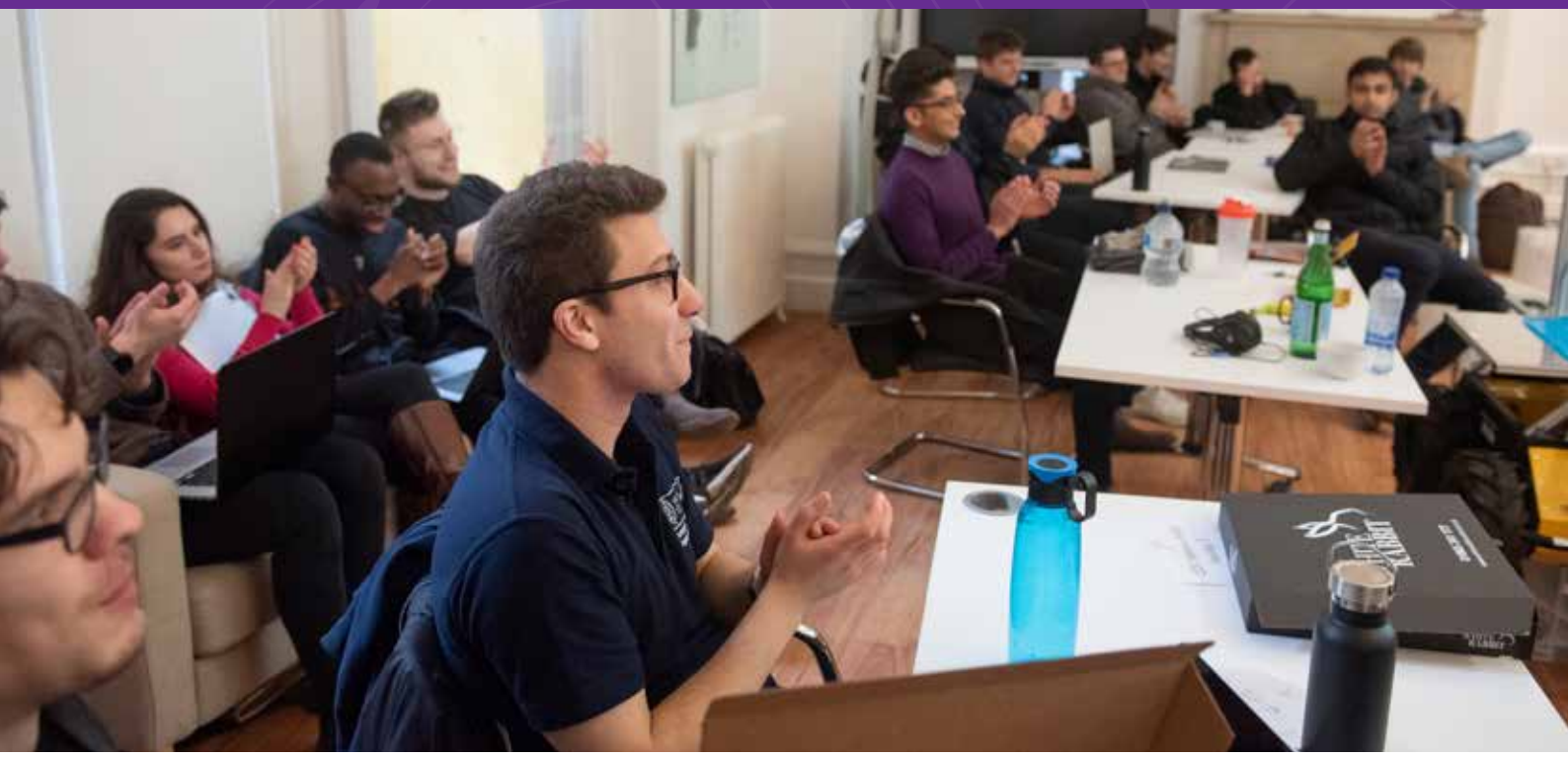
AIMS

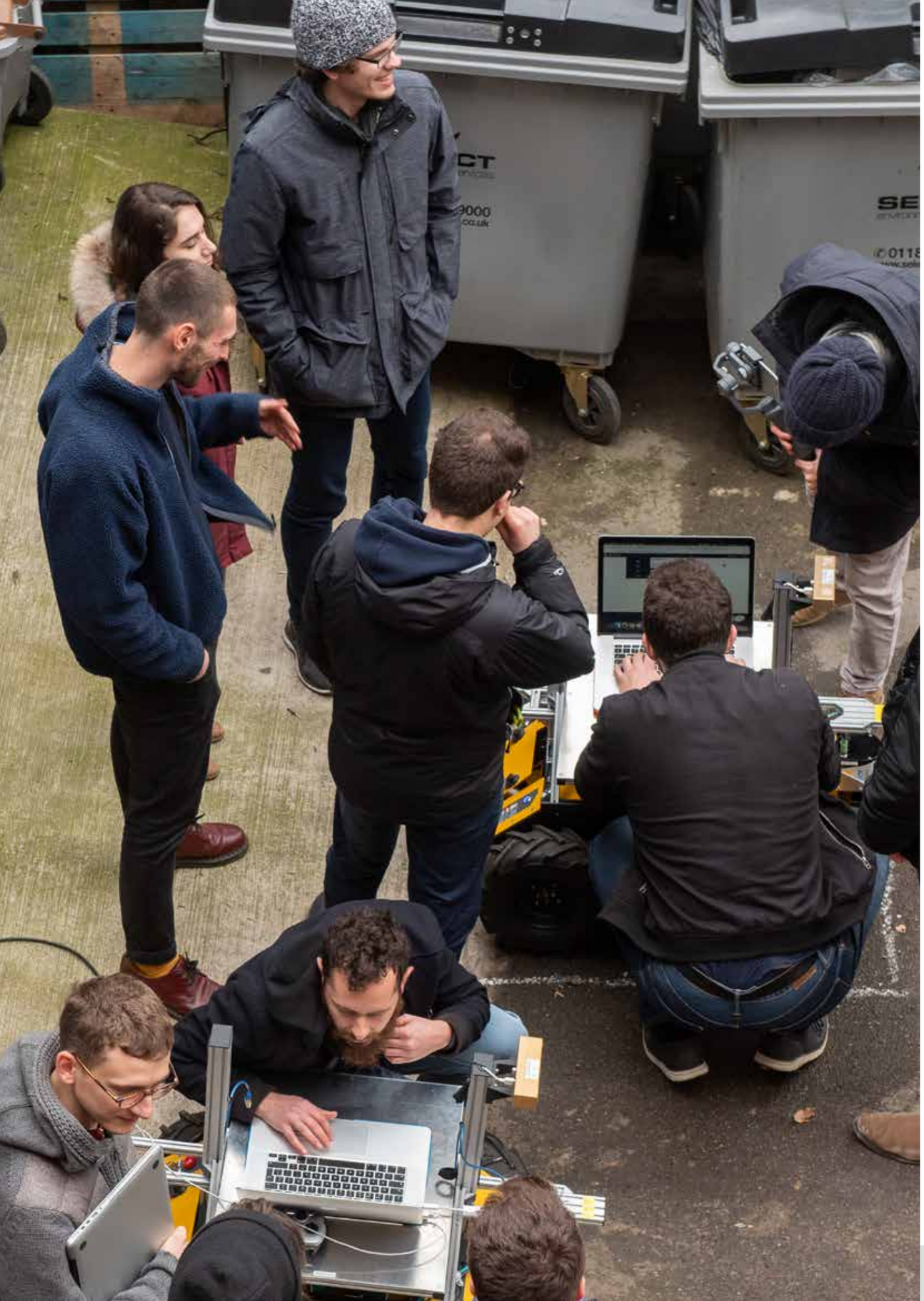
EPSRC Centre for Doctoral Training in
Autonomous Intelligent Machines & Systems

Annual Review 2019/20



Engineering and Physical Sciences Research Council

UNIVERSITY OF OXFORD



AIMS

EPSRC Centre for Doctoral Training in
Autonomous Intelligent Machines & Systems

Foreword

The pandemic has presented a challenging year, but the AIMS CDT has risen to that challenge. This report, the sixth annual review, will give some of the highlights of the CDT's 2020 activities.

The CDT has never been more attractive to applicants, with more than 200 applications (for about a dozen places) in the most recent admissions exercise. The CDT has also welcomed several new Industry Partners this year: Amazon Web Services, FiveAI, Oxehealth and Satellite Catapult. Thanks to their generosity, we have been able to fully-fund more students for this year and beyond.

Our students continue to excel academically, publishing prolifically at top conferences, graduating and securing high-profile jobs in industry and academia. We have held a successful AIMS seminar series, featuring speakers from the AIMS supervisory pool, industry representatives, including from DeepMind, Mathworks, ABB, Wayve, Nvidia, along with speakers from other Universities and Research Centers.

We would like to warmly acknowledge EPSRC and our industry partners for their continued support for the CDT: thanks for helping us make the CDT such a success in even such a trying year.

Mike Osborne
Director

Alex Rogers
Co-Director

Wendy Poole
Centre Administrator

About Us

Autonomous systems powered by artificial intelligence will have a transformative impact on economy, industry and society. Our mission is to train cohorts with both theoretical, practical and systems skills in autonomous systems - comprising machine learning, robotics, sensor systems and verification- and a deep understanding of the cross-disciplinary requirements of these domains. Industrial Partnerships have been and will continue to be at the heart of AIMS, shaping its training and ensuring the delivery of Oxford's world-leading research in autonomous systems to a wide variety of sectors, including smart health, transport, finance, tracking of animals, energy and extreme environments.

The CDT is underpinned by key skills areas in four interconnected themes, in which Oxford has research strengths, led by members of the CDT team and strengthened by industrial contacts.

