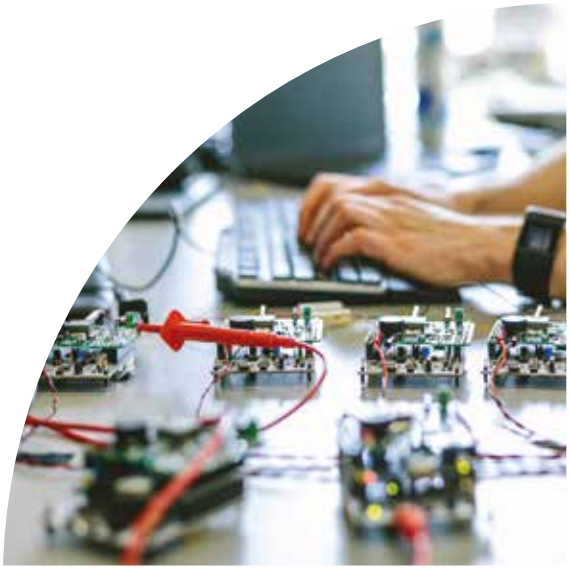
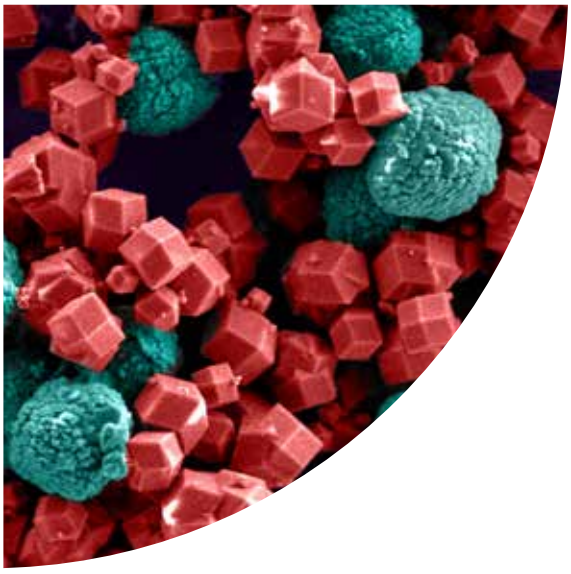
DEPARTMENT OF ENGINEERING SCIENCE

UNIVERSITY OF OXFORD

# DEPARTMENT OF ENGINEERING SCIENCE NEWSLETTER

ISSUE 9: 2019





## INSIDE THIS ISSUE:

# Welcome from the Head of Department

In my first welcoming message as the new Head of Department, I am pleased to announce that Oxford's Department of Engineering Science continues to excel in the international engineering league table, earning a 5th ranking worldwide after having ranked #1 in 2018. Although this is technically a drop in our ranking, the scoring differential between 1st and 5th place is exceedingly small. Engineering Science continues to reside in the very highest echelon of engineering departments across the globe. This is a huge accolade for the Department and a wonderful endorsement of our teaching, research and innovation. I congratulate the students, researchers, staff, and academics who make this happen.

In addition, I would like to offer my thanks and congratulations to Professor Lionel Tarassenko - thanks for doing such an outstanding job as Head of Department over the past five years, and congratulations for being named the first Head of House of Parks College, a new Oxford graduate college established in the past year. Lionel will continue to play a prominent role in the Department while leading the College, and we wish him the very best of luck with this exciting new project.

For those of you who don't know me, I am a relative newcomer to Oxford. After spending 26 years as a researcher in industry and an academic in four different research universities dotted across the US, I joined Oxford in 2013 as the Professor of Mechanical Engineering. My research speciality is physical acoustics – the physics of sound – and the application of physical acoustics principles to problems in biomedical acoustics, industrial ultrasonics, and acoustical oceanography. However, my true passion is the acoustics of bubbles and bubbly media. Sonoluminescence (light from sound), acoustic cavitation dynamics, shock-driven cavity collapse physics, and bubble-mediated therapeutic ultrasonics are topics of past and current interest. I have thoroughly enjoyed my time in Oxford and look forward to leading the department in a period of continued growth and opportunity.

Under Lionel's leadership, the department has expanded substantially and either established or consolidated world leading positions in a number of exciting fields, including multiple aspects of information engineering, biomedical engineering, and turbomachinery. We have expanded our portfolio to include the new Oxford Suzhou Centre for Advanced Research in China. We have won a number of high-profile professorships sponsored by the Royal Society and the Royal Academy of Engineering and consolidated 5 research Institutes within the Department. Innovation has been a key aspect of our portfolio, with over 30 new spinouts originating from the Department in the past 4-5 years. We have expanded the undergraduate course to include new offerings in Biomedical and Information Engineering. We have helped set up successful MSc in Energy Systems and Nanotechnology.

The latest avenue for opportunity is space, as in new buildings and laboratories. In the coming years, I hope to be able to share exciting news about new buildings and facilities designed to enhance our research capability and overall ability to deliver a 21st century course.

There are many other research highlights from the Department in this newsletter, but I would draw your attention to the news item on First Light Fusion, one of the many exciting spinouts from our research. They are endeavouring to solve one of the world most compelling and difficult problems: how to induce controlled inertially confined fusion for power generation. The company is a shining example of how universities can deliver impact today as well as help shape the future.

Finally, I would like to highlight the fact that the 46th Maurice Lubbock Lecture will feature Dr Anita Sengupta, an aerospace engineer and veteran of the US space program who spent 16 years at NASA and is now Co-Founder and CPO at Airspace Experience Technologies (ASX), which is developing urban aerial mobility solutions based on emission-free autonomous VTOL technology. I hope to see many of you at her lecture on Thursday 4th June 2020 at Pembroke College.

**Professor Ronald A. Roy**

## Front cover images

***Top Right:*** Doctoral student Damien Frost, working with Professor David Howey, tests his patented control algorithm for a 'smart battery system' that uses distributed power converters to improve battery life and performance in applications such as grid energy storage systems. This is now being used by University spin-out Brill Power Ltd.

***Top Left:*** Oxford University spinout First Light Fusion is researching energy generation by inertial confinement fusion using Machine 3, the biggest pulsed power machine in the world. Image shows a top view of Machine 3 showing the vacuum chamber and five of the six "limbs" with their capacitor banks and transmission lines.

***Bottom Left:*** Rhodes Scholar Naomi Mburu's DPhil research aims to study the practicality of using liquid metal walls on the inside of nuclear fusion reactors. Her work specifically involves experimentally and computationally quantifying flow patterns of liquid metals in nuclear fusion reactor relevant conditions. Image by John Russell, Vanderbilt University.

***Bottom Right:*** Crystalline (red) and amorphous (green) phase of ZIF-8 crystals, variations of Metal-Organic Framework (MOF) crystals, a emergent class of hybrid materials used in gas absorption and separation, guest encapsulation, and drug delivery. Image by Barbara Souza.

# The 46th Maurice Lubbock Memorial Lecture 2020

The Lubbock Lecture will be held at Pembroke College on 4th June 2020, from 5-6pm (followed by a drinks reception). We are pleased to welcome rocket scientist and aerospace engineer Dr Anita Sengupta. Dr. Sengupta is an aerospace engineer, rocket scientist, pilot, and veteran of the space program.

She worked for NASA for 16 years where her engineering projects included her PhD research on developing the ion propulsion system for the Dawn Mission, the supersonic parachute that landed the Curiosity rover on Mars, and the Cold Atom Laboratory - an atomic physics facility now on board the International Space Station.

Anita Sengupta

# From Flying Cars to Humans on Mars - The Future of Transportation

In the global marketplace that transfers knowledge at the speed of light, we have a massive time delay that is modern transportation methods. We each spend up to 30% of our lives commuting on congested freeways, airports, and train stations.

We put greenhouse gases into the atmosphere and change our climate with global consequences to health, habitat loss, and our economic future. On the cargo front this results in lost revenue and productivity, with no clear path to address the growing demands of the global market place. What if we could disrupt transportation, an aging and non-agile industry which has not seen a new mode in over 100 years. By introducing game changing technologies we can increase capacity, enhance energy efficiency, and shrink our carbon footprint.

Dr. Sengupta will discuss how space-age tech coupled to the VC funded innovation environment are enabling the revolution in green transportation. She will share her real-world engineering projects from her work developing the world's first hyperloop in Las Vegas Nevada, to autonomous VTOL air taxis her new company is designing in Detroit Michigan, to her research on entry systems that will land the first humans on Mars.

# CONTENTS



# Alumni Weekend and Jenkin Lecture

As part of the 2020 Oxford University Alumni Weekend (11th-13th September 2020) we will hold the annual Jenkin Lecture on Saturday 12th September – the speaker will be announced nearer the time.

There will also be the chance to meet academics from the Department and fellow alumni over drinks and canapés.

**For more information and to register for these events visit www.eng.ox.ac.uk/events**

# Famous freak wave recreated in laboratory mirrors Hokusai's 'Great Wave'

**Researchers have recreated for the first time the famous Draupner freak wave. Measured in the North Sea in 1995, it was one of the first confirmed observations of a freak wave in the ocean.**

Freak waves are unexpectedly large in comparison to surrounding waves. They are difficult to predict and are commonly attributed as probable causes for maritime catastrophes such as the sinking of large ships.

A team of researchers led by Oxford engineers Dr Mark McAllister and Professor Ton van den Bremer, in collaboration with Professor Thomas Adcock (University of Oxford) and Dr Sam Draycott at the University of Edinburgh, set out to reproduce the Draupner wave under laboratory conditions.

They successfully reconstructed the wave using two smaller wave groups and varying the 'crossing angle' – the angle at which the two groups travel. The researchers found it was only possible to reproduce the freak wave when the crossing angle was approximately 120 degrees.

When waves are not crossing, wave breaking limits their height. However, when waves cross at large angles, wave breaking behaviour changes and no longer limits their height in the same manner.

