

AIMMS

EPSRC Centre for Doctoral Training in
Autonomous Intelligent Machines & Systems

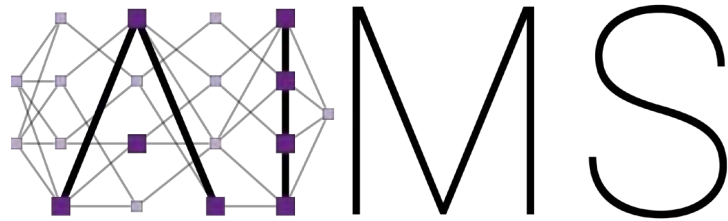
Annual Review 2020/21



Engineering and
Physical Sciences
Research Council







EPSRC Centre for Doctoral Training in
Autonomous Intelligent Machines & Systems

Foreword

Welcome to the annual review of the EPSRC Centre for Doctoral Training in Autonomous Intelligent Machines & Systems, the AIMS CDT, for 2020/2021. In this, AIMS's seventh full year, the CDT has continued to thrive, with our most recent admissions round attracting in excess >250 applications.

We are delighted that Toyota and Mind Foundry have joined our list of Industry Partners. Thanks to their generosity, we have been able to fully-fund more excellent students to expand our cohorts.

The last year has been another successful one for publications in top conferences, students submitting their dissertations, and students graduating to jobs both in industry and academia.

We held another successful AIMS seminar series, with speakers from the AIMS supervisory pool, industry representatives, including Lyft, DeepMind, V7 labs, AirBus, Snap Inc, Twitter and Nvidia, along with speakers from other Universities and Research Centers. We would like to warmly acknowledge EPSRC and our industrial partners for their continued support of internships and studentships.

We hope you enjoy this tour through some of AIMS's accomplishments in 2020/2021.

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 2020/2021 in the following areas: Data Estimation & Inference, Machine Learning, 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 Robotics, 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 last year. They have also published many papers at top conferences. These include: AAMAS (Autonomous Agents and Multiagent Systems), MICCAI (Medical Image Computing & Computer Assisted Intervention), ICRA (International Conference on Robotics & Automation), ICLR (International Conference on Learning Representations), NeurIPS (Neural Information Processing Systems), Royal Society Open Science to name but a few. A full list of publications can be found at: <https://aims.robots.ox.ac.uk/publications/>

- Tim Rudner 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.
- Graduate students [Sören Mindermann](#) and [Jan Brauner](#) (AIMS), together with [Mrinank Sharma](#) (AIMS) from the Department of Computer Science, were invited to give a talk on their work on ‘inferring the effects of non-pharmaceutical interventions against COVID-19’, at the German Centre for Infection Research/ University of Cologne.
- A team of researchers at the Oxford Robotics Institute are working on the control of legged robots. They are developing solutions for these legged robots to be able to perceive their environment and make intelligent decisions to move from one point to the other.

Lead author of a [recent paper](#) on this work and AIMS DPhil student [Siddhant \(Sid\) Gangapurwala](#) explains, “For example, it is extremely natural for us as humans to be able to move in a location with uneven terrain and significant obstacles. However, for a robot in the same environment, it needs algorithms that can help sense the



environment from sensors and then use this information to decide where to step, and how to step without falling over. This has been a difficult problem to solve. Full article at: <https://aims.robots.ox.ac.uk/news/>

- AIMS CDT student Vitaly Kurin received an Outstanding Reviewer Award at ICLR2021
- Best Paper Award for Charig Yang, Hala Lamdouar, Erika Lu, Andrew Zisserman and Weidi Xie at CVPR2021. *"Self-supervised Video Object Segmentation by Motion Grouping"*
- Amanda Matthes and Jonas Beuchert with Professor Alex Rogers, developed SnapperGPS, a low-cost, low-power wildlife tracking system based on satellite navigation and deployed it for the first time on wild animals: endangered loggerhead sea turtles in Cape Verde. Full article at: <https://aims.robots.ox.ac.uk/news/>



- Kelsey Doerksen was included in the space & Satellite Professionals International (SSPI) was included in fourth annual "20 Under 35" list of outstanding young space and satellite professionals aged 35 and under. The honourees will be

celebrated at SSPI's 16th annual [Future Leaders Celebration](#) on October 5 during the Satellite Innovation 2021 conference, produced by SatNews publishers.