Key Skills Areas

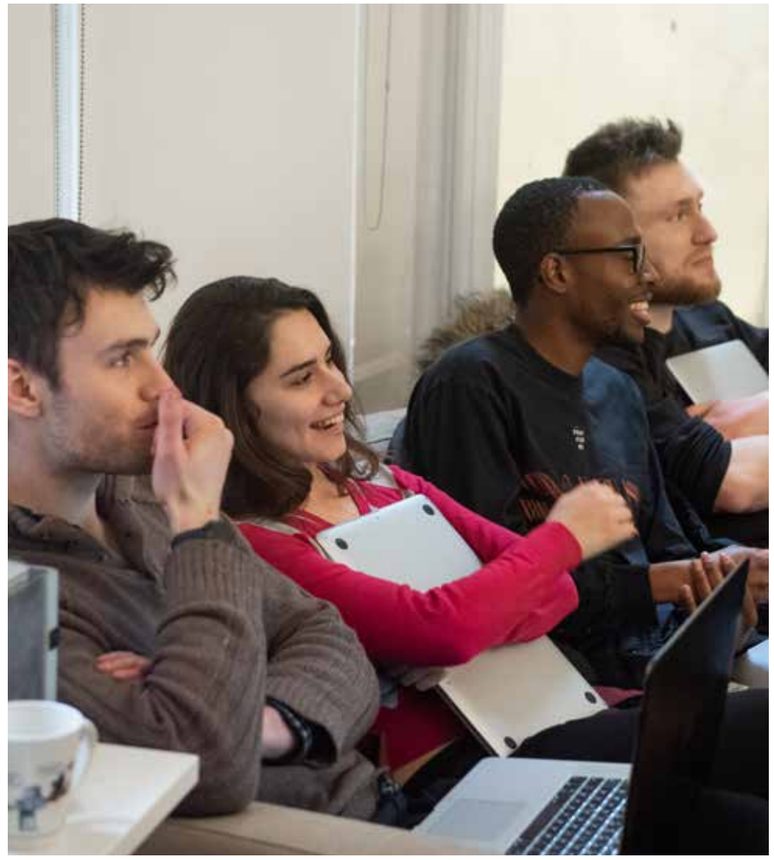
What's holding up the real-world impact of Artificial Intelligence? Today, too often, innovation is overly focussed on new component algorithms, particularly those from Machine Learning. To realise impact on the world, however, such algorithms must be integrated with complete autonomous systems – in which there are far–too–few trained experts. AIMS imparts unified training in four important and intimately connected components of such systems:

1. Machine Learning, as a unifying core.
2. Robotics & Vision.
3. Cyber-Physical Systems (e.g. sensor networks); and
4. Control & Verification.

As examples of autonomous systems, AIMS aim is at building systems to impact upon

- sustainable urban development (transport, financial services and smart infrastructure),
- extreme and challenging environments (space robots and satellite data) and
- smart health (cancer diagnosis).

To deliver training in these core research themes, we delivered a series of modules in 2019/2020 in the following areas: Data Estimation & Inference, Online Learning and Multi-Armed Bandits, Signal Processing, Optimization, Embedded Systems Programming, Introduction to Modern Control, Discriminative & Deep Learning for Big Data , Computer Vision, Autonomous Systems Safety & Governance, Systems Verification, Security in Wireless and Mobile Networks, Computational Game Theory, Reinforcement Learning, Internet of Things, Autonomous Robotics and Deep Learning in Distributed and Constrained Systems.



Events, highlights, outreach and publications

AIMS students have taken part in a wide range of research and outreach this year. They have also published many papers at top conferences. These include: Uncertainty in Artificial Intelligence (UAI), British Machine Vision Association (BMVC), International Conference on Machine Learning (ICML), Neural Information Processing Systems (NeurIPS), the Journal of European Geoscience Unio to name but a few. A full list of publications can be found at: www.aims.robots.ox.ac.uk/publications

- Niki Trigoni wins CTO of the year award at Women in IT Awards London 2020. The winners of the sixth annual Women in IT Awards London 2020 have been revealed at a gala ceremony in Grosvenor House Hotel, Park Lane. The awards, organised by Information Age and DiversityQ in partnership with Amazon Web Services, serve to showcase the achievements and innovation of women in technology and identify new role models in a sector where female representation stands at only 19%. Niki won her award in recognition for her role as (founder and) Chief Technical Officer at spinout company Navenio.

- Xu Ji - I have enjoyed collaborating with researchers from MILA over the summer, and we have decided to continue it into winter. MILA researchers are interested in causality, generalization, reasoning: the difficult questions in AI that we are still very far from satisfactorily solving. I find MILA director Yoshua Bengio's attitude towards research to be unusually pure and level-headed, and very refreshing. It's been an incredible privilege to establish this link between our labs in Oxford and Montreal.

- Yuki Asano was awarded a fellowship with Qualcomm Innovation. The Qualcomm Innovation Fellowship began in 2009 and has continued to grow with the addition of more universities, more candidates, and expansion to our research centres internationally.

- Alessandro de Palma was awarded an IBM Fellowship. For 70 years IBM has recognized and rewarded outstanding PhD students around the world through a highly competitive PhD Fellowship Award program. The distinguished 2020 IBM PhD Fellowship Award recipients demonstrated expertise in pioneering research areas, such as artificial intelligence, blockchain, quantum computing, data science, security, hybrid cloud technology, and the next generation of cutting-edge processors.