Dr McAllister explains, "The measurement of the Draupner wave in 1995 was a seminal observation initiating many years of research into the physics of freak waves and shifting their standing from mere folklore to a credible real-world phenomenon. By recreating the Draupner wave in the lab we have moved one step closer to understanding the potential mechanisms of this phenomenon."

Professor van den Bremer said: "Not only does this laboratory observation shed light on how the famous Draupner wave may have occurred, it also highlights the nature and significance of wave breaking in crossing sea conditions. The latter of these two findings has broad implications, illustrating previously unobserved wave breaking behaviour, which differs significantly from current state-of-the-art understanding of ocean wave breaking."

The laboratory recreation of the Draupner wave. Image: McAllister, M.L. et al. J. Fluid Mech. (2019); CC BY 4.0

To the researchers' surprise, the wave they created in the lab bore an uncanny resemblance to 'The Great Wave off Kanagawa,' a woodblock print published in the early 1800s by the Japanese artist Katsushika Hokusai. Hokusai's image depicts an enormous wave threatening three fishing boats and towering over Mount Fuji, which appears in the background.

The researchers hope this study will lay the groundwork for being able to predict these potentially catastrophic and hugely damaging waves that occur suddenly in the ocean without warning.

Watch a video of the recreated wave: **http://bit.ly/DraupnerWave**

Japanese artist Katsushika Hokusai's famous print. Image: © Katsushika Hokusai; Henry L. Phillips Collection, Bequest of Henry L. Phillips, 1939.

# Materials for next-generation nuclear fission reactors

Associate Professor Felix Hofmann, with colleagues at MIT and North Carolina State University in the US, has been awarded EPSRC and US Department of Energy Nuclear Energy University Program (NEUP) funding worth over £1m to work on materials for the next generation of nuclear fission reactors.

Liquid lead cooled reactors have the potential to offer dramatically improved efficiency over current water-cooled reactors. However, development has been at a standstill for decades because of concerns about the corrosion this high temperature liquid coolant would cause. This grant will accelerate the understanding of the specific corrosion mechanisms, very different to those in water- cooled reactors, and develop new materials to operate in these extreme conditions.

Previously, experiments on a specialised research reactor would have been required to test candidate material systems - prohibitively costly and slow.

Professor Hofmann explains, "A much faster way of studying combined irradiation and corrosion of materials for liquid lead cooled fast reactors is needed. With our partners at MIT, we will use a new, one-of-a-kind facility that allows the simultaneous exposure of materials to Pb/LBE corrosion and in-situ irradiation with protons, mimicking the effect of neutrons in a fission reactor."

"We will explore the performance of five of the current front-runner alloys for cladding and structural components in these reactors to determine which is the most promising and merits more extensive further testing and development."

Sizewell B nuclear power station

# Centre of Excellence to propel UK on 'Road to Zero'

A new virtual Centre of Excellence aims to accelerate the UK's transition to zero emission transport, in line with the UK government's 'Road to Zero' strategy.

The Centre of Excellence for Hybrid Thermal Propulsion Systems, funded by the EPSRC, involves the Universities of Oxford and Bath, Jaguar Land Rover and Siemens Digital Industries Software.

The partnership's overriding ambition is to develop a thermal propulsion system that, when combined with a matched hybrid energy recovery system, will be capable of powering electric vehicles from a liquid fuel at an equivalent or lower economic and environmental cost than if they were to be charged directly from the current EU average grid.

They aim to provide UK motorists with access to highly efficient and more affordable electrified vehicles able to operate at zero emissions within urban environments, significantly enhancing inner city air quality, while at the same time delivering lower fuel bills and reducing CO2 emissions.

Professor Martin Davy, Principal Investigator and Associate Professor of Engineering Science at Oxford, says, "This project will firmly establish UK industry and UK academia as world-leaders in hybrid thermal propulsion system science and technology."

"The core research activities of the academic teams at Oxford and Bath are highly complementary and together we are extremely well equipped to develop and test these new technologies in a virtual framework. Our combined expertise and our established relationships with the industry partners provide a solid foundation for an effective collaboration".

# Artificial Intelligence helping to identify cancer cells

Engineers at the University of Oxford have developed a new method of identifying and counting cells, using estimates provided by artificial intelligence.

They accelerated the process of cell counting using an algorithm that estimates the number of cells present in an image. This could supplant the current time-consuming method of manually counting cells, and make available previously unattainable data from overlapping or clumped cells.

In a study, 294 cells were detected using the algorithm, versus 297 detected when counting manually.

Cell counting from images is used in many medical and biological procedures, including inferring a patient's health from their white and red blood cells counts.

Research Fellow Weidi Xie identifies two further benefits of this new technique: firstly that it is capable of detecting cells, including cancerous ones. Secondly, that once cancerous cells are discovered, researchers can separate out each layer for individual analysis. Especially useful where cell structures are complex, as in those that evolve or adapt, this could help us to more fully understand cell behaviour.

The research won the Taylor & Francis Best Paper Award. Weidi says, "I'm happy to be recognized by the scientific community, and I'm looking forward to contributing more work at the intersection of healthcare, vision and machine learning".

# World's fastest high-volume camera will help unlock the mysteries of ultra high-speed phenomena

The world's most advanced real-time high-speed video camera will be the key to understanding new techniques that use light and sound to treat some of the most lethal forms of cancer, with minimal side effects for patients.

The new instrument is being developed through a collaboration between Oxford engineers and Invisible Vision, a company specialising in high-speed imaging. It was commissioned by, and will be housed at the new Rosalind Franklin Institute being built at the Harwell Research Complex in Oxfordshire for use by researchers in the UK and the rest of the world.

Professor Eleanor Stride (pictured) explains: "A major challenge with current delivery methods for cancer drugs is that they rely on the active molecules reaching and entering the tumour cells by diffusion. This makes it difficult to ensure that all parts of a tumour are treated and leads to terrible side effects because large volumes of healthy tissue also absorb the drug."

"Our approach introduces harmless particles into the bloodstream and then uses ultrasound to activate them, releasing the drug at a specific site and helping to drive it into the tumour to reach all of the cells within."

It will be the first camera in the world able to capture up to 100 million individual frames per second at 1 megapixel resolution and operate across a wide optical spectrum from ultraviolet to infrared. Researchers will be able to see how ultrasound interacts with drug-loaded particles and tissue and how that enables the controlled uptake of drugs into cancer cells.

Currently, the fastest such cameras operate at speeds up to 25 million frames per second. The new camera will be smaller and more compact (looking similar to a conventional video camera). It will be faster, more sensitive, and give higher resolution real-time imaging than any other device available today.

Once completed, the new instrument can be configured in a variety of ways and applied to a broad range of problems in materials science, plasma physics, combustion and fluid dynamics. It will produce exceptional images of the interaction of ultrasound with tissue and provide fundamental scientific insights that could lead to important new discoveries.

Those involved in this project in addition to Professor Eleanor Stride are Dr Jason Raymond, Dr Shamit Shrivastava, Professor Robin Cleveland, and Professor Ronald Roy.

# Engineering Science leads University's involvement in 'Energy Superhub' and 'Local Energy Oxfordshire' projects

Professors David Howey and Malcolm McCulloch are leading Oxford University's involvement in two smart energy systems demonstrator projects as part of UKRI's Prospering from the Energy Revolution programme. These projects aim to create new systems, intelligently linking energy supply, storage, transport and heating to support decarbonisation whilst securing affordable supply and developing smart clean technologies.

Energy Superhub Oxford (ESO) is a £41 million, world-first project, showcasing rapid electric vehicle charging, hybrid battery energy storage systems, low carbon heating, and smart energy management to help Oxford City Council's journey to zero carbon. A hybrid battery energy storage system connected to the transmission network is teamed with machine learning to secure delivery of power to the customer, as well as the profitability needed to support the future expansion of clean energy systems. The Department of Engineering Science and the Environmental Change Institute are providing expertise in areas including the project's impact on transport in Oxford, energy policy, and hybrid battery system design and performance.

The £40m Project Local Energy Oxfordshire, led by Scottish and Southern Electricity Networks (SSEN), is one of the most wide-ranging and comprehensive smart grid trials ever conducted in the UK. It will explore how the growth in local renewables, electric vehicles (EVs), battery storage, and demand side response can be supported by a local, flexible, and responsive electricity grid unlocking new opportunities for consumers and market providers.

Engineering Science researchers will work closely with Oxford Brookes University and Oxfordshire County Council, focussing on stakeholder engagement, system evaluation and future system planning. The work will investigate and establish the required processes to collect, store and process information regarding multi-vector energy services and user involvement which is required to successfully operate a smart flexible local energy system.

**For further information visit:**
**www.energysuperhuboxford.org**
**www.project-leo.co.uk**

# Adaptable 'soft' robots are inspired by nature

**Soft robotics is a relatively new field in engineering. It is based on the notion that robots are better equipped to adapt and be flexible in a changing environment when they are given soft, rather than rigid, structures.**

"Robots in factories can be designed to be rigid because they perform a precise, repetitive task in an unchanging environment," explains Professor Perla Maiolino. "Now we are working on having robots unconstrained in our environments and we need the systems to potentially adapt to changes in terrain or between a hard or a soft surface in order to perform more than one task."

The computer processing load that such adaptability would demand is considerable. So much so that researchers have looked to the natural world to understand the evolutionary distribution of processing skills throughout an organic system – not only the brain, but the body itself. In fact, it is the connection between body, mind and environment that provides the focus of much of the research. In terms of the body, softness seems a key feature that enables those attributes.

"The body of a fish has evolved to be responsive to water. It applies resistance and movement to the flow of water in order to navigate it," says Professor Maiolino. "What we want is for the robot to respond to the relevant environmental stimuli so that the body moves accordingly, without the need for complex processing," she adds.

