# 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, AAAI and CONCUR
- Thesis title: *Formal Verification of Dynamical Models via Neural Synthesis*
- Broader research include machine learning, artificial intelligence and formal verification, and how each field can allow the others to construct better, more robust models

### MEng in Engineering Science (First Class)

*University of Oxford*                                                                                               *2014–2018*

- Awarded scholarships following $1^{st}$ and $2^{nd}$ year exams
- Specialised in Control and Information Engineering: Machine Learning, Nonlinear and Networked Control, Vision and Robotics, Mathematical Techniques
- Completed a $4^{th}$ 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 $3^{rd}$ 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, enables safety verification of difficult-to-analyse models
- Resulted in papers at NeurIPS 2022 and QEST 2023 (with verifiably repeatable results)

#### 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 2023, HSCC 2024, ADHS 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 tool combines machine learing and verification and 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
- Awarded best RE prize at HSCC 2024
- 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-to-use command line interface

## Additional Experience.....................................................................................................

### Research Associate in AI and Formal Verification

*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 certication, bringing in expertise from formal verification and machine learning
- Identifying how recent ML advancements such as LLMs and federated learning can be used to improve digital twins
- 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

### MSc Project Supervisor

*University of Oxford*                                                                                                *2022*
- Supervised a CS MSc student on a project quantifying the probability a probabilistic program is safe via certificates
- 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 GCRF
- 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 exprience with Python and machine learning packages (e.g., PyTorch, Jax)
- Advanced user of SMT-solving tools, including Marabou (ReluPlex), DNNV, DReal and Z3
- Intermediate experience with C

## Publications

Alessandro Abate, Alec Edwards, and Mirco Giacobbe. Neural abstractions. In *NeurIPS*, 2022.

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, 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)*, 2018.

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, AAAI 2023.

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

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

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.