  The 2020 IBM PhD Fellowship Award Program received hundreds of applications from 140 universities in 31 countries. Applications were reviewed by eminentechnologists from across IBM. The award recipients demonstrated academic excellence as well as provided innovative, exceptional research proposals.

- Anna Gautier and Shuyu Lin participated in the "I'm a researcher- Machine Learning Zone" where the student answered questions from grade school children about her life as a PhD student and working in science in general. Further details can be found here: www.machinelearning.imaresearcher.uk

  Anna also participated at the Westgate Ideas Festival. We brought our autonomous robot Betty to the mall and she interacted with kids of all ages. They got to see how she was able to avoid running into them if they jumped in her path, and she also took selfies of the kids and uploaded them to twitter.

- Adam Goliński interned at Qualcomm AI Research Amsterdam working on learned video compression

- In spring 2020, Fabian Fuchs, conducted an internship at the Bosch Centre for AI (www.bosch-ai.com) supervised by Volker Fischer. As Germany's leading industrial Machine Learning team (measured by number of papers accepted at ML conferences), their expertise is broad enough to offer students to choose from a broad range of topics. Together with collaborators from the University of Amsterdam (Max Welling and Daniel Worrall), he examined deep learning architectures for point clouds which leverage the symmetries and geometrical properties of the task. They will present their work at in NeurIPS 2020. Paper + Code + Video explanations can be found here: www.fabianfuchsml.github.io/se3transformer

- Tim Rudner received outstanding reviewer awards at ICML and NeurIPS this year. ICML 2020 awarded reviewer awards to the top 33% of reviewers but NeurIP 2020 awarded outstanding reviewer awards to the top 10% of reviewers. He was also named an Invited Expert to the OECD's Working Group on Trustworthy AI and the OECD's Working Group on AI Classification.

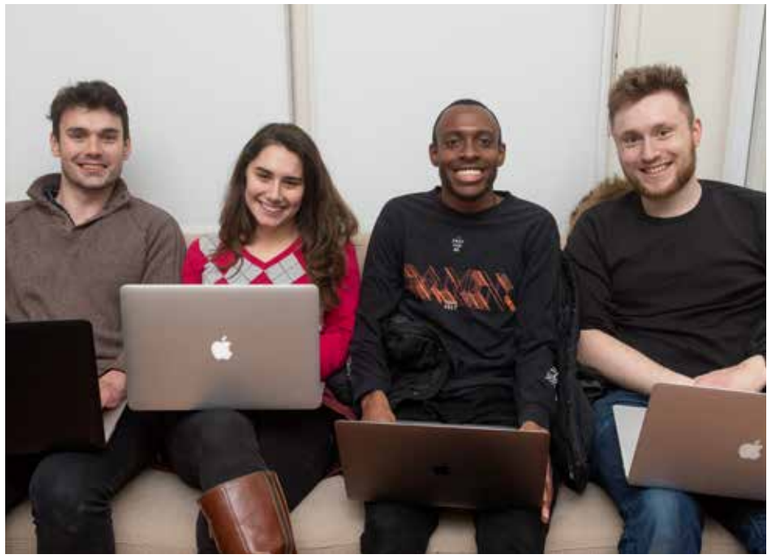
- Bryn Elesedy has been working with DELVE – Data Evaluation and Learning for Viral Epidemics This is a multi-disciplinary group, convened by the Royal Society, to support a data-driven approach to learning from the different approaches countries are taking to managing the covid-19 pandemic. More information can be found here: www.rs-delve.github.io

- Jonas Beuchert became a laureate of the USAIRE Student Awards 2020. The Association of United States and European Aerospace Industry Representatives (USAIRE) is a network of companies such as Airbus, Boeing, Rolls-Royce, and BAE Systems and the French Civil Aviation Authority and honoured him for his competition entry titled "Greener Aircraft with AI." Subsequently, he was invited to play an active role in the Paris Air Forum 2020.

- Jan Brauner et al gave an invited talk at Africa CDC, Africa's intercontinental public health agency, in June 2020. They presented their work on nonpharmacetical interventions against COVID-19 to the COVID-19 modelling group:
  www.oatml.cs.ox.ac.uk/publications/202006_Brauner2020effectiveness.html

- Jan's work has received quite some media coverage, for example from Vox:
  www.medrxiv.altmetric.com/details/83060529/news
  and has also been cited in the world bank report:
  www.openknowledge.worldbank.org/handle/10986/34518.
  He has also been interviewed by major radio stations and newspapers in Germany on the effectiveness of interventions against COVID-19.

- Students have taken up placements/internships with Bosch, Qualcomm,Frontier Development Laboratory, Quebec AI Institute (MILA) and Facebook Artificial Intelligence Research (FAIR) and Dyson.



Feedback from Students – Cohort 2019

The first year of the AIMS programme gave me the opportunity to explore a wide range of topics. Due to the small group sizes in the lectures it is incredibly easy to talk with world-class academics about their research and benefit from their expertise. What makes the AIMS programme stand out is the opportunity to do two mini-projects in two different labs at the end of your first year. This enables students to get a good understanding about how well one would work with a given supervisor. This greatly benefits the students because they can be sure that they will start their DPhil in a research group that they feel comfortable in and that is aligned with their research goals.