The recreation of the micro-motor movements of the human hand is a case in point. Able to perform movements with surgical precision and sensitive enough to hold a baby or grasp a breezeblock with appropriate gentleness or force, this is the kind of sensitive tactility that researchers are ideally after.

"The technology could, in time, be used in agricultural settings to harvest produce appropriately or even in diagnostic settings," she says. "Palpation in soft tissue is being looked at, although the technology has to develop further."

Along with colleagues at the University of Genova, Professor Maiolino has worked on robot skin for a number of years. CySkin is comprised of flexible, interconnected, triangular sensor pads that can cover small or large areas. The pads send tactile feedback to Intelligent Hub Boards (IHB) that constitute the CySkin nervous system.

"I have always been interested in how to improve tactility in robots and technologies to really take the notion of morphology further. So my main research will be devoted to soft robots and I will also remain involved in tactile sensing technologies", she says.

See all of our news at www.eng.ox.ac.uk/news

# The secrets behind the dynamics of splashing

Professor Alfonso Castrejon-Pita explains how his team identified a way to predict liquid splashes, and why that could be important for manufacturing.

"Splashing is one of the most challenging topics within the field of microfluidics, as events happen very quickly and at very small scales. Armed with ultra-high speed cameras and high-resolution numerical simulations, we aimed to reveal the underlying secrets behind the dynamics of splashing.

Previously, there were two factors used to explain splashing behaviour: known as Ca and K numbers (Capillary and Splashing), they describe a droplet (its speed, viscosity, and surface tension), but not how it will interact with the surface it lands on.

Ultra-high speed cameras, recording 200,000 frames per second for extended periods of time, allowed us to watch how droplets performed upon impact. We examined water, ethanol, and an aqueous solution of glycerol, dropping them onto various surfaces.

We realised that we could predict splashing by noting the contact angle, combined with those Ca and K factors. However, this varied between liquids; for a universal predictor of splashing behaviour, we would have to look elsewhere.

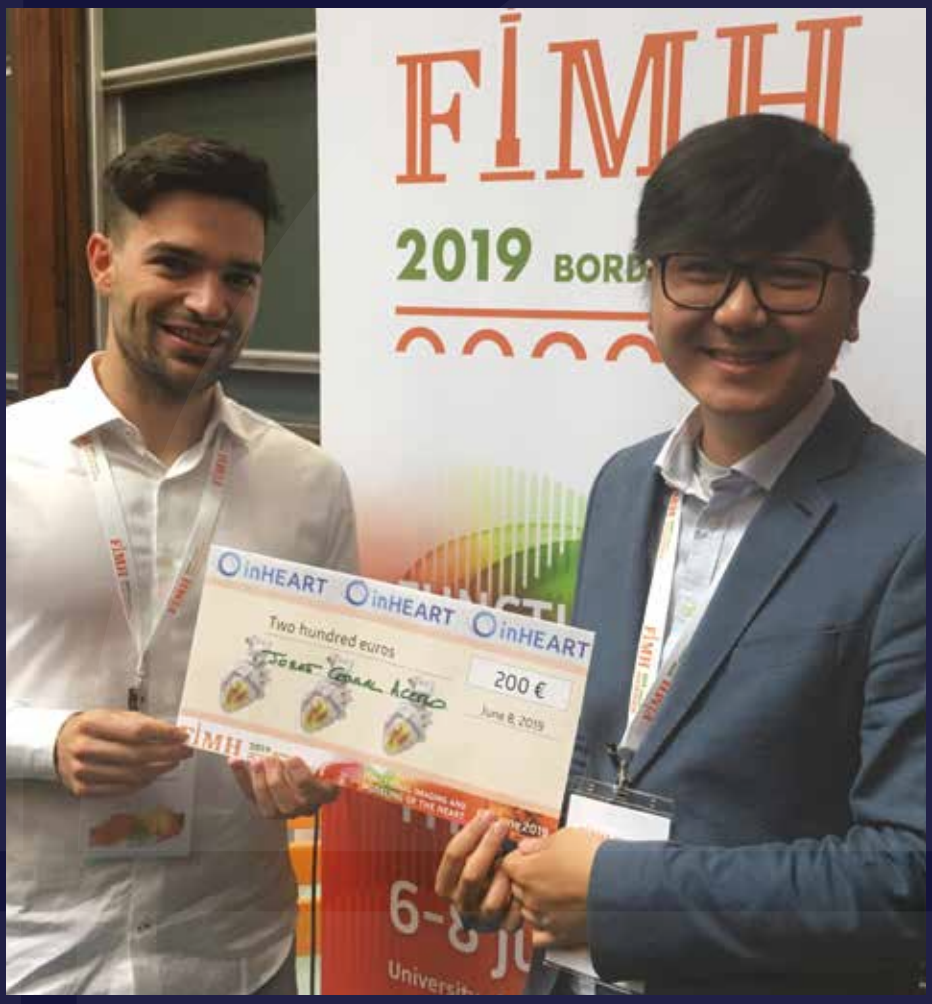
The solution was the 'splashing ratio'. This describes how, when the droplet lands, it spreads out and forms a thin liquid sheet. The leading edge of this sheet lifts off the surface. With all these factors in mind, the team were able to consistently predict splashes across all three liquids for the first time ever.

This research could be applied to a number of situations in which 'dangerous' or 'nasty' fluids are used. It's surprisingly easy to aerosolise droplets – a drop of a typical solvent (like ethanol or methanol) will splash if dropped from a height of about 20cm, and that generates droplets which will be small and light enough to be carried away by air.

So if you're working with dangerous chemicals or biological materials, it would be helpful to know that you won't be generating sprays when drops fall, exposing us to diseases or harmful materials. This is also the case with the use of instrument trays during surgery – they could be designed in such a way as to prevent the splash of bodily fluids.

Our ongoing research aims to unravel the micromechanics of splashing, including studies of drop impact onto rough surfaces, flexible substrates and immiscible fluids."

# Institute of Biomedical Engineering




The Institute of Biomedical Engineering (IBME) is based on the Medical Sciences campus at the Churchill University Hospital. It maximizes the translational and clinical impact of novel technologies.

2018/19 saw the strategic expansion of the IBME into two new and exciting strategic areas. First, neurotechnology, following the recruitment of Professor Tim Denison from Medtronic to a Royal Academy of Engineering Chair in Emerging Technologies. Secondly, biomaterials, following the appointment of Professor Eleanor Stride, newly recognized as "one of the 100 most influential women in engineering", to the first, landmark cross-divisional statutory chair across the Mathematical/Physical and the Medical Sciences Divisions of the University.

There have also been several notable successes at all levels across the four established focus areas of the Institute. In the field of non-invasive therapies & drug delivery, DPhil student Oliver Vince (supervised by Professor Stride) received the Institution of Engineering and Technology (IET)'s coveted 2019 Scholarship award for his work in the non-invasive delivery of drugs to treat microscopic brain tumours. A major cross-disciplinary clinical study led by IBME Director Professor Constantin Coussios was also published in Lancet Oncology (Lyon et al. 2018), demonstrating for the first time the safety and feasibility of remotely triggering and targeting chemotherapy by ultrasound to treat liver tumours.

In e-health and biomedical signal processing, Dr Tingting Zhu received a Royal Academy of Engineering Fellowship as well as the IET J.A. Lodge award in support of her work on the development of machine learning for understanding complex patient data in the developing world. Inaugural IBME director and immediate past Head of Department Professor Lionel Tarassenko CBE FREng received the Oxford Trust Lifetime Achievement Award for his contribution to biomedical engineering and innovations in healthcare technology. In biomedical imaging, DPhil candidates Jorge Corral Acero and Hao Xu (supervised by Professor Vincente Grau) received the Best Paper Award during the 10th International Conference on Functional Imaging and Modelling of the Heart (FIMH) for their work on automating MRI-based functional assessment of the heart (pictured left).

DPhil student Elisabeth Pickles, (pictured below), received a Prince Albert Fellowship from the Royal Commission for the Exhibition of 1851 to support her work with Perspectum Diagnostics on assessing the effects of chemotherapy and other therapies on liver tumours using MRI. Research Fellow Weidi Xie, working with Professors Alison Noble and Andrew Zisserman, has won the Taylor and Francis Best Paper Award for his DPhil research into microscopy cell counting and detection (see p.5). And Professor Alison Noble, OBE FRS FREng, has received the 2019 MICCAI Society Enduring Impact Award and the Royal Society's Gabor Medal for developing solutions to a number of key problems in biomedical image analysis and substantially advancing automatic extraction of clinically useful information from medical ultrasound scans.

Last but not least, Professor Coussios has been elected a Fellow of the Royal Academy of Engineering for his contributions to the translation of novel therapeutic technologies into clinical practice.

**For more IBME news, see: www.ibme.ox.ac.uk**

# Oxford Robotics Institute

The Oxford Robotics Institute (ORI) has had a cracking year in which we have grown markedly, sent robots to unusual places and seen the completion of the robot "bat cave" in the new Keble College graduate centre.

We welcomed two new academics. Firstly, Professor Perla Maiolino has started the Soft Robotics Lab, where she is using the very latest in 3D manufacture to print robotic flesh and make robots feel in a very real sense (see p.7). Secondly, Dr Lars Kunze has joined us as a Departmental Lecturer to build a new group with a focus on explainable AI, joining the latest in Machine Learning to the latest in semantic reasoning.

Our robots have been out and about - to solar-farms and stately homes, they've served plants to princes and explored caves in North America, strolled around fire training grounds and raced around our coasts. Next year there is talk of flying over sugar cane fields in Brazil.

There are also some notable retirements - the RobotCar is going to the London Science Museum. It was the first autonomous vehicle on the UK's roads and arguably was the origin story for not only the Robotics Institute, but the UK driverless vehicle endeavour. It's hard to believe that all that started 10 years ago, with a cold call to the Department of Transport - "I was thinking about building a driverless car because transport is a bit broken - what do you think?". The equivalent calls are being made now: "we fix/improve robotic surgeons"; "our robots should run"; "our warehouses are too dumb"; etc - if only we had a palantir to see where that leads us.