SSPI's annual list of the "20 Under 35" features 20 employees and entrepreneurs to keep your eye on in coming years. They were selected from nominations submitted by the membership and evaluated by a panel of judges made up of many of the Mentors supporting SSPI's student outreach programs. At the Future Leaders Celebration, the three top-ranked members of the 20 Under 35 will be named as this year's Promise Award winners. Full article at: <https://aims.robots.ox.ac.uk/news/>

- Peering into the Moon's permanently shadowed regions with AI – (Ben Moseley)

The Moon's polar regions are home to craters and other depressions that never receive sunlight. Permanently shadowed lunar craters contain water ice but are difficult to image. An AI algorithm now provides sharper images, allowing us to see into them with high resolution for the first time.

Near the lunar north and south poles, the incident sunlight enters the craters and depressions at a very shallow angle and never reaches some of their floors, [Dr. Valentin Bickel, MPS](#).

A group of researchers led by the Max Planck Institute for Solar System Research (MPS) in Germany, supported by the University of Oxford and the NASA Ames Research Centre, have taken a closer look at some of these regions and presented the highest-resolution images to date covering 17 such craters in the journal [Nature Communications](#). Full article at: <https://aims.robots.ox.ac.uk/news/>

- This year AIMS ran a computer science essay competition for students at Brampton Manor School. Brampton Manor is a state-funded academy school situated in the socio-economically deprived area of East Ham, Newham (East London). 78% of their pupils speak English as an Additional Language, 59% of pupils received Free School Meals in 2019 and the vast majority of students in the sixth form (approx. 97%) are from Black, Asian and Minority Ethnic (BAME) backgrounds. Despite these barriers, however, Brampton Manor is one of the top performing academic sixth forms in the country. The essay competition encouraged students to explore areas of computer science in depth that they would not usually encounter in their A-level studies.

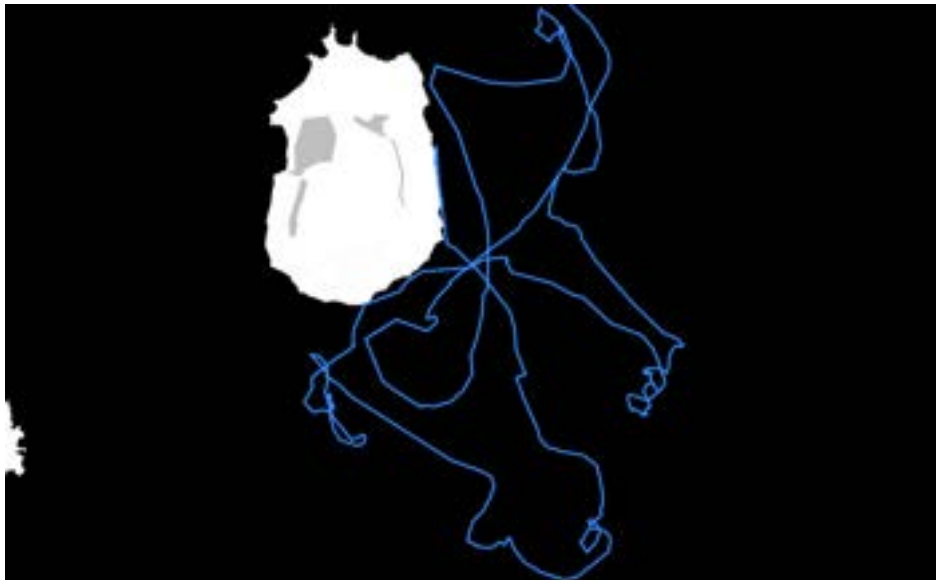


- Internships – AIMS students took up interns with the following companies this past year: Twitter, Cervest, Facebook AI Research, Microsoft Research, Second Mind, Waymo and FDL
- Three CDT's came together to talk about their current research at a student symposium at Trinity College Oxford. The three CDTs were: Autonomous Intelligent Machines & Systems (AIMS), Cyber Security and Health Data Science (HDS).