The AIMS courses and seminars are conducted by world-leading academics who are usually willing to steer the content of the high-quality classes towards the interests of the students and take considerable time to address questions and discussions that are brought up by the students.

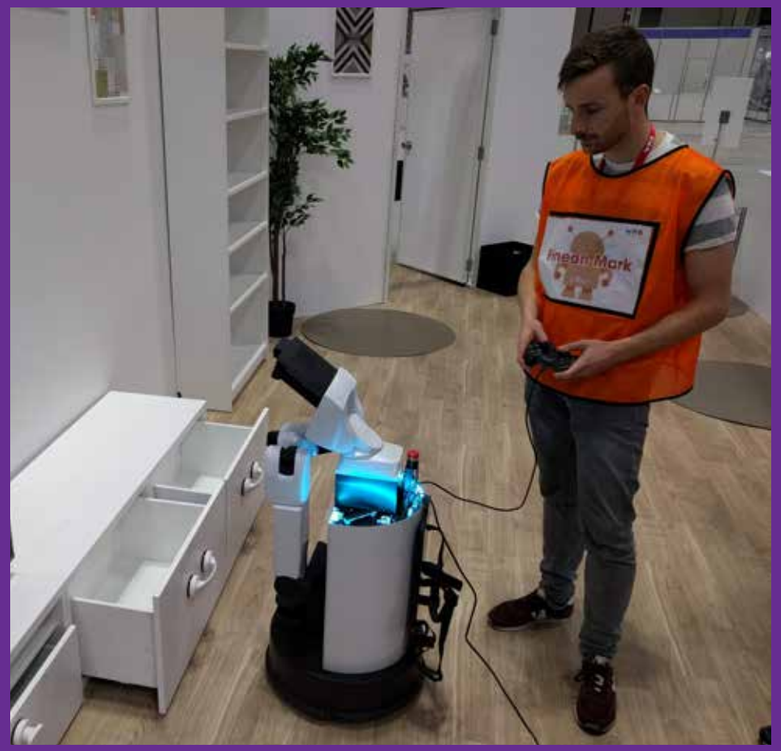
The even more exciting section of the program starts with the research phase after half a year. I learned to highly value the knowledgeable supervisors with their motivating ideas and inspiring suggestions. Beyond that it is worthwhile to mention that AIMS equips you with all the resources you need to successfully move forward with your research.

I had a great time in the first year of AIMS. It had all the things you expect from Oxford: inspiring professors, interesting course mates, great supervisors to work with. One thing especially stood out to me, which probably is very unique to AIMS: There are very few annoying hoops you have to jump through. Students are treated as grown-ups and are given a lot of flexibility because the course organisers, tutors and professors trust that students have a high motivation to learn and do good research and can make their own decisions about how to do so best.

The first year of AIMS was very enjoyable. I gained valuable insight into various research fields related to machine learning, and it gave me a chance to explore my options and decide on a DPhil research area that I feel passionate. I found the afternoon practicals especially helpful to gain more hands-on experience of implementing algorithms we learnt during the lectures, such as Gaussian Processes, Multi-Armed Bandits, and Reinforcement Learning. The most intense and enjoyable part of the course was the one with Autonomous Robots at the Oxford Robotics Institute. I was very impressed by the quality of the practicals provided, which gave us an opportunity to work on a rescue mission challenge and work both on simulation and on real robots.

The current situation with Covid-19 meant that we had to do our mini-projects remotely without a proper introduction to the lab, which was an interesting experience. Having said that, the pandemic no doubt has affected all activities worldwide, and from that standpoint, my two mini-projects couldn't have gone smoother. Both my supervisors were very helpful, friendly and accessible, and gave me very useful feedback and pointers. I was also able to join the weekly meetings of the lab which was now held on Zoom, as well as bi-weekly discussion groups. These helped me slowly get to know some of the members at the lab, which might have been a good thing since I am typically bad at memorising names, and Zoom takes away that awkwardness in a way.

The first year of the AIMS CDT was hugely beneficial to me. The labs gave me valuable experience and confidence in both programming and independent working. The course structure also helped me broaden my research interests into fields which I was previously unaware of.



Feedback from Courses – Cohort 2019

Systems Verification - All the lecturers were knowledgeable and were very open to answer any questions that would come up. I also thought that the GAN lab was great because it was exactly the right amount of difficulty and I learned something from having to implement a GAN.

Deep Learning in Distributed Constrained Systems - Motivated lecturer; very up-to-date slides - please keep updating for future cohorts; friendly lab tutor.

The labs were cool. Very well constructed. I didn't know that you could run a neural net on a microcontroller and that it would be that easy!

The practical was very well prepared. I liked how microcontrollers were provided for the practical and we were able to test out neural network models both on the computer and on the micron controller.

Optimization - I thought the lecture course was well taught and covered a range of essential topics for any future ML specialisation. The practical supervisors were excellent and helped me through the lab activities in an engaging and highly informative manner.

Online Learning and Multi-Armed Bandits - Good course content and very knowledgeable lecturer. It was interesting to see some of the "proof techniques" that were used in the multi-armed bandit field as I have not seen them before. For proofs writing on the whiteboard instead of having slides is nice because it forces the lecturer to explain every step.

