https://arxiv.org/abs/2405.16541

Repelling Random Walks
ICLR 2024
Isaac Reid, Eli Berger, Krzysztof Choromanski, Adrian Weller
Synopsis: A QMC scheme that correlates the directions of walkers on a graph, providing better sample efficiency and improving the concentration of a host of statistical estimators
https://arxiv.org/abs/2310.04854

General Graph Random Features
ICLR 2024
Isaac Reid*, Krzysztof Choromanski*, Eli Berger*, Adrian Weller
Synopsis: A random feature mechanism to approximate arbitrary functions of a weighted adjacency matrix, unlocking kernel-based learning on very large graphs
https://arxiv.org/abs/2310.04859

Quasi-Monte Carlo Graph Random Features
NeurIPS 2023, accepted as spotlight paper
Isaac Reid, Krzysztof Choromanski, Adrian Weller
Synopsis: A QMC scheme that induces correlations between the lengths of terminating random walks on a graph, with possible applications in bioinformatics and graph-based Transformers
https://arxiv.org/abs/2305.12470

Simplex Random Features
ICML 2023, accepted with oral presentation
Isaac Reid, Krzysztof Choromanski, Valerii Likhosherstov, Adrian Weller
Synopsis: Derivation of an optimal random feature mechanism for unbiased approximation of the Gaussian kernel, motivated by a host of new analytical results and tested with Transformer experiments
https://arXiv.org/abs/2301.13856

Entanglement Barriers in Dual-Unitary Circuits
Phys. Rev. B 104, 014301 – Published 1 July 2021
Isaac Reid, Bruno Bertini
Synopsis: Exact characterisation of the dynamics of quantum entanglement arising after a quantum quench in a many-body, locally interacting system, including both the integrable and completely chaotic regimes
https://arxiv.org/abs/2103.12794

Teaching

Engineering 2P7 *Michaelmas 2023 - present*
Synopsis: Supervisions in mathematics for engineers (vector calculus, linear algebra and probability)

Pembroke International Summer Programme *Jun-Aug 2023*
Synopsis: Research project on density ratio estimation in machine learning

Talks

Efficient Transformers – Machine Learning Group, Cambridge *Nov 2024*
Synopsis: Seminar on mathematical tricks for subquadratic attention

Quasi-Monte Carlo Graph Random Features – NeurIPS@Cambridge, Cambridge *Dec 2023*
Synopsis: Invited talk to accompany NeurIPS spotlight paper

Simplex Random Features – ICML 2023, Honolulu *July 2023*
Synopsis: Oral presentation to accompany paper

Simplex Random Features – Microsoft Research, Cambridge *Jun 2023*
Synopsis: Research talk on ICML paper

Random Features for Kernel Approximation – Machine Learning Group, Cambridge *Mar 2023*
Synopsis: Seminar on random feature methods and recent QMC schemes to improve their convergence

Experience

Research Associate, IQ Capital *Nov 2024 - present*
1 day/week advising and investing in ML startups and supporting portfolio companies

Student Researcher, Google *May 2024 - Nov 2024*
Project on efficient Transformers, working closely with Krzysztof Choromanski and Avi Dubey

Systems Engineer, Opsydia *Sep 2021 - Sep 2022*
R&D engineer at deep-tech startup specialising in laser technology and adaptive optics, spun out of Oxford University Engineering Department

Research Intern, Max Planck Institute for Dynamics and Self-Organisation, Göttingen *Summer 2020*
Computational study of Bose-Einstein condensation in active matter, applying theoretical results from many-body quantum physics to classical clustering phenomena observed in Kob-Andersen particle dynamics
Supervisors: Dr Benoit Mahault and Prof. Ramin Golestanian

Research Intern, Rudolf Peierls Centre for Theoretical Physics, Oxford *Summer 2019*
Study of relationship between spectral properties of Hessian of loss function and Bayesian prior upon deep neural network initialisation, estimated using random sampling of weights and Gaussian processes
Supervisor: Prof. Ard Louis

Scholarships and awards

Google PhD Fellowship in Algorithms and Theory *2024-2026*
Funding from Google for remainder of PhD

G-Research Grant *July 2023*
Financial award to help fund attendance of ICML conference

Trinity College External Studentship *2022-2025*
Full scholarship for a PhD in Machine Learning

Encaenia *Jun 2022*
One of six undergraduate students invited to attend Oxford's historic Encaenia ceremony

Gibbs Prize *2020-2021*
For submitting the highest scoring MPhys research project (87%)

Scott Prize *2017-2021*
For best overall performance in the MPhys (92%)

Scott Prize *2019-2020*
For best performance in the third year (92%)

Winton Capital Prize *2018-2019*
For best performance in the second year (93%)

Hertford College Academic Scholarship *2018-2021*
For performance in first year (88%)