Students from all CDT's spoke on topics from *"Hot takes on Bayesian modelling of COVID-19"*, *"The HAPPY Project: Histology Analysis Pipeline.PY"*, *"Self-Supervised Multi-Modal Alignment for Whole Body Medical Imaging"*, *"Understanding Sleep's Association with Cardiovascular Diseases Using Machine Learning for Wearables"*, & *"Dead Man's Switch: Forensic Autopsy of the Nintendo Switch"*.

This was a great opportunity for students to network with other CDT's.

- The joint CDT conference with Oxford, Lincoln, Bristol and Edinburgh CDT took place in August 2021. This was a great opportunity to listen to various talks on research by all four CDTs.



A location track of a loggerhead sea turtle captured by a SnapperGPS tag.

Feedback from Students – Cohort 2020

I really enjoyed my first year at AIMS, which was intensive but fruitful. The first two terms consisted of 16 carefully selected teaching modules which cover many diverse and important topics in AI. They broaden my horizon and deepen my understanding of the related fields thanks to the insightful introduction from the knowledgeable professors. The combination of lectures and practices also provide great help on better understanding the key concepts of each module. In the second half of the academic year, we were provided a lot of interesting and exciting mini-projects ongoing in different labs, and we could choose two of them to work on. I have really enjoyed the two mini-projects I chose, which offers a great opportunity to get hands-on experience on different research directions before determining which lab to join. Moreover, due to the pandemic, I have worked remotely for the full year, and I have had a very pleasant online learning experience thanks to the efforts and support from the CDT administrative team, professors, TAs, and all the students who have worked together with me on different projects.

The first year of AIMS covers a wide range of topics from those that I am very familiar with to those that are completely foreign to me, which is extremely helpful and allows me to appreciate the interconnectedness of the various sub-disciplines in this field. The small class sizes allow interaction with lecturers who are specialised and highly passionate about the topic they teach. The practical's are great and allow hands-on applications of topics freshly learned from lectures. What I cannot undermine is also the community of AIMS students from different backgrounds who offer different perspectives and solutions to the same problem during our interactions during practical's. After exploration the mini projects allowed me to delve into two topics that I am interested in before choosing a DPhil project, allowing me to make a very confident decision on what to work on and who to work with, something that a traditional DPhil is unable to offer. Overall, this is a very fruitful year despite COVID restrictions. I strongly recommend AIMS to anyone who is interested in this field.

Despite the challenges of the past year, I have thoroughly enjoyed the 1st year of AIMS. The courses were well taught, highly interesting and have prepared me well for the next three years of research. The inter-disciplinary nature and the exposure to a wide range of topics has played a key part in this. For example, I'm currently applying concepts covered in the Robotics course to problems in healthcare.

I had a great time during the first year of the AIMS program. World-class academics gave us inspiring classes and presented us with chances to engage with them and their research. I particularly enjoyed the variety of topics we covered. Each class went deep enough for me to realise which topics I was more interested in and gave me pointers to extend my knowledge.

AIMS also has significant benefits outside of the classroom and labs. Interacting with other AIMS students from all cohorts and learning about their DPhil experience and specialisations has been incredibly valuable. And the AIMS administration went out of their way to ensure we were in the best possible conditions to adjust to remote work.