Data Estimation and Inference - I liked the assignment as it was a good way to make sure that one understands all the different parts of the Gaussian Process.

Autonomous Systems Safety & Governance - The lectures from Dr Veliz were amazing. It was nice to first have some foundations in philosophy and then have them applied to digital ethics. I really liked how she was open for discussions.

Student Biographies – Cohort 2020

ONDREJ BAJGAR

I studied mathematics (with a pinch of economics) at the University of Warwick, then switched into machine learning, working as a research scientist for IBM Watson for 3 years, mainly in the areas of text understanding, dialogue systems, and the methodology of evaluating machine learning architectures. Interests and worries around the long-term safety of AI have led me to move to the Future of Humanity Institute in Oxford, where I spent 2 years as a Senior Research Scholar looking into the shareability of AI safety solutions and their suitability for global AI regulation. I'm planning to partly continue working on these areas even during my doctoral studies. In my spare time, I'm co-organizing Summer Academy Discover, helping high school students find a meaningful future path, and enjoy running, hiking, and dancing Swing.

FREDDIE BICKFORD-SMITH

I studied mechanical engineering at the University of Bristol, working on 3D printing with Ben Hicks (Design & Manufacturing Futures Lab) and on composite materials with Fabrizio Scarpa (Bristol Composites Institute). Implementing sequential Monte Carlo for a final-year robotics project got me hooked on probabilistic inference. So, after finishing at Bristol and taking a year off to ski and travel, I joined a master's programme in machine learning at University College London. My research there involved using deep neural networks to better understand the influence of attention in visual perception. I did this in collaboration with Brad Love, Brett Roads and Ken Luo (Love Lab), and with additional supervision from Ed Grefenstette (UCL NLP / FAIR). Currently I'm especially interested in generative models and reinforcement learning.

JONATHAN CARTER

I'm from rural Pembrokeshire, West Wales. I graduated from St. John's College, Cambridge with an MEng in Information and Computer Engineering, specialising in machine learning and statistical signal processing. My Master's project looked at safe and efficient approaches to model-based reinforcement learning. My research interests include scalable uncertainty quantification and self-supervised learning. My DPhil research is kindly sponsored by the healthcare company Oxehealth and will look to develop the existing state-of-the-art in non-contact health monitoring. Previously I interned at British Cycling where I worked on sensor design and signal processing algorithms, developing equipment for use by Olympic athletes. Outside of research I love football, running, reading and (courtesy of lockdown) have recently become an avid baker.

BENJAMIN ELLIS

Before joining the AIMS CDT, I worked for 2 years as a software engineer at Man AHL in London. While there I worked on the position management for futures trading, and particularly on projects to make this more automated, reliable and maintainable. Before joining Man AHL, I graduated in 2018 from Homerton College, Cambridge with an MEng in Computer Science, where my dissertation was on the application of reinforcement learning to distributed stream processing systems. This prompted an interest in reinforcement learning and I look forward to expanding upon this in the AIMS CDT. In my spare time I enjoy bouldering.

FRANCISCO GIRBAL EIRAS

I am originally from Lisbon, Portugal, where I received my BSc in Electrical and Computer Engineering. In 2017 I obtained a master's in computer science from the University of Oxford, mainly focusing for my thesis on efficient applications of formal methods and model checking to motion planning in semi-autonomous vehicles. After I graduated, I moved to Edinburgh and started as a Research Engineer at the autonomous driving start-up Five AI, working primarily on motion planning problems via constrained optimisation, and contributing to the company's research on provably robust training of neural networks. My main research interests lie in the robustness of deep neural networks and the development of efficient techniques that can improve the scalability of network verification mechanisms, allowing them to be applied to state-of-the-art systems. I am excited to pursue these interests further through the support of the AIMS CDT and Five AI. In my spare time, I enjoy web design and reading about world history.

LAURYNAS KARAZIJA

I graduated with MEng from the University of Cambridge, where I worked on improving neural network application in low-data regimes common in the biomedical domain. Afterwards, I worked in the industry, applying machine learning to computer vision and finance problems. I am excited by the different areas explored by AIMS CDT. Currently, my research interests are generative modelling, interpretability and object-based representations. In my free time, I enjoy running, cooking and probably watch more Netflix than I should.

DOMINIK KLOEPFER

After growing up in Germany, I studied Natural Sciences (specialising in Physics) for my BA and then Mathematics for my MMath at the University of Cambridge. I gained my first experience in machine learning through a summer internship with IBM and a research internship at the Department of Computer Science in Cambridge, after which I decided to pursue that direction for my PhD. My current interests lie in scene understanding and perception for robots, but at the AIMS CDT I also look forward to learning about topics that I have not had much contact with. I love skiing and rowing, and very much enjoy devouring a good book.

PIERRE OSSELIN

I come from the Paris Area, France, where I studied Mathematics and Physics at Lycée Janson de Sailly Preparatory Classes before attending the engineering school École Centrale Paris. During this curriculum I also completed a Bachelor of Science degree in Pure Mathematics at University Paris-Sud and spent my last year in the Part C Mathematics and Statistics of the University of Oxford as part of a double degree. I then specialized in Computer Vision and Machine learning at Ecole Normale Supérieure of Cachan. During my studies I had the opportunity to work in a start-up in biotechnology, at the University of Versailles and at J.P Morgan on various research subjects. I look forward to joining the AIMS CDT and contributing to the scientific community.