And whatever the outcome, along the way, we are working on common fundamental problems of robotics - to plan, to understand, to act and interact. This is what drives the ORI, the teaching and the exploration.

**For more Oxford Robotics Institute news, see: www.ori.ox.ac.uk**

# Oxford e-Research Centre

Photo: Ian Wallman

The Oxford e-Research Centre combines expertise in interdisciplinary research and digital research methods.

During 2019 we have celebrated a number of achievements during a typically busy and successful year. Highlights include Janet Pierrehumbert, Professor of Language Modelling (pictured above), being elected as a member of the prestigious National Academy of Sciences in the United States; and the Digital Delius project, a collaboration with the Faculty of Music, winning a prize at the Vice-Chancellor's Public Engagement with Research Awards (see p.15).

The Centre has continued to secure significant new funding from a diverse variety of funders, ranging from the Wellcome Trust, STFC, EPSRC, and Innovate UK to the National Institutes of Health, the MET Office and the Silicon Valley Community Foundation. Substantial new awards include £6.5m of UKRI funding for the Software Sustainability Institute to continue its work and further funding to maintain the Centre's contribution to the Square Kilometre Array (SKA) project, as this major international collaboration moves into its construction phase.

There have been numerous new collaborations and industrial engagements, with a range of partners as varied as the National Trust, The Alan Turing Institute, ARM, the EU's Horizon 2020 'RISE' programme, the HathiTrust Digital Library and the Innovate UK 'Smart Grants scheme'.

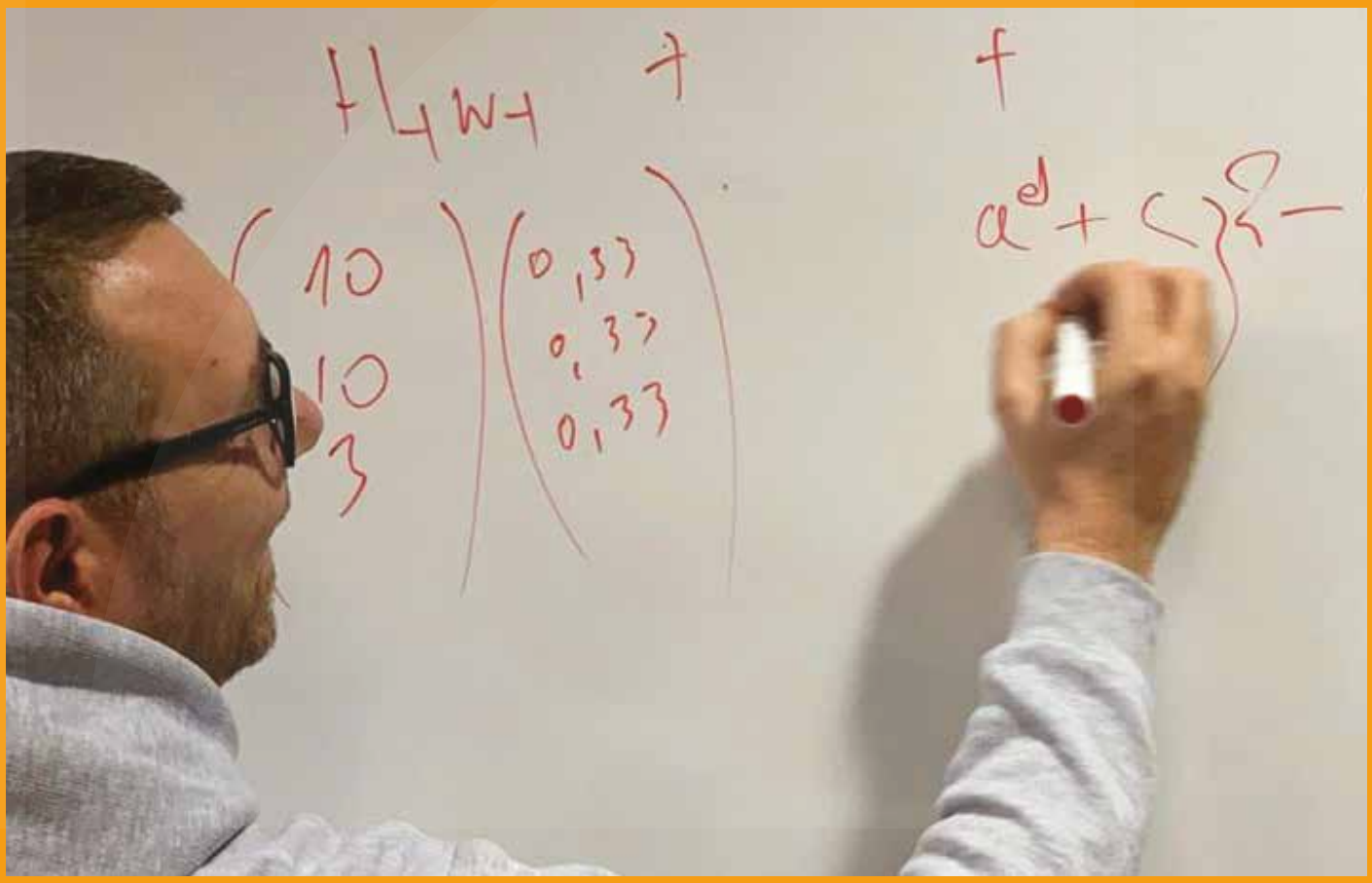
A new book on the Theory and Practice of Social Machines was published, an output from the FAST project, and our FAIRsharing educational resource has been adopted, used and promoted by major academic publishers, including Springer Nature, Wiley and Elsevier. Our data management and publication platform has been implemented by the USA NASA GeneLab Data Repository and a 'Music by Numbers' article was prominently featured in the January issue of BBC Music Magazine.

Our teaching endeavours continue to grow, with the new MSc in Energy Systems accepting its first cohort of students in October. In July, the Centre hosted the CUDA programming summer school, the first time it has been run in the Department of Engineering Science, with over 60 attendees from industry and academia.

**For more Oxford e-Research Centre news see: www.oerc.ox.ac.uk**

Energy Systems MSc students at Sandford Lock Hydroelectric Powerstation

# Oxford-Man Institute




This year has seen AI and machine learning even more prominent in the media.

From playing Go to advances in autonomous systems and self-driving cars, innovations seem to arrive at an unprecedented rate. Our keen focus on principled AI and machine learning within the OMI means that we are able to follow these advances, develop and innovate new ones and work to make them deployable at scale in the finance industry.

Our ability to produce world-leading science requires a commitment to bring talent into the OMI. We are delighted that over the past year we have been consolidating our expansion. We not only welcomed three new faculty members and new postdoctoral researchers into the OMI, but we have also hosted 14 interns in the past year and welcomed seven graduates in October 2019.

We have worked over the year to develop in-house hardware and software to accelerate our research.

Most notably, our IT team have created a rapid development infrastructure, co-located with our data servers. This has enabled development and testing of models, techniques and deployments with fast, reliable access to our vast data repositories. Allied with hardware capability, we have spent time creating new software to distil the data feeds that come into the OMI, creating a data lake of derived measures essential for research.

Over the past two summers we pioneered the development of a trade simulator. This enables us to test, for the first time, the effectiveness of algorithmic trading strategies in a digital twin of a live financial market. Further, it allows different algorithms to compete in the marketplace, paving the way to realistic multi-agent simulations.

This past year has seen links throughout the University strengthen, with associate members from Computer Science, the Saïd Business School and the department of Economics as well as from Engineering Science. Our members have published particularly broadly, producing innovative work at the heart of finance to novel algorithms for machine learning on quantum computers - a transformation yet to come. Indeed, over the past year alone, OMI members have published some 70 papers.

We have been involved throughout the year at high-profile external events; OMI members have delivered dozens of invited and keynote seminars and taken part in policy workshops at the heart of government and the finance industry. Our internal termly Machine Learning workshops have continued to be very well supported, building outreach and collaboration across the University, and our quantitative finance seminar series has attracted top academic speakers.

We look forward to the challenges, inspiration and innovation the coming year will bring!

**For more Oxford-Man Institute news see: www.oxford-man.ox.ac.uk**

# Oxford Thermofluids Institute

The Oxford Thermofluids Institute, (OTI) is a world leader in the field of turbomachinery, energy, microfluidics and hypersonic flow research with current grants exceeding £35 million.

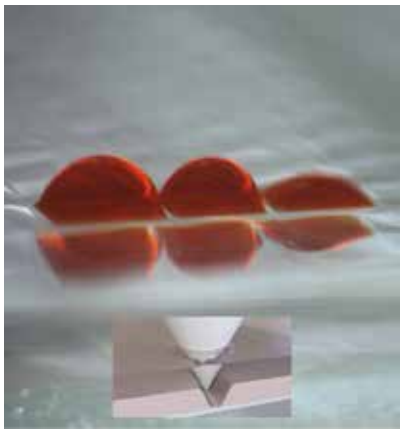
The OTI is very proud of its long-term partnerships with Rolls Royce, the Aerospace Technology Institute, the EPSRC, DSTL, Mitsubishi Heavy Industries and Siemens. Our collaboration with leading companies enables our research students and postdocs to study the science and technologies needed to reduce carbon emissions from flight and land based gas turbines.

Over the last year, the Oxford Thermofluids Institute has continued to grow, with Dr John Coull joining us from Cambridge University. John is an expert in aerodynamics and leads research programmes in the aerodynamics of the turbines stage. Our 11 faculty members supervise research students who are sponsored by a range of different sources. Some are supported by our Centre for Doctoral Training (CDT) which is organised in collaboration with Cambridge and Loughborough Universities. This year, the CDT was renewed for a further five years which will enable us to train future research leaders in Future Propulsion and Power.