In the first year of the AIMS program, the environment is set for us to succeed in our research journey. The first part consists of courses especially tailored for us and tremendous effort is put into the material and support to make sure the courses are as insightful as they can be. From the courses and the weekly seminars, we have the opportunity to converse with world-class researchers, both from within the university and from around the world. The second part of the year consists in the completion of two mini-projects. During this period, in addition to discovering two research labs and research topics, autonomy, curiosity and initiative are fostered. As a result, we develop skills to become successful researchers and are able to make an informed decision about our future research direction and choice of supervision style for the Dphil.



Kelsey Doerksen – Space & Satellite Professionals International (SSPI) announced the fourth annual “20 Under 35” list of outstanding young space and satellite professionals age 35 and under.

Feedback from Courses – Cohort 2020

Computer Vision – The lectures were very interesting; it was great to see a more classical view of computer vision. The demonstrators were also very good and helped understand the material better. The quality of the presentations and explanations was amazing. All of the lecturers did a great job at explaining the material and finding a good balance of depth and breadth of the topics presented. The labs perfectly got us to experiment with the material seen in the lectures and asked good questions to make us think about it. The format of working on our own and then having group discussions worked well for me too.

Data Estimation & Inference – The lectures were well organized, and the fact that at least part of them were provided ahead of time was really helpful. The lab was also interesting and relevant to the understanding of the topic.

Machine Learning – The lectures were well organized, and the fact that at least part of them were provided ahead of time was really helpful. The lab was also interesting and relevant to the understanding of the topic.

Embedded Systems – Very engaging professor, the assessment offers the freedom to explore any topics we are interested in.

I am new to this topic, so have gained a lot of valuable knowledge in this topic. The labs are self-contained, instructions are clear, and challenges are good enough for the time slot allocated. I have a positive experience overall.

Autonomous Systems Safety & Governance – I enjoyed the lectures on practical AI ethics and Governance, and the class participation with regards the practical ethics. It was satisfying to push people into thinking about the ethics of their funding sources.
Reinforcement Learning – I very much enjoyed the amount of theory assessment; many prior week's felt like they lacked this. I grew to enjoy the pacing of the lectures; initially I thought they were too fast but looking back I now think they're well-paced. Content was great, well-structured and enjoyable

Internet of Things – I thought the topics were well explained, and the pace of the lectures was very good. The labs were very well aligned with the theory. They were also well made so that we only focused on the important understanding aspects, rather than focus on overhead coding (such as plots, data loading, etc.). The lecturers and TA were also friendly and available to help.

Game Theory – I found the topic and the material amazing. Everything was well presented, the lecture slides were very complete and easy to follow, the lab complemented the lectures perfectly, and the lecturer and TAs were all very friendly, knowledgeable, and supportive. I especially appreciated how they all kept a good mood and spirit despite how complicated interactions were with the online setting



Student Biographies – Cohort 2021



PATRICK BENJAMIN

After studying Russian and Arabic at the University of Oxford, I conducted anti-corruption investigations for two years at a risk consultancy firm. I became interested in safe and beneficial AI, in pursuit of which I undertook a master's in computer science at Imperial College. I have worked for the last year as a researcher at Imperial, designing a machine learning-based tool to be used by the National Crime Agency in combatting sexual offences against children. I am looking forward to continuing to contribute to the development of human-aligned AI during and after the CDT programme. Outside of research I enjoy long walks, especially when they end with food or a pub.



YASH BHALGAT

My main research interests are 3D Computer Vision, Language + Vision (multimodal AI) and self-supervised learning. I have been a Research Scientist at Qualcomm AI Research, San Diego for the last 2 years, where my work was primarily at the intersection of Computer Vision and Efficient Deep Learning. Prior to that, I graduated from University of Michigan - Ann Arbor with a master's in computer science and from Indian Institute of Technology (IIT) - Bombay with a Bachelors in EE. To get away from my exciting yet stressful life as a computer scientist, I indulge myself into the realms of music. I am passionate about Tabla, an Indian percussion instrument, and also a bit into beatboxing.