BENJAMIN RAMTOULA

I am originally from France and studied in Switzerland, where I graduated with a BSc in Microengineering from EPFL. I pursued a double-degree program focused on machine learning and robotics which I applied to multi-robot SLAM and object pose estimation. While completing an MSc from EPFL and an MSc from Polytechnique Montreal, Canada, I got the opportunity to carry out part of my studies as a visiting student researcher in Stanford University's Multi-Robot Systems Lab and as an intern in NASA's Jet Propulsion Laboratory's CoSTAR team, working on the DARPA Subterranean Challenge. For my DPhil, I am interested in making robust tools to help robots make sense of their surroundings under challenging practical constraints and in a wide variety of environments.

ALEKSANDAR SHTEDRITSKI

I grew up in Sofia, Bulgaria, and completed MEng in Engineering Science at the University of Oxford, specialising in Information Engineering. In my final year project, I worked on developing supervised and unsupervised computer vision algorithms for analysing the layout of historical documents. During my studies I had the opportunity to undertake internships focusing on NLP and deploying computer vision on embedded devices. My current research interests are in computer vision and unsupervised learning. In my free time I love cooking and going to the gym.

LISA SCHUT

From a young age, I've been passionate about chess and previously was a member of the Dutch Olympic team. I obtained my BSc in Econometrics and Operations Research from Erasmus University Rotterdam, and two MScs in Statistics and Computer Science from the University of Oxford. As part of OATML, I spent time working on various machine learning projects under the supervision of prof. Gal. My interests fall in the general areas of machine learning and optimization.

BASKARAN SRIPATHMANATHAN

After studying a BA and MMath at the University of Cambridge, both specialising in probability and statistics, I joined UBS as a Quantitative Trader in Equities. I learnt to be an equity trader on the CRB desk in London, before moving onto more open ended projects in the New York office; there, I expanded on things I'd learnt, building hierarchical models in PyMC3 to cope with low-data stocks, inferring theory behind opaque models and tuning trading strategies I'd refined with Bayesian Optimization. After I left, I also worked at a small consultancy doing data science for dogs. While my reading has been centered around Bayesian Optimization and Probabilistic Programming (mostly in Haskell), I'm hoping to expand my horizons on the AIMS CDT. My job also gave me experience in clicking very exactly, writing in obscure functional/APL-like programming languages and taking risks on things I don't have full information for. I intend on keeping these as hobbies in future.

ALEX STEPHENS

I grew up in Australia and graduated with a BEng Hons in Mechatronics and a BSc in Computer Science and Physics from the University of Sydney. Alongside my studies, I worked as a research intern in several physics research groups and the Australian Centre for Field Robotics, and as a software engineering intern at Atlassian. I had the incredible privilege of completing my Honours thesis at the NASA Jet Propulsion Laboratory in California as a member of their team in the DARPA Subterranean Challenge, where my work focused on robotic perception and multi-agent SLAM in challenging environments. My core research interests are in robotic autonomy and intelligence, and applications of robotics in space exploration.

ZHENG XIONG

I'm from Beijing, China. I graduated from Tsinghua University with a Master of Science in 2020, majoring in computer science. I'm especially interested in how to design intelligent machines to help people make better decisions in real-world problems, which has great potentials to improve the efficiency of the whole society. To achieve this goal, I mainly research on reinforcement learning, automated machine learning and meta learning during my Master study and would continue my research in the crossing field of computing and engineering at AIMS CDT. Outside of research, I'm also interested in soccer, music, reading (especially history), and Peking Opera.

CHARIG YANG

I was born and raised in the outskirts of Bangkok, Thailand, and then completed my undergraduate degree in Engineering Science at Oxford. For my final year project, I investigated how machines learn motion, and how motion helps machines learn other things. The project drove my interest towards machine vision and perception, and I am excited to join AIMS to further explore the field of artificial intelligence. Outside of work, I enjoy teaching, organising events, cooking, and trying out different places to eat in my free time.

AIMS Contacts

The AIMS administration team comprises the Director, the co-Director and the Centre Administrator.

MICHAEL OSBORNE

Michael A Osborne is an expert in the development of intelligent algorithms capable of making sense of complex big data. His work in Machine Learning and non-parametric data analytics has been successfully applied in diverse and challenging contexts. For example, in astrostatistics, Michael's probabilistic algorithms have aided the detection of planets in distant solar systems, and in autonomous robotics, his work has enabled self-driving cars to determine when their maps may have changed due to roadworks. More recently, he has addressed key societal challenges, analysing how intelligent algorithms might soon substitute for human workers, and predicting the resulting impact on employment. Michael is an Associate Professor in Machine Learning, an Official Fellow of Exeter College, and a Faculty Member of the Oxford-Man Institute for Quantitative Finance, all at the University of Oxford.