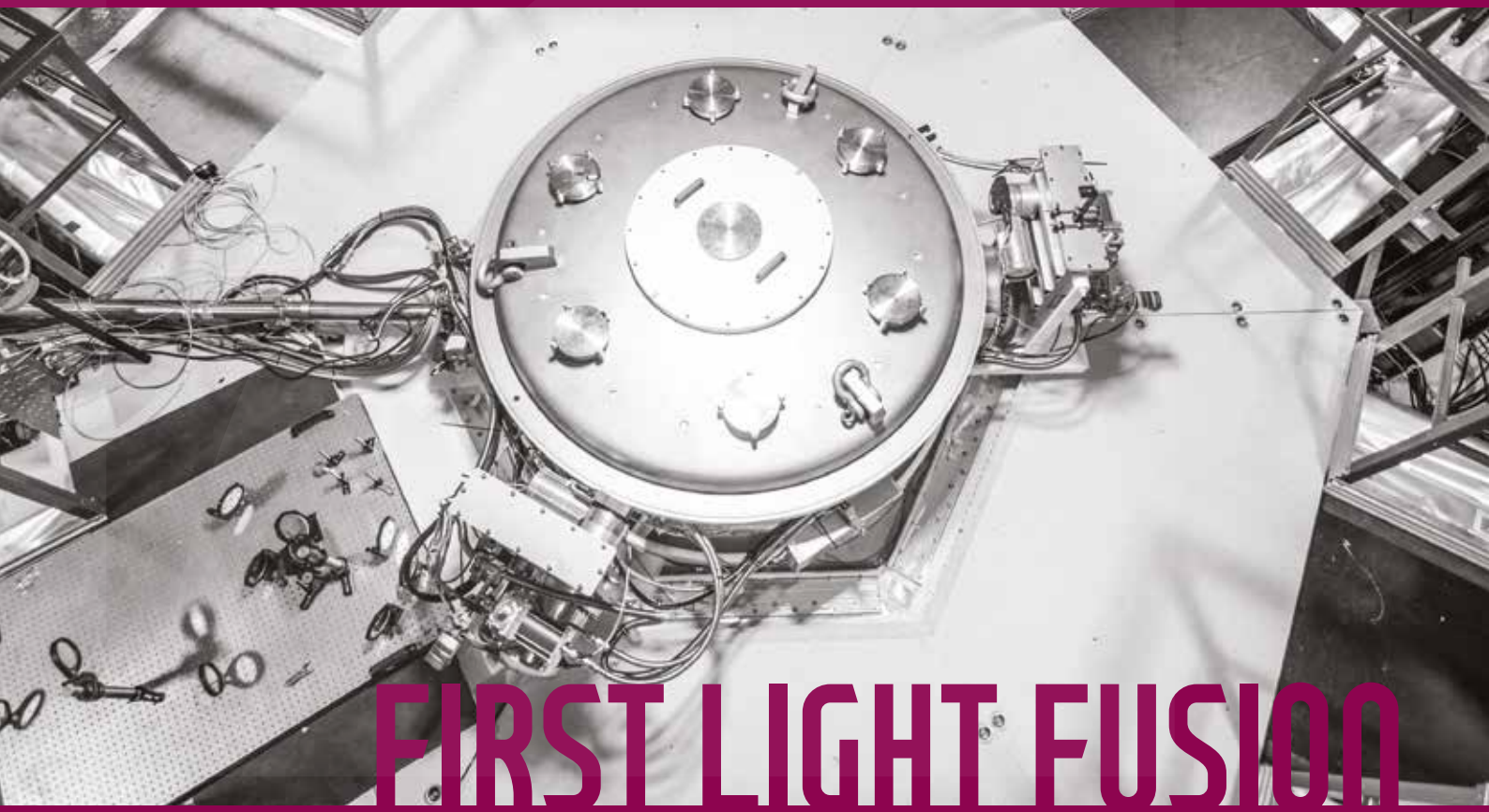
Since the group was founded by Don Schultz in the 1970s, our academics, students and researchers have won many prizes. This year was no exception, with three students having their work recognised in international events and competitions. The Society for Laboratory Automation and Screening (SLAS) has bestowed one of their highest honours, the SLAS Innovation Award 2019, on Cristian Soitu (pictured right), one of our DPhil students (supervised by Professor Ed Walsh and Professor Alfonso Castrejon-Pita) for his work in micro-fluidics. This award was open to scientists from both academia and industry at all career stages. It honours a fundamental study to develop new technology and/or use of technology to solve a unique problem. Cristian won out of ten high-calibre finalists, from hospitals, academia and industry, selected to present their work in the USA. At the award ceremony, judges recognized Cristian's presentation, 'Microfluidic Chambers Using Fluid Walls for Cell Biology', as outstanding.

DPhil student Nicholas Holgate won a prestigious ASME Heat Transfer prize (presented at the ASME Turbo Expo conference in the USA) for his work on turbine film cooling. And finally, Boon Ki Sia (an undergraduate) won the Heat Transfer Society award for her final year project on the "Experimental determination of shell-side pressure distribution at high spatial resolution in a shell and tube heat exchanger".

**For more Oxford Thermofluids Institute news, see: www.oti.eng.ac.uk**



# Spinouts



## FIRST LIGHT FUSION

Fusion power is the attempt to generate energy by smashing together atomic nuclei. The process that heats up the sun, it has the potential to deliver safe, clean, virtually limitless energy, helping to solve problems including climate change, energy inequality and the world's declining stocks of fossil fuels.

Oxford spinout First Light Fusion are working on making that future a reality, with the help of 'Machine 3'. Their research focuses on 'inertial confinement fusion'. This involves firing a high-velocity projectile, creating a shockwave and collapsing a plasma-filled cavity. This reaction creates energy, which can then be captured and used.

Their approach was inspired by the only example of inertial confinement found on Earth – the pistol shrimp, which clicks its claw to produce a shockwave that stuns its prey. The only other naturally occurring inertial confinement phenomenon is a supernova.

Machine 3 is the biggest pulsed power machine in the world dedicated to researching fusion energy. Costing £3.6m, it is capable of discharging up to 200,000 volts and more than 14 million ampere (the equivalent of nearly 500 simultaneous lightning strikes) within two microseconds. It contains some 3km of high voltage cables and another 10km of diagnostic cables. Using electromagnetic force, the machine fires projectiles at around 20km/s – enough to travel from London to New York in 4 minutes.

Now that Machine 3 is fully operational, the company seeks to demonstrate fusion capability in 2020, followed by the attainment of 'gain', whereby the amount of energy created outstrips that used to spark the reaction, by 2024.

First Light Fusion, based in nearby Yarnton, was co-founded by Dr Nick Hawker and Professor Yiannis Ventikos along with Dr Brett Tully, Dr Phil Anderson and Professor Ronald Roy.. The seeds for its work were planted here in 2007, when Dr Hawker wrote his Masters' thesis on cavity collapse, under the supervision of Professor Ventikos. The pair launched First Light Fusion in 2011.

"Our experimental campaigns will culminate in the first demonstration of fusion from one of our target designs," Dr Hawker says. "These targets have many elements and we are holding ourselves to a very high scientific standard, verifying operation of each element in isolation and cross-comparing with simulation predictions at all stages.

"In parallel we are working on the reactor concept and on the commercial aspects of the technology.

Our technology is uniquely scalable and we believe we can see a clear pathway to the first reactors producing power. We must be led by the science and there is still a lot to do, but if we can find the target that works with our reactor design, fusion would not be 'always 30 years away' – we could make it happen much faster than that"

Professor Ventikos delivered the 32nd Jenkin Lecture here as part of the 2019 Alumni Weekend.

**Watch it in full at bit.ly/JenkinLecture2019**

# Oxbotica


Autonomous vehicles have the potential to transform not just our daily commute, but also everything from airports to haulage companies. Oxford spinout Oxbotica is leading the charge.

Oxbotica was founded in 2014 by two of our professors, Paul Newman and Ingmar Posner. One of the world's leading autonomous driving software companies, they work across sectors including mining and logistics.

Professor Newman first developed an early version of the company's Selenium software while studying for his PhD, programming submarines in his native Australia. The code he wrote for those submarines is still used to navigate them today. Now, thanks to partnerships with firms including taxi company Addison Lee, that software has evolved and is being applied on the streets, with trials of driverless cars taking place in Milton Keynes, Oxford and Hounslow, outer London.

That self-contained software enables robots to navigate without relying on GPS or external maps. Instead, it uses onboard sensors, cameras, lasers and radars to interpret and act in specific environments.

Recently, the company have been a key player in the 30-month DRIVEN consortium, the most complex trial of its kind to date. Seeking to explore the fundamental barriers to commercial deployment of autonomous vehicles, it deployed a fleet of self-driving vehicles around the Queen Elizabeth Olympic Park in Stratford. The £13.6m initiative demonstrated autonomous vehicles operating safely and legally in real-life situations (albeit, so far, with a safety driver on hand to take over in case of emergency).

"We're delighted with the success of the DRIVEN project," says Professor Newman. "It provides yet more evidence that driverless vehicles will be hugely important to our future transport systems. These trials demonstrate how far down the road we already are to making that future a reality."

Still based primarily in Oxford, the company now employs 150 people in their offices in Cowley, while a new office in Toronto underlines their global ambitions. "We're currently supporting three PhD students in the Department," he explains. "We also have our own graduate training programme, and Oxford engineering undergraduates are common among our intake."

"The way in which people and goods are moved is about to change beyond recognition. To be able to make a contribution to that global revolution here in the UK makes me proud, happy and thankful to all my colleagues, employers, funders and partners."

# University Impact Awards celebrate real-world impact of research

**The 2019 MPLS Impact Awards recognised two Engineering Science researchers for their commercial and research impact.**

Professor Byron Byrne (pictured above) triumphed in the Commercial Impact category, for his contribution to new design methods for the foundations that support offshore wind turbines.

