Daniel James Mills

About

I am a Research Scientist at Quantinuum, holding a PhD in theoretical quantum computation from The University of Edinburgh. With extensive experience in mathematics, physics and computer science, I am eager to participate in research and development leading to the widespread utilisation, expanded applicability, and heightened understanding of quantum computation.

Highlights

- PhD on "Benchmarking, verifying and utilising near term quantum technology".
- Masters of science by research on quantum computing (Distinction, top of class).
- Masters of Mathematics (1st class).
- Extensive practical research experience in technology industry and achademia.
- Experienced in research management.
- Skilled and well practised programmer, writer, and communicator.

Current Role

Research Scientist **Quantinuum** **July 2020 - Present**

I am a research scientist in the quantum software team. My interests are primarily in using software tools to optimise the use of near term quantum devices. In particular I held leading roles in projects on error mitigation, distributed quantum computing, and full stack benchmarking. I also have active interests in quantum circuit compilation, simulation of noise in quantum devices, and the theoretical foundations for quantum computational supremacy. I designed and developed several open source software packages during my research, notably Qermit and pytket-dqc.

Education

The University of Edinburgh **Doctorate** **2016 - 2020**

- Thesis "Benchmarking, Verifying and Utilising Near Term Quantum Technology" supervised by Professor Elham Kashefi. Focusing on the verification of early stage quantum computers by observing limited architecture, experimental noise, etc.
- Other research areas: quantum machine learning, classical simulation of quantum computations, superiority of quantum over classical computing, quantum computing software.

The University of Edinburgh MSc by research: Distinction, top of class 2015 - 2016

- Grade of 90% for dissertation 'Information Theoretically Secure Hypothesis Test for Temporally Unstructured Quantum Computing', supervised by Professor Elham Kashefi.
- Courses on machine learning, categorical quantum computing and complexity theory. Courses on effective research, improving my time management, planning, and reflection skills.

The University of Warwick **MMath: 1st class** **2011 - 2015**

- Broad studies with a focus on analysis; particularly information theory and dynamical systems. Fourth year project, 'Communication Over Binary Symmetric Channel With Random Failure Rate', supervised by Professor Oleg Zaboronski.
- Extensive coverage of algebra, number theory, probability theory, geometry, fluid dynamics, computational mathematics, numerical analysis and scientific programming; as well as many modules from physics including those on quantum mechanics and cosmology.

Other Recent Experience

Supervisor - Quantum Computing **The University of Cambridge** **2021 - 2023**

- I supervised 6 students each year, meeting with them biweekly to assess their problem sheet solutions, and to address their questions.

Tutor - Introduction to Quantum Computing **The University of Edinburgh** **2019**

- Presenting and preparing tutorials for this course taught me to articulate complex ideas at appropriate levels, while also clarify my own understanding of the field.

Research Intern **Cambridge Quantum Computing** **2019 (3 months)**

- Developing benchmarking procedures for quantum technology, at all layers of the technology stack, taught me about results in quantum complexity, the intricacies of quantum computing architectures, and a variety of applications of quantum computers.
- Implementing these benchmarks familiarised me with interfaces for quantum devices such as Rigetti's Forest SDK and cloud service, and the IBM Quantum Platform.

Research and Development Intern **Atos** **2017 - 2018 (6 months)**

- Implementing a classical simulator of my own developed my understanding of: programming languages C, C++, python and openMP; development tools Git, Jenkins and Callgrind; and how to integrate my work into a team project through annotations and presentations.
- Utilised classical simulation and HPC as a tool to provide new insights into quantum computing and, in particular, into the impact of physically motivated noise.

Other Skills and Achievements

Software development tools: programming languages Java, MATLAB, Python, C++ and C; quantum computation programming tools such as pyQuil, pytket, and qiskit; Linux and Windows; Microsoft Office and LaTex; agile project management tools such as Jira; code quality and management tools such as pytest, linting, Git, and automactic documentation generation.

Technical skills: As a Makerspace Technician I maintained, utilised, and taught the use of digital manufacturing technologies and related software, including: 3D printing, scanning and design; CNC milling and cutting; virtual and augmented reality; Raspberry Pis and electronics.

Popular Science Communication: I hosted my own science news show on the Edinburgh student radio station and was elected as head of the news team. I was also part of the team producing the Edinburgh informatics pod-cast. As materspace technician I managed and developed marketing material, including social media profiles and instructional videos

Event organisation: I co-organised QuHackEd, Scotland's first quantum computing hackathon. This four day event, consisting of talks and a competition, taught me to manage and mediate between suppliers, communicate with speakers and motivate attendees, and acquire sponsorship totalling £15000.

Peer-review: I have been a reviewer for several journels, for example Quantum, Quantum Machine Intellegence, and Physical Review journels, and conferences, such as QIP, QPL, and IWQC.

Personal Information and Contact Details

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Publications

Pre-Prints

Pablo Andres-Martinez, Tim Forrer, Daniel Mills, Jun-Yi Wu, Luciana Henaut, Kentaro Yamamoto, Mio Murao, and Ross Duncan. **Distributing circuits over heterogeneous, modular quantum computing network architectures.** arXiv preprint arXiv:2305.14148 (2023).

Jun-Yi Wu, Kosuke Matsui, Tim Forrer, Akihito Soeda, Pablo Andrés-Martínez, Daniel Mills, Luciana Henaut, and Mio Murao. **Entanglement-efficient bipartite-distributed quantum computing with entanglement-assisted packing processes.** arXiv preprint arXiv:2212.12688 (2022).

Published

Cristina Cirstoiu, Silas Dilkes, Daniel Mills, Seyon Sivarajah, and Ross Duncan. **Volumetric benchmarking of error mitigation with qermit.** Quantum 7 (2023): 1059.

Daniel Mills, Seyon Sivarajah, Travis L. Scholten, and Ross Duncan. **Application-motivated, holistic benchmarking of a full quantum computing stack.** Quantum 5 (2021): 415.

Brian Coyle, Daniel Mills, Vincent Danos, and Elham Kashefi. **The Born supremacy: quantum advantage and training of an Ising Born machine.** npj Quantum Information 6, no. 1 (2020): 60.

Vankov, Iskren, Daniel Mills, Petros Wallden, and Elham Kashefi. **Methods for classically simulating noisy networked quantum architectures.** Quantum Science and Technology 5, no. 1 (2019): 014001.

Daniel Mills, Anna Pappa, Theodoros Kapourniotis, and Elham Kashefi. **Information theoretically secure hypothesis test for temporally unstructured quantum computation.** Electronic Proceedings in Theoretical Computer Science (QPL 2017).

Notable Presentations

Besides the following, additional posters and presentations may be found at my website.

Quantum Buisiness Europe Congress 2023 (invited speaker): Best Practices in Running Quantum Algorithms on NISQ Devices.

IWQC 2023: Distributing circuits over heterogeneous, modular quantum computing network architectures.

IEEE Quantum Week 2022: Developing and Executing Error-mitigated NISQ Algorithms across Devices and Simulators.

APS March 2022 (invited speaker): Application-motivated, holistic benchmarking of a full quantum computing stack.

Quantum Simulation and Computing 2019: The Born Supremacy - Quantum Advantage and Training of an Ising Born Machine

QPL 2017: Information Theoretically Secure Hypothesis Test for Temporally Unstructured Quantum Computation.