ALEX ROGERS

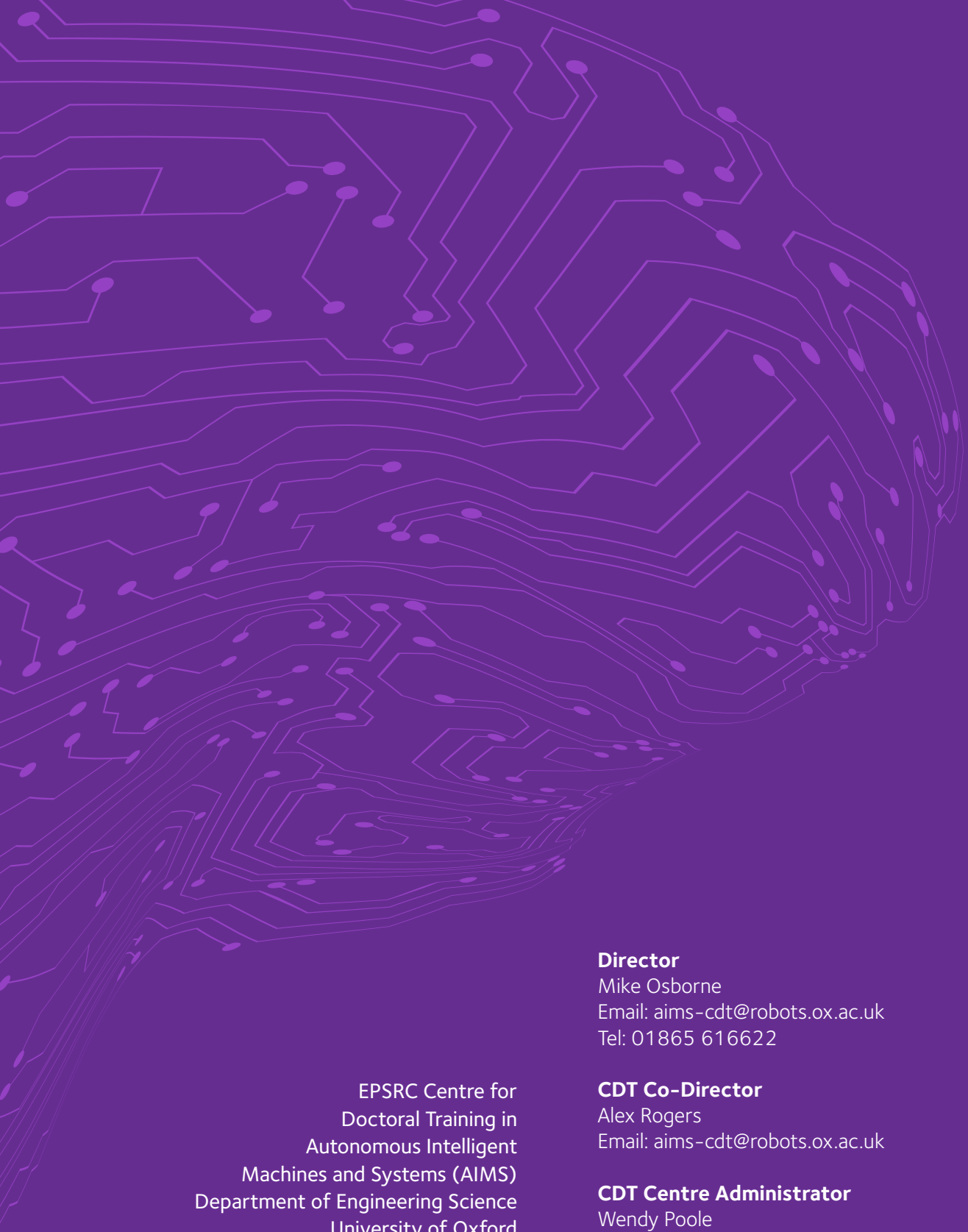
I originally studied Physics at Durham University before joining Schlumberger as a wireline logging engineer. After five years working in various oilfields around the world, I took suspended employment to study for a PhD applying statistical physics to models of evolving populations. Upon completing my PhD I worked for a spin-out from the Santa Fe Institute applying complexity science to business problem before returning to academia, initially at the University of Southampton, and now at the University of Oxford.

WENDY POOLE

I have been working in the University for 26 years now. I took up the position as CDT Centre Administrator, after working in the Department of Computer Science as the MSc Course Administrator for 20 years.

Academic Supervisors

A full list of academic supervisors can be found at:
www.aims.robots.ox.ac.uk/academics-and-staff



EPSRC Centre for
Doctoral Training in
Autonomous Intelligent
Machines and Systems (AIMS)
Department of Engineering Science
University of Oxford
Parks Road
Oxford OX1 3PJ

Director
Mike Osborne
Email: aims-cdt@robots.ox.ac.uk
Tel: 01865 616622

CDT Co-Director
Alex Rogers
Email: aims-cdt@robots.ox.ac.uk

CDT Centre Administrator
Wendy Poole
Email: aims-cdt@robots.ox.ac.uk
Tel: 01865 283155

www.aims.robots.ox.ac.uk

AIMS
EPSRC Centre for Doctoral Training in
Autonomous Intelligent Machines & Systems