He has developed new design methods that reduce the risk and cost associated with the monopile foundations that support offshore wind turbines. These foundations are large diameter steel tubes, usually 8m to 10m in diameter, 30m to 50m long, and weighing up to 1000 tonnes. They are typically impact driven into the seafloor using pile-driving equipment.

Professor Byrne says: "By taking into account complex offshore ground conditions, lighter and more cost effective structures can be created. This research has significant implications for the future of energy production, in particular because of its contribution towards the goal of making offshore wind subsidy-free."

Dr Abhishek Dutta (pictured right) received the Early Career Impact Award for his open source image annotation software VIA, which has been downloaded more than 1,000,000 times since its release in April 2017.

It simplifies the process of manually annotating image, video and audio data – key to a variety of research topics. Oxford's Anthropology department turned to the software to manually annotate chimpanzee faces across hundreds of hours of video, while the 15cBOOKTRADE project are annotating 15th-century printed book illustrations with the programme's help.

Dr Dutta says: "The VIA software has quickly become an essential and invaluable research support tool in many academic disciplines. The credit for this widespread adoption goes to our users who not only send valuable feedback to us but also contribute software code to improve or add new features to VIA. This has helped us nurture an active and vibrant community of users around this open source project."

# Potential students get a taste of Oxford life

We were joined in the summer of 2019 by 84 gifted sixth-formers, taking part in our UNIQ and Headstart outreach courses as they considered their post A-Level options.

"These courses are designed for young people facing that big decision – what they want to do with their lives," explains Access and Alumni Officer Libby McGowan. "It's a way for them to get a sense of the undergraduate experience, which is why it's so great to have them staying in the iconic surroundings of a real Oxford college.

"The chance to sit in on a taster lecture and engage with our lecturers in an Oxford tutorial is the ultimate glimpse into student life. It's ideal for those who didn't expect to go to university at all or those who didn't see Oxford as being 'for them'.

"Student ambassador Adam Bush helped to supervise a trip to the Culham Centre for Fusion Energy (CCFE). "We were given an in-depth, all-access tour by a very experienced engineer," he explains. "Seeing the students' faces light up as we were shown around the interior of the Joint European Torus was a fantastic moment.

"Inspiring students to consider Oxford and Engineering is the primary aim of the UNIQ program, and given their reaction to this cutting-edge research facility, I would say it was definitely achieved."

Fellow Ambassador Daffodil Dhayaa adds: "Seeing the students' passion and creativity for engineering evolve during the week, helping them to understand what engineering was and seeing their enthusiasm for the subject grow, put a huge smile on our faces."

The UNIQ and Headstart courses were successful in attracting students to Engineering at Oxford – of the 48 who attended UNIQ, 19 applied to Oxford and 10 were offered places. For Headstart, 11 of the 38 attendees applied and 4 were successful in being offered a place. We look forward to welcoming them in Michaelmas 2020!

# DPhils and researchers help to inspire the next generation of female engineers

In June we welcomed 12 girls in Year 12 and 13 to join us in Oxford as part of our International Women in Engineering Day celebrations. They took part in hands-on experiments on the effect of temperature on liquid crystals with DPhil candidate Naomi Mburu, had afternoon tea with current female academics, researchers and students at Keble College, and did a People Like Me quiz to determine which careers would suit their preferred ways of working.

One of the student visitors said she "really enjoyed the practical part of the workshop, since you don't get that very often" and for another, the highlight of the day was "meeting female engineers that are doing what I aspire to do". Other participants commented that the day "showed me that there are lots of options and not one right way to get into engineering", and that "it reinforced the fact that engineering is such an exciting discipline that is constantly changing and adapting, which has made me really look forward to studying it".

International Women in Engineering Day (INWED) is an international awareness campaign to raise the profile of women in engineering and focuses attention on the amazing career opportunities available to girls in this exciting industry.

In the UK as a whole, only around 15% of engineering undergraduates are female (although around 20% of Oxford's engineering undergraduate admissions are female). The Department is committed to inspiring more women to enter Engineering, by encouraging them to study Maths and Physics at GCSE and 'A' level, to choose Engineering degrees and to develop careers within this exciting field. As part of our outreach activities we reach out to girls in secondary schools to show them what a career in Engineering can offer, and how they can give themselves the best chance of studying at Oxford.

"The day reinforced the fact that engineering is such an exciting discipline that is constantly changing and adapting, which has made me really look forward to studying it"

Sixth Form Student

# 'Digital Delius' project wins Vice-Chancellor's Public Engagement and JCDL Awards

The 'Digital Delius: Interpretation, Performance, and Analysis' project received a Project Award in this year's Vice-Chancellor's Public Engagement with Research Awards.

The project explored the cosmopolitan connections of the composer Delius and his creative affinity with the landscapes and cultures of other countries. The team created a catalogue of his works, demonstrating his painstaking compositional process and the multiple versions his pieces went through as he refined them.

"This was fundamentally a team effort, bringing together musicologists, computer scientists, performers and heritage experts, leading to a number of collaborative projects and papers. It lays the foundation for future researchers in heritage and digital musicology," said Professor Grimley, Faculty of Music, who led the project.

The Oxford e-Research Centre's work on the project was led by co-investigator Dr Kevin Page, a Senior Researcher and Associate Member of Faculty within the Department of Engineering Science.

He says: "Digital Delius demonstrates how technologies developed by the team can be used not only to support digital musicology, but also to present this scholarship to new audiences in approachable and exciting ways, increasing public access and understanding."

The team hoped to enable wider understanding and appreciation of musical sources, using Delius' manuscripts to show what they mean and to provide a holistic view of the whole lifecycle of a musical work.

Engagement activities included a commercially-released recording, a schools workshop with the Oxfordshire County Youth Orchestra, a performance by the orchestra for primary age children and a seminar for GSCE and A-level students on composer manuscripts.

"It was very interesting to see how composers wrote their music and how they didn't write it from start to finish but a little bit at a time"
Schools workshop participant

# Designing the Future at Oxford Science + Ideas Festival

A number of our researchers took part in October's IF Oxford Science + Ideas Festival. At the Westgate Centre, they demonstrated engineering innovations and ideas ranging from robotics and wireless power toys to origami structures and algorithmically enhanced stylophones.

Visitors to the Westgate were invited to take part in hands-on activities showing how engineering designs play a part in their daily lives.

Researchers from Professor Zhong You's Civil Engineering research group were demonstrating the origami structures they use to design structures and devices. Since most of the sheet materials used in engineering are relatively rigid, the researchers model origami structures as rigid facets connected by rotating hinges.

This allows origami models to be manufactured from materials such as plastic, metal or carbon fibre, producing structures that are sufficiently strong and durable for large scale applications. Origami models are being used to design structures that absorb energy when crushed, for example during a vehicle collision.

We also asked budding future engineers visiting the stands to imagine what future technology they would like to design.

Suggestions included a time machine, a jet pack, something to go to Mars, a device to help you talk to your pets, a portable fold-up car, a house you could carry in a suitcase, a car that runs on water and a robot to help elderly people at home take out the rubbish.

# Our student ambassadors

**Meet some of our student ambassadors! We asked them why they love engineering, their favourite things about living and studying in Oxford, and where they see their degree taking them in the future.**

## Dami Tariuwa, 1st Year, Jesus College

**What makes you excited about engineering?**
*"The ability to use maths and scientific knowledge to create amazing technology and structures that can significantly improve the lives of everyday people. Engineering excites me because it represents a world full of so many possibilities."*

**What kind of engineer do you think you will become?**
*"I actually have no idea! It is one of the reasons why I chose the engineering science course, it provides an opportunity to learn about different types of engineering so I can make an informed decision by the end of my degree. I am passionate about sustainable engineering so I hope to work in that sector in the future."*

## Solace Hussein, 2nd year, St Peter's College

**What makes you excited about engineering?**
*"Engineers do not design things to be left on shelves. Instead, their work is to create things that bring people together and, in turn, create a world that is better off. I am studying Engineering so I can go on to positively impact people's lives."*

**What kind of engineer do you think you will become?**
*"I want to become a biomedical engineer because I am inspired by the concept of improving the quality of healthcare that people, especially in the more deprived areas of the world, have access to."*

## Felix Peterken, 3rd year, Balliol College

**What makes you excited about engineering?**
*"The application of maths to real world scenarios to model systems is something that gives me great satisfaction, as well as the joy of problem solving and arriving at the correct result after a long method. In a longer-term approach, it would be nice to consider what I do as being worthwhile to people, like playing a role in reducing climate change or creating tech that treats people's illnesses."*

**What is your favourite thing about Oxford?**
*"The college system creates a nice sense of community where you know everyone in it and everything that's going on."*

## Nobel Basser, 4th Year, Lincoln College

**What makes you excited about engineering?**
*"The fact that we are surrounded by it. From the floor we stand on, to the pens we use, to the ceilings above us. Engineering is everywhere we go, and the only way to escape from it is to go deep into nature. The practicality and applicability of engineering is also exciting - everything we learn in the degree we see in our daily lives."*

**What kind of engineer do you think you will become?**
*"I think I will be a Biomedical engineer – it combines all disciplines, and applies that to our own bodies, meaning we can see the effects of it up front. The biomedical modules have also been the ones I've enjoyed studying most."*

# Young engineers named as 2019 IET Scholars


Each year, the Institute of Engineering and Technology recognises five early-career researchers whose work demonstrates excellence and innovation in tackling real-world problems. 2019 saw three Oxford engineers honoured with IET Scholarships.

Saumya Jetley researches computer vision, specialising in human saliency estimation – that is, in training robots to mimic the attention patterns of humans when looking at a given scene. Her work has potential applications including the design of autonomous vehicles and in building assistive technologies for the partially sighted.