KELSEY DOERKSEN

Kelsey Doerksen - I am originally from Ontario, Canada, where I received my bachelor's degree in Aerospace Engineering, Space Systems Design with a Minor in Business from Carleton University, and my master's degree in Electrical and Computer Engineering from the University of Western Ontario. During my Masters, I completed an internship at the NASA Jet Propulsion Laboratory in the Machine Learning and Instrument

Autonomy group working on Mars rover technology, and an internship at l'Observatoire de Paris with the Celestial Mechanics and Space Weather Laboratories, where I now research and lecture part-time. I am a Space Systems Engineer and Satellite Operator at Planet, operating the world's largest Earth Observation satellite constellation. I am looking forward to deepening my knowledge in the field of Machine Learning at AIMS and in particular how to utilize Earth Observation datasets and Machine Learning to research climate change and its impacts.



AMON ELDERS

Amon Elders - My main research interest lies in the safety and stability of machine learning systems. I have done work on algorithmic fairness at IIT, AI-safety at Stanford, and worked as a datascientist for Spark Wave, a company that works to alleviate mental health at scale. I have had some stints in finance through internships in investment banking, private equity, and venture capital. I enjoy letting the mind wander by taking walks in nature, contact-juggling and I have extensive tai-chi and meditation

experience, spending 2 years in retreat. I once reached grandmaster level in Starcraft 2.





GUNSHI GUPTA

I grew up in New Delhi, India where I got my applied-math engineering degree from DTU, New Delhi. After dabbling in software engineering and robotics research for 2 years at Microsoft and IIIT Hyderabad, I joined Mila under Prof Liam Paull's supervision at the Real and embodied agent's lab. My master's research was on the topics of bayesian deep learning, meta learning and continual learning. Before joining the AIMS CDT, I've been working for a year at the autonomous driving startup Wayve that aims to solve the self-driving problem using end-to-end deep learning. My DPhil research will revolve around the problem of probabilistic and causally correct learning from data, with a focus on robotics tasks. I love being outdoors and enjoy most physical activities, and while indoors I enjoy reading and cooking.



BENJAMIN GUTTERIDGE

I grew up in Worcestershire and completed my MEng at the University of Oxford, specialising in information engineering. For my final year project I investigated gradient descent in variational inference as part of the Bayesian Exploration Lab. In 2020 I undertook a summer internship on the HumBug project within the MLRG at Oxford, working on voice activity detection and removal in aid of mosquito detection and classification systems. I am broadly interested in machine learning, particularly Bayesian methods, and am excited to continue to learn and engage in impactful research projects within the AIMS CDT. In my free time I enjoy reading, playing D&D, and finding interesting pubs.



MATTHEW JACKSON

I grew up in Nottingham and graduated from the University of Cambridge with a BA in Computer Science. Following this, I moved to University College London for an MSc in Machine Learning, where I researched model-based meta-reinforcement learning with Tim Rocktaeschel and Edward Grefenstette. Outside of academia, I have completed internships working on Alexa at Amazon and efficient neural network inference at Arm. Whilst in the AIMS CDT, where I am kindly supported by AWS and the Oxford–Singapore HMC initiative, I am keen to explore how reinforcement learning agents can use their prior experience to rapidly adapt to new tasks and environments.



SHRESHTH MALIK

After growing up in Birmingham, I studied Natural Sciences (specialising in Physics) at St John’s College, Cambridge. For my thesis, I worked on developing a machine learning approach for predicting the outcomes of material synthesis procedures. This project sparked my interest in ML and led me to then explore its industrial applications through an internship at a Cambridge-based start-up. I then joined a ML Master’s programme at UCL, working with Humanloop (a ML start-up) for my thesis on combatting some of the issues with using active learning in practice.

