

Alec Edwards | PhD | MEng

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Education

DPhil in Computer Science

University of Oxford

2019–2024

- DPhil supervised with Alessandro Abate in conjunction with CDT in Autonomous Intelligent Machines and Systems (AIMS)
- Published papers at top conferences across machine learning and formal verification, including Neurips and HSCC
- Thesis title: *Formal Verification of Dynamical Models via Neural Synthesis*
- Broader research interests lie at the intersection of machine learning and formal verification, and how each field can allow the other to construct better, more trustworthy models

MEng in Engineering Science (First Class)

University of Oxford

2014–2018

- Awarded scholarships following 1st and 2nd year exams
- Specialised in Control and Information Engineering: options including Machine Learning, Nonlinear and Networked Control, Vision and Robotics, Mathematical Techniques
- Completed a 4th year project on Distributed Energy Management in Building Networks; a conference paper based on the work appeared in UKACC 2018
- Awarded the BP Prize for best Chemical Engineering 3rd Year Project

The Coleshill School & Solihull Sixth Form College

Qualifications

2007–2014

- A Levels: A*s in Maths, Chemistry, Physics and Further Maths, A in AS Biology and English Lit
- GCSEs: 9A*s and 1A (including A*s in Maths, English Lang, English Lit, Triple Science)

Relevant Experience

High Quality Research

Neural Abstractions

University of Oxford

PhD

- Led development (code, design & theory) of a novel method for formally abstracting dynamical model using neural networks
- Relies on interpretability of piecewise affine (ReLU) networks
- The method enables safety verification of difficult-to-analyse models
- Resulted in papers at Neurips 2022 and QEST 2023 (with results found to be repeatable)

Neural Certificates

University of Oxford

PhD

- Led and collaborated in a wide range of projects on the use of neural networks as formal certificates
- Approaches generally train neural networks and verify their properties using SMT-solving (and a counterexample-guided approach)
- Involvement includes: leading code, design & theory; providing field expertise; supervision of students;
- Papers with a range of collaborators accepted at HSCC 2021, CONCUR 2023, AAAI 2024; under review at L4DC 2024, TAC, HSCC 2024

Research-Driven Software Development

Fossil

University of Oxford

PhD

- Developed a tool as part of a development team to enable certificate synthesis dynamical systems using neural networks
- The Python-based verification tool is designed to be modular and extensible
- Tool was accepted at HSCC 2021 having been reviewed on repeatability, usability and robustness

Fossil 2.0

University of Oxford

PhD

- Led the development of a new version of Fossil, expanding its verification portfolio from two to seven certificates
- Significant rewrite and refactor of the codebase to improve usability, extensibility and model coverage
- Built new interfaces for Fossil, including a Python API and a simple command line interface

Additional Experience

Research Associate

University of Oxford

2024–present

- Research Associate in the Department of Computer Science, working on digital twins and energy systems
- Surveying and scoping state-of-the-art challenges in digital twins calibration and certification, bringing in expertise from formal verification and machine learning
- Working with industry partners to understand their needs and challenges in the areas of digital twins and energy distribution networks

Doctoral-level Verification Course Tutor

University of Oxford

2022–2023

- Conceived, designed and taught a lab course *An Introduction to SMT-Solving* for AIMS CDT (and external) students
- The course encourages ML-familiar students to interact with logic common in formal verification using SMT-solving
- Taught in Python using Z3, example tasks involve building a Sudoku solver and synthesising a Lyapunov function using CEGIS
- Received positive and constructive feedback from students both years, allowing improvements for successive years

MSc Project Supervisor

University of Oxford

2022

- Supervised a CS MSc student on a project involving the use of SMT-solving to quantify the probability a probabilistic program is safe
- The student achieved a high grade and the work culminated in a paper at CONCUR 2023

High Performance Server Administrator

OxCav

2020–Present

- Administer the Oxford Computer Aided Verification (OxCav) server
- Implemented custom Bash and Docker-based login system allowing users local control over installation and running of programs without access to host root
- Maintain and update the server, provide assistance to users and IT in case of issues

Research Assistant

Energy Futures Lab, Imperial College London

2018–2019

- Conducted a scoping project on the potential for light electric vehicles in Sub-Saharan Africa, funded by the Global Challenges Research Fund
- Research to gain both technical and social insight into the corresponding challenges and opportunities, including those relating to transport usage, charging possibilities and business case feasibility
- Worked closely with Research Management teams to organise workshops with local stakeholders and researchers

Skills

- Advanced experience with Python and machine learning packages including: PyTorch, Jax
- Advanced user of SMT-solving tools, including Marabou (ReLUplex), DNNV, DReal and Z3
- Intermediate experience with C

Publications

Alec Edwards, Mirco Giacobbe, and Alessandro Abate. On the trade-off between efficiency and precision of neural abstractions. In *QEST*, 2023a.

Alessandro Abate, Alec Edwards, Mirco Giacobbe, Hashan Punchihewa, and Diptarko Roy. Quantitative verification with neural networks. In *CONCUR*, 2023.

Alessandro Abate, Alec Edwards, and Mirco Giacobbe. Neural abstractions. In *Thirty-Sixth Conference on Neural Information Processing Systems*, 2022.

Alessandro Abate, Daniele Ahmed, Alec Edwards, Mirco Giacobbe, and Andrea Peruffo. FOSSIL: A software tool for the formal synthesis of lyapunov functions and barrier certificates using neural networks. *HSCC '21*, May 2021.

Alec Edwards, Jan-Peter Calliess, and Kostas Margellos. Distributed optimisation for energy management in building networks. In *2018 UKACC 12th International Conference on Control (CONTROL)*, pages 44–49, 2018. doi: 10.1109/CONTROL.2018.8516737.

Alessandro Abate, Sergiy Bogomolov, Alec Edwards, Kostiantyn Potomkin, Sadegh Soudjani, and Paolo Zuliani. Safe reach set computation via neural barrier certificates. *AHDS* 2024.

Virginie Debauche, Alec Edwards, Alessandro Abate, and Raphael M. Jungers. Stability analysis of switched linear systems with neural lyapunov functions, 2023.

Virginie Debauche, Alec Edwards, Alessandro Abate, and Raphael M. Jungers. Formal synthesis of lyapunov stability certificates for linear switched systems using relu neural networks, 2024. Under review.

Alec Edwards, Andrea Peruffo, and Alessandro Abate. Fossil 2.0: Formal Certificate Synthesis for the Verification and Control of Dynamical Models, 2023b. HSCC 2024.

Alec Edwards, Andrea Peruffo, and Alessandro Abate. A General Verification Framework for Dynamical and Control Models via Certificate Synthesis, 2023c. Under review, arXiv:2309.06090.