Saumya says: "I'm told that the judges were impressed not only by my research work but also by the energy with which I presented it. I recently received an invitation for the role of a Young Professional Ambassador at IET. This has certainly opened some new doors for me, and I am excited to be walking through them!"

John Sandford O'Neill (pictured above) uses lasers to 3D print at the micro scale and build photonic structures from liquid crystals. Instead of plastic, his 'resin material' is liquid crystals – a state of matter with properties that fall between those of liquids and of solid crystals. This could lead to us finally achieving the kind of flexible LCD screens that have been predicted for so long.

He adds: "I am absolutely delighted to have been recognised by the IET for my DPhil research, it makes all those hours in the lab worth it! It's really gratifying to get such positive feedback from the wider engineering community and I'm looking forward to using this award as a springboard to engage with the public and further develop my skills in science communication."

Oliver Vince's research uses ultrasound and microbubbles to deliver drugs non-invasively; he aims to improve both its tumour-targeting accuracy and therapeutic efficacy. He explains: "Microscopic brain tumours are one of the most dangerous forms of cancer, often causing severe illness even before they are large enough to image. By delivering drugs selectively to the tumour sites, we hope to develop the first effective treatment for microscopic brain tumours, whilst simultaneously reducing the side effects associated with chemotherapy."

Oliver Vince

"I am extremely grateful to the IET for this award in recognition of the research achievements in my PhD so far. This work would not have been possible without the help and support given to me by many people across the Departments of Engineering Science and Oncology."

# First prize for Solid Mechanics DPhil candidate

DPhil candidate Akash Trivedi won first prize in the British Society for Strain Measurement (BSSM) 2019 Young Stress Analyst competition.

His presentation described a novel approach to developing a model for impact behaviour of polymers, using data obtained in simpler experiments that can be performed at lower speeds.

The model is based on the principle that the behaviour of polymers under rapid loading is equivalent to that at low temperature and is described in a paper authored by Akash and his supervisor, Professor Clive Siviour.

# Schmidt Science Fellowship for Rhodes Scholar Gladys Ngetich


Gladys Ngetich was among the early-career researchers announced for the 2019 cohort of Schmidt Science Fellows. Her work is in advanced cooling processes for jet engines, which it is hoped could help develop more efficient and less environmentally damaging aircraft engines.

The Fellowships aim to develop interdisciplinary science leaders who can tackle the world's most significant problems. On completion of their PhD, the Fellows undertake a disciplinary change in their research, exposing them to new ideas and techniques from different scientific disciplines.

Gladys, from Kenya, will receive mentoring from world-leading scientists, as well as a stipend of $100,000.

"I am absolutely honored to have made it to the list of this year's Schmidt Science Fellows," she says. "I sincerely thank the Schmidt Science Fellowship team in collaboration with The Rhodes Trust for this special chance that will enable me to hone both my engineering research skills and leadership skills."

# DPhil candidate presents in Parliament

DPhil candidate Bárbara Souza attended Parliament in March 2019 to present her research to politicians and a panel of expert judges, part of the STEM for BRITAIN competition.

Bárbara presented a poster on her research into the uses of Metal-Organic Frameworks (MOFs) as drug delivery systems and their integration into polymeric nanofibers for the fabrication of multifunctional wound dressings applied to the active treatment of skin cancer and other chronic skin diseases.

Bárbara was short listed from hundreds of applicants to appear in Parliament. She says, "I am thrilled to present my research and show the potential Metal-Organic Frameworks have to overcome current treatment challenges and improve patients' quality of life whilst reducing the costs of treatment."

# Singapore summit for young engineer

Laura Diment, DPhil student, was selected to represent the Department at the 2019 Global Young Scientists Summit in Singapore (20-25 January).

She says: "Having the opportunity to engage with over 200 doctoral and postdoctoral students from around the world from disciplines of engineering, chemistry, physics, medicine, mathematics, and computer science – and to discover how science is being shaped and how our knowledge of the world around us is expanding – was exciting.

"A highlight for me was hearing from Barry Barish, who showed video footage of two black holes merging.

I also enjoyed hearing Michael Graetzel explain his discovery of a new type of solar cell based on dye sensitised nanocrystalline oxide films, which mimic the light reaction occurring during natural photosynthesis. Ben Feringa's work on developing molecular motors and Ada Yonath's on modelling the effect of antibiotics on ribosomes were also highlights."

# Engineers without Borders inspire school children

Student engineers spent a week teaching at village schools in rural Karnataka, southern India. Organised by the Oxford branch of the Engineers Without Borders charity, the students ran interactive workshops which aimed to engage the young people they met.

DPhil candidate Leon Romano-Brandt led the trip. A St Hugh's College student specialising in Materials Engineering, he tells us more about what it involved.

***What was the thinking behind your visit?***

Our goal is to inspire schoolchildren from less advantaged backgrounds to pursue engineering and natural sciences at university. We think this is one way to improve the overall economic situation in rural Indian villages.

Science classes in rural Indian schools can be very dry, due to a lack of practical experiments.

We designed hands-on classes on topics including:

- Robotics: Building, programming and controlling your own robot using the VEX Robotics kit
- Electronics: Building and understanding a DC motor
- Binary numbers: Building a binary adding machine using only cardboard and marbles

***What was the experience like?***

For most of our team members, it was their first stay in India. We were based in Bangalore – a very modern and busy IT metropolis – from where it was approximately two hours' drive to the villages. It took us a day or two to get used to the very heavy traffic and pollution in the city.

Once in the villages, we were overwhelmed by the friendliness and hospitality that we experienced.

As all the students understood that our summer school was a great opportunity to learn about science and engineering in an interactive way, they were extremely motivated and hard working.

***What's next?***

We are currently in the process of recruiting Oxford students and applying for funding for our next visit, which is planned for the beginning of next year. We would like to thank the Department of Engineering Science for their contribution towards our last trip, through the Engineering Undergraduate Innovation Fund.

# DPhil student's machine learning skills help NASA to map settlements

Currently, nearly one quarter of the world's urban population lives in informal settlements or encampments. They are home to some of the poorest people on the planet. However, efforts to improve living standards are hampered by a lack of information, with their sizes and locations often unknown.

For this reason, 2018 saw the Frontier Development Lab (FDL) announce their goal of mapping informal settlements. A collaboration between NASA, the European Space Agency and private enterprise, they aimed to create a 'Mission Control for Planet Earth', using satellites to make a difference to people on the ground.

DPhil student Bradley Gram-Hansen (part of the Department's Centre for Doctoral Training in Autonomous Intelligent Machines and Systems) has been lending his Machine Learning expertise to help make this goal a reality. He explains: "Mapping informal settlements is vital for providing local government and nongovernmental organisations with geographic locations of informal settlements, allowing the delivery of targeted economic and social aid.

"However, generating these maps is currently very costly; it costs approximately $10,000 to obtain a high-resolution image the size of the urban area of Nairobi."

Machine learning makes it possible even for cash-strapped NGOs. "For the first time," says Bradley, "we can make use of freely available global low-resolution satellite imagery, predicting and generating maps that provide the locations of these settlements."

The team also demonstrated a second method for detecting informal settlements with satellite images. By applying simple classifications algorithms, they can detect materials that are known to be used regularly in the construction of informal settlements.

Bradley concludes: "It's nice to work on applications that have the potential to have a profound impact on society. There is still an awful lot of work left to do, but these experiments provide a base which we can build upon."

# Alumna profile - Laura Mason

**Laura Mason, Oxford Engineering alumna and CEO of Institutional Retirement at Legal & General, tells us how her studies proved invaluable in the business world and discusses the partnership between L&G and Oxford University.**

Laura Mason first came to Oxford University as an undergraduate in the Department of Engineering Science. She went on to complete her DPhil here, choosing to specialise in neural networks and signal processing. Her thesis focused on the analysis of brain frequencies to monitor respiration in a non-invasive fashion.

Alongside her Engineering Science expertise, Laura is a qualified actuary. That role sees her dealing with risk and uncertainty in complex financial systems – but that's not as big a leap as you might think.

"My career path ended up being very different to my studies," says Laura. "But engineering gave me the ability to solve problems, and to look at things in a unified way. It allows me to take financial systems as a whole and spot where the issues are, approaching them from different angles."

Her career began in consultancy, a career in which Oxford's broad-based engineering course proved particularly helpful. Having studied so many different facets of modern Engineering Science, from energy engineering to biomedical, she had developed the ability to quickly find her feet when working alongside various different businesses.

After eight years in consultancy, it was time for Laura to move on. She joined financial services group Legal & General, initially with responsibility for Annuity Investment. In January 2018, she was named CEO of the firm's Institutional Retirement arm, which assists companies with their pension schemes and works to secure their members' benefits.

In 2019, Legal & General announced a major partnership with Oxford University, worth an impressive £4 billion. It will see the University working together with L&G to develop homes for University staff and students, together with science and innovation districts in and around Oxford.

As well as much-needed graduate accommodation, the project will see subsidised housing for staff, which will help Oxford compete with other universities that have more capacity in this area. New science parks will bring together academic departments, University spin-outs and commercial partners, working together to create new companies and high quality jobs.

For Laura, her part in the project was a chance to give back to the University. "I loved my time at Oxford and I was delighted to have a chance to help the University advance its future," she says.

"My colleagues and I are delighted to have formed this partnership, and we're looking forward to working together to address some of the most pressing challenges facing higher education today. Great universities, like Oxford, need the infrastructure to attract people and businesses with worldleading potential."

"It's great for the students who are learning there as I did, as well as for the academics I had the opportunity to learn from."