In general, I am interested in the problems that currently limit ML systems to be taken out of the lab and used with confidence in the real world. This includes topics such as uncertainty quantification, data-efficient/self-supervised learning, robustness, and AI ethics/safety/policy. Away from the computer, I enjoy cycling and racquet sports, and am training for my first marathon.





BENEDETTA MUSSATI

Originally from Italy, in 2020 I obtained a master's in computer science from the University of Oxford, funded by the DeepMind Scholarship. Before that, I graduated with a Bachelor in Artificial Intelligence and Mathematics from the University of Edinburgh.

I specialised in reinforcement learning, focusing on multi-agent systems for my Bachelor Honours Project. For my Master dissertation, I investigated metrics for early detection of a useful auxiliary task in deep reinforcement learning, working with Professor Shimon Whiteson. Before starting the AIMS CDT, I am working on model-based reinforcement learning with Professor Massimiliano Pontil at the Istituto Italiano di Tecnologia.

In my DPhil I want to investigate aspects of continual meta learning, improving the learning of useful latent representation and working on multi-task and transfer learning. I am curious about research in other areas and eager to draw connections with my own work.

Outside of research I like going for a hike or a run and practicing yoga, and I love exploring new places!



ALEKSANDAR PETROV

After graduating from the TU Delft Aerospace Engineering program, I joined a startup working on autonomous aircraft. I fell in love with the question of how to make autonomous systems safe, and even more critically, how to certify that we have done so successfully. So, looking for answers to these questions, I joined ETH Zürich for a masters in Robotics,

Systems and Control, during which I focused on statistics and machine learning theory. I also interned at Motional, an autonomous driving company, where I was working on tools for detecting the safe operational envelope of their self-driving stack.

At Oxford, I am continuing my work on safety and reliability of intelligent systems, focusing on both fundamentals and applications. I will be working on formal guarantees for safety-critical machine learning systems with a focus on perception for autonomous driving. My research at the AIMS CDT is generously sponsored by Toyota and is



LUKE RICKARD

I graduated from the University of Oxford in 2021, obtaining an MEng in Engineering Science with a focus on information and control. In my final year project, I investigated distributed charging of electric vehicles with considerations for uncertainty in supply.

I am particularly interested in multi-agent systems and reinforcement learning, with considerations on safety and verification but am excited for the broad range of topics the AIMS CDT has to offer.

I have previous experience from an internship with SteelRock Technologies in which I worked on the design of UAV and counter-UAV systems. In my spare time I enjoy hiking, playing KSP and am hopeful to take up bouldering once lockdown eases.



SEBASTIAN TOWERS

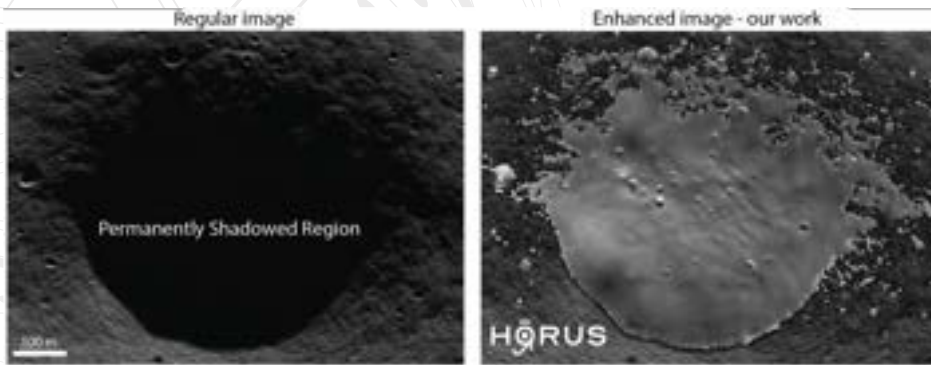
I have been lucky to be able to study at Oxford, studying Mathematics and Computer Science at St Johns. Throughout the years, I have accumulated a wide range of academic interests that I want to investigate further, such as reinforcement learning, mathematical social choice, and game theory.

For my Master's project I investigated some problems in game theory, in particular envy-free cake cutting, supervised by the excellent Professor Paul Goldberg.

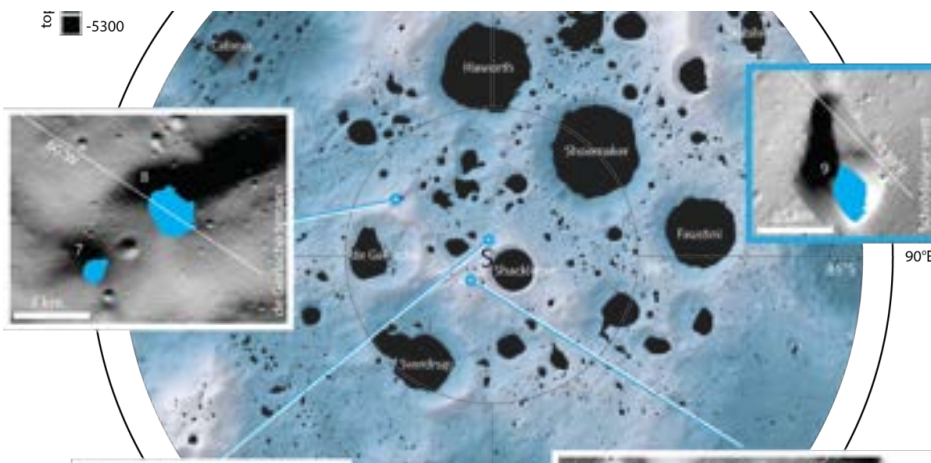
I have also interned at both Erda Energy and G-Research, applying machine learning to supermarket heating solutions and financial markets, respectively. Both have been incredibly interesting and gave me an appreciation for how machine learning is used in industry.

Otherwise, I have a casual interest in history, philosophy, and video/board games. Talk to me about any of these, and we are bound to have an interesting conversation!





An as-yet unnamed crater near the Moon's south pole and close to the proposed landing site of NASA's Volatiles Investigating Polar Exploration Rover. Left shows an image taken by the Lunar Reconnaissance Orbiter. Right shows the same image after our image processing. credits: left: NASA/LROC/GSFC/ASU; right: MPS/University of Oxford/NASA Ames Research Center/FDL/SETI Institute.



The 17 newly studied craters and depressions are located near the South Pole. Their sizes range from 0.18 to 54 square kilometres. Region 9 is not located in the section of the south polar region shown here, but a bit further to the North, in the Schrödinger Basin. credits: MPS/University of Oxford/NASA Ames Research Center/FDL/SETI Institute

AIMS Contacts

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



MICHAEL OSBORNE

Mike Osborne is a Professor of Machine Learning at the University of Oxford and the Director of the AIMS CDT. Mike has broad interests in the practical use of machine learning, while ensuring that such advances are made in sympathy with societal needs. Mike's technical expertise in Bayesian optimisation and probabilistic numerics underpins recent advances in automated and interpretable machine learning pipelines. His algorithms have been deployed in industrial and scientific applications ranging from battery monitoring, pigeon navigation and self-driving cars. As co-director of the Oxford Martin Programme on Technology and Employment, his research on the future of work has resulted in both sustained coverage in almost all major media venues (e.g. his being interviewed on BBC Newsnight, a cover feature in the Economist) and policy impact (including presenting oral evidence to the House of Commons Science and Technology Committee).



ALEX ROGERS

Alex Rogers originally studied Physics at Durham University before joining Schlumberger as a wireline logging engineer. After five years working in various oilfields around the world, he took suspended employment to study for a PhD applying statistical physics to models of evolving populations. Upon completing my PhD he 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

Wendy Poole has been working in the University for 27 years now. She 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:
<http://aims.robots.ox.ac.uk/academics-and-staff/>



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