For more Alumni news and profiles, see: www.eng.ox.ac.uk/alumni

# Oxford Engineering Alumni (OEA)

**OEA includes all Oxford Engineering Science graduates, and present and past members of teaching and research staff of the Department. If this applies to you and the Department has your contact details, you are already a life member.**

## Our Annual General Meeting

Oxford Engineering Alumni held their Annual General Meeting at the Thom Building during the afternoon of 21st September, during the Alumni Weekend. The President, Professor Rod Smith (alumnus), introduced the new Head of Department Professor Ron Roy, who spoke on recent developments in the Department.

Some changes to the OEA Committee were agreed. There was also a presentation of the Department's ambition to develop its relationship with alumni further, including a role for the OEA Committee in its operational structure. Alumni welcomed this new development.

## Final Year Project Presentation Prizes

Each year at the Maurice Lubbock Memorial Lecture since 2001, 4th year Engineering Science undergraduate students have presented their final year projects to Alumni and visitors.

Their posters are judged by Alumni representatives now working in industry, with prizes going to winners in 11 categories, and an overall winner is chosen by the Oxford Engineering Alumni (OEA) group.

### Main Prize Winners

OEA Prize for best Project Presentation
**Diarmid Xu**
*'Performance of Construction Support Fluids: Experimental Testing'*

OEA Runner-up Project Presentation Prize
**Andreea-Maria Oncescu**
*'Failure detection of low-cost wearable devices using recorded data and reports'*

### Category Winners

The Rolls-Royce prize for most innovative exhibit
**Matthew Wilson**
*'Locking Mechanism for a Breathing-Powered Prosthetic Arm'*

The Osborne prize for best civil engineering exhibit
**Lukasz Skowron**
*'Bearing Capacity of Perforated Offshore Foundations'*

The GlaxoSmithKline prize for best biomedical engineering exhibit
**Megha Hegde**
*'Neural networks for gestational age estimation of brain ultrasound'*

The UK AEA prize for best mechanical engineering exhibit
**Benjamin Naylor**
*'Effects of Scour and Protection on Foundation Behaviour'*

The Sony prize for most impactful exhibition
**Max Bain**
*'Fine-Grained Recognition in the Wild'*

The Ecrin Investments prize for best information and control engineering exhibit
**Shu Ishida**
*'Robot Path Planning for Multiple Target Regions'*

The BP prize for most comprehensive exhibit
**Jonathan Collins**
*'Derivation of Seismic Fragility Curves for Typical Nepalese Houses'*

The EDF prize for most engaging speaker
**Michael Newsome**
*'The effect of sleep on human intervertebral disc nutrition'*

The EIBF prize for best Engineers in Business Project
**Jian Lim**
*'Bayesian Optimisation for Automated Machine Learning'*

# 2019 "Meeting Minds" Alumni Weekend events

Former students of the Department of Engineering Science returned to Oxford on 21st September to take part in the University's Alumni Weekend. Around 90 alumni attended.

They took part in a programme of events in the Department that included building tours and lab viewings, showcasing some of the new laboratories and teaching and research facilities now housed in the Thom Building.

The highlight of the afternoon was the 2019 Jenkin Lecture by Professor Yiannis Ventikos on 'Fusion as a method of power generation: science, engineering, entrepreneurship and adventure' (see page 12).

"Great - I actually understood it this year! Very relevant and interesting, great demo to really explain things."
Alumni feedback

Didn't make it to the Alumni Weekend? Take a look around our labs with the Virtual Building tour on our website.

**You will find it at:**
**www.eng.ox.ac.uk/virtual-tour**

# A message from the Alumni Officer

I'd like to take this opportunity to introduce myself to you all. My name is Libby McGowan and I am the Department's Access and Alumni Officer. I've been here for just over a year, although I worked in various sections of the wider University before this.

My role is split between overseeing our outreach work – you can find out more about that on p.15, and managing alumni relations. That ranges from talking to alumni about what you want from the Department, to organising our events.

I've met many of you already at those events – including the Alumni Weekend and Lubbock Lecture – and I've heard so much about your memories of your time here and your ideas for the future of Engineering Science at Oxford. The interest and involvement of our alumni community is a huge strength of this Department, and I'm passionate about harnessing that to encourage a close collaboration between the Department, our alumni, and our current student population.

I'd like to say a massive thank you to the OEA Committee, as well as to all of the Alumni community for making me feel so welcome. I'd love to hear from you, and you can always email me on alumni@eng.ox.ac.uk

We're also always looking for interesting Alumni to feature on our website. Please email: alumni@eng.ox.ac.uk if you would like to be featured.

We'd particularly like to hear from female alumnae in 2020, as the University celebrates a century since the first women collected degrees at Oxford.

# Academic News

**The Department continued to grow in 2019, and we welcomed seven new academics.**

**Professor Laurence Brassart** focuses on the development of advanced mathematical theories that are useful to understand and predict the mechanical behaviour of a broad range of materials, from metallic alloys and composites to polymers and biomaterials. The general objective of her research is to elucidate the complex relationships between microstructure and macroscopic properties, essential for the rational design of advanced materials and structures in many engineering fields.

**Dr John Coull** joined us as a Senior Research Fellow in Gas Turbine Aerodynamics. His research interests cover many aspects of turbine aerodynamics and heat transfer, together with fundamental fluid flow and measurement techniques.

**Dr Roisin Buckley** took up the position of Ørsted REMS CDT Departmental Lecturer in Geotechnical Engineering. Her research aims to understand the mechanics of and improve the design of pile foundations subjected to axial and lateral loading for onshore and offshore applications.

**Professor Felix Leach's** research interests lie in combustion, and specifically emissions and efficiency in internal combustion engines. He has run projects with Oxford City Council and Oxford Bus Company measuring emissions from buses, identifying pollution 'hot-spots' such as poorly-designed junctions.

**Professor Barbara Rossi** joins us from KU Leuven in Belgium, where she led a research group exploring the structural behaviour of metallic structures. Over the last ten years, she has also branched into the research area of life-cycle analysis and sustainability applied to steel construction.

**Dr Edmund Tarleton** completed his DPhil in Materials Science and MSc in Mathematical Modelling and Scientific Computing here at Oxford. He joins us as an Associate Professor and EPSRC Research Fellow. He is developing computational models to understand the mechanical behaviour of engineering materials.

**Professor Noa Zilberman** is leading research in Digital Electronics. Her research focuses on the integration of micro-level architectures and macro-level, large scale networked-systems. Before joining Oxford, she spent close to 15 years in industry, and was a Fellow and an Affiliated Lecturer at the University of Cambridge.

We also saw some changes to the makeup of our Senior Management Team. Following the appointment of Professor Ron Roy as Head of Department, he was replaced as Associate Head of Research by Professor Martin Booth. The new Associate Head of Graduates is Professor Robin Cleveland, taking over from Professor Mark Thompson.

# Academic Awards

Former member of Faculty **Professor Alistair Borthwick** was presented with the Institute of Civil Engineers' prestigious Gold Medal for his lifelong contribution to engineering. Alistair worked here from 1990–2011, and his nomination was supported by four former Heads of Department. His career has spanned civil, coastal and offshore engineering across industry and academia.

**Professor Paul Newman,** Director of the Oxford Robotics Institute, received the Royal Academy of Engineering's Silver Medal. The award recognised his pioneering work on developing the technology behind autonomous vehicles, including the RobotCar (the first autonomous vehicle on UK roads).

Also honoured by the Royal Society was **Professor Alison Noble**, who received the Gabor Medal. It is awarded annually for distinction in interdisciplinary work between the life sciences and other disciplines. Professor Noble also received the 2019 MICCAI Society Enduring Impact Award, recognising an individual who has made a lasting mark on the field of medical image computing and computer assisted interventions.

**Professor Eleanor Stride** was a Finalist in the Blavatnik Awards for Young Scientists in the UK, and was also recognised as one of the 100 Most Influential Women in Engineering, in a list compiled by board appointment firm Inclusive Boards. Learn more about her research on p.6.

**Professor Lionel Tarassenko** received the Oxford Trust's Outstanding Achievement Award at their 2019 Enterprise Awards. It recognised his pioneering work in the clinical use of machine learning, which has had a huge influence on the development of e-health, not just in Oxford but around the world.

**Professor Andrew Zisserman** was awarded a Royal Society Research Professorship, the Royal Society's premier research award. He plans to use his Professorship to develop new ways for computers to understand the content of video streams, inspired by how infants may 'learn to see'. He will split his time between Oxford and Google DeepMind.

**Janet Pierrehumbert**, Professor of Language Modelling at the Oxford e-Research Centre, was elected as a member of the National Academy of Sciences in the United States, in recognition of distinguished and continuing achievements in original research.

And finally, four of our academics were named as Royal Academy of Engineering Fellows: **Professors Alan Cocks**, **Constantin Coussios**, **Peter Ireland** and **Philip Torr** were elected in recognition of their outstanding and continuing contributions to the profession.

# Thank you for your support

We would like to acknowledge the important role played by our individual and corporate supporters, and we thank them for the invaluable contribution they have made to the Department.

# Find out more

To see more news about the Department, pleasevisit our website www.eng.ox.ac.uk.

Please send us any news likely to be of interest to other Engineering alumni, for inclusion on the website, to alumni@eng.ox.ac.uk

You can also follow us on Twitter @oxengsci and on LinkedIn.

# Help current students

Could you help us to enrich the student experience at Engineering Science? If you feel you could offer any of the following, please contact Libby McGowan on alumni@eng.ox.ac.uk.

- Offer student placements or internships at your company
- Act as a student mentor. We especially welcome female former students to mentor our growing number of female engineers
- Give a talk or arrange a site visit of engineering interest.

# Alumni Profiles

As part of the new website, we are looking at updating our alumni pages. One of the things we would like to include is an alumni profiles page showcasing Engineering Science alumni. If you would like to have your profile showcased on the website, please get in touch with Libby McGowan, Access and Alumni Officer, at alumni@eng.ox.ac.uk.

We are hoping to launch the webpages in late 2020 so please look out for this when it goes live! You may recognise some ex-classmates or people in the